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grain

# Identifying lines of the black-eyed cowpea having high productivity and quality commercial grain[1]

## Identificação de linhagens de feijão-caupi do tipo fradinho com alta produtividade e qualidade comercial de grãos

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**ABSTRACT -** The black-eyed cowpea, is consumed in Brazil and valued in various other countries, and for this reason, can be found on the domestic market, showing the potential for export. The aim of this study was to identify lines of the black-eyed cowpea having high productivity and quality commercial grain. Twenty-four lines of black-eyed commercial subclass of cowpea, taken from the breeding program of Embrapa Meio-Norte, and two controls (BRS Itaim and CB-27) were evaluated. The experiments were carried out in Nova Ubiratã, in the State of Mato Grosso, Brazil (MT) during 2014, and in Primavera do Leste MT and Sinop MT during 2015, in the off-season; planting was in February/March and harvesting in May/June. The experimental design was of randomised complete blocks with four replications, in plots of 4 rows of 5 metres spaced 0.45 metres apart. Crop value, lodging and grain productivity were evaluated. The occurrence of blemished grain was also assessed, both by counting the blemished grain (visual selection), and by colorimetric analysis, using the CIE L\* a\* b\* colour scale. Four lines showed potential for inclusion in the trials for crop value and use (VCU) as per the recommendation of the State of Mato Grosso, by combining grain productivity comparable to that of the BRS Itaim cultivar and a low percentage of blemished grain. Visual evaluation by counting the blemished grain, was efficient in identifying lines of the black-eyed cowpea with better grain quality in relation to the BRS Itaim cultivar. Colour reading using the CIE L\* a\* b\* scale did not satisfactorily differentiate the occurrence of blemished grain in lines of the black-eyed cowpea.

**Key words:** Plant breeding. *Vigna unguiculata*. Grain quality. CIE L\* a\* b\*.

**RESUMO -** O feijão-caupi do tipo fradinho é consumido no Brasil e apreciado em diversos países, por este motivo, apresenta mercado interno e potencial para exportação. Objetivou-se com este trabalho identificar linhagens de feijão-caupi do tipo fradinho com alta produtividade e qualidade comercial de grãos. Foram avaliadas 24 linhagens do tipo fradinho provenientes do programa de melhoramento da Embrapa Meio-Norte e duas testemunhas (BRS Itaim e CB-27). Os experimentos foram conduzidos em Nova Ubiratã-MT em 2014 e em Primavera do Leste-MT e Sinop-MT em 2015, no período de safrinha, semeadura em fevereiro/março e colheita em maio/junho. Foi utilizado o delineamento experimental de blocos completos casualizados com quatro repetições e parcelas de 4 linhas de 5 metros, espaçadas de 0,45 metros. Foram avaliados o valor de cultivo, o acamamento e a produtividade de grãos. Também foi avaliada a ocorrência de grãos manchados, por meio da contagem de grãos com a presença de manchas (seleção visual), e pela análise no colorímetro, utilizando-se a escala de cor CIE L\* a\* b\*. Quatro linhagens apresentaram potencial para inclusão nos ensaios de Valor de Cultivo e Uso (VCU), visando a recomendação no estado de Mato Grosso por associarem produtividade de grãos comparável a cultivar BRS Itaim e baixa porcentagem de grãos manchados. A avaliação visual, por meio da contagem de grãos manchados, foi eficiente para identificar linhagens de feijão-caupi do tipo fradinho com melhor qualidade de grãos em relação à cultivar BRS Itaim. A leitura de cor, por meio da escala CIE L\* a\* b\*, não discriminou satisfatoriamente a ocorrência de grãos manchados em linhagens de feijão-caupi do tipo fradinho.

**Palavras-chave:** Melhoramento vegetal. *Vigna unguiculata*. Qualidade de grãos. CIE L\* a\* b\*.

# INTRODUCTION

Production of the cowpea [*Vigna unguiculata* (L.) Walp] has been on the increase in the Brazilian Midwest, especially in the State of Mato Grosso (MT). This increase has taken place due to the demand for the cowpea in Brazil, particularly in the Northeast, and to the export potential of the product; in addition, cowpea is a good option for crop rotation in the Midwest, being considered a late off-season crop.

