PLANTA DANINHA
SOCIEDADE BRASILEIRA DA CIÊNCIA DAS PLANTAS DANINHAS
SBCPD
<http://www.sbcpd.org>
ISSN 0100-8358 (print)
1806-9681 (online)

Article

Pre-Harvest Desiccation in Productivity and Physiological Quality of Cowpea Seeds

Dessecação em Pré-Colheita na Produtividade e Qualidade Fisiológica de Sementes de Feijão-Caupi

ASSIS, M.O.[1]*
ARAUJO, E.F.[1]
FREITAS, F.C.L.[1]
SILVA, L.J.[1]
ARAUJO, R.F.[1]

ABSTRACT - Pre-harvest desiccation is an important strategy to anticipate harvesting, preventing the seed from being left in the field in unfavorable climatic conditions. However, little is known about the use of desiccants and their application times on cowpea (*Vigna unguiculata*). The objective of this study was to evaluate the effect of desiccant application at different seasons and of desiccant herbicides on productivity and physiological quality of cowpea seeds. Five dessicants were evaluated: paraquat, paraquat sequential application, glufosinate- ammonium, glyphosate with sequential application of paraquat and paraquat + diuron mixture applied in four seasons: 50% of the pods with green coloration and with seeds formed (season I); 70% of the pods in the purple coloration (season II), 90% of the pods in the coloration brown (season III) and 100% of the pods in the coloration brown (season IV), plus a control without the application of desiccants, in which harvesting was performed when 100% of the pods were brown. The number of days of anticipation of harvest, productivity, uniformity test, mass of one hundred seeds, germination and vigor of the seeds were evaluated. None of desiccation strategies affect the physiological seed quality, independent of the application season. The desquaments paraquat, glufosinate-ammonium and the paraquat+diuron mixture, when applied in seasons I and II, provided anticipation of the harvest in up to 13 days and 9 days, respectively, however, the size of the seeds and consequently the productivity were affected.

Keywords: *Vigna unguiculata*, desiccants, vigor, paraquat, glyphosate, glufosinate-ammonium.

*RESUMO - A dessecação pré-colheita é uma estratégia importante no sentido de antecipar a colheita, evitando que a semente fique no campo em condições climáticas desfavoráveis. No entanto, pouco se sabe sobre o uso de dessecantes e as épocas de aplicação destes na cultura do feijão-caupi (**Vigna unguiculata**). Objetivou-se neste trabalho avaliar efeito da aplicação de dessecantes em diferentes épocas e de herbicidas dessecantes sobre a produtividade e a qualidade fisiológica de sementes de feijão-caupi. Foram avaliados cinco dessecantes: paraquat, aplicação sequencial de paraquat, amonio-glufosinate, glyphosate com aplicação sequencial de paraquat e mistura paraquat+diuron aplicados em quatro épocas: 50% das vagens com sementes formadas, com coloração verde (época I), 70% das vagens na coloração roxa (época II), 90% das vagens na coloração marrom (época III) e 100% das vagens na coloração marrom (época IV), mais uma testemunha sem a aplicação de dessecantes, em que a colheita foi realizada quando 100% de vagens estavam na coloração marrom. Avaliaram-se o número de dias de antecipação de colheita, produtividade, teste de uniformidade, massa de cem*

*** Corresponding author:**
<miqueias.assis@ufv.br>

Received: March 29, 2017
Approved: September 4, 2017

Planta Daninha 2019; v37:e019177741

[1] Universidade Federal de Viçosa, Viçosa-MG, Brasil.

Doi: 10.1590/S0100-83582019370100014

sementes, germinação e vigor das sementes. Nenhuma das estratégias de dessecação afetou a qualidade fisiológica das sementes, independentemente da época de aplicação. Os dessecantes paraquat, amonio-glufosinate e a mistura paraquat+diuron, quando aplicados nas épocas I e II, proporcionaram antecipação da colheita em até 13 dias e 9 dias, respectivamente, porém o tamanho das sementes e, consequentemente, a produtividade foram afetados.

Palavras-chave: *Vigna unguiculata*, dessecantes, vigor, paraquat, glyphosate, amonio-glufosinate.

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.), commonly called black-eyed peas or macassar bean, is a species traditionally cultivated by producers in the North and Northeast of Brazil, who generally use low technological level (Freire Filho et al., 2011), involving manual harvesting of the pods. However, in recent years there has been an improvement in the technological level in these regions and in the expansion of the cultivated area in the country, especially in the Midwest region, where, according to Teixeira et al. (2010), the culture is in full expansion under the mold of business agriculture, with fully mechanized farming.

To produce seeds, the harvest should be carried out at or near the physiological maturity, as the delay may negatively influence the quality of the seeds due to their exposure to possible unfavorable environmental conditions (Terasawa et al., 2009). However, Nogueira et al. (2014), evaluating the development and physiological quality of cowpea seeds, verified that in the physiological maturity the water content of the seeds was 53.6%; according to Terasawa et al. (2009), seeds with high water content make mechanized harvesting impossible, as there are difficulties for picking and trail, as well as the occurrence of severe levels of mechanical damage by kneading. As a result, farmers await the reduction of the seed water content and the natural defoliation of the plant and begin harvesting as soon as possible.

However, unlike crops of soybeans (*Glycine max*) and common bean (*Phaseolus vulgaris*), which have defoliation and natural death of the plant concomitantly to the drying of the pods, in the cowpea, the plant continues with green leaves and branches, which hinder the harvest even after the seeds reach the moisture content at compatible levels for the mechanized harvest (14% to 18%).

In view of the above, it is necessary to apply desiccant herbicides as a strategy to anticipate the harvest, which reduces the time the seeds remain in the field and consequent exposure to the weather, preserving the physiological quality, besides making mechanized harvest feasible.

Studies related to pre-harvest desiccation for seed production have been conducted mainly in crops such as rice (He et al., 2015), beans (McNaughton et al., 2015; Tavares et al., 2016), soybean (Kappes et al. al., 2012) and wheat (Jaskulski and Jaskulska, 2014). For the soybean crop, several authors report that pre-harvest desiccation allows uniformity of maturation, promoting uniform drying of the pods and seeds, so that it anticipates the harvest without harming the yield and the quality of the seeds, since they do not induce the dehiscence of the pods (Lacerda et al., 2003; Pelúzio et al., 2008; Kappes et al., 2009). However, some important aspects should be considered in a seed production system when desiccants are used, such as: mode of action and dose of the desiccant, environmental conditions, phenological stage of the crop at the time of application, possible possibility of toxic residues in the material harvested and influence on seed germination and vigor (Lacerda et al., 2005).

However, for cowpea, the research is still very incipient regarding the use of desiccant herbicides in anticipation of harvest, as well as the ideal season of application of these products, besides the absence of herbicides registered for this purpose, in Brazil. Hubner Junior and Toledo (2016), evaluating the viability of cowpea seeds harvested at different seasons after physiological maturity in non-desiccated areas and with pre-harvest desiccation, through the application of the herbicide paraquat, observed that harvest delay reduces the viability and germination of cowpea seeds, regardless of pre-harvest desiccant application.

The herbicides paraquat and glufosinate-ammonium are registered for pre-harvest desiccation in soybeans and beans in Brazil (AGROFIT, 2017) because they are contact action herbicides that do not affect the physiological integrity of the seeds. In addition, paraquat acts as a false electron acceptor in photosystem I, generating free radicals, which cause lipid peroxidation and membrane disruption, leading to desiccation of the plants in a short period (Silva et al., 2007). Glufosinate-ammonium causes rapid accumulation of ammonia, associated with the destruction of chloroplasts, reduction of photosynthesis levels and reduction of amino acid production, resulting in the inhibition of photosynthesis and cell death (Sauer et al., 1987). The first symptom is yellowing of foliage and other tissues, followed by wilting and death of the plant, between 7 and 14 days (Silva et al., 2007).

Although not recommended for pre-harvest desiccation, some studies have been conducted evaluating the use of glyphosate for this purpose in soybean crop (Daltro et al., 2010; Toledo et al., 2014). Glyphosate is a systemic herbicide that inhibits the action of the enzyme 5-enolpyruvylshikimate-3-phosphate5 synthase (EPSPS) in the route of synthesis of the aromatic amino acids phenylalanine, tyrosine and tryptophan and has slow action, with the death of plants occurring between 10 and 15 days after application (Silva et al., 2007).

Based on the above considerations, the objective of this work was to evaluate the effect of the application of desiccants at different seasons and of desiccant herbicides on the productivity and physiological quality of cowpea seeds.

MATERIAL AND METHODS

The study was conducted in the field and in the laboratory. In the field, the experiment was carried out from March to July 2015, in the experimental design in randomized blocks with four replicates. The treatments were arranged in factorial scheme 5x4 + 1. The first factor corresponded to five strategies of desiccation: paraquat (400 g i.a. ha^{-1}); sequential application of paraquat (400 + 400 g i.a. ha^{-1}), the second five days after the first; glufosinate-ammonium (400 g i.a. ha^{-1}); glyphosate (1.080 g e.a. ha^{-1}) with sequential application of paraquat eight days later (400 g i.a. ha^{-1}); commercial mixture of paraquat + diuron (200 + 400 g i.a. ha^{-1}), plus an additional control without desiccant application, where harvesting was performed when 100% of the pods were brown in color.

In the second factor, four seasons of desiccation were evaluated, which were established based on the percentage of pods with certain staining (Figure 1), which consisted of:

- Season I: 50% of the pods with green coloration and seeds formed;
- Season II: 70% of the pods in the purple coloration;
- Season III: 90% of the pods in the brown coloration;
- Season IV: 100% of the pods in the brown coloration.

