Magnetic Fluid Conditioning of Onion *(Allium cepa)* Seed Lots To Increase Germination[1]

P. Krishnan and A. G. Berlage[2]

ABSTRACT

In magnetic fluid seed conditioning, the seed lot is treated with a ferromagnetic fluid and passed over a magnetic drum separator. The effects of magnetic-fluid conditioning on germination of treated onion seeds (*Allium cepa* L.) (low- and high-grade) were investigated. Magnetic fluid was used in three different dilutions (15:1, 10:1, and 5:1 water-to-fluid ratio by volume). A commercial, permanent, magnetic drum separator, measuring 0.08 tesla magnetic flux density at its surface, was used to separate the magnetics from the nonmagnetics. Germination tests were carried out on the seeds in the nonmagnetic fraction and the control. Seed conditioning with magnetic fluid significantly ($P < 0.05$) improved germination percentages of the nonmagnetic (cleaned) onion seeds for the low-grade seed lot, but not those of the high-grade seed lot.

A continuous-flow treatment and drying system is described. Conditioning with the 5:1 dilution of magnetic fluid not only removed more shriveled and low-germinating seeds than conditioning with the 15:1 dilution of magnetic fluid, but also removed some good seeds. Our study indicated that low-grade seed lots should be conditioned with the 10:1 dilution and high-grade seed lots with the 15:1 dilution of magnetic fluid for effective removal of shriveled and low-germinating seeds and for optimizing the number of seedlings in the field.

Additional index words: ferromagnetic fluid, drum separator.

INTRODUCTION

Seed conditioners sometimes find difficulty in conditioning seed lots to meet acceptable marketing or legal standards for germination. Lots containing excessive shriveled, cracked, and immature seeds are usually discarded from their inventory or attempts are made to salvage them by blending with another seed lot of higher quality. The use of magnetic fluid offers an alternative to improve germination percentage of an individual lot.

In magnetic fluid seed conditioning, the seed lot is treated with a ferromagnetic fluid and passed over a magnetic drum separator. The fluid is a colloidal suspension of submicron-sized ferrite particles in a carrying fluid (e.g., water, kerosene, heptane, silicone, flourocarbon) with a dispersing agent to prevent flocculation (Rosensweig, 1966). The magnetic fluid can contain ferromagnetic particles other than iron, namely cobalt, nickel, gadolinium, and dysprosium (Khalafalla, 1975). The magnetic drum separator can be either permanent or electromagnetic.

Several seed-conditioning methods have been used to improve the mean germination percentage of a seed lot. Researchers have used pneumatic separation (Niffenegger et al., 1959; Smittle et al., 1976; Kunze et al., 1969; Cundiff and Williamson, 1976; Everson, 1957; Longden et al., 1974; Smith et al., 1973; Delouche, 1965), or screening techniques (Niffenegger et al., 1959; Longden et al., 1974) to improve germination. These techniques make use of one or more physical characteristics of seeds, i.e., seed weight, thickness, diameter, size etc. that are associated with higher germination potential. In general, seeds that were lifted and removed were light and shriveled and had a low germination percentage; seeds that were not lifted were heavy and plump and had a high germination percentage.

Delouche (1965) successfully used a commercial-size electronic color sorter and an electrostatic separator to improve the germination of the crimson clover (*Trifolium incarnatum* L.) seed lots. Harmond and Moore (1969) found that germination and appearance of cotton *(Gossypium)* seed lots were improved materially by removing the gin-saw cut, cracked, and partly crushed seeds with the magnetic separator. Moore (1958) used iron powder and a magnetic separator to improve germination of crimson clover seed lots by removing the mechanically damaged seeds.

The use of the magnetic fluid process has been demonstrated on certain crop seeds. The purpose of this study was to define the effectiveness of this process in improving onion seed lot germination percentage. The specific objective was to study effects of magnetic fluid conditioning on germination of treated onion (*Allium cepa* L.) seeds.

MATERIALS AND METHODS

Two commercial onion seed lots (A, low-grade; and B,

[1]Research done in cooperation with the Oregon Agricultural Experiment Station; Technical Paper No. 7313. Received for publication 12 October 1984.

