The effect of long fumigation on the viability of sorghum seed (Sorghum bicolor [L.] Moench.) During storage

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ABSTRACT

In storage, the seeds can be deteriorated by storage time and also caused by pests in warehouse. Sorghum seed is very susceptible to pest attacks in warehouse. Fumigation on the seed not only to prevent pest attacks in warehouse, but also have negative effects on seed viability. This study aimed to determine the effect of long-term fumigation with phosphine (PH_3) and long-term storage on viability of seed sorghum. This experiment was conducted at the Laboratory of Seeds and Plant Breeding, Faculty of Agriculture, University of Lampung from July 2016 to April 2017. The treatment is applied to the experimental unit in a randomized complete block design (RCBD) factorial treatments consisted long-term fumigation and long-term storage. Each treatment was repeated three replication. If the assumptions are complete, the performed will be analysis of variance. Separation of the middle value did with honestly significant difference test (HSD) at 5% level. The results showed that the interaction effect of long-term fumigation and long-term storage on viability of seed sorghum which shown by the variable of electrical conductivity, speed of germination, and normal seedling total. Long-term fumigation for 48 hours does not lead to decreased viability until 9 months old and long term fumigation for 72 hours led to loss of viability in storage time of 6 months.

Keywords: sorghum seed, long-term fumigation, long-term storage, and viability.

INTRODUCTION

Sorghum*(Sorghumbicolor* L. Moench) is the fifth important cereal crop after rice, wheat, corn, and barley. This plant has great potential to be developed as an alternative food source in Indonesia. All parts of the plant sorghum can be put to good use, especially sorghum seed. Sorghum seed can be used as food, animal feed, and fuel (bioethanol). Sorghum nutritional content consists of protein 13%, fat 2.05%, 48.75% carbohydrate, 12.6% ash, 13.5% crude fiber and 10.64% water. The nutrient content equivalent to rice and corn that is potentially as food and animal feed ingredients (Martawijaya*etal.,* 2004).

Seed storage is one aspect of post-harvest handling to produce more competitive products. The main purpose of seed storage to maintain seed viability over a long storage period as planting material from one season to the next (Koes and Arief, 2014). The seeds are stored for too long can lead to deterioration of seed. Deterioration of seed is a process of gradual reduction of seed quality and cumulative and irreversible. According to Oyo et al. (2006) showed a decline in sorghum seed germination percentage is relatively higher at 9 and 12 months of storage, reaching 16.7 to 24.7%, compared to 3 and 6 months of storage ranging from 1.4 to 4.7%. Kartika Sari (2015) states rice seeds stored for 9 months has vigor lower indicated by the value *of First count germination* (FCG), Shoot Length of Normal Seedling, and Primary Root Length of Normal Seedling than the storage time 7 and 8 months , According to Naguib*et al.* (2011) Storage of wheat seeds after 12 months and 18 months less than recommended for the germination percentages less than 85% that is equal to 62.9% and 53.6%.

The presence of pests such as pest warehouse contribute significantly to lowering the quality of the seeds both quantitatively and qualitatively during storage. According to the Ministry of Agriculture (2007) for the release of a pest in agricultural commodities in storage is by fumigation. Fumigant phosphine (PH3)while have an active ingredient is aluminum phosphide fumigation materials are widely used in storage and warehouse effective for controlling pests. The use of aluminum phosphide is widely used in the market because the price is cheap, effective in reducing pest attacks, the effects of the resulting residue is low, and does not undermine the viability of the seeds (Moghadamnia, 2012).

Long-term of fumigation affect the level of toxicity in controlling pests. The longer fumigation performed may cause damage and leave a residual effect on the seed. The resulting residual effects can affect seed viability. Because the compound is absorbed by the seed fumigant is getting greater as the old fumigation. The research resulted by Vijayanna (2006) on peanut seed showed ethylene dibromide fumigation and aluminum phosphide for 24 hours resulted in a higher percentage of germination than longer fumigation performed for 168 hours.

