Evaluation of Seed Quality of Grain Corn Varieties through Accelerated Ageing

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 a vital agricultural crop that plays a significant role in the food, feed, and seed industries. In Malaysia, it serves as a primary component in animal feed formulations. The demand for grain corn has led to a sharp increase in imports, surpassing 3 million tons in 2018 [6]. Ensuring seed supply security has been a key objective under the National Agro-Food Policy (DAN) 2011-2020. As a result, it is crucial to conduct research aimed at enhancing seed productivity and quality. Seed quality is a critical factor that influences the productivity of plants used for animal feed and grain production. One of the essential assessments of seed quality is seed germination. Parameters such as germination speed, germination index (GI), and the proportion of normal and abnormal seedlings provide insights into the growth potential of plants before they are transplanted to the field. There is currently limited information on the quality of grain corn seeds in Malaysia. Consequently, this research was undertaken to evaluate the seed quality of different grain corn varieties and their impact on growth performance and crop improvement. To meet the growing demand for food grains driven by population growth, it is important to minimize seed losses during and after harvest. Seeds are stored for various periods to ensure a steady and balanced supply throughout the year. Studying the physical, physiological, and biochemical changes in seeds under accelerated aging conditions can enhance our understanding of the seed deterioration process. The relative storability of a seed lot can be predicted through accelerated aging, which involves exposing seeds to high temperatures (40°C) and high relative humidity (100%). This method is useful in deciding whether to retain or dispose of a particular seed variety or lot. Accelerated aging has been developed as a self-aging technique, and it is widely used to estimate seed vigor and deterioration during storage [2]. Seed deterioration is an inevitable process that affects all seeds, leading to a gradual decline in seed viability. The rate of deterioration is influenced primarily by storage temperature and seed moisture content, which are key factors in determining seed longevity. The ability of seeds to withstand degradation varies between species [3]. Processing and storage challenges are particularly prevalent in tropical countries like India, where hot and humid conditions, coupled with fluctuating temperature and relative humidity, complicate seed preservation. Seed deterioration is typically marked by reduced seedling growth, germination capacity, and viability [8]. The present study aims to assess the relative longevity of two corn varieties by subjecting them to deterioration tests involving prolonged incubation at 40°C (48, 96, and 144 hours) and elevated moisture content of 20%. Additionally, the study seeks to identify physiological changes in deteriorated seeds that could serve as indicators 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.The hybrid cultivar 4546, developed by Pioneer/Corteva Agriscience, is the result of advanced hybridization techniques aimed at improving yield and stress resistance. Manufactured in Thailand, it is specifically adapted to tropical environments, enhancing agricultural productivity. Whilecultivar 888 was developed by Green World Genetics (GWG) a seed producing company in Malaysia.It was designed for the region's tropical climate and offers improved resistance to local pests and diseases, enhancing yield stability while reducing the need for chemical inputs.

2.2 Accelerated ageing test

The accelerated aging (AA) test was performed at 40ºC over three time periods: 48, 96, and 144 hours. The test involved three replicates of 50 seeds each. The seeds were placed in plastic germination boxes with deionized water, arranged in a single layer on a net to prevent direct contact with the water. For each treatment, subsamples of 50 seeds were sealed in laminated foil packets, incubated at 40°C, and then removed after 48, 96, and 144 hours. Seed lots that did not undergo the accelerated aging test served as controls. The moisture content of the seeds was measured using the high constant temperature oven method.

2.3 Moisture content test

Seed moisture content is a crucial factor affecting seed quality and storability, making its accurate estimation essential during seed quality assessments. To determine the seed moisture content, the high constant temperature oven drying method was employed at 130°C for two hours [7]. Before drying, the seeds were ground to ensure consistency. The calculations were based on the wet basis, with moisture content typically expressed as a percentage of the fresh or wet weight. The moisture content was calculated using the following formula:

Where W1 is the seed weight before oven drying, and W2 is the seed weight after oven drying.

2.4 Germination Test

Grain corn seeds were subjected to a germination test, which was conducted with four replicates of 50 seeds each. Clean plastic germination containers were filled with sand as the growing medium, and the sand was moistened with distilled water. Fifty seeds were placed on top of the sand in each container, and the lids were secured to minimize moisture loss. The medium was rehydrated if it became dry. Germination was evaluated on the eighth day after sowing, with results expressed as the percentage of normal seedlings. Both the germination percentage and germination rate were calculated and recorded. The germination percentage was determined using the following formula:

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

To determine the speed of germination, measured as the mean germination time (MGT), 50 seeds were used for germination. Seed counts were recorded daily for up to seven days. The MGT was calculated using the following formula:

Mean germination time (MGT) = $\Sigma nd / \Sigma n$

Where, n= number of seeds which germinated on day d

d= number of days counted from the beginning of germination test.

