April 2021

# Development and Evaluation of Impermeable Seed Coats For Preserving Soybean Seed Quality

E. E. Hartwig

H. C. Potts

Reprinted from *Crop Science*
Vol. 27, No. 3

# Development and Evaluation of Impermeable Seed Coats for Preserving Soybean Seed Quality

**E. E. Hartwig and H. C. Potts**

# Development and Evaluation of Impermeable Seed Coats for Preserving Soybean Seed Quality[1]

E. E. Hartwig and H. C. Potts[2]

## ABSTRACT

**Advanced generation soybean [*Glycine max* (L.) Merr.] breeding lines have been developed that have impermeable seed coats. The donor parent for impermeable seed coats was the wild soybean [*Glycine soja* Sieb. and Zucc.]. A group of 11 impermeable seed coat lines along with the parent 'Forrest' were grown at five southeastern USA locations to further evaluate the effectiveness of the character for maintaining seed quality. Center rows of 4-row plots were harvested at maturity, and a border row was harvested 4 to 6 weeks later. Seeds from the delayed harvest were exposed to prolonged warm, rainy weather. At Starkville, MS, rain fell on 18 days with a total of 220 mm during October. Total viable seeds from Forrest were 96% for the early harvest and 5% for the delayed harvest. For D81-9776, one of the best impermeable seed coated lines, total viable seeds for early and late harvest were 95 and 86%, respectively. From another group of material, one line exhibited 100% viable seeds after 6 weeks exposure to warm, rainy weather, while 'Epps' had only 27% viable seeds.**

***Additional index words:*** ***Glycine max*** **(L.) Merr.,** ***Glycine soja*** **(Sieb. and Zucc.), Total viable seed, Wild soybean, Exotic germplasm.**

MOST COMMERCIALLY grown soybean [*Glycine max* (L.) Merr.] cultivars have highly permeable seed coats. A high percentage of these seed placed in water will be fully imbibed within 2 h. However, seed of the wild soybean (*Glycine soja* Sieb. and Zucc.), PI 163453, are impermeable and must be scarified to permit rapid imbibition. Kilen and Hartwig (5) reported on the inheritance of the impermeable seed coat character in soybean and concluded that it may be controlled by as few as three major genes. Some of the advantages and disadvantages of using the impermeable seed coat to maintain quality of soybean seed when exposed to adverse weather conditions were described by Potts et al. (6). A 4-week delay in the harvest of 'Dare' in 1973 resulted in a decline in percentage of viable seed from 89 to 51%. Percentage of viable seed for the line having impermeable seed coats was 95 and 92% during the same 4-week period. It had been assumed that a scar-

[1] Cooperative research between USDA-ARS, and the Mississippi Agric. and Forestry Exp. Stn., Stoneville, MS 38776. Received 5 June 1986.

[2] Research agronomist, USDA-ARS, Soybean Production Res., P.O. Box 196, Stoneville, MS 38776, and former professor of agronomy (deceased), Seed Technology Lab., Mississippi Agric. and Forestry Exp. Stn., Mississippi State, MS 39762.

Published in *Crop Sci.* 27:506–508 (1987).

**Table 1. Environmental conditions for October 1984 for locations where soybean plants with impermeable seed coats were grown.**

| Location | Total rainfall | No. of days with rain | Temperature | |
|---|---|---|---|---|
| | | | Mean minimum | Mean maximum |
| | mm | | °C | |
| Stoneville, MS | 280 | 18 | 14.4 | 25.0 |
| Starkville, MS | 220 | 18 | 12.0 | 25.6 |
| St. Joseph, LA | 298 | 14 | 16.0 | 26.7 |
| Jay, FL | 86 | 12 | 15.6 | 28.9 |
| Blackville, SC | 60 | 5 | 15.0 | 28.4 |

ification treatment would be required if an impermeable seed coat cultivar were grown commercially. A later study was conducted by Potts (7) in large plots harvested with a standard field combine. Sufficient scarification resulted from the combine that in a field planting of the harvested seed the impermeable seed coat line had 87% emergence at the time Dare had 100%. A line closely related to the impermeable seed coat line used in that study has been used as a parent to develop breeding lines having superior agronomic and pest resistant qualities. Several of these lines were grown in replicated plantings in 1984 when a prolonged rainy period (Table 1) occurred in much of southern USA. This paper presents additional evidence of the effectiveness of the impermeable seed coat in maintaining seed quality of soybean in the field during warm, rainy periods.

