DISINFECTION OF COWPEA (*Vigna unguiculata)* SEEDS ON SEEDLINGS DEVELOPMENT †

[DESINFECCIÓN DE SEMILLAS DE CAUPÍ (*Vigna unguiculata*) EN EL DESARROLLO DE PLÁNTULAS]

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SUMMARY

The fast expansion of annual crops in recent decades with little phytosanitary management has led to the dissemination of several pathogens in the Brazilian cowpea-producing regions. Although, seed treatment is a common practice, there are no registered products for the cowpea and farmers apply the fungicides recommended for soybean cultivation. This study aimed to evaluate the influence of sodium hypochlorite and fungicidal treatments on the germination and initial development of seedlings of five cowpea cultivars under greenhouse conditions. Two experiments were established, one with seeds of five cultivars stored during 120 d, and another with newly collected seeds, disinfected or not with sodium hypochlorite, and treated with five fungicides. Emergence in sand, germination speed, and dry mass of seedlings were evaluated. Germination in sand, germination speed and dry mass of seedlings obtained from seeds of cowpea cultivars were negatively influenced by sodium hypochlorite disinfection. Fungicides used negatively influenced cowpea seed vigor for BRS Cauamé and BRS Novaera, even in the absence of sodium hypochlorite. Seed germination of five cowpea cultivars was not affected by the fungicides fludioxonil, carbendazim, carbendazim + thiram and carboxin + thiram.

Key words: *Vigna unguiculata;* seedling emergence; seedling vigor.

RESUMEN

La rápida expansión de cultivos anuales, en las últimas décadas, sin ningún tipo de cuidado fitosanitario, ha activado la propagación de varios patógenos en las regiones productoras de caupí de Brasil. Aunque la técnica de desinfección de semillas es una práctica común, no hay disponibles productos registrados para caupí y los agricultores aplican los fungicidas recomendados para el cultivo de la soya. El objetivo de este estudio fue evaluar la influencia del tratamiento con hipoclorito y fungicida sobre la germinación de semillas y el desarrollo inicial de plántulas de cinco cultivares de frijol en condiciones de invernadero. Se establecieron dos experimentos, el primero con cinco cultivares de semillas almacenadas durante 120 d, y el segundo con semillas recién cosechadas, con o sin desinfección mediante hipoclorito de sodio, y tratadas con cinco fungicidas. Se evaluó la germinación en arena, la velocidad de germinación y el peso seco de las plántulas. La germinación en arena, la velocidad de germinación y el peso seco de las plántulas obtenidas a partir de semillas de los cinco cultivares de frijol estuvieron influidos negativamente por la desinfección con hipoclorito de sodio. Los fungicidas usados afectaron negativamente el vigor de las semillas de caupí BRS Cauamé y BRS Novaera, incluso en ausencia de hipoclorito de sodio. La germinación de las semillas de los cinco cultivares de frijol no fue afectada por los fungicidas fludioxonil, carbendazim, carbendazim + thiram, y carboxin + thiram.

Palabras clave: *Vigna unguiculata;* emergencia de plántulas; vigor de plántulas.

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INTRODUCTION

In Brazil, the cowpea contributes to around 30% of the planted area and 15% of the total production of beans (cowpea + common beans) (Smiderle *et al*., 2016). Historically, the cowpea [*Vigna unguiculata* (L.) Walp.] production is concentrated in the Northeast (1.2 million ha) and North (55.8 thousand ha) regions of the country (Smiderle *et al*., 2017a). However, the crop is gaining production areas in the Central-West region due to cultivars with traits favorable to mechanized cultivation (Oliveira *et al*., 2015; Filgueiras *et al*., 2009). Cowpea is a staple food for low income populations of the Brazilian Northeast region and are grown mainly under subsistence conditions (Torres *et al*., 2015; Teófilo *et al.*, 2008; Amaral *et al*., 2005). Its traits include a short cycle, low water requirement and hardiness, which in addition to the development in low fertility soils, makes cowpea an attractive crop (Almeida *et al*., 2014; Xavier *et al*., 2008).

