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SEED QUALITY STUDY IN PEPPER (*Capsicum annuum* Linn.) USING SEEDLING EMERGENCE AND ELECTRO-CONDUCTIVITY AS INDICES

***Ibrahim H., Adediran, O.A., Muhammad, A.N., Adewumi, O.A. and Oladiran, J.A.**

Department of Crop Production, Federal University of Technology, Minna.
*Correspondence author's Email: harunamokwa@futminna.edu.ng
Phone No 08036970843

ABSTRACT

An investigation was conducted in the screen house of Crop Production Department, Federal University of Technology, Minna, Niger State, Nigeria to determine the effect of two seed extraction methods (wet ripe and dry fruits) and two drying methods (sun and air) on seed quality of six pepper (*Capsicum annuum* L.) cultivars. The cultivars used were 'Rodo-Dan Sokoto' (RD-DSK), 'Rodo Dan-Brini-Gwari' (RD-DBG), 'Tatashe Dan Kano' (TS-DKA), 'Tatashe Dan Kaduna' (TS-DKD), 'Shombo Dan Sokoto' (SB-DSK) and Shombo Dan Guru' (SB-DGU). The study was a 2 X 2 X 6 factorial experiment subjected to the Completely Randomized Design. The seeds of the different treatment combinations were placed in open plastic containers and stored at 80% relative humidity and 35 °C for eight weeks. Seedling emergence test was conducted every-other-week (two-weekly-interval). Seeds of cultivar 'Shombo-Dan Guru' (SB-DGU) generally recorded significantly higher seedling emergence percentage, longer seedling and lower electrical conductivity (EC) and greater longevity were recorded in cultivar 'Shombo' than in the other cultivars. Seeds of cultivar 'TS-DKA' recorded significantly lower values for all parameters except EC compared to all other genotypes. Seeds extracted from wet fruits before drying maintained viability for a longer period than those from dry fruits. Shade-drying resulted in significantly higher germination than sun-drying all through the storage period except in SB-DGU. The study revealed that longevity was better maintained when seeds of different pepper cultivars were extracted from wet fruits and afterwards dried in shade except in TS-DKA in which seeds extracted from shade-dried fruits had significantly greater quality than those of its other treatment combinations. Significant interaction effects of cultivar, extraction and seed drying methods were also recorded. Seed viability, seedling emergence and length declined with age while EC increased with age.

Keywords*:* Cultivar, extraction method, seedling emergence, sun- and shade-drying.

INTRODUCTION

Pepper (*Capsicum annuum*) is a member of the Solanaceae family. About 30 species were identified under the genus *Capsicum* (Falusi, 2007). Out of these, five domesticated species (*Capsicum annuum*, *Capsicum frutescens*, *Capsicum baccatum*, *Capsicum chinense* and *Capsicumpubescens*) are mostly cultivated (Bosland, 2004). *Capsicum annuum* is the most widely cultivated both at subsistence and commercial scale worldwide (Chakradhar *et al.*, 2016). The crop is basically grown for its pungent fruits. The longevity of pepper seeds is largely determined by moisture content and storage environment. When physiologically matured seeds of pepper are freshly harvested, they are known to have high moisture content (about 40 – 50 %). This has to be reduced to safe moisture level of about 8-9 % by drying using several methods such as air-, sun- or mechanical drying for viability maintenance during storage (Sahoo, 2014). Dried seeds are prevented from the activities and development of micro-organisms (Barua *et al.*, 2009). Most

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vegetable seeds tolerate desiccation to low moisture level (about 5 % MC) to enhance their storage life; the method or process of desiccation (drying) differs with crop species for effective seed conservation (Caixeta *et al*., 2013).

