Australian Journal of Crop Science AJCS

AJCS 14(05):739-743 (2020) ISSN:1835-2707
doi: 10.21475/ajcs.20.14.05.p2069

The physiological quality of 'Chilli pepper' seeds, extracted from fruits harvested at different stages of maturation, with and without post-harvest rest

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Abstract

The objective of this study was to evaluate the physiological quality of 'Chilli pepper' seeds, extracted from fruits harvested at different stages of maturation, with and without post-harvest rest. Twelve treatments resulted from the 6 x 2 factorial, with six maturation stages (100% green fruits, 90% green and 10% orange fruits, 10% green and 90% orange fruits, 100% orange fruits, 100% red fruits and 100 % matte red fruits, corresponding to 44, 53, 60, 63, 70 and 73 days after anthesis (DAA), respectively), and fruits with and without rest for seven days. Seeds were evaluated two months after extraction as well as after 14 months of storage in a dry chamber (40% relative humidity and 20°C). The characteristics evaluated were: weight of a thousand seeds, germination, first count, electrical conductivity, emergency test and shoot length of seedlings. Fruits of orange chilli pepper 'Malagueta' kept at rest for seven days and bright red fruits and matte without rest produce seeds with physiological quality, which are maintained after a period of 14 months stored in a chamber with 40% relative humidity at 20°C.

Keywords: *Capsicum frutescens,* Maturity, Germination, Vigor.
Abbreviations: DAA_ days after anthesis;

Introduction

There is a great variety of peppers in the Brazilian market and the 'Chilli pepper' (*Capsicum frutescens*) is one of the most important and commercialized (Embrapa, 2007). It is produced mainly by small family farmers, and it is easy to produce and trade. It is common some growers to produce and store their own seeds for later crops (Nascimento, 2004).

Due to its undetermined development, with vegetative and reproductive growth simultaneously, it is not possible to make a single harvest, because the maturation is not uniform (Abud et al., 2013). However, the fruits are climacteric and it is possible to harvest in the immature stage and, after a post-harvesting rest period, maturation occurs and the seeds can reach physiological maturity.

Improvements were observed in the physiological quality of the seeds with the post-harvest harvest of the fruits in zucchini (Marrocos et al., 2011), cucumber (Nakada et al., 2011), tomatoes (Dias et al., 2006; Vidigal et al., 2006), eggplant (Martins et al., 2012), okra (Castro et al., 2008), and several types of peppers (Vidigal et al., 2009; Queiroz et al., 2011; Vidigal et al., 2011; Ricci et al., 2013; Pereira et al., 2014; Gonçalves et al., 2015; Justino et al., 2015). But for 'Chilli pepper' it is not observed any research about it. So, the objective of this study was to evaluate the physiological quality of 'Chilli pepper' seeds, extracted from fruits harvested at different stages of maturation, with and without post-harvest rest.

Results and discussion

Fruit characteristics

The highest fruit length was reached at 69 DAA (Figure 1). Fruit diameter data adjusted to the quadratic model, with maximum value estimated in 6.75 mm at 69 DAA, with a little decreasing in the value until 75 DAA. For fruit weight there was no significant difference, and the average was 614 mg per fruit.

Gonçalves et al. (2015), studying maturation stages of 'Bode Vermelha' pepper (*Capsicum chinense*), verified maximum fruit diameter in light red fruits, with a reduction in values after this stage, probably due to loss of water, as well as in the present study . For *C. baccatum* fruits, maximum diameter, length and weight values were reached when fruits were intense red at 45 DAA (Pereira et al., 2014). In yellow pepper fruits (*C. annuum*), between 40 and 45 DAA, color between green and yellow, reached higher values for these characteristics, remaining stable up to 75 DAA (Vidigal et al., 2011).

Physiological quality of the seeds

For 1000 seed weight only the factor fruit age was significant and data adjusted to quadratic model. The highest values of 1000 seed weight were estimated in 3,9 and 4,3 g for 62 and 67 DAA, with and without fruit post-harvest resting, respectively (Figure 1).

Interaction between fruit age and post-harvest rest was significant for most characteristics related to physiological quality of the seeds: germination, first count of germination, emergency, dry weight of seedlings and electric conductivity (Table 1).

