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Research

Seed Longevity of Soybean (*Glycine max* L.) Cultivars Under Lightless Storage

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ABSTRAK

Soybean seeds in tropical countries are prone to rapid deterioration due to environmental condition during storage, leading to a decrease in seed quality and ultimately resulting in low potential yield. Longevity of seed during storage is influenced by genetic and environmental factors such as light. Therefore, this study aimed to determine the effect of light on the vigour of two soybean seeds cultivars (Demas 1 & Devon 1 cvs) stored for three months. The investigation was conducted from February to May 2022 at Seed Technology Laboratory, Faculty of Agriculture, Universitas Padjadjaran. A correlational method was employed to assess the relationship between seed quality of Demas 1 and Devon 1 in light and lightless storage. Furthermore, data were analyzed using correlation regression and t-test to compare the two populations. The results showed that there was a high correlation between the physical and physiological quality of seeds. There were also differences in seed response to light, and this was observed from the moisture content, weight of 100 seeds, germination rate, and simultaneous growth percentage traits. Considering the seed quality traits, Demas 1 had the best vigour value after storage in dark conditions. It is worth noting that both cultivars exhibited signs of deterioration during storage. However, the rate of deterioration was slowed down due to lightless condition.

Key words: Deterioration, light, seed quality, soybean, vigour

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INTRODUCTION

Soybean (*Glycine max* (L.) Merril) is an important crop in Indonesia, ranking after rice and corn in Indonesia. Furthermore, it stands among the top 5 food crops in the world, serving as a crucial source of protein and a major oil producer (FAO, 2023). The high protein content in soybean makes it irreplaceable. According to the BPS-Statistics Indonesia agency (BPS, 2017), the trend of national soybean demand is increasing year by year, but the supply remains dominated by imports. This situation arises from the fact that domestic production is below national needs. In 2018, Indonesia's soybean production was recorded at 982,598 tonnes and is projected to continuously decline until 2024. As a result, a substantial 2.4 million tonnes of this crop should be imported to meet national needs (BPS, 2020; Rizaty, 2022).

The low production of soybeans in Indonesia was caused by several factors such as seed quality, cultivation technique, and processing. Seed quality played a crucial role in influencing the total yield and production (Alemu, 2019), as it was maintained during storage before use by farmers. Seed quality is the characteristics of a seed that meet minimum standards for cultivation and/or storage purposes and it is shown by genetic, physical, and physiological traits (Hampton, 2002; Muhamad, 2021; Sundareswaran, 2023). Moreover, during storage, the seed quality will change depending on two factors, the first factor is environmental effects known as external factors such as temperature, relative humidity, light, and oxygen. The second factor comes from the inner of the seed and is called an internal factor such as structure or physical, water content, chemical composition, and initial viability of the seed (Ballesteros, 2020).

There was interaction between internal and external factors during seed storage. In which, the modification of environmental conditions may enhance the storability of seed. In the case of soybean, reported that soybean has low storability caused by internal factors and external factors (Rahajeng & Hapsari, 2018; De Vitis *et al*., 2022; Koskosidis *et al*., 2022). They reported that the different storability of soybean seed is due to an interaction between genetic and environmental conditions., several cultivars showed a low reduction in germination rate after 2 months of storage, while, the germination rate of other cultivars decreased during the same storage period, and conditions.

There were limited studies on light modification during storage related to seed viability. However, a previous study suggested that light affected soybean and pea seed metabolism during storage (Vertucci & Leopold, 1987). The dark storage rooms affected the oxygen uptake of seed, which affected the respiration rate and had different responses for each species (Vertucci & Leopold, 1987). Besides, the oxidation process caused by light and oxygen during storage drives the breakdown of the food reserve of seed as reported by Wu *et al*. (2019), they reported that in light exposure conditions during storage of Coix seeds, fatty acids, peroxides, malondialdehyde, and electrical conductivity increased. Where the changes in chemical compounds were signs that indicated a decrease in seed quality. The decrease in seed quality or deterioration may be indicated by seed viability traits such as seed germination, increased abnormal sprouts, slowed growth and development of sprouts, increased breakdown of food reserves, and increased plant sensitivity to environmental stress (Abdalla & Roberts, 1968; Groot *et al*., 2012; Wu *et al*., 2019; Jawak *et al*., 2022). Therefore, this study aims to determine the effect of light on the seed quality traits of two soybean cultivars after storage in light and dark conditions.

