REVISTA DE CIÊNCIASAGRÁRIAS
Amazonian Journal
of Agricultural and Environmental Sciences
www.ajaes.ufra.edu.br

http://dx.doi.org/10.4322/rca.2014.011

ORIGINAL ARTICLE

# Physiological quality of upright and prostrate growth cowpea seeds produced in Roraima state, Brazil

## *Qualidade fisiológica de sementes de feijão-caupi com crescimento ereto e prostrado produzidas em Roraima*

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**KEYWORDS**
*Vigna unguiculata*
Cerrado
Germination
Seed vigor

**PALAVRAS-CHAVE**
*Vigna unguiculata*
Cerrado
Germinação
Vigor de sementes

**ABSTRACT:** The physiological quality of seeds is important to obtain high crop yields. The aim of this study was to evaluate the physical and physiological quality of 16 upright growth habit lineages and 15 prostrate growth habit lineages of cowpea seeds produced in Roraima state, Brazil. Two trials were assessed: the first with 16 lineages and the second with 15 lineages. The study was carried out in a completely randomized experimental design with four replicates. After field operations of harvesting and threshing, seeds were assessed for mass of one thousand seeds and water content. The physiological quality of seeds was assessed with respect to germination rate, first germination count, electrical conductivity, plantlet emergence and plantlet emergence velocity in sand substrate. The results obtained showed that the seed breeding lines presented low water contents. MNCO2-682F-2-6 upright habit lineage showed better germination rate and vigor, while MNCO2-684F-5-6 lineage presented lower percentage of germination and emergence in sand substrate. MNCO1-649F-1-3 prostrate habit lineage showed lower performance. Ten of the upright habit lineages and none of the prostrate habit lineages studied presented seeds with germination rates higher than 80%.

**RESUMO:** *A qualidade fisiológica das sementes é importante para se obterem elevadas produtividades nos cultivos. O objetivo deste trabalho foi avaliar a qualidade física e fisiológica de sementes de 16 linhagens de hábito de crescimento ereto e 15 linhagens de hábito prostrado de feijão-caupi, produzidas em Roraima. Foram avaliados dois experimentos, sendo um composto de 16 linhagens e outro de 15 linhagens. O delineamento experimental utilizado foi o inteiramente casualizado com quatro repetições. Após a colheita e a trilha do material no campo, as sementes foram submetidas às avaliações de massa de mil sementes, teor de água e qualidade fisiológica das sementes quanto à germinação: primeira contagem de germinação, condutividade elétrica e emergência e velocidade de emergência das plântulas em areia. As sementes das linhagens apresentaram baixos teores de água. A linhagem MNC02-682F-2-6 de hábito ereto apresenta melhor germinação e vigor, enquanto a linhagem MNC02-684F-5-6 apresenta menor porcentagem de germinação e emergência em areia. A linhagem MNC01-649F-1-3 de hábito prostrado apresenta o menor desempenho. Dez linhagens de hábito ereto e nenhuma linhagem de hábito prostrado apresentam sementes com germinação superior a 80%.*

Received: 06/22/2013
Accepted: 11/19/2013

## 1 Introduction

Cowpea (*Vigna unguiculata* (L.) Walpers) cultivation is an activity of great importance for agricultural development, both in the economic and nutritional aspects, because it is a staple food of the deprived populations, playing the social role of supplying their nutritional needs (TEÓFILO et al., 2008).

In Brazil, the average annual production of this crop is 482,000 t, concentrated in the North (80,500 hectares) and Northeast (1.05 million hectares) regions of the country (CONAB, 2012; SILVA, 2009). In the state of Roraima, the cowpea production is intended primarily for the domestic market, being consumed mainly in the form of green beans, but it is not enough to supply the existing demand, thus having a very attractive market (SMIDERLE; SCHWENGBER, 2008).

The Cerrado areas, which are used for cowpea cultivation in Roraima state, are within latitudes 2-5° N, in the Brazilian northern hemisphere, where the predominant climate type is Aw according to Köppen classification, characterized by a well-defined long dry season, from September to March, and a rainy season, from April to August. Annual rainfall in the region is 1608 mm and 80% of this amount occurs during this period, while the driest months are January, February and March, with monthly average rainfall of 30 mm. The temperature and relative humidity are high throughout the year: the average annual temperature is 25.5 °C and the relative humidity is 76% in the months of higher rainfall (EMBRAPA, 2009).