Seeds of fruits that remained at rest for seven days after harvesting presented higher germination and first count of germination compared to fruits without rest, except for the youngest fruits (44 DAA) (Table 1). The post-harvest rest improved the emergency in substrate for most ages, except 63 and 73 DAA. During the rest it must occur translocation of reserves of the pulp of the fruit to the seeds, improving its quality.

Highest germination values were also observed in pepper 'Dedo de Moça' (*C. baccatum*) (Pereira et al., 2014) and 'Amarela Comprida' (*C. annuum*) (Vidigal et al., 2009) when fruits remained in rest for 10 and 12 days, respectively. Similar result occurred in Habanero Yellow pepper seeds (*C. chinense*) (Ricci et al., 2013), with a higher percentage of emergence in seeds extracted from green and red fruits that remained at rest.

The older the fruit the higher the germination and the first count of germination, with and without post-harvest fruit rest (Figure 1). At the lowest age (44 DAA) the germination was null, and the values increased until 90 and 73% at 73 DAA for the fruits with and without rest, respectively.

The values obtained for germination at the highest age of the fruits with and without rest reach the minimum germination (70%) for the commercialization of seeds of the genus *Capsicum* in Brazil (Brasil, 2005).

Normally, seeds acquire maximum physiological quality when reach the maximum dry weight accumulation (Nakada et al., 2010). In this study, the highest values of 1000 seed weight occurred 61 and 68 DAA, with and without post-harvest resting, respectively (Figure 1). However, germination and first germination counts showed higher values at 73 DAA (Figure 1), therefore, the best physiological quality did not coincide with the highest 1000 seed weight. However, the most common is maximum germination and vigor coincide with the maximum dry weight accumulation as observed in seeds of other peppers (Vidigal et al., 2011; Pereira et al., 2014; Gonçalves et al., 2015), and tomato (Vidigal et al., 2006).

The emergence data adjusted to the quadratic model in function of maturity stage of the fruits with maximum emergencies estimated in 100% and 90% at 67 and 72 DAA for fruits with and without post-harvest rest, respectively (Figure 1). After these ages, there was a reduction in values, similar to observed for 1000 seed weight, confirming that, normally, seeds acquire maximum physiological quality when reach the maximum dry weight accumulation (Nakada et al., 2010).

Physiological quality of seeds after 14 months of storage

The germination after 14 months of storage (Figure 2) followed the same pattern of test performed one year before (Figure 1); fruit seeds that remained at rest for one week had a higher percentage than those without rest, except for fruits harvested at 73 DAA (Table 2). This was probably due to the fruits being harvested already very ripe (red matte color), possibly the seeds had already reached physiological maturity, had disconnected from the mother plant, and with rest, this period ended up damaging, seeds consumed energy during respiration , affecting the viability of the seeds in storage.

The germination data were adjusted to the quadratic model (Figure 2), with maximum germination rates of 86% and 82% at 65 DAA and 71 DAA, with and without post-harvesting rest of fruits, respectively. Before storage, a linear model was set up, reaching maximum values of 90% and 73% at 73DAA (Figure 1), with and without resting fruits, respectively.

The first germination count (Figure 2) was adjusted to the linear model, with maximum germinations obtained from 100% red matte fruits (73 DAA): 50% and 29% with and without resting, respectively.

Nakada et al. (2010) report the production of free radicals intensifies during the drying process and, along storage in orthodox seeds, tolerant to desiccation. In the study of the quality of cucumber seeds throughout the storage, they verified that after the six months there is a reduction in storage potential.

If the producer of 'Chilli pepper' aims at the marketing of fruits or seeds, he can harvest more volume in the same, being able to select fruits in two categories, fruits 100% orange, and leave in rest for a week, which will change color to red, making them with market characteristics, as well as obtaining high quality seeds, also allowing to store for a period of 14 months with quality guarantee, and also to harvest bright and matte red fruits, without letting them rest, especially if the seeds are used to plant new crops after this period.