MATERIALS AND METHODS

Plant materials and light treatments

This study was conducted at the Seed Technology Laboratory, Faculty of Agriculture, Universitas Padjadjaran. The ambient temperature and relative humidity ranged from 20 °C-25 °C and 80% - 85% respectively. The two cultivars used in this experiment were Demas 1 and Devon 1, with medium-sized seeds of 13 g - 14 g/100 grains. These seeds were obtained from the Indonesia Legumes and Tuber Crops Research Institute Storage, Malang Regency, East Java. The trial was conducted by packing 250 g seed per replication in transparent mica plastic of 4 L (14.5 cm × 8 cm × 3 cm) in two light conditions. Storage under bright conditions was performed by placing the transparent mica plastic box containing the seeds in a room with full lighting for 24 hr. The light source was a luminescent tube lamp with a power of 20 watts and an intensity of 65 lux (dim). Storage in dark conditions was performed by wrapping the seed box (transparent mica plastic) with black cardboard in a dark room. Additionally, environmental conditions such as temperature and humidity were recorded. For every cultivar, the experiment was performed using four replicates and was repeated twice. The analysis was conducted using a regression-correlation test and t-test at a 5% confidence level to compare two populations.

Determination of seed physical quality

Moisture content was measured using the oven method (basic method) and the procedure was repeated twice for accuracy, following ISTA, 2015 standard. The test involved drying 5 g of seeds at 130 ± 3 °C until a constant weight was achieved. The following formula was applied to obtain the moisture content value:

$$MC(\%)=\frac{\text{The difference of seed weight before and after drying (g)}}{\text{the weight of the seed before drying (g)}}\times 100$$

The weight of the 100 seeds was determined by weighing ten repetitions of 10 seeds and by multiplying the average weight obtained from the ten repetitions by ten grams (g) (Scariot *et al*., 2021).

Determination of seeds physiological quality

The seed germinated test using rolls paper in plastic test method with 40 seeds per test (the test was performed in duplet for each treatment) and kept in a germinator at ambient condition (25 ± 3 °C and photoperiod of 12 hr, approximately). Evaluations of seed quality by this test involve the percentage of germination rate for normal seedlings after 8 days of sowing and simultaneous growth after 5 days of sowing according to rules for seed analysis (ISTA, 2015).

RESULTS AND DISCUSSION

The low value in seed vigor traits is an indicator decreasing of seed quality such as shown by low germination rate percentage and low simultaneous seedling growth. Besides, changes in physical quality such as moisture content and weight of 100 seeds can be used as monitoring traits for the quality of seed during storage that is influenced by environmental conditions. In this study, accelerated aging was affected by light exposure and varied between cultivars, Demas 1 and Devon 1.

Overall, Demas 1 had high vigor in dark conditions compared to Devon 1 cultivar as showed by seed vigor traits. Even though, lightless may delay seed deterioration in two cultivars. This study revealed that storage under lightless conditions was negatively correlation between the physical and physiological quality of seed in two cultivars. These occurrences suggest that lightless may reduce harmful effects on physical traits, thereby maintaining a satisfactory level of physiological quality and Devon under both light and dark conditions indicated that increases in weight of 100 seeds were related to a rise in seed moisture content. In both cultivars, storage in light conditions showed a higher increase in moisture content. These indicated that the absence of light had a mitigating effect on the respiration rate, hence inhibiting the increase in humidity of the package and seed moisture content during storage (Chidananda *et al*., 2014).

