**Maize seed quality evaluation at the temperature room storage**

**with open package condition**

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 **ABSTRACT**

Traditional farmers do seeds storagesimply by putting it on the floor of their home without specific treatment. Seed quality testing carried out in several varieties was stored at room temperature with open packaging condition to determine the viability and vigor. The experiment was conducted in Indonesian Cereal Research Institute (ICERI), Maros South Sulawesi from May 2014 to January 2015. The seeds were taken from the ICERI seed storage warehouse. Furthermore, seeds were stored in temperature room with open packaging condition. Parameter observations conducted on the moisture content of the seed, 1000 grain weight, electrical conductivity, germination, growth rate, primer root length and shoot length. Stored periodof the seeds in an open package at room temperature shelf life was strongly influenced by the previous seed storage and seed weight of current variety. The seed that had long been stored in the storage shed and small seed weight would accelerate the decline of physiological seed quality, especially the growth rate and percentage of germination. Storage of seeds in an open package at room temperature could maintain the quality of the seeds up to 3 months with large grain weight on the varieties and the low water contentof the initialstorage.

Keywords : maize, open package, room temperature, seed quality, storage

**INTRODUCTION**

The success cultivation in the field is strongly influenced by the use of quality seeds other than the application of proper cultivation techniques. Good quality seed can be obtained by performing the appropriate post-harvest processing. Starting from harvesting, drying, selection cob, shelling, grain drying, seed sorting, packaging and storage. Harvesting maize for seed required physiologically ripening, cobs dried until the moisture content of 17-18%, the selection is done by separating the large cob from the small one and diseased. Shelling performed on the selected cob, then dry the seeds to moisture content 10-11%. The sorting is done to separate small and large seeds, then packed using airtight packaging and storage in the low temperature. (Oyekale, Daniel, Ajala, & Sanni, 2012), to maintain quality during storage, seeds should be protected from air humidity and temperature, the growth of microorganisms and pests.

 Deterioration of the seed is a process of degradation gradualy and cumulative also irreversible as the result of physiological changes due to inside factors. The aging process or the withdrawal of vigor physiologically characterized by a decrease in germination, increasing the number of abnormalsprouts, decrease the appearance of shoot in a field (field emergence), inhibition of plant growth and development, increased sensitivity to extreme environments that ultimately can decrease crop production (Copeland & Donald, 1985).

To suppress the deterioration of seed quality during storage was required a good seed storage methodso that the rate of decline in seed quality can be pressed. Maize seeds classified as orthodox seeds,soextend the shelf should use low temperatures with air-tight packaging and storage initial moisture content was reduced to a safe moisture content for storage.

(Saenong, Syahfrudin, Widiyati, & Arief, 1999), stated that the initial moisture content of 10-11% of seeds stored in an airtight container at room temperature (28-32oC) had germination stand above 80% after being stored for 1 year and study result of (Rahmawati & Saenong, 2010) showed that the storage of maize seed Lamuru, Anoman and Srikandi Kuning-1 varieties which packed with polyethylene plastic, initial moisture content below 11% and stored in silo plastic for 10 months still had germination in above 85%.In another study, the experiment for Lamuru varieties maize seeds stored in seed storage warehouse with range of temperatures from 18-21oC for 23 months using high-density polyethylene plastic packaging still had a germination of 86,50% (Rahmawati & Syamsuddin, 2014). Even the seeds for a period of 5 years (varieties Gumarang, Srikandi Kuningand Bisma) still have germination above 90%. The use of plastic containers of polyethylene with a thickness of 0.09 mm and stored at room temperature 18-21oC with relative humidity of 50-55% capable of suppressing a decrease in the quality of seed, both physically and physiologically (Rahmawati & Arief, 2011).

That technology was difficult to applied in farmers level because of limited facilities. Some farmers do seed storage simply by putting it on the floor in their house without treatment. In addition, some farmers obtain seed from the breeder or other seed producers which are already packed. When planting time, delays often occur because of any particular case. Seeds have been opened from the packaging left without repackaged resulting in a decrease in viability and vigor.

