Content List Available at ThaiJo

Khon Kaen Agriculture Journal

Journal Home Page : https://li01.tci-thaijo.org/index.php/agkasetkaj

The early harvesting time and drying temperature management on maize seeds storability and seeds vigor

Natthida Trakunpaisan[1], Sutkhet Nakasathien[1], Sukumarn Lertmongkol[1], Damrongvudhi Onwimol[1], Michael Bredemeier[2] and Pitipong Thobunluepop[1]*

[1] Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.
[2] Forest Ecosystems Research Group, Center for Biodiversity and Sustainable Land Use (CBL) Universität Göttingen, Buesgen Weg 1, D-37077 Göttingen, FRG, Germany.

ABSTRACT: Harvesting process by seed drying temperature becomes a very important process to decrease seed moisture content down to a desired level that could maintain seed quality. Thus, the experiment was aimed to evaluate the effect of harvesting time and drying temperature on maize storability and seed vigor after early harvested. The experimental design was arranged in 2x4 factorial in randomized complete block design (RCBD) with four replications. The effect of two different harvesting times were H_1: 100 day after emergence (DAE; R5), H_2: 110 DAE (R6), and four drying temperatures (T_1: 30 °C, T_2: 35 °C, T_3: 40 °C, T_4: 45 °C) were observed. Then, seed qualities and vigor were tested. From the experiment, H_2 had the highest speed of germination. The seed can be used immediately without storage by drying temperature at 45 °C. Whereas for storage, seeds should be dried at 35 °C.
Keywords: maize; harvesting time; drying temperature; seed vigor; storage

Introduction

The maize demand in Thailand has been continuously increasing and has reached approximately 7.41 million ton (Department of Agriculture, 1997). Thailand had a total yield of about 4.62 million tons. As is evident from the statistics, maize production is not enough to meet the country's demand (Office of Agricultural Economics, 2019). So, the research on increasing the yield and season of maize produce was crucial and has become a new area of interest (Department of Internal Trade, 2017). Seed quality production is one of the major factors for successful crop production (Shaheb et al., 2015). Furthermore, maize seed production systems currently operate by conducting early harvests then the seed lot is submitted for seed processing and then marketed within a short period. In some cases, improper environmental such as heavy rain, flooding, drought, and damage due to diseases and other pests force the need for early harvests. For these reasons, it is impossible to wait for the proper harvesting time. Unfortunately, high moisture content in the seeds occurs as a result of these premature harvests (Greven et al., 2004). Harvesting time is an important factor since both seed immaturity and drying temperature could reduce seed quality (Greven et al., 2004). Dharmalingam and Basu (1990) reported that seed development and maturation studies are important in order to ensure good yield associated with viability, vigour and field performance. Moisture content of harvested crops also affects seed quality. Harvesting with high moisture content

* Corresponding author: fagrppt@ku.ac.th

Received: date; May 21, 2020 Accepted: date; August 27, 2021 Published: date; February 5, 2022

in the crops increases of mycofloral infection on seeds, while harvesting at low moisture content increases mechanical damage to seeds (Yadav et al., 2005). Duncan and Marston (1925) reported that seeds germination decreased as high seed drying temperature. Differences were observed between seeds that were over dried at higher temperatures and seeds were dried at lower temperatures. These differences could be due to injuries resulting from an abnormally rapid uptake of water and lesion formation associated with the water uptake (Nutlie, 1964).

Therefore, seed drying management become a very vital process in order to decrease seed moisture content to an appropriate level that could maintain seed quality (Duncan and Marston, 1925). Storability of seeds is influenced by pre-storage history of the seeds, seed maturation, and environmental factors during pre and post-harvest (Mahesha et al., 2001). Thus, the experiment was aimed to study the effects of harvesting time and drying management on maize seed vigor during storage.

Materials and Methods

Seed production management and plant samples

The experiment was supported by Syngenta Seed (Thailand) Co. Ltd. In both of research place and plant materials. The experimental field was conducted under farmer field condition at U-Thong district, Suphan Buri province, Thailand. Research period duration December 2018 to July 2020 (dry seasons).

