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A STUDY OF VIGOR OF STORABILITY OF SEEDS OF SOME SORGHUM (*Sorghum bicolor* L. Moench.) GENOTYPES WITH ACCELERATED AGEING

Eko Pramono[1], Muhammad Kamal[1], F. X. Susilo[2], Paul B. Timotiwu[1]

[1]*Department of Agronomy and Horticulture, College of Agriculture University of Lampung, Indonesia*
[2]*Department of Plant Protection, College of Agriculture University of Lampung, Indonesia*

E-mail: pramono.e61@gmail.com

ABSTRACT

An experiments evaluating vigor of storability of seeds of several genotypes of sorghum were conducted during March - October 2015. The sorghum seeds harvested from the planting area in Village of Marhaen, Sub district of Sulusuban, District of Central Lampung, Lampung Province, Indonesia were used in this experiment. The accelerated ageing method with temperature of 40^0C and relative humidity of 100% for 0 (control), 2, 4, ..., 16 days were used to make seed ageing took place fast. After each treatment applied, viability of sorghum seeds were evaluated to measure percentage of normal seedling (PNS), germination speed (GS), seed leakage (SL), and percentage of dead seeds (PDS). Grouping genotype based on vigor of storability was conducted using cluster analysis with similarity of 70% by variable of PNS. Result showed that the 34 genotypes can be grouped into four groups of vigor of storability, namely high vigor (9 genotypes), medium-high vigor (7 genotypes), medium-low vigor (9 genotypes), and low vigor (9 genotypes).

Keywords: accelerated ageing, sorghum seed, vigor of storability.

I. INTRODUCTION

Sorghum (*Sorghum bicolor* [L.] Moench.) is one of the species of the open-seeded plant class (Spermatophyta, Angiospermae), single-seeded cotyledone (Monocotiledonae), order of Poales, family of graminae (poaceae), genus of Shorghum (Iriany and Makkulawu, 2013) which has potential to be developed in Indonesia. The potential of the sorghum includes a) it is annual crops of C4 metabolism plant; b) it can produce grain 2.8-3.0 tones/ha (Pabendon *et al*., 2013) with good nutrition (71% carbohydrate, 10.4% protein, and 3.1% fat) (Ministry of Health of Republic of Indonesia, 1992) (Pabendon *et al.,* 2013), c) it can produce livestock feed (17.1-21.4 ton / ha fresh forage) (Pabendon *et al*., 2013), d) it can produce bioethanol (3900-5700 L/ ha) (Pabendon *et al*., 2013); e) it is more water-efficient crop (332 kg water per kg of dry matter) than corn (368 kg water per kg of dry matter) (House 1995, Reddy *et al*. 2005);f) its ratun plants can produce grain and fresh stover enough high (Setyowati *et al*., 2005; Efendi *et al*., 2013); and g) it can keep high production at high level of CO_2 (700 □mol.mol^{-1}) and at high temperature (26-36^0C) (Prasad *et al*., 2006).

Level of CO2 recorded increased 35% (Keeling and Whorf, 2003) from pre-industry to 2002. In 2016, CO2 levels became 0.04%, or increased 33%, and the world average temperature increased 1.1 C^0 from before Industrial revolution 1860-1899 (Kompas.com, 2017). The monthly average temperature in Indonesia 2000-2011 was between 26.0-27,5^0C, with a maximum temperature of 30.2-32.1^0C and a minimum temperature of 23.4-24.4 ^0C (Fadholi, 2013)

Up to now, a lot enough of superior varieties of Indonesia sorghum had been released since 1970-2013 by Cereals Plant Research Institute in Maros (Aqil *et al*., 2013), among others 1) No.6C, 2) UPCA-S2, 3) KD4, 4) Keris, 5) UPCA-S1, 6) Badik, 7) Hegari Genjah, 8) Mandau, 10) Numbu, 11) Kawali, 12) Super-1, and 13) Super-2, 14) Suri-3, 15) Suri-4; and 3 varieties released from breeders of the National Atomic Energy Agency (BATAN) have also been released by the Government of Indonesia, namely Pahat, Samurai-1, and Samurai-2 (Human, 2012). The improved line (IL) of sorghum produced by sorghum breeders from BATAN was also a lot enough.

