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Seed Vigour Test: An Overview

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Abstract: *Seed vigour is "the sum total of those properties of the seed which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence". Seed vigour is an important quality parameter which needs to be assessed to supplement germination and viability tests to gain insight into the performance of a seed lot in the field or in storage. Seed vigor can be measured by a variety of methods including accelerated aging (AA), electrical conductivity (EC), seed vigour imaging system (SVIS), cold test, speed of germination (SG) count. Seed vigour is an important component of seed quality and satisfactory levels are necessary in addition to traditional quality criteria of moisture, purity, germination and seed health to obtain optimum plant stand and high production of crops.*

Keywords: Seed vigour, Germination, Accelerated Ageing (AA), Electrical Conductivity (EC), Seed Vigour Imaging System (SVIS), Cold Test

I. INTRODUCTION

The term 'seed vigor' was introduced by F. Nobbe in 1876, in his "Handbuch der Samenkunde". In 1911, Hiltner and Ihssen used the term *triebkraft* to imply "driving force" and "shooting strength" of germinating seedlings, to highlight seeds that produced seedlings with longer roots in comparison to those from "weaker" seeds from the same lot. The early days of research on seed vigor and its evaluation included studies conducted by Hiltner and Ihssen (AOSA, 1983) who developed the brick grit test, Fick and Hibbard (1925) the electrical conductivity, Stahl (1931) that evaluated speed of germination and the first observations about the cold test (Alberts, 1927; Tatum and Zuber, 1943). During the first half of the twentieth century, relatively little was added to the knowledge base on the evaluation of the physiological potential, except for the development of the tetrazolium test by Lakon in the 1940s, as reported by França-Neto et al. (1998).

Seed vigour is a very important parameter of quality, as it indicates the ability of seeds to germinate in sub-optimal conditions (low temperatures, wet soil, etc.). Moreover, vigour determines seed longevity as well as speed and uniformity of seed germination and emergence. Vigour is a better indicator of seed quality then standard germination test (Matthews et al., 2012; Tabaković et al., 2013; Vujaković et al., 2015).

II. SEED VIGOUR

Seed vigour is an important quality parameter which needs to be assessed to supplement germination and viability tests to gain insight into the performance of a seed lot in the field or in storage. Several definitions have been offered to explain seed vigour. Looking into the complexity of the situation. the ISTA congress in 1977 adopted the definition of seed vigour as " the sum total of those properties of the seed which determine the level of activity and performance of the seed or seed lot during germination and seedling emergence". Although differences in physiological attributes of seed lots can be demonstrated in the laboratory, it was recommended that the term should be used to describe the performance of seeds when sown in the field (Perry. 1984a).

Seedling vigour, being a sum total of seed attributes favour uniform field establishment. Seed vigour has long been recognized as one of the important aspects of seed quality. High yielding varieties with high seed vigour are desirable for their easy adaptation and fast spread. Its impact on crop performance has, however, been variable in different species. Different in vigour is only revealed in practice when routine germination tests fail to indicate emergence differences in the field (Lal M singh et al., 2011). The basis of difference in seed vigour lies in two processes: aging and imbibitions; and all tests of vigour and their improvement can be explained in terms of these processes. Vigour tests, in general are probably most effective when used as a production and operational tool.

Seed vigor determines the potential for rapid and uniform emergence of plants under a wide range of field conditions (Rajjou, L. et al., 2012; Finch - Savage et al., 2010). Seedling vigor mainly reflects seedling weight or height, which usually neglects germination speed (Lu, X. et al., 2007; Lowe, L. B. & Ries, S. K. 1972). Moreover, most experimental conditions involved in seedling vigor in various studies (germination time, temperature, management, etc.) were different with standard germination testing in seed industry. Nowadays, seed industry uses seed vigor to evaluate seed quality. High seed vigor is associated with the potential for increasing growth and productivity in agricultural production (Han, Z. et al., 2014). However, standard testing of seed vigor needs one or more weeks, which is labor intensive and time consuming. Therefore, there is tremendous interest in and demand for exploring rapid testing methods for seed vigor.