The research resulted by Yudhisthiraet al.(2014) showed long-term fumigation while using methyl bromide for 12 hours showed in a mortality rate of 51.09% compared pest fumigation old for 2 hours and 4 hours. According to Badawi*et al.* (2017) stated chemical treatment using phosphine in wheat seeds with a dose level of 8 ppm during storage produce insect damage percentage of 2.93%, a decline of 5.12 g seedling dry weight, abnormal sprouts 0.62%, and the final germination percentage 97.35 %. The research result peanut seeds were fumigated with aluminum phosphide can maintain germination percentage of 70% during the storage period of four months withinsect population *serratusCaryedon*thedecrease (Kamble*et al.,* 2013).

The use of fumigation at the beginning of storage was instrumental in controlling and killing the pests that carry over during the process of harvesting the seed in the field, in order to obtain good quality seeds. Quality seeds at the beginning of the storage can reduce the rate of deterioration is rapid seed during storage. The study was conducted to determine theeffect of fumigation and storage time on viability of sorghum seed.

MATERIALS AND METHODS

This research was conducted at the Laboratory of Seed and Plant Breeding, Faculty of Agriculture, University of Lampung from July 2016 to April 2017. The materials used in this research is the sorghum seed varieties of Super-2, phosphine trademark 56TB Phostek active ingredient with the formulation of aluminum phosphide tablet, water ion-free, CD paper and straw paper. The tools used in this research is a plastic clip 7 x 10 cm, staples, stationery, rubber, nails, ruler, plastic, tray, labels, seed blower, oven,seed countertype Seedburo 801 count- A-PAK, electric scales scount type pro, cole analytical balance Parmer PA 120, electro conductivity metertype series WTW pH/Cond 720, grain moisture testertype GMK 303 RS , and plastic cups.

The treatments were arranged factorial in a randomized complete block design (RCBD).The first factor is long-term of fumigation (F) consisting of old fumigation (24 hours) (f1), long fumigation (48 hours) (f2), and longer fumigation (72 hours) (f3). The second factor is the long-term storage (P) consisting of the storage period of three months (p1), the storage period of six months (p2), and storage period of nine months (p3). There are 9 combined treatment in each trial and each treatment consisted of three replications, in order to obtain 27 units of experimental units. Homogeneity of variance of data were tested by Barltett test and additivity of data by Tukey. The difference of means were tested using Honestly Significant Difference (HSD) at α 0.05.

Implementation research:

Harvesting: sorghum seeds obtained from experimental estate starch technology center, Bumi Aji village, Anak Tuha sub district, Central Lampung. The seed that had been collected, then it dried and cleaned using a seed blower. **Packaging:**200 grains of cleaned seeds had put in plastic clip a 7 x 10 cm with three replication and then placed into box plastic 15x12x10 cm, and is placed on treatment in an open plastic clips. **Fumigants Applications:** fumigant phosphine (PH_3) which contain Aluminum phosphide had put into the plastic clip a 7 x 10 cm as a tablet and then the plastic is perforated using a nail as many as two holes. Fumigants were put into a *box* plastic which containing the seeds and then fumigated by long-term fumigation treatment. **Storage:** a seed that has been treated fumigation then resealed adhesive plastic and stored at room temperature in the space 26 ± 0.4°C with a humidity of ± 70% and is based on a three-month storage periode (p1), the storage period of six months (p2), and storage period of nine months (p3).