Seed is one of the essential components for agricultural production and its genetic quality associated to the physical, sanitary and physiological conditions, directly influence the production potential of the crop (Oliveira *et al*., 2016; Smiderle *et al*., 2017b). Thus, to obtain high crop yields seedling emergence and the number of established seedlings per unit of area must be guaranteed (Rodrigues *et al*., 2015). To obtain plant uniformity in the field, fungicides treatment of seed has been used intensively by farmers in large crops, such a soybean and corn; this provide immediate and long-run benefits (Ceccon *et al*., 2013).

In the Amazonia region, studies have shown increased grain yield with the inoculation of bacteria of the genus *Bradyrhizobium* in cowpea seeds (Lacerda *et al*., 2004; Zilli *et al*., 2006, 2009). Positive effects of inoculation of the cowpea in different edaphoclimatic regions enables increased grain yield of the crop and provides an alternative to nitrogen fertilization (Franco *et al*., 2002). Fungicides are chemical compounds acting as protectants, with healing and systemic action in plants (Juliatti, 2017). Chemical treatments are able to control seed pathogens present in soil and storage, and early leaf pathogens (Sallis *et al*., 2001; Torres and Bringel, 2005; Menten and Moraes, 2010). In areas where planting is annual, seed treatment with fungicides is necessary to avoid the incidence of diseases present in the soil affecting the crop. The fast expansion of crops in recent decades, often with little phytosanitary management, has led to the dissemination of many pathogens in the cowpea-producing regions, as the seed is the main carrier of dissemination and introduction into new growing areas (Henning, 2004; Torres and Bringel, 2005). Although seed treatment is a common practice, there are no products registered for cowpea, and many farmers apply fungicides recommended for soybean (Concenço *et al*., 2015). Nevertheless, the effect of fungicides on the germination and initial development of cowpea seedlings is unknown. In addition, initial tests for selection of nitrogen-fixing bacteria employ seed-disinfection methods, including sodium hypochlorite, to eliminate bacteria and other microorganisms that can influence the performance of new strains (Xavier *et al*., 2006). Therefore, this study aimed to verify the influence of sodium hypochlorite and fungicide treatment on seed emergence and initial development of seedlings of five cowpea cultivars under greenhouse conditions.

MATERIAL AND METHODS

From December 2010 to January 2011, two experiments were conducted under controlled conditions (28 ºC; 65 ± 5% of air relative humidity) in a greenhouse in the station Roraima, EMBRAPA, located at BR174, Km 08, municipality of Boa Vista–RR, Brazil. In the first experiment, seeds stored for 120 d were sown. In the second experiment, recently-collected seeds were utilized to verify the influence of the treatments on seeds with germination differences. Cowpea cultivars utilized in the experiments were: 'BRS Guariba', 'BRS Novaera', 'BRS Tumucumaque', 'BRS Cauamé' and 'BRS Xiquexique'. Seeds of the five cultivars were disinfected or not in a 2.5% solution of sodium hypochlorite (commercial NaClO) for 5 min, followed by five successive washings with distilled water and later drying at room temperature. Then, seed were treated with four different fungicide treatments, alone or in combination (fludioxonil, carbendazim, carbendazim + thiram, carboxin + thiram) plus the control. Fungicides were applied according to the dose recommended by the manufacturer for utilization in soybean seeds (Table 1) and dried at room temperature in the laboratory. Both experiments were conducted in a randomized block design with three replicates in a factorial scheme 5 x 5 x 2.

For each cultivar, recently collected seeds presented a mean of 95% in germination, and 85% for stored seeds. Agronomic traits such as cropping cycle in days, growth habit of the plants and 100-seed mass of the five cultivars utilized in this study are shown in Table 2.

Table 1. Concentration of active ingredients of fungicides, and dose utilized in the treatment of cowpea seeds.