Materials and methods

Locality and soil characterization

The fruits and seeds were obtained from plants grown at the São Manuel Experimental Farm and the physiological quality of the seeds was evaluated at the Seeds Laboratory of the Horticulture Department of São Paulo State University (UNESP), in Botucatu, SP, Brazil. The geographical coordinates of the site are 22°46' S, 48°34' W, and it has an average altitude of 750 m. The predominant climate of the region, according to Köppen climate classification, based on meteorological observations, is type Cfa (umid subtropical, mesothermal) (Cunha and Martins, 2009). During the experimental period, the average daily temperature varied from 11 ^{o}C to 36 ^{o}C.

Table 1. First count of germination (FC), germination (G) and emergence (E) of seeds of 'Chilli pepper' as a function of maturity stage (days after anthesis) of fruits with and without rest after harvest.

	FC (%)		G (%)		E (%)	
	Rest		Rest		Rest	
Maturity stage	with	without	with	without	with	without
44	0 A[1]	0 A	5 A	0 A	39 A	2 B
53	6 A	0 B	21 A	2 B	91 A	71 B
60	8 A	2 B	34 A	5 B	92 A	56 B
63	14 A	3 B	34 A	6 B	94 A	86 A
70	19 A	10 B	64 A	17 B	99 A	87 B
73	46 A	39 B	90 A	73 B	100 A	95 A
CV[2] (%)	21.4		15.1		9,2	

[1]Means followed by the same letter in the line do not differ by Tukey test at 5% probability. [2]CV (%): coefficient of variation.