Storage temperature and relative humidity

The humidity and temperature of the storage room are factors that greatly affect the condition of the seeds during storage. Table 1 shows the temperature and relative humidity of the storage room.

Table 1. Temperature and Relative Humidity of Storage Room

Month	Temperature (°C)	Relative Humidity (%)
1st	21,75	81,69
2nd	21,87	79,83
3rd	22,15	80,98
average	21,91	80,82

Note: Temperature and humidity data were logged every hour during the storage period using a digital thermo hygrometer. Recorded data were extracted using specific software and averaged monthly.

The average temperature and relative humidity of the storage room were 21.91 °C and 80.82%, as presented in Table 1. The average temperature was a good condition for seed storage, while the relative humidity was still too high. To maintain the longevity of soybean seeds, the favorable conditions included temperature range and humidity of 19 °C – 22 °C and 64% - 67%, respectively (Noviana *et al*., 2016). Meanwhile, unfavorable conditions in the seed storage room accelerated seed deterioration. According to the Rules of Thumb, at a temperature and moisture content of 0 °C – 50 °C and 5% - 14%, any increase by 5 °C and 1% will reduce the storability of the seeds by half (Harrington, 1972).

Physical quality

Moisture content was an important parameter that greatly affected seed quality during storage. Seed storage was closely related to the moisture content which was affected by the temperature and humidity of the storage room (Mbofung, 2012). According to the t-test results in Figure 1, lightless storage can reduce the rate of increasing moisture content in both cultivars by around 0.77% compared to light treatment. This was similar to a previous study the oxygen uptake rate increased in a lighted storage, hence, the seed respiration rate was elevated (Vertucci & Leopold, 1987). Respiration products in the form of water were released into the environment, causing an increase in storage room humidity (Chidananda *et al*., 2014). Due to their hygroscopic nature, the seeds absorbed the moisture content around them to reach equilibrium. Differences in the moisture content of the two cultivars were due to the genetic trait. A previous study reported that the hygroscopic difference between two cultivars was due to seed coat permeability (Chandra *et al*., 2020). Low impermeability levels indicated a high rate of water absorption (imbibition) from the environment reaching equilibrium moisture content and potentially accelerated electrolyte leakage (Marwanto, 2007). The results of regression and correlation tests showed that an increase in moisture content leads to an elevated weight of 100 seeds (Figures 2 & 3).