To determine the decrease in viability and vigor seeds during open packaging, seeds varieties was testedby placed in temperature room with open packaging condition. The study results observe after the limit time for storage of the seeds weretaken from the warehouse in the open packaging condition.

**MATERIAL AND METHODS**

The experiment was conducted in Indonesian Cereal Research Institute (ICERI), Maros South Sulawesi from May 2014 to January 2015. The observation of seed quality wereconducted in ICERI Seed Testing Laboratory. The sample seed taken from the seed storage warehouse ICERI. Furthermore, the seeds were stored in room temperature with open packaging condition.

The study was split into two periods. Maize seeds sample in the first study was Lamuru varieties which been storaged for 9 months, Srikandi Kuning19 months, Anoman 11 months, while in the second study using varities Anoman, Bisma, Lamuru storage in seed warehouse for 2 months. In the first study the condition of storage to kept seeds hadtemperature ranges from 28o-31oC and relative humidity ranges from 58% - 68%,, while in the second study the storage temperature ranges 28o-32oC and relative humidity ranges from 44%-70%. The first study observations was conducted at 0, 2, 4, 6, 8 and 10 weeks after the packaging was opened while the second study was conducted at 0, 1, 2 and 3 months after the packaging was opened. Parameter observations conducted on the seed moisture content, 1000 grain weight, electrical conductivity, germination, growth rate, root length and shoot length.

**Moisture content.** Moisture content measurement carried out on seed samples tested, using a water content measuring device models Kett PM-400.

**Germination.**Prepare two sheets ofpaper that has been wetted and covered with plastic. The seeds were then sown in the top half of the paper. Furthermore, the other half of the paper closes with the seed that has been planted, then rolled and labeled (the date of planting, the seed code and replication number). Germinate using room germinator and observed. Each observation, normally sprouts grow calculated and moldy/rotten seeds were counted and discarded. Test carried out using 4 replications, each replication using 100 grains of maize which consists of two media rolls (1 roll of 50 seeds).

**Seed growing rate.** Data obtained from the test substrat seed germination result. In the each observation, the percentage of normal seedling divided by etmal (24 hours). Etmal cumulative value was obtained when the seeds were sown until the time of observation.

**Electrical conductivity (EC).** Electrical conductivity was observed with a conductivity meter. 25 seeds taken random, each weighed then washed and soaked in deionized water for 24 hours with a water volume of 75 ml in a glass bottle, then it was measured using conductivity meter.

**1000 grain weight.** 1000 grain weight of seed was done by taking samples at random, then counted the seeds in 1000 and subsequently weighed using electric scales.

**Primer root length.** The primary root length measurement was done by using gauges/ruler. Sprouts roots were stretched then measured from the base to the tip of the root.

**Shootslength.** Measuring the length of shoots done using gauge/ruler. Shoots were stretched then measured from the base to the tip of the leaf.

**RESULTS AND DISCUSSION**

**Moisture content**

Seed quality is strongly affectedbymoisture content, particulary if the seeds are stored in the long term. Maize grouped in orthodox seedso that the storage process requires a low moisture content. Biological and biochemical activity occurs when water is available. Therefore, the seed storage should use the low moisture content seed and low temperature of the surrounding air and monitored (Jayas & White, 2003). The seeds moisture content in the room temperature storage treatment using the open packaginghadshown in Table 1 (first study) and Table 3 (the second study).

Table 1. Average moisture content, 1000 grain weight and electrical conductivity of Anoman, Srikandi Kuning and Lamuru varieties during the open packaging stored at room temperature