[2]Assistant Professor, Department of Agricultural Engineering, Oregon State University, Corvallis 97331; Agricultural Engineer, Agricultural Research Service, U. S. Department of Agriculture, Department of Agricultural Engineering, Oregon State University, Corvallis 97331.

Mention of a trademark or proprietary product does not constitute a guarantee or warranty of the product by the USDA or imply approval to the exclusion of other products that also may be suitable.

Table 1. Seed germination and seed count of nonmagnetic (cleaned) fraction of two onion seed lots.

Magnetic fluid treatment*	Iron content (% by wt)	Seed Lot A			Seed Lot B		
		Crop seed saved (% by wt)	Germination (%)	Seeds (per g)	Crop seed saved (% by wt)	Germination (%)	Seeds (per g)
15:1	0.54	96	79 ± 8 b†	277 ± 4	98	86 ± 4 a†	246 ± 2
10:1	0.77	90	82 ± 5 ab	268 ± 1	97	87 ± 2 a	241 ± 3
5:1	1.70	73	87 ± 2 a	258 ± 2	90	83 ± 2 a	241 ± 6
Control‡	-	-	72 ± 0 c	286 ± 2	-	87 ± 0 a	253 ± 2

* Parts of water to parts of magnetic fluid, by volume.
† Values followed by the same letter in the respective germination % columns are not significantly different from each other at the 5% level of probability based on Duncan's multiple range test.
‡ The single-replicate control was not treated with the magnetic fluid or processed over the permanent magnetic drum.

high-grade) precleaned in the laboratory air-screen separator were used in the test. A Boerner divider was used to divide the seed lots into 25-g samples. A laboratory batch-type mixing unit with wooden stirrer was used to mix the magnetic fluid with seed samples. A commercial permanent magnetic-drum separator, measuring 0.08 tesla magnetic flux density at its surface, was used to separate the magnetics from the nonmagnetics.

LIGNOSITE® FML (Georgia-Pacific Corporation, 1980) magnetic fluid was used in the trials. It is an aqueous colloidal solution of a ferromagnetic iron lignosulfonate. Magnetite particles averaged 100 Å in diameter with an approximate range of 50 to 200 Å. Magnetic fluid was used in three different dilutions (15:1, 10:1, and 5:1 water to fluid ratio by volume). The 15:1, 10:1, and 5:1 dilutions had 0.54, 0.77, and 1.70 percent of iron, by weight, and 1.70, 2.40, and 5.30 percent of total solids, respectively (Krishnan et al., 1983). The original magnetic fluid (before dilution) had an iron content of 10.27 percent and a total solids content of 32 percent, by weight. Each treatment was replicated three times. Order of testing was randomly selected.

A 25-g onion seed sample was placed in a glass jar and 4 ml of magnetic fluid of a given dilution (15:1, 10:1, or 5:1) was injected into it. This combination was mixed in the laboratory batch-type mixer for 4 min. Mixing action was enhanced by a wooden-spiked stirrer. The treated mixture was allowed to dry in a tray for about 12 hr. under ambient conditions before being passed over the drum separator. The control sample was not treated or mixed with the magnetic fluid and not processed over the drum separator.

The drum separator feed rate, speed, and space between divider and drum were held constant at 2.1 kg/hr, 40 r/min and 18 mm, respectively, for all tests. The magnetic fractions and the nonmagnetic cleaned fractions of each test were weighed and analyzed.

All germination tests were carried out according to the Rules for Testing Seeds, Association of Official Seed Analysts (1978). The seed lots tested were the nonmagnetic fractions (treated with the magnetic fluid and processed over the drum separator) and the control.

Treatment effects were tested by analysis of variance. Duncan's multiple range test (Little and Hills, 1978) was used to test the means.

RESULTS AND DISCUSSION

Treatments significantly ($P < 0.05$) affected the germination percentages of onion seeds in the nonmagnetic (clean) fractions for seed lot A (Table 1). Seeds conditioned with the 5:1 diluted magnetic fluid (treated with 5:1 diluted magnetic fluid and passed over the drum separator) had 8% higher germination than those conditioned with 15:1 diluted magnetic fluid. They also had 15% higher germination than that of the control. However, seeds conditioned with 5:1 diluted magnetic fluid did not have significantly higher germination percentages than those conditioned with 10:1 diluted magnetic fluid. Also, seeds conditioned with 10:1 magnetic fluid had 10% higher germination than those of the control.