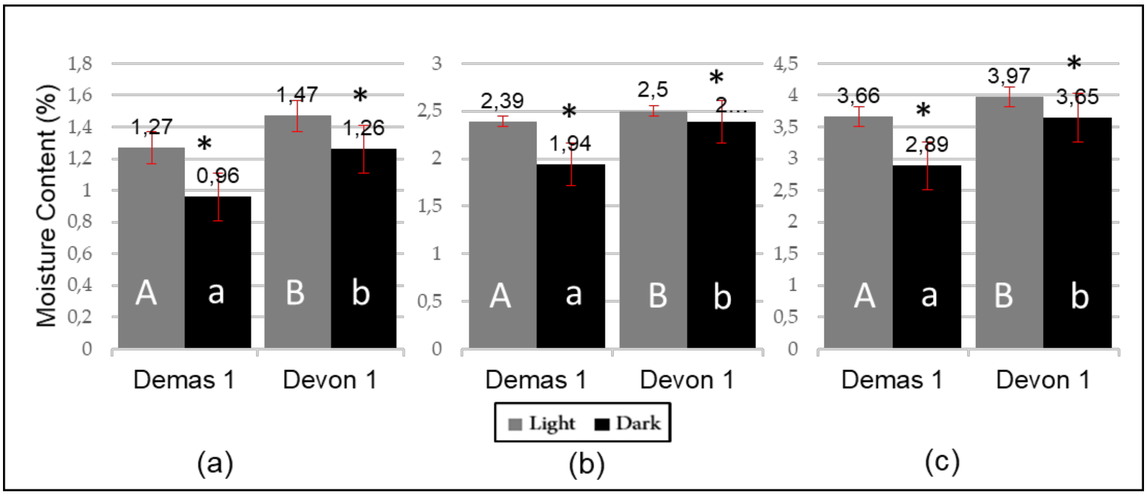

Fig. 1. Deviation in seed moisture content of Demas 1 and Devon 1 cultivars under light and dark conditions. (a) different between 1 and 0 month of storage (b) different between 3 and 1 month of storage (c) different between 3 and 0 months of storage.

Note: asterisks (*) indicate the effect of light on the same cultivar. Capital letters indicate the effect of cultivars under light conditions and lowercase letters indicate the effect of cultivars under dark conditions. The same letter in the same storage condition indicates no effect of light.

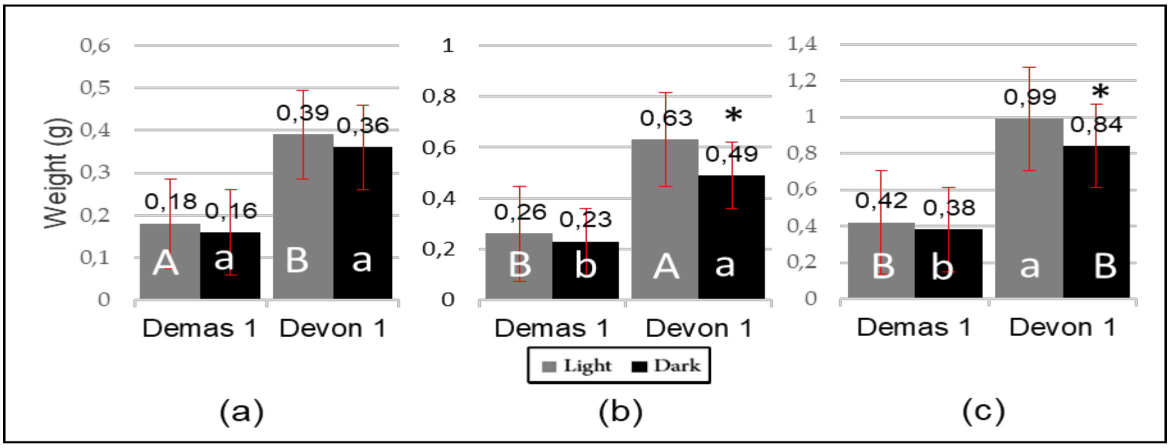

Fig. 2. Deviation in weight 100 seeds of Demas 1 and Devon 1 cultivars under light and dark conditions. (a) different between 1 and 0 months of storage (b) different between 3 and 1 month of storage (c) different between 3 and 0 months of storage.

Note: asterisks (*) indicate the effect of light on the same cultivar. Capital letters indicate the effect of cultivars under light conditions and lowercase letters indicate the effect of cultivars under dark conditions. The same letter in the same storage condition indicates no effect of light.

