Physiological seed quality in relation to maturity stage in two pepper (*Capsicum annuum* L.) cultivars

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ABSTRACT

Production of high quality seeds depends upon the appropriate time of harvest. In this study, variation in physiological seed quality in relation to maturity stage was assessed in two pepper (*Capsicum annuum* L.) cultivars (Legon 18 and BAG 14/001) which have different fruit shapes and sizes. Fruits were harvested at four maturity stages (*i.e.* initially ripe, half ripe, fully ripe and rotten) and seeds extracted after each harvest. Seed quality was assessed by 100-seed weight, seed vigour and germination percentage. The results showed that the seeds extracted at the initially ripe stage had the lowest 100-seed weight in both cultivars. Whereas, seeds extracted at the fully ripe and rotten stages gave higher vigour and germination percentage than those harvested at the initial and half ripe stage in both cultivars. Also, the seeds extracted from Legon 18 had higher viability than BAG 14/001 at all maturity stages.

Key words: *Capsicum annuum*, Germination, Maturity stage, Pepper, Seed quality, Vigour.

INTRODUCTION

Pepper (*Capsicum annuum* L.) is a dicotyledonous flowering plant which belongs to the family Solanaceae (Knapp, 2002). It is an important commercial crop cultivated in tropical and temperate zones of the world and grown on more than 1.5 million hectares worldwide (FAO, 2007). They are usually classified based on fruit characteristics, including pungency, colour, shape, flavour, size and use (Bosland, 1992, 1994). The mature and immature fruits can be cooked or eaten raw as vegetable in soups and stews (Tindall, 1983). The dried fruit is used as a spice and seasoning (Dagnoko et al., 2013). Despite the high nutritional and economic values of hot pepper, the average yield is still low in West Africa (Grubben and Tahir, 2004) including Ghana.

Physiological maturity is a point where there is stabilization of dry matter translocation to the seed (Marcos-Filho et al., 1994). Maximum seed viability and vigour may be achieved if seeds are harvested at the correct stage of maturity (Vidigal et al., 2011; Saddique and Wright, 2003; Shivankar et al., 2001). According to Copeland and McDonald (1995), if harvesting is delayed seed quality may decline due to adverse environmental conditions such as high temperature, high humidity, rainfall, over drying, attacks by diseases, pests or damage by birds and animals.

Studies on the right stage of physiological maturation of seeds and the determination of the best harvest time, as well as their practical implications on seed production are very important. There are variations among species in occurrence of maximum seed quality during development and its association with seed and fruit characteristics (Passam et al., 1997). TeKrony and Egli (1997) indicated that the relationship between the occurrence of maximum seed dry weight and maximum seed vigour may depend on the experimental techniques used in the investigations, particularly how the seeds are harvested and dried. Ellis et al., (1993) reported that in tomato (*Solanum lycopersicum*) and pepper (*Capsicum spp.*) as well as cereals, seed quality was maximum after the seed-filing stage.

Methods of seed production are highly variable (Blay et al., 1999). Some farmers extract seeds from either the first harvest, middle or at the end of the production period. Besides, the stage of ripening is also quite varied. The objective of the present study was therefore to determine the right stage of physiological maturity for harvesting pepper fruits for high quality seed production.

MATERIALS AND METHODS

The study was carried out at the experimental site of Council for Scientific and Industrial Research - Plant Genetic Resources Research Institute, Bunso, Eastern Region from May 2017 to December, 2017. Field experiment on seed production and laboratory evaluation of seed quality was conducted. Seeds of two pepper cultivars (Legon 18 and BAG 14/001) were obtained from the same institute. Pepper seeds were sown on 9 May, 2017 and transplanted at 29 days after sowing (DAS) at a spacing of 60 cm x 60 cm. The experiment was arranged in a randomized complete block design (RCBD) with three replications.

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Agronomic practices which were undertaken during the experimental period included fertiliser application (NPK-15-15-15) at a rate of 5g plant\(^{-1}\). Watering and weeding were carried out as and when necessary. Insect pests were controlled using K-optimal insecticide (Landa-cyhalothrin 15 g l\(^{-1}\)+Acetamiprid 20 g l\(^{-1}\): EC) at a recommended rate of 40 ml to 15 l of water at two weeks interval.

Harvesting of fruits was done at different physiological maturity stages for seed extraction; for Legon 18 at 118 DAS and for BAG 14/001 at 111 DAS. Fruits were sorted into different categories of four comprising initially ripe, half ripe, fully ripe and rotten fruits. Before seed extraction, fruits were rinsed with tap water to remove unwanted materials. Seeds were extracted manually and air dried at ambient temperature for 7 days to attain lower moisture content. After drying, manual cleaning of seeds was done to remove inert materials and bad seeds. Seeds were placed on silica gel to attain constant moisture content.