The experiment was conducted at Crop Physiology and Renewable Energy Crops Laboratory, Seed laboratory, Department of Agronomy, Faculty of Agriculture, Kasetsart University (KU), farmer field at U-Thong district, Suphan Buri province, Thailand and Georg - August University of Gottingen, Germany during December 2018 to July 2020.

Plant materials and seed samples were collected from parental hybrid lines for produced F_1 maize hybrid seeds. Plants were grown by 20 x 40 cm. of crop spacing. Compound fertilizer (15-15-15) amount 60 kg h^1, 40 kg h^1 after 3-5 days of germination, 20 kg h^1 after 40 days of germination was applied as top dressing fertilizer when single fertilizer (46-0-0) was applied as basal fertilizer amount 50 kg h^1 to 30 kg h^1 at 20 days after emergence and 15 kg h^1 after 40 days after emergence. Drip irrigation was applied once a week. Weeds were controlled by spraying herbicides (2.4-D, glufosinate1.0 L h^1 + fluroxypyr 0.3 L h^1).

The experimental design was arranged in 2x4 factorial in Randomized Complete Block Design (RCBD) with four replications. The effect of two different harvesting times (H_1: 100 Day after emergence (DAE) (R5; dent stage), H_2: 110 DAE (R6; physiological maturity stage)) and four drying temperatures (T_1:30 °C, T_2:35 °C, T_3:40 °C, T_4:45°C) were the experimental treatments. After each harvest, samples containing 10 ears were placed in paper bags and then taken to a hot air oven for drying at 30 °C, 35 °C, 40 °C, 45 °C. The drying was performed until the seeds reached approximately 10 % of moisture content. Seeds were stored in plastic sealed bag in dry and clean room at 25 °C. Then, seeds were sampling for seed qualities and vigor were tested at 0 and 6^{th} month**.** Seed qualities were tested following;

Determination of drying time: The moisture content of seed samples was determined according to ISTA (2015). Ground (100 seeds) seed samples of each harvesting time were taken into moisture cup and put into an hot-air oven at temperature of 130 °C, for 4 hour ± 12 min according to ISTA (2015). Four replicates were taken. After cooling, the weight of the container with its cover and contents were taken. The seed samples were cooled in desiccators and weighed to work out the percent moisture content of the grains. The seed moisture content was determined by fresh weight basis and was calculated by the following formula:

Seed moisture content (%) = {(M2-M3) / (M2-M1)} × 100

Where, M1 is the weight in grams of the container and its cover,

M2 is the weight in grams of the container, its cover and its contents before drying

and M3 is the weight in grams of the container, its cover and contents after drying.

Determination of germination percentage: Germinations were carried out according to ISTA (2015) in laboratory. For each treatment, 100 seeds were put into between two layer of paper. Four replicates were used. The samples were put up in germinator at temperature regime of 20 °C for 16 hours and 30 °C for 8 hours. After four and seven days, normal seedling, abnormal seedling and diseased seeds were counted.

Measurement of root and shoot length: After seven days, five plants were randomly selected for study, taking from each replicate of each treatment. The seedlings were cut into root (cut from the micropyle where the root grow up) and shoot parts (cut from the micropyle where the shoot grow up). Then, their lengths were measured (in cm).

Determination of fresh and dry weight of seedling: After measuring the root and shoot length as described above, fresh weight of seedlings was recorded. Then the root and shoot were put into paper packet separately, and placed into the preheated oven (70°C) for 48 hours. After cooling in desiccators, the dry weight was taken.

Determination of seed vigor: Seedling vigor was calculated based on the following formulae:

Accelerated aging (AA) test (ISTA, 2015): The samples were put up in hot air oven at 42 °C for 72 hours.