The problem that arises was what genotypes that have seed with high, medium, or low vigor of storability. The vigor of storability (VSA) is the functional line of the relationship between the value of viability on the Y axis and the natural time or relative time of accelerated aging intensity, and can be expressed as a straight line (Pramono, 2000; 2001; 2009a; 2009b). Differences VSA among seed lots can be expressed as the difference in slope value of the VSA line (Pramono, 2010), i.e. the larger the slope value of the VSA line the lower the VSA value of the seed lot or vice versa. This VSA was related to the storability (SA) of seed lot. The storability of seed is the ability of seeds can be stored (Sadjad, 1989) which retains high viability and vigor upon replanting. The storability can also mean the time period required by viability of a seeds lot to decrease to a certain viability value in a certain storage condition (Pramono, 2009b). The higher the VSA the higher the storability (SA) of a seed lot.

The accelerated aging method was to accelerate aging of seeds by giving seeds with treatments of high temperature (40^{0}C) and high relative humidity (100%) over a certain time interval, as introduced by Delouche and Baskin (1973). This method has been used by many researchers to differentiate the vigor of storability among seed lots, among others radish (Neeru, Kopaar, and Saxena, 2006), peanut seeds (Pramono, 2008), and soybean seeds (Pramono 2000 and 2001). This accelerated aging method can also evaluate the difference of soybean seed vigor due to differences in storage environment (Mbofung et al., 2013).

This study aimed to determine the VSA of seeds from 34 genotypes of sorghum using accelerated aging method. Furthermore, the 34 genotypes of sorghum were grouped into high, medium, and low based on the vigor of storability of its seeds. By knowing VSA with this accelerated aging method, the relative storability of the seed can be predicted. Seeds that have high relative storability can be stored longer than those with lower relative storability.

II. MATERIALS AND METHODS

A. *Seed preparation*

The sorghum seeds of 34 genotypes were harvested from late July to early August 2015 from the cultivated land in Village of Marhaen, Subdistrick of Anak Tuha, Districk of Central Lampung, Lampung Province, Indonesia were used in this experiment. The seeds were from monoculture cultivation of sorghum with spacing of 80cm x 20cm, and fertilized with Urea 200kg/ha, SP36 100kg/ha, and KCl 100 kg/ha. The seeds were harvested at the maturity level 41 days after flowering. The sorghum seeds in panicles were dried until the water content reached 9-10% and then the seeds were threshed from the panicles, and the clean seeds were packed in a plastic bag with clip and stored in a refrigerator at ± 8°C until the seeds were treated with an accelerated ageing treatment. Testing seed vigor of storability was done at Laboratory of Seed and Plant Breeding, Department of Agronomy and Horticulture, Faculty of Agriculture, University of Lampung, and it was held from September to October 2015.

B. *Application of Accelerated Aging Treatment*

Seed of sorghum, 50 grains in a bag of strimin cloth dipped in a fungicide solution (2 g/l) for one minute, then drained. Then put in an incubator chamber with 100% relative humidity and 40^{0}C temperature, following accelerated aging method by Delouche and Baskin (1973). Viability and leakage of seeds were observed at each accelerated aging interval of 0 day (control), 2, 4, 6, 8, 10, 12, 14, and 16 days.

C. *Seed germination test*

A number of 50 seeds were placed between the moist straw-paper which was then rolled together with the moist straw-paper according to the rolled paper test layered with plastic (ISTA rule modified by Sadjad, 1972), then this rolled paper was placed in a germinator Type IPB 72-1 under room temperature (26 ± 2.2 ^{0}C) with upright position. Observations and calculations of normal seedlings were performed at 2, 3, 4, and 5 days after seeds germinated. The variables measured in the viability test were 1) the percentage of normal seedling (PNS), 2) the speed of germination (SG), and 3) percentage of dead seed (PDS). The PNS was the normal percentage of seedling that appear during the test period up to 5 days, which is the total count of 2, 3, 4, and 5 days, so PNS = ΣP_i with P_i = the percentage of normal seedling that appeared on the i-day observation and i= {2, 3, 4, 5]. The speed germination (SG) was calculated as the cumulative number of percentage of daily normal seedlings, up to 5 days. By mathematical formula, SB was calculated as follows (Maguire, 1962), SG= $\Sigma P_i / T_i$; with P_i = the percentage of normal seedling that appeared on i-day observations and T_i = number of days since the germinated seed on observation i-day, {i = 2, ..., 5}