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variety | Storage period(weeks) | Moisture content(%) | 1000 grain weight(g) | Electrical conductivity (µscm-1g-1) |
| Anoman | 0 |  11.00def |  267.90de | 14.59ab |
|  | 2 |  12.50a |  262.67e | 12.69ab |
|  | 4 |  12.00abc |  268.98cd | 14.85ab |
|  | 6 |  11.83abcd |  267.83de |  16.59a |
|  | 8 |  12.23ab |  267.70de | 14.24ab |
|  | 10 |  12.53a |  269.73bcd | 12.23bc |
| Srikandi Kuning | 0 |  11.23cdef |  271.60bcd | 8.22d |
|  | 2 |  11.63a-e |  271.57bcd | 7.63d |
|  | 4 |  11.63a-e |  272.15bcd | 8.87cd |
|  | 6 |  11.47b-f |  272.80bcd | 5.96de |
|  | 8 |  11.57a-e |  274.27bc | 5.40de |
|  | 10 |  12.07abc |  275.00b | 6.68de |
| Lamuru | 0 |  10.57f |  307.60a | 6.77d |
|  | 2 |  11.93abcd |  310.40a | 5.28de |
|  | 4 |  11.57a-e |  308.86a | 7.53d |
|  | 6 |  11.20cdef |  309.63a | 6.50d |
|  | 8 |  10.70ef |  308.97a | 6.56d |
|  | 10 |  12.40ab |  307.33a | 6.70d |
| CV (%) |  | 4.26 |  1.06 | 25.19 |

Means in each column, followed by similar letters are not significantly different at 5% probability level using duncan test

The increase of seed moisture content during open packaging treatment affected by the condition of storage space. In the first study the condition of store space had a temperature range from 28-31oC and relative humidity ranges from 58% -68%, while the second study the condition of store space had a temperature range from 28 - 32oC and relative humidity ranges from 44-70%. At the second study humidity greatly varies from low to high due seed storage treatment were held at the end of the dry to the rainy season. Wet and humid conditions during storage initiate the seeds to absorb water from the environment (Devereau, 2002), increased moisture content will accelerate the deterioration. (Surki, Sharifzadeh, & Afshari, 2012), stated that unfavorable storage conditions, especially temperature and humidity, accelerating damage to the seed during storage. Stored maize are hygroscopic and tend to absorb or emit water (Sulaeiman, Rosentrater, & Bern, 2013). During a certain time there will be equilibrium moisture content of seeds. RH conditions of environment greatly affects the occurrence of moisture balance. The absorption process in the seed maize was faster than a desorption (release) of water vapor from the seed. Saenong (1987) and research, showed that the equilibrium moisture content of maize seed can be obtained at 39 days of storage at 86% RH, 42 days at 86% RH, 46 days at 76% RH, 51 days at 62.5% RH, 59 days 52.5% RH and 65 days at RH 42.5%. The lower seed storage humidity due to the longer process of equilibrium moisture content of seeds. Seed maize that had a low water content stored at room sealed (airtight), or in a room with humidity below 75%. On the current air humidity, the moisture content of maize seed had reached 12% (maximum moisture content of seeds) in the tropics in store room temperature (28 - 32oC). (Samuel, Saburi, E., I., & U., 2011) , reported that the maize harvested in the tropics, after drying to certain moisture content, when placed in the open air, the water content of seeds exchanged with the environment until it reaches the equilibrium moisture content.

**1000 grain weight**

Each maize variety had different grain weight and was influenced by genetic factors. The observation result of the grain weight in the first study (Table 1) showed the average seed weight each varieties stable during open package stored at room temperature, while in the second study (Table 3), seed weight increased during the storage period. Seed weight increased influenced by increase ofmoisture content (Table 3), whereas in the first study (Table 1) moisture content increase obtained doesn’t effect to changes in seed weight. The average moisture content increase of the seeds from the beginning to the end of the storage period in the first study was lower than the second study. The result study of (Seifi & Alimardani, 2010), that the 1000 maize grain weight increased from 271 to 321 g concomitantwith the increasing moisture content of 4.73 to 22% wet basis, and the resultstudy of (Shirkole, Kenghe, & Nimkar, 2011), also showed 1000 grain weight of soybean seed cv. TAMS-38 and JS-335 increased with increasing moisture content. TAMS-38 increased moisture content of 7.30% to 30.80% and the weight of 1000 seeds of 124.2 g to 154.4 g. Similarly, the JS-335 varieties increased moisture content of 7.35% to 30.70% (bk) and the weight of 1000 seeds of 103.5 g to 137.3 g.