Speed of germination test: Speed of germination = sum of (The number of normal seedlings that germination each day/ number of days after germination)

Results and Discussion

Harvesting time at H_1 had the highest time of drying followed by H_2 (**Table 1**). According to the drying temperature, the highest recorded drying time was at 30 °C followed by 35 °C, 40 °C, 45 °C, respectively (**Table 2**). In the effect of harvest time on the maize seed quality at 0 and 6^{th} month of storage, H_2 had the highest speed of germination (**Table 3 and 4**). The results for the effect of drying temperature on the maize seed quality at 0 and 6^{th} month of storage showed that at 0 month the highest germination percentage, speed of Germination, shoot length, root length and seedling dry weight were obtained at 45 °C (**Table 5**). At 6^{th} month of storage, the highest germination percentage, AA-test, root length and seedling dry weight were obtained at 35 °C (**Table 6**).

Table 1 Effect of harvest time on the drying time maize seed

Harvesting time	Drying time (hour)
H_1	449.44a
H_2	383.51b
$LSD_{(0.05)}$	0.26

H_1 = 100 DAE, H_2 = 110 DAE and a, b compared with LSD (P<0.05)

Table 2 Effect of drying temperature on the drying time maize seed

Drying temperature (°C)	Drying time (hour)
30	455.56a
35	437.22b
40	408.11c
45	365.02d
$LSD_{(0.05)}$	0.37

Table 3 Effect of harvest time on the maize seed quality in laboratory at 0 month of storage

0 Month		
Harvesting time	Germination (%)	Speed of Germination
H_1	66.000b	13.042b
H_2	86.625a	16.366a
$LSD_{(0.05)}$	6.368	1.294

H_1 = 100 (R5) DAE, H_2 = 110 (R6) DAE and a, b compared with LSD (P<0.05)

Table 4 Effect of harvest time on the maize seed quality in laboratory at 6^{th} month of storage

6^{th} Month	
Harvesting time	Speed of Germination
H_1	12.475 b
H_2	14.516a
$LSD_{(0.05)}$	0.850

H_1 = 100 (R5) DAE, H_2 = 110 (R6) DAE and a, b compared with LSD (P<0.05)

Table 5 Effect of drying temperature on the maize seed quality at 0 month of storage

0 Month						
Temperature (°C)	Germination (%)	Shoot length (cm)	Root length (cm)	Seedling dry weight (g)	Speed of Germination	Accelerated aging (AA) test (%)
30	40.000b	6.300c	2.745b	0.339c	7.420c	59.000c
35	93.750a	8.992b	5.625a	0.347bc	19.071a	92.000a
40	80.000a	9.145ab	4.955a	0.377ab	15.103b	74.500b
45	91.500a	10.303a	4.845a	0.382a	17.223ab	66.750bc
$LSD_{(0.05)}$	9.007	0.624	0.732	0.016	1.831	6.129

a, b, c compared with LSD (P<0.05)

Table 6 Effect of drying temperature on the maize seed quality at 6th month of storage

	6th Month		
Temperature (°C)	Germination (%)	Root length (cm)	Accelerated aging (AA) test (%)
30	59.000c	7.201ab	74.500ab
35	92.000a	7.805a	92.000a
40	74.500b	7.176ab	87.500a
45	66.750bc	5.643b	64.500b
$LSD_{(0.05)}$	6.130	0.781	8.962

a, b, c compared with LSD ($P<0.05$)

It was found that the harvesting time at R6 (physiological maturity stage) used less drying time than the harvesting time at R5 (dent stage). This is because the moisture content in seeds remains high in the harvesting time before R6 which causes the water in the seeds in the R5 stage to take a longer time to evaporate (Department of Agriculture, 1997). The seed drying temperature at 45 °C used the least time at high temperatures liquids evaporate faster as opposed to low temperatures where liquids are less volatile. Therefore, evaporation of water will be faster in high temperatures (Eames, 1997)

Speed of germination was higher in H_2 compared to H_1 at 0 and 6th month. This was observed because at the R5 stage the seed was harvested before the physiological maturity stage which causes damage and subsequently low yields and poor seed quality. Moreover, the seeds had high moisture content which in turn causes seeds to be easily destroyed by disease, and therefore it is not possible to reduce seed moisture content to a safe level in time (Department of Agriculture, 1997). Early harvested seeds will be immature and poorly developed and as such will have poor storability compared to seeds harvest at physiological maturity (Singh and Lachanna, 1995; Deshpande et al., 1991). At physiological maturity seeds will have maximum viability and vigor. (Kole and Gupta, 1982; Mahesha et al., 2001). Harvesting stage influences the quality of seeds in relation to germination, vigor, viability and also storability (Khatun et al., 2009).

The effect of drying the drying temperature at 30 °C and 40 °C have more accelerated aging (AA) test percentage at 6th month of storage higher than 0 month of storage (**Table 5 and 6**). Since, Joshi and Nigam (1973) reported that the increase in water absorption after imbibition is faster in old seeds as compared to fresh ones and that the former which germinate faster, absorb two times more water than the latter when both are put for imbibition under similar conditions of temperature and duration.

From the result of effect of drying temperature on the maize seed quality. The drying temperature at 30 °C has the least germination percentage because the moisture content of seed has a strong bearing on its keeping quality and its longevity in storage. In addition it causes heat and water production as a result of respiration influences the levels of seed vigor and germination affects the amount of damage caused during threshing, drying, and processing and has a strong effect on the development of storage moulds and insect activity (Hill and Johnstone, 1982). The drying temperature at 35 °C has the highest germination percentage followed by 40 and 45 °C due to seeds are also susceptible to seed drying injury when the seed had high moisture content percentage (Kernick, 1961). Consistent with the reported of Surki (2012) that the drying seeds at temperatures of 45 °C directly affect viability, germination, and vigor of seeds, with a further negative impact on the storage potential. The prejudicial effect worsens the immediate problems caused by drying which reduce the potential of seed storage.

It was seen that at 0 month of storage, the highest germination percentage, speed of germination, shoot length, root lenght, seedling dry weight (SDW), and seedling growth rate were obtained at 45 °C. In addition, at 6^{th} month the highest germination percentage, AA-test, and SDW were obtained at 35 °C. This means that if the seeds are dried at 35 °C, the seed can be storage. The seed can be used immediately without storage by drying temperature at 45 °C. Eichelberger and Portella (2003) reported that when seeds are subjected to high drying temperatures, an increase in the vapor pressure gradient between the interior of the seed and the drying air is observed. This, therefore, results in high rates of drying and hence the highest probability of occurrence of cracks and fissures. Burris and Navratil (1980) reported that a possible relationship between dryer-induced injury has been attributed to faulty membrane reorganization. The expression of dryer injury may be a consequence of permanent membrane damage. Mahesha et al. (2001) reported that storability of seeds is mainly a genetic character and is influenced by pre-storage history of seeds, seed maturation and environmental factors during pre and post-harvest.

Conclusion

Maize seed production systems are currently being used to conduct early harvest followed by submitting the seeds for seed processing and then taken to market within a short period of time. As a result it impossible to wait for the harvest period. Seed drying at 45 °C can be used for immediate use of seeds without storage. For storability, the anticipation of harvest and seeds drying at temperatures of 35 °C.

Acknowledgements

This work was supported by Syngenta Seeds (Thailand) Co. Ltd. for the source of maize seeds. We are grateful to farmer field at U-Thong district, Suphan Buri province for place of planting. Thank you Department of Agronomy, Faculty of Agriculture, Kasetsart University for working place at Crop Physiology and Renewable Energy Crops Laboratory, Seed laboratory and Prof. Dr. Michael Bredemeier at Georg - August University of Gottingen, Germany for supporting.

Reference

Burris, J. S., and R. J. Navratil. 1980. Drying high moisture seed corn. Proc. Annu. Corn Sorghum Res. Conf. 35.

