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Soybean Seed Quality Harvested at Different Maturity Stages

Kualitas Benih Kedelai Dipanen pada Kematangan yang Berbeda

Marwanto

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ABSTRACT

Timely harvest of soybean seed is very important due to its susceptibility to field conditions conducive to deterioration during seed development and maturation. The purpose of this study was to determine timely maturity stages that high quality soybean seed can be harvested commercially. Seeds of five soybean cultivars were grown in research plots at Agriculture Faculty, Bengkulu University on October 1999 in a split-plot arrangement, with harvest stages as main plots and cultivars as sub plots with three replications. At maturity stages R7, R7.5, R8, 1 and 2 weeks after R8, the seeds from each cultivar were harvested and evaluated for viability (standard germination test), vigor (accelerated aging germination test) and seed moisture. Seed viiability and vigor were highest at R7 for all cultivars. At all harvest stages, viability of Tidar and Cikuray seeds remained above 80% (acceptable germination level), while viability of Lawu, Wilis and Lokon seeds maintained at this level only until R8. Following this harvest stage, their viability markedly reduced to below acceptable germination level. Vigor of Tidar and Cikuray seeds was maintained at above 80% until R8 and declined significantly following this stage, reaching a level of around 70% and 60% at 1 and 2 weeks after R8 respectively. While vigor of Lawu, Wilis and Lokon seeds had declined to 80% at all harvets stages. Their vigor reached a level of less than 50% within 1 week after R8. Harvest maturity (R8) approximated the first date that soybean seed could be harvested commercially because the first time the seeds reached a harvestable moisture level (arround 14%). Seed of Tidar and Cikuray had a inherently better capacity to withstand field conditions conducive to deterioration than that of Lawu, Wilis and Lokon.

Key words: soybean, seed viability, seed vigor, harvest stage

INTRODUCTION

A major obstacle to the expansion of soybean [Glycine max (L.) Merrill] production to new areas of the tropics is the difficulty in producing high quality seed. Tropical conditions of high relative humidity and temperature during soybean seed production both before and after the seed reaches a harvestable moisture level are not conducive to production of high quality seed necessary to establish acceptable stands (TeKrony et al., 1980).

Several reports concluded that high

relative humidity and temperature cause soybean seed vigor, as well as viability, to deteriorate rapidly, making soybean seed impossible for farmers to use it for planting (Horlings et al., 1991; Keigley and Mullen, 1986; Yacklich and Kulik, 1987). Delouche (1974) has documented many instances of poor seed quality in soybean seeds and strongly contends that adverse weather conditions during seed development, maturation and storage on the mother plant caused moderate to severe seed quality problems.

With such mounting evidence that the environment plays a significant role in affecting the quality of soybean seed, timely harvest

of mature soybean seed is extremely important in protecting and maintaining high seed quality. Early harvest gives rise to a larger proportion of small-immature seeds, such seeds do not show good germination and can not be used for planting. Several workers have reported that soybean seed attains its high potential quality at physiological maturity (maximum seed dry weight) (Andrews, 1966; Delouche, 1974; Wahab and Burris, 1971). Unfortunately, due to high moisture content, the seed can not be harvested commercially at this growth stage and must remain in storage on the plant through a dessication period. This period may vary from a few days to over 3 weeks before the seed reaches a harvestable moisture level (TeKrony et al., 1980). Meanwhile, when seed harvest is delayed beyond optimum maturity caused by wet field conditions, it extends exposure of mature soybean seed to unfavorable conditions in the field and intensifies seed deterioration. Such weathering resulted in embryo destruction and lower seed quality (Moore, 1971). TeKrony et al. (1980) concluded that weathering of soybean seed for 14 days following harvest maturity increased its susceptibility to mechanical damage and lowered its quality.

