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USE OF SEEDLING GROWTH RATES, GLUTAMIC ACID DECARBOXYLASE ACTIVITY, AND RESPIRATION AS SEED QUALITY CONTROL TECHNIQUES

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Certain phases of the seed industry may employ different types of tests in a quality control program at various times and under different circumstances. In some instances speed in determining quality is of essence. In other instances facilities may dictate the type of tests used. The information desired about a seed lot will influence the type of test selected. Indeed, several tests may be desired.

Tests directly or indirectly related to enzyme activity are useful in research and may also be of use in a quality control program.

Three tests that may fit into a quality control program are: seedling growth rate, glutamic acid decarboxylase activity and measurements of respiration.

Seedling Growth Rate

Seedling growth has been used by researchers for a number of years as an indication of seed quality. Some of the aspects of seedling growth utilized are length of root and shoot; speed of germination, speed of emergence and total emergence in the field or gree greenhouse, rate of seedling growth in the field or greenhouse; and green or dry weights of seedlings. Let's examine each of these in more detail:

Root and Shoot Length:

This is an actual measurement of the length of the primary root or shoot of a seedling or a combination of both at a specified number of days after the seed have been planted in towels, blotters

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or petri dishes as for regular germination tests. When several lots of seed are compared in this manner the lot making the most growth is considered to be the highest in quality. Several replications should be planted as in a germination tests and the growth calculated on a per germinated seed basis.

Speed of Germination:

In this test, seed should be planted just as in the case of a standard germination test. After the seed have begun to germinate, plantings must be checked daily at approximately the same time each day. Normal seedlings are removed when the root or shoot reaches some predetermined length. The number of seedlings removed each day is multiplied by the reciprocal of the day on which the seedlings were removed. The sum of these calculations provides an index of vigor. The higher the index value the better the seed quality.

Example: Two lots of cotton are to be compared. It is decided to remove normal seedlings when the radicle-hypocotylaxis reaches 2 inches in length. Daily checking begins on the third day after planting and developed seedlings are removed each day until germination is complete. We have the following information from 200 seed planted from each lot.

	Lot 1			Lot 2		
Day Seedling Removed	Number of Seedlings	Reciprocal (of day)	Index	Number germinated	Recripocal	Index
3	25 X	1/3	8.33	10 X	1/3	3.33
4	100 X	1/4	25.00	50 X	1/4	12.50
5	35 X	1/5	7.00	75 X	1/5	15.00
6	15 X	1/6	2.50	35 X	1/6	5.83
7	5 X	1/7	0.71	5 X	1/7	0.71
8	5 X	1/8	0.63	5 X	1/8	0.63
9	- -	-	-	5 X	1/9	0.55
		Total	44.17			38.55

Using this system we would consider lot one to be the better quality seed even though both lots germinated 92.5%

A variation of this test is based on speed of emergence and is used by some companies in the vegetable seed industry. Greenhouse emergence allows better control of consitions than does field emergence although either may be used.

Again, daily counts at approximately the same time each day are necessary, if comparisons are to be valid. The lot with the greatest number of normal seedlings emerged in the fewest number of days would be the highest in quality.

First Count:

The germination percentage obtained at the time of the first or preliminary count of a germination test is also an index of speed of germination. Taking the same two lots of cotton we have just considered, if the first count was made on the fourth day we would have removed 125 seedlings (out of 200 seed planted) from lot one and only 60 seedlings from lot two. We would then consider lot one the better quality.

To use this method and compare lots of seed over a period of several months, all first counts must be made at the same interval (number of days) after planting. Germination conditions must also be carefully controlled. If some plantings are allowed to become too dry, for example, the number of seedlings removed on the first count might be affected and a valid comparison could not be made.

Speed of Seedling Growth:

This test is very similar to root and shoot growth. The total growth of the seedlings in the greenhouse or field is actually measured at a specified number of days after the seed are planted. The lot of seed producing the most growth per normal seedling is considered to be the better quality.