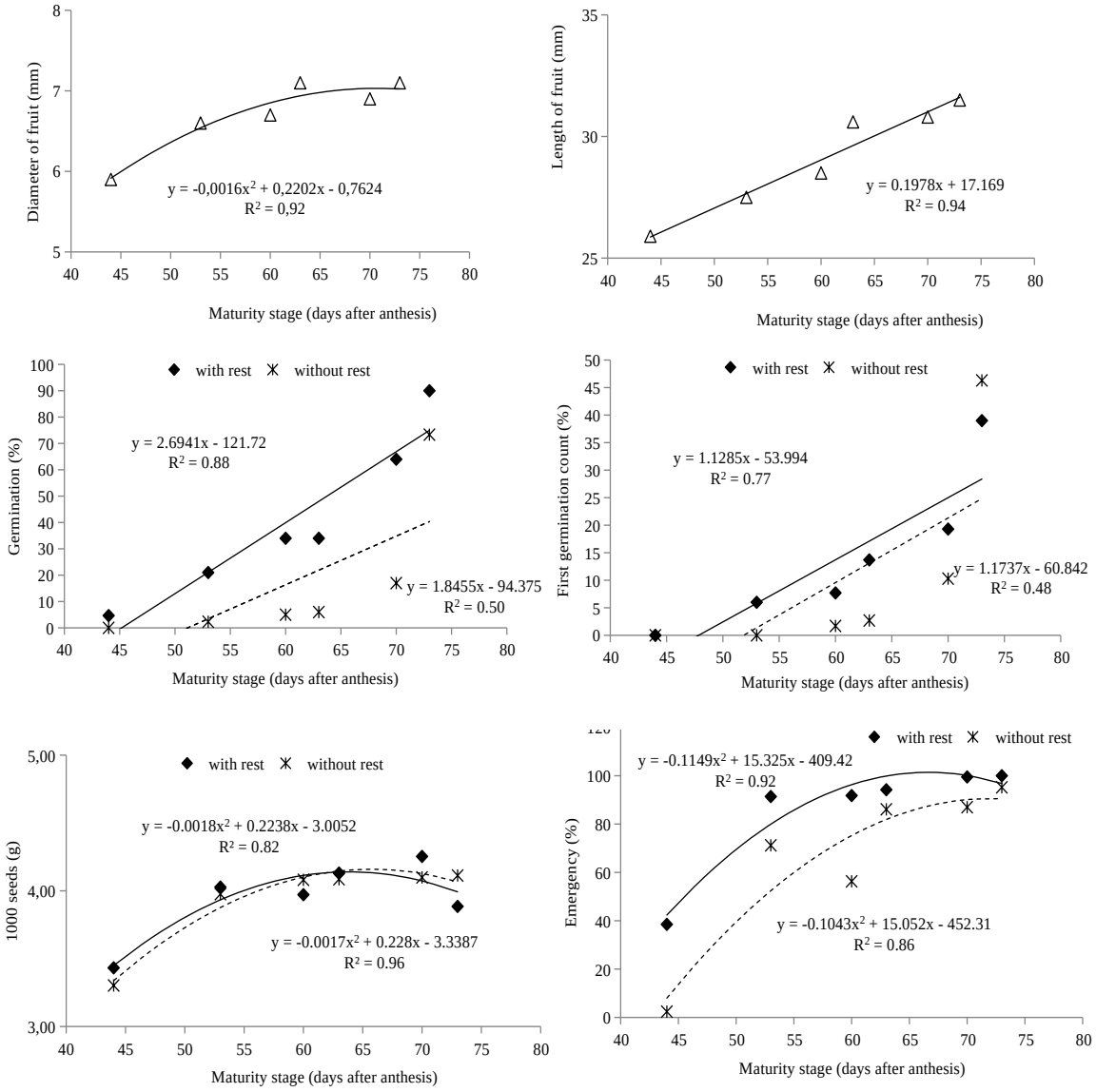

Fig 1. Diameter and length of fruit, due to maturation stages only. Germination, first germination count, mass of one thousand seeds and emergence of 'Chilli pepper' seeds evaluated two months after extraction as a function of maturity stage (days after anthesis) of fruits with and without rest after harvest.

Table 2. first germination count and percentage of germination of 'Chilli pepper' seeds evaluated 14 months after extraction as a function of maturation stage (days after anthesis) of fruits with and without rest after harvest.

Maturity stage	First germination count (%)		Germination (%)	
	rest		rest	
	with	without	with	without
44	5 A[1]	0 A	48 A	7 B
53	22 A	4 B	80 A	74 A
60	31 A	3 B	79 A	62 B
63	34 A	5 B	85 A	65 B
70	29 A	21 A	83 A	82 A
73	57 A	45 B	81 A	87 A
CV[2] (%)	24.4		9.1	

[1]Means followed by the same letter in the line do not differ by Tukey test at 5% probability. [2]CV (%): coefficient of variation.

