Evaluation of Seed Quality of Grain Corn Varieties through Accelerated Ageing

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ABSTRACT

In an accelerated aging test conducted to evaluate seed quality, two hybrid grain corn varieties, 4546 and 888, were subjected to aging conditions to assess their tolerance. The objective was to identify any differences between the varieties in their ability to maintain seed quality under accelerated aging conditions. These tests simulate and hasten the natural aging process of seeds, providing insight into their performance during storage over time and under adverse conditions. Following the aging process, factors such as germination rate, vigor, and overall seed quality were assessed.The seeds of hybrid grain corn varieties 4546 and 888 were exposed to accelerated aging by maintaining them at 40°C and 100% relative humidity in a growth chamber. Evaluations were conducted at intervals of 0, 48, 96, and 144 hours. The overall results indicated that seed quality in grain corn deteriorates following accelerated aging treatment. Variety 4546 exhibited a rapid decline in germination, germination speed, and seedling vigor over the testing period. Both varieties experienced an increase in moisture content from 11% to 20% during the aging process. Additionally, the electrical conductivity of seed leachate increased for both varieties as the testing progressed.The experiment concluded that the 888 grain corn variety outperformed 4546 in all evaluated parameters. The 4546 variety was found to be highly sensitive to accelerated aging.

Keywords:Grain corn, germination, accelerated ageing test

1. INTRODUCTION

Grain corn is an important agricultural crop which plays a major role in the food, feed and seed industries. In Malaysia, grain corn is used as a major component in animal feed formulation. The usage of grain corn has caused a surge in importation which has now reached more than 3 million tons in 2018. [6]. Seed supply security has been an important agenda for *Dasar Agromakanan Negara* (DAN) 2011 -2020. Therefore, research to increase seed productivity and quality must be conducted. Seed quality is an important factor that contributes to productivity of plants for animal feed and grain. One key evaluation in seed quality is germination of seeds. Seed germination parameters such as speed of germination, germination index (GI), number of normal and abnormal seeds can indicate or predict the growth pattern of plants before field planting is conducted. There is lack of information regarding grain corn seed quality in Malaysia. Therefore, this research was conducted to evaluate seed quality of grain corn varieties on growth performance and crop improvement. To cope with the current and future demand of the increasing population for the food grains, it is emphasized to reduce the loss of seeds during and after harvest. Seeds are stored for varying periods to ensure a proper and balanced public distribution throughout the year. The study on physical, physiological and biochemical changes under accelerated ageing conditions will be helpful to better understand the process of seed deterioration. The relative storability of a particular seed lot could be predicted through accelerated ageing by exposing the seeds to high temperature (40°C) and relative humidity (100%), which will be useful in retention or disposal of a particular variety or seed lot. Accelerated ageing has been developed as a self-ageing technique. The accelerated ageing test has been used to estimate seed vigour and

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deterioration during storage [2].Seed deterioration is a natural phenomenon that occurs in all the seeds and leads to the gradual decline in seed viability. Storage temperature and the seed moisture content are the most important determinants of longevity in storage. The rate at which the seed deterioration process takes place depends on the tolerance of seeds to resist degradation which is specific for different species [3]. The processing and storage problems are common in tropical countries like India which has hot and humid tropical and subtropical conditions with fluctuations in relative humidity and temperature throughout the year. Seed deterioration is generally characterized by reduced seedling growth, germination capacity and viability [8].The present study was thus aimed to determine the relative longevities of two varieties by subjecting them to a deterioration test allowing longer period of incubation at 40ºC (48, 96 and 144 hours) as well as raising the moisture content to 20% and also determine some of the physiological changes occurring in the deteriorated seeds which can serve as indices of seed quality.

2. MATERIAL AND METHODS

2.1 Seed materials

The research was conducted at the Malaysian Agriculture Research and Development Institute (MARDI) in Serdang, Selangor, using two varieties of grain corn seeds, 4546 and 888.

describe the varieties of these hybrids

Show the conditions under which variety 4546 was produced and the conditions under which variety 888 was produced

2.2 Accelerated ageing test

The accelerated aging (AA) test was carried out at 40ºC for three durations: 48, 96, and 144 hours. The test was conducted with three replicates of 50 seeds each. The seeds were placed in plastic germination boxes containing deionized water and spread in a single layer on a net to avoid direct contact with the water. Subsamples of 50 seeds per treatment were sealed in laminated foil packets, incubated at 40°C, and removed after 48, 96, and 144 hours. Seed lots that were not subjected to the accelerated aging test served as controls. The moisture content of the seeds was determined using the high constant temperature oven method.