D. *Measurement of electric conductivity (EC) for seed leakage*

Electric conductivity measured seeds leakage that indicate the deterioration of seeds. A number of 25 grains of sorghum seeds were soaked in 50 ml distilled water for 24 hours. The EC value was measured in the water immersion of the seeds with a EC-meter device *Type Cyber Scan Con 11*, by dipping the end of the sensor in the water until an EC value appeared on the display screen. The measured variable was EC water immersing the seeds reduced by EC distilled water, in units of $\mu S.cm^{-1}$, which was an indicator of seeds leakage.

E. *Experimental design and data analysis*.

This experiment used a randomized complete block design with three blocks as replicates. A single treatment of 34 genotypes of sorghum were plotted randomly in each of three blocks. Data obtained in this experiment were the percentage of normal seedlings (PNS), speed germination (SG), percentage of dead seed (PDS), and electric conductivity (EC). Grouping genotypes based on the vigor of storability of seed was done by dendrogram cluster method using variable of PNS.

III. RESULTS AND DISCUSSION

A. Grouping genotypes based on vigor of storability

Percentage of normal seedling (PNS) data from seeds of 34 sorghum genotypes was presented in Table 1. Grouping the 34 sorghum genotypes based on seed vigor of storability was done by PNS variable using cluster dendogram analysis. Result of the dendogram cluster analysis was presented in Fig. 1. The cluster divided the 34 genotypes of sorghum into 4 groups of VSA, namely:

- Group A consisted of 7 genotypes, namely Numbu, Samurai 2, Cymit, GH-4, GH-5, GH-8, and GH-10);
- Group B consisted of 9 genotypes, namely Super-1, Super-2, UPCA, Mandau, P / F 5-193-C, P / F 10-90A, P / W WHP, GH-6, and GH- 7)
- Group C consisted of 9 genotypes, namely Samurai-1, GH-2, GH-9, GH-11, GH-13, GH-33, GHP-3, GHP-5, GHP-11; and
- Group D consisted of 9 genotypes (Kawali, Pahat, GHP-1, Talaga Bodas, GH-1, GH-3, GH-12, GH-14, and GHP-29). The vigor line of seed of storability of the four different groups was presented in Fig. 2.

According to Fig. 2, group B were genotypes that have a high vigor of storability, group A was genotypes that have a medium-high vigor of storability, group D was genotypes that have a low-storage vigor of storability, and group C was genotypes that have low vigor of storability. Consistently, the genotypes that have high seed vigor of storability also have higher percentage of normal seedlings, higher speed germination, lower percentage of dead seeds, and lower electric conductivity than those genotypes with lower vigor of storability. Vigor of storability, sequentially from the highest to the lowest was group B > A > D > C.

This difference in vigor of storability (VSA) was a genetic vigor, because the VSA was comparing among 34 genotypes of sorghum. Some properties of genetic factors that may be the cause of VSA differences were a) the chemical content of seeds and b) the physical traits of the seed. In rice seeds reported by Kapoor *et al*. (2011), the dissolved protein content decreased proportionately as the intensity of rapid aging was increase, but did not show any apparent correlation to the decrease in germination percentage. The decrease in germination percentage was not only influenced by the protein content of the seeds, but also by the carbohydrate content as indicated by the decline of java bean seed (*Cicer arietinum* L.) (Kapoor *et al*., 2010). Arief and Saenong (2006) reported that the smaller-seed size of corn variety of Lamuru had lower vigor storability than large ones. The different in seed size in sorghum seeds may affect VSA of sorghum seeds. The Penaloza *et al*. (2005) study on lettuce seed (*Lactuca sativa* L.) showed that large seeds had higher germination, higher SSAA (Saturated Salt Accelerated Aging) values, higher index of SVIS (Seed Vigor Imaging System), and faster and more uniform in the greenhouse emergence. Black-seed varieties of lettuce had higher seed quality and fewer fungus attack when evaluated by SSAA test. In relation to Penaloza *et al*. (2005) research, it can be estimated that physical seed size seeds, and other physical properties of seeds, may affect seed vigor of storability. Mohammad-Yasseen *et al*. (1994) stated that the seed coat was very influential, both physically and biochemically, on seed viability, and this wuld certainly affect the seed vigor of storability . In soybean seeds (De Souza and Marcos-Filho, 2001) seed coat permeability was closely related to porosity, and colors that affect seed vigor, storability, fungal attack, and sensitivity to imbibition damage.

