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COMPUTER-AIDED ANALYSIS OF DIGITAL IMAGES FOR EVALUATION OF RADICAL EMERGENCE RATE

PRAJAKTA PRADIP BELSARE, PROF. M. M. DEWASTHALE

Dept. of Electronics and Telecommunication, Smt. Kashibai Navale College of Engineering, Pune, India.

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Corresponding Author

Ms. Prajakta Pradip Belsare

Abstract

Seed vigor testing and monitoring the seed quality is important aspect so as to maintain the seed quality. This can be done by calculating early seedling growth. Hand measurement of seedling growth is quite tedious and results vary from laboratory to laboratory; from person to person. Computer-aided analysis improves the results providing consistency and accuracy in measurement. Images of soybean seeds were captured over a period of its imbibition and then image processing algorithm is applied to calculate some of the parameters related to seed size and shape. Time course of each descriptor is similar to that of the triphasic curve of water uptake. This system can be applied to germination under different condition, different seeds, etc. Seed size and shape factor are useful to estimate the radical emergence rate of the seeds.

Introduction

Seed is the most important and basic entity of agriculture, it has high impact on the agriculture produce. Seed vigor is one of the most important aspects of seed quality. Seed vigor tests are generally tedious to perform on regular basis; it requires expert persons to carry out these tests. The results of these tests may also vary from lab to lab. So there is a need of objective system which will give consistent and accurate results.

Many attempts are made to make an objective system which will help to achieve accuracy in the vigor assessment. Ball Seed (Chicago) developed a vigor index by using a video camera to capture digital images of emerged seedlings in a plug tray to determine cotyledon area [12]. This has proven to be very successful in a limited number of bedding plant species. However, it relies on seedling emergence under greenhouse or growth chamber conditions. This limits its usefulness as a general vigor test for the industry, where greenhouse conditions vary with location or time of the year. The significant amount of space required to evaluate seedlings in plug flats would be limiting for evaluation of many species and seed lots.

Seed vigor can also be evaluated by measurement of seedling or radicle length of plants grown under controlled environments. This has been used successfully to test vigor in a number of small-seeded vegetable crops, including carrot (*Daucus carota* L.), lettuce (*Lactuca sativa* L.) [8],[15], radish (*Raphanus sativus* L.), sugar beet (*Beta vulgaris* L.)[14], cauliflower (*Brassica oleracea* L. Botrytis Group), onion (*Allium cepa* L.) and leek (*Allium ampeloprasum* Tausch.) [13]. Radicle length or growth rate, measured by using a slant-board test, was correlated with field emergence in these crops. These studies and others have established a strong correlation between radicle growth and the vigor level of a seed lot [16]. One problem with the slant-board test is that it is time consuming for the analyst to evaluate radicle length by hand and it can introduce analyst error in measuring radicle length.

McCormac et al. (1990) attempted to use digital image analysis of radicle length of small-seeded vegetable crops using the slant-board test. Although this was an accurate measure of radicle length, problems with lighting and background color made it difficult to evaluate the small roots of these crops. Paradigm Research Corp. (South Haven, Minn.) developed an improved digital camera system that has better control of lighting and contrast between the seedling and background and uses standard petri dish germination test conditions (D. McNertney, personal communication). Several other researchers have tried to automate this type of vigor test using machine vision [7], time sequence photography [17], and computerized automated seed analysis with a hand potentiometric caliper [18]. The results of tests have correlated well with those of hand measurements of radicle length, but have failed to become routine tests used by commercial analysts for a variety of reasons related to standardized conditions for collected images used by the computer.

The swelling process in small sized brassica seeds has been assessed as increase of seed volume [8].The parameter of seed area has also been used to study the imbibition time-course of cabbage seeds under salt stress and to develop a fast germination test [2]. An automatic vision system, that uses a fuzzy logic classification algorithm, has been used for controlling germination quality in lettuce, cauliflower and tomato seeds [11]. In addition, the roundness factor, as seed shape variation descriptor, has been used to establish the onset of radicle protrusion in cabbage, lentil, pepper and tomato seeds [3].