For instance, drying seeds of pepper cultivars too rapidly or with high air temperature will cause injury to seed (Copeland, 1976). Unlike in eggplant and tomato which are also members of the Solanaceae where seeds are mostly extracted using fermentation method, pepper seed extraction is mostly done by traditional farmers after drying of the ripened fruit in the sun (Peter *et al*., 2014). High temperature of drying causes rapid deterioration of seeds resulting in poor seed germination, low seedling emergence and lower productivity (Peter *et al*., 2014). Seed longevity is reduced by approximately half for every 1 % increase in moisture content or 5 ^{O}C increase in temperature. This principle suggests that seed storage life can be enhanced significantly by lowering the moisture content to a safe level especially in tropical conditions. If drying is too slow, there is the possibility of reduction in the quality of the seeds during the process due to ageing (Ellis and Roberts, 1980). Ellis and Roberts (1980) further reported that if seeds are dried rapidly, a larger proportion may be lost due to desiccation injury.

According to recent studies by Peter *et al.* (2014), delay or slow drying with high temperature above 25 ^{O}C will reduce viability significantly in orthodox seeds. The best method for safe seed drying to a low moisture content is to use seed drying chambers, seed dryers, where the relative humidity of the drying environment is kept under control (Ellis *et al*., 1985). This is however not easily affordable even in established seed industries due to the high cost of establishing, operating and maintenance of facilities. Hence the need for low cost drying methods which are readily available and affordable to be used as alternatives to such expensive equipment among resource-poor farmers who are the major producers of this crop.

Presently, most researches have focused on the moisture content to which seed should be dried. Very little information exists on how seeds should be safely dried to obtain seeds of high quality with high performance capability over long period of storage. At the moment, there seems to be no suitable low cost method of seed drying which resource-poor farmers can adopt to achieve high quality seeds of pepper that will store well. Some researchers dried seeds following extraction from fresh fruits while others extracted seeds from dry fruits. Most farmers in Nigeria practice the latter. Seeds of different cultivars of the same species may also respond differently to the same drying method. This study therefore determined the quality response of different cultivars to seed extraction and drying methods.

MATERIALS AND METHODS

The experiment was conducted in the Crop Production laboratory and screen house of the Federal University of Technology, Gidan-Kwano campus, Minna, Nigeria (latitude 9' 22°N and longitude 6'15°E). Seeds from fruits of six (6) cultivars of pepper namely, 'Rodo Dan Sokoto'(RD-DSK), 'Rodo Dan Brini-Gwari' (RD-DBG), 'Tatashe Dan Kano' (TS-DKA), 'Tatashe Dan Kaduna' (TS-DKD), 'Shombo Dan Sokoto' (SB-DSK), 'Shombo Dan Guru' (SB-DGU) sourced from farmers in Kaduna, Kaduna State were used for the study. Fruits of each cultivar were divided into four lots. Fruits of the first lot of each cultivar were cut open and the seeds extracted from them were washed and then sun-dried for 28 days. Seeds extracted from the second fruit lot of each cultivar were also washed but air-dried on the bench in ambient condition in the laboratory for 28 days. The fruits of the third lot were left intact and sun-dried while the fruits of the fourth lot were also kept intact but air-dried on bench in the laboratory with same duration as in lots 1 and 2. Seeds from the last two lots were later extracted from the dried fruits.

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A sample of seeds of each of the extractions and drying methods was spread in open plastic plates and stored in an incubator at 35 °C and relative humidity of about 80% for 8 weeks to accelerate ageing of the seeds. Four replicates of 10 seeds each of the extraction and drying methods were sown into sand in plastic pots in the screen house at 0, 4 and 8 weeks after storage (WAS), using the Completely Randomized Design (CRD) method. The pots were watered just before sowing the seeds and then daily after sowing. Data were collected daily on seedling emergence percentage and seedling length at two weeks intervals. Emergence percentage (EP) was calculated using the relationship:

$$EP = \frac{N_e}{N_t} X100 \qquad \text{(Kader, 2005)} \quad (1)$$

where, N_e is total number of emerged seedlings; N_t is total number of seeds sown.