III. SEED VIGOUR EVALUATION METHODS

Seed vigor can be measured by a variety of methods including accelerated aging (AA), electrical conductivity (EC), seed vigour imaging system (SVIS), cold test, speed of germination (SG) count, and in some cases, indices that combine these measurements to more accurately predict seed performance in the field than speed of germination alone (Egli et al., 1978; Kolasinska et al., 2000; McDonald, 1998; TeKrony and Egli, 1977; Torres et al., 2004; Zorrilla et al., 1994). The AA test is a widely used method of measuring seed vigor and entails subjecting seed to high temperatures and high humidity for 48 h, followed by a SG test. This test was designed to be a measure of storability of seed and has proven to be a useful gauge of seed vigor (Kulik and Yaklich, 1982; McDonald and Phaneendranath, 1978; TeKrony and Egli, 1977). The EC test measures leakage from seed soaked in deionized water using an electrical conductivity meter, with seeds having higher EC values being lower vigor (Vieira et al., 2001). SVIS testing uses computer generated scans to digitally measure the emergence of 3 d old seedling root length and shape, and calculates a Vigor Index with a scanned image of seedlings and computer software (Hoffmaster, 2003; Hoffmaster, 2005). Seed laboratory tests are important to relate to seed performance in the field. A seed lot can have acceptable levels of SG and low levels of vigor at the time of testing (Hamman et al., 2002). Seed can be viable and have high SG values, but have low vigor and be less able to germinate and grow a healthy seedling under stress. Consequently, SG can overestimate field emergence, as ideal growth conditions are not always present in the field (McDonald and Phaneendranath, 1978; TeKrony and Egli, 1977). Some vigor tests do predict field emergence better than others in some planting situations, but as for which vigor test is the most effective previous research reports vary (Andric et al., 2007; Kulik and Yaklich, 1982; TeKrony and Egli, 1977). Accurate prediction of seed field performance can be elusive, as actual seed performance is related to the condition of the seedbed environment, which can be highly variable (Egli and TeKrony, 1996; Hamman et al., 2002; Zorrilla et al., 1994). However, generally speaking, high vigor seed do have increased field emergence, as higher vigor seed are better able to accommodate challenges in the growing environment (Isley, 1957; Roy and Ratnayake, 1997; Zorrilla et al., 1994). Conversely, low vigor seed are associated with difficulties in field emergence (Cho and Scott, 2000), as low vigor seed are more affected by challenging planting environments than higher vigor seed (Hamman et al., 2002).

IV. ACCELERATED AGEING TEST

Controlled deterioration tests were first developed to identify low vigor seeds (Powell AA et al., 1984) and consist of subjecting to high temperatures (around 40–45 °C) prearranged high seed moisture content (from 18 to 24%) for 24 to 96 h (Powell AA & Matthews S. 2005). In contrast, accelerated aging (AA) tests consist of exposing seeds to high temperatures around 40–45 °C over water, generating an atmosphere with high relative humidity (RH). The AA test was first developed by (Delouche and Baskin 1973) to estimate the longevity of seeds stored in a warehouse, as the decline in germination following AA is proportional to the initial physiological potential of the seed lot. Accelerated ageing technique is a widely used tool to test the seed quality. This ageing test of seed vigor can give better indications of probable field emergence for vegetable crop seeds than germination and growth tests (Pandey et al., 1999). Accelerated ageing techniques have great potential for understanding the mechanism of ageing and associated deterioration processes of seeds (McDonald, 1999). Aged seeds show decreased vigour and produce weak seedlings that are unable to survive once reintroduced into a habitat (Aiazzi et al., 1996). Based on seed performance potential under field conditions, the accelerated aging test has proven to be effective in selecting lots for sowing soybean based on the performance potential of the seed under field conditions and in evaluation of storage potential, and it may provide information with a high degree of consistency (Popinigis, 1985; Tekrony, 1995). Unfavourable storage conditions (high air temperature and high humidity of air) accelerate seed deterioration, causing seed quality losses and therein lower germ inability percentage of stored seed (Burris, 1980; Tewari and Gupta, 1981; Al-Yahya,1995; Depaula et al., 1996; Beratlief and Iliescu, 2005).