**Electrical Conductivity**

Observations of electrical conductivity in the first study (Table 1) showed that there was not a difference between the storage period for all varieties, but the electrical conductivity at Anoman varieties different with Srikndi Kuning and Lamuru. Anoman variety had a shelf life in the barn was lower (11 months) than Srikandi Kuning(19 months). Anoman seed variety had lower weight than other varieties so rapidly deteriorate during storage, but the electrical conductivity was obtained good. Cell membrane integrity was determined by the seed setback because of a change in biochemical or physical damage, this can be considered as the basic cause of the difference in viability that does not directly specify the leakage of seeds for trials electrical conductivity (Matthews & Powell, 2006).

Table 2. Average germination, growth rate, primary root length and shoot length of Anoman,Srikandi Kuningand Lamuru varietiesduring the open packaging stored at room temperature

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variety | Storage period(weeks) | Germination(%) | Growth rate (%/etmal) | Primary root length(cm) | Shoot length(cm) |
| Anoman | 0 | 83.33cde | 25.33def | 14.60abc | 8.93a-d |
|  | 2 | 78.00def | 22.93g | 15.07ab | 9.37ab |
|  | 4 |  75.33ef | 21.82gh | 15.75a | 9.91a |
|  | 6 |  72.00f | 19.00i | 13.19b-e | 7.67c-f |
|  | 8 |  78.00def | 19.23i | 12.98b-e | 7.18efg |
|  | 10 |  72.00f | 16.23j | 11.53d-g | 5.87g |
| Srikandi Kuning | 0 |  91.33abc | 27.63a-d | 12.90b-e | 7.46def |
|  | 2 |  90.00abc | 26.17cde | 12.37c-f | 8.33a-f |
|  | 4 | 90.00abc | 27.77a-d | 15.77a | 9.05a-d |
|  | 6 | 86.67bcd | 23.72efg | 13.63a-d | 7.80b-f |
|  | 8 | 78.00def | 19.00i | 13.15b-e | 7.53def |
|  | 10 |  78.67def | 19.33hi | 11.05efg | 7.13fg |
| Lamuru | 0 |  98.00a | 29.39ab | 13.65a-d | 8.77a-e |
|  | 2 |  96.67ab | 29.03abc | 13.97a-d | 8.47a-f |
|  | 4 |  95.33ab | 27.82a-d | 14.45abc | 9.64a |
|  | 6 |  95.33ab | 24.37efg | 14.41abc | 9.25abc |
|  | 8 |  97.33a | 25.51def | 12.58b-e | 7.80b-f |
|  | 10 |  98,67a | 24,76d-g | 12,85b-e | 7.88b-f |
| CV(%) |  |  6.04 |   6.47 |   9.75 | 10.08 |

Means in each column, followed by similar letters are not significantly different at 5% probability level using duncan test

In the second study (Table 3) showed that there was difference in electrical conductivity in the storage period of 0 and 3 months on Anoman and Bisma varieties, while Lamuru varietynot yet to showed any different electrical conductivity between the storage period of 0 and 3 months, although Anoman, Bisma and Lamuru had the same shelf life (2 months). Lamuru was maize varieties that had a large enough grain weight so as to maintain its quality despite experiencing deterioration process of seeds. Keep moisturecontent high seed will accelerate the deterioration of seed. At 3-month storage period, the moisture content Lamuru was lower than Anoman and Bisma. (Hampton, Johnstone, & Umpon, 1992) stated that there were several factors that affect the measurement results electrical conductivity on seed beans and soybeans, including ion content in water immersion, at room temperature while soaking, soaking time, the current temperature measurement, amount of seed measured, moisture content and seed size.

**Germination**

In the first study (Table 2) showed the Lamuru varietygermination was not occurred differencesbetween storage period, while Anoman and Srikandi Kuning germination were decreased of the 0-10 weeks storage period at room temperature.These three varieties of the Anoman and Srikandi Kuninggermination percentage decreased rapidly compared to Lamuru, and both varieties shelf life longer than Lamuru varieties. Otherwise Lamuru seed weight was greater than both varieties. (Moshatati & Gharineh, 2012), state that 1000 grain weight was the important scale in the seed quality. Seed sizerelated to the size of the seed embryo and seed storage that give effect to the germination and growth. (Mandal, Chakraborty, & Gupta, 2008), stated that large seeds gave to good germination in unfavorable environmental conditions. (Jorge & Ray, 2005), showed that in the increasing of 100 *Parthenium argentatum* L grains weight, the germination percentage was increased, for example, an increase in weight of 100 seeds from 0.08 g to 0.1 g, germination percentage increased from 34% to 80%.