In the off-season, the final date for sowing cowpea is later than for maize, resulting in a larger sowing period. This has given producers the option of cultivating areas that are not suitable for maize, with the cowpea therefore occupying areas that would otherwise remain idle following the ideal sowing period of the maize crop. Other factors that reinforce the viability of planting cowpea during the off-season in Mato Grosso, are the short cycle (CRAUFURD *et al.*, 1997; EHLERS; HALL, 1997; MACHADO *et al.*, 2008), good nitrogen-fixation capacity (ABDELNABY *et al.*, 2015; REGO *et al.*, 2015; SOARES *et al.*, 2014) and tolerance to drought (AGBICODO *et al.*, 2009; NASCIMENTO *et al.*, 2011; RODRIGUES *et al.*, 2016; SOUZA *et al.*, 2015), besides being a lower-cost planting option for farmers compared to other crops.

One of the factors that has contributed the most to the spread of the crop and expansion of the consumer market is genetic and plant breeding, making available productive cowpea cultivars that are adapted to the cropping system (FREIRE FILHO *et al.*, 2006; FREIRE FILHO *et al.*, 2011). The selection of cultivars adapted to the soil and climate conditions of Mato Grosso, and with the capacity for use in corporate farming systems, has been fundamental in developing the crop and meeting the growing demand for cowpea grain in the domestic and international markets (AGUIAR, 2016).

Noteworthy among the principal aims of cowpea breeding is the selection of erect lines, which would allow all stages of production to be mechanised in the Midwest, where there is a predominance of large areas and of mechanised harvesting. It is essential that cultivars be not only erect, but have good-quality commercial grain. In the case of the black-eyed cowpea, the size, colour and shape of the grain are very important for consumer acceptance (FREIRE FILHO *et al.*, 2011).

Considering the high demand for the black-eyed cowpea, and the low availability of cultivars with this type of grain recommended for cultivation in Mato Grosso, research into the development of new lines adapted to the region is fundamental to the success of the crop in the state. The cowpea breeding program of Embrapa is mainly carried out in the Northeast, where the selection of lines takes place under climatic conditions that are very different from those found by the crop during the off-season in the Midwest, where the rainy season can be prolonged, and where harvesting takes place during periods of greater humidity. Under such conditions, when the black-eyed varieties bred in the northeast of Brazil are grown in Mato Grosso, blemishes may occur on the white part of the grain integument.

The occurrence of blemishes compromises the appearance of the grain and hinders market acceptance. Identifying lines that have white grain with no blemishes and the black hilum typical of the black-eyed commercial subclass, is therefore important for success when adopting the cultivar. This work was carried out with the aim of identifying black-eyed varieties of the cowpea having high productivity and quality commercial grain.

# MATERIAL AND METHODS

The experiments were conducted during the off-season in the town of Nova Ubiratã MT in 2014, and in the towns of Primavera do Leste MT and Sinop MT in 2015. Sowing was carried out in February and March, and harvesting in May and June.

Twenty-four erect plant, elite lines of black-eyed commercial grain from the breeding program of Embrapa Meio-Norte were evaluated, together with two controls (BRS Itaim and CB-27). The control, CB-27, is a black-eyed variety that was introduced to Brazil, but is not recommended as a cultivar; it was included in the experiment as it was used as the parent of most of the lines under evaluation. The BRS Itaim cultivar is used as primary reference, being the only cultivar of the black-eyed cowpea recommended for Mato Grosso. The experimental design was of randomised blocks with four replications and plots of 4 rows of 5 metres spaced 0.45 metres apart. The working area comprised the two central rows of each plot (4.5 m²).

The crop value (VC) of the lines was evaluated before the pods were harvested, and was based on the general appearance of the plant (size, plant architecture, number of pods, appearance of the grain, and plant health), according to a rating scale where: 1 = plant with characteristics unsuitable for commercial cultivation; 2 = plant with few characteristics suitable for commercial cultivation; 3 = plant with most characteristics suitable for commercial cultivation; 4 = plant with all characteristics suitable for commercial cultivation; 5 = plant with excellent characteristics for commercial cultivation. Plant lodging (LDG) was also evaluated before harvesting, taking into account the percentage of lodged plants and/or plants with a broken main stem, where: 1 = no lodged plants or

broken main stem; 2 = from 1 to 5% lodged plants or with broken main stem; 3 = from 6 to 10% lodged plants or with broken main stem; 4 = from 11 to 20% lodged plants or with broken main stem; 5 = over 20% lodged plants or with broken main stem. Grain productivity (GP) was evaluated after harvesting, using the total weight in grams of the grain harvested in the working area of the plot; this was later transformed into kg ha$^{-1}$.

