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The development of non destructive testing methods for water content and viability of soybean seed using standing wave

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Abstract

Rapid detection of moisture content and viability of seed is very important in seed technology. Identification of moisture content and viability of non-destructive seeds is necessary to prevent or reduce damage to seeds. The use of sound waves by identifying the value of absorption coefficient in seeds with different moisture and viability levels needs to be re-examined, since it has not been studied. The objective of the study was to develop non-destructive seed testing by identifying changes in absorption coefficient value on several seed quantities, water seed levels and different seed viability levels. The material used was soybean grobogan variety with the amount 120 grains. The frequency range used in the experiment was the frequency of 4000Hz-4750Hz. The result obtained from all measurements was the value of the absorption coefficient. The frequency that can be used to identify the difference of water content was at the frequency of 4750Hz. As for testing the level of viability, the measurement using sound waves could only distinguish between viable and non-viable seeds on the frequency 4250-4500Hz.

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Introduction

Soybean is one of the most consumed crops because of its high nutritional value. Soybean contains about 37% protein, 17 fat and 6% carbohydrates (Bawley & Black 1982). Indonesia is one of soybean producing countries. Soybean production in Indonesia always increase every year. Indonesian Central Bureau of Statistics (2014) recorded that domestic soybean production reached 955 000 tons/year, increased about 22.44% from 2013. However, the increasing value is still lacking considering the needs of soybean average that reached 2.2 million tons for a year. Subsequently, to meet these needs, there must be a bigger effort to increase soybean production. One of alternatives to increase production is by using qualified seeds. High quality seed become a determinant factor for the success of crops cultivation. The use of low quality seeds will perform non-uniform plants with a low number of growth percent and can be inoculum source of seed-borne disease (Ilyas 2012). According to Sadjad (1993), if the seeds are planted without going through the quality testing process, the new variances will be observed after in the field so will harm consumers due to loss of time, cost and energy.

Seed quality testing can be conducted by two methods, namely direct method and indirect method. The direct method is a test performed by observing the growth process in each individual seed, while the indirect method is a test of metabolism, the physical form of which is all regardless of the symptoms of growth (Copeland & McDonald 1995). The direct method is a highly relevant and often used method of quality testing, but the length of the process and can not be done in a single test makes the method slower (Justice and Bass, 2002). So also with indirect methods (fast test) of course have some advantages and disadvantages. Copeland & McDonald (1995) said the obstacle in rapid test evaluation is the standardization of analytical ability to determine seed vigor. In addition, rapid testing is also destructive. Boner *et al.* (1994) says the weakness in the use of rapid test methods on seeds is destructive.

One method currently being developed is the method of testing without damaging the seed (non destructive method). Non destructive methods can be done by utilizing sound waves. According to Matnut (2011), sound waves are longitudinal waves that have pressure caused by vibrations in the recurrence range of an object. Malik *et al.* (2002) states that wave utilization can be used as one of the non destructive testing methods in estimating the quality of wood based on wave propagation speed. In addition, the utilization of sound waves as non destructive measurements can be done by calculating the amount of sound energy absorbed (absorption coefficient). Rusmawati (2007) stated that the absorption coefficient is one of the important parameters in the determination of a material. In addition, for having accurate results, the measurement using the absorption coefficient can distinguish one material from the others. The absorption coefficient can be done by standing wave method. Standing waves or stationary waves are waves that do not move through the medium. Standing waves are different from running waves due to the ability to move through medium with the speed of wave. Standing waves are often used in identifying a material because it has good accuracy.

This research was aimed to develop non-destructive testing methods for estimating water content and viability of soybean seed by the way: 1. identifying wave absorption at several levels of soybean seed water, 2. identifying wave absorption at several levels of soybean seed viability.

Materials and methods

Place and time of research

The research was conducted in Laboratory of Seed Science and Technology, Department of Agronomy and Horticulture, Faculty of Agriculture and Electronic Laboratory, Department of Physics, Faculty of Mathematics and Natural Sciences, Bogor Agricultural University, from April 2016 until February 2017. The material used in this research was seed Grobogan soybean varieties obtained from Balai Besar Research and Development of Biotechnology and Genetic Resources of Agriculture, Cimanggu, Bogor.