For determination of 100-seed weight, hundred seeds from each treatment were counted and weighed with an electronic balance and replicated four times. Seed vigour and germination tests were conducted in petri dishes and seed boxes. Germination test was carried out under field conditions using seed boxes, with sterilised top soil and laboratory condition using petri dishes and filter paper. For each treatment, 50 seeds were used and replicated four times. The RCBD and completely randomised design (CRD) were used for field and laboratory test respectively. The first count (seed vigour) and final count (germination percentage) were established on the 10\(^{th}\) and 14\(^{th}\) day respectively. Seed germination was calculated by the following formula (ISTA, 1999):

\[
\text{Seed germination} \ (\%) = \frac{\text{Seed germinated}}{\text{Total seeds}} \times 100
\]

Statistical analysis was conducted using the SPSS Statistics 21 (IBM, Chicago, IL, USA). Data was subjected to two-way ANOVA and when the treatment means were significant, Tukey’s HSD test was performed to identify significant differences among treatments.

**RESULTS AND DISCUSSION**

Fig 1 shows different maturity stages of two pepper cultivars (Legon and BAG 14/001) at harvesting. Initially ripe = Legon 18: Green with brown spot, BAG 14/001: light green. Half ripe=Legon 18: Red with brown spots, BAG 14/001: Orange with light green spots, fully ripe=Red, Rotten=Red with decomposing texture.

**Table 1:** Effect of maturity stage on 100-seed weight of two pepper cultivars (Legon 18 and BAG 14/001).

| Cultivar  | Maturity stage (MS) | 100-seed weight (g) |
|-----------|---------------------|---------------------|
| Legon 18  | Initially ripe      | 0.473 (0.011)bc     |
|           | Half ripe           | 0.499 (0.015)ab     |
|           | Fully ripe          | 0.503 (0.012)a      |
|           | Rotten              | 0.452 (0.002)cd     |
| BAG 14/001| Initially ripe      | 0.323 (0.015)f      |
|           | Half ripe           | 0.415 (0.018) e     |
|           | Fully ripe          | 0.443 (0.006) d     |
|           | Rotten              | 0.400 (0.004) e     |

ANOVA: Maturity stage (MS) *** Cultivar (C) *** MS x C ***

Each value is the mean of four replicates and the standard deviation is shown in parentheses. Two-way ANOVA: *** p<0.001. When significant interaction between maturity stage (MS) and Cultivar (C) was detected, Tukey’s HSD test was performed to identify significant differences among the 4 treatments. Values with different letters are significantly different at p<0.05.

Haruna (2000) also got heavier seeds from earlier stages. Haruna (2000) also got heavier seeds from
red-ripe pepper fruits compared to less ripe stages. Seeds extracted at the initial stage in the present study had lower weight in both cultivars. This may be due to the presence of immature and under developed seeds with lesser food reserves and nutrients in the seeds (Naik et al., 1996). The results are also in agreement with Alan and Eser (2008), Hunje et al. (2007) and Demir and Samit (2001) who made similar observations in chilli pepper cultivars.

Maturity stage had significant (p<0.001) effect on seed vigour in both cultivars (Table 2). In Legon 18, seeds extracted at the fully ripe stage had the highest vigour but was not significantly different from seeds extracted at the half ripe and rotten stages. In BAG 14/001, seeds extracted at the rotten stage obtained the highest vigour in both petri dish and seed box. Seeds extracted at the initially ripe stage had the least vigour in both cultivars with BAG 14/001 recording the least. Powell and Matthews (1995) stated that seed vigour is affected by genotype, seed size, seed density, the incidence of seed borne pathogens and ageing. Low germination speed, high sensibility to stresses of seeds and seedlings during germination process and plants with slow, low and irregular growth or with less root development, are typical characteristics of seed with low physiological potential (Marcos-Filho, 2005). According to van Gastel and Bishaw (1993), seed size is the common difference among seeds and generally varies from one plant to another. van Gastel et al. (1996) and Massimi (2018) observed a positive correlation between seed size and seed vigour as larger seed tends to produce more vigorous seedlings. Furthermore, Poorter and Rose (2005) indicated that seed reserve food, frequently represented by seed mass, potentially contributes to seedling vigour as it is generally assumed that larger seeds produce more vigorous seedlings. The observed differences in 100-seed weight in the present study could have accounted for differences in seed vigour among treatments in both cultivars.