Department of Agriculture. 1997. Corn academic paper no.4. 1st edition. Thanapradit Printing. Bangkok.

Department of Internal Trade.2017.3 Year Forecasts of Feed Plans (2017-2020). Available: https://www.prachachat.net/economy/news-9005. Accessed Nov. 2, 2020.

Deshpande, V. K., G. N. Kulkarni, and M. B. Kurdikeri. 1991. Storability of maize as influenced by time of harvesting. Current Research University of Agricultural Sciences Bangalore. 20: 205-207.

Dharmalingam, C., and R. N. Basu. 1990. Seed development and maturation studies in mungbean. Seed Research, 6: 101-109.

Duncan, J.R., and A.R. Marston. 1925. The effect of different temperatures in drying seed corn of different stages of maturity on germination. Michigan State University Agricultural Experiment Station, Quarterly Bulletin. 8: 66-68.

Eames, I. W., N. J. Marr and H. Sabir. 1997. The evaporation coefficient of water: A review. International Journal of Heat and Mass Transfer. 40: 2963-2973.

Eichelberger, L., and J. A. Portella. 2003. Drying of corn grains in a fixed bed dryer: physical damage. Pesquisa Agropecuária Gaúcha (PAG). 9: 85-91.

Greven, M. M., B. A. McKenzie, J. G. Hampton, M. J. Hill, J. R. Sedcole, and G.D. Hill. 2004. Factors affecting seed quality in dwarf french bean (*Phaseolus vulgaris* l.) before harvest maturity. Seed Science and Technology. 32: 797-811.

Hill, M.J., and C.R. Johnstone. 1982. Heat damage and drying effects on seed quality. Grassland Research and Practice, New Zealand. 7: 53-57.

ISTA. 2015. International Rules for Seed Testing. International Seed Testing Association, Bassersdorf.

Joshi, M. C., and B. C. Nigam. 1973. Effect of high temperature on moisture loss, imbibition and germination in the seeds of *Trianthema Crystallina* VAHL. and its distribution. Österreichische botanische Zeitschrift. 12: 1–14.

Kernick, M. D. 1961. Drying and Cleaning. Food and Agricultural Organization of the United Nations, Italy. 186: 86-88.

Khatun, A., G. Kabir, and M. A. H. Bhuiyan. 2009. Effect of harvesting stages on the seed quaility of lentil (*Lens culinaris* L.) During Storage. Journal of Agricultural Research, Bangladesh. 34: 565-576.

Kole, S., and K. Gupta. 1982. The timing of physiological maturity of seeds of sunflower: evaluation through multiple tests. Seed Science and Technology. 10: 457-467.

Mahesha, C. R., A. S. Channaveeraswami, M. B. Kurdikeri, M. Shekhargouda, and M. N. Merwade. 2001. Seed maturation studies in sunflower genotypes. Seed Research. 29: 95-97.

Nutlie, G. E. 1964. Effect of desiccation on viability of seeds. Crop Science. 4: 325-328.

Office of Agricultural Economics.2019. The maize demanding in Thailand. Available: http://www.oae.go.th/view/1/Home/EN-US. Accessed Dec. 12, 2020.

Shaheb, M. R., M. N. Islam, A. Nessa, and M. A. Hossain. 2015. Effect of harvest times on the yield and seed quality of French bean. SAARC Journal of Agriculture, Bangladesh. 13: 01-13.

Singh, A. R., and A. Lachanna. 1995. Effect of dates of harvesting, drying and storage on seed quality of sorghum parental lines. Seed Research. 13: 180-185.

Surki, A. A., F. Sharifzade, and R. T. Afshari. 2012. Effect of drying conditions and harvest time on soybean seed viability and deterioration under different storage temperature. African Journal of Agricultural Research. 36: 5118-5127.

Yadav, S.K., S. Yadav, P.R. Kumar, and K. Kant. 2005. A critical overview of chickpea seed technological research. Seed Research. 33: 1-5.