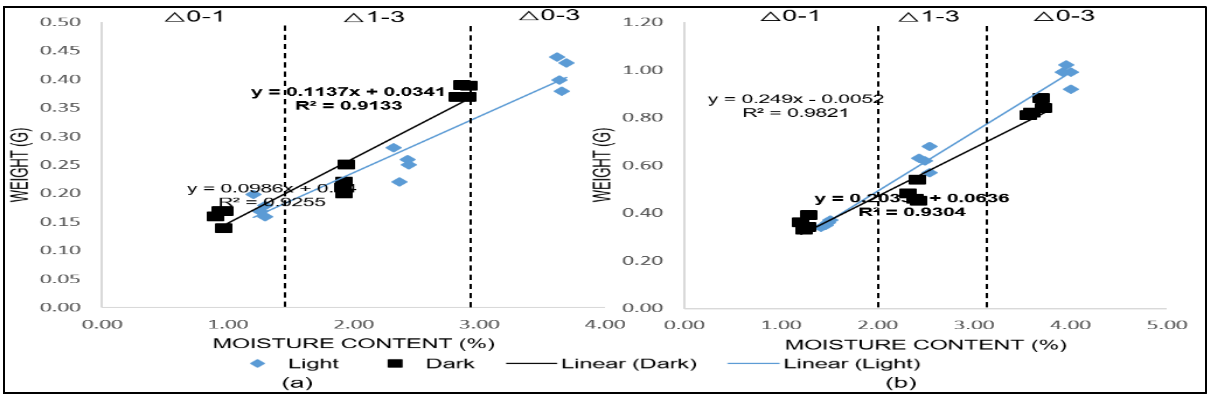

Fig. 3. Correlation between moisture content and weight of 100 seeds under light and lightless conditions. (a) Demas 1 (b) Devon 1

Psychological quality

Seed germination and vigor traits such as simultaneous germination rate are crucial traits that reflect storability. According to Figure 4, storage in a lightless room reduced the decrease in seed germination. The decline in germination was primarily attributed to ongoing respiration and enzymatic activity during storage, which leads to the metabolization of the seed's reserved food, resulting in an energy deficiency (Tefa, 2017). Storage in a lighted room led to increased respiration and enzymatic activity, thereby accelerating the decline in germination rate. Deterioration causes the breakdown of food reserves such as carbohydrates, proteins, and lipids, which are essential for supporting the seed germination process (Tatipata *et al*., 2004).

Regression and correlation tests showed that changes in germination rate have a positive relationship with a decrease in simultaneous growth, as shown in Figure 5. The positive and high R square value indicated the effect of germination traits on seed quality. The decreased growth rate affected the reduction in simultaneous germination of Demas 1 and Devon 1 cvs. in both storage conditions. Storage in light showed a greater deviation value, hence affecting the decrease in the value of seed germination. The results of regression and correlation tests also show that the seed's physical and physiological quality correlated (Figure 6). Furthermore, increased seed moisture content had a relationship with changes in the germination rate of Demas 1 and Devon 1 cultivar seeds, irrespective of the storage conditions.

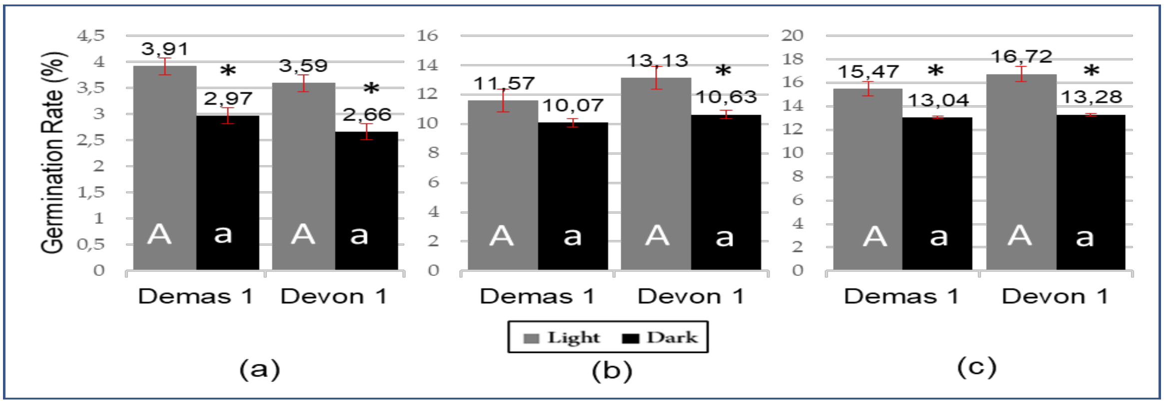

Fig. 4. Deviation in germination rate of Demas 1 and Devon 1 cultivars under light and dark conditions. (a) different between 0 and 1 month of storage (b) different between 1 and 3 months of storage (c) different between 0 and 3 months of storage.
Note: Data shown in negative values. Asterisks (*) indicate the effect of light on the same cultivar. Capital letters indicate the effect of cultivars under light conditions and lowercase letters indicate the effect of cultivars under dark conditions.