The detrimental effects of unfavorable weather conditions on soybean seed quality have been well established; therefore, timely harvest of mature soybean seed is extremely important in obtaining high quality seed. There is little information available, however, on the changes in soybean seed quality harvested at different maturity stages. The objective of this study was to determine timely maturity stages that high quality soybean seed can be harvested commercially.

MATERIALS AND METHODS

Seeds of five soybean cultivars were used in these studies. The names of the cultivars and their seed characteristics are given in Table 1. The seeds were planted in research plots at Agriculture Faculty, Bengkulu University on August 15, 2000 in a split-plot arrangement, with

harvest stages as main plots and cultivars as subplot with three replications. Each cultivar was planted in a plot consisting of a single raised bed, 65 cm wide and 4 meters long. Two rows were planted per bed. Row spacing was 35 cm between rows within beds and 65 cm between beds. Seeds were planted in hills 20 cm apart with 3-4 seeds per hill. N, P, and K fertilizer at a rate of 40, 60 and 80 kg ha⁻¹ was applied prior to planting.

At maturity stages R7, R7.5, R8, 1 and 2 weeks after R8 (Fehr and Caviness, 1977), the seeds from each cultivar were harvested for quality evaluation by hand picking of the pods. The time of occurrence of physiological maturity was determined by harvesting 25 pods at approximately daily intervals and measuring the seed moisture content and weight per seed. For seed quality evaluation, 50 pods were picked from each treatment-replicate, then they were dried with heated air (<35°C) to reduce moisture content to 10-12% for threshing. The dried pods contained in jute bags were threshed by flailing and the seeds were separated from the pod walls and anotherplant parts by sieving. Sieving (round hole) was used to eliminate the small, immature and insect damaged seeds.

Table 1. Selected soybean cultivars with their seed characteristics used in this study.

	Seed characteristics					
Cultivars	Seed Coat	100-Seed	Seed Coat			
	Color	Weight (g)	Permeability(g g ⁻¹ h ⁻¹)			
Tidar	Yellow green	7.0	0.082			
Cikuray	Black	11.5	0.086			
Lokon	Yellow	10.8	0.094			
Lawu	Dark brown	12.0	0.104			
Wilis	Yellow	10.0	.0.107			

Seed quality evaluation of each cultivar harvested at each maturity stage included seed moisture content, viability and vigor. Seed moisture was determined on seed fraction of the soybean sample. Samples of about 20 g in duplicate from each treatment-replicate were placed in an oven at 105°C for 24 hours to obtain dry weight and determine the amount of moisture lost. Seed

Table 2.	Temperature (Temp.) and rainfall for the period of November 1, 2000 through Januari 31,
	2001 at the Agriculture Faculty Research Plot in Bengkulu.