Fungicide	Active ingredient	Commercial concentration	Dose of commercial product (mL kg^{-1} of seeds*)
Maxim	fludioxonil	25 g L^{-1}	2
Derosal 500sc	carbendazim	500 g L^{-1}	1
Derosal plus	carbendazim + thiram	150 +350 g L^{-1}	2
Vitavax+thiram	carboxin + thiram	200 + 200 g L^{-1}	30

*Recommended dose for soybean crop.

Table 2. Cropping cycle, growth habit, and 100-seed mass of the cultivars BRS Guariba, BRS Novaera, BRS Tumucumaque, BRS Cauamé and BRS Xiquexique, used in this research.

Cultivars	Cropping cycle (d)	Growth habit	100-seed mass (g)
BRS Guariba	65-70	Semi-erect	19.5
BRS Novaera	65-70	Semi-erect	20.0
BRS Tumucumaque	65-70	Semi-erect	20.5
BRS Cauamé	65-70	Semi-erect	17.2
BRS Xiquexique	65-75	Semi-prostrate	16.5

Each fungicidal treatment consisted of 10 g of seeds of each cowpea cultivar, arranged in 50 mL plastic cups. Following the fungicide treatment, seeds were sown in plastic pots containing 2 kg of medium-textured sand as substrate, with 10 seeds of each cultivar per pot. Three replicates were performed for each cultivar and each of the five treatments. Humidity in the pots was maintained close to 70%, by adding distilled water according to weight. After sowing, the following trials were evaluated: a) Sand Emergence: counts of normal emerged seedlings were performed from the start of emergence until 10 days, with results expressed in percentage (Brasil, 2009). b) Emergence Speed: daily counts of the number of emerged seedlings until the 10th day after planting (dap). At the end of the test, the index was calculated through the sum of the number of emerged seedlings on each day, divided by the number of days elapsed between sowing and emergence (Maguire, 1962). Dry Matter Mass: all emerged seedlings were collected after the last count on day seven. Seedlings were washed in running water to eliminate residues of the substrate and placed into paper bags for drying in an air circulation oven at 60 ºC until they reached constant weight. Next, mass was determined on samples on a 0.001 g precision balance. Data on each experiment was submitted to analysis of variance and means were compared by the Tukey test (P = 0.05) using the program Sisvar (Ferreira, 2011).

RESULTS

There were no significant differences in the five evaluated cultivars nor between the different fungicide treatments in the absence of sodium hypochlorite (Table 3). Values of seed germination obtained were in accordance of accepted values for commercialization of large crops, such as cowpea (Brasil, 2009), which should be over 80 to 85%.

Mean germination speed did not differ between cultivars treated with all five fungicides and the control (Table 4) in the absence of sodium hypochlorite. Fungicide treatments did not influence dry mass for most of the cultivars, regardless of treatment with sodium hypochlorite (Table 5).

For the second experiment (Tables 6, 7 and 8), using recently collected seeds, values of emergence percentage and germination speed index obtained from the evaluated cultivars did not obtain significant difference when treated with the fungicides applied, with the exception of the cultivar BRS Cauamé, that obtained significant difference for the fungicide carbendazim + thiram, when the seeds were disinfected with sodium hypochlorite.

DISCUSSION

The application of sodium hypochlorite followed by fungicide treatments led to reduced emergence, compared to untreated seeds, with differences between the cultivars but not the fungicides treatment (Table 3) which was expected considering the genetic differences among cultivars (Xavier *et al.*, 2005). For the cultivar BRS Novaera, germination failed (7%) even in the control seeds receiving no fungicides, with no germination on the other treatments. Sodium hypochlorite (along with the fungicide) may have caused the death of the seeds. In common beans, Jauer *et al.* (2002) observed germination over 80%. According to Oliveira (1997), carioca bean seeds contaminated with *Rizoctonia solani*, treated with carboxin + thiram, presented good indices of disease control and germination of normal seedlings, similar to that found in the absolute control, showing that the non-germination of the seeds was not due to contamination by pathogens.

