BKAP686
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RESEARCH ARTICLE Bhartiya Krishi Anusandhan Patrika

Seed Quality and Longevity of Four Cowpea Accessions in Relation to Seed Coat Colour

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10.18805/BKAP686

ABSTRACT

Background: Cowpea is one of the most important legumes grown as a sole crop or integrated into farming systems in Africa. Seed quality plays a crucial role in plant population establishment in stressed environment. However, the behaviour of cowpea seeds with different seed coat colours at storage is not known. The study therefore aimed to assess the effect of seed coat colour on seed quality and longevity of seeds of four cowpea accessions.

Methods: Two experiments (field and laboratory) were conducted at the CSIR-Plant Genetic Resources Research Institute, Bunso, Ghana for a period of 3 years. Seeds of four cowpea accessions dried to a moisture content of 7% and packaged in aluminium foil packets were stored at -20°C in a deep freezer for 30 months. The quality of stored seeds was measured by seed vigour and germination percentage at 6, 12, 18, 24 and 30 months after storage (MAS). Before storage, the 100-seed weight and initial seed quality were assessed.

Result: The study showed significant differences in seed vigour and germination percentage at 6 and 12 months after storage (MAS) among the four cowpea accessions. Light-coloured accessions (GH7175 and GH8800) of cowpea seeds showed higher vigour and were of better quality than those of dark colours (GH3677 and GH2323) at 6, 12, 18, 24 and 30 months after storage.

Key words: Cowpea, Longevity, Seed quality, Seed storage.

INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is a member of the Fabaceae family. It is a major grain legume cultivated in semi-arid regions of sub-Saharan Africa. In Africa, it is a rich source of protein for many households (Ajeigbe *et al*., 2012; Dube and Fanadzo, 2013).

The protein content of the leaves ranges from 27 to 43% while the protein concentration of the dry grain ranges from 21 to 33% (Ddamulira *et al*., 2015; Abudulai *et al*., 2016; Kyei-Boahen *et al*., 2017). Its leaves and green pods are consumed as a vegetable and the dried grain is used in different food preparations. Worldwide, cowpea production is estimated at over 8.9 million metric tonnes per year on about 14.4 million hectares (FAOSTAT, 2020). More than 95% of this production is in Africa, especially in sub-Saharan Africa, with Nigeria being the world's largest producer, followed by the Niger Republic and Burkina Faso. With the emerging changes in climatic conditions worldwide, cowpea genotypes with the best storability and quality over a longer period of time are needed for future crop improvement to address food and nutritional security.

The seed coat attains its specific colour at physiological maturity and the seed coat pigmentation has been reported to play an important role in seed dormancy and germination (Debeaujon *et al*., 2000; Ochuodho and Modi, 2008). This pigmentation of the seed coat in crop species is mainly determined by flavonoids and anthocyanins (Dixon and Sumner, 2003). Studies by Yaseen *et al*. (1994) highlighted that seeds with hard seed coat protects the seed not only from mechanical stress but also from microorganism invasion and from temperature and humidity fluctuations during storage. In addition, the seed coat also improves the survival of seeds in the soil especially, in adverse environmental conditions and helps to avoid the extinction of species in nature (Souza and Marcos-Filho, 2001; Tiryaki and Topu, 2014). Notwithstanding, the quality of cowpea seeds with different seed coat colours during cold storage is not well understood or documented.

Research has established that seed coat colour influences the uptake of water (Powell *et al*.,1986), gas diffusion, seed dormancy (Baskin *et al*., 2000), seed quality, germination and seedling emergence (Mavi, 2010) in some crop plants, due to the colour pigments located in the seed coat (Abdullah *et al*., 1991). To date, no information has been documented on the effect of seed coat pigmentation on cowpea seed quality and longevity**.** The study aimed to assess the effect of seed coat colour on seed quality and longevity of seeds of four cowpea accessions.

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How to cite this article: Tetteh, R., Aboagye, L.M., Obirih-Opareh, J., Kotey, D.A., Adams, F.K. and Yeboah, A. (2024). Seed Quality and Longevity of Four Cowpea Accessions in Relation to Seed Coat Colour. Bhartiya Krishi Anusandhan Patrika. DOI: 10.18805/BKAP686.

Submitted: 23-10-2023 **Accepted:** 03-01-2024 **Online:** 17-01-2024

MATERIALS AND METHODS

Experimental site and plant material

The study was conducted at the experimental site and seed laboratory of the CSIR-Plant Genetic Resources Research Institute, Bunso, Eastern Region, Ghana from 26 September, 2018 to 19 September, 2021. Seeds of four cowpea accessions with different seed coat colours (Fig 1: White/ cream (GH7175), brown (GH8800), red (GH3677) and black (GH2323)) from the national genebank of Ghana were used in the study.

Production of cowpea accessions

Seeds of the four cowpea accessions were grown under field conditions during the minor season (September to December) to obtain good quality seeds for the storage experiment. Agronomic practices carried out during the period include watering, insect pest control and weeding as and when required. Insect pests during the cowpea cultivation period were controlled using a systemic insecticide (Landa-cyhalothrin 15 g/L +Acetamiprid 20 g/L: EC) at a recommended rate of 2.7 ml/litre of water at two weeks intervals. Weeds were controlled manually using a hoe. Cowpea plants were irrigated when needed using a watering can.