The varieties of Anoman, Bisma and Lamuru were used in the second study (Table 4) had 2 month long storage in warehouses seed, so it didn’t affect the decrease in the percentage of germination. Mettananda, Weerasena, & Liyanage, (2001)stated that most of the maize seed fail to germinate after 5-6 months storage in woven polypropilen sacks at 12% moisture. The longer seeds stored food reserves lost opportunities greater.

Table 3. Average moisture content, 1000 grain weight and electrical conductivity of    Anoman, Bisma and Lamuru varieties during the open packaging stored at room temperature.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Variety | Storage period(month) | Moisture  content(%) | 1000 seeds weight (g) | Electrical conductivity(µscm-1g-1) |
| Anoman | 0 |  9.13e | 250.63h |  3.24e |
|  | 1 | 10.50d | 253.27g |  5.27d |
|  | 2 | 11.80a | 253.10g |  3.49e |
|  | 3 | 12.13a |  256.87f |  9.47b |
| Bisma | 0 | 10.23d | 259.33e |  10.87b |
|  | 1 | 11.37b | 262.13d |  11.13b |
|  | 2 | 11.93a |  263.77d |  10.82b |
|  | 3 | 12.13a |  263.13d |  14.51a |
| Lamuru | 0 |  9.10e |  268.43c |  5.32d |
|  | 1 | 10.26d |  276.07b |  6.88cd |
|  | 2 | 11.00c |  277.17ab | 7.25c |
|  | 3 |  11.30bc |  278.60a |  6.42cd |
| CV (%) |  | 2.08 | 0.57 |  14.56 |

Means in each column, followed by similar letters are not significantly different at 5% probability level using duncan test

**Growthrate**

Seed growth rate the varieties ofLamuru, Srikandi Kuningand Anoman in the first study (Table 2) decreased along of 10 weeks the storage period. Growth rate is one of the determine to detect level of a seed vigor. In the first study (Table 2) seeds were usedhad storage for a long time (9-19 months) so to provide opportunities for seed deterioration. In addition to the storage conditions after open packaging (storage at room temperature 28o-31oC) and high water content further accelerate the deterioration of seed, it appears from the seed growing rate of decline rapidly. (Hayma, 2003) reported that seed moisture content increase the respiration rate. Temperature and high moisture content will accelerate the seeds respiration rate sothe faster shake-up of food reservesand gradually reduced food reserveswere a source of energy to power the growing seed. Thus the growth rate of seeds would be decreased. (Vieira, Scappa Neto, Bittencourt, & Panobianco, 2004) reported soybean seeds were stored in aluminum foil at a temperature of 20oC and a paper bag wal in open space, the growing power and vigor decreased rapidly and the electrical conductivity increases rapidly.

In the second study (Table 4), the varieties of Anoman, Bisma and Lamuru didn’t indicate significantly decline on growth rate, except the Bisma variety has shown decline in growth rate on three months storage period (30.98%/etmal), however still in a state the good condition.The varieties of Anoman, Bisma and Lamuru had a shelf life in the seed storage for 2 for months,so not much happening revamp food reserves in seeds. This affected to resilience seeds when that was stored in an open package at room temperature.

**Primer Root length**

The observation of the primary root length in the first study (Table 2), indicated Srikandi kuning and Lamuru had not difference of root length on storage period of 0 and 10 weeks except Anoman. Contras the first study, the second study (Table 4), showed that the varieties of Anoman, Bisma and Lamuru had different primary root length of the storage period of 0 and 3 months. Seedling root growth was affected by the weight of the seed of a variety. Seeds that have greater grain weight effect on the length of the primary root because that seed can provide greater energy to help the root growth. (Moshatati & Gharineh, 2012), reported that the germination and emergence of shoots requires a amount of energy that was produced from the oxidation process in seeds stored. In the second study (Table 4), the weight of seeds of each variety was small enough so that within 3 months had begun to appear long decline roots, although the percentage of germination and seed growth rate was still high.