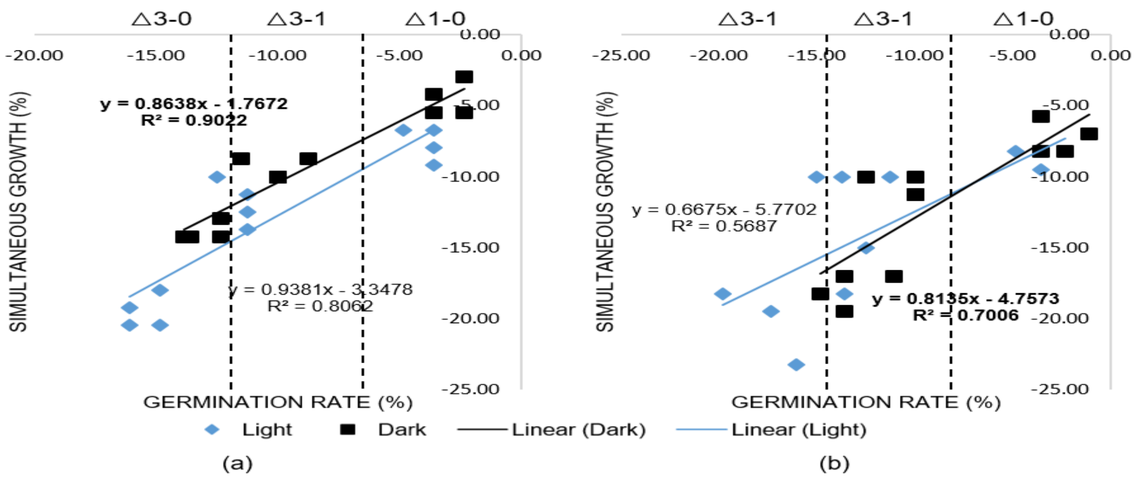

Fig. 5. Correlation between deviation seed simultaneous and germination rate under light and lightless conditions. (a) Demas 1 cv. (b) Devon 1 cv.

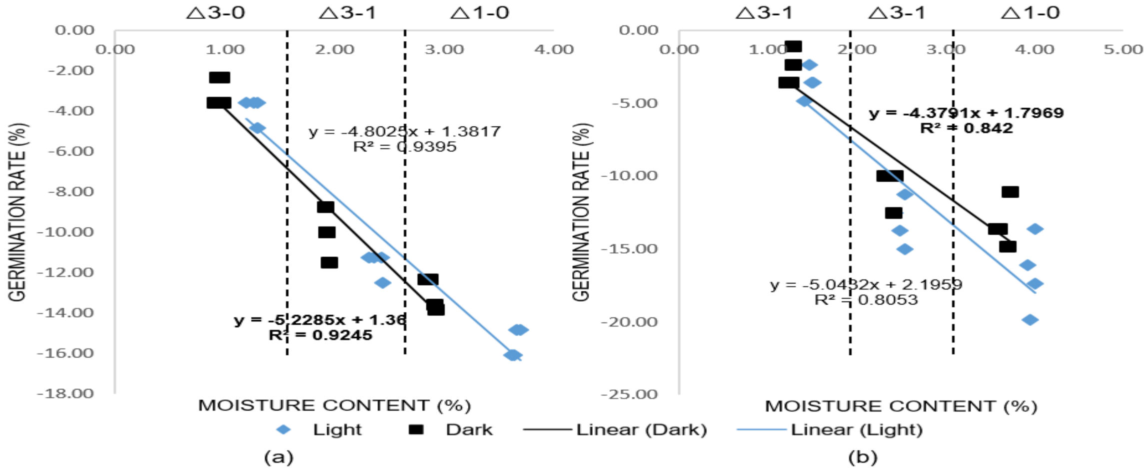

Fig. 6. Correlation between deviation of seed germination rate percentage and moisture content under light and lightless conditions. (a) Demas 1 cv. (b) Devon 1 cv.