Identification of seed absorption at various levels of water content using standing wave method

Seed treatment

Before measuring the coefficient of absorbtion value using standing wave method, firstly, the level of seed moisture was observed. The level of seed moisture content was determined using a sealed plastic jar with three liters of water. Subsequently, the seed lot placed placed in a jar was bounded by a mesh net in the center of the jar. The seeds were stored at room temperature (25-29 ^{o}C) with a time-varying temperature according to the desired moisture level: KA ± 12% for 9 hours, KA ± 16% for 19 hours, KA ± 20% for 30 hours and without treatment (Control) KA ± 8% (Goddess 2013).

Measurements using standing waves

The value of the absorption coefficient was obtained by placing the seed at the end of the resonance tube (Fig. 1). The generator through the speaker is the transmitter of sound waves and osciloscope through the microphone as a sound-catcher. The motor's functions is to move from the end of the tube to the end of the tube to find the maximum and minimum point of the wave. The value of absorption coefficient was obtained when sound waves generated by speakers about seed, some energy will be reflected and some will enter the seed mass. The number of seeds used for the measurement was 120 grains. The frequency used in the measurement was 4000 Hz, 4250 Hz, 4500 Hz, 4750 Hz and 5000 Hz. The result obtained was the minimum pressure value and the maximum pressure value shown oscilloscope which is then calibrated into equation 1.

$$\frac{((Vmin/Vmax)-1)^2}{((Vmin/Vmax)+1)^2} \quad \text{...} \quad (1)$$

With description: α is coefficient of absorbtion, V min is minimum voltage (mV), V max is maximum voltage (mV).

This research used complete randomized design of two factors, namely the moisture content of seed and frequency. Each treatment has three replication, so that there were 60 experimental units.

The absorption coefficient data in the form of graph is analyzed using F-test, significant difference will be test furtherly with Duncan Multiple Range Test with α = 5%.

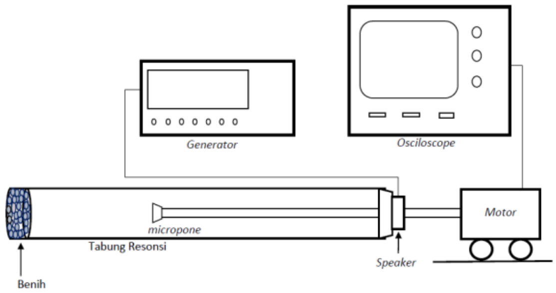

Fig. 1. Schematic of standing waveform method.

Identify wave absorption at multiple levels of the viability of soybean seeds using standing wave method

Seed ttreatment

Seed vability consisted of four treatments: high viability (DB: ≥ 81%), medium viability (DB: 71-80%), low viability (DB: 61-70%) and dead seed (DB 0%). Preparation of seed viability level was conducted by storage treatment under optimum and suboptimum conditions. High viability seeds were stored at optimum conditions (AC room) with low temperature and RH. Whereas seeds with medium, low and dead viability were obtained by physical exhaustion treatment (devigoration). Devigoration was done by storing seeds at 40^{o}C for 52 hours (medium viability), temperature 40^{o}C within 72 hours (low viability) and stored at 60^{o}C within 72 hours (dead seed). Storage was done in an oven with a plastic jar and a sieve in the center (in order to keep the seeds from submerged) and the bottom with water (Dewi 2013). This condition was set appropriately so that the humidity in the box was high which will result in the water content in the seed will increase drastically which will result in decreased viability. The dried seeds were exposed for 22 days in the AC room with temperature about 16 °C temperature obtained the equilibrium water content (KA ± 10%), then validated the viability of the seed. Measurement conducted was refered to benchmark ISTA 2014 method, namely: Germination Rate (GR), Vigor Index (VI), Maximum Growing Potential (MGP) and Electrical Conductivity Test (EDT).

Measurements using standing waves

In this experiment, measurement using standing waves were conducted similarly with the previous experiments. Experimental design used was complete randomized design of two factors namely the level of seed viability to the frequency with three replications. The absorption coefficient data was analyzed using F-test, treatments with significant difference will be continued with Duncan Multiple Range Test (DMRT) test with α = 5%.

Results and discussion

Identification of seed absorbtion at various levels of water content using standing wave method

Seed moisture using the jar increased the water content of the seed. Humidity within 9 hours increased the seed water content by 11.46%, humidity within 16 hours increased the water content of the seeds up to 16.31%, and humidity within 32 hours moisture increased the seed water content up to 21%. Moisture increasing in the seeds is related to imbibition process in seeds. In addition, soybean seeds are also hygroscopic so that the water content of soybean seeds is volatile (Justice and Bass 2002). The results about identification of several levels of water content using the wave method showed different responses on several frequencies as shown in Fig. 2.

