Agronomic performance of cowpea cultivars in first crop in Southwest of Minas Gerais, Brazil

Performance agronômica de cultivares de feijão-caupi no período de primeira safra no Sudoeste de Minas Gerais, Brasil

Desempeño agronómico de cultivares de caupí en temporada de primera cosecha en el Suroeste de Minas Gerais, Brasil

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ABSTRACT

The cowpea (*Vigna unguiculata* (L.) Walp.) is well adapted to high temperatures, water deficits and low fertility soils, being widely cultivated in regions less favorable to common beans. Its grains are rich in proteins, vitamins and minerals, representing an important food source and a promising alternative for producing protein at low cost, in a short space of time, given the precocity of its cycle. However, in the state of Minas Gerais there is only a recommendation for one cowpea cultivar, the Poços de Caldas cultivar. In addition to being quite old, it is no longer found in crop production fields. The aims of study was to evaluate the agronomic performance of cowpea cultivars and to recommend cultivars adapted to cultivation in edaphoclimatic conditions of Southwest Region of Minas Gerais State, Brazil. The experiments were carried out in Passos city, Minas Gerais State, Brazil, during the first crop period, in 2021/2022 and 2022/2023 years, with 10 commercial cowpea cultivars, in a randomized block experimental design, with five replications. The mass of a thousand seeds and the grain index correlated directly with the yield. Cultivars with the lowest grain yields promoted the highest pod lengths and number of grains per pod. The best morphophysiological results for cowpea were obtained in 2021/2022 year. The most adapted cowpea cultivars for period of first crop in edaphoclimatic conditions of Southwest Region of Minas Gerais State, Brazil, were BRS Novaera, BRS Guariba, and BRS Xique-Xique and least indicated was BRS Marataoã. More studies are needed to consolidate cowpea cultivation in the Southwest Region of Minas Gerais, mainly in second-crop crops.

Keywords: *Vigna unguiculata*. Grain Yield. Genotype x Environment Interaction. Adaptability. Stability.

RESUMO

O feijão-caupi (*Vigna unguiculata* (L.) Walp.) apresenta boa adaptação a altas temperaturas, ao déficit hídrico e a solos de baixa fertilidade, sendo bastante cultivado em regiões menos favoráveis ao feijão-comum. Seus grãos são ricos em proteínas, vitaminas e minerais, representando importante fonte alimentar e uma alternativa promissora para produção de proteína a baixo custo, em curto espaço de tempo, dado a precocidade de seu ciclo. Entretanto, em Minas Gerais só existe a recomendação de uma cultivar de feijão-caupi, a cultivar Poços de Caldas. Além de bastante antiga, esta não é mais encontrada nos campos de produção da cultura. O objetivo do trabalho foi avaliar o desempenho agronômico de cultivares de feijão-caupi e recomendar as cultivares mais estáveis e adaptadas ao cultivo nas condições edafoclimáticas da Região Sudoeste de Minas Gerais. Os experimentos foram conduzidos em Passos – MG, durante o período de primeira safra, nos anos agrícolas de 2021/2022 e 2022/2023, com 10 cultivares comerciais de feijão-caupi, em delineamento experimental de blocos casualizados, com cinco repetições. A massa de mil sementes e o índice de grãos correlacionaram diretamente com a produtividade. As cultivares com as menores produtividades de grãos promoveram os maiores comprimentos de vagens e números de grãos por vagem. Os melhores parâmetros morfofisiológicos para o feijão-caupi foram obtidos no ano agrícola 2021/2022. As cultivares de feijão-caupi mais adaptadas para o período da primeira safra nas condições edafoclimáticas da Região Sudoeste de Minas Gerais foram BRS Novaera, BRS Guariba e BRS Xique-Xique e a menos indicada foi a BRS Marataoã. Mais estudos são necessários para consolidação da cultura do feijão-caupi na Região Sudoeste Mineira, principalmente em cultivos de safrinha.

Palavras-chave: *Vigna unguiculata*. Produtividade. Interação Genótipo x Ambiente. Adaptabilidade. Estabilidade.

RESUMEN

El caupí (*Vigna unguiculata* (L.) Walp.) se adapta bien a las altas temperaturas, el déficit hídrico y los suelos de baja fertilidad, siendo ampliamente cultivado en regiones menos favorables al frijol común. Sus granos son ricos en proteínas, vitaminas y minerales, representando una importante fuente de alimento y una alternativa prometedora para producir proteínas a bajo costo, en corto espacio de tiempo, dada la precocidad de su ciclo. Sin embargo, en Minas Gerais solo hey la recomendación de un cultivar de caupí, el cultivar Poços de Caldas. Además de ser bastante antiguo, ya no se encuentra en los campos de producción agrícola. El objetivo del trabajo fue evaluar el desempeño agronómico de cultivares de caupí y recomendar los cultivares más estables y adaptados al cultivo en las condiciones edafoclimáticas de la Región Suroeste de Minas Gerais. Los experimentos se realizaron en Passos-MG, durante el primer período de cosecha, en los años agrícolas 2021/2022 y 2022/2023, con 10 cultivares comerciales de caupí, en un diseño experimental de bloques al azar, con cinco repeticiones. La masa de mil semillas y el índice de grano se correlacionaron directamente con la productividad. Los cultivares con menor rendimiento de grano tuvieron las mayores longitudes de vaina y mayor número de granos por vaina. Los mejores parámetros morfofisiológicos del caupí se obtuvieron en el año agrícola 2021/2022. Los cultivares de caupí más adaptados al primer período de cosecha en las condiciones edafoclimáticas de la Región Suroeste de Minas Gerais fueron BRS Novaera, BRS Guariba y BRS Xique-Xique y el menos recomendado fue BRS Marataoã. Se necesitan más estudios para la consolidación del cultivo de caupí en la Región Suroeste de Minas Gerais, principalmente en cultivos fuera de temporada.

Palabras clave: *Vigna unguiculata*. Productividad. Interacción Genotipo x Ambiente. Adaptabilidad. Estabilidad.

1 INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp.) is well adapted to high temperatures, water deficit, and low fertility soