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Different harvest times and physiological quality of coriander seeds

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A B S T R A C T

The season of harvest is one of the most important factors influencing seed quality. This study evaluated the effect of different harvesting times on the physiological quality of *Coriandrum sativum* L. seeds, cv. Palmeira. The experimental design was completely randomized, with six treatments (harvest times) and four replications. The experiment was conducted during the months of April to October 2010. The first moment to harvest seeds was carried out 15 days after full bloom, when approximately 50% of plants were in flowering phase. Other harvests (22, 29, 36, 43 and, 50 days after bloom) were carried out at 7 days intervals until the seeds reached 16.0% of moisture, which occurred in the 6th harvest. Immediately after each harvest, the seeds were analysed for water content, germination and vigor (first count, seedling emergence and emergence rate index). The harvest season most suitable for *C. sativum* seeds cv. Palmeira occurred between 46 and 50 days after flowering, when the seeds have the highest physiological quality and moisture content between 20 and 16%.

Palavras-chave:
Coriandrum sativum L.
germinação
vigor
teor de água

Diferentes épocas de colheita e qualidade fisiológica de sementes de coentro

R E S U M O

A época de colheita é um dos fatores mais importantes que influencia a qualidade das sementes. Este estudo avaliou o efeito de diferentes épocas de colheita na qualidade fisiológica de sementes de *Coriandrum sativum* L., cv. Palmeira. O delineamento experimental foi inteiramente casualizado, com seis tratamentos (épocas de colheita) e quatro repetições. O experimento foi conduzido durante os meses de abril a outubro de 2010, em que a primeira época de colheita das sementes foi realizada aos 15 dias após a floração quando aproximadamente 50% das plantas apresentavam flores. As demais colheitas (22, 29, 36, 43 e 50 dias após floração) foram realizadas em intervalos de 7 dias até as sementes atingirem aproximadamente 16% de umidade, o que ocorreu na 6ª colheita. Imediatamente após cada colheita as sementes foram avaliadas quanto ao teor de água, germinação e vigor (primeira contagem, emergência de plântulas e índice de velocidade de emergência). A época mais adequada para a colheita de sementes de *C. sativum* cv. Palmeira ocorreu entre 46 e 50 dias após a floração quando as sementes apresentaram a mais alta qualidade fisiológica e teor de umidade entre 20 e 16%.

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Introduction

Coriander (family Apiaceae) is considered an annual herbaceous vegetable native to the Mediterranean basin. Due to the versatility of use, it is of considerable value, especially in Asia, where the centers of production and consumption are located (Diederichsen, 1996). Despite the presence in the Brazilian market of coriander cultivars of high commercial value, there is a regional genetics program to identify and recommend those best adapted to the different agro-ecological conditions of cultivation areas (Oliveira et al., 2007).

In Brazil, little research has been conducted with the coriander, including the appropriate technology for the production and development of new cultivars (Pereira et al., 2005). Optimal seed quality is obtained by following proper field production practices, especially the appropriate time of seed harvest. This allows the seed to escape sub-optimal environmental conditions and attack by pests and diseases (Carvalho & Nakagawa, 2012). The ideal moment to seed harvesting would be at its physiological maturity, or immediately after it turn off physiologically the plant; from this point on do not occur significant increases in dry mass (Terasawa et al., 2009).

Studies on maturation and harvesting of seeds are important as it reaches their high quality in the field Vidigal et al. (2009), such knowledge is essential, especially in regard to design and characterization of the optimal harvest moment to minimize the effects of deterioration caused by the extended permanence in the field. Also, it can increase the seed's production, because the ideal harvest span diminishes the quantity of immature seeds. Studies on maturation and seed harvest have been shown in a variety of crops (Freitas et al., 2007; Medeiros et al., 2010; Nakada et al., 2011; Duarte et al., 2012; Figueiredo Neto et al., 2012; Lima & Smiderle, 2014). However, in species where maturation is irregular, such as coriander, research are still scarce. Thus, the influence of different harvest time on the physiological quality of coriander seeds cv. Palmeira was studied.

Material and Methods

The experiment was conducted during the months of April to October 2010. Coriander was cultivated in the Garden of Medicinal Plants of the Department of Agricultural Sciences (DCA), Universidade Estadual de Montes Claros, UNIMONTES, and laboratory analyzes were performed at the Analytical Laboratory of Seeds DCA/UNIMONTES in the city of Janaúba, Minas Gerais, Brazil. Coriander seeds cv. Palmeira were used because it is considered to be adapted to the climate of the region.

The city of Janauba is located at 15º 49' 51.5" S latitude and 43 º 16' 18.2" W longitude, at an altitude of 540 m. The rainfall in this region is approximately on average of 870 mm. The weather is classified by Koeppen as "AW", tropical dry winters.

Soil samples were taken and soil amended according to Ribeiro et al. (1999). It was applied 6.0 kg m^{-2} of cattle manure, 46.8 gm^{-2} of Single Super Phosphate (140 kg ha^{-1} P_2O_5), 7.02 g m^{-2} of KCl (70 kg ha^{-1} K_2O) and 5.4 g m^{-2} of Urea (40 kg ha^{-1} N) to the soil broadcast during preparation of area. Additionally, 4.0 g m^{-2} of N and 7.0 g m^{-2} of K_2O was also applied 20 days after seedling emergence. With 10.0 cm spacing between rows, seeds were sown at a deep of 3.0 cm. After emergence, plants were thinned to one plant every 8.0 cm. Ten rows of plants were used to data collect, disregarding the plants in the boundary lines. Weed control by hand and irrigation by micro-sprinkler system were performed to provide the required conditions for plant growth. Due to the absence of pests and diseases in this period, no insecticides or fungicides were applied.

The experimental design was completely randomized (CRD), consisting of six treatments (harvest times), with four replicates per treatment. The first harvest of seeds was performed August 3, 2010, 15 days after full bloom, when approximately 50% of the plants had flowers. The other harvests were carried out at intervals of seven days, until the seeds attained around 16.0% moisture, which occurred during the sixth harvest (September 7, 2010).

During harvest the umbels were removed at random in a representative sample of all the planting rows, to attain the amount of seed needed for later analyzes. After harvesting, the umbels were transported to the laboratory packed in plastic bags, sealed, and then processed manually for removal of the seed.

The water content of the seeds was determined as prescribed in RAS - Rules for Testing Seeds (Brazil, 2009), using the oven method at 105 ± 3 ºC for 24 h, with four replicates of 10 g of seeds per treatment, and the results expressed as % water content.

The germination test was conducted using gerbox plastic boxes (11 x 11 cm), with the seeds distributed on a sheet of blotting paper, previously moistened with distilled water at a volume equivalent to 2.5 times the weight of the dry paper. The boxes containing the seeds were placed in an incubator preset at 20 ºC and constant light. Germination evaluations were carried out on the seventh and twenty-first days after placement, and the results expressed as a percentage of normal seedlings, as recommended by the RAS (Brasil, 2009).

The seedling emergence test was conducted under laboratory conditions, using sand previously washed and sterilized in an oven at 200 °C for 2 h. The seeds were sown in gerbox plastic boxes (11 x 11 cm) with 5 cm of soil two moistened to 60% capacity retention (Brazil, 2009). It was used four replicates of 50 seeds per treatment and determined the percentage of normal seedlings emerged that showing cotyledon visible, on the twenty-first day after sowing.

The index of germination speed was calculated in conjunction with the seedling emergence test, by recording daily, the number of seedlings that were 5 cm tall and with visible cotyledon. It was calculated the rate of emergence using the formula proposed by Maguire (1962).

The results were submitted to analysis of variance and regression. The estimates of the regression parameters were evaluated by the "t" test at the 5% level of significance.

Results and Discussion

The water content of coriander seeds was significantly influenced by the time of harvest (Figure 1).

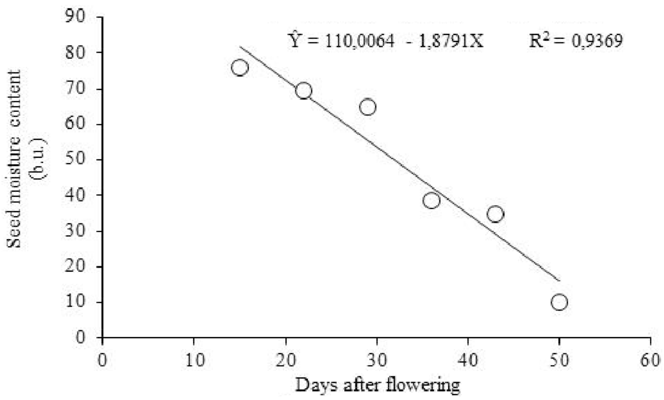

Figure 1. Seed moisture content (%) of *Coriandrum sativum* L. cv. Palmeira, in relation to harvest date (days after flowering)

It was observed steady decline in seed moisture over the period, well-described by a linear regression equation. On average, the seed lost approximately 1.87% of its water content daily.