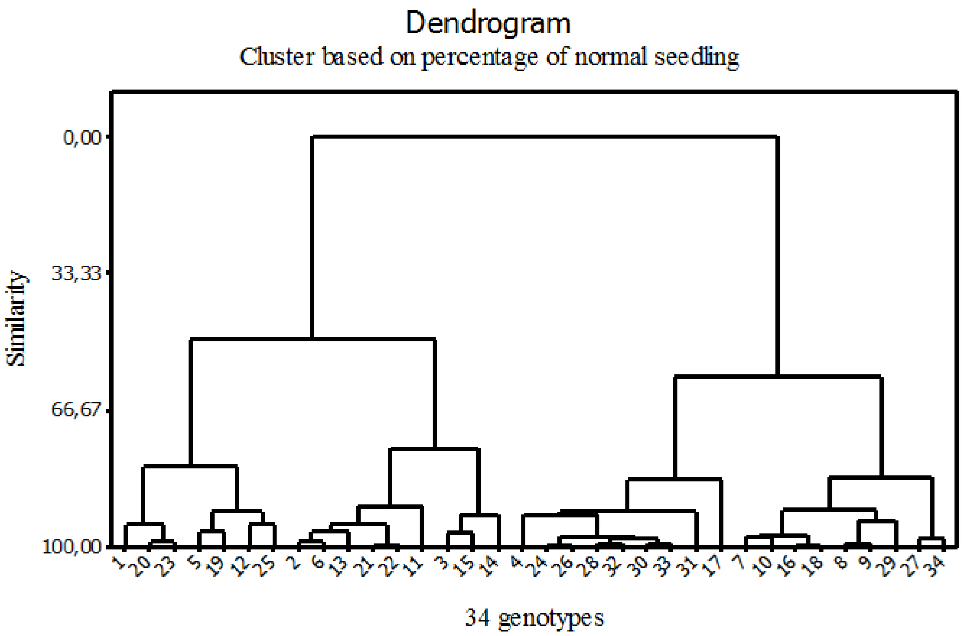
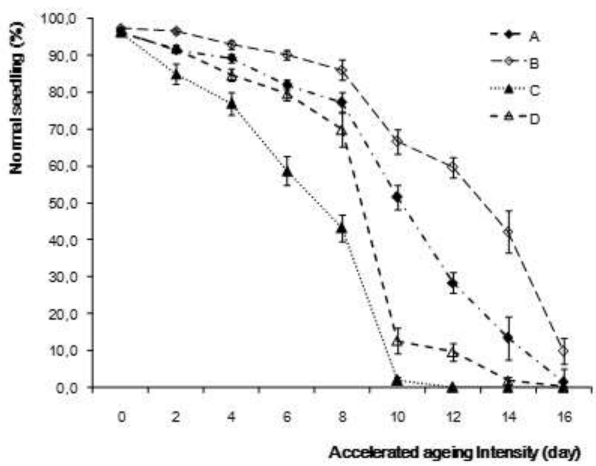


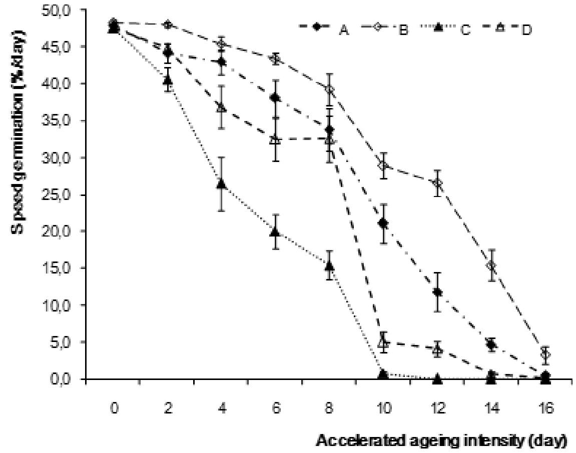
Fig. 1. Cluster dendogram of grouping genotypes based on vigor of storability (VSA) from 34 genotypes of sorghum using variable of percentage of normal seedling.