Observations:

Seed Moisture: seed moisture content measurements performed using the moisture test-er. Measurement was done by taking five grain sorghum seeds at random and be repeated thrice.**Electrical Conductivity (EC):** 50 grains of sorghum seeds soaked in deionized water 50 ml and then covered with plastic and allowed to stand for 24 hours.Seeds that have been soaked for 24 hours and then measuredthe value of electrical conductivity using a conductivity meter. According to Presly (1958) on Research by Vijayanna, (2006) The calculation of the value of electrical conductivity can be calculated using the formula:

$$\text{Conductivity}\ (\mu S.\ Cm^{-1}) = \text{Conductivity of bath water} - \text{blank}$$

Germination test: the methodused germination test based on ISTA (2009) namely trolled paper with plastic method. Seed germination test consisted of **(1) Test Germination Speed**50 grains of sorghum seed every trial is put on two layers of straw paper then covered with two layers of straw paper, afterwards it was rolled. Seeds in straw paperrolls in moist condition. All the rolled paper were placed in a germinator IPB type 71-2A to room temperature (26 ± 0.4^{0}C) (ISTA, 2009). Observation consists of **Germination Speed (SG)** is a cumulative total percentage of normal seedling daily since observation 2 to 5. Germination speed is calculated by the following formula (Maguire, 1962); Copeland and Donald, 2005):

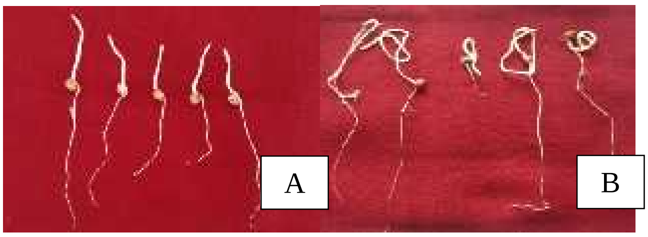
$$SG = \frac{NS_1}{d_1} + \frac{NS_2}{d_2} + \frac{NS_3}{d_3} + \cdots + \frac{N_n}{d_n}$$

SG= speed of germination (%/day); KN= The percentage of normal seedlings at each observation (%); d= day of observation; n = days of final count.

Total Normal Seedlingsis a normal seedling number calculated from observations of day 2 until day 5. Total normal germination percentage was calculated using the following formula (ISTA, 2010):

$$TNS = \frac{\sum NSi}{n}\ x\ 100\%$$

Abnormal germination and dead seedsis the number of abnormal and dead sprouts calculated on 50 seeds on the 5th observation day (Figures 1a and Fig. 1b) **(2) Test simultaneity germination :** 50 grains of sorghum seed every trial is put on two layers of CD paper then covered with two layers of CD paper, afterwards it was rolled. Seeds in CD paper rolls in moist condition. All the rolled paper were placed in a germinator IPB type 71-2A to room temperature (26 ± 0.4^{0}C) (ISTA, 2009). Observation consists of **Normal Strong Seedling** had strong growth in shoot and primary root compared to other normal sprouts and were observed on the 5th day after planting (Figure 1c), **Normal Weak Seedlings** is characterized by a shoot length and a primary root less than one cm and has a weak growth in the primary shoot and roots compared to other normal seeds and were observed on the 5th day after planting(Figure 1d), **Shoot Length of Normal Seedling** by measuring the length of the shoot that grows from the base of the seed to the crown of the shoot, **Primary Root Length of Normal Seedling** by measuring from the length of the roots that grow at the base of the seed to the root tip, **Dry Weight of Normal Seedling** by measurement using five samples of normal seedling which has been dried in the oven for 3x24 hours using a temperature of 80^{0}C.



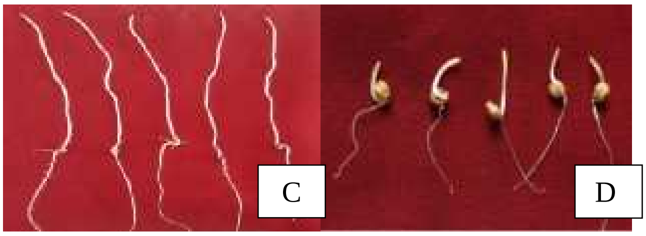


Figure 1 (A) normal seedling (B) abnormal seedling (C) Normal Strong Seedling, dan (D) Normal Weak Seedlings

RESULTS AND DISCUSSION

Summary results of analysis of variance (Table 1) show that the interaction time of fumigation and storage time significant effect on the viability of sorghum seeds are shown in a variable electrical conductivity, speed of germination and normal seedling total.