The t-test results in Figure 7 showed that lightless storage suppressed the decline in the simultaneous growth of seeds. The value of simultaneous growth was a vigor trait, representing the potential of seeds to grow normally and uniformly under sub-optimal environmental conditions (Wahyuni *et al*., 2022). Its continuous decrease during storage indicated the occurrence of deterioration. However, the breakdown of food reserves during deterioration depends on seed chemical compounds. For instance, Devon 1 cv. seeds had a lower value of simultaneous growth due to the chemical composition of the seeds, specifically the isoflavone contents which slowed deterioration due to their antioxidant activities (Khan *et al*., 2017). Isoflavones affected the absorption of water from the storage environment, particularly at low levels of relative humidity (RH) (Qu *et al*., 2021).

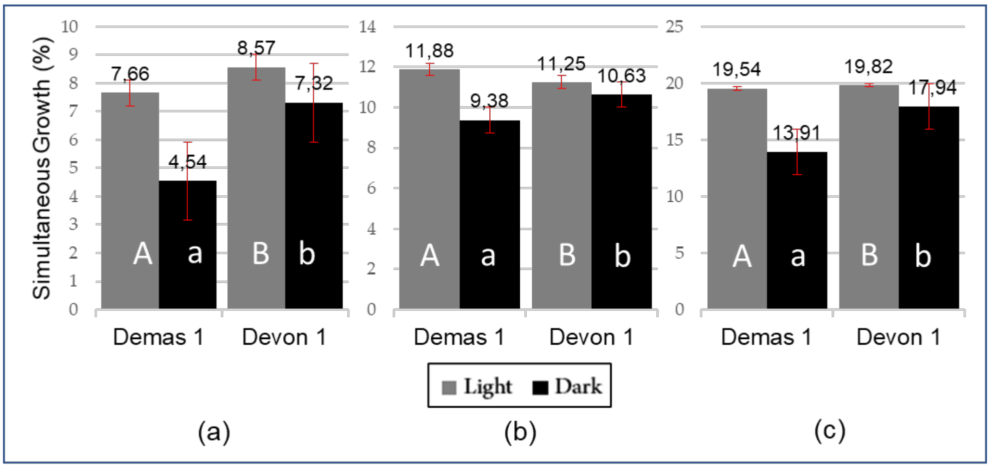

Fig. 7. Deviation in simultaneous growth of Demas 1 and Devon 1 cultivars under light and dark conditions. (a) different between 0 and 1 month of storage (b) different between 1 and 3 months of storage (c) different between 0 and 3 months of storage
Note: Data shown in negative values. Asterisks (*) indicate the effect of light on the same cultivar. Capital letters indicate the effect of cultivars under light conditions and lowercase letters indicate the effect of cultivars under dark conditions. The same letter in the same storage condition indicates no effect of light.

CONCLUSION

In conclusion, storage in dark conditions maintained seed longevity, and both cultivars experienced deterioration during storage. However, the presence of light and chemical compounds significantly affected the longevity of soybean seeds. Lightless storage slowed the rate of deterioration, as evidenced by improvements in moisture content, weight of 100 seeds, germination rate, and simultaneous growth traits. It was observed that the physical quality during storage had a strong correlation with the physiological quality of soybean seeds of Demas 1 and Devon 1 cvs.

CONFLICT OF INTEREST

The authors declare no conflict of interest

ETHICAL STATEMENT

Not applicable

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