	Weather Condition			Weather Condition			Weather Condition	
Date	Temp (°C)	Rainfall (mm).	Date	Temp.	Rainfall (mm)	Date .	Temp. (°C)	Rainfall (mm)
Nov. 1	25.6	Tracex	Dec. 1	27.8	0 у	Jan. l	26.8	Trace
Nov. 2	27.1	4	Dec. 2	26.7	0	Jan. 2	26.8	11
Nov. 3	25.5	4	Dec. 3	28.0	0	Jan. 3	27.6	0
Nov. 4	26.3	9	Dec. 4	28.0	0	Jan. 4	28.0	0
Nov. 5	26.0	Trace	Dec. 5	27.0	0	Jan. 5	28.6	0
Nov. 6	26.6	Trace	Dec. 6	26.0	4	Jan. 6	26.5	0
Nov. 7	26.9	5	Dec. 7	26.7	0	Jan. 7	26.7	0
Nov. 8	26.2	37	Dec. 8	26.5	5	Jan. 8	27.5	3
Nov. 9	26.8	5	Dec. 9	27.2	5	Jan. 9	27.2	0
Nov. 10	27.3	Trace	Dec. 10	26.1	Trace	Jan. 10	25.8	0
Nov. 11	27.3	0	Dec. 11	26.6	12	Jan. 11	26.9	10
Nov. 12	27.0	15	Dec. 12	27.1	54	Jan. 12	27.7	60
Nov. 13	27.2	0	Dec. 13	26.4	0	Jan. 13	27.4	Trace
Nov. 14	25.4	22	Dec. 14	28.0	Trace	Jan. 14	26.2	0
Nov. 15	25.8	95	Dec. 15	28.1	Trace	Jan. 15	28.0	12
Nov. 16	26.5	0	Dec. 16	26.7	4	Jan. 16	26.8	3
Nov. 17	24.3	45	Dec. 17	26.1	<i>7</i> 3	Jan. 17	26.3	69
Nov. 18	25.1	11	Dec. 18	26.1	4	Jan. 18	26.1	6
Nov. 19	24.8	6	Dec. 19	26.2	Trace	Jan. 19	26.1	3
Nov. 20	25.6	56	Dec. 20	26.7	101	Jan. 20	25.7	126
Nov. 21	24.4	51	Dec. 21	28.0	11	Jan. 21	25.8	10
Nov. 22	26.0	39	Dec. 22	27.7	21	Jan. 22	25.8	28
Nov. 23	28.3	11	Dec. 23	26.7	0	Jan. 23	26.7	2
Nov. 24	26.5	13 .	Dec. 24	27.8	Trace	Jan. 24	27.1	Trace
Nov. 25	27.1	Trace	Dec. 25	26.8	0	Jan. 25	26.8	0
Nov. 26	27.3	1	Dec. 26	23.3	100	Jan. 26	23.4	9
Nov. 27	27.2	Trace	Dec. 27	23.7	105	Jan. 27	23.6	109
Nov. 28	25.4	9	Dec. 28	23.5	84	Jan. 28	24.9	74
Nov. 29	28.3	29	Dec. 29	26.0	15	Jan. 29	26.3	10
Nov. 30	26.8	1	Dec. 30	26.9	Trace	Jan. 30	27.0	1
			Dec. 31	27.2	20	Jan. 31	28.6	Trace

^{*:} trace means rainfall less than 1 mm

moisture content was calculated on a wet weight basis and expressed in %.

Seed viability was determined by the standard germination test. In this test, 50 seeds from each treatment-replicate were placed on mosit paper towels, which were rolled and placed inside plastic bags and kept at a room temperature. Germinated seeds were counted aftar 5 and 8 days. Dead seeds were removed after 5 days, while hard seeds after 8 days and counted with germinated seeds. The number of germinated

seeds was expressed as a percentage of the total.

Seed vigor was determined by the accelerated aging test. In this test, 50 seeds from each treatment-replicate were subjected to a period of accelerated aging, 42°C and near 100% RH, for 48 hours prior to standard germination test. They were placed on a wire mesh tray of 20x5x2.5cm. The tray was placed inside a plastic box of 30x10x5cm and the box was filled with 100 ml of water. A 10-mm gap was maintained

y: 0 m eans no raifall

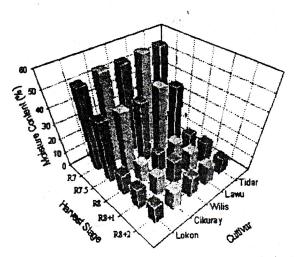


Fig. 1. Moisture content of soybean seeds harvested at different maturity stages

between the water surface and the seed tray. The box was covered with airtight lid and kept in oven at 42°C for 48 hours. After aging, seeds were taken out of the aging box and subjected to standard germination test.

Analysis of variance of each variable except seed moisture was conducted as a split plot design. When significant differences were revealed by use of the F test, comparasions of the means involved were made, using the Duncan's Multiple Range Test (DMRT) at the 0.05 level of probability. Regression analysis was also used to determine the relationship between seed coat permeability and seed quality at a certain harvest stage.