Table 1. Percentage of normal seedling (PNS) of seeds of 34 genotypes of sorghum during deterioration by accelerated ageing.

Genotype	Accelerate ageing Intensity (days)									
	0	2	4	6	8	10	12	14	16	Total
Numbu	98,7	93,3	92,7	81,3	86,7	25,3	22,7	2,7	0,0	503,4
Super-1	96,0	99,3	96,7	91,3	94,0	62,7	65,3	25,3	0,0	630,6
Super-2	96,0	97,3	96,0	96,7	92,0	86,7	46,7	53,3	1,3	666,0
Samurai 1	100,0	88,7	84,0	45,3	47,3	0,0	0,0	0,0	0,0	365,3
Samurai 2	96,0	88,0	78,0	66,7	84,7	53,3	57,3	16,0	0,0	540,0
UPCA	100,0	93,3	91,3	89,3	89,3	64,0	56,0	44,0	0,0	627,2
Kawali	96,0	92,7	92,0	86,0	77,3	8,0	18,7	0,0	0,0	470,7
Pahat	97,3	93,3	88,0	73,3	72,7	8,0	2,7	0,0	0,0	435,3
GHP-1	96,0	94,0	86,7	74,7	58,7	16,0	10,7	2,7	0,0	439,5
Talaga	94,7	92,7	84,7	84,7	85,3	0,0	18,7	1,3	0,0	462,1
Mandau	98,7	97,3	92,7	91,3	71,3	73,3	58,7	18,7	0,0	602,0
Cymit	97,3	98,0	98,7	95,3	89,3	54,7	14,7	20,0	5,3	573,3
P/F 5-193-C	98,7	95,3	94,0	90,7	88,7	64,0	54,7	38,7	16,0	640,8
P/F 10-90A	98,7	98,7	96,0	92,7	87,3	73,3	65,3	69,3	12,0	693,3
P/W WHP	96,0	93,3	86,0	85,3	74,0	65,3	76,0	64,0	30,7	670,6
GH-1	98,7	86,7	80,7	85,3	77,3	26,7	4,0	9,3	1,3	470,0
GH-2	98,7	84,7	60,0	36,7	29,3	4,0	0,0	0,0	0,0	313,4
GH-3	97,3	93,3	89,3	81,3	78,0	10,7	17,3	1,3	0,0	468,5
GH-4	96,0	92,7	85,3	74,7	70,0	65,3	37,3	17,3	4,0	542,6
GH-5	96,0	93,3	88,0	74,7	61,3	56,0	16,0	18,7	0,0	504,0
GH-6	96,0	96,7	92,0	84,0	86,0	52,0	61,3	37,3	16,0	621,3
GH-7	97,3	97,3	91,3	91,3	92,7	58,7	53,3	29,3	12,0	623,2
GH-8	96,0	82,7	90,7	88,0	74,7	37,3	21,3	9,3	0,0	500,0
GH-9	96,0	88,7	71,3	55,3	56,0	5,3	0,0	0,0	0,0	372,6
GH-10	96,0	92,7	92,0	93,3	74,0	69,3	29,3	9,3	0,0	555,9
GH-11	94,7	83,3	71,3	69,3	52,7	1,3	0,0	0,0	0,0	372,6
GH-12	94,7	86,0	79,3	69,3	45,3	30,7	8,0	1,3	0,0	414,6
GH-13	96,0	94,7	78,7	68,7	35,3	2,7	0,0	0,0	0,0	376,1
GH-14	96,0	93,3	76,7	78,7	82,7	13,3	6,7	0,0	0,0	447,4
GH-33	97,3	97,3	71,3	70,7	32,7	0,0	0,0	0,0	0,0	369,3
GHP-3	94,7	73,3	85,3	56,0	36,0	0,0	0,0	0,0	0,0	345,3
GHP-5	93,3	83,3	85,3	68,0	41,3	4,0	0,0	0,0	0,0	375,2
GHP-11	96,0	71,3	85,3	58,7	58,7	0,0	0,0	0,0	0,0	370,0
GHP-29	96,0	94,7	84,7	84,0	52,0	0,0	0,0	0,0	0,0	411,4