**Shoot length**

The result observation of shoots length in the first study (Table 2) and the second study (Table 4) showed a decline shoots length of Anoman variety, while Srikandi Kuning and Lamuru (first study) Bisma and Lamuru (second study) had not shown differences of shoots length on 0 and 10 weeks (first study) or 0 and 3 months (second study) storage period. 1000 grains weight of Anoman variety were lower than other varieties, so affect on the length shoots growth. (Moshatati & Gharineh, 2012), showed the result of sprouts growth (shoot + root), 1000 grain weight affected on sprouts length (shoot + root) and dry weight of sprouts (shoot + root). Weight of 1000 grain higher provide sprouts length (shoot+ root) was higher and at the opposite lower 1000 grain weight gave lower sprouts length (shoot + root), as well as the dry weight of sprouts (shoot + root).

Table 4. Average germination, growth rate, primary root length and shoot length Anoman, Bisma and Lamuru maize seed varieties during the open packaging stored at room temperature.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Variety | Storage period(month) | Germination (%) | Growth rate (%/etmal) | Primary rooth length(cm) | Shoot length(cm) |
| Anoman | 0 | 99.50a |  33.15a |  12.44a | 4.36bc |
|  | 1 | 99.50a |  33.02ab |  9.90cde | 3.78cd |
|  | 2 |  97.75abc |  31.22d |  10.45cd | 3.36d |
|  | 3 |  98.00abc |  32.60ab |  9.84cde | 3.53d |
| Bisma | 0 |  97.25abc |  32.38abc |  12.46a | 4.92ab |
|  | 1 |  96.75bc |  32.17bc |  11.13bc | 4.80ab |
|  | 2 | 96.50c |  31.73cd |  8.89e | 4.39bc |
|  | 3 | 93.25d |  30.98d |  9.35de | 5.19a |
| Lamuru | 0 |  98.75abc |  32.92ab |  11.79ab | 4.60ab |
|  | 1 |  99.25ab |  33.00ab |  10.84bc | 4.94ab |
|  | 2 |  99.25ab |  31.21d |  9.76cde | 3.72cd |
|  | 3 | 99.50a |  33.15a |  9.85cde | 4.25bc |
| CV (%) |  | 1.59 | 1.71 | 7.89 | 10.37 |

Means in each column, followed by similar letters are not significantly different at 5% probability level using duncan test

**CONCLUSION**

Stored periodof the seeds in an open package at the room temperature was strongly affected by the previous seed shelf life (in the seed storage warehouse) and theseeds weight of a variety. The old stored seed and light weight seed accelerate the declining of physiological seed quality, particulary the growth speed and percentage of germination. Storage of seeds in an open package at room temperature maintain seeds quality up to 3 months whenevergrain weight waslarge on the varieties and the started storage using low moisture content.

**References**

Copeland, L. ., & Donald, M. B. M. (1985). Principles of seed science and technology. *Jurnal Burgess Publishing Company*, (12), 916.

Devereau, A. . (2002). Physical Factors in Post-Harvest Quality. In G. F. and J. E. O. 0 P. Golob (Ed.), *Crop Post-Harvest: Science and Technology* (1st ed., pp. 69–84). Greenwich: Blackwell Publishing and the Natural Resources Institute, University of Greenwich.

Hampton, J. G., Johnstone, K. ., & Umpon, V. E. (1992). Bulk conductivity test variables for mungbean, soybean and French bean seed lots. *Seed Science and Technology*, *20*, 677–686.

Hayma, J. (2003). *Agrodok 31: The storage of tropical agricultural products*. 4th Edn.Wageningen, Netherlands: Agromisa Foundation.