In the present study maturity stage had significant (p<0.001) effect on germination percentage in both cultivars (Table 3). In Legon 18, seeds extracted at the fully ripe stage had the highest germination percentage but was not significantly different from seeds extracted at the half ripe and rotten stages. In BAG 14/001, seeds extracted at the rotten stage showed the highest germination percentage in both petri dish and seed box. Seeds extracted at the initially ripe stage had the least germination percentage in both cultivars with BAG 14/001 recording the lowest. Seed germination increased slightly up to the end of maturation when the maximum dry matter content of the seeds was achieved. Seeds from fruits harvested at half ripe, fully ripe and rotten stage in Legon 18 had similar physiological qualities resulting in increased seed germination than in BAG 14/001. However, the germination percentage observed at

| Cultivar    | Maturity stage | Petri Dish | Seed box |
|-------------|----------------|------------|----------|
| Legon 18    | Initially ripe | 30.5 (3.1) d | 28.0 (3.7) c |
|             | Half ripe      | 49.5 (0.6) a | 49.0 (0.8) a |
|             | Fully ripe     | 49.8 (0.5) a | 49.5 (0.6) a |
|             | Rotten         | 49.3 (1.0) a | 49.5 (0.6) a |
| BAG 14/001  | Initially ripe | 1.3 (0.5) f  | 1.3 (0.5) d |
|             | Half ripe      | 27.0 (1.4) e | 23.8 (3.5) c |
|             | Fully ripe     | 41.8 (1.3) c | 38.3 (1.3) b |
|             | Rotten         | 45.8 (1.5) b | 42.5 (4.4) b |

ANOVA:
- Maturity stage (MS) ***
- Cultivar (C) ***
- MS x C ***

Each value is the mean of four replicates and the standard deviation is shown in parentheses. Two-way ANOVA: *** p<0.001. When significant interaction between maturity stage (MS) and Cultivar (C) was detected, Tukey’s HSD test was performed to identify significant differences among the 4 treatments. Values with different letters are significantly different at p<0.05.

| Cultivar    | Maturity stage | Petri Dish | Seed box |
|-------------|----------------|------------|----------|
| Legon 18    | Initially ripe | 68.0 (2.3) c | 67.0 (4.2) b |
|             | Half ripe      | 99.5 (1.0) ab | 99.0 (1.2) a |
|             | Fully ripe     | 100.0 (0.0) a | 99.5 (1.0) a |
|             | Rotten         | 99.5 (1.0) ab | 100.0 (0.0) a |
| BAG 14/001  | Initially ripe | 3.0 (2.0) e  | 3.5 (1.0) b |
|             | Half ripe      | 59.0 (2.3) d | 56.5 (1.0) a |
|             | Fully ripe     | 96.0 (2.3) b | 95.5 (1.9) a |
|             | Rotten         | 98.0 (0.0) ab | 97.5 (1.0) a |

ANOVA:
- Maturity stage (MS) ***
- Cultivar (C) ***
- MS x C ***

Each value is the mean of four replicates and the standard deviation is shown in parentheses. Two-way ANOVA: *** p<0.001. When significant interaction between maturity stage (MS) and Cultivar (C) was detected, Tukey’s HSD test was performed to identify significant differences among the 4 treatments. Values with different letters are significantly different at p<0.05.

Table 2: Effect of maturity stage on seed vigour of two pepper cultivars (Legon 18 and BAG 14/001).

Table 3: Effect of maturity stage on germination percentage of two pepper cultivars (Legon 18 and BAG 14/001).
significantly increased seed germination in all cultivars. Alan and Eser (2008) observed that seeds extracted from fruits harvested at 40 days after anthesis (DAA) had less than 50% germination in both cultivars. However, when seeds were extracted from fruits ripened for 10 and 20 days after harvest, their viability and vigour increased to 81% and 89% in hot pepper and 77% and 89% in red pepper, respectively. Demir and Samit (2001) suggested that the time for harvest of tomato seeds is related to the fruit colour and not to the seed dry weight and seeds should be harvested when fruits are red-firm i.e. at 70 DAA. Tetteh et al., (2018) also observed a high germination from seeds extracted at half ripe, fully ripe and rotten stages in two tomato accessions. The results obtained in this study clearly shows that physiologically mature pepper seeds of high quality can be obtained when fruits attain red ripe stage.

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CONCLUSION

In the present study, a significant increase in 100-seed weight was observed in the two pepper cultivars along the maturation stages. Seeds from Legon 18 were heavier than those of BAG 14/001 at all maturity stages. Pepper seeds extracted at the fully ripe and rotten stages in both cultivars gave higher vigour and germination percentage than those harvested at initial and the half ripe stage. Seeds extracted from Legon 18 had higher viability than BAG 14/001 at all maturity stages.

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