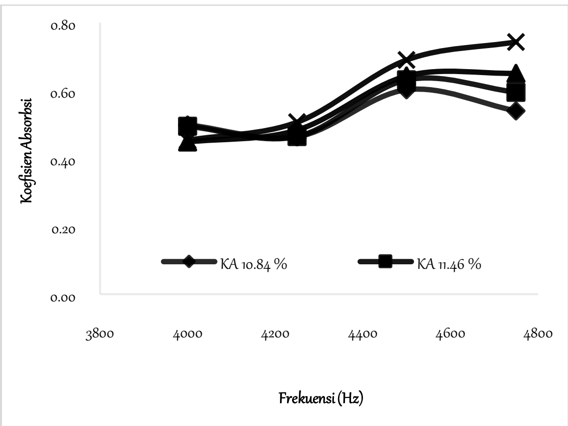

Fig. 2. Coefficient of absorbtion of several level of soybean water content in different frequency.

Generally, it can be stated that the higher the water content correlated with the higher coefficient of absorption value. Increased absorption coefficient is most noticeable at the frequency of 4 750 Hz. At lower frequencies (4000-4500 Hz), different levels of water content do not have different absorption values. At the frequency of 4000 Hz with the water content of 10.84% and 11.46% did not have the difference of absorption coefficient value, as well as the water content of 16.31% and 21.00%, did not show any difference of absorption coefficient value.

Table 1. The value of seed absorption coefficient at several wave frequency levels at different seeds water content.

Water Content (%)	Coefficient of Absorbtion			
	Frequency (Hz)			
	4000	4250	4500	4750
10.84	0.50 a	0.46 b	0.60 c	0.54 d
11.46	0.49 a	0.46 b	0.63 b	0.60 c
16.31	0.45 b	0.48 ab	0.64 b	0.65 b
21.00	0.45 b	0.51 a	0.69 a	0.74 a

Means followed by different letter showed significant different according to DMRT α=5%.

Similarly, the frequency of 4250 Hz shows absorption coefficient which is not different between water content 10.84%, 11.46% and 16.31%. At 4500 Hz, the coefficient of seed absorption with moisture content of 11.46% and 16.31% was not different, but different in water content of 10.84% and 21.00%. The increase of coefficient of absorption value is assumed to be the pore of the seeds by water vapor. Water vapor has a low velocity of sound, so that the value of resistance is greater than air, thus causing more moisture to absorb the sound energy. Sound absorption according to Nurizki (2012) was affected by the density of the object, temperature,frequency, and water content. Increasing of water content on the materials according to Tsoumis (1991) would increased sound absorption coefficient

Identification Absorbtion of Seed on Some Vulnerability Different Seeds Use Standing Wave Method

The decline of seeds can be done artificially through the process of devigoration. Devigoration with high RH will increase the moisture content of the seeds, so drying should be performed before the viability test using standing waves. Drying is done at room temperature for 4 x 24 hours. The result of drying moisture content is still high 16.36% (Medium Viability), 15.82% (low Viability) and 25.02% (Dead Seed) so it needs to be re-drying. Furthermore, drying is done in the AC room with temperature ± 16 ^oC for 22 days. Water content obtained from each treatment is 10.84% (High Viability), 9.15% (Medium Viability), 8.59% (Low Viability) and 8.42% for dead seeds. The re-drying aims to obtain the criteria for storing soybean seeds, ie 8% -12%. Further validation tests such as GR, VI, MGP and EDT are performed. Validation is done to ensure the parameters to be measured have reached the desired criteria, so it is appropriate for future testing. The results of seed viability testing showed that germination without devigorasimasih consistent with high germination rate and decreased according to duration of feeding (Table 2). The decrease in seed viability is also characterized by an increase in electrical conductivity values. The increase of electrical conductivity showed the height of loss the important metabolites which will lead decrease of the seed metabolism.

The measurement of absorption coefficient indicates that standing wave utilization is unable to differentiate seed viability. Wave harnessing is only able to distinguish live seed group (high, medium and low) with group of dead seed. (Table 3).