Seedling length was measured from the root tip to the shoot apex using a ruler.
At the onset of storage (i.e 0) and at 4 and 8 WAS. 100 seeds of each treatment were weighed and then soaked in 40 ml distilled water for 24 hrs. The electrical conductivity of the soak water (leachate) was measured in duplicates using Jen-way Conductivity Meter (model- DDS-307) and the results were expressed as $\mu S\ cm^{-1}\ g^{-1}$ seeds (ISAT, 1995). This was done to determine changes in cell membrane integrity at different storage periods.

All the data collected were subjected to analysis of variance (ANOVA) for completely randomized design (CRD) using SAS Statistical Package 9.2. Means were separated using the Student-Newman-Keuls (SNK) test. Data in percentages were transformed to arcsin values before statistical analysis.

RESULTS

Effects of cultivar, extraction and drying methods on seedling emergence percentage (EP) are shown in Table 1. The highest values of 68 and 69 % recorded for SB-DSK and SB-DGU respectively at 0 WAS were at par and were significantly greater than those other cultivars. The value of 26% recorded in TS-DKA was significantly lower than those of all other cultivars. At 4 WAS, the highest EP (61%) recorded for SB-DGU was similar to those of SB-DSK (57 %), RD-DSK (54 %) and RD-DBG (56 %). The 33% recorded in TS-DKA was significantly lower than those of all other accessions. The similar values of 44 and 34 % recorded for SB-DSK and SB-DGU respectively at 8 WAS were significantly greater than those of other accessions. Seeds extracted from wet fruits before drying (E1) recorded significantly higher emergence percentages compared to seeds extracted from dry fruits (E2) at both 0 and 4 WAS but the values were similar at 8 WAS. Furthermore, air-drying of seeds (D2) resulted in significantly higher seedling emergence compared to sun-drying (SD) at 0 and 4 WAS while values for both drying methods were similar at 8 WAS. CxE interaction was significant at 0 and 4 WAS while CxD, ExD and CxExD interactions were significant at all storage periods.

When seeds were stored both at 0 and 4 WAS, seedling emergence percentage was significantly higher when seeds were extracted from fresh fruits before drying (C1) than when extracted from dried fruits (E2) in all cultivars except in TS-DKA (Table 2).

At 0 and 4 WAS, air-drying of seeds (D2) resulted in significantly higher seedling emergence percentage than in sun-drying in all cultivars except in SB-DGU where the reverse was the case (Table 3). The trend was almost the same at 8 WAS except in TS-DKA in which no significant difference was recorded between sun-dried and air-dried seeds.

Drying method did not significantly influence seedling emergence percentage for seeds extracted from fresh fruits (E1) at both 0 and 8 WAS (Table 4). Whereas, seedling emergence percentage was significantly higher when fruits were air-dried than when sun-dried. At 4 WAS, air-drying resulted in significantly higher emergence percentages than sun-drying. The magnitude of increase from D1 and D2 was however greater (28%) when fruits were first dried before seeds were extracted from them (E2) compared to 8% when seeds were extracted prior to drying (E1).

Values followed by the same letter under each storage period are not significantly different at 5% level of probability.

Table 5 shows the effect of cultivar, extraction and drying methods interaction on seedling emergence percentage. When sun-drying (D1) method was used for all cultivars, seedling emergence percentage was significantly higher in E1 than in E2 extraction method at all storage periods. When air-drying (D2) method was adopted, seedling emergence was significantly greater in E1 than E2 extraction method in TS-DKD (C4), SB-DSK (C5) and SB-DGU (C6) for all storage periods; at 0 and 4 WAS in RD-DBG (C2) and 4 WAS in RD-DSK (C1). The values for E2 were significantly greater than those of E1 seeds in TS-DKA (C3) at 0, and 4 WAS. Furthermore, the use of seeds extracted from air-dried (D2) fruits resulted in significantly greater seedling emergence compared to those extracted from sun-dried (D1) seeds in all cultivars except in SB-DGU (C6) for which the reverse was recorded.