In the experiment carried out in Primavera do Leste during 2015, the grain was sent to the seed laboratory of Embrapa Agrosilvipastoril in Sinop MT after harvesting, for quantification of the blemished grain. For each lot, a sample of 100 grains was randomly taken and visually separated into blemished and unblemished grain. The blemished and unblemished grains were later counted to obtain the percentage of blemished grain.

The same samples were submitted to colour analysis using the ColourQuest XE colorimeter (HunterLab) with d/8° sphere geometry, and using the CIE L* a* b* colour scale (HunterLab, 1996). On this scale, the vertical L* axis (brightness) ranges from zero (black) to 100 (white), the a* axis ranges from -a* (green) to +a* (red), and the b* axis ranges from –b* (blue) to +b* (yellow) (MARCUS, 1998). To carry out the colour reading, the colorimeter was calibrated with a white reference standard. The grain was homogenised and placed in a 40 mL quartz vat with a fixed path of 20 mm, and five readings were taken for each lot. With each reading, the grain was removed and rearranged in the vat. Statistical analysis was carried out using the average of the five readings.

The data obtained from each environment were subjected to individual analysis of variance for each characteristic, considering the effects of the treatments as fixed, and the following statistical model: $Y_{ij} = m + t_i + r_j + e_{ij}$ where: $Y_{ij}$ is the value seen in the plot that received treatment $i$ within block $j$; m is the overall mean value

for the experiment; $t_i$ is the effect of treatment $i$ ($i$ = 1, 2, 3, ..., 26); $r_j$ is the effect of replication $j$ ($j$ = 1, 2, 3 e 4); $e_{ij}$ is the experimental error associated with observation $Y_{ij}$, assuming that the errors are independent and show a normal distribution, with a mean value of zero and a variance of $\sigma^2$. For grain productivity, lodging and crop value, a joint analysis of variance was later carried out considering the three environments.

The mean values of each line for crop value, lodging, grain productivity, percentage of blemished grain, and L*, a* and b* were submitted to the Scott-Knott cluster test (1974). The analyses were carried out using the GENES software (CRUZ, 2013).

## RESULTS AND DISCUSSION

There was a significant difference between the treatments in Nova Ubiratã and Sinop for crop value, (Table 1). For lodging, a significant effect was detected for treatments in the three environments. For grain productivity, a significant difference was found between the treatments in Primavera do Leste and Sinop (Table 1). The mean value for grain productivity in the Sinop environment was lower than at the other sites, due to excessive rain during the crop cycle. For this reason, the plants displayed greater than usual growth, and maturation was uneven; also, rainfall occurred during the harvest period.

With the joint analysis, a significant difference (P<0.05) was seen between lines for lodging and grain productivity (Table 2). The lines x environments interaction was significant (P<0.05) for the three characteristics under evaluation (VC, LDG and PROD), showing that the classification of the lines had changed in the different environments. A significant interaction between genotypes

Table 1 - Summary of the individual variance analysis for crop value, lodging and grain productivity in lines of the black-eyed cowpea, evaluated in Nova Ubiratã MT (2014), Primavera do Leste MT (2015) and Sinop MT (2015)

| Environment | Crop Value | | | Lodging | | | Productivity (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | MS | P | CV(%) | MS | P | CV(%) | MS | P | CV(%) |
| Nova Ubiratã MT | 0.394 | 0.008 | 11.54 | 0.830 | 0.031 | 30.36 | 52098.73 | 0.194 | 14.28 |
| Primavera do Leste MT | 0.125 | 0.404 | 10.89 | 1.279 | 0.002 | 28.12 | 212802.96 | 0.000 | 14.35 |
| Sinop MT | 0.315 | 0.042 | 11.74 | 2.467 | 0.000 | 43.87 | 49674.49 | 0.004 | 33.18 |
| | Mean | | | Mean | | | Mean | | |
| Nova Ubiratã MT | 3.78 | | | 2.25 | | | 1404 | | |
| Primavera do Leste MT | 3.14 | | | 2.58 | | | 1642 | | |
| Sinop MT | 3.67 | | | 2.22 | | | 449 | | |