2.5 Seed leachate

A sample of 30 seeds was soaked in 250 ml of deionized water at 25°C for 24 hours in an incubator. The electrical conductivity (EC) of the seed leachate was measured using a conductivity meter (EUTECH Instruments CON 510). The conductivity was expressed in $\mu S\ cm^{-1}\ g^{-1}$ of seed.

2.6 Tetrazolium (TZ) Test

The tetrazolium test (TZ) for seed viability was conducted on two varieties, 4546 and 888, both before and after the aging process. To prepare for this test, the seeds were preconditioned by immersing them in distilled water at 20°C for 36 hours. The seeds were then longitudinally sectioned through the center of the embryonic axis and a quarter of the endosperm's length. Each seed was submerged in a 1.0% solution of 2,3,5-triphenyltetrazolium chloride, incubated in the dark at 30°C for 3 hours. The test was conducted using 20 seeds placed inside plastic cups. After the staining period, the solution was drained, and the seeds were rinsed under running water. The seeds were evaluated based on the uniformity, location, and intensity of the staining in the embryonic tissues, and classified into two categories: viable and non-viable. The staining intensity and pattern of the embryo were observed under a 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

Germination percentage, germination index and mean germination time

The results indicated that the grain corn seeds initially had low moisture content, with 11.4% for variety 888, which increased to 21.5% after 6 days, and 10.6% for variety 4546, which rose to 18.2% (Table 1). This increase in moisture content could be attributed to the continuous and gradual absorption of moisture by the seeds, given their hydrophilic nature. In this study, seed quality deterioration was linked to a decrease in germination percentage (G%), germination index (GI), and mean germination time (MGT) as storage time progressed under accelerated aging conditions (Table 1). Similar reductions in physiological parameters during aging have been reported by Vijay [10] in soybean and Godakahriz [5] in safflower.

For variety 4546, seed quality declined with aging, where the G% of control seeds was initially 76.7%, dropping to 42.1% by the 4th day and further to 15% by the 6th day of accelerated aging. In contrast, variety 888 showed better resilience, with an initial G% of 95%, which remained at 81.6% after 6 days of accelerated aging. This variability in response to natural and accelerated aging may be due to genetic factors and the inherent ability of each cultivar to withstand stress. The results suggest that variety 888 maintained the highest quality in terms of germination, germination index, and mean germination time. The increase in G%, GI, and MGT after 48 hours of controlled deterioration in this variety indicates that vigorous metabolic repair likely occurred, enhancing seed invigoration due to the high moisture content and the elevated temperature during the test.The Germination Index (GI) for both varieties decreased as the experiment progressed (Table 1). Variety 888 started with a GI of 8.1 (control), which declined to 6.5 (48 hours), 5.8 (96 hours), and 2.6 (144 hours). Variety 4546 began with a lower GI of 4.76 (control), which decreased to 0.4 by the end of the experiment at 144 hours. Seed deterioration in variety 4546 was slightly more pronounced than in variety 888. The Mean Germination Time (MGT) for control seeds of variety 888 ranged from 3.2 to 6.4, while for variety 4546, it ranged from 3.4 to 7.6 (Table 1). The maximum MGT was observed at 96 hours for variety 888 (5.3) and for variety 4546 (4.3) (Table 1). As the aging period extended to 144 hours, all varieties showed a significant increase in MGT (Table 1). The highest MGT was recorded for variety 4546 (7.6) and for variety 888 (6.4), while the lowest MGT was recorded for variety 4546 (3.9) and for variety 888 (3.2). When seed metabolism is disrupted, initial changes slow down the germination process, leading to delayed seedling emergence.This delays key processes like water uptake, enzyme activation, and growth hormone production. As a result, seedling emergence is slower, as the seed struggles to transition into active growth [11].

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

Means in each table with the different letters indicate significant differences at P≤0.05% level according to Tukey's HSD.

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

Means in each table with the different letters indicate significant differences at P≤0.05% level according to Tukey's HSD.