Harvesting of cowpea accessions

Harvesting of pods of the four cowpea accessions were done at the dry stage at maturity and seeds extracted and processed for seed quality test before storage. Manual cleaning of seeds was done to get rid of inert materials and bad seeds. Seeds was placed on Silica gel for a week to attain a constant moisture content of 7% using the grain moisture meter (model: LDS series) before storage.

Table 1: Effect of seed coat colour on 100-seed weight of the four cowpea accessions before storage.

Accession	100-seed weight (g)
GH7175	9.92 (0.09)^{d}
GH8800	13.96 (0.15)^{b}
GH3677	14.63 (0.01)^{a}
GH2323	10.88 (0.17)^{c}
ANOVA	***

Each value is the mean of three replicates and the standard deviation is shown in parentheses. One-way ANOVA: ***p<0.001.

Measurement of 100-seed weight

The hundred seed weight was determined by counting hundred seeds from each accession in four replicates and weighed with an electronic balance.

Germination test

Seed vigour and germination test were carried out before storage and at 6 months intervals after storage. Germination test was carried out using petri dishes with 90 mm filter paper. For each of the four treatments, 25 seeds were used in three replicates and was arranged in a completely randomised design. The seed vigour (first count) and germination percentage (final count) were established on the 7th and 14th days respectively after seed germination. Percentage seed germination was computed as a ratio of the number of seeds germinated to the total seeds sown multiplied by 100 (ISTA, 1999).

Storage of cowpea seeds

Seeds of the four cowpea accessions with a moisture content of 7% were packed into aluminum foil packets (5.0 mil) for storage at -20°C in a deep freezer. For each cowpea accession, ten replicates of hundred seeds were counted into Ziploc bags of dimension 8 cm × 12 cm and sealed with cellotape to make them air-tight for storage. This was done to avoid contact with the seeds during sampling for seed quality test.

Statistical analyses

Statistical analyses was conducted using the SPSS Statistics 21 (IBM, Chicago, IL, USA). One-way ANOVA was conducted and when the treatment means were significant, Tukey's HSD test was used to seperate treatments.

RESULTS AND DISCUSSION

Seed storage is an essential component of crop production which aims at maintaining the high-quality standards of the seed from harvest till the time of sowing the crop in the next or successive seasons. The longevity of seeds depends on environmental factors such as the moisture, temperature and oxygen. Healthy seeds with a lower moisture content have higher longevity compared to infested seeds with a higher moisture content.

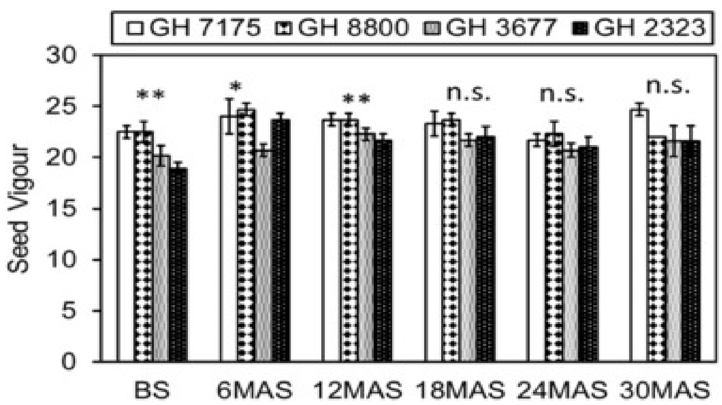
Table 1 shows the the 100-seed weight of the four cowpea accessions before storage. Significant (p<0.001) difference was observed in 100-seed weight among the four

Fig 1: Four cowpea accessions with different seed coat colour at physiological maturity.

cowpea accessions. Accession GH3677 had the highest seed weight (14.63 g) followed by GH8800 (13.96 g). The lowest seed weight was observed in GH7175 (9.92 g).

The effect of seed coat colour on seed vigour is shown in Fig 2. Significant ($p<0.05$) difference was observed in seed vigour among the four cowpea accessions before storage (BS), at 6 and 12 MAS with no significant difference at 18, 24 and 30 MAS. The highest seed vigour was observed in GH7175 and GH8800 before storage. At 6 MAS, the highest vigour was observed in GH8800 while GH3677 recorded the lowest. GH7175 and GH8800 had the highest seed vigour with the least being GH2323 at 12 MAS. Accession GH3677 recorded the lowest germination at 6, 18, 24 and 30 MAS. Seed vigour is influenced by many factors and this is due to the fact that seed development includes a series of ontogenetic process ranging from fertilisation, to accumulation of nutrients, to maturation and acquiring desiccation tolerance, to dormancy (Copeland and McDonald, 2001). However, poor seed vigour is the feature of seed deterioration, which is mirrored by a decrease in germination rate or increased incidence of seedling abnormalities (Delouche and Baskin, 1973). Studies have reported that the process of seed deterioration include several physiological and structural changes within the seed. Some of these structural changes include membrane permeability, proteins, sugars, nucleic acids, fatty acids and volatile substances, while the physiological processes involve enzyme activity, respiratory competence, lipid peroxidation and physiological repair mechanisms (Walters, 1998; Sun *et al*., 2007). Walters (1998) and Walters *et al*. (2005) observed that in seed storage, seeds deteriorate, lose vigour and, as a result, become more sensitive to stresses during germination and ultimately die. Besides, the speed of ageing depends on the seed moisture content, temperature and initial seed quality. The observed differences among cowpea accessions with regards to seed vigour could be attributed to seed aging. This might affect the crop yield by reducing the potential of field emergence thus resulting in reduced plant population. Furthermore, the reduction in seed vigour may influence the individual plant performance, as young seedlings still rely on the seed reserves for initial growth and development.