MS: mean square of the treatments; P: probability; CV: coefficient of variation

**Table 2 -** Summary of the joint analysis of variance for crop value, lodging and grain productivity in lines of the black-eyed cowpea, evaluated in Nova Ubiratã MT (2014), Primavera do Leste MT (2015) and Sinop MT (2015)

| SV* | DF | Crop Value | | Lodging | | Productivity (kg ha$^{-1}$) | |
|---|---|---|---|---|---|---|---|
| | | MS | P | MS | P | MS | P |
| Environments (E) | 2 | 12.077 | 0.000 | 4.190 | 0.000 | 41463964.6 | 0.000 |
| Treatments (T) | 25 | 0.290 | 0.017 | 2.750 | 0.000 | 100630.6 | 0.000 |
| Lines (L) | 23 | 0.248 | 0.070 | 2.963 | 0.000 | 95302.8 | 0.000 |
| Controls (C) | 1 | 1.450 | 0.033 | 0.050 | 0.999 | 276490.7 | 0.008 |
| L vs. C | 1 | 0.096 | 0.999 | 0.551 | 0.999 | 47310.2 | 0.273 |
| T x E | 50 | 0.272 | 0.007 | 0.912 | 0.051 | 106972.8 | 0.000 |
| Lines x E | 46 | 0.266 | 0.012 | 0.955 | 0.035 | 100009.7 | 0.000 |
| Controls x E | 2 | 0.681 | 0.017 | 0.788 | 0.298 | 203483.2 | 0.006 |
| L vs. C x E | 2 | 0.002 | 0.999 | 0.047 | 0.999 | 170613.3 | 0.014 |
| Mean Error | 225 | 0.165 | | 0.649 | | 39336.2 | |
| CV (%) | | 11.48 | | 34.22 | | 17.02 | |

* SV: source of variation; DF: degrees of freedom; MS: mean square of the treatments; P: probability; CV: coefficient of variation

and environments is common in the cowpea for various characteristics (AKANDE, 2007; ROCHA *et al*., 2007, TORRES *et al*., 2006; YOUSAF; SARWAR, 2008).

Table 3 shows the mean values by environment for the lines and controls under evaluation. For crop value, the lines only formed distinct groups in Nova Ubiratã MT, where two groups were formed. For lodging, two groups were formed in Sinop MT, one group in Nova Ubiratã MT and three groups in Primavera do Leste MT (Table 3). For grain productivity, the lines only formed distinct groups in Primavera do Leste MT, 12 of which did not differ from the BRS Itaim control cultivar, indicating the good potential for grain productivity of these lines (Table 3).

Table 4 shows the overall mean values by environment for the lines and controls. For crop value, 13 lines (54.16%) had a statistically similar rating as the BRS Itaim control cultivar, the only cultivar of the black-eyed cowpea recommended for Mato Grosso. For lodging, 18 lines presented a statistically similar performance to the BRS Itaim cultivar (Table 4). Although some lines have a greater rating for lodging than the controls, they are all erect cultivars, and may be harvested mechanically. Erect plant cultivars that do not display lodging are essential for the mechanisation of all farming stages (FREIRE FILHO *et al*., 2011; MACHADO *et al*., 2008; MATOS FILHO *et al*., 2009).

Eleven lines (45.83%) had a statistically similar performance to the BRS Itaim cultivar for grain productivity, demonstrating the potential of the lines under evaluation for inclusion in VCU trials of the black-eyed cowpea for the State of Mato Grosso (Table 4).

The results of the evaluation of the blemished grain are presented in Tables 5 and 6. There was a significant difference (P<0.05) between lines for the percentage of blemished grain, demonstrating the possibility of selecting lines having a lower percentage of blemished grain. A significant effect was also seen for the contrasting interaction lines vs. controls (L vs. C), showing that the mean value of the lines (7.60%) was different from that of the controls (17.13%) (Table 5).

In the colour analysis, there was no significant difference between lines for the colour bands of the CIE L* a* and b* three-dimensional system (Table 5); it was therefore not possible to use the colorimeter readings as an aid to visual selection. One possible explanation for the colorimeter not being able to discriminate the lines is that the grain of the black-eyed cowpea has an integument that is part white and part black (black hilum). The black hilum may have masked the presence of blemishes, causing all the lines to display the same colour pattern. Use of the colorimeter has been successfully applied to quantifying the darkening of stored grain in the common bean (BRACKMANN *et al*., 2002; SIQUEIRA, 2013).