2.3 Moisture content test

Seed moisture content is one of the most important factors influencing seed quality and storability. Therefore, its estimation during seed quality determination is important. Seed moisture content was determined using high constant temperature oven drying at 130^{0}C for two hours [7]. The seeds were grinded prior to drying in oven. Calculations were based on the wet basis. The seed moisture content usually expressed on fresh weight or wet basis which can be calculated using the following formula.

$$Moisture\ content\ (\%) = \frac{W_1 - W_2}{W_1} \times 100$$

Where W1 is the seed weight before being oven dried and W2 is the seed weight after oven dried.

2.4 Germination Test

Grain corn seeds were subjected to germination test conducted with four replicates of 50 seeds. Each cleaned, germination plastic container was filled with sand as media. Then, the sand was moistened with distilled water. A total of 50 seeds were placed on top of the sand and the cover plastic germination container were closed using the lid to reduce loss of moisture. Media was watered if dry. Germination was assessed at day 8 after sowing and results were expressed as the percentage of normal seedlings. The germination percentage and germination rate were calculated and recorded. The germination percentage was calculated using the following formula:

$$\text{Germination percentage (\%)} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds}} \times 100$$

2.5 Seed leachate

A sample of 30 seeds was soaked in 250ml of deionized water at 25°C for 24 hours in an incubator. A conductivity meter, EUTECH Instruments CON 510 was used to measure electrical conductivity (EC) of seed leachate. Conductivity was expressed in $\mu Scm^{-1}g^{-1}$ of seed.

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2.6 Tetrazolium (TZ) Test

The tetrazolium test (TZ) for viability was performed for different varieties 4546 and 888 seeds before and after ageing. For this test, seeds were preconditioned by immersing in distilled water at for 36 hours (h) at 20 °C. The seeds were longitudinally sectioned in the centre of the embryonic axis and ¼ of the length of the endosperm. Each seed was submersed in solution of 2,3,5- triphenyltetrazolium chloride, at the concentrations of 1.0%, in the dark, at temperatures of 30 ºC for 3 h, using 20 seeds, inside plastic cups. After the periods of coloration, the solutions were drained and the seeds were washed in running water and evaluated for uniformity, location and intensity of coloration of embryonic tissues, being classified into two categories: viable and non-viable. The staining intensity and pattern of the embryo were observed under microscope.

2.7 Statistical Analysis

The experiments were carried out in a Complete Randomized Design (CRD) with four replications. The SAS software was used for analysis of variance (ANOVA). Treatment means were were compared by Tukey's test ($p \leq 0.05$).

3. RESULTS AND DISCUSSION

The results indicated that the grain corn seed had low moisture content initially (11.4 %) and it was higher after 6 days (21.5 %) on variety 888 and 10.6% initial for variety 4546 and 18.2 % (Table 1). The possible reason could be due to continuous and slow supply of moisture to the seed which increased the moisture content of the seeds as the seeds are hydrophilic in nature. In the present investigation, deterioration in seed quality was associated with decrease in germination percentage (G%), germination index (GI) and mean germination time (MGT) become evident with advancement of time in storage under accelerated ageing condition (Table1). Similar reduction in physiological parameters during ageing was also reported by Vijay [10] in soybean and Godakahriz[5] in safflower. Progressive loss in the seed quality attributes occurred with ageing in for variety 4546, the G% of control seeds was 76.7 % and showed declining trend with period of accelerated ageing. The germination reached of 42.1% on 4th day of accelerated ageing and it was reduced further to 15% on 6th day of accelerated ageing. Compared with variety 888, the G% still in good performance with 95% in initial and after 6th day of accelerated ageing the G% was 81.6%. This kind of variability in response to natural and accelerated ageing can be attributed to genetic constitution and the inherent capacity of a cultivar to withstand stresses. The results imply that variety 888 had the highest quality in terms of germination, germination index and mean germination time. The increase in the G%, GI and MGT after 48 hours of controlled deterioration in this variety implies that vigorous metabolic repair leading to invigoration of seeds has taken place due to high moisture content of the seeds as well as the higher temperature to which the seeds were exposed during the test.Germination Index (GI) for both varieties decreased towards the end of the experiment (Table 1). Variety 888 had and initial GI of 8.1 (control) which decreased to 6.5 (48 hours), 5.8 (96 hours) and 2.6 (144 hours). Variety 4546 started off with a rather low GI at 4.76 (control) and decreased to 0.4 (144 hours) at the end of the experiment. Seed deterioration in variety 4546 was slightly higher than variety 888.MGT for control seed of variety 888 ranged from 3.2 to 6.4 and for variety 4546 the ranged from 3.4 to 7.6 (Table 1). The maximum MGT was observed at 96 hours for variety 888 (5.3) while variety 4546 (4.3) (Table 1). As the ageing duration progressed for 144 hours all the varieties recorded a drastic and significant increase in MGT (Table 1). The highest MGT was recorded for variety 4546 (7.6) while variety 888 (6.4) whereas the lowest MGT was recorded for variety 4546(3.9) and variety 888 (3.2). When the seed metabolism is disturbed, initial changes occur resulting in slowing down of germination process leading to late emergence of the seedlings.

Is the difference the result of the genetics of the varieties or the influence of the environment in which the seeds were grown?

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Table 1. Mean moisture content, germination percentage, germination index and Mean germination time due to accelerated ageing on grain corn seeds

Treatment	Moisture Content (%)		Germination Percentage (%)		Germination Index (GI)		Mean Germination Time (MGT)	
	Variety 888	Variety 4546	Variety 888	Variety 4546	Variety 888	Variety 4546	Variety 888	Variety 4546
Control	11.4c	10.9b	95.0a	76.7a	8.1a	4.76a	3.2c	3.9b
48 hours	16.3b	16.5a	94.5a	43.3b	6.5ab	2.79ab	4.7bc	3.4b
96 hours	19.8ab	16.2a	86.7a	42.1b	5.8b	2.5b	5.3ab	4.3b
144 hours	21.5a	18.2a	81.6a	15c	2.6c	0.4c	6.4a	7.6a

Mean with the same letter are not significantly different

Table 2: Electrical conductivity due to accelerated ageing of grain corn seeds

Treatment	Electrical conductivity (µS cm-1g-1)	
	Variety 888	Variety 4546
Control	11.4c	10.9b
48 hours	16.3b	16.5a
96 hours	19.8ab	16.2a
144 hours	21.5a	18.2a

Mean with the same letter are not significantly different

Electrical conductivity of seed leachate is a good index of seed deterioration. Intensity of membrane damage during storage was measured by electrical conductivity of the seed leachate [9]. In this study, the electrical conductivity of seed leachate increased with increase in period of accelerated ageing (Table 2). In grain corn, the electrical conductivity was less in control seeds variety 888, (11.4 µS cm-1g-1) and variety 4546 (10.9 µS cm-1g-1). In accelerated ageing, it showed an increasing trend and reached 21.5 µS cm-1 (variety 888) and 18.2 (variety 4546) on 6th day (144 hours) of accelerated ageing (Table 2). According to Gupta [4] that electrical conductivity increased after the seeds were subjected to accelerated ageing because of membrane deterioration and metabolic changes in the seed. Seeds with low electrolyte leakage were considered to be of high vigour and those with high leakage considered as having low vigour. The increase in seed leachate may be due to the poor ability of seed cellular membranes to reorganize and repair any damage that may have occurred during imbibitions, prior to germination [1].

Seed viability

Seed viability was determined by TZ staining on variety 888 and variety 4546. Subsequent TZ staining showed that almost all seeds were still viable. Seed viability was interpreted according to the topographical staining pattern of the embryo and the intensity of the colouration on the grain corn seed tissues.

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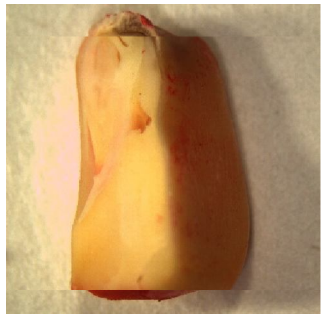

Figure 1. Tetrazolium staining pattern of grain corn seeds (Left - Seeds were viable when the living embryo tissues stained red; Right - Non-viable when seeds remained unstained or white)