Fig 3 highlights the effect of seed coat colour on germination percentage of the four cowpea accessions before storage and at months after storage. Significant ($p<0.05$) difference was observed in germination percentage among the four cowpea accessions at 6 and 12 MAS with no significant difference at 18, 24 and 30 MAS. At 6 MAS, the highest germination was observed in GH8800 while GH3677 recorded the lowest. The highest seed germination was observed in GH7175 and GH8800 before storage. Accession GH3677 recorded the lowest germination at 6, 12, 18, 24 and 30 months after storage. Seed longevity is the capacity of the seed to germinate after an extended period of storage (Groot *et al*., 2012; Nguyen, 2014). One of the ways of measuring seed longevity is by quantifying the rate of germination and seed deterioration over a storage period (Nguyen, 2014). Powell *et al.* (1986) reported that seed coat colour affects the uptake of water in many legume species, especially in bright-coloured varieties. However, cultivars which absorb water faster than those of darker colour have a lower germination percentage. Seeds with soft seed coats have been reported to have light colour, whereas the hard seeds are darker indicating a certain degree of chemical or mechanical differences (Büyükkartal *et al*., 2013). Zhang *et al.* (2008) in their studies found that water uptake and tolerance of seeds to excess water were closely related to the seed colour in rape species and coloured seeds showed a slower uptake of water, low electrical conductivity and high tolerance to excessive water. Although these parameters were not considered in this study, the observed differences in germination percentage among the four cowpea accessions at storage may be attributed to the differences in seed coat colour. Studies by Sano *et al.*



One-way ANOVA: n.s.: Not significant, *Significant at $p<0.05$, **Significant at $p<0.01$. Seed vigour was expressed as the number of seeds germinated at first count.

Fig 2: Effect of seed coat colour on seed vigour of four accessions before storage (BS) and at months after storage (MAS).

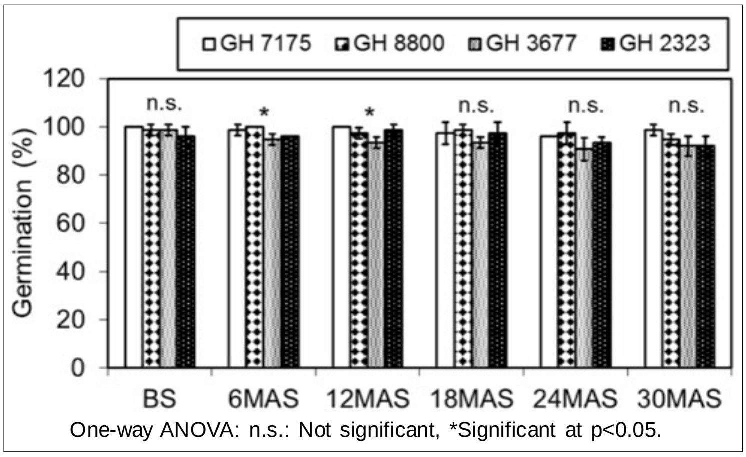


Fig 3: Effect of seed coat colour on germination percentage of four accessions before storage (BS) and at months after storage (MAS).

(2015) attributed the deterioration of seeds under storage to oxidation of lipids, cell and mitochondrial membranes, DNA, RNA and proteins. Vertucci and Roos (1990) reported that during seed storage optimum protocols such as the chemical composition of the seed, the physiological status of the seed and the physical status of water within the seed must be taken into consideration. Shaban (2013) also indicated that high vigour seedlots will be able to withstand environmental stresses such as changes in temperature or relative humidity in uncontrolled storage and the decline in seed quality will be at slower rate than lower vigour seedlots.

CONCLUSION

Seed coat colour had significant effect on seed vigour and germination percentage among the four cowpea accessions at months after storage. Light-coloured accessions (GH7175 and GH8800) of cowpea seeds indicated stronger vigour and were of better quality than those of dark colours (GH3677 and GH2323) at months after storage.

ACKNOWLEDGEMENT

The authors acknowledge the CSIR-Plant Genetic Resources Research Institute of Ghana for the facilities and plant material. We are also grateful to Mr. Benjamin Kwakye Adu and all staff at the seed store of CSIR-PGRRI for their support during the study.

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