(a)



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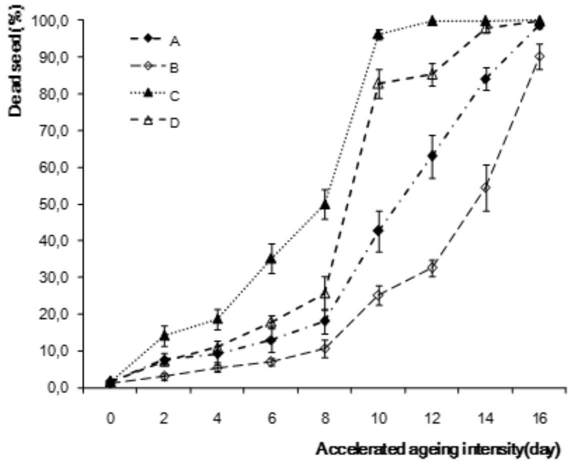

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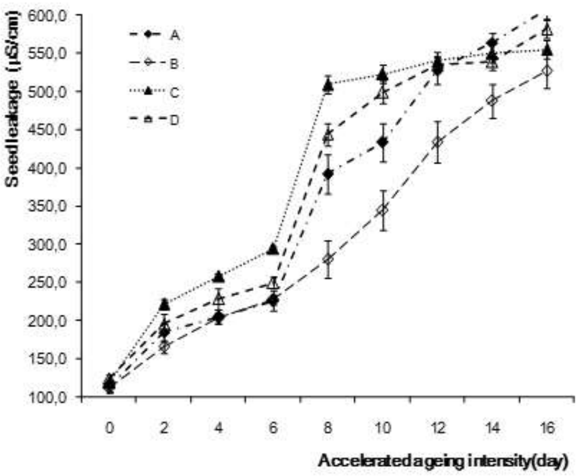

(d)

Fig. 2. Curves of vigor of storability of seed 4 groups of sorghum genotype, based on percentage of normal seedling (a); Speed Germination (b); Percentage of dead seed (c); and electrical conductivity of seed leakage (d). Bars were standar error of mean.

IV. CONCLUSION

The vigor of storability of seed of 34 genotypes of sorghum could be grouped into 4 groups based on the total percent normal germination percentage. The four groups were,

1. Genotypes having high vigor of storability, consisting of 9 genotypes, namely 1) Super-1, 2) Super-2, 3) UPCA, 4) Mandau, 5) P / F 5-193-C, 6) P / F 10-90A, 7) P / W WHP, 8) GH-6, and 9) GH-7;
2. Genotypes having a medium-high vigor of storability, consisting of 7 genotypes, namely 1) Numbu, 2) Samurai-2, 3) Cymit, 4) GH-4, 5) GH-5, 6) GH-8, 7) GH-10,
3. Genotypes having a medium-low vigor of storability consisting of 9 genotypes, namely 1) Kawali, 2) Pahat, 3) GHP-1, 4) Talaga Bodas, 5) GH-1, 6) GH-3, 7) GH-12, 8) GH-14, and 9) GHP-2,
4. Genotypes having a low vigor of storability, consisting of 9 genotypes, ie 1) Samurai-1, 2) GH-2, 3) GH-9, 4) GH-11, 5) GH-13, 5) GH -33, 7) GHP-3, 8) GHP-5, and 9) GHP-11.

The relationship between the vigor of storability of sorghum seed and the components of genetic factors of physical properties and physiological properties is suggested for further investigation. The nest research will be to find out the variables directly related to seed vigor of storability.

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