Table 6 shows the mean values of the lines for the percentage of blemished grain. Values ranged from 2% (Line 14) to 30% (BRS Itaim). By the Scott-Knott test (P<0.01), the lines formed two distinct groups (groups b and c). It was found that all the lines had a lower percentage of blemished grain than the control, BRS Itaim (group a), with 15 lines being grouped with less than 8% blemished grain (Table 6), and four lines with a productivity comparable to that of the BRS

**Table 3 -** Mean values for crop value (VC), lodging (LDG) and grain productivity (PROD) in lines of the black-eyed cowpea, evaluated in Sinop MT (2015), Nova Ubiratã MT (2014) and Primavera do Leste MT (2015)

| Lines | Sinop MT | | | Nova Ubiratã MT | | | Primavera do Leste MT | | |
|---|---|---|---|---|---|---|---|---|---|
| | VC | LDG | PROD | VC | LDG | PROD | VC | LDG | PROD |
| 1 | 3.0 a | 4.8 a | 197 a | 3.8 a | 3.3 a | 1602 a | 3.5 a | 4.5 a | 1888 a |
| 2 | 3.5 a | 3.0 a | 326 a | 4.4 a | 1.8 a | 1600 a | 3.1 a | 3.3 b | 1608 b |
| 3 | 3.8 a | 1.8 b | 488 a | 3.3 b | 2.5 a | 1306 a | 3.0 a | 2.8 c | 1408 b |
| 4 | 3.8 a | 2.3 b | 516 a | 3.8 a | 2.3 a | 1456 a | 3.1 a | 2.3 c | 1725 a |
| 5 | 3.8 a | 2.0 b | 372 a | 3.9 a | 2.3 a | 1381 a | 3.1 a | 2.3 c | 1630 b |
| 6 | 3.8 a | 2.0 b | 537 a | 4.0 a | 1.5 a | 1503 a | 3.0 a | 2.5 c | 1343 b |
| 7 | 3.8 a | 1.3 b | 570 a | 4.1 a | 1.8 a | 1413 a | 3.0 a | 3.5 b | 1930 a |
| 8 | 4.0 a | 1.3 b | 672 a | 4.1 a | 2.0 a | 1413 a | 3.3 a | 1.8 c | 1555 b |
| 9 | 3.8 a | 1.5 b | 422 a | 3.5 b | 2.5 a | 1366 a | 3.0 a | 2.3 c | 1615 b |
| 10 | 4.0 a | 2.5 b | 481 a | 3.3 b | 2.0 a | 1281 a | 3.1 a | 2.0 c | 1785 a |
| 11 | 4.0 a | 2.0 b | 340 a | 3.9 a | 2.3 a | 1292 a | 3.1 a | 2.0 c | 1585 b |
| 12 | 3.8 a | 1.8 b | 418 a | 3.8 a | 2.8 a | 1476 a | 3.1 a | 2.5 c | 1595 b |
| 13 | 3.8 a | 2.0 b | 428 a | 4.1 a | 2.3 a | 1350 a | 3.3 a | 2.3 c | 1668 a |
| 14 | 4.0 a | 1.5 b | 634 a | 3.5 b | 1.8 a | 1304 a | 3.3 a | 2.5 c | 1280 b |
| 15 | 3.3 a | 3.5 a | 302 a | 3.5 b | 3.3 a | 1194 a | 3.3 a | 2.3 c | 1665 a |
| 16 | 3.3 a | 3.0 a | 323 a | 3.6 b | 2.3 a | 1373 a | 3.0 a | 3.3 b | 1753 a |
| 17 | 3.8 a | 1.5 b | 601 a | 4.0 a | 2.5 a | 1300 a | 3.4 a | 2.3 c | 1868 a |
| 18 | 3.5 a | 2.5 b | 357 a | 3.9 a | 2.3 a | 1370 a | 3.1 a | 2.8 c | 1523 b |
| 19 | 3.8 a | 2.0 b | 509 a | 4.0 a | 2.5 a | 1306 a | 3.3 a | 2.5 c | 1755 a |
| 20 | 4.0 a | 2.5 b | 411 a | 3.9 a | 1.5 a | 1473 a | 3.1 a | 2.3 c | 1490 b |
| 21 | 3.5 a | 1.8 b | 504 a | 3.5 b | 2.5 a | 1340 a | 3.5 a | 2.3 c | 2033 a |
| 22 | 4.0 a | 1.8 b | 574 a | 3.8 a | 2.0 a | 1466 a | 2.8 a | 2.8 c | 1683 a |
| 23 | 3.3 a | 2.5 b | 397 a | 3.6 b | 2.8 a | 1287 a | 2.9 a | 2.8 c | 1143 b |
| 24 | 3.3 a | 3.3 a | 398 a | 3.9 a | 2.3 a | 1465 a | 3.3 a | 3.0 b | 2055 a |
| BRS Itaim | 3.8 a | 2.3 b | 454 a | 4.4 a | 1.8 a | 1638 a | 3.4 a | 2.5 c | 1855 a |
| CB 27 | 3.8 a | 1.8 b | 463 a | 3.3 b | 2.5 a | 1565 a | 3.0 a | 2.5 c | 1275 b |