In order to evaluate the seed quality accurately and consistently; the seed vigor test should be able to give approximately same results from lab to lab and analysts to analysts; it should be objective and simple; it should resemble the same performance as field or greenhouse emergence tests. This paper presents an objective system to calculate the seed germination rate.

I. Materials and Methods

Soybean Seeds were taken for germination evaluation. Four and five seeds were sown for two sets of soybean, respectively. This experiment was carried out using 8.5cm diameter glass petri dishes containing one piece of germination paper and a black paper (to get good image for segmentation purpose). Water was added prior to placing seeds; approximately 4mL of water was added. The characteristics of seed were evaluated based on the water holding capacity. Water uptake for 18-hr imbibition was evaluated.

Evaluation of seedling growth can be done either by hand using ruler, or using computer-aided analysis of digital images. Hand measurements may include many errors since the change in parameters may be small. In order to get consistent results seedling growth was evaluated by using computer aided analysis. Images were captured for 18hr with 1hr interval for each set. CCD camera with 12MP resolution was used to capture images. These images were transferred to computer for further image processing to measure image analysis parameters. The description of all measured image analysis parameters is reported in Table 1. Area, perimeter, length and width, i.e. size change parameters, and the roundness factor, i.e. shape change parameter, were determined for each seed.

Table I. Image analysis parameters

Parameter	Measure Unit	Definition
Seed Area	mm^2	The area of polygon that defines the seed's outline
Seed Perimeter	mm	The length of outline of each seed
Seed Length	mm	The diameter along the major axis of the seed
Seed Width	mm	The diameter along the minor axis of the seed

II. Results

The sequence of soybean seed images captured from the start of imbibition up to 18h is shown in Fig.1. Figure 2a, 2b, 2c, and 2d shows the graph of area, perimeter, length and width, respectively with respect to imbibition time for the given set of soybean seeds. This graph shows triphasic curve of the water uptake; the first phase of rapid increase was completed at 2-4hr, followed by a second phase of little apparent change or almost steady state. This state was terminated at 10-12hr imbibition. Seed area evaluation is most sensitive parameter in monitoring seed imbibition.

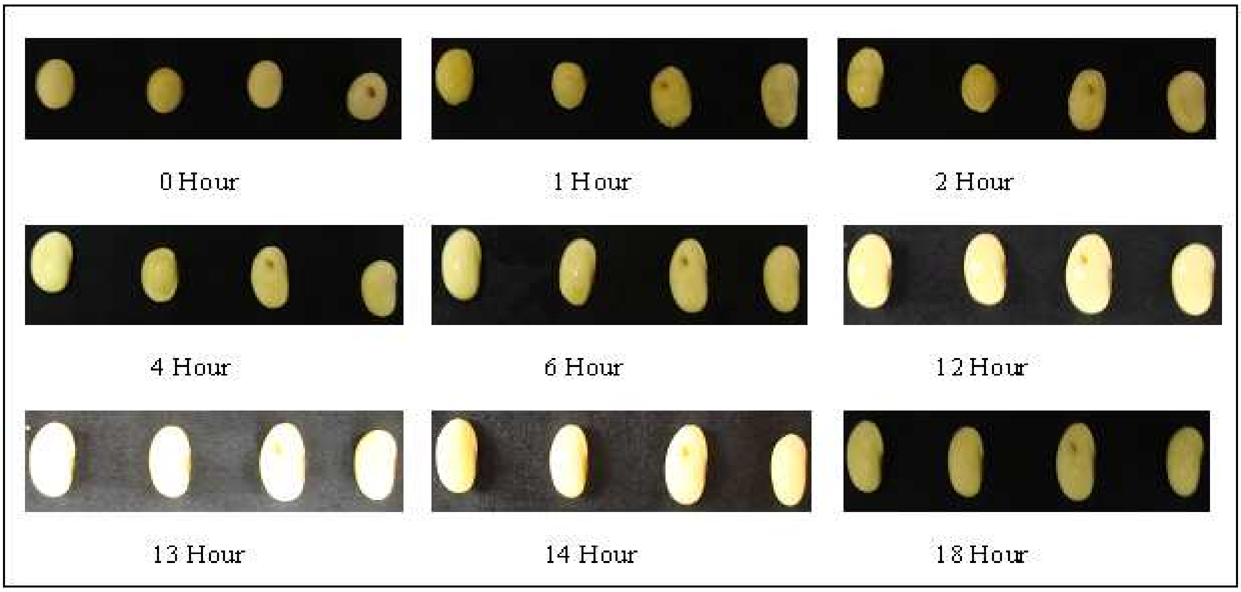

Fig.1 Sequence of images captured images of a soybean seed during 18h of imbibition