The grain provides good quality protein at low-cost. In addition, the surplus produced by small farmers enhances family income. It also adapts to different soil types and can be grown all over the state of Roraima, except in wetlands during the period of crop development (VILARINHO et al., 2010).

Cowpea is cultivated through the use of seeds, in various ways, and their quality influences the appropriate crop establishment (SMIDERLE et al., 2009). According to Gaspar and Nakagawa (2002), the seed is an essential input in agricultural production, playing an important role in increasing productivity both in quantity and quality; therefore, the use of high quality seeds is a key factor for the success of any culture.

The improvement of the technological level adopted in crops of cowpea, associated with the use of seeds of high physiological quality (TEIXEIRA et al., 2010) are essential for yield increase. The success of crops depends not only on their proper management by the farmer, but also on the socio-economic environment around the agribusiness and, in particular, on the quantity and quality of the required input supplies at low prices and, first of all, on seed quality (SOUZA; YAMASHITA; CARVALHO, 2007).

Seed analysis, in turn, is an important stage in a system of seed production, because it allows knowing the actual quality (physical, physiological and sanitary) of a batch and, hence, making the right decisions regarding their management, mainly during harvest, processing and commercialization (TOKUHISA et al., 2009).

The development of lineages and the achievement of new cultivars are important insofar as they bring with them new alternatives and opportunities for the culture. Lineages precede cultivars in the development of plant breeding programs. Thus, the identification of seed quality will predict the possibility of future success in the crops of rural producers and on the tables of consumers.

The cowpea plant, of upright or prostrate habit, grows well under the edaphoclimatic conditions of Roraima state, requiring low use of mineral inputs. The main difference between the two growth habits is the productive period, which is longer in prostrate strains, adapting better to manual harvesting. Upright strains can be harvested mechanically at once.

The aim of this study was to evaluate the physical and physiological quality of 16 upright growth habit lineages and 15 prostrate growth habit lineages of cowpea seeds from the Embrapa breeding program produced in the Cerrado of Roraima state.

## 2 Materials and Methods

The study was carried out at the Seed Testing Laboratory (LAS) at Embrapa Roraima between November 2010 and January 2011. Two experiments were conducted with lineages of upright and prostrate growth seeds, respectively, all from the cowpea breeding program.

The seeds used in the experiments were produced at the 'Água Boa' Experimental Field, Embrapa Roraima, located in a Cerrado area of Boa Vista, Roraima state, within latitudes 2-5° N, in the Brazilian northern hemisphere, where the predominant climate type is Aw according to Köppen classification, characterized by a well-defined long dry season, from September to March, and a rainy season, from April to August. The lineages were sown in July and harvested in October 2010. The study was conducted in a completely randomized experimental design with four replicates, with each plot comprising four five-meter-long lines. The space between lines was 0.5 m for seeds of upright growth habit and 0.8 m for seeds of prostrate growth habit, with 80 seeds per row. After threshing, which was performed between 10 and 15 days after plant emergence, 40 plants per row were left in the upright habit assay and 25 plants per row in the prostrate habit assay. Maintenance fertilization and weed control were performed as required and recommended throughout the field study.

The experimental design used in the laboratory was completely randomized with four replications. Seeds of 16 lineages of upright growth habit (MNC02-675F-4-9; MNC02-675F-4-2; MNC02-675F-9-2; MNC02-675F-9-3; MNC02-676F-3; MNC02-682F-2-6; MNC02-683F-1; MNC02-684F-5-6; MNC03-725F-3; MNC03-736F-7; MNC03-737F-5-1; MNC03-737F-5-4; MNC03-737F-5-9; MNC03-737F-5-10; MNC03-737F-5-11; MNC03-737F-11) and 15 lineages of prostrate growth habit (MNC01-649F-1-3; MNC01-649F-2-1; MNC01-649F-2-11; MNC02-675F-4-9; MNC02-675F-9-5; MNC02-676F-1; MNC02-677F-2; MNC02-677F-5; MNC02-680F-1-2; MNC02-689F-2-8; MNC02-701F-2; MNC03-736F-2; MNC03-736F-6; MNC03-761F-1; PINGO DE OURO-1-2) were used in the experiments.