Mean values followed by the same letter in a column do not differ by Scott-Knott test at 5% probability (P<0.05)

**Table 4 -** Mean values of the joint analysis for crop value, lodging and grain productivity in lines of the black-eyed cowpea, tested in Nova Ubiratã MT (2014). Primavera do Leste MT (2015) and Sinop MT (2015)

| Line | Crop Value | Lodging | Productivity (kg ha⁻¹) |
|---|---|---|---|
| 1 | 3.42 b | 4.17 a | 1229 a |
| 2 | 3.67 a | 2.67 b | 1178 a |
| 3 | 3.33 b | 2.33 c | 1067 b |
| 4 | 3.54 a | 2.25 c | 1232 a |
| 5 | 3.58 a | 2.17 c | 1128 b |
| 6 | 3.58 a | 2.00 c | 1127 b |
| 7 | 3.63 a | 2.17 c | 1304 a |
| 8 | 3.79 a | 1.67 c | 1214 a |

*Continued Table 4*

| | | | |
|---|---|---|---|
| 9 | 3.42 b | 2.08 c | 1134 b |
| 10 | 3.46 b | 2.17 c | 1182 a |
| 11 | 3.67 a | 2.08 c | 1072 b |
| 12 | 3.54 a | 2.33 c | 1163 b |
| 13 | 3.71 a | 2.17 c | 1148 b |
| 14 | 3.58 a | 1.92 c | 1073 b |
| 15 | 3.33 b | 3.00 b | 1053 b |
| 16 | 3.29 b | 2.83 b | 1150 b |
| 17 | 3.71 a | 2.08 c | 1256 a |
| 18 | 3.50 b | 2.50 c | 1083 b |
| 19 | 3.67 a | 2.33 c | 1190 a |
| 20 | 3.67 a | 2.08 c | 1123 b |
| 21 | 3.50 b | 2.17 c | 1292 a |
| 22 | 3.50 b | 2.17 c | 1241 a |
| 23 | 3.25 b | 2.67 b | 942 b |
| 24 | 3.46 b | 2.83 b | 1306 a |
| BRS Itaim | 3.83 a | 2.17 c | 1316 a |
| CB 27 | 3.33 b | 2.25 c | 1101 b |

Mean values followed by the same letter in a column do not differ by Scott-Knott test at 5% probability (P<0.05)

**Table 5 -** Summary of analysis of variance for percentage of blemished grain (%BG). luminosity (L*) chroma (a*) and chroma (b*) in lines of the black-eyed cowpea, tested in Primavera do Leste MT (2015)

| SV[1] | DF | %BG | | L* | | a* | | b* | |
|---|---|---|---|---|---|---|---|---|---|
| | | MS | P | MS | P | MS | P | MS | P |
| Treatments | 25 | 121.04 | 0.000 | 5.74 | 0.999 | 1.23 | 0.999 | 1.58 | 0.999 |
| Lines (L) | 23 | 44.80 | 0.045 | 5.42 | 0.999 | 1.05 | 0.999 | 1.66 | 0.204 |
| Controls (C) | 1 | 1326.13 | 0.000 | 6.28 | 0.305 | 2.08 | 0.201 | 0.73 | 0.999 |
| L vs. C | 1 | 669.38 | 0.000 | 12.42 | 0.150 | 4.59 | 0.059 | 0.71 | 0.999 |
| Residual | 75 | 13.46 | | 5.89 | | 1.25 | | 1.28 | |
| Mean | | 8.33 | | 64.40 | | 6.25 | | 17.53 | |
| Mean Lines | | 7.60 | | 64.50 | | 6.19 | | 17.52 | |
| Mean Controls | | 17.13 | | 62.32 | | 6.98 | | 17.83 | |
| CV(%) | | 44.01 | | 3.77 | | 17.86 | | 6.46 | |