Table 3. Mean* values of sand emergence obtained from seeds stored for 120 days of five cowpea cultivars treated with fungicides, plus the control, either with or without sodium hypochlorite.

Fungicides	BRS Guariba		BRS Tumucumaque		BRS Cauamé		BRS Novaera		BRS Xiquexique	
Sand emergence	%		%		%		%		%	
with NaClO										
carbendazim + thiram	40	aA	20	aAB	27	aAB	0	aB	33	aA
carbendazim	33	aA	20	aAB	33	aA	0	aB	27	aAB
carboxin + thiram	40	aA	33	aA	40	aA	0	aB	20	aAB
fludioxonil	40	aA	40	aA	40	aA	0	aB	27	aAB
Control	46	aAB	27	aABC	53	aA	7	aC	20	aBC
Mean	40	A	28	BC	39	AB	2	D	26	C
without NaClO										
carbendazim + thiram	100	a	93	A	87	a	87	a	87	a
carbendazim	93	a	87	A	87	a	93	a	87	a
carboxin + thiram	100	a	93	A	80	a	93	a	87	a
fludioxonil	100	a	87	A	87	a	93	a	87	a
Control	93	a	87	A	100	a	93	a	93	a
Mean	97	A	89	A	88	A	92	A	88	A

*Means followed by equal small letters in the column, and capital letters in the line, do not differ from one another by Tukey test (P = 0.05).

Table 4. Mean* values of germination speed (index) obtained from seeds stored for 120 days of the five cowpea cultivars treated with fungicides, plus the control, either with or without sodium hypochlorite.

Fungicides	BRS Guariba		BRS Tumucumaque		BRS Cauamé		BRS Novaera		BRS Xiquexique	
with NaClO										
carbendazim + thiram	12.7	abA	5.5	aB	6.0	aAB	0.0	aB	8.3	aA
carbendazim	5.4	bAB	6.1	aB	9.2	aA	0.0	aB	6.0	aAB
carboxin + thiram	10.1	abA	9.2	a	10.0	aA	0.0	aB	5.0	aAB
fludioxonil	10.8	abA	10.4	a	9.7	aA	0.0	aB	7.3	aAB
Control	14.7	aA	5.8	aB	14.0	aA	1.3	aB	7.3	aAB
Mean	10.7	A	7.4	AB	9.8	AB	0.27	C	6.77	B
without NaClO										
carbendazim + thiram	32.8	aA	24.2	aB	20.0	aB	21.2	aB	24.0	aB
carbendazim	30.0	aA	25.6	aAB	21.7	aB	25.8	aAB	21.2	aB
carboxin + thiram	31.7	aA	27.8	aAB	22.3	aB	20.4	aB	24.1	aAB
fludioxonil	30.9	aA	24.3	aAB	23.1	aAB	28.3	aAB	21.5	aB
Control	25.3	aA	26.4	aA	25.9	aA	28.5	aA	24.6	aA
Mean	30.1	A	25.7	B	22.6	B	24.9	B	23.1	B

*Means followed by equal small letters in the column, and capital letters in the line, do not differ from one another by Tukey test (P = 0.05).

Table 5. Mean* seedlings dry matter mass (g) of seeds stored for 120 d of five cowpea cultivars treated with fungicides, plus the control, either with or without sodium hypochlorite.