Electrical conductivity of seed leachate serves as a reliable indicator of seed deterioration. The extent of membrane damage during storage can be assessed by measuring the electrical conductivity of the seed leachate [9]. In this study, electrical conductivity increased with the duration of accelerated aging (Table 2). For grain corn, control seeds exhibited lower electrical conductivity, with variety 888 at 11.4 µS cm^{-1} g^{-1} and variety 4546 at 10.9 µS cm^{-1} g^{-1}. However, under accelerated aging conditions, the conductivity values rose, reaching 21.5 µS cm^{-1} g^{-1} for variety 888 and 18.2 µS cm^{-1} g^{-1} for variety 4546 by the 6th day (144 hours) of aging (Table 2). Gupta [4] reported that the increase in electrical conductivity following accelerated aging is attributed to membrane deterioration and metabolic changes in the seed. Seeds with low electrolyte leakage are considered to have high vigor, while those with high leakage are deemed to have low vigor. The rise in seed leachate may result from the diminished ability of seed cellular membranes to reorganize and repair damage incurred during imbibition, 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.

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)

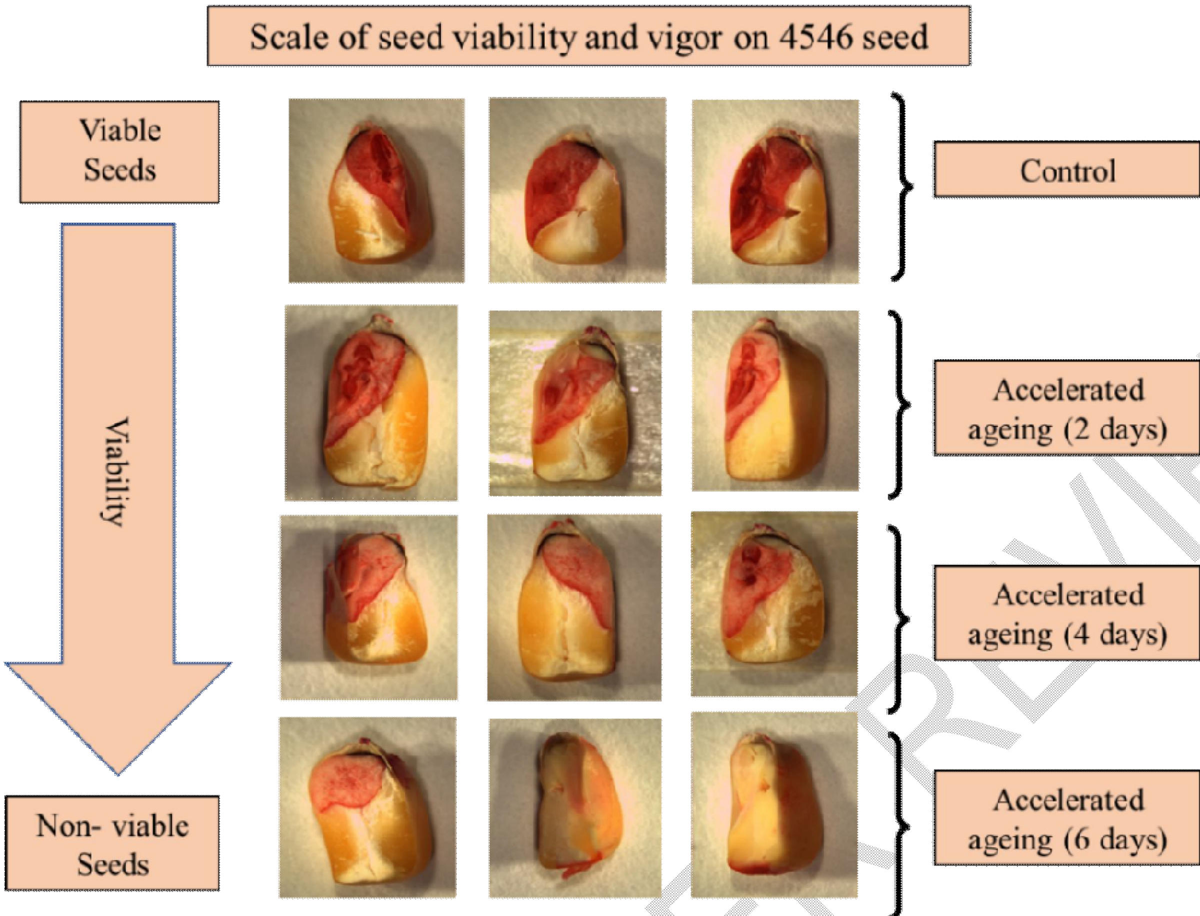

Figure 2: Scale of the seed viability and vigour for sorghum seed on 4546 seeds

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.

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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