Jayas, D. S., & White, N. D. G. (2003). Storage and drying of grain in Canada: Low cost approaches. *Food Control*, *14*(4), 255–261. http://doi.org/10.1016/S0956-7135(03)00014-8

Jorge, M. H. A., & Ray, D. T. (2005). Germination characterization of guayule seed by morphology, mass and, X-ray analysis. *Industrial Crops and Products*, *22*(1), 59–63. http://doi.org/10.1016/j.indcrop.2004.05.007

Mandal, S. M., Chakraborty, D., & Gupta, K. (2008). Seed Size Variation: Influence on Germination and Subsequent Seeding Performance in Hyptis suaveolens (Lamiaceae). *Research Journal of Seed Science*, *1*(1), 26–33. http://doi.org/10.3923/rjss.2008.26.33

Matthews, S., & Powell, A. (2006). Electrical Conductivity Vigour Test: Physiological Basis and Use. *Seed Testing International*, *131*(131), 32–35.

Mettananda, K. ., Weerasena, S. ., & Liyanage, Y. (2001). Effect of storage environmnet, packing material and seed moisture content on storability of maize (Zea mays L.) seeds. *Annals Ot the Sri Lanka Department of Agriculture*, *3*, 131–142.

Moshatati, A., & Gharineh, M. H. (2012). Effect of grain weight on germination and seed vigor of wheat. *Int. J. Agric. Crop Sci.*, *4*(8), 458–460.

Oyekale, K. O., Daniel, I. O., Ajala, M. O., & Sanni, L. O. (2012). Potential longevity of maize seeds under storage in humid tropical seed stores. *Nature and Science*, *10*(8), 114–124.

Rahmawati, & Arief, R. (2011). Evaluasi mutu benih jagung dalam gudang penyimpanan benih UPBS. *Prosiding Seminar Nasional Serealia*, 582–589.

Rahmawati, & Saenong, S. (2010). Mutu Fisiologis benih pada beberapa varietas jagung selama periode simpan. *Prosiding Pekan Serealia Nasional*, (2010), 478–485.

Rahmawati, & Syamsuddin. (2014). Mutu benih jagung Lamuru pada umur simpan berbeda dengan beberapa metode pengujian. *Agros*, *16*(1), 53–60.

Saenong, S. (1987). Kadar air keseimbangan dan upaya mempertahankan viabilitas benih jagung (Zea mays L.) dan kedelai (Glycine max L. Merr) pada beberapa kelembaban nisbi. *Buletin Penelitian Pertanian Maros*, *2*(3), 79–88.

Saenong, S., Syahfrudin, Widiyati, N., & Arief, R. (1999). Penetapan cara pendugaan daya simpan benih Jagung. *Teknologi Unggulan Pemacu Pembangunan Pertanian*, *2*, 29–39.

Samuel, A., Saburi, A., E., U. O., I., I., & U., I. I. (2011). Post–harvest food losses reduction in maize production in Nigeria. *African Journal of Agricultural Research*, *6*(21), 4833–4839.

Seifi, M. R., & Alimardani, R. (2010). The Moisture Content Effect on Some Physical and Mechanical Properties of Corn (Sc 704). *Journal of Agricultural Science*, *2*(4), 125–134. http://doi.org/10.5539/jas.v2n4p125

Shirkole, S. ., Kenghe, R. ., & Nimkar, P. . (2011). Moisture Dependent Physical Properties of Soybean. *Journal of Engineering Science and Technology*, *3*(5), 3807–3815.

Sulaeiman, R. A., Rosentrater, K. A., & Bern, C. J. (2013). Effects of Deterioration Parameters on Storage of Maize: A Review. *Journal of Natural Sciences Research*, *3*(9), 2224–3186. http://doi.org/10.13031/aim.20131593351

Surki, A. A., Sharifzadeh, F., & Afshari, R. T. (2012). Effect of drying conditions and harvest time on soybean seed viability and deterioration under different storage temperature. *African Journal of Agricultural Reseearch*, *7*(36), 5118–5127. http://doi.org/10.5897/AJAR12.060

Vieira, R. D., Scappa Neto, A., Bittencourt, S. R. M. De, & Panobianco, M. (2004). Electrical conductivity of the seed soaking solution and soybean seedling emergence. *Scientia Agricola*, *61*(2), 164–168. http://doi.org/10.1590/S0103-90162004000200007

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