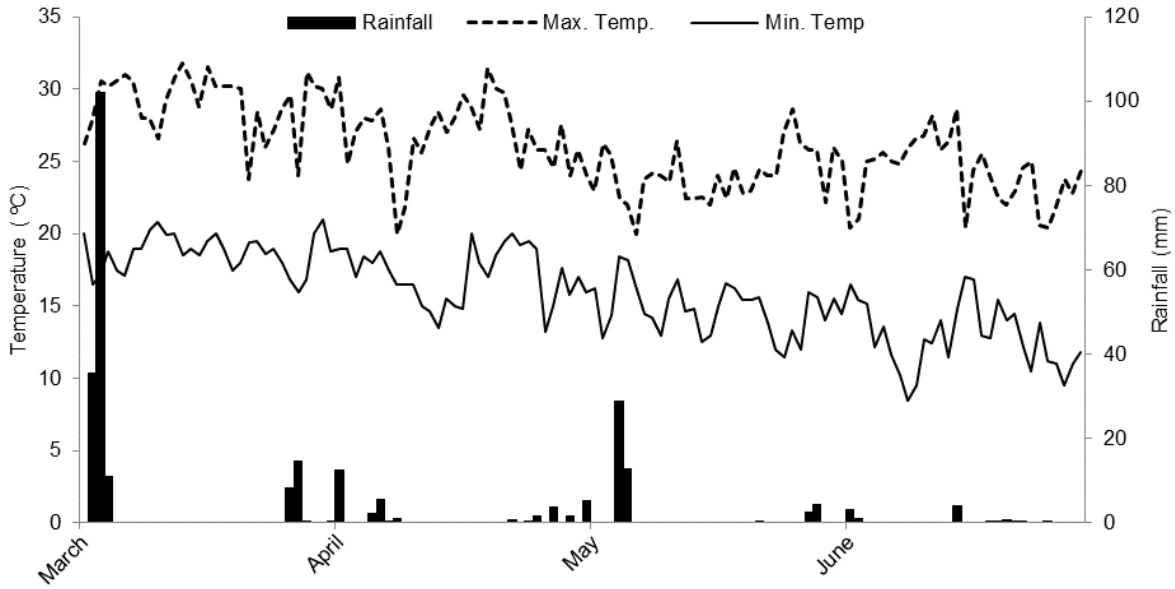
Each plot consisted of five rows of 5 m in length, spaced 0.50 m. The three central rows were considered as useful area, 0.50 m being discarded at each end. Planting fertilization was done based on soil chemical analysis, using 200 kg ha^{-1} of the formulation N-P-K 08-28-16. The sowing was done on March 2, 2015, using a regulated tractor seeder to distribute 10 seeds per linear meter of row. The cultivar used was BRS Tumucumaque, which has plants with semi-artificial architecture, purple pods and white grains (Oliveira et al., 2014). The rainfall data and maximum and minimum temperatures for the study period are shown in Figure 2. During the test, supplementary irrigation was carried out by means of spraying when necessary.

Before the desiccant applications, 10 plants were randomly sampled in each plot, from which seeds were collected to determine the water content by the greenhouse method at 105 ± 3 °C for 24 hours (Brasil, 2009). The water content of the seeds at seasons I, II, III and IV was 58, 54, 25 and 23%, respectively.

In the application of the desiccants, a costal sprayer maintained at a constant pressure of 200 kPa, equipped with a bar with two XR11002 tips, spaced 0.5 m, with a syrup volume of 200 L ha^{-1} was used.

After application of the desiccants, the plants were monitored daily until they appeared completely defoliated with dry pods. Harvest was carried out at different seasons, as described in

Figure 1 - Coloring of the pods at the different desiccation seasons: Season I: 50% of the pods with seeds formed, but still with green coloration (A); Season II: 70% of the pods in the purple coloration (B); Season III: 90% of the pods in the brown coloration (C); Season IV: 100% of the pods in the brown coloration (C); and Control: treatment without application of desiccant herbicide and harvested when 100% of the total pods were brown (C).



Source: INMET (2015).

Figure 2 - Daily data of precipitation and maximum and minimum air temperatures during the period of conduction of the experiment in the field. Viçosa (MG), 2015.

Table 1. After harvesting, productivity was determined by evaluating all the plants contained within the useful area of each plot, which were manually harvested and dried in the sun; then the pods were threshed manually. When weighing, the water content of the seeds was determined by the greenhouse method, at 105 ± 3 ºC, for 24 hours (Brasil, 2009), for correction of the weight to 13% of humidity. Productivity was calculated and expressed in kg ha^{-1}.

Table 1 - Period of anticipation of harvest, time between sowing and harvest (cycle), period between application of desiccant and harvest and date of harvest of cowpea, in relation to the control without desiccation

Season of desiccation	Desiccant				
	Anticipation of harvest (days)				
	Paraquat	Paraquat sequential application	Glufosinate-ammonium	Glyphosate with paraquat sequential application	Paraquat + diuron
Season I	13	11	13	9	13
Season II	9	8	8	6	9
Season III	2	0	0	-	2
Season IV	-	-	-	-	-
Cycle of the crop (days)					
Season I	99	101	99	103	99
Season II	103	104	103	106	103
Season III	110	112	110	115	110
Season IV	117	119	117	121	117
Control	112				
Period between desiccation and harvesting(1) (days)					
Season I	6	8	6	10	6
Season II	4	5	4	7	4
Season III	5	7	5	10	5
Season IV	5	7	5	9	5
Date f the harvest					
Season I	June, 2	June, 4	June, 2	June, 6	June, 2
Season II	June, 6	July, 6	June, 6	June, 9	June, 6
Season III	June, 13	June, 15	June, 13	June,18	June, 13
Season IV	June, 20	June, 22	June, 20	June,24	June, 20
Control	June, 15				

(1) for treatments with sequential application, the first application was taken into account. Season I: 50% of the pods with seeds formed, but still with green coloration; Season II: 70% of the pods in the purple coloration; Season III: 90% of the pods in the brown coloration; Season IV: 100% of the pods in the brown coloration; Control: treatment without application of desiccant herbicide and harvested when 100% of the total pods were brown.

Subsequently, the seeds stored in paper bags were kept in an air-conditioned room at a temperature of 20 °C and a relative humidity of 60%, to carry out the following evaluations:

Test of seed uniformity (retention in sieves): Test of seed uniformity (retention in sieves): the total samples of each plot, after weighing, were passed in a set of five-dimensional, inch-sized, metal oblong sieves: 13/64 x ¾ (Sieve 13), 12/64 x ¾ (Sieve 12), 11/64 x ¾ (Sieve 11), 10/64 x ¾ (Sieve 10) and 9/64 x ¾ (Sieve 9). At the end, each fraction retained by sieve was weighed, and the result, expressed as a percentage (Brasil, 2009). Only the results concerning the sieves 12 and 11 of the uniformity test will be presented and discussed, since they presented, together, seed retention of more than 90%.

Mass of 100 seeds: two subsamples of 100 seeds of the production, obtained in each field repetition, were used to determine the mass, by weighing in a precision scale (0.01 g). At the end, the mass of the 100 seeds was corrected for the water content of 13%.

First germination count: performed in conjunction with the germination test, the number of normal seedlings was evaluated on the fifth day after the start of the test. The results were expressed as percentage of normal seedlings (Brasil, 2009).

Germination test: three subsamples of 50 seeds were used for each field repetition, placed to germinate on paper roll (Germitest type), moistened with distilled water in the amount of 2.5 times the weight of the dry substrate. After preparation of the rolls, these were packed in plastic bags and kept in BOD at a constant temperature of 30 °C. The normal seedlings were counted on the eighth day after the test, and the results were expressed as percentage of normal seedlings according to (Brasil, 2009).

Sand emergence: it was conducted in a greenhouse, using three subsamples of 50 seeds for each field repetition. These were sown three centimeters deep in plastic trays containing sand washed and sterilized. Irrigation was done with sprays in two irrigations daily. Count of emerged seedlings was performed on the eighth day after sowing. The results were expressed as a percentage.

Emergency speed index: was determined in conjunction with the emergency test. The emerged seedlings were counted daily until stabilization of the number of seedlings. Only seedlings with cotyledons above the substrate were counted. The emergence speed index of the seedlings was calculated according to Maguire (1962).

The data were submitted to the normality test (Lilliefors) and to the uniformity of variance, and then to the analysis of variance. When the desiccant x desiccation season was significant ($p<0.05$), the necessary unfolding was performed. The averages were compared by the Tukey test ($p<0.05$), and the control was compared with the other treatments by the Dunnet test ($p<0.05$). The statistical analysis of the data was performed with the aid of the Computational Application in Genetics and Statistics GENES (Cruz, 2006).

RESULTS AND DISCUSSION

The desiccation of the cowpea in season I provided the anticipation of the harvest and consequent reduction of the crop cycle between 9 and 13 days in relation to the treatment without desiccant, while the desiccation in season II resulted in anticipation between 9 and 6 days, with higher reduction rates observed for the desiccants paraquat, paraquat+diuron, glufosinate-ammonium and sequential application of paraquat (Table 1). In the III season, the harvest anticipation was only two days, when the treatments paraquat and paraquat + diuron were applied. The desiccation in the IV season resulted in a prolongation of the cycle in at least five days, due to the necessity of a period between the application of the herbicide and the harvest.

Harvest anticipation is an important factor in seed production when it is intended to harvest a high-quality product, as it allows the maintenance of seed vigor and viability, through the reduction of exposure to potentially unfavorable climatic events (Daltro et al., 2010). It is worth mentioning that weather conditions such as mild temperatures during the conduction of the test (Figure 1), provided the prolongation of the crop cycle, highlighting the benefit of desiccation in anticipation of the harvest, according to Oliveira et al. (2014) the cultivar BRS Tumucumaque cycle is 65 to 70 days in tests performed at higher temperatures. However, the same may not be observed for high temperature climate regions, where the natural drying of the plants is much more accelerated, as these conditions may provide a reduction of the crop cycle, so that harvest anticipation does not occur (Lacerda et al., 2001).

Analyzing the productivity, it was observed that the desiccation of the cowpea plants in the seasons I and II yielded results inferior to those of the control and the other desiccation periods (Table 2). Pelúzio et al. (2008) also detected significant reductions in the production of soybean seeds when desiccation was performed at a stage prior to physiological maturity, in relation to the other stages and to the control that did not receive desiccant application. According to these authors, this happened because possibly the plant was still translocating photoassimilates to the seed and, with desiccation, the supply stopped, which directly affected the productivity reduction.

For the uniformity test, it was observed that in season I, independently of the desiccant, the percentage of seeds retained in sieve 11 (lowest sieve) was higher than that of control, and the percentage of seeds retained in sieve 12 (highest sieve) was lower than the control (Figure 3), that is, there was a higher proportion of seeds of smaller size. At this time of desiccation, cowpea plants were found to have a high degree of maturity of pods when compared to later seasons. In the same plant it was possible to observe pods in formation, green, purple and brown. As the desiccants act mainly to damage the plasma membrane structure, there is a sudden cessation in the transport and storage of reserves, not allowing the seeds to complete the maturation

Table 2 - Productivity (kg h$^{-1)}$ e and mass of one hundred seeds (g) of cowpea (*Vigna unguiculata*) from plants submitted to the application of desiccant herbicides at different seasons before harvest and harvested without desiccation

Desiccant	Desiccation seasons			
	Season I	Season II	Season III	Season IV
Productivity				
Paraquat	955.72*	1048.36*	1977.62	2215.09
Paraquat sequential application	855.88*	860.05*	2110.30	1930.03
Glufosinate-ammonium	937.28*	1001.93*	2045.53	2109.60
Glyphosate with paraquat sequential application	1024.38*	1162.80*	2204.20	2216.02
Paraquat + diuron	925.98*	1148.24*	2107.26	2093.90
Average	939.80 B	1044.28 B	2088.98 A	2113.02 A
Control	2131.09			
DMS (Dunnet)	459.80			
CV (%)	13.77			
Mass of one hundred seeds				
Paraquat	15.10 Bab*	14.95 Ba*	16.75 Aa	16.45 Aa
Paraquat sequential application	14.47 Bb*	15.00 Ba*	16.70 Aa	17.01 Aa
Glufosinate-ammonium	14.64 Bab*	15.02 Ba*	16.53 Aa	16.85 Aa
Glyphosate with paraquat sequential application	15.44 Ba*	15.25 Ba*	16.54 Aa	16.59 Aa
Paraquat + diuron	14.90 Bab*	15.26 Ba*	16.31 Aa	16.51 Aa
Control	16.6			
DMS (Dunnet)	0.9908			
CV (%)	2.95			

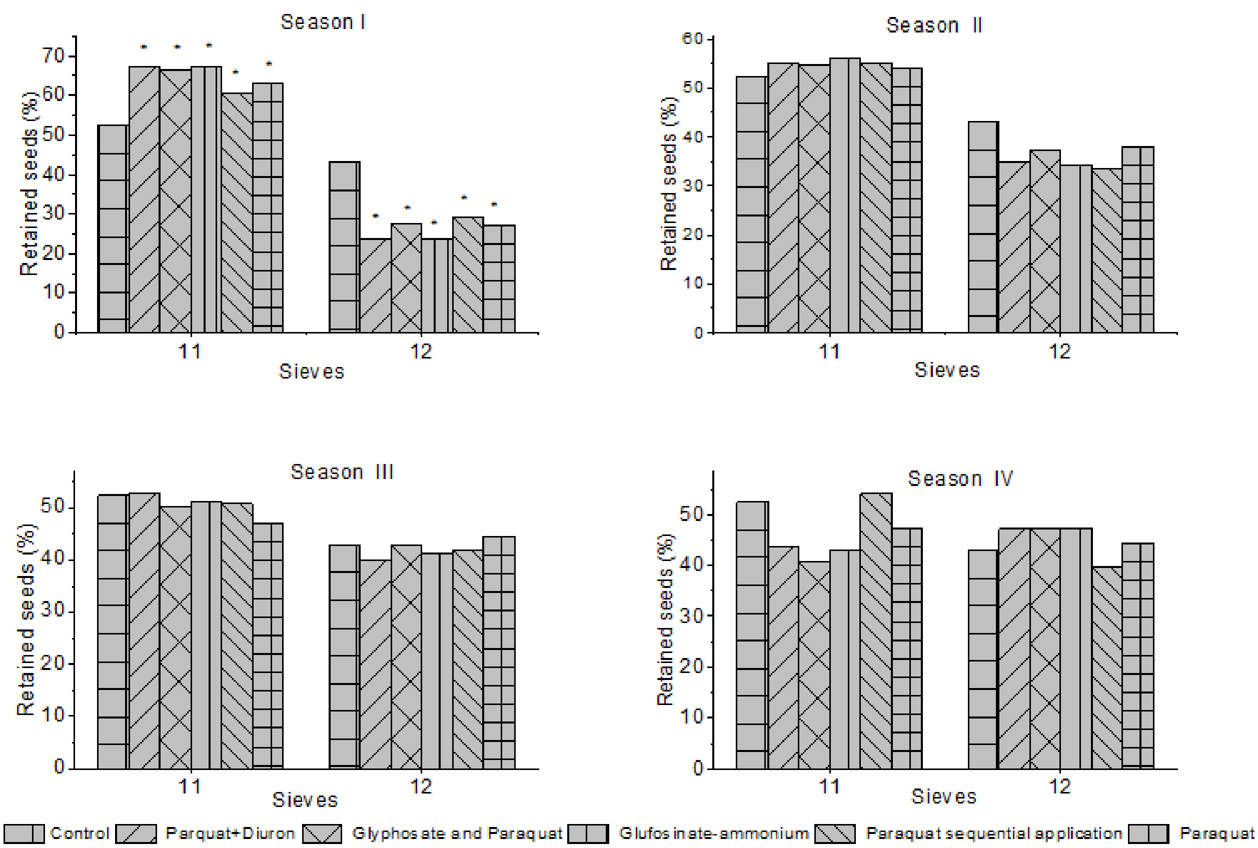
Averages followed by the same letter, upper case in the row and lower case in the column, do not differ statistically from each other by the Tukey test ($P<0.05$). Season I: 50% of the pods with seeds formed, but still with green coloration; Season II: 70% of the pods in the purple coloration; Season III: 90% of the pods in the brown coloration; Season IV: 100% of the pods in the brown coloration; Control: treatment without application of desiccant herbicide and harvested when 100% of the total pods were brown. * They differ from the control by the Dunnet test ($P<0.05$).

process (Larceda et al., 2001; Marcos Filho, 2015), which results in larger quantities of immature, malformed and small seeds. This fact can be observed in Table 2, where it can be observed for the mass variable of one hundred seeds that the desiccation in the seasons I and II resulted in seeds with a lower mass than those collected in the control without desiccation and in the treatments with desiccation in the seasons III and IV.

The lower mass of one hundred seeds with desiccation at seasons I and II is possibly associated with the fact that the seeds did not fully complete phase III at the maturation stage, where, according to Pereira et al. (2015), the accumulation of dry matter is intensified until reaching the maximum point. In addition, less favorable conditions of relative humidity and temperature during the seed harvest period, as observed in Figure 1 for seasons I and II, may have contributed to the reduction of seed mass, since under these conditions there is acceleration of the respiratory process and of oxidation of reserve substances (Marcos Filho, 2015).

It is also observed that the desiccation of the plants in season I, with glyphosate and sequential application of paraquat, resulted in the production of seeds of greater mass in relation to the sequential application of paraquat treatment (Table 2). The longer interval between the application and the glyphosate effect contributed to the results obtained. This is because glyphosate is a systemic desiccant whose final effect takes 10 to 15 days after the application, without interrupting immediately the transfer of dry matter to the seed, as it happens with the other evaluated herbicides, that have contact action, but with a faster effect, preventing the seed from continuing to accumulate dry matter (Marcos Filho, 2015).

In the first germination count and seed germination tests of dried cowpea plants in season I, there was a high incidence of fungi, possibly compromising seed vigor, interfering with the results (Table 3). The high incidence observed may be related to the fact that the seeds were



Season I: 50% of the pods with seeds formed, but still with green coloration; Season II: 70% of the pods in the purple coloration; Season III: 90% of the pods in the brown coloration; Season IV: 100% of the pods in the brown coloration; Control: treatment without application of desiccant herbicide and harvested when 100% of the total pods were brown. (*) They differ from the control by the Dunnet test (P<0.05).

Figure 3 - Proportion of cowpea (*Vigna unguiculata*) seeds from plants submitted to the application of desiccant herbicides at different seasons before harvest and harvested without desiccation, retained in sieves 12 and 11.

harvested under unfavorable weather conditions, with frequent incidence of rainfall in the experimental area (Figure 1), which is why they became more susceptible to fungal infections. However, for the sand emergency test, there was no direct interference of fungi, even for seeds from dried plants at season I (Table 4). The possibility of escape by the seedlings, which, when emerging in the sand, leave the contaminated tegument in it, leaving the cotyledons free of these fungi, probably contributed to the results not being compromised.

Analyzing the percentages and the emergency speed index (Table 4), it was observed that the desiccation of the cowpea plants, regardless of the season, did not affect the physiological quality of the seeds when compared to the control. Hubner Junior and Toledo (2016) also observed that the viability of the cowpea seeds was not influenced by the desiccation of the plants.

Evaluating the isolated effect of desiccants on the emergency speed index (Table 4), a higher index was observed for seeds from plants desiccated with glyphosate with sequential application of paraquat, in relation to the treatments that received paraquat and glufosinate-ammonium. As discussed earlier, the longer interval between the application and the effect of glyphosate contributes so that the seeds do not immediately interrupt the dry matter transfer during the maturation process, thus producing more vigorous seeds, since the accumulated reserves are responsible for the nutrient supply and energy required for the full manifestation of the vital functions of the seeds and for the formation of seeds of higher physiological quality (Marcos Filho, 2015).

The application of the desiccants, when the cowpea plants had 50% of the pods with green coloration and seeds formed (season I) and 70% of the pods in the purple coloration (season II), negatively affected the seed yield. However, regardless of the season of desiccation, the physiological quality of the seeds was not affected by desiccant herbicides.

Table 3 - First germination (%) and germination (%) counts of cowpea (*Vigna unguiculata*) seeds from plants submitted to the application of desiccant herbicides at different seasons before harvest and harvested without desiccation

First count of the germination				
Desiccant	Desiccation seasons			
	Season I	Season II	Season III	Season IV
Paraquat	68 Ba*	81 Aa	83 Aa	74 Ba
Paraquat sequential application	70 Ba*	80 ABa	85 Aa	83 Aa
Glufosinate-ammonium	78 Aa	81 Aa	82 Aa	84 Aa
Glyphosate with paraquat sequential application	76 Aa	82 Aa	85 Aa	83 Aa
Paraquat + diuron	68 Ba*	82 Aa	84 Aa	85 Aa
Control	86			
DMS (Dunnet)	13.6476			
CV (%)	8.07			
Germination				
Paraquat	68,5 Bb*	83 Aa	84 Aa	81 Aa
Paraquat sequential application	71 Bab*	82 Aa	86 Aa	84 Aa
Glufosinate-ammonium	79 Aa	83 Aa	85 Aa	86 Aa
Glyphosate with paraquat sequential application	79 Aa	85 Aa	87 Aa	85 Aa
Paraquat + diuron	70 Bab*	83 Aa	86 Aa	87 Aa
Control	87			
DMS (Dunnet)	11.2018			
CV (%)	6.47			

Averages followed by the same letter, upper case in the row and lower case in the column, do not differ statistically from each other by the Tukey test ($P<0.05$). Season I: 50% of the pods with seeds formed, but still with green coloration; Season II: 70% of the pods in the purple coloration; Season III: 90% of the pods in the brown coloration; Season IV: 100% of the pods in the brown coloration; Control: treatment without application of desiccant herbicide and harvested when 100% of the total pods were brown. * They differ from the control by the Dunnet test ($P<0.05$).

Table 4 - Sand emergency (%) and emergence speed index of cowpea (*Vigna unguiculata*) seeds from plants submitted to the application of desiccant herbicides at different seasons before harvest and harvested without desiccation

Sand emergency				
Desiccant	Desiccation seasons			
	Season I	Season II	Season III	Season IV
Paraquat	80 Bb	88 Aa	88 Aa	84 ABab
Paraquat sequential application	91 Aa	87 Aa	88 Aa	82 Bb
Glufosinate-ammonium	85 Aab	84 Aab	83 Aa	87 Aa
Glyphosate with paraquat sequential application	86 ABab	79,8 Bb	87 ABa	89 Aa
Paraquat + diuron	85 Aab	85 Aab	90 Aa	88 Aa
Control	87			
DMS (Dunnet)	8.6935			
CV (%)	4.78			
Emergency speed index				
Paraquat	9.36 b			
Paraquat sequential application	9.84 ab			
Glufosinate-ammonium	9.36 b			
Glyphosate with paraquat sequential application	10.42 a			
Paraquat + diuron	9.69 ab			
Control	10.17			
DMS (Dunnet)	2.20			
CV (%)	10.64			

Averages followed by the same letter, upper case in the row and lower case in the column, do not differ statistically from each other by the Tukey test ($P<0.05$). Season I: 50% of the pods with seeds formed, but still with green coloration; Season II: 70% of the pods in the purple coloration; Season III: 90% of the pods in the brown coloration; Season IV: 100% of the pods in the brown coloration; Control: treatment without application of desiccant herbicide and harvested when 100% of the total pods were brown. * They differ from the control by the Dunnet test ($P<0.05$).

The desiccants paraquat, glufosinate-ammonium and the paraquat+diuron mixture, when applied to cowpea plants with 50% of green-colored pods and with seeds formed (season I), provided an anticipation of the 13 day harvest, but affected the productivity.

ACKNOWLEDGEMENTS

To the Coordination for the Qualification of Higher-Level Staff (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES),code 001. To the Foundation for Supporting Research in the states of Minas Gerais (Fundação de Amparo à Pesquisa do Estado de Minas Gerais – FAPEMIG and the National Council for Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPq), for granting financial resources for the development of the project. To the company Sementes TOMAZETTI, for the collaboration in the accomplishment of this research.

REFERENCES

Sistemas de Agrotóxicos Fitossanitários - AGROFIT [acessado em: 04 de ago. 2017]. Disponível: http://agrofit.agricultura.gov.br/agrofit_cons/principal_agrofit_cons.

Brasil. Ministério da Agricultura, Pecuária e Abastecimento. Regras para análise de sementes. Brasília, DF: 2009.

Cruz CD. Programa Genes: Biometria. Viçosa, MG: UFV; 2006.

Daltro EMF, Albuquerque MCF, França Neto JB, Guimarães SC Piza Gazziero DL, Henning AA. Aplicação de dessecantes em pré-colheita: efeito na qualidade fisiológica de sementes de soja. Rev Bras Sementes. 2010;32(1):111-122.

Freire Filho FR, Ribeiro VQ, Rocha MM, Silva KJD, Nogueira MSR, Rodrigues EV. Produção, melhoramento genético e potencialidades do feijão-caupi no Brasil [cd-rom]. In: Resumos 4ª Reunião Nacional de Biofortificação. Teresina: 2011. Teresina: Teresina Embrapa Meio Norte; 2011.

He YQ, Cheng JP, Liu LF, Li XD, Yang B, Zhang HS et al. Effects of pre-harvest chemical application on rice desiccation and seed quality. J Zhejiang Univ Sci B. 2015;16(10):813-23.

Hubner Junior S, Toledo MZ. Viabilidade de sementes de feijão-caupi colhidas em diferentes épocas em áreas dessecadas em pré-colheita. Rev Eletr Faculdade de Ciências Exatas e da Terra - produção/construção e tecnologia. 2016;5:75-85.

Jaskulski D, Jaskulska I. The effect of pre-harvest glyphosate application On grain quality and volunteer winter wheat. Romanian Agric Rese. 2014;31:283-9.

Kappes C, Carvalho MAC, Yamashita OM. Potencial fisiológico de sementes de soja dessecadas com diquat e Paraquat. Sci Agr. 2009;10:1-6.

Kappes C, Arf O, Ferreira JP, Portugal JR, Alcalde AM, Arf MV. et al. Qualidade fisiológica de sementes e crescimento de plântulas de feijoeiro, em função de aplicações de Paraquat em pré-colheita. Pesq Agropec Trop. 2012;42:9-18.

Lacerda ALS, Lazarini E, Sá ME, Walter Filho VV. Aplicação de dessecantes na cultura da soja: antecipação da colheita e produção de sementes. Planta Daninha. 2001;19(3):381-90.

Lacerda ALS, Lazarini E, Sa ME, Valerio Filho WV. Armazenamento de sementes de soja dessecadas e avaliação da qualidade fisiológica, bioquímica e sanitária. Rev Bras Sementes. 2003;25(2):97-105.

Lacerda ALS, Lazarini E, Sa ME, Valerio Filho WV. Efeitos da dessecação de plantas de soja no potencial fisiológico e sanitário das sementes. Bragantia. 2005;64(3):447-57.

Maguire JD. Speed of germination-aid in selection and evaluation for seedling emergence and vigour. Crop Sci. 1962;2:176-7.

Marcos Filho J. Fisiologia de sementes de plantas cultivadas. Londrina: Abrates; 2015.

McNaughton KE, Blackshaw RE, Waddell KA, Gulden RH, Sikkema PH, Gillard CL. Effect of application timing of glyphosate and saflufenacil as desiccants in dry edible bean (*Phaseolus vulgaris* L.). Can J Plant Sci. 2015;95(2):369-75.

Nogueira NW, Freitas RMO, Torres SB, Leal CCP. Physiological maturation of cowpea seeds. J Seed Sci. 2014;36(3):312-7.

Oliveira IJ, Fontes JRA, Silva KJD, Rocha MM. BRS Tumucumaque: cultivar de feijão-caupi com valor nutritivo para o Amazonas. Manaus: Embrapa Amazônia Ocidental; 2014. (Comunicado técnico, 106)

Pelúzio JM, Ramo LN, Fidelis RR, Afférri FS, Castro Neto MD, Correia MAR. Influência da dessecação química e retardamento de colheita na qualidade fisiológica de sementes de soja no sul do estado do Tocantins. Biosci J. 2008; 24(2):77-82.

Pereira T, Coelho CMM, Souza CA, Mantovani A, Mathias V. Dessecação química para antecipação de colheita em cultivares de soja. Semina: Cienc Agr. 2015;36(4):2383-94.

Sauer H, Wild A, Rühle W. The effect of phosphinotricin (glufosinate) on photosynthesis. II. The causes of inhibition of cell photosynthesis. Z. Naturforsch. 1987;42c:270-8.

Silva AA, Ferreira LR, Santos JB. Biologia de plantas daninhas. In: Silva AA, Silva JF, Tópicos em manejo de plantas daninhas. Viçosa, MG: Universidade Federal de Viçosa; 2007. p.17-55.

Tavares CJ, Ferreira PC, Jakelaitis A, Sales JF, Resende O. Physiological and sanitary quality of desiccated and stored azuki bean seeds. Rev Caatinga. 2016;29:66-75.

Teixeira IR, Silva GC, Oliveira JPR, Silva AG, Pelá A. Desempenho agronômico e qualidade de sementes de cultivares de feijão-caupi na região do cerrado. Rev Cienc Agron. 2010;41(2):300-7.