4-1-1981

Seed Vigor Index- Possibilities and Problems

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SEED VIGOR INDEX - POSSIBILITIES AND PROBLEMS

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The area of seed/seedling vigor has attracted much attention during recent years. Several reasons account for this but basically these focus on the need to know the production potential of any given line, cultivar, hybrid, and/or seed lot. This additional awareness has largely resulted from economic factors associated with the production, conditioning, marketing, and planting of seed. This will be further discussed under the section entitled "Importance of Vigor."

Definition of Vigor

During the last several years, work in the area of seed/seedling vigor has been somewhat hampered by the lack of an adequate definition of "vigor." Recently, however, the AOSA Vigor Test Subcommittee proposed the following definition: "Seed vigor comprises those seed properties which determine the potential for rapid, uniform emergence and development of normal seedlings under a wide range of field conditions." This definition encompasses several important concepts. First, a vigorous seed has the potential for rapid emergence. It is generally accepted that a vigorous seed will emerge rapidly, and thus, not be subjected to the numerous pathogens in the soil for any prolonged period of time. Generally, if a seedling is slow to emerge, the likelihood of being weakened and killed by these organisms is greater. It might be noted, however, that some recent evidence suggests that seedlings emerging "too rapidly" may be more succulent and thus more susceptible to pathogenic attack. Further work will need to be conducted to clarify this relationship; however, it is almost universally accepted that vigorous seedlings will emerge "rapidly." Secondly, a vigorous lot of seed should emerge uniformly. This will insure that most of the seedlings will have near equal competitive abilities for the production factors such as water, nutrients, light, etc., and as a result make a contribution to the production of economic yield (forage, grain, etc.). Conversely, if seedlings do not emerge uniformly, the later emerging seedlings will likely become stunted and, hence, non-productive plants because of a lack of adequate amounts of nutrients, water, and light. As a result, they became nothing more than "weeds" in that they do use

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some of the above production factors yet do not produce a significant amount of economic return. A third component of the definition of vigor is the development of normal seedlings. Generally, a vigorous seedling will develop into a normal seedling/plant and thus be productive, whereas, a non-vigorous seedling may develop into an abnormal seedling/plant and be relatively non-productive. The fourth concept associated with this definition is that a vigorous seedling will exhibit these qualities under a wide range of field conditions. When a farmer plants the conditions of soil temperature, soil moisture, soil physical properties, soil pathogens, etc. are frequently not conducive for optimum seedling performance. Therefore, a vigorous seed/seedling should have the potential/ability to perform reasonably well under these non-ideal conditions. This definition is a very useful one in that not only are the concepts of vigor identified, but, in addition, they are somewhat quantifiable.

Importance of Vigor

The vigor of any lot of seed is important to all of those who will be producing, conditioning, selling, and using the seed for planting purposes. First, the seed producers (breeders and/or breeding institutions) are vitally concerned with seed vigor in that they only want to produce and market high quality seed. In our competitive marketplace this is the only way that seed companies can stay in business. Secondly, the conditioners of seed do not want to invest money in the cleaning, sizing, treating, and bagging of seed that is of poor quality. If they are aware that a lot of seed is of such quality as to be unsuitable for planting they can move it into various food or feed channels before investing any additional money in conditioning. Thirdly, seed salesman are interested in seed vigor. Knowing the vigor of a seed lot can aid them in their pricing structure and in making recommendations to farmers as to planting date, planting rate, etc. Finally, the farmer is interested in the vigor of the seed he will be planting. This information will be useful in deciding which seed to plant early when the environmental conditions are more stressful, what rate to plant, etc. Thus, all individuals associated with planting seed from its production to its ultimate planting in the field should be concerned with information relative to its vigor. In addition, various regulatory agencies are becoming more interested in the vigor rating of seed. With the prospect that some time in the future seed may be labeled as to vigor, it is important that the industry develop various tests that are not only accurate, but reproducible.

Factors Controlling Vigor

The expression of vigor is controlled by a number of factors. These include such things as the genetic makeup of the seed, the en-

vironment under which the plant and seed develop, the harvesting, conditioning, and storage conditions, and the age of the seed.

The upper level of performance potential of any living seed/plant is set by its genetic makeup. The extent to which that inherent performance potential is expressed will be dictated by the environment under which that seed/plant develops. Therefore, for the production of higher vigor seed, it is imperative that plant breeders incorporate into their breedings programs a selection procedure for vigor. Vigor, as is the case with yield, is not a simply inherited trait. It is controlled by many genes. These include the genes for such traits as the rate at which various enzymes break down stored energy compounds, the rate at which these products are translocated to growing tissues and synthesized into new compounds, the rate of water inhibition and uptake, the photosynthetic process, nutrient absorption and translocation, etc. Once seeds have the genetic potential for vigor, they need to be produced under near optimum environmental conditions such that they fully mature - physically, physiologically, and biochemically.