Table 1. Summary of results of analysis of variance longer fumigation effect (F) and storage time (P) of the observed variables

Variable	Treatment		
	Long-term Fumigation (F)	Long-term storage (P)	interaction
Seed moisture content (%)	ns	*	ns
Electrical conductivity (μS.cm^{-1})	*	*	*
Germination Speed (%/day)	ns	*	*
Total normal seedling (%)	ns	*	*
Abnormal seedling (%)	ns	ns	ns
Dead seed (%)	ns	*	ns
Normal strong seedlings(%)	ns	*	ns
Normal weak seedlings (%)	ns	*	ns
Shoot length of normal seedling (cm.seedling^{-1})	ns	*	ns
Primary root length ofnormal seedling (cm.seedling^{-1})	ns	*	ns
Dry weight of normal seedling (mg.seedling^{-1})	ns	ns	ns

Description:* = significantly differentat α = 0.05, ns = not significantly different at α = 0.05

In the variable of electrical conductivity, the interactions occur due to fumigation 72 hours old and 9 months storage time shows the value of the highest electrical conductivity. The value of electrical conductivity caused indicate a higher seed deterioration. Seed deterioration indicates the occurrence of cell membrane damage resulting in many compounds leaking out of the cell. According to Fitriningtyas (2008) expressed the high value of electrical conductivity is generated when the immersion process occurs due to the release of dissolved substances from the cytoplasm to the media imbibisi mainly on seeds have broken the membrane structure. The higher the electrical conductivity value indicates the low vigor and seed viability (Table 2).

Table 2. Effect interaction of long-term fumigation and long-term storage on variable of electrical conductivity

Long-term fumigation	Long-term storage		
	p1 (3 months)	p2 (6 months)	p3 (9 months)
	……………………….. (μS.cm^{-1})	…………………….	
f1 (24 hours)	74,53 a A	77,57 a A	110,90 b A
f2 (48 hours)	86,39 a AB	80,82 a A	118,07 b A
f3 (72 hours)	104,22 a B	128,87 b B	136,40 b B

HSD	18,16

Description:The mean value in the image followed by the same letter is not significantly different based on the HSD test on 5% level. Lowercase for comparison in rows and uppercase for comparison in columns.

In variable speed of germination, long fumigation had no significant effect but the storage time significantly. Interaction is influenced by factors of seed storage duration (Table 1). Interaction of long fumigation and storage time showed vigor they show the highest speed on a long germination fumigation 24 hours every level of the storage time and storage time of 3 months old at any stage of fumigation (Table 3). Germination speed shows the average number of seeds that germinated within the time period specified. According to Taliroso (2008) suggested that the seeds have high germination rate value indicates that the seed has a higher vigor. This is related to the rate of imbibition affecting the germination process, so that the effect in the rate of seed germination rate.

Table 3. Effect interaction of long-term fumigation and long-term storage on variable of speed germination

Long-term fumigation	Long-term storage		
	p1 (3 months)	p2 (6 months)	p3 (9 months)
	……………………… (%/hari) ………………….		
f1 (24 hours)	40,80 a	37,75 a	36,56 a
	A	A	A
f2 (48 hours)	42,78 a	38,18 ab	34,39 b
	A	A	AB
f3 (72 hours)	46,22 a	30,17 b	29,33 b
	A	B	B
HSD	6,88		

Description: The mean value in the image followed by the same letter is not significantly different based on the HSD test on 5% level. Lowercase for comparison in rows and uppercase for comparison in columns.

In variable of totalnormal seedling long fumigation had no significant effect but the storage time significantly. Interaction is influenced by factors of seed storage duration (Table 1). Factors storage time showed seeds stored for 9 months resulted in a lower normal seedling storage longer than 3 months (Table 6). This is because food reserves dwindling seed during storage. This result is supported by the correlation between the total normal seedling with the seed dies. Normal seedling lower total death caused by the higher seed.