The water content of the seeds at 15 days after flowering was 82.0%, but fell sharply to reach approximately 20.0% 48 days after flowering. This corresponds to physiological maturity of seeds (i.e., maximum germination and vigor). However, it is noteworthy that the water content of the seed alone is not a good indicator of physiological maturation, as it can be influenced by genetic and environmental condition (Hunter et al., 1991; Sousa et al., 2011).

According to Sousa et al. (2011), physiological maturation of coriander seeds cv. Verdão occurred at 42 days after flowering with the 28.0% moisture in the seed. At 50 days after flowering, the water content of the seeds was relatively low (16.0%). In addition, Coimbra et al. (2009) highlighted that reduced water content is essential for obtaining consistent results in seed quality. The seed longevity is linked to water content since this directly affects physiological processes, with reduced seed quality, reaching directly effects in the vigor, even germination (Marcos Filho, 2005).

The results of the germination test (Figure 2) were affected by the time of harvest. Only about 20% of the seeds germinated at 15 days after flowering, but increased to 89% in the fifth harvest (46 days after flowering). This represents increase of 345% in the percentage of germination from the first harvest to the point of maximum (46 days after flowering).

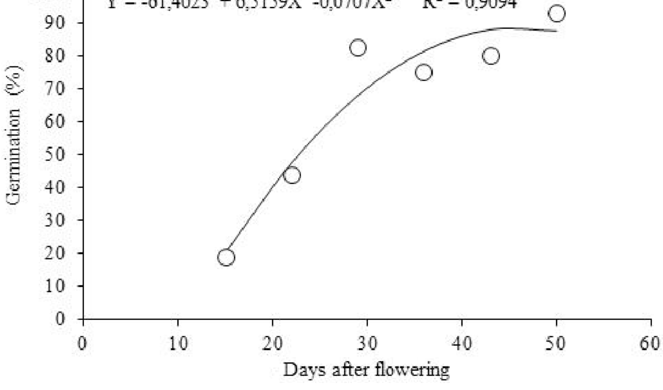

Figure 2. Germination of *Coriandrum sativum* L. cv. Palmeira, in relation to harvest date (days after flowering)

In studies conducted by Sousa et al. (2011), the highest percentage of germination of coriander cv. Verdão harvested at 42 days after flowering, which was similar to the results of this research. In Crambe (*Crambe abyssinica* Hochst) seeds, Oliveira et al. (2014) found that seeds showed approximately 76% of germination on the first harvest season, which occurred at 14 days after flowering.

National standards for the production and marketing of coriander seeds require germination percentage of at least 65.0% for basic seed, and certified 70.0% for first-and second-generation seeds and S1 and S2 (MAPA, 2011). In the study presented here, germination in the third harvest and onwards exceeded these levels.

However, during some period in which there was a higher percentage of germination, the seeds possessed high water content (23.0%), a fact considered not conducive to mechanized harvesting of this crop. Thus, the harvest may be delayed until about 50 days after flowering, resulting in seeds with reduced water content (16.0%) but high germination (around 88.0%).

The high percentage of seed germination in the first harvests, though possessing high water content and not conducive to mechanical harvesting, may be useful to accelerate breeding programs, thus obtaining more than one generation per year. Indeed, the seeds harvested with high moisture content, after natural drying, showed germination values similar to those of seeds harvested with lower water content, corroborating with results obtained by Sousa et al. (2011). In fact, Faria et al. (2002) assume that the initial biochemical composition after flowering is simpler and, thus, the seed would be able to imbibe quickly water to initiate the chain of enzymatic reactions required to convert metabolized in reserve materials capable of initiating and germination.

Beginning about 50 days after flowering (Figure 3), germination tended to decrease. However, this did not significantly affect seed quality, because germination remained above 85.0%.

Germination was strongly influenced by harvest dates. At 15 days after flowering (first crop), the seeds showed little vigor. From that time onwards, however, germination values increased sharply, reaching 83.0% at 48 days after flowering. Thereafter, germination remained relatively stable.