After field operations of harvesting and threshing, 2.0 kg of seeds were sampled and taken to the Seed Testing Laboratory (LAS) at Embrapa Roraima, where they were cleaned with the aid of sieves to eliminate impurities. They were then conditioned in polyethylene terephthalate bottles, “Pet type”. The bottles were stored in the LAS under temperature of 24±2 °C and relative humidity of 60±5% during the assessment period.

The following laboratory analyses were performed to evaluate the physical and physiological quality of upright habit and prostrate habit cowpea seeds: Mass of one thousand seeds: eight replicates of 100 seeds for each lineage repetition were separated and then weighed on a precision scale (0.001 g) according to Brasil (2009). The average values obtained were expressed in grams after correction for 13% moisture. Water content: it was performed by the oven method, at 105±3 °C, for 24 h (BRASIL, 2009), with a repetition of 10 g per lineage. Results were expressed in percentage. Germination rate: four replications of 50 seeds for each line. The seeds were distributed on germination paper moistened with distilled water in amount 2.5 times the weight of the dry paper; they were then taken to a germination chamber, where they were maintained at constant temperature (25 °C) under constant light for eight days. Final count evaluation was performed eight days after test installation according to the Rules for Seed Analysis (BRASIL, 2009). First germination count: it was conducted in conjunction with the germination test, and verification of normal plantlets occurred on the fifth day after test installation. The results obtained were expressed in percentage. Mass electrical conductivity: four replications of 50 seeds (intact) were weighed, placed in disposable plastic cups (180 mL) containing 75 mL of distilled water and kept at constant temperature (25 °C) for 24 h. Readings were performed after 6 and 24 h of immersion using a digital microprocessed conductivity meter, Quimis manufactured. Prior to reading performance, the samples were gently shaken to homogenize the solution. The results were expressed in $\mu S\ cm^{-1}\ g^{-1}$ of seed. Plantlet emergence in sand substrate: four replications of 50 seeds per treatment were sown in 1 m long/3 cm deep furrows. Irrigation was performed as needed to maintain constant moisture. Results were expressed in percentage. Plantlet emergence velocity: it was carried out jointly with the test of plantlet emergence in sand. Daily counts were performed since the emergence of the first plantlet, considering only the plantlets with cotyledons above the soil level, until constant number was reached, thus obtaining the emergence velocity index.

Data were subjected to analysis of variance using Microsoft Excel® spreadsheet and the statistical package SISVAR (FERREIRA, 2011) and the means of treatments were compared by the Tukey test at 5% probability.

## 3 Results and Discussion

Differences ($p < 0.05$) were observed among the lineages evaluated, separately, regarding the growth habits of plants (upright and prostrate), as it can be verified in the results of the variables analyzed (Tables 1-4). Low coefficients of variation were also observed, ranging from 1.4 to 9.1% for strains of upright habit (Tables 1 and 2) and from 1.3 to 12.5% for strains of prostrate habit (Tables 3 and 4), indicating experimental precision, except for the variable first germination count for prostrate habit strains (12.5%). Tables 1 and 2 show the results of the evaluated variables for lineages of plants with upright growth habit.

The data presented for the variable mass of one thousand seeds (Table 1), lineage MNC03-737F-11 with 166.76 g presented smaller seeds, not differing from other four lineages. Lineages MNC02-675F-4-9, MNC02-675F-9-3, MNC02-675F-9-2 and MNC02-675F-4-2 presented larger seeds, with lineages MNC02-675F-9-3 and MNC02-675F-4-9 also showing higher water contents among the 16 lineages analyzed. This aspect was also verified by Ferreira and Torres (2000) in their study with *Acacia senegal* seeds, in which larger seeds presented lower water content compared with smaller seeds. These water contents, varying form 7.76 to 9.61%, found in the 16 lineages were lower than those reported by Arruda, Smiderle and Vilarinho (2009), who determined the contents to verify the uniformity of cowpea seeds produced in two different environments in Roraima state.

The water contents and the color of tegument observed in the seeds of the 16 upright habit cowpea lineages, even without comparison among them, did not influence the germination rates obtained as well as the vigor of seeds verified in the values of first germination count (Table 1).

Regarding germination rate percentage (Table 1), mean values ranging from 65 to 92% were observed. Except for lineages MNC03-736F-7, MNC02-676F-3, MNC03-737F-5-4, MNC02-675F-9-3, MNC02-675F-9-2 and MNC02-684F-5-6, which showed no significant differences, the values obtained for the other 10 lineages fall within the minimum required for commercialization, which is currently 80%. Lineage MNC02-682F-2-6 presented the highest germination rate (92%), although it did not differ significantly from the other ten lineages evaluated. Lineage MNC02-684F-5-6, in turn, presented lower performance, with only 65%, possibly because it has more disorganized internal membranes, as verified by the higher ion release after six hours of immersion in water for electrical conductivity and emergence in sand (Table 2). This lower value was not noted with respect to the other variables. Batista et al. (2012), studying the physiological quality of cowpea seeds, cultivar BRS Guariba, obtained germination rate between 97 and 100%.

With respect to the seed vigor verified on first germination count, lineage MNC02-682F-2-6 presented seeds of superior quality (89%), together with eight other lineages. Lineage MNC02-675F-9-3 showed the lowest vigor, with 47%, but it did not differ from lineages MNC02-675F-4-9, MNC02-675F-4-2, MNC02-675F-9-2, MNC02-676F-3 and MNC02-684F-5-6. The values obtained for lineages MNC02-675F-4-9, MNC02-675F-4-2, MNC02-675F-9-2 and MNC02-675F-9-3, may be influenced by the larger size of their seeds in relation to the other strains (Table 1), needing to absorb more water, therefore requiring more time. These results disagree with those obtained by Barbosa et al. (2010) who, when studying seeds of soybean, cultivar BRS Tracajá, according to size in storage, found that larger seeds result in higher means of vigor and germination compared with smaller seeds. Likewise, Pádua et al. (2010) concluded that larger soybean seeds showed higher germination rate and vigor. However, higher germination (97%) in smaller cowpea seeds was obtained

**Table 1.** Mass of one thousand seeds (MTS), percentage water content (WC), germination rate percentage (GR), and first germination count percentage (FGC) obtained from seeds of 16 upright habit cowpea lineages.

| Lineage | Tegument | MTS | WC | GR | FGC |
|---|---|---|---|---|---|
| | | (g) | | (%) | |
| MNC02-682F-2-6 | White | 179.17 de* | 8.96 | 92 a | 89 a |
| MNC03-737F-5-9 | White | 172.35 fgh | 8.63 | 90 ab | 84 ab |
| MNC03-737F-5-1 | White | 170.55 fgh | 8.95 | 89 abc | 83 abc |
| MNC03-737F-5-11 | White | 174.07 efg | 8.45 | 89 abc | 83 abc |
| MNC03-737F-11 | White | 166.76 h | 8.62 | 88 abcd | 83 abc |
| MNC03-737F-5-10 | White | 191.02 bc | 8.15 | 87 abcd | 82 abcd |
| MNC03-725F-3 | White | 176.27 ef | 8.12 | 85 abcd | 80 abcd |
| MNC02-675F-4-9 | Brown | 207.94 a | 7.91 | 84 abcde | 57 efg |
| MNC02-675F-4-2 | Brown | 206.31 a | 9.42 | 82 abcde | 51 fg |
| MNC02-683F-1 | White | 169.30 gh | 9.61 | 81 abcde | 75 abcde |
| MNC03-736F-7 | White | 197.45 b | 8.25 | 79 abcdef | 73 abcde |
| MNC02-676F-3 | Brown | 176.76 ef | 9.32 | 75 bcdef | 64 cdefg |
| MNC03-737F-5-4 | White | 185.56 cd | 8.37 | 73 cdef | 69 bcdef |
| MNC02-675F-9-3 | Brown | 207.58 a | 7.76 | 73 def | 47 g |
| MNC02-675F-9-2 | Brown | 206.55 a | 8.72 | 69 ef | 49 fg |
| MNC02-684F-5-6 | White | 173.27 efgh | 9.36 | 65 f | 63 defg |
| CV(%) | | 1.4 | | 6.4 | 9.1 |

CV = coefficient of variation. *Means followed by different letters in the column differ by the Tukey test at 5% probability.

by Arruda, Smiderle and Vilarinho (2009) when assessing uniformity of seeds in 19 lineages of cowpea cultivated in two environments in Roraima state.

For plantlet emergence in sand substrate (Table 2), superiority was observed compared with germination in laboratory, with values ranging from 67 to 96%. Similar results were reported by Pereira, Pereira and Fraga (2000) who, when investigating the physiological quality of seeds of early maturing soybean cultivars grown in three different periods, observed that the germination rates in sand were higher than those obtained in paper rolls in the laboratory.

Although lineages MNC02-684F-5-6 and MNC03-737F-5-4 presented lower vigor values, they did not differ significantly from lineages MNC02-683F-1, MNC02-676F-3 and MNC03-725F-3. While lineage MNC03-737F-5-10, with 96% (Table 2), although having produced seeds with higher emergence, did not differ significantly from other ten lineages, all with values higher than the minimum accepted for commercialization. Furthermore, this strain showed an increase of 9% in relation to the germination emergence percentage observed in laboratory, which was 87% (Table 1).

The mean values obtained for emergence velocity in sand (EVS) showed that lineages MNC02-682F-2-6 and MNC03-737F-5-9 presented higher seed vigor indices, without differing significantly from lineages MNC03-737F-5-10, MNC03-737F-5-1, MNC03-737F-5-11, MNC03-737F-11 and MNC03-736F-7. Lineage MNC02-675F-9-3 (7.54) showed the lowest vigor, but it did not differ significantly from the other lineages (Table 2). It was possible to observe that lineages MNC02-682F-2-6 and MNC02-675F-9-3 presented comparative results similar to those obtained in the first germination count. The low vigor value verified for lineage MNC02-675F-9-3 may result from the fact of presenting seeds of larger size; similarly to what was verified by Arruda, Smiderle and Vilarinho (2009), who also identified lower vigor values in lineages with higher values of mass of one thousand seeds.

Regarding first germination count percentage (Table 1) and emergence velocity index (Table 2), it was possible to verify that larger seeds of lineage MNC02-675F-9-3 presented low vigor. Ferreira and Torres (2000), studying the physiological quality of seeds, concluded that seed size had greater influenced on the vigor than on the germination rate of *A. senegal* seeds.

Two readings were performed on the electrical conductivity of the immersion solution (Table 2): six and 24 h after immersion of seeds. The first reading (EC 6 h) identified lineage MNC02-675F-9-3 as the one with the lowest value of electrical conductivity, indicating better seed vigor. Lineage MNC02-684F-5-6 presented more ions released to the solution, indicating lower seed quality, just as verified for germination rate and emergence in sand substrate, demonstrating good relationship among the results obtained in the tests performed.

The second reading (EC 24hs) identified lineages MNC02-675F-4-2, MNC02-675F-9-2 and MNC02-675F-9-3 as those with lowest electrolyte leakage, with lineage MNC02-683F-1 releasing more ions to the immersion solution, but not differing significantly from other six lineages (Table 2). This reading also showed that the seeds that released fewer electrolytes to the solution were those with higher mass of one thousand seeds. Good precision between the two readings was not verified for seeds of upright habit lineages. When reading was performed after six hours of seed immersion, a shorter time in obtaining the result would anticipate the presentation of the final result.

The determination of electrical conductivity allows us to identify seed batches with different levels of vigor, even if germination has not yet been affected, as verified for the

**Table 2.** Plantlet emergence percentage in sand (ES), plantlet emergence velocity index in sand (EVS), and electrical conductivity (EC 6 h and EC 24 h) obtained from seeds of 16 upright habit cowpea lineages.

| Lineage | Tegument | ES | EVS | EC 6 h | EC 24 h |
|---|---|---|---|---|---|
| | | (%) | (index) | (μS cm$^{-1}$g$^{-1}$) | |
| MNC02-682F-2-6 | White | 93 ab* | 13.23 a | 97.4 efg | 173.8 defg |
| MNC03-737F-5-9 | White | 90 ab | 12.49 a | 100.4 fg | 183.0 efg |
| MNC03-737F-5-1 | White | 93 ab | 12.38 ab | 94.7 efg | 176.8 defg |
| MNC03-737F-5-11 | White | 93 ab | 12.37 ab | 96.4 efg | 181.3 efg |
| MNC03-737F-11 | White | 88 abc | 12.13 abc | 92.4 defg | 174.4 defg |
| MNC03-737F-5-10 | White | 96 a | 12.29 ab | 89.7 def | 164.9 de |
| MNC03-725F-3 | White | 79 bcd | 10.19 bcd | 83.4 d | 159.1 cd |
| MNC02-675F-4-9 | Brown | 85 abc | 7.85 ef | 29.0 b | 98.8 b |
| MNC02-675F-4-2 | Brown | 90 ab | 9.46 def | 20.6 b | 79.2 a |
| MNC02-683F-1 | White | 74 cd | 9.98 cde | 98.8 efg | 189.8 g |
| MNC03-736F-7 | White | 87 abc | 12.25 abc | 88.7 de | 167.2 de |
| MNC02-676F-3 | Brown | 78 bcd | 9.49 def | 61.9 c | 143.2 c |
| MNC03-737F-5-4 | White | 68 d | 8.88 def | 92.1 defg | 169.8 def |
| MNC02-675F-9-3 | Brown | 86 abc | 7.54 f | 8.9 a | 75.5 a |
| MNC02-675F-9-2 | Brown | 88 abc | 8.76 def | 22.3 b | 77.8 a |
| MNC02-684F-5-6 | White | 67 d | 8.98 def | 101.9 g | 188.0 fg |
| CV(%) | | 5.90 | 7.10 | 5.00 | 4.10 |

CV = coefficient of variation. *Means followed by different letters in the column differ by the Tukey test at 5% probability.

highest germination (Table 1) with high electrical conductivity values (Table 2). According to Batista et al. (2012), these higher values of solute leakage result in lower rates of root growth, and this is a good parameter for evaluating the quality of cowpea seeds.

Vigor tests applied to seeds, when compared to germination tests, provide more detailed information about the quality levels of different seed batches, especially the electrical conductivity test. Therefore, the importance of pooling the results of several tests to evaluate seed physiological potential should be highlighted. Results similar to those obtained in the present study were reported by Barbosa et al. (2010) when working with two sizes of soybean seeds, cultivar BRS Tracajá.

Mass of one thousand seeds was higher in lineages MNC03-736F-6 and PINGO DE OURO-1-2. In contrast, the lowest values for mass of one thousand seeds were obtained from lineages MNC02-676F-1 and MNC02-680F-1-2 (Table 3). Lineage MNC02-680F-1-2 of smaller seeds presented the highest water content (9.87%); this value was lower than those reported by Arruda, Smiderle and Vilarinho (2009). This low humidity will better preserve the quality of the seeds. While Trés et al. (2010) observed that the soybean seeds of smaller size and weight originated less vigorous plantlets.

High vigor seeds presented faster metabolic processes, providing faster primary root emission, with increased growth rate, thus favoring the early development of plantlets (MUNIZZI et al., 2010). Lineage MNC01-649F-1-3 showed lower physiological performance compared with the others, with only 35% germination (Table 3). It was possible to verify that none of the prostrate habit lineages analyzed showed seeds with germination rate higher than 79%. This result did not occur because of the mean percentage water contents (6.99 to 9.87%), which were verified because they were all below those accepted for commercialization and, especially, those suitable for the proper preservation of seeds, provided that they present high initial physiological quality.

Seeds of lineages PINGO DE OURO-1-2 and MNC02-677F-2 with vigor of 69 and 70%, respectively, did not differ significantly from other eight lineages on the first germination count. While lineages MNC03-761F-1 and MNC01-649F-1-3 presented lower vigor, as well as lineages MNC02-689F-2-8, MNC02-675F-9-5 and MNC02-676F-1, compared with the others (Table 3).

Regarding plantlet emergence percentage in sand (Table 4), it was possible to observe that lineage MNC02-689F-2-8 presented higher emergence compared with lineages MNC02-677F-5, MNC02-676F-1 and MNC01-649F-1-3. The variation of emergence percentage in sand ranged from 62 to 93%, values higher than those obtained in laboratory germination. Carvalho et al. (2012), in a research comparing the physiological quality of conventional soybean seeds and its derived transgenic species, observed that, in the plantlet emergence test, higher mean values were also observed in the germination test.