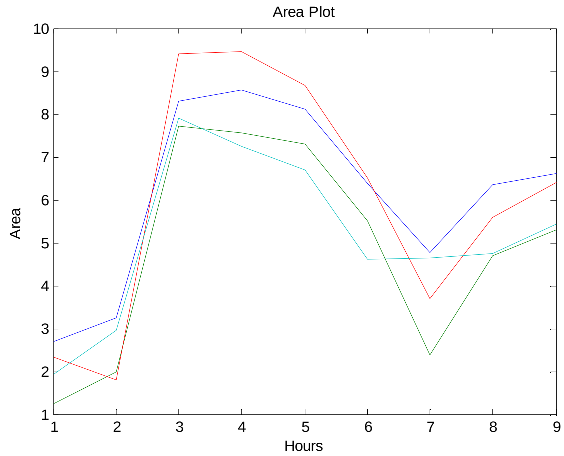

Fig.2a Time factor of area increase

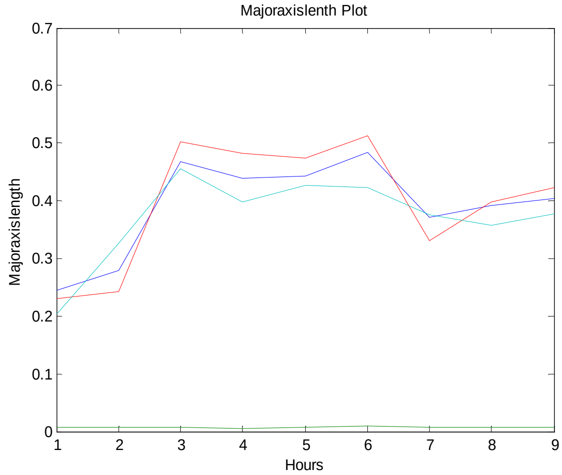

Fig.2c Time factor of length increase

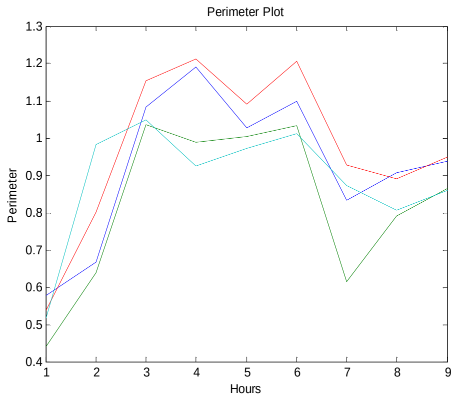

Fig.2b Time factor of perimeter increase

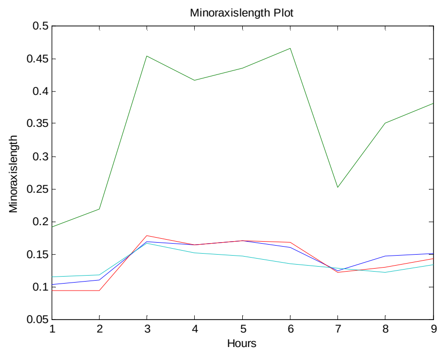

Fig.2d Time factor of width increase

Conclusions

Number of methods has been recently developed for seed sorting and quality evaluation. All these methods are based on the detection of various physical and physiological properties of the seeds. Various methods for seed quality assessment are defined by *International*

Seed Testing Association (ISTA) and *Association of Official Seed Analysts (AOSA)*; some of the methods are destructive and time consuming. So there is more emphasis on use of alternate non-destructive and efficient method. Machine vision system can be used to monitor changes in seed parameters non-destructively and can provide consistent results. The versatility and the sensitivity of the method suggest that image analysis techniques have a high application potential in seed quality and biology studies.

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