Table 4.Effect interaction of long-term fumigation and long-term storage on variable of total normal seedling

Long-term fumigation	Long-term storage		
	p1 (3 months)	p2 (6 months)	p3 (9 months)
	……………………….. (%) …………………….		
f1 (24 hours)	90,67 a	90,67 a	88,67 a
	B	AB	A
f2 (48 hours)	94,00 a	94,67 a	88,00 a
	AB	A	A
f3 (72 hours)	98,67 a	86,00 b	84,00 b
	A	B	A
HSD	7,43		

Description: The mean value in the image followed by the same letter is not significantly different based on the HSD test on 5% level. Lowercase for comparison in rows and uppercase for comparison in columns.

The results showed that the longer fumigation 24, 48, and 72 hours of no effect in reducing the sorghum seed viability shown by all variables except the variable electrical conductivity values increased after fumigated for 72 hours (Table 5). The use of phosphine as fumigation does not cause a decline in the quality of sorghum seed physiology. According to the Departemen Pertanian (2007), when the aluminum phosphide reacts with moisture in the air releases phosphine gas, the gas can be eliminated through the aeration process that is done after fumigation so the resulting residue is relatively low. These results are supported by the results of research Krzyzanowskiand Lorini(2013) on the soybean seeds are fumigated for seven days using three phosphine pellet formulations do not cause damage to soybean seed physiological quality.

Table 5.Effect of long-term fumigation on viability of seed sorghum

Variable	Long-term fumigation			HSD 5%
	24 hours	48 hours	72 hours	
Seed moisture content (%)	8,44a	8,53a	8,58a	0,17
Electrical conductivity (μS.cm^{-1})	87,67a	95,09a	123,16b	10,48
Germination Speed (%/day)	38,37a	38,45a	35,24a	3,97
Total normal seedling(%)	90,00a	92,22a	89,56a	4,29
Abnormal Seedling (%) $\sqrt{x+0.5}$	1,44 (1,97)a	1,52 (2,77)a	1,73 (5,71)a	0,28
Dead seed (%) $\sqrt{x+0.5}$	1,73 (5,71)a	1,59 (3,61)a	1,60 (3,74)a	0,24
Normal strong seedlings(%)	90,67a	90,00a	88,67a	5,93
Normal weak seedlings(%) $\sqrt{x+0.5}$	1,45 (2,07)a	1,49 (2,46)a	1,56 (3,23)a	0,36
Shoot length of normal seedling (cm.seedling^{-1})	10,88a	9,91a	10,00a	2,25
Primary root length ofnormal seedling (cm.seedling^{-1})	10,88a	10,29a	10,05a	1,52
Dry weight of normal seedling (mg.seedling^{-1})	6,16a	6,44a	5,94a	1,15

Description:The number in brackets is the number of detranformations. Mean value followed by the same letterswas notdifferent at α 0.05 refers to Tukey test of HSD.

The results showed that the difference in storage time effect on seed viability sorghum shown by variable seed moisture content electrical conductivity, speed of germination, total normal seedling, the seed dies, normal seedling strong, normal seedling weak, long canopy normal seedling and root length primer normal seedling (Table 6).

Table 6. Effect of long-term storage on viability of seed sorghum

Variable	Long-term storage			HSD 5%
	3 months	6 months	9 months	
Electrical conductivity (μS.cm^{-1})	88,38a	95,75a	121,79b	10,48
Germination Speed (%/day)	43,27a	35,36b	33,43b	3,97
Total normal seedling(%)	94,44a	90,44ab	86,89b	4,29
Abnormal Seedling (%) $\sqrt{x+0.5}$	1,59 (3,62)a	1,54 (3,00)a	1,57 (3,36)a	0,28
Dead seed (%) $\sqrt{x+0.5}$	1,46 (2,16)a	1,70 (5,21)ab	1,76 (6,25)b	0,24
Normal strong seedlings(%)	94,89a	88,67b	85,78b	5,93
Normal weak seedlings(%) $\sqrt{x+0.5}$	1,32 (1,04)a	1,45 (2,06)ab	1,73 (5,71)b	0,36
Shoot length of normal seedling (cm.seedling^{-1})	8,42a	10,67ab	11,70b	2,25
Primary root length ofnormal seedling (cm.seedling^{-1})	11,24b	9,41a	10,57ab	1,52
Dry weight of normal seedling (mg.seedling^{-1})	6,25a	6,10a	6,18a	1,15
Seed moisture content (%)	8,63b	8,30a	8,62b	0,17