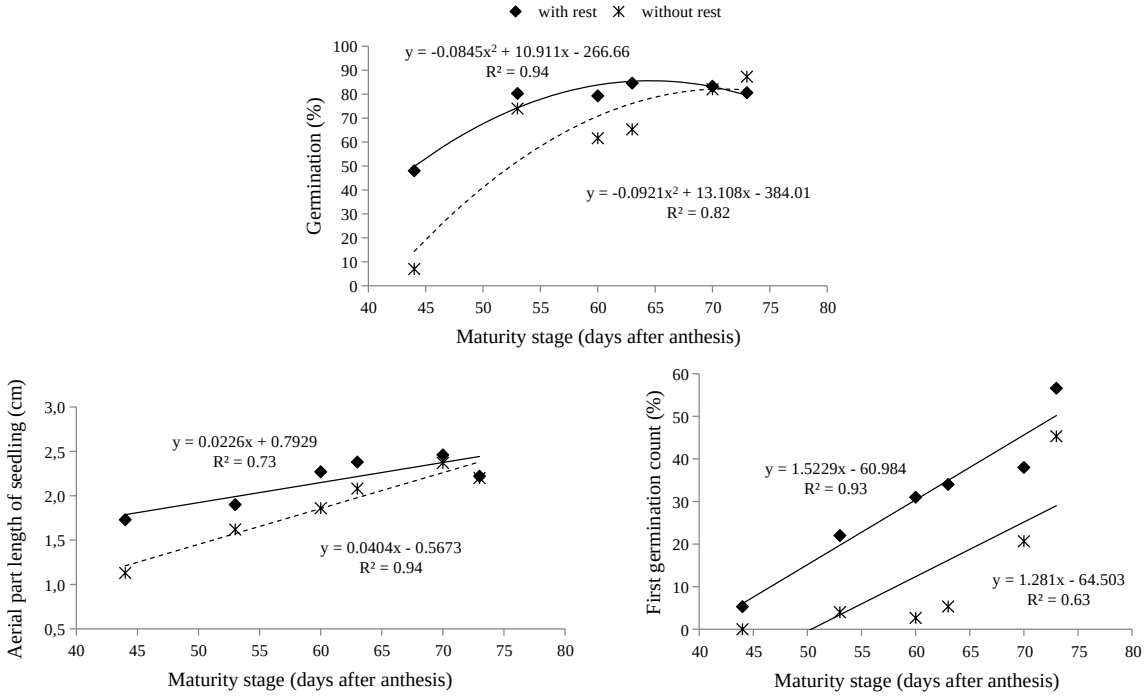

Fig 2. Percentage of germination, aerial part length of seedling and first germination count of 'Chilli pepper' seeds evaluated 14 months after extraction as a function of maturation stage (days after anthesis) of fruits with and without rest after harvest.

$mmol_c\ dm^{-3}$; Mg = 9 $mmol_c\ dm^{-3}$; sum of basis = 38 $mmol_c\ dm^{-3}$; cation exchange capacity = 52 $mmol_c\ dm^{-3}$ and V = 72%. No liming was required. The planting and cover fertilization were carried out according to recommendation for Sao Paulo State by Raij et al. (1997).

Plant material

The 'Chilli' pepper seedlings were produced in polypropylene trays of 162 cells and transplanted after 41 days in a protected environment (arch type, dimensions of 7.0 x 20.0 m and height of 2.5 m, covered with low density polyethylene (LDPE) of 150 µm). The spacing was 1.0 m between rows and 0.5 m between plants.

Treatments and experimental design

Twelve treatments, resulted from the 6 x 2 factorial, were evaluated in a randomized block design, with four replicates. The first factor was six maturation stages (fruits 100% green; fruits 90% green and 10% orange; fruits 10% green and 90% orange; fruits 100% orange; fruits 100% red; and fruits 100 % matte red, corresponding to 44, 53, 60, 63, 70 and 73 days after anthesis (DAA), respectively), and the second factor was the post-harvest rest of fruits for seven days before the extraction of the seeds: with and without rest. During the rest, the average laboratory temperature was 25 ° C. The fruits harvest was from 137 to 162 days after transplanting the seedlings.

Characteristics measured

For each treatment, seeds of 100 fruits were extracted manually and they were stored (in a chamber: 40% relative humidity and 20°C) for two months, until they reach 8% of water content, as well as to avoid problems with possible dormancy (Nascimento et al., 2006). After this period, the seeds were analyzed physically and physiologically by the following tests: a) weight of one thousand seeds (g); b) germination (%), 50 seeds were sown in each plot, with four

replicates, and germination was evaluated on the 14th day after sowing (DAS); c) first germination count (%) was evaluated in the germination test at 7th DAS (ISTA, 2016); d) seedling dry matter (mg): normal seedlings of the germination test were placed in paper bags, which were kept in an oven at 40 °C until weight stabilization; e) emergency test (%): 50 seeds per plot, with four replicates, in polypropylene trays of 162 cells, filled with commercial substrate Topstrato®, which remained in greenhouse, and counting was performed at 14th DAS; f) conductivity (µS cm^{-1} g^{-1}): evaluated according to the methodology proposed by Vidigal et al. (2011).

Seeds samples of each treatment were stored in dry chamber (40% relative humidity and 20°C) in permeable paper bags for a period of 14 months of storage, and, after this period, were evaluated for germination, first germination count and electrical conductivity, according the methodology described before.

Statistical analyzes

Data were submitted to analysis of variance, in a factorial scheme, and the means with and without rest compared by the Tukey test at 5% probability and regression analysis for the maturation stages, according days after anthesis (DAA).

Conclusion

Fruits of orange chilli pepper 'Malagueta' kept at rest for seven days and bright red fruits and matte without rest produce seeds with physiological quality, which are maintained after a period of 14 months stored in a chamber with 40% relative humidity at 20°C.

Acknowledgement

The authors acknowledge to the Coordination for the Improvement of Higher Education Personnel (CAPES) and National Council for Scientific and Technological Development (CNPq) for the scholarships granted.

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