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Seed Research: Implications for Seedsmen

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SEED RESEARCH: IMPLICATIONS FOR SEEDSMEN

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Seed research has begun to attract the interest of many scientists. This has been partly shown by the 10-fold increase in publications about seeds over the past decade. The purpose of this paper is to discuss briefly some of the most recent work in the U.S.A. in four areas of research: variety identification, energy and macromolecule synthesis, seed invigoration, and vigor in soybeans. These topics may sound fragmented, nevertheless, they are of immediate interest to seedsmen.

Variety Identification

With the passage of the Plant Variety Protection Act, the use of reliable tests to identify varieties has become more important. For years, Drs. L. Nittler, G. McKee, D. Grabe, A. Larsen and others have wrestled with the problem of trying to distinguish varieties; and I believe most of you are familiar with their various approaches.

First, I will review some current research on variety identification being carried out by Dr. R. Payne at the National Seed Testing and Standardization Laboratory, AMS.

For a test to be of value for variety identification it should be quick, simple, inexpensive and repeatable. A commonly used test that does not meet all these criteria is the plant grow-out test. This test is considered to be the most reliable of the existing tests because it compares the growth characteristics of one variety against those of another.

At Beltsville in May, 1976, Dr. Payne planted 190 seed lots representing 65 soybean varieties and evaluated many plant characteristics. Plant height was found to be an unreliable indicator in soybeans for several reasons, one of which was vigor. Lots with different vigor levels will not grow to the same height in the field.

Leaf shape was found to be a valuable indicator of some varieties prior to flowering. After flowering, there was a general change in leaf shape of the new growth, and leaf shape became less reliable.

Pigmentation of the hypocotyl and epicotyl of seedlings was found to be a variety characteristic. Soybean varieties could be classed into five groups, depending on pigmentation. The groups of hypocotyl-epicotyl pigmentation were as follows: green-green; bronze-green; purple-green; purple-pale purple and purple-purple. These groups were distinguishable in the growth chamber and in the field.

[1/] Plant Physiologist, USDA/ARS Seed Research Laboratory, Beltsville, MD.

In other laboratory work, enzymes are being investigated to determine their value in variety identification. Peroxidase enzyme from seed coats has been found useful. It's an "either-or" type of test. Varieties either contain the enzyme in their seed coat or they do not. Electrophoresis is being used to determine other useful enzymes. Payne plans to present this information, and more, as a key to the identification of soybean varieties.

Energy and Macromolecule Synthesis

Drs. Abdul-Baki and Anderson (1) used embryonic axes of seeds to study the ability of seeds to synthesize complex macromolecules such as proteins and polysaccharides from amino acids and soluble sugars. They noted that as vigor declined, so also did the ability of axes to synthesize those macromolecules. Syntheses of macromolecules, as well as most other metabolic processes, require chemical energy generated as adenosine triphosphate (ATP) by the seed. Ching and Danielson (3) noted a decline in the ability of seeds to synthesize ATP as seeds deteriorated.

Anderson, studying germination of soybean axes, compared the induction periods of various biochemical processes, such as protein synthesis, ATP synthesis and respiration. He discovered that within one-half hour after the start of imbibition, ATP accumulation was significant, but that synthesis of protein and RNA could not be detected. Further, he noted that although the machinery to synthesize protein was present in deteriorated soybeans, their ability to produce ATP was limiting.

Presently, the ability of a seed sample to produce ATP is an important criterion for determining the quality of the seed lot. Further information concerning enzymes that regulate ATP production is presently under investigation by Anderson.

Seed Invigoration

Ways to improve seed performance have been tried for years. This is done in anticipation of breaking dormancy, providing a faster emergence or establishing a more uniform stand. A recently developed method for attaining these goals is organic solvent infusion (2,8). An organic solvent, such as dichloromethane, is used to solubilize hormones, pesticides or growth regulators. The seeds are then soaked in the solvent-chemical solution until the desired results are obtained. The seeds are dried, over forced cool air until the solvent is completely evaporated, and then stored. This method does not require the use of water.

Methods involving water to improve seed performance, include alternate wetting and drying of seeds, the use of salts, such as KCl and KNO_3, and use of osmoticums, such as polyethlene glycol-6000 (4,5,6). Generallly, these methods hasten radicle emergence during germination and improve uniformity of the stand. However, the results obtained vary from lot to lot within a variety. Scientists have been trying to improve seed performance for a number of years, as has been pointed out in a review by Kidd and West (7).

Soybean Vigor

In Beltsville, the Seed Research Laboratory, ARS, has been conducting a research project on soybean seed vigor since 1975. Although this study has been carried out mainly by Dr. M. Kulik and myself, the following scientists have also contributed to this project; C. S. Garrison, L. Woodstock, J. D. Anderson, J. Velasco and A. Abdul-Baki. The purpose of the project is to compare the results of laboratory vigor tests with field results.