Significant differences in electroconductivity (EC) values among the different cultivars were recorded at all storage periods. At 0 WAS, the highest EC (0.34 μS cm $^{-1}$ g^{-1}) was recorded in TS-DKA but the value was not significantly different from those of RD-DSK, RD-DBG, TS-DKD and SB-DSK. The lowest EC value (0.19 μS cm^{-1} g^{-1}) recorded in SB-DGU was only significantly different from that of TS-DKA. Seeds extracted from dry fruits recorded significantly higher EC (0.47 μS cm^{-1} g^{-1}) than those from wet fruit (0.09 μS cm^{-1} g^{-1}). Drying method did not significantly affect EC except at 4 WAS when sun-drying resulted in a higher EC value (0.32 μS cm^{-1} g^{-1}) than in the air-dried (0.29 μS cm^{-1} g^{-1}). At 4 WAS, the value recorded for TS-DKA was significantly higher than all the other values; the lowest in SB-DGU (0.231 μS cm^{-1} g^{-1}) was significantly different form all the others. EC was significantly higher in seeds extracted from dry fruits (0.54 μS cm^{-1} g^{-1}) than in those from fresh fruits (0.08 μS cm^{-1} g^{-1}). Furthermore, higher EC was recorded in sun-dried (0.32 μS^{-1}cm^{-1}g) than in shade-dried (0.29 μS cm^{-1} g^{-1}). At 8 WAS, the highest EC of 0.57 μS cm^{-1} g^{-1} recorded for TS-DKD was only significantly different from the value recorded for RD-DBG which in turn was at par with those of RD-DSK, SB-DSK and SB-DGU.

At 0 WAS, significantly higher EC were recorded in seeds extracted from dry fruit than in those of wet fruits in all cultivars except in RD-DBG in which EC values for wet and dry fruit extraction methods were similar. Furthermore, whereas E1 values were similar among all cultivars, significant differences in EC values were recorded among cultivars in respect of E2. The value (0.62 μS cm^{-1} g^{-1}) recorded for E2 in TS-DKA (C3) was significantly higher than those of RD-DBG (C2) and SB-DGU (C6). At 4 WAS, EC values were significantly different among cultivars when seeds were extracted from dry fruits, whereas seeds of cultivars RD-DSK (C4) and RD-DBG from wet fruits were similar in EC but were both significantly different from those of all other cultivars. At 8 WAS, there were no significant differences among the EC values of the different cultivars when wet fruit (E1) extraction method was used. When the dry fruit (E2) extraction method was used, the highest EC of 0.86 μS cm^{-1} g^{-1} recorded for TS-DKD was significantly different from that of RD-DBG (0.56 μS cm^{-1} g^{-1}) but similar to the values recorded for the other cultivars (0.64-0.84 μS cm^{-1} g^{-1}). Also the value (0.56 μS cm^{-1} g^{-1}) recorded for RD-DBG was similar to those of RD-DSK, SB-DSK and SB-DGU.

At 4 WAS air-drying resulted in significantly higher EC compared to sun-drying in RD-DSK (C1), TS-DKD (C4), SB-DSK (C5) and SB-DGU (C6) while the opposite was the case in RD-DBG (C2) and TS-DKA (C3). The EC values of seeds of all cultivars were not significantly affected by drying method in all cultivars except in TS-DKA in which significantly higher EC was recorded in sun-dried seeds (D1) than in the ones air-dried (D2). Also, while air-dried seeds of all cultivars had similar EC, sun-dried seeds of TS-DKA recorded significantly higher EC than sun-dried (D1) seeds of RD-DBG.

At 0 WAS although drying method did not affect EC values significantly within each extraction method, the magnitude of reduction from sun (D1) to air-drying (D2) was greater in the wet fruit (E1) than in dry fruit (E2) extraction method. At 4 WAS, air-drying resulted in significant decline in EC than in sun-drying irrespective of extraction method. However, the decline was greater when dry fruit extraction method was used (about 0.07 $\mu S^{-1} cm^{-1} g$) than when wet fruit extraction method was used (about 0.01 $\mu S\ cm^{-1}\ g^{-1}$). At 8 WAS, drying method had no significant effect on the EC of seeds of the two extraction methods. However, whereas air-drying of seeds extracted from wet fruits resulted in an increase of about 0.04 $\mu S\ cm^{-1}\ g^{-1}$ compared to the sun-dried lot, fruits air-drying resulted in an EC decrease of about 0.07 $\mu S^{-1} cm^{-1} g$ compared to sun-drying.