Table 2. Means of germination rate (GR), vigor index (VI), maximum growing potential (MGP) and electrical conductivity test (EDT) of soybean seeds.

Seed Viability	GR(%)	VI(%)	MGP(%)	EDT(μmol g^{-1})
High	90	35	98	28.38
Average	72	23	92	34.93
Low	61	16	88	39.02
Dead	0	0	0	104.99

Viability and electrical conductivity test were conducted with ISTA 2014 method.

Differences in absorption coefficient values between live seeds and dead seeds are thought to be due to physical changes in dead seeds. Dead seeds are smaller and irregular (wrinkled), allowing for more fine cavities formed when seeds are measured. The number of cavities that formed resulted in the sound emitted is not absorbed to the maximum. Other things are attributed to membrane damage, where the seed membrane damage can be seen from the increased value of electrical conductivity in the pen. The better the membrane in the seeds of the absorption coefficient value is also increased, and conversely the higher the membrane leakage in the seeds of the absorption coefficient value is also low. Bewley and Black (1982), suggest factors that reduce the viability of seeds among other loss of membrane integrity. While the absence of differences in absorption coefficient value at the live seed level is suspected in the ability of seeds that grow is also still high. This phenomenon can be seen from the maximum growth potential is still above 80%.

Table 3. The value of seed absorption coefficient at several wave frequency levels at different viability of seed.

Seed Viability	Absorption coefficient			
	Frequency (Hz)			
	4000	4250	4500	4750
High	0.85 a	0.86 a	0.66 ab	0.59 b
Average	0.86 a	0.79 b	0.63 b	0.58 b
Low	0.67 b	0.87 a	0.68 a	0.69 a
Dead	0.65 b	0.61 c	0.51 c	0.59 b

Means followed by different letter showed significant different according to DMRT α=5%.

Conclusion

Non destructive methods using standing waves can be used to differentiate seed quality based on the resulting absorption coefficient value. The higher the number and the higher the water content of the seed, the resulting coefficient of absorption increases. The number of selected seeds that can be used in the measurement of the absorption coefficient is 120 grains with the frequency range 4000Hz - 4750Hz.On 4750 Hz water content levels can be detected well, while the 4250-4000Hz frequency of coefficient value is able to distinguish between viable and nonviable seeds.

References

Bewley JD, Black M. 1982. Physiology and biochemistry of seed in relation to germination. New York, US : Spinger-Verlag Berlin.

Bonner FTJV, Elam WW, Land SB. 1994. Tree seed technology training course: instructor's manual. New York, US: United state Department of Agriculture.

[BPS] Badan Pusat Statistik. 2014. The data of soybean in 2014 [internet]. [downdloaded on 2015 Dec 2]. Available in : www.bps.go.id

Copeland LO, McDonald MB. 1995. Principles of seed science and technology. New York, US: Burgess Publishing Company.

Dewi NR. 2013. The utilization of sound detector to predict seed moisture content and viability of soybean (*Glycine max* L. Merrill). MSc thesis, Bogor Agricultural University,Indonesia.

Han F, Seiffert G, Zhao Y, Gibbs B. 2003. Acoustic absorption behaviour of an open-cell aluminium foam. Journal of Physics Applied Physic **36,** 294-302

Ilyas S. 2012. Seed science and technology: theory and the results of research.Bogor, ID: IPB Press.

[ISTA] The International Seed Testing Association. 2014. International rules for seed testing. 2014 ed. Switzerland, CH: ISTA

Jutice LO, Bass LN. 1979. Principles and seed storage practices. London, GB:Castle House Publications Ltd.

Malik AS, Mattarbeh HMA, Nuruddin MF. 2002. Non destructive testing and evaluation on timber, wood and wood product. [Prosiding]. The 7th Word Conference on Timber Engineering; 2002 Agust 12-15; Shah Alam, Malasyia (ML).

Manut. 2011. Definition of sound wave. [Internet]. [downloaded 2016 Dec 6]. Available in: www. gelombangelektronikasar.htm

Nurizki DP. 2012. Measurment of sound absorbtion coefficient of several types of wood using the standing wave method in resonance tube. MSc thesis, Bogor Agricultural University, Indonesia.

Rusmawati E. 2007. The determination of absorption coefficient using two microphones method in impedance tube. BSc thesis, Sepuluh November Technical College, Indonesia.

Sadjad S. 1993. From seed to seed. Jakarta, ID: Grasindo Press.