Once seed have reached physiological and harvest maturity - hopefully at a high vigor level - this vigor needs to be preserved during the harvesting, conditioning, and storage phases. This will include timely and careful harvest to prevent field deterioration and mechanical injury, care in the conditioning processes to minimize any damage, and storage under proper conditions to retard, as much as possible, the deterioration process. Lastly, vigor is influenced by the age of the seed. This is interrelated with the conditions under which the seed are stored, but seed will generally decline in vigor as age increases. Therefore, steps need to be taken such that the seed can be utilized within a reasonable period of time.

Problems Associated with Vigor Analysis

Problems associated with "indexing" seed as to vigor basically fall into two areas. First, any test(s) must <u>accurately</u> rate the seed lot as to its vigor potential. With several vigor tests currently available, this criterion may not seem formidable. However, many of these tests are designed to analyze seed vigor under a very specific set of conditions - such as cool and/or moist media conditions, media mechanial resistance to emergence, various pathogenic conditions, etc. Therefore, many of these tests may be accurate under various "local" conditions, but suffer from a lack of universal application from one area to another. A second major area of concern in vigor testing is that of <u>reproducibility</u> of test results. This facet becomes increasingly important as vigor testing becomes more common place in the seed industry and becomes

imperative if a vigor rating is to be included in the labeling of seed. This would involve various regulatory agencies and the issue of liability would become paramount. Currently the AOSA (Association of Official Seed Analysts) is addressing this concern by defining vigor in quantitative terms, attempting to standardize vigor tests, and conducting referred tests among various labs - all in an effort to improve vigor test reliability and reproducibility. Currently, for the most part, these efforts are encouraging, but very time-consuming.

In addition and intricately associated with these two major problem areas, is the manner in which vigor test results are expressed. One option would be to express vigor on some type of continuum scale - for example on a one to ten basis. If this is the case the test(s) will need to be standardized, sensitive, and reproducible. Another alternative would be to "categorize" seed lots into vigor groups - for example, low, medium, high or some other suitable catergorization. With this method, the test(s) would still need to be standardized, sensitive, and reproducible, but there would be somewhat more flexibility. As the industry moves more into vigor testing this categorization method might be better initially although some "grey" areas will still exist.

Vigor Test Possibilities

Tests for seed/seedling vigor have been classified by a number of authors into the following categories: (1) physical tests, (2) physiological tests, and (3) biochemical tests. Generally, the physical tests involve the measurement of some physical parameter of the seed such as weight, volume, length, width, density, etc. The tests that involve some performance parameter(s) are classified as physiological tests. Included here would be such tests as the standard warm germination test (rate and total), the accelerated aging test, the cold test, the "cool" test, and various seedling growth rate tests (radicle and hypocotyl elongation, dry matter loss and accumulation in various seedling structres, leaf area accumulation, etc.). The biochemical tests involve assaying the seed for various chemical components (protein, starches and sugars, and oil along with free fatty acids), or monitering the rates of various metabolic reactions (e.g. respiration, glutamic acid decarboxylase activity, etc.) and the integrity of seed membranes by means of electrical conductivity (seed and/or leachate).

Results using the various physical tests have been somewhat variable due to the crops being tested. Of the physical tests probably the most often measured parameters would be that of seed weight (seed index) and seed density. Physical tests have not been extensively used to vigor rate seed in many species; however, some exceptions do exist. For example, several studies in cotton have indicated a strong positive relationship between seed density and seed vigor.

A number of workers have had varying degrees of success in quantifying vigor based on certain of the physiological tests. Inherently, the physiological tests should provide very useful vigor information in that most of them measure some aspect of seedling performance which by nature integrates the sum total of the physiological processes going on within the seed/seedling. In addition, most of these tests impose some type of stress condition(s) (mechanical resistance, temperature, moisture, pathogens, aging, etc.) on the seedling in order to simulate early stress planting conditions and/or periods of storage. Probably the most often used physiological tests would be the low temperature stress tests (cold test and Texas cool test) and the aging test (accelerated aging).

As previously indicated the biochemical tests measure the amounts of various chemical components (starches, sugars, lipids, free fatty acids, etc.), the degree or rate of various enzymatic reactions (respiration, biochemical component breakdown or synthesis, etc.), and the degree of seed membrane integrity (via electrical conductivity). Historically, the tetrazolium test (TZ) and the assay for free fatty acids in certain species have provided very useful information relating to vigor. The results with certain of the other tests have been variable depending upon the species being studied. More recently, studies involving measurement of electrical conductivity of seed leachates have shown promise in evaluating viability and vigor in certain species.

In this paper I have not attempted to detail the procedures for any of the vigor tests. In most cases, standarized procedures are still being formulated. Currently the AOSA Vigor Test Subcommittee is making substantial progress in an effort to compile and publish a handbook dealing with vigor and the measurement of such. The AOSA Vigor Test Handbook is slated for release in 1983. It will suggest procedures for the measurement of vigor for several species. It should be emphasized that these procedures are not intended to be "final and standard" procedures, but should represent a "giant step" toward this goal. For those desiring more immediate vigor test procedures, the literature abounds with this information.