There were no significant differences among treatments for the germination percentages of onion seeds in the nonmagnetic fractions for seed lot B.

Seed count for seeds in the nonmagnetic fraction in seed lot A treated with the 5:1-, 10:1-, and 15:1-diluted fluid were 258, 268 and 277 seeds/g, respectively; for seeds in seed lot B, 241, 241 and 246 seeds/g, respectively. The 5:1 fluid had 1.16% by weight more submicron-sized iron content than 15:1 fluid. Conditioning with the 5:1 fluid not only removed more shriveled and low-germinating seeds than 15:1 fluid but also removed some good seeds. This was observed by examining the magnetic crop seeds under the light microscope and by germination tests.

The number of onion seedlings expected in the field under favorable weather conditions can be calculated from onion seeds saved in the nonmagnetic fraction, germination percentage, and seed count data (Table 1).

Mathematically, $NSD = CSS \times SC \times G$

where
NSD = number of seedlings
CSS = crop seed saved, g
SC = seed count, seeds/g
G = germination %

For the low-grade seed lot and 15:1 fluid conditioning treatment, CSS, SC, G, and NSD values are 0.96 g, 277 seeds/g, 79%, and 210, respectively. Seeds conditioned with 15:1 fluid would produce 22% (seed lot A) and 14% (seed lot B) more seedlings than those treated with 5:1 fluid.

Seeds conditioned with 10:1 fluid would produce 17% (seed lot A) and 12% (seed lot B) more seedlings than those treated with 5:1 fluid.

Results from these trials can be applied to the problem of improving the germination of seed lots. Seed lots should be conditioned with 10:1 or 15:1 fluid depending upon seed lot conditions. Low-grade seed lots should be conditioned with 10:1 fluid and high-grade seed lots with 15:1 fluid.

APPLICATION

Based on our laboratory studies, we designed, constructed, and tested a continuous-type magnetic-fluid treatment and drying system. This system included a 15 cm wide electromagnetic feeder, 163 cm long vibrator, two Teejet flat spray nozzles (# 730-023), magnetic fluid reservoir, pressure regulator, on-off valve, and four 250 W infrared lamps (Fig. 1). Seeds were fed in a vertical stream to the

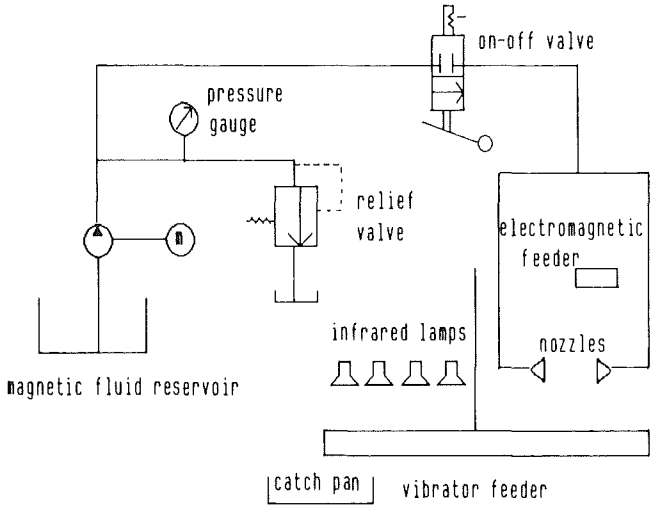


Figure 1. Schematic diagram of the continuous-type magnetic fluid spraying system.

vebrator conveyor by the electromagnetic feeder positioned 58 cm above the conveyor. The two Teejet flat spray nozzles, one on either side of the seed stream 25 cm above the conveyor, sprayed the diluted magnetic fluid on seeds to provide sufficient fluid to wet the mixture. The treated seed-soil mixture was dried by infrared lamps (located 10 cm above the conveyor), so the mixture flowed freely before it was collected at the conveyor discharge. This treated mixture was then passed over the magnetic separator to remove the soil particles. Seeds included in these trials were bentgrass (*Agrostis palustris* Huds.) and white clover (*Trifolium repens* L.). Best results for the bentgrass were obtained with the 15:1 diluted magnetic fluid at a flux density of 0.63 tesla. This operating condition resulted in minimizing crop seed loss while meeting phytosanitary tolerances for soil particles of 0.03 percent by weight required for bentgrass seed being exported to Japan (Krishnan et al., 1983).