Prior to sowing, drying method did not significantly affect EC values of seeds extracted from fresh fruit in all cultivars. The trend was similar in seeds extracted from dry fruits except in TS-DKA (C3) in which sun-drying resulted in significantly higher EC than air-drying. The EC value of 0.86 $\mu S\ cm^{-1}\ g^{-1}$ was significantly higher than those recorded for all other seed lots except in seed of RD-DSK (C1) extracted from sun- and air-dried fruits and those of TS-DKD (C4) and SB-DSK (C5) extracted from air-dried fruits. In RD-DSK (C1) and TS-DKD (C4), the EC values for E1D1 and E1D2 combinations were significantly lower than those of E2D1 combinations whereas in RD-DBG (C2) and SB-DGU (C6), EC values were similar for all extraction and drying method combinations. At 4 WAS, RD-DSK (C1), TS-DKD (C4) and SB-DGU (C6) seeds extracted from fresh fruits had significantly lower EC when air-dried than when sun-dried whereas the reverse was the case in seeds extracted from dry fruits. In RD-DBG (C2) drying method did not have a significant effect on the EC values of seed extracted from fresh fruits while seeds extracted from sun-dried fruits recorded significantly higher EC than those from air-dried fruits. In TS-DKA (C3), sun-drying resulted in higher EC irrespective of the seed extraction method. The EC (0.92 $\mu S\ cm^{-1}\ g^{-1}$) value recorded for this cultivar when seeds were extracted from sun-dried fruits was significantly higher than those of all other C X D X E interactions.

Air-drying resulted in significantly higher EC values than when sun-drying method was adopted for SB-DSK (C5) irrespective of the extraction method used. At 8 WAS, drying method did not significantly affect EC values of seeds extracted from fresh fruits in all cultivars. The trend was almost repeated in seeds extracted from dry fruits except in TS-DKA (C3) in which sun-drying resulted in significantly higher EC than in air-drying. General increases in EC values were recorded for all cultivars, extraction and drying combinations throughout the storage period. Furthermore, TS-DKA (C3) seeds extracted from sun-dried fruits recorded the highest EC (0.86-1.10 $\mu S^{-1} cm^{-1} g$) throughout the storage period.

DISCUSSION

The significant differences in percentage seedling emergence in this study agree with other studies Hunje *et al.* (2007) likewise observed variation between two varieties of pepper. Significant variations in respect of emergence percentage in pea varieties was also reported by Jatoi *et al.* (2001) Such variations have been attributed to difference in genetic makeup of the cultivars.

Seeds extracted from wet fruits before drying were generally superior to those extracted from dry fruits in respect of the parameters evaluated. Available information seems to be non-specific as to the extraction method that should preferably be adopted for pepper.

Sukprakan *et al.* (2005) and AVRD (2005) suggested that pepper seed may be extracted from fresh fruits or fruits that have been dried in the sun for a few days. The general practice among pepper farmers in Nigeria and other developing countries of the world seems to be that of sun-drying of fruits followed by seed extraction. Savaraj *et al.* (2008) observed that wet extraction was beneficial to seedling vigour of eggplant. Rahman *et al.* (2015) also advocated that seeds of eggplant be extracted by wet method and then shade-dried to ensure high quality.