## MATERIALS AND METHODS

### Experiment 1

'Forrest' and eleven advanced $F_6$ lines, in the $F_8$ generation, from the cross Forrest × D67-5679 were grown in replicated trials at Stoneville and Starkville, MS; St. Joseph, LA; Jay, FL; and Blackville, SC. Forrest (2) is a highly productive cultivar of Group V maturity. D67-5679 is of similar maturity to Forrest with impermeable seed coat derived from the wild soybean, PI 163453, from the Yangtze River Valley in China. Populations of $F_2$ through $F_5$ generations were grown in bulk on soybean cyst nematode (SCN race 3) infested soil at Ames Plantation in Tennessee. Seeds harvested from the $F_3$ and $F_4$ generations were placed in water for 4 h. Imbibed seed were discarded. Seeds remaining were dried, scarified mechanically, and planted. Seeds from approximately 500 $F_5$ plants were harvested and progeny tested for reaction to SCN. One hundred $F_6$ lines, resistant to SCN race 3, were grown at Stoneville, MS in 1981. Plots were harvested 6 weeks after maturity, and seeds were evaluated for percent germination and percent impermeable seed coats. Thirty-six lines were selected for further evaluation on the basis of their seed characteristics. There was no selection for seed characteristics in 1983 as seeds from Forrest harvested 6 weeks after maturity germinated in excess of 90%. There was no measurable rainfall during this period. The 11 lines selected for evaluation in 1984 had appeared equal to Forrest in seed yield and agronomic qualities.

In 1984, seed from the two center rows of each 4-row plot, (6 m long, three replications) at each location were harvested shortly after maturity. Seeds from a border row of each replication were harvested 4 to 6 weeks after the first harvest. Seeds from each harvest were evaluated at the Seed Technology Laboratory, Mississippi State University. Seed quality was evaluated according to standard germination tests that were conducted according to the rules for testing seeds established by the Association of Seed Analysts (1). Seeds were classified as either dead or viable, and only normal seedlings were counted as germinated. Seeds that imbibed no water after 8 days were considered viable. Normal seedlings and viable seeds were totaled to determine total viable seeds (TVS).

### Experiment 2

Thirty-five breeding lines from a research program to develop productive, impermeable seed-coated lines of Maturity Group V were evaluated at Stoneville, MS along with 'Epps' (4). These lines were from the cross D65-2262 × D78-12309. D65-2262 is of Maturity Group IV, selected for improved seed quality. D78-12309 is an impermeable seed-coated line of Maturity Group VI from D67-5679 × 'Tracy' (3).

Seeds from $F_2$ plants were evaluated in the laboratory by placing 60 seeds from one plant in a petri dish and submerging the seed in water for 24 h at 22°C. Lines in the $F_3$ generation were grown from the plants having 80% or more impermeable seed. Selection in $F_3$, $F_4$, and $F_5$ was for agronomic characters and Maturity Group V. Selected $F_5$ lines, each tracing to a different $F_2$ plant, were harvested and seeds were evaluated for impermeability. Lines varied from permeable to highly impermeable. Selected lines were evaluated in replicated trials at Stoneville, MS in 1984 as in Exp. 1. Seed samples from early and late harvests were also evaluated as in Exp. 1.

## RESULTS AND DISCUSSION

### Experiment 1

Rainfall and temperature for October for each of the locations are shown in Table 1. Rainy weather continued through the first 10 days of November, making conditions favorable for seed deterioration. Total viable seed for Forrest from the early harvest at Stoneville and Starkville, MS; St. Joseph, LA; Jay, FL; and Blackville, SC was 87, 96, 75, 93, and 80%, respectively (Table 2). At the same locations total viable seed percentages for the delayed harvest of Forrest were 17, 5, 4, 0, and 25%, respectively (Table 2). The delayed harvest viable seed percentage for D81-9760 at each of the same locations was 88, 89, 88, 80, and 74% (Table 2). In each case the percentage of impermeable seeds after 8 days in the germination chamber was <70%,

**Table 2. Total viable seed for Forrest and lines selected for impermeable seed coats when harvested shortly after maturity and after exposure to approximately 42 days of adverse weather, 1984.**

| Soybean strain | Locations | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Stoneville† | | Starkville | | St. Joseph | | Jay | | Blackville | |
| | Harvest date | | | | | | | | | |
| | Early | Late | Early | Late | Early | Late | Early | Late | Early | Late |
| | % | | | | | | | | | |
| Forrest | 87 | 17 | 96 | 5 | 75 | 4 | 93 | 0 | 80 | 25 |
| 81-9749 | – | 91 | 96 | 84 | 95 | 56 | 89 | 46 | 81 | 63 |
| D81-9760 | – | 88 | 96 | 89 | 95 | 88 | 93 | 80 | 92 | 74 |
| D81-9764 | – | 89 | 94 | 81 | 91 | 84 | 93 | 80 | 92 | 59 |
| D81-9766 | – | 87 | 94 | 66 | 89 | 91 | 93 | 87 | 89 | 69 |
| D81-9771 | – | 78 | 96 | 75 | 90 | 68 | 89 | 49 | 88 | 63 |
| D81-9776 | 91 | 85 | 95 | 86 | 91 | 85 | 85 | 52 | 86 | 63 |
| D81-9780 | – | 91 | 95 | 77 | 91 | 87 | 66 | 67 | 90 | 65 |
| D81-9792 | – | 87 | 93 | 80 | 89 | 85 | 80 | 81 | 82 | 60 |
| D81-9794 | – | 82 | 93 | 73 | 90 | 71 | 88 | 67 | 89 | 63 |
| D81-9795 | – | 88 | 92 | 76 | 95 | 89 | 92 | 76 | 92 | 73 |
| D81-10505 | – | 79 | 95 | 75 | 85 | 81 | 88 | 57 | 81 | 63 |

† Continued rains prevented early harvest of all strains following maturity.