RESULTS AND DISCUSSION

Climatological data presented in Table 2 show that less significant raifall occurred on the first week of November 2000, December 2000 and January 2001, several days before R7 of all cultivars. Significant raifall mostly occurred after the first week of the months when most seeds were scheduled for harvest. This less favorable condition was probably responsible for lower seed vigor of most cultivars.

The results indicated that harvest stage ignificantly affected seed quality as reflected by

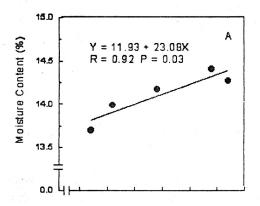
s seed viability and vigor. Averaged across cultivars, seed viability as measured by standard germination were 90.17% at R7, 87.53% at R7.5, 86.67% at R8, 73.33% at 1 week after R8 and 63.33% at 2 weeks after R8, respectively. Germination percentage was highest at R7 and there was only a little change in viability between R7, R7.5, and R8. However, it declined rapidly at 1 and 2 weeks after R8. Averaged across cultivars, seed vigor as measured by accelerated aging germination were 80.13% at R7, 78.13% at R7.5, 75.93% at R8, 55.87% at 1 week after R8 and 45.73% at 2 weeks after R8, respectively. The vigor levels were also highest at R7 and only slightly declined at R7.5 and R8, but reduced significantly at 1 and 2 weeks after R8. As a seed quality indicator, seed vigor tended to be lower than seed viability at each harvest stage. The difference between seed viability and vigor were not significant at R7, R7.5 and R8. The first significant difference (∝=0.05) between them occurred at 1 week after R8. At this stage, seed vigor was near 17.5 percentage points less than viability. This indicates that a decline in seed vigor proceeded seed viability and this was due to seed exposure to high temperature and relative humidity during the accelerated aging test. The early decline in vigor reported here emphasizes the value in using a vigor test such as accelerated aging in addition to the standard germination test when evaluating a seed lot's initial seed quality. The wide range in viability and vigor at each harvest stage also demonstrates the importance of timely harvest of seed in the field.

The analysis of variance revealed a significant cultivar difference and a significant cultivar x harvest stage interaction for seed viability and vigor. The significant cultivar x harvest stage interaction for seed viability and vigor was due to cultivar differences in the rate of decrease of seed viability and vigor at a different harvest stage.

Harrington (1972) reported that at physiological maturity stage (R7) nutrients are no longer flowing to the seed from the mother plant and the seed has not previously been

exposed to storage deterioration and should therefore have its greatest potential seed quality. The results indicated that seed viability and vigor were highest at R7 for all cultivars, but three of them -Lawu, Wilis and Lokon-failed to express their greatest potential quality at this stage (Table 3). At R7, seed viability exceeded acceptable germination levels (>80%) for all cultivars. Seeds of Tidar and Cikuray were 16.33 and 12.50 percentage points above the accetable germination level, repectively while seeds of Lawu, Wilis and Lokon were only arround 0.67-9.00 percentage points. At this stage, seed vigor exceeded 80% only for Tidar and Cikuray, but less than 80% for Lawu, Wilis and Lokon. The failure of certain cultivars on attaining its greatest potential seed viability and vigor at physiological maturity suggests that the seed had deteriorated in the field prior to physiological maturity. According to Marwanto (2003a, c) and TeKrony et al. (1980), environmental factor mainly moist condition and high temperature during seed development before physiological maturity was responsible for the reduction of its vaibility and vigor. Tedia (1976) also observed declines in seed quality before physiological maturity.

There was only a little change in seed viability and vigor for each cultivar between R7, R7.5 and R8 (Table 3). Until R8 seed viability for Tidar and Cikuray remained high (above 90%) while for Lawu, Wilis and Lokon was at a medium level (80-90%). Seeds of Tidar and Cikuray maintained their vigor above 80% until R8 while seed vigor for Lawu, Wilis and Lokon remained below 80% until this stage.