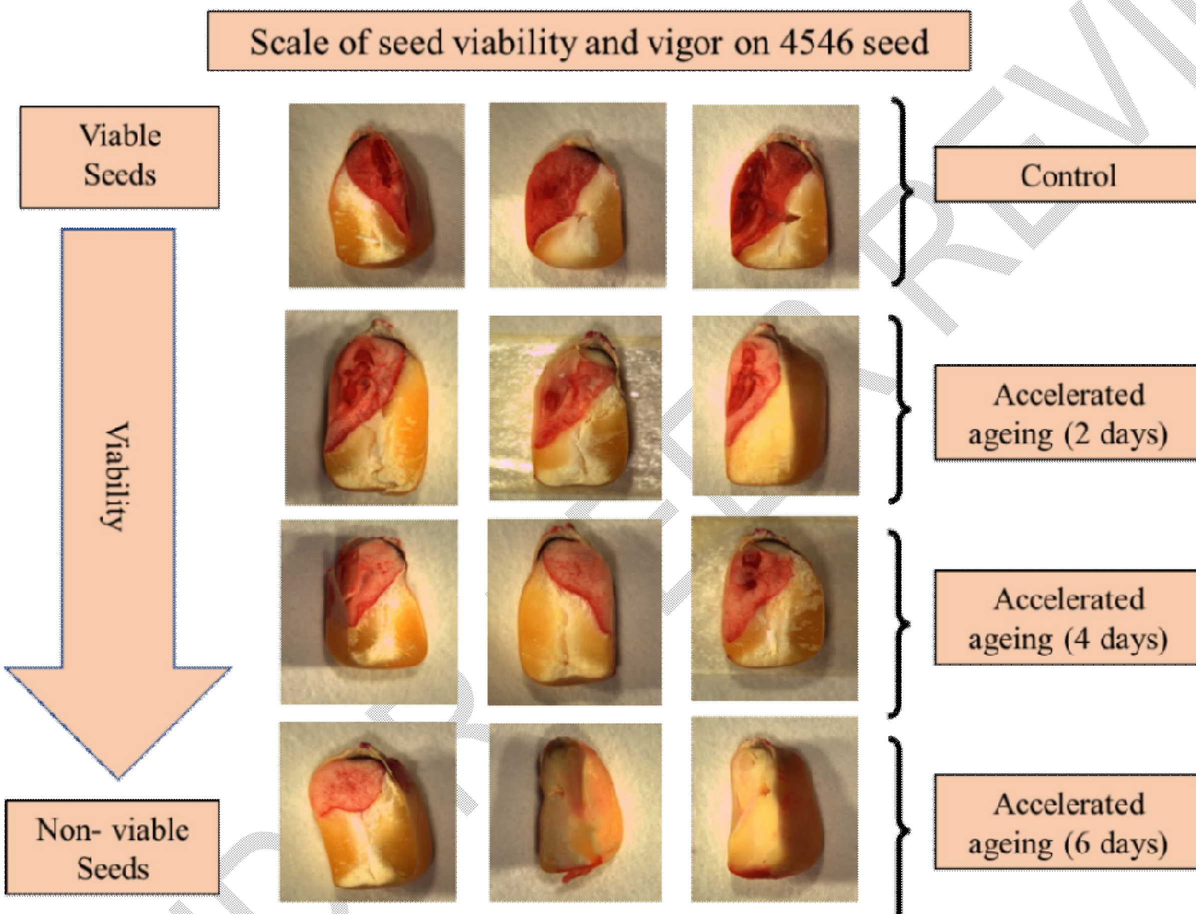

Figure 2: Scale of the seed viability and vigour for sorghum seed on 4546 seeds

From the TZ test, a scale of seed viability and vigour is obtained to categorize the seed according to their staining pattern. The formation of this scale starts with viable seeds with high vigour on top while the lower viability seeds in the middle and the dead seeds located at the bottom of the scale (Figure 2). This scale will then be used to determine other grain corn seeds tested using the TZ test. Viable seeds were considered as that which embryo showed uniform intense red colour, tissue with normal aspect, firm, with embryonic axis and cotyledon node region coloured and cotyledon with more than 50% of its surface coloured (Figure 1). Non-viable seeds were those with totally white or incomplete staining pattern, soft tissues, characterizing dead tissue.

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4. CONCLUSION

The experiment found that the 888 grain corn variety outperformed the 4546 variety across all evaluated parameters. The 4546 variety was notably more sensitive to accelerated aging. This study demonstrates that different grain corn varieties deteriorate at varying rates under similar conditions. It also highlights that initial vigour, rather than the initial germination percentage, is a more reliable indicator of a seed lot's performance when subjected to adverse environmental conditions. Additionally, the results underscore the importance of careful processing and storage for varieties with lower vigour potential due to their increased susceptibility to accelerated deterioration.

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