[1] SV: source of variation; DF: degrees of freedom; MS: mean square of the treatments; P: probability; CV: coefficient of variation

Itaim cultivar by the Scott-Knott test at 5% probability (Table 4). These lines show potential for inclusion in the VCU trials for the State of Mato Grosso, as they combined grain productivity equal to that of the BRS Itaim cultivar and a low percentage of blemished grain.

For the colour bands of the L*, a* and b* three-dimensional system, the lines formed only one group by the Scott-Knott test (Table 6); it is therefore not possible to use the information obtained with the colorimeter to aid in the visual selection of lines of the black-eyed cowpea with a lower percentage of blemished grain.

**Table 6 -** Mean values for blemished grain (% BG), luminosity (L*), chroma (a*) and chroma (b in lines of the black-eyed cowpea, tested in Primavera do Leste MT (2015)

| Line | %GM | L* | a* | b* |
|------|------|--------|-------|---------|
| 1 | 6.00 c | 66.81 a | 6.64 a | 18.07 a |
| 2 | 6.75 c | 65.25 a | 5.58 a | 16.79 a |
| 3 | 4.75 c | 64.32 a | 5.81 a | 16.99 a |
| 4 | 13.5 b | 64.45 a | 6.04 a | 17.41 a |
| 5 | 5.50 c | 64.75 a | 5.75 a | 16.84 a |
| 6 | 5.25 c | 63.91 a | 6.02 a | 17.43 a |
| 7 | 11.0 b | 66.20 a | 5.66 a | 17.06 a |
| 8 | 10.5 b | 63.82 a | 6.16 a | 17.04 a |
| 9 | 4.50 c | 63.21 a | 5.99 a | 17.05 a |
| 10 | 10.25 b | 63.78 a | 6.42 a | 17.47 a |
| 11 | 5.50 c | 65.11 a | 7.13 a | 18.79 a |
| 12 | 5.50 c | 66.20 a | 7.28 a | 18.98 a |
| 13 | 5.00 c | 64.55 a | 6.01 a | 17.45 a |
| 14 | 2.00 c | 64.82 a | 6.33 a | 17.29 a |
| 15 | 7.00 c | 64.88 a | 6.11 a | 17.69 a |
| 16 | 9.75 b | 64.89 a | 6.02 a | 17.49 a |
| 17 | 5.75 c | 62.99 a | 6.30 a | 17.80 a |
| 18 | 8.75 b | 65.53 a | 5.91 a | 17.84 a |
| 19 | 5.50 c | 62.75 a | 7.57 a | 18.60 a |
| 20 | 4.25 c | 64.52 a | 6.32 a | 18.03 a |
| 21 | 15.5 b | 64.12 a | 5.87 a | 17.46 a |
| 22 | 12.75 b | 63.30 a | 5.70 a | 16.81 a |
| 23 | 7.75 c | 65.83 a | 5.81 a | 17.63 a |
| 24 | 9.50 b | 62.08 a | 6.06 a | 16.38 a |
| BRS Itaim | 30.00 a | 64.09 a | 6.47 a | 17.53 a |
| CB 27 | 4.25 c | 62.32 a | 7.48 a | 18.13 a |

Mean values followed by the same letter in a column do not differ by Scott-Knott test at 1% probability (P<0.01)

## CONCLUSIONS

1. Four lines show potential for inclusion in the VCU trials for the State of Mato Grosso, combining grain productivity comparable to that of the BRS Itaim cultivar and a low percentage of blemished grain;

2. Visual evaluation, by counting the blemished grain, was efficient in identifying lines of the black-eyed cowpea having better grain quality in relation to the BRS Itaim cultivar;

3. Colour readings, using the CIE L* a* b* scale, did not satisfactorily differentiate the occurrence of blemished grain in lines of the black-eyed cowpea.

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