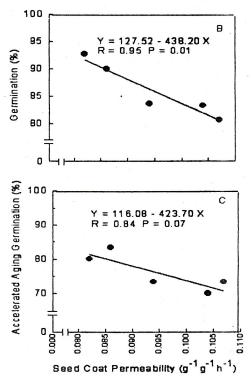


Fig.2. Interrelationship of seed coat permeability, germination, accelerated aging germination and moisture content in soybean seeds.

As mentioned earlier that seed harvested at maturity stages R7, R7.5, and R8 were not significantly different in quality for each cultivar as reflected by seed viability and vigor. However, when harvest was conducted at 1 and 2 weeks after R8, their seed quality markedly declined. This suggests that seed can only be harvested between R7, R7.5, and R8 for each cultivar. Unfortunately, due to high moisture the seed can not be harvested at R7 and R7.5. At R7, seed moisture for all cultivars was higher than 50% and at R7.5 was more than 40% except for Tidar (Fig. 1). At R8, seed for all cultivars had reached a harvestable moisture level (13-15%) With regard to seed viability and vigor, seed viability for all cultivars and vigor of Tidar and Cikuray seeds remained above acceptable germination levels (>80%) at this harvest stage. While vigor of Lawu, Wilis and Lokon seeds was only 10 percentage points below acceptable germination levels and also there were no major differences in seed vigor among them between R8 and earlier harvest stages (R7 and R7.5).

Table 3. Seed quality of 5 soybean cultivars harvestad	l at R7, R7.5, R8,	R8+1 (week a	ifter R8)
and R8+2 (2 weeks after R8).				

Seed Quality	Haminat Stone	Cultivars				
	Harvest Stage	Tidar	Lawu	Wilis	Cikuray	Lokon
SG (%)*	R7	A 96.33 a	AB 88.50 a	B 84.50 a	AB 92.50 a	AB 89.00 a
	R7.5	A 94.00 a	AB 86.67 a	B 81.33 a	A 91.33 a	AB 84.33 a
	R8	A 92.67 a	AB 83.67 a	B 80.67 a	A 90.00 ab	AB 83.33 a
× •	R8+1	A 88.00 a	B 63.67 b	B 64.67 b	A 84.33 ab	B 66.00 b
	R8+2	A 86.67 a	B 53.67 c	B 41.33 c	A 80.33 b	В 54.67 с
AA (%) ^y	R7	A 84.00 a	B 74.67 a	AB 76.67 a	A 89.33 a	AB 76.00 a
	R7.5	A 82.67 a	B 73.33 a	AB 76.00 a	A 84.00 a	B 74.67 a
	R8	A 80.00 ab	B 70.00 a	AB 73.33 a	A 83.00 ab	AB 73.33 a
	R8+1	A 71.33 bc	C 40.00 b	B 44.67 b	A 73.33 bc	B 50.00 b
	R8+2	A 66.67 c	В 25.33 с	B 34.00 c	A 69.33 c	В 33.33 с

Means not followed by the same capital letters within rows and the same small letters within columns within the same variable differ significantly at the 0.05 level of probability according to DMRT.

At 1 and 2 weeks after R8, seed viability and vigor for all cultivars declined at a different rate. Seeds of Tidar and Cikuray performed better than Lawu, Wilis and Lokon in the two quality tests suggesting that they had superior capacity to withstand field conditions conducive to deterioration. Germination percentages of Tidar and Cikuray remained above 80% at 1 and 2 weeks after R8 while germination of Lawu, Wilis and Lokon had declined to arround 60% by 1 week after R8 and arround 40-50% by 2 weeks after R8. The first decline in viability below 80% was observed at 1 week after R8 for Lawu, Wilis and Lokon while the decline in seed viability below 80% for Tidar and Cikuray was not observed until 2 weeks after R8. In the accelerated aging test, the response shown by Tidar and Cikuray indicated that the first decline in vigor below 80% occurred at 1 week after R8 while vigor of Lawu, Wilis and Lokon seeds at R7. The vigor of Tidar and Cikuray remained above 50% germination at 1 and 2 weeks after R8, while the vigor of Lawu, Wilis and Lokon had declined to low level (<50% germination) within 1 week after R8. These data demonstrate the need of resistant cultivar to field weathering, the importance of timely harvest and