This new technique should be further investigated to examine magnetic fluid application methods, seed drying requirements, effect on seed quality, and application to seeds of other plant types. These may include beet (*Beta vulgaris* L.), parsnip (*Pastinaca sativa* L.), hybrid cabbage (*Brassica oleracea* L.), and radish (*Raphanus sativus* L.).

CONCLUSIONS

1. Magnetic-fluid conditioning treatment significantly ($P < 0.05$) affected germination percentages of the nonmagnetic (cleaned) onion seeds for the low-grade seed lot. The 5:1 diluted magnetic-fluid conditioning increased germination by 8 and 15% more than seed treated with 15:1 diluted magnetic-fluid conditioning or control, respectively. The 10:1 diluted magnetic-fluid conditioning increased germination by 10% more than that of the control. There were no significant differences among conditioning treatments for the nonmagnetic onion seed germination for the high grade seed lot.
2. The 5:1 dilution magnetic-fluid conditioning not only removed more shriveled and low-germinating seeds than 15:1 dilution magnetic fluid conditioning but also removed some good seeds. This will affect the number of seedlings expected in the field under favorable weather conditions.
3. Our study indicated that the low grade seed lots should be conditioned with the 10:1 diluted magnetic fluid for effective removal of shriveled and low-germinating seeds and for optimizing the number of seedlings in the field.

REFERENCES

1. Anon. 1978. Association of Official Seed Analysts Rules for testing seeds. J. Seed Tech. 3:126.
2. Anon. 1980. LIGNOSITE® FML. Tech. Bull. Georgia-Pacific Corp., Bellingham, WA. 1 p.
3. Cundiff, J. S., and R. E. Williamson. 1976. Tobacco seed segregation based on differences in terminal velocities. ASAE Paper No. 76-3457. 44 p.
4. Delouche, J. C. 1965. A preliminary study of methods of separating crimson clover seed on basis of viability. Proc. Assoc. Off. Seed Anal. 55:30-36.
5. Everson, L. E. 1957. The climax blowing point for the analysis of Kentucky bluegrass. Proc. Assoc. Off. Seed Anal. 47:73-76.
6. Harmond, J. E., and V. P. Moore. 1969. Cotton planting seed quality can be improved. The Cotton Gin and Oil Mill Press. 1 p.
7. Khalafalla, S. E. 1975. Magnetic fluids. CHEMTECH September:540-546.
8. Krishnan, P., N. R. Brandenburg, D. M. Bilsland, and A. G. Berlage. 1983. Magnetic fluid-aided separation of contaminants from crop seeds. TRANS. of the ASAE 26:610-612 and 616.
9. Kunze, O. R., L. H. Wildes, and G. A. Niles. 1969. Field emergence and growth response related to the physical characteristics of cottonseed. TRANS. of the ASAE 12:608-610, 613.
10. Little, T. M., and F. J. Hills. 1978. Agricultural Experimentation. John Wiley and Sons, Inc. New York. pp.63-65.
11. Longden, P. C., R. K. Scott, and D. W. Wood. 1974. Grading monogerm sugarbeet seed and its influence on performance. J. Agric. Sci., Camb. 83:125-133.

12. Moore, C. E. 1958. Magnetic separation of seed. M.S. Thesis. Mississippi State University, State College, Mississippi. 75 p.
13. Niffenegger, D., R. F. Eslick, and D. J. Davis. 1959. The effect of screening and blowing on the pure live seed concept of alfalfa seed quality. Proc. Assoc. Off. Seed Anal. 49:40-43.
14. Rosensweig, R. E. 1966. Magnetic fluids. Int. Sci. & Tech. July:48-56.
15. Smith, O. E., N. C. Welch, and T. M. Little. 1973. Studies on lettuce seed quality: I. Effect of seed size and weight on vigor. J. of Am. Soc. for Hort. Sci. 98:529-533.
16. Smittle, D. A., R. E. Williamson, and J. R. Stansell. 1976. Response of snap bean to seed separation by aerodynamic properties. Hortscience 11:469-471.