Description:The number in brackets is the number of detranformations. Mean value followed by the same letterswas notdifferent at α 0.05 refers to Tukey test of HSD.

Effect of storage duration shown in the percentage of moisture content of seeds which have a different percentage. In the variable moisture content of seeds stored for 6 months is lower in comparison storage periods 3 and 9 months. The water content is one of the internal factors that affect sorghum seed viability during storage. The results of research by Maemunah and Adelina (2009) showed that the longer the seed saved causes a decrease in the percentage of moisture content during storage, while research conducted by Indartono (2011) on soybean seed showed seed moisture content tends to increase after being stored for 4 months. According to Umar (2012) suggested during seed storage moisture changes will continue until achieving a balance so that the seed moisture content during storage can be increased or decreased.

In normal seedling variable strong, long storage of 6 and 9 months of normal seedling strong cause the resulting lower. These results are supported by the strong correlation between normal germination and normal seedling total. A dwindling food reserves led to the formation of a strong normal seedling diminished by normal seedling total produced decreases. According to Justice and Bass (2002) during the storage process in the seed respiration causes a reduction in food reserves. This is because the food is used as a backup reserve of energy in the process of respiration, so the seeds lose energy to the process of germination. The seeds that cause energy loss germination process is inhibited.

The process of germination is inhibited causing death resulting seed higher. In the variable seed dies and normal seedling weak, seeds stored for 9 months produce normal seeds and sprouts weak die is higher than the storage time of 3 months. This result is supported by the negative correlation between the speed of germination of the seed dies and normal seedling weak.

In the variable length header normal germination and normal seedling primary root length. Seeds stored the longer produce long canopy longer and normal seedling primary root length produced relatively constant. It is suspected vigor sprouts produced decreases with a high water content sprouts. These results are supported by the absence of correlation between the length of a long header normal seedling and primary roots sprout normal with normal seedling dry weight. Mugnisyah and Nakamura (1984) *in* Koes and Arief (2013) suggests the primary root length and hypocotyl length can be used to assess seed germination vigor. Root length affects the ability of plants to absorb nutrients. Nutrient absorption is not perfect, especially N cause interference with the metabolism of plants, especially in the process of photosynthesis, so the plant growth process will be interrupted and symptoms generally indicated by stunted plant growth and yellowing leaves early.

In this study, long fumigation on sorghum seed is better done through a long 24 hours for long fumigation fumigation is able to maintain the quality of the physiological longer until the storage time of 9 months old compared fumigation 72 hours. Postharvest handling such as storage of seeds should be done properly, especially by providing fumigation treatment at the beginning of storage for storing seeds for farmers, the use of phosphine as a fumigation can be used in a storage area because the price is cheap, readily available, and the effects of the resulting residue is relatively low.

CONCLUSION

Long-term fumigation has no effect on seed viability of sorghum, which is shown by all variables except the variable electrical conductivity. The longer fumigation (24, 48, and 72 hours) did not decrease the viability of sorghum seed varieties Super-2. Long-term storage affects the viability of sorghum seed. The longer storage (3, 6, and 9 months) causes the sorghum seed viability on the skids. Long interaction fumigation and storage time affects the viability of sorghum seed. shown by the variable electrical conductivity, speed of germination and normal seedling total. Old fumigation for 48 hours does not lead to decreased viability until 9 months old and long storage fumigation 72 hours led to loss of viability in storage time of 6 months.

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