**Table 3. Effect of impermeable seed coats for preserving seed viability in soybean plants exposed to adverse weather conditions, Stoneville, MS, 1984.**

| Soybean strain | Impermeable seed | | Total viable seed after 42 days adverse weather§ | Seed yield |
|---|---|---|---|---|
| | 1983† | 1984‡ | | |
| | % | | | kg ha$^{-1}$ |
| Epps | 0 | 0 | 27 | 3420 |
| D83-3719 | 0 | 0 | 64 | 3064 |
| D83-3724 | 83 | 87 | 92 | 3084 |
| D83-3725 | 47 | 3 | 44 | 2863 |
| D83-3729 | 68 | 32 | 80 | 3326 |
| D83-3728 | 0 | 0 | 68 | 3017 |
| D83-3763 | 0 | 1 | 26 | 3232 |
| D83-3770 | 0 | 0 | 77 | 3427 |
| D83-3773 | 69 | 46 | 87 | 3629 |
| D83-3809 | 86 | 66 | 78 | 2755 |
| D83-3852 | 46 | 20 | 45 | 3071 |
| D83-3869 | 91 | 83 | 90 | 2896 |
| D83-3875 | 59 | 20 | 49 | 2950 |
| D83-3891 | 84 | 74 | 86 | 3313 |
| D83-3893 | 90 | 80 | 91 | 3078 |
| D83-3898 | 93 | 87 | 100 | 3179 |
| D83-3905 | 64 | 42 | 77 | 3286 |
| LSD (0.05) | – | – | – | 450 |
| CV | – | – | – | 9% |

† Percent impermeable seed determined after 24 h.
‡ Percent impermeable seed determined after 8 days.
§ Total viable seed is percent normal seedlings plus impermeable seed after 8 days.

suggesting that additional factors may have been contributed by the wild soybean that preserve seed quality. Plants suffered from drought stress prior to maturity at Blackville, SC where seed yields were <1500 kg ha$^{-1}$. Seed yields at the other locations ranged from 2400 to 4000 kg ha$^{-1}$. Both seed size and yield of lines selected for impermeable seed coats were slightly below that of Forrest.

### Experiment 2

Performance data for 15 of the lines together with Epps are listed in Table 3. Percentage of impermeable seeds ranged from 0 to 93% in 1983 and from 0 to 87% in 1984. Table 3 also lists seed yields for these lines together with that for Epps and TVS for seed samples harvested after 42 days exposure to adverse weather in 1984.

There was good agreement for lines having the highest percentage of impermeable seeds in 1983 and highest TVS after exposure to adverse environment in 1984. D83-3770 had no impermeable seeds either in 1983 or 1984 but had 77% TVS after exposure as compared with 27% for Epps (Table 3). These results give further suggestion that the wild soybean may have contributed qualities in addition to impermeable seed coat that enhance seed quality. Seed yields of several lines having impermeable seed coats equaled the seed yield for Epps. These lines are in the ninth breeding cycle removed from the wild.

The measure of seed quality in these studies was TVS. Respiratory level of the seeds would remain low if seeds did not imbibe water. Growth of fungi on the seeds would also be inhibited if seeds did not imbibe water. The results demonstrate the feasibility of transferring a character such as an impermeable seed coat from a nonagronomic wild soybean parent to a cultivated type.

No disadvantages are visualized for the processing of soybean seed having impermeable coats. The results obtained by Potts (7) showing that a high percentage of the impermeable seed coats were scarified in the normal commercial harvesting suggests that seed for planting would not require added treatments in the normal seed conditioning process.

## ACKNOWLEDGMENTS

The cooperation of Dr. D.J. Bouquet, agronomist, Northeast Research Station, Louisiana Agricultural Experiment Station, St. Joseph, LA; Dr. H.A. Peacock, director, University of Florida Agricultural Research Center, Jay, FL; and Dr. H.L. Musen, agronomist, South Carolina Research and Extension Center, Blackville, SC is appreciated.

## REFERENCES

1. Association of Official Seed Analysts. 1981. Rules for testing seeds. J. Seed Technol. 6:1–128.
2. Hartwig, E.E., and J.M. Epps. 1973. Registration of 'Forrest' Soybeans. Crop Sci. 13:287.
3. ——. 1974. Registration of Tracy Soybeans. Crop Sci. 14:777.
4. ——. 1984. Registration of Epps Soybeans. Crop Sci. 24:998–999.
5. Kilen, T.C., and E.E. Hartwig. 1978. An inheritance study of impermeable seed in soybean. Field Crops Res. 1:65–70.
6. Potts, H.C., J. Duangpatra, W.G. Hairston, and J.C. Delouche. 1978. Some influences of hardseededness on soybean seed quality. Crop Sci. 18:221–224.
7. ——. 1978. Hard seeded soybeans. p. 33–42. *In* Proc. 8th Soybean Seed Res. Conf., Chicago, IL. 14–15 Dec. American Seed Trade Association, Washington, DC.