Fungicides	BRS Guariba		BRS Tumucumaque		BRS Cauamé		BRS Novaera		BRS Xiquexique	
Seedling dry matter mass	g		g		g		g		g	
with NaClO										
carbendazim + thiram	11.7	aA	4.3	aAB	6.2	aAB	0.0	aB	8.3	aAB
carbendazim	7.7	aAB	6.6	aAB	10.1	aA	0.0	aB	7.7	aAB
carboxin + thiram	8.9	aAB	10.4	aA	7.7	aAB	0.0	aB	5.2	aAB
fludioxonil	11.5	aA	11.7	aA	10.7	aA	0.0	aB	9.7	aA
Control	14.1	aA	7.1	aABC	12.1	aAB	2.7	aB	4.5	aAB
Mean	10.8	A	8.0	A	9.4	A	0.5	B	7.1	A
without NaClO										
carbendazim + thiram	36.8	aA	24.3	aB	21.5	aB	22.2	aB	19.8	aB
carbendazim	25.1	bAB	28.7	aA	20.5	aAB	26.3	aAB	19.7	aB
carboxin + thiram	31.7	aA	30.1	aAB	22.7	aBC	23.6	aABC	20.7	aC
fludioxonil	31.5	aA	29.7	aAB	21.9	aBC	30.7	aAB	20.1	aC
Control	24.1	bAB	30.4	aA	22.0	aAB	25.0	aAB	20.1	aB
Mean	29.8	A	28.6	AB	21.7	BC	25.6	BC	20.1	C

*Means followed by equal small letters in the column, and capital letters in the line, do not differ from one another by Tukey test (P = 0.05).

Table 6. Mean* values of germination in sand (%), using recently collected seeds of five cowpea cultivars treated with fungicides, plus the control, with and without sodium hypochlorite.

Fungicides	BRS Guariba		BRS Tumucumaque		BRS Cauamé		BRS Novaera		BRS Xiquexique	
Sand emergence	%		%		%		%		%	
with NaClO										
carbendazim + thiram	37	aA	47	aA	27	bAB	0	aB	10	aAB
carbendazim	27	aBC	40	aAB	50	aA	0	aD	13	aCD
carboxin + thiram	33	aAB	37	aA	40	abA	0	aC	13	aBC
fludioxonil	37	aA	47	aA	50	aA	0	aB	3	aB
Control	33	aA	37	aA	47	abA	3	aB	3	aB
Mean	33	A	41	A	43	A	1	B	9	B
without NaClO										
carbendazim + thiram	100	a	90	a	90	a	100	a	97	a
carbendazim	97	a	87	a	83	a	90	a	87	a
carboxin + thiram	100	a	100	a	93	a	93	a	87	a
fludioxonil	97	a	90	a	97	a	100	a	87	a
Controle	93	a	93	a	97	a	83	a	90	a
Mean	97	A	92	A	92	A	93	A	92	A

*Means followed by equal small letters in the column, and capital letters in the line, do not differ from one another by Tukey test (P = 0.05).

Table 7. Mean* germination speed (index) obtained for recently collected seeds of five cowpea cultivars treated with fungicides, plus the control with and without sodium hypochlorite.

Fungicides	BRS Guariba		BRS Tumucumaque		BRS Cauamé		BRS Novaera		BRS Xiquexique	
with NaClO										
carbendazim + thiram	9.2	aA	11.0	aA	10.4	aA	0.0	aB	4.3	aAB
carbendazim	7.2	aBC	12.7	aAB	16.2	aA	0.0	aC	3.7	aC
carboxin + thiram	10.4	aAB	14.4	aA	13.4	aA	0.0	aC	4.3	aBC
fludioxonil	9.5	aA	16.1	aA	15.2	aA	0.0	aB	0.8	aB
Control	12.0	aA	15.6	aA	12.9	aA	2.3	aB	1.1	aB
Mean	9.7	B	14.0	A	13.6	A	0.47	C	2.9	C
without NaClO										
carbendazim + thiram	40.1	aA	34.7	aAB	28.6	aB	40.3	aA	33.2	aAB
carbendazim	40.2	aA	32.8	aAB	29.5	aB	34.4	aAB	28.3	aB
carboxin + thiram	38.0	aA	36.4	aA	30.7	aAB	32.9	aAB	27.2	aB
fludioxonil	42.8	aA	28.7	aC	32.4	aBC	37.5	aAB	31.3	aBC
Control	39.7	aA	35.7	aA	33.6	aA	34.7	aA	31.7	aA
Mean	40.1	A	33.7	BC	31.0	C	35.9	B	30.3	C

*Means followed by equal small letters in the column, and capital letters in the line, do not differ from one another by Tukey test (P = 0.05).

Table 8. Mean* dry matter mass of seedlings (g) obtained for recently collected seeds of the five cowpea cultivars treated with fungicides, plus the control, with or without sodium hypochlorite.

Fungicides	BRS Guariba		BRS Tumucumaque		BRS Cauamé		BRS Novaera		BRS Xiquexique	
Seedling dry matter mass	g		g		g		g		g	
with NaClO										
carbendazim + thiram	9.0	aAB	13.1	aA	7.9	aAB	0.0	aC	4.0	aBC
carbendazim	7.6	aAB	12.2	aA	12.9	aA	0.0	aC	3.6	aBC
carboxin + thiram	10.9	aAB	12.2	aA	12.3	aA	0.0	aC	4.0	aBC
fludioxonil	8.9	aA	13.2	aA	14.2	aA	0.0	aB	0.7	aB
Control	7.3	aAB	10.3	aA	7.9	aA	0.9	aB	0.9	aB
Mean	8.7	B	12.2	A	11.8	AB	0.17	C	2.6	C
without NaClO										
carbendazim + thiram	29.1	aB	26.9	aBC	24.0	cBC	38.0	aA	20.5	aC
carbendazim	29.7	aA	31.1	aA	29.9	bcCA	32.8	abA	19.9	aB
carboxin + thiram	27.3	aAB	26.5	aAB	26.5	cAB	30.6	bA	20.3	aB
fludioxonil	33.5	aAB	30.4	aB	38.2	aA	32.1	abAB	20.8	aC
Control	31.5	aAB	28.3	aB	35.7	abA	31.5	abAB	19.9	aC
Mean	30.2	AB	28.6	B	30.9	AB	33.0	A	20.3	B

*Means followed by equal small letters in the column, and capital letters in the line, do not differ from one another by Tukey test (P = 0.05).

On the other hand, the application of sodium hypochlorite reduced the indices of the five cultivars and in a distinguishing way, fungicides did not influence this process, except on BRS Guariba, in which there was a reduction in the indices obtained with the application of carbendazim (Table 4). BRS Novaera was found to be the most susceptible cowpea variety to sodium hypochlorite, with a mean index reduction of 24.9 to 0.27.

Germination speed (Table 4) of the cultivar BRS Guariba was higher regardless of the treatment in the absence of sodium hypochlorite, which is desirable, since the seedlings remain vulnerable to the adverse conditions of the medium for a shorter time during the early developmental stages (Santos and Correa, 2011). In the cultivar BRS Guariba, an effect of the fungicide carbendazim was found in the absence of sodium hypochlorite, but values were similar to those of the control. The dry mass of seedlings receiving sodium hypochlorite was lower for the five cultivars, when compared to those not receiving sodium hypochlorite; BRS Novaera presented a 50-fold reduction on mass, from 25.6 g to 0.5 g. Dry mass of seedlings was determined, considering that samples with the highest values were the most vigorous, since the most vigorous seeds produce seedlings with increased growth. Due to the greater translocation of storage tissue reserves for the growth of the embryonic axis. Souza *et al*. (2016), indicated that reserves of nutrients stored by plants in seeds are supplied to the embryo for development and establishment of the new plant. Disinfection with sodium hypochlorite negatively affected the three variables evaluated. These results are important, considering the need to understand the effects of sodium hypochlorite application on cowpea seeds stored for 120 d.

The application of sodium hypochlorite on the seeds of the five cowpea cultivars resulted in a reduction of the mean emergence values, from 92% or greater, obtained without application, to 43% or less, regardless of the fungicidal treatment (Table 6). These values remained below 51%, and in some cases there was no germination at all, for some fungicide treatments in the seeds of BRS Novaera. On the other hand, in the absence of sodium hypochlorite, no significant differences were found between cultivars and fungicides, with means above 82%. These values are higher than the minimum necessary for seed commercialization in Brazil.