V. ELECTRICAL CONDUCTIVITY TEST

Electrical conductivity was proposed as a test to determine the physiological potential of seeds. Its objective was to indirectly evaluate the degree of cellular membrane damage resulting from seed deterioration. The electrical conductivity test has been recommended to evaluate seed vigor for peas. It has also been suggested for soybean seeds (Hampton & TeKrony, 1995). Despite specific recommendations for these two species, the test has been studied for use with other crops due to its simplicity in execution and rapid response (Vieira & Krzyzanowski, 1999). Seed samples stored at 20ºC presented rapidly decreasing values for standard germination and accelerated aging tests, accompanied by increased electrical conductivity values (Vieira et al., 2001). Conductivity test allows a quick, objective vigour test that can be conducted easily in most seed testing laboratories with minimum expenditure for equipment and training of personnel. Conductivity tests have high correlations with field emergence (Metthews, Powell, 1981), hence its wide use in seed vigour tests.

VI. SEED VIGOUR IMAGING SYSTEM (SVIS)

Computerized image analysis of seedlings has been used for seed vigor evaluation in several species; these are non-destructive methods and can provide objective information in a short period of time with less human interference (McCormac et al., 1990; Marcos Filho et al., 2006). The feasibility of using computerized image analysis was first demonstrated by McCormac et al. (1990) who determined the average length of the primary roots of tomato, lettuce and cauliflower seedlings. Similarly, in researches conducted by Geneve and Kester (2001) on cauliflower, tomato and impatiens seeds, and Tohidloo and Kruse (2009) on radish seeds using seedlings imaging analysis systems, were able to determine correlations between seedling growth and seedling emergence. In this context, Sako et al. (2001) developed an automated system for assessing the vigor of lettuce seeds called the Seed Vigor Imaging Sistem (SVIS®). The process involves scanning the seedlings and then generating vigor, growth and uniformity indexes. Further studies were conducted using this technique and successfully evaluated seed vigor, for crops such as soybean seeds (Hoffmaster et al., 2003), corn (Hoffmaster et al., 2005), melon (Marcos-Filho et al., 2006), peanut (Marchi et al., 2011), cucumber (Chiquito et al., 2012) and okra (Kikuti and Marcos Filho, 2013). Computerized image analysis of seedlings using the software SVIS® was effective in determining the vigor of carrot seeds and has a level of sensitivity comparable to traditional vigor tests (José Luís de Marchi and Silvio Moure Cicero 2017).

VII. COLD TEST

Cold test is most often used for maize, sorghum and soybean in North America and Europe (Ferguson,1990; Hampton, 1992.). Ferguson (1988) observed that soybean seeds stored at 10ºC (temperature normally utilized in a cold chamber) had a reduced physiological potential when evaluated by germination and accelerated aging tests; Effects of low temperatures (-6ºC) on germination and seed vigour depended on genotype and applied test (Woltz *et al*., 2006). Lovato *et al* (2005) tested the influence of three different temperatures (5, 7,5 and 10^0C) in cold test on maize germination, and obtained data showed that the cold test can be successfully applied at 10^0C for separation of lots according to vigour, but lower temperatures (5 and $7{,}5^0$C) were better for separation of lots highly tolerant to cold conditions. Milosevic *et al* (1994) applied different methods of maize vigour testing and obtained high correlation between cold test and field emergence. Balesevic *et al* (2007) revealed that in five sunflower genotypes stored in a warehouse under controlled conditions, and aging checked by the cold test the content of linolenic acid was reduced when the cold test was applied. This is yet another confirmation that vigour tests can determine changes in chemical composition of seeds. Vieira et al. (2001) evaluated six seed lots with distinct physiological potentials. They observed that at 10ºC, germination obtained after accelerated aging was reduced for all stored lots. Cold test proved to be a good indicator of field emergence (Woltz and TeKrony, 2001; Noli et al., 2008), when stressful conditions prevail during germination and emergence.

VIII. CONCLUSION

The issue of seed vigour is of central importance to agriculture and the seed industry, yet is still poorly understood and generally overlooked in academic research. With the rapidly growing human population and rapid changes in climate, the significance of seed vigour is increasing with time. Research is needed to further refine the current seed vigour test methods and to develop new methods which are rapid and more related to field/storage conditions.

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