evaluation of seed viability and vigor soon after harvest in the production of high quality soybean seed. If the viability and vigor levels were available to a seed producer shortly after harvest, a decision could be made regarding the seed lot's potential prior to the additional storage necessary for planting seed.

Among cultivars included in this study, seeds of Tidar and Cikuray showed a greater resistance to the unfavorable conditions during their seed development and maturation than Lawu, Wilis and Lokon. Cultivar differences for resistant to deterioration were also reported by others (Marwanto, 2003a, c; Paschal and Ellis, 1978). The resistance to field weathering exhibited by the two cultivars was a result of their seed coat permeability. The similar reason was also reported by others (Horlings et al., 1991; Marwanto, 2003a, c). Seeds of Tidar and Cikuray with low seed coat permeability tended to absorb water at a slower rate than the others (Fig. 1) and this finally protect them from deterioration in the field.

The regression analysis for seed moisture and seed coat permeability indicates that an increase in seed coat permeability was positively

^{*} Standard germination.

Accelerated-aging germination.

matched with an increase in seed moisture content. This was supported by a positive correlation between these two variables (Fig. 2A). The similar result was also reported by Marwanto et al. (2003). The regression analysis for standard germination as a meausre for seed viability and seed coat permeability showed that there was a significantly inverse relationship between the two variables (Fig. 2B). An inverse relationship was also observed between accelerated aging germination as a measure for seed vigor (Fig. 2C). These indicate that an increase in seed coat permeability was followed both by a decrese in seed viability and vigor. Similar negative relationship was also reported by others (Horlings et al., 1991; Marwanto et al., 2003). According to Kuo (1989), soybean seed with low seed coat permeability tended to resist absorption of water (moisture) and then protect seed from deterioration. He further stated that the respiraton rate of seed was accelerated with increased seed moisture content and this respiration interferes with the seed quality of rapid-imbibed seeds to greater extent than slow-imbibed seeds.

Small seed size for Tidar and black seed coat color for Cikuray was probably responsible for such resistance as wll. According to Dassou and Kueneman (1984) and Marwanto (2003a, c), soybean lines with small seed size or black seed coat were resistant to exposure of high humidity and temperature of tropical conditions. Smallseeded cultivar may gain their protection from a seed coat that tends to be less permeable while black-seeded cultivar from a seed coat that tends to be thicher than that of yellow-seeded cultivar (Mugnisjah et al., 1987). Additional research is moreover needed comparing a wide range of commercially available cultivars to determine if additional genetic variability exists for resistance or susceptibility to field deterioration. Among less resistant cultivars, Lawu was inferior in quality and exhibited its incapability to withstand the field conditions that favor deterioration. The less resistance exhibited by seed of Lawu to field weathering was probably due to its large seed size (Table 1). According to Calero et al. (1981), Marwanto (2003b) and Mugnisjah et al. (1987),

one possible explanation for the relationship between large seed size and low seed qaulity is the positive correlation between seed size and seed coat permeability.

With regard to timely harvest, it appears that with or without cultivar resistant to field weathering, harvesting as soon after maturity as possible is necessary to obtain seed viability and vigor above acceptable germination levels. The first date when all cultivars in this study were commercially harvestable occurred at maturity stage R8.

CONCLUSIONS

The findings of this study indicated that harvest maturity (R8) approximated the first date that soybean seed could be harvested commercially. Seeds of Tidar and Cikuray with low seed coat permeability and small seed size had a better capacity to withstand field conditions conducive to deterioration than that of Lawu, Wilis and Lokon.

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