Again seed may be planted in the greenhouse, field, or in the germinator. An equal number of seedlings are randomly harvested from each plot at a specified number of days after planting. Seedlings may be weighed fresh or dry for growth rate comparisons. The lot giving the greatest seedling weights is considered to be the best quality.

If one is equipped to conduct germination tests no additional investment need be made for root and shoot growth and speed of germination tests; in many instances, small investments may need be made in equipment and additional personnel.

Emergence tests, speed of seedling growth and green fresh weight tests will of course require facilities (mostly field plots or greenhouses) and investments outside the ordinary laboratory.

It is well to keep in mind, that the better one is able to control conditions under which tests are conducted, the more reliable and the more valuable will be the comparisons made. Laboratory conditions are easier to control than greenhouse condi - tions while field conditions are beyond control.

The greatest advantage of these tests are their simplicity. Any laboratory techaician can conduct them.

The greatest disadvantage is time. Ten days to 2 weeks may be longer than one can wait to determine the quality of a lot of seed.

Glutamic Acid Decarboxylase Activity (GADA)

The GADA test is designed to measure the activity of one particular enzyme, which has been shown (1,2,4,5,6,7,8) to be closely related to seed quality. The more enzyme activity present in a sample of seed the higher the seed quality.

The procedure for measuring GADA is relatively simple, it does not require a large investment and can be completed in a short period of time.

The equipment needed for this test consists of a water bath to control temperature, inexpensive manometers, a scale for measuring manometer fluid movement, small containers (1/2 pint jars), and a small grinder.

The seed sample is ground, placed in the container, and chemicals (buffered glutamic acid) added to the ground seed. The amount of carbon dioxide that is given off is a measure of activity of the enzyme. The more CO_2 evolved, the better is the quality of the seed. GADA is closely related to storage life and yields of certain seeds (4,5,6).

Work by Grabe (5) has shown that GADA is directly related to the storage life of corn. GADA is also related to corn yield. Corn with high GADA out-yielded corn with low GADA activity by as much as 8%. Similar studies with oats have shown like relationships. Other studies have also been conducted with wheat and rice (1,2).

Root growth and GADA are closely related (8). Some of the advantages of GADA tests are simplicity, speed, and low cost.

Varieties differ in GADA, so comparisons should be made within varieties and not between varieties. GADA measurement is too sensitive to be used as an indicator for stand establishment.

Respiration

One of the new techniques in the area of determining seed quality involves measuring seed respiration. Respiration studies are still in their infancy when compared to other seed quality tests. Here in our laboratory and at the USDA-ARS laboratories in Beltsville, Maryland, a considerable number of tests are being conducted with seed respiration.

Some of the earlier work by Woodstock, et. al. (9) showed differences in rate of respiration in lima beans that were allowed to to imbibe water at different temperatures. Temperatures of 15° C. and lower during the first hours of germination severely inhibited respiration and later seedling growth.

Woodstock and Grabe (8) found a high correlation between GADA, root growth, and respiration during early germination. Work in our laboratory indicates a relationship between respiration during the first 6 hours of imbibition and relative storability of seed lots (3).

Our work also indicates a relationship between respiration and accelerated aging of corn lots (3).

Two values in respiration seem to give some indication of seed quality: the amount of oxygen taken up by the seed and the respiratory quotient. The amount of oxygen taken up by corn, for example, has a positive relationship to seed quality, the more oxygen taken up the higher the seed quality. The respiratory

quotient, or R. Q., is the relationship between carbon dioxide given off and oxygen taken up and is calculated as CO_2 divided by O_2. The higher the R. Q. the lower the quality of the seed. For example, corn seed having an R. Q. of 1.1 is of higher quality than corn seed having an R. Q. of 1.8.

Let me emphasize that respiratory measurements are still in the early stages of development as possible tests for seed quality. There is considerable work to be done before any final conclusions can be made.

The technique of measuring respiration is simple, fast, and very accurate measurements can be made.

The cost of equipment is considerably higher than that required for the other tests discussed: somewhere between $2500.00 and $3500.00 depending on the size and kind of equipment purchased.

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