The results obtained in the emergence velocity index indicated the best vigor for lineage MNC03-736F-6, while lineage MNC01-649F-1-3 (7.68) presented low vigor, without differing from other eight lineages assessed in this study (Table 4).

A possible explanation for lineages PINGO DE OURO-1-2 and MNC03-736F-6 present better quality seeds may be because they also present larger seeds, as it can be verified in the mass of one thousand seeds (Table 3). Also, Gaspar and Nakagawa (2002), working with pearl millet, concluded that larger seeds presented better quality than smaller seeds. Barbosa et al. (2010), analyzing soybean seeds, cultivar BRS

**Table 3.** Mass of one thousand seeds (MTS), percentage water content (WC), germination rate percentage (GR), and first germination count percentage (FGC) obtained from seeds of 15 prostrate habit cowpea lineages.

| Lineage | Tegument | MTS | WC | GR | FGC |
|---|---|---|---|---|---|
| | | (g) | (%) | | |
| MNC02-689F-2-8 | Brown | 187.68 g* | 6.99 | 79 a | 37 cd |
| MNC02-675F-4-9 | Brown | 188.81 fg | 8.01 | 77 a | 57 ab |
| MNC03-736F-2 | White | 195.60 cde | 8.47 | 77 a | 67 ab |
| PINGO DE OURO-1-2 | Brown | 215.24 a | 8.89 | 77 a | 69 a |
| MNC02-680F-1-2 | Brown | 170.11 h | 9.87 | 76 a | 66 ab |
| MNC02-677F-2 | Brown | 204.66 b | 7.21 | 75 a | 70 a |
| MNC02-675F-9-5 | Brown | 194.90 cdef | 6.80 | 73 a | 48 bcd |
| MNC02-677F-5 | Brown | 203.50 b | 6.87 | 72 a | 57 abc |
| MNC02-676F-1 | Brown | 175.33 h | 8.98 | 71 a | 47 bcd |
| MNC03-761F-1 | Brown | 192.04 defg | 8.29 | 70 a | 28 d |
| MNC02-701F-2 | White | 189.25 efg | 8.31 | 69 a | 60 ab |
| MNC03-736F-6 | White | 216.64 a | 7.93 | 69 a | 62 ab |
| MNC01-649F-2-1 | Brown | 201.31 bc | 7.49 | 67 a | 60 ab |
| MNC01-649F-2-11 | Brown | 189.93 defg | 9.45 | 63 a | 57 ab |
| MNC01-649F-1-3 | Brown | 196.28 cd | 8.82 | 35 b | 31 d |
| CV(%) | | 1.3 | | 7.7 | 12.5 |

CV = coefficient of variation. *Means followed by different letters in the column differ by the Tukey test at 5% probability.

**Table 4.** Plantlet emergence percentage in sand (ES), plantlet emergence velocity index in sand (EVS), and electrical conductivity (EC 6h and EC 24h) obtained from seeds of 15 prostrate habit cowpea lineages.

| Lineage | Tegument | ES | EVS | EC 6 h | EC 24 h |
|---|---|---|---|---|---|
| | | (%) | (index) | (μS $cm^{-1}g^{-1}$) | |
| MNC02-689F-2-8 | Brown | 93 a* | 9.13 bcde | 21.6 ab | 83.2 b |
| MNC02-675F-4-9 | Brown | 84 ab | 9.69 abcde | 31.6 c | 95.4 bc |
| MNC03-736F-2 | White | 82 ab | 11.29 ab | 74.0 f | 166.2 hi |
| PINGO DE OURO-1-2 | Brown | 87 ab | 10.50 abc | 53.5 de | 112.3 cde |
| MNC02-680F-1-2 | Brown | 80 ab | 11.04 ab | 57.9 e | 130.9 f |
| MNC02-677F-2 | Brown | 81 ab | 9.45 abcde | 29.9 bc | 99.6 bc |
| MNC02-675F-9-5 | Brown | 82 ab | 7.91 de | 26.6 bc | 103.6 c |
| MNC02-677F-5 | Brown | 77 b | 9.08 bcde | 45.2 d | 122.7 def |
| MNC02-676F-1 | Brown | 78 b | 8.34 cde | 33.2 c | 105.8 cd |
| MNC03-761F-1 | Brown | 82 ab | 8.57 cde | 12.6 a | 61.2 a |
| MNC02-701F-2 | White | 80 ab | 8.55 cde | 84.4 g | 181.0 i |
| MNC03-736F-6 | White | 83 ab | 11.56 a | 73.6 f | 150.8 gh |
| MNC01-649F-2-1 | Brown | 81 ab | 10.18 abcd | 57.0 e | 135.8 fg |
| MNC01-649F-2-11 | Brown | 83 ab | 9.93 abcde | 51.9 de | 130.1 ef |
| MNC01-649F-1-3 | Brown | 62 c | 7.68 e | 79.3 fg | 178.9 i |
| CV(%) | | 5.40 | 8.20 | 6.70 | 4.80 |