The maximum seed vigor based on the test results of the first count was reached at 43 DAF (5th harvest season) when seeds showed 79% germination in study of maturation of

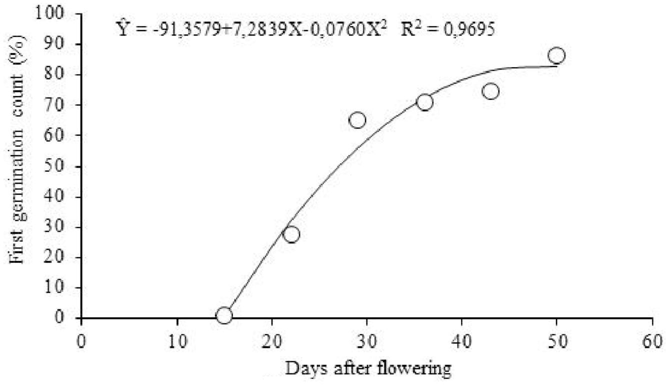

Figure 3. First germination acount of *Coriandrum sativum* L. cv. Palmeira, in relation to harvest date (days after flowering)

coriander cv. Palmeira seeds (Sousa et al., 2011). Also in their remarks, Sousa et al. (2011) underline that from the time of maximum force it was detected by a drop test first count more pronounced than the decrease in germination as it slowed the harvest. However, these reductions were not as significant points to derail the delay in crop seeds. Evaluating seed of *Sesamum indicum* L., Nobre et al. (2013) observed that the values of percentage of normal seedlings obtained through the first count test showed the seeds harvested at 143 DAS, as the average, and different from the others.

Seedling emergence was influenced by harvest dates (Figure 4). Seed vigor as determined by the seedling emergence test, initially reached 63.0%. However, after this period there were reductions in seedling emergence.

This was possibly due to seed not yet fully formed due to the unevenness observed in the maturation of umbels. There was considerable environmental stress, such as high temperatures and relative humidity, observed during this period, which also may have favored the reduction in seed vigor. Thereafter, emergence rates rose, and at 50 days after flowering (6th harvest), the seeds displayed emergence values close to 100% (Figure 4). At 46 DAF, time of maximum germination, the level of seedling emergence was 85.0%.

Germination speed was influenced by date time of seed harvest (Figure 5). Similar to seedling emergence, the emergence index initially showed decreases until the third harvest (29 DAF), reaching levels of 1.9. From that period

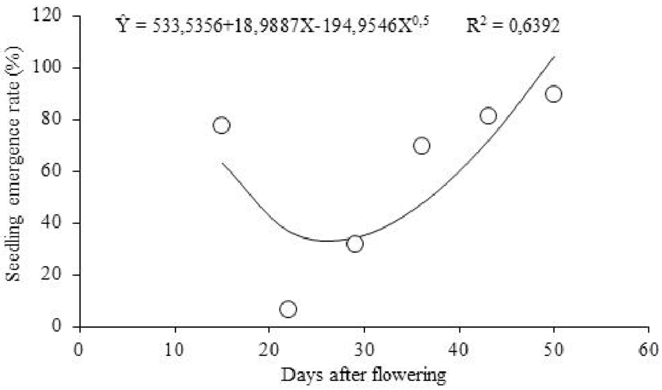

Figure 4. Seedling emergence rate of *Coriandrum sativum* L. cv. Palmeira, in relation to harvest date (days after flowering)

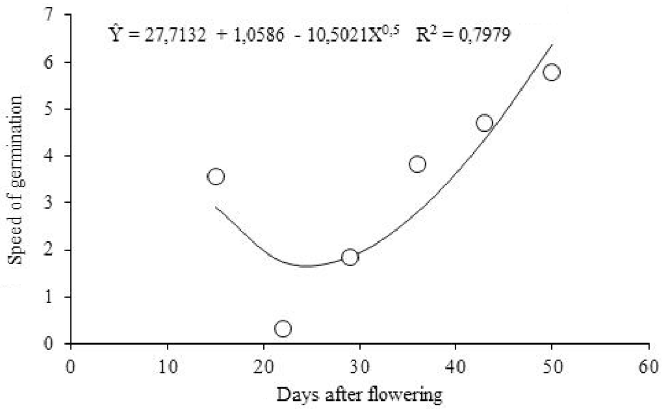

Figure 5. Speed of germination index of *Coriandrum sativum* L. cv. Palmeira, in relation to harvest date (days after flowering)

onwards increases were observed in the indices obtained, reaching a maximum value of 6.4 at 50 days after flowering (Figure 5). These results are in agreement with those obtained by Sousa et al. (2011) who found higher rates (4.9) in the coriander seeds cv. Verdão 50 days after flowering.

Conclusion

Optimal harvest time for coriander seeds, cv. Palmeira, occurs between 46 and 50 days after flowering, when the seeds have high vigor and water content between 20 and 16%.

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