The current study furthermore revealed that drying method did not generally affect the quality of seed that were extracted from fresh fruits before drying in the sun or shade whereas seeds from sun-dried fruits were generally of poor quality compared to shade-dried fruits. The poorer quality recorded in seeds extracted from sun-dried fruits maybe due to over-heating of seeds in fruits especially in all the cultivars except SB-DGU while the moisture content of the seed is high. Contrary to this report, Hunje *et al.* (2007), Christinal and Tholkkappian (2012) and Krishnamurthy (1995) recorded better seed quality when fruits were dried in sun than those dried in the shade. The reason given was that slow-drying of seeds in the shade must have resulted in deterioration which manifested in poor field emergence. This is perhaps what happened in SB-DGU. Muthoka (2003) reported that neither sun nor shade drying were detrimental to seed quality in *Milletia leucantha*.

The increase in seedling emergence percentages with storage time especially in RD-DSK and RD-DBG in this study was probably due to loss of dormancy which is known to exist in freshly harvested seeds of most crop species and is lost after some period of storage. This is in agreement with earlier findings of Oladiran and Kortse (2002) which showed that 'Rodo' seeds were dormant at harvest and recorded improvement on germination after storage. Lee *et al.* (2002) also reported that seed storage is known to break dormancy in some species. The decline in seedling emergence percentage after attainment of maximum point in this study suggested that deterioration sets in with progress in storage. Copeland *et al.* (2001) reported that seed vigour usually decreases with time in storage.

This study further revealed significant differences in the electroconductivity (EC) of the solute leachate from seeds of different cultivars and seed handling treatments. Abreu *et al.* (2011) stated that EC test is employed to evaluate the extent of damage caused to cell membranes resulting from seed deterioration. The higher the reading, the poorer the vigour of a seed lot (Vidigal *et al.* 2011). It therefore follows that there were variations in the potential vigour of seeds of the different cultivars of pepper used in the current study prior to storage. De Carvalho *et al.* (2009) listed genotype as one of the factors capable of affecting EC results. Szemruch *et al.* (2015) reported that high oleic genotype of sunflower had higher EC values which correlated with lower germination percentage. Panobianco and Vieira (1996) and Vieira *et al.* (1999) also reported that EC varied significantly with genotype in pea. In this study, EC values were generally significantly lower in seeds of RD-DSK (C1) and TS-DKD (C4) extracted by wet method compared to those seeds extracted by dry method in both varieties indicating that seeds from wet fruits had better cell membrane integrity and hence more vigourous. This result is contrary to that of Christinal and Tholkkappian (2012) which showed that higher EC values were obtained from the leachate of air-dried pepper seed compared to those dried in the sun. The authors were of the opinion that slow drying was responsible for the poor quality of air-dried seeds. The increase in EC values as storage progressed in the current study is in agreement with the work of Mirdad *et al.* (2006) and Demir *et al.* (2008) in respect of cabbage seeds subjected to controlled deterioration, which is an indication of increasing loss of membrane integrity with increase in storage. Maximum electrical conductivity coincided with the lowest seedling emergence while lower EC values were recorded when seed vigour was high. Vieira *et al.* (1999) also reported that higher EC value was an indicator of lower vigour, due to an increase in membrane permeability of lower vigour seeds.

CONCLUSION

It is concluded that seeds of SB-DSK and SB-DGU performed better than those of RD-DSK and RD-DBG which were in turn better than those of TS-DKA and TS-DKD. Seeds extracted from wet fruits prior to drying recorded better seedling emergence than those extracted from dry fruits in all cultivars except in TS-DKA where seed extracted from air-dried fruits were of better quality than those extracted from wet fruits (irrespective of drying method) and those extracted from sun-dried fruits. Also, seeds extracted from fruits prior to drying recorded lower EC than those from dried fruits. Seeds extracted from sun-dried fruits of TS-DKA recorded the highest EC values. The study also revealed that the use of seeds from air-dried fruits resulted in seedling emergence than those from sun-dried fruits in all cultivars except SB-DGU. Seedling emergence percentage declined in all cultivars after some period of storage irrespective of seed extraction and drying methods. Electro-conductivity of seed leachate increased with storage period.

RECOMMENDATION

It is recommended from this study that to obtain high seedling emergence percentage, pepper seeds should be extracted from wet fruits and then dried in the sun or shade.

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