CV = coefficient of variation. *Means followed by different letters in the column differ by the Tukey test at 5% probability.

Tracajá, observed higher germination rate and vigor in larger seeds (6.0 and 6.5 mm).

Among the lineages evaluated, we found variations in size, vigor, and physiological quality of seeds that can be attributed to genetic variability, which will enable us to select the superior strains at the expense of the inferior ones. Such variability was also observed in common bean lineages by Maia et al. (2011).

The mean values of electrical conductivity (Table 4) show lineage MNC03-761F-1 with lower values, indicating that the seeds presented better vigor. On the other hand, lineage MNC02-701F-2 showed the highest value for the reading performed after six hours of seed immersion, without differing from lineage MNC01-649F-1-3. For the reading performed after 24 hours, lineages MNC01-649F-1-3, MNC02-701F-2 and MNC03-736F-2 released more ions to the solution, resulting in higher values of electrical conductivity, therefore indicating seeds of less vigor. The lineages of white tegument showed the highest values of electrolyte leakage to the seed immersion solution, which can be verified by the higher electrical conductivity (Table 4).

These results corroborate those obtained by Batista et al. (2012), who were successful in differentiating the physiological potential of cowpea seeds through the electrical conductivity test.

The seeds of cowpea lineages presented variations in size, and adjustments were needed in order to reduce possible effects on the results, given that they are not classified mechanically. According to Santos et al. (2006), classification of soybean seeds has been performed in Brazil for several years, and it is an important technique considering that seed size uniformity results in higher precision sowing, which facilitates the attainment of the desired plant population in the field. In this context, studies have been conducted to evaluate the germination rate and vigor of seeds and identify differences in quality, although some studies have failed to demonstrate a positive correlation between these factors. Barbosa et al. (2010) assessed the size of soybean seeds, cultivar BRS Tracajá, and obtained higher percentages of germination and vigor during storage for seeds of larger size (6.0 and 6.5 mm).

The results of this study indicate that for both upright growth habit and prostrate growth habit cowpea lineages, the variables analyzed in determining the physiological quality of seeds showed different and/or similar variations. Mass of one thousand seeds (MTS) between 166.76 g and 207.94 g were verified for seeds of upright growth habit, while for prostrate growth habit seeds the MTS reached 216.64 g, and 170.11 g for smaller seeds. The mean water content found in the seeds was lower than 9.61%. The seed germination rate of upright habit lineages was 65 to 92%, while of prostrate habit lineages was 35 to 79%. Regarding seed vigor, seven upright growth habit lineages stood out, with values ranging from 80 to 89% of the germinated seeds. Regarding the other parameters of vigor analyzed (ES, EVS, EC 6h and EC 24 h), no consistency was verified in the determinations, with slightly higher mean values, indicating better vigor in seeds of upright habit lineages for ES and EVS, and slightly lower values for electrical conductivity (EC 6 h and EC 24 h).

## 4 Conclusions

MNC02-682F-2-6 upright habit lineage presents better germination rate and vigor, while MNC02-684F-5-6 lineage presents lower percentage of germination and emergence in sand substrate;

MNC01-649F-1-3 prostrate habit lineage presents the worst performance among the 15 lineages assessed;

Ten of the upright habit lineages and none of the prostrate habit lineages studied present seeds with germination rates higher than 80%.

## Acknowledgements

The authors are grateful to the National Council for Scientific and Technological Development (CNPq) for the scholarship of scientific initiation (PIBIC) granted to the first author and to Embrapa Roraima for the structure provided for the realization of this research.

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