During the past 2 years we evaluated in the field, 225 lots of soybeans representing eight varieties. The lots were evaluated for three dates of planting; early, sub-optimum and optimum and two soil types; light and heavy. The plants were counted at four growth stages: a. initial emergence, seedlings emerging from all plots; b. final emergence, plants 13-18 cm tall; c. initial stand, plants 25-36 cm tall; and d. final stand, mature plants. Yields were determined for the soybeans planted on the optimum date in the heavy soil.

The following vigor tests were determined on all the seed lots in the laboratory: germination, including Spain's seedling classification, root-shoot length, and dry weight; tetrazolium staining according to R. P. Moore; cold test; accelerated aging; sand bench emergence; conductivity test; speed of germination, three-way criteria; ATP content; specific gravity; respiration; and 1,000 seed weight.

Thus far, we have analyzed both the laboratory and field data for only 1975. Correlations were performed by comparing the various laboratory vigor tests with planting dates and soil types. Those vigor tests that gave r values of 0.6-0.8 were the following: cold test, accelerated aging, TZ staining, sand bench emergence, conductivity test and speed of germination. This means that each of these tests will predict from 36-64% of what is observed in the field.

The field data for 1975 and 1976 have been statistically analyzed. Generally speaking, the difference in emergence between two lots had to be greater than 15% for significance. This means that according to Duncan's Multiple Range test at the 5% level, there is no difference between a seed lot with 90% emergence and one that had 75% emergence. We believe that this large difference required for significance was due to variability in the field environment and to a wide variation of vigor within a seed lot caused by different rates of declining vigor.

Seed environment will vary from plot to plot within a field. This is due not only to soil heterogenity but also to other conditions, such as pH, soil moisture, seed-soil contact, and so on. Thus, there would be a different set of environmental parameters at each plot, both quantitative and qualitative. Theoretically, these environmental parameters should cause a larger variation in emergence of a seed lot that has become weak through loss of vigor, compared to a strong seed lot.

To test this hypothesis, we took the emergence results from the 1976 field planting for optimum planting date on heavy soil. Seed lots were grouped according to their emergence into the following categories: 90% and above, 80-89.99%, 70-79.99%, 60-69.99% and 50-59.99%. An analysis of variance was performed on these categories to obtain the standard deviation, a measure of variability. The standard deviations, in percent, for the highest emergence group to the lowest were as follows: 4.4, 6.4, 7.9, 12.9 and 8.7, respectively. As the mean emergence percentage decreases, the standard deviation increases. This shows that: (1) a lot with high vigor will deviate less from the mean than a lot that has lost some or most of its vigor, and (2) the quantitative and qualitative environmental parameters at a particular plot affect the performance of a high vigor lot the least.

The above results, which represent a small portion of our unpublished data, suggest a skewed population curve, with maximum variablility in the lots with 60-69.99% emergence. Further analyses of the existing data should clarify the distribution of the standard error.

At present, we do not believe we will be able to predict the exact performance of a seed lot in a particular field. However, we do believe we have collected enough data to know when a seed lot has acceptable vigor or high, medium or low vigor. Hopefully, someday we will be able to report a range for the vigor of a seed lot--for example, one lot may emerge between 90-94% compared to another lot that emerges between 60-80%.

Literature Cited

1. Abdul-Baki, A. and J. D. Anderson. 1972. Physiological and biochemical deterioration of seeds. In Seed Biology, T. T. Kozlowski, ed., Academic Press, New York, 3:283-315.

2. Braun, J. W., V. R. Rao and A. A. Khan. 1976. Release of lettuce seed thermodormancy by plant growth regulators applied in organic solvent. Hortscience 11:29-30.

3. Ching, T. M. and R. Danielson. 1972. Seedling vigor and adenosine triphosphate level of lettuce sees. Proc. Assoc. Off. Seed Anal. 62:116-124.

4. Ells, J. E. 1963. The influence of treating tomato seed with nutrient solutions on emergence rate and seedling growth. Proc. Am. Soc. Hort. Sci. 83:684-687.

5. Heydecker, W., J. Higgins and Y. J. Turner. 1975. Invigoration of seeds. Seed Sci. & Technol. 3:881-888.

6. Kanehon, S. D. 1973. Effect of hardening on emergence and seedling growth in sweet pepper (var. California Wonder). Curr. Sci. 42: 762-763.

7. Kidd, F. and C. West. 1918. Physiological pre-determination: The influence of the physiological condition of the seed upon the course of subsequent growth and upon yield. II Review of Literature. Chapter I. Ann. App. Biol. 5:112-142.

8. Meyer, H. and A. M. Mayer. 1971. Permeation of dry seeds with chemicals: Use of dichloromethane. Science 171:583-584.

9. Puls, E. E. and V. N. Lambeth. 1974. Chemical stimulation of germination rate in aged tomato seeds. J. Amer. Soc. Hort. Sci. 99:9-12.