Percentage of germination means of the recently collected seeds were above that accepted for commercialization in Brazil for the five cultivars, with BRS Guariba standing out with a mean of 97% emergence. Germination means obtained in this experiment were above the 80% obtained by Teixeira *et al*. (2010) and 90% obtained by Santos and Correa (2011), both of which used rolls of germitest towel paper, moistened with water 2.5 times the weight of the dry substrate and placed to germinate at 25 °C. In addition, the cultivar BRS Guariba (Table 7) also stood out with a mean germination speed index of 40.1, higher than that obtained by Santos and Correa (2011), who obtained germination speed indices below 11.09 for the evaluated cultivars. It was also higher than that obtained for the same cultivar when using seeds stored for 120 d. The good performance was probably due to the use of recently collected seeds and the greater vigor of this cultivar.

Results obtained in relation to sodium hypochlorite disinfection were quite pronounced for the three variables evaluated in the two experiments. Mean germination reduction was above 60% in the two experiments and germination speed indices were reduced from more than 25 to less than 10 in both experiments.

Overall, results for germination in the two experiments (Tables 3 and 6) were higher than those obtained by Santos and Correa (2011), who investigated seeds of the cowpea cultivars BRS Tumucumaque, BRS Cauamé, BRS Itaim and BRS Guariba and lines MNC03-737F-5-1, MNC03-737F-5-4, MNC03-737F-5-9 and MNC03-737F-5-1, sown on germitest type paper towels (moistened with water equivalent to 2.5 times the weight of the dry substrate and placed to germinate at 25 °C, regarded as adequate conditions to verify the germination progress of seeds). Germination conditions in this study were not restrictive at all. According to Silva *et al*. (2013), efficient methodologies are important to optimize laboratory procedures and enable the analysis of further samples with reduced cost. Similarly, germination speed was lower on seeds with application of sodium hypochlorite, but without differences between fungicides groups; this also occurred in seeds without application of sodium hypochlorite. However, differences were found between cultivars, both in the presence and absence of sodium hypochlorite (Table 7). Heights showed were pronounced differences. In the presence of sodium hypochloride indices were below 16.3 and those without sodium hypochlorite reached 42.8, and never lower than 27.2.

For seedling dry matter, BRS Cauamé presented a lower mean than the control when the seeds were treated with fungicides carbendazim + thiram, carbendazim and carboxin + thiram (Table 8), showing a significant reduction in seedling development. For the cultivar BRS Novaera, seed treatment with carboxin + thiram negatively influenced seedling development, presenting the lowest indices (Table 8).

Among cultivars, significant differences were found in seedling dry mass. In the presence of sodium hypochlorite, poorer values were obtained; for cultivars BRS Tumucumaque and BRS Cauamé, the best values were obtained as a function of fungicide treatment. In seeds without sodium hypochlorite, cultivars BRS Cauamé, BRS Novaera and BRS Guariba were superior in some treatments (Table 8).

As for seedling dry mass in the second experiment, means followed the trends for nutrient storage in the grain, with BRS Cauamé standing out with 100-seed mass lower than those of cultivars BRS Guariba, BRS Tumucumaque and BRS Novaera, but producing a mean dry mass similar to these cultivars (Table 8).

Regardless of whether seeds were recently collected or had been stored for 120 d, the application of sodium hypochlorite to disinfect seeds of the five evaluated cultivars led to decreased germination and vigor of the seeds; also, cultivars BRS Cauamé and BRS Novaera presented the greatest reductions.

CONCLUSIONS

Sand germination, germination speed and dry mass of seedlings obtained from seeds of the five cowpea cultivars were negatively influenced by disinfection with sodium hypochlorite. Fungicides used negatively influenced the vigor of cowpeas seeds BRS Cauamé and BRS Novaera, even in the absence of sodium hypochlorite. Seed germination of the five cowpea cultivars is not influenced by the fungicides fludioxonil, carbendazim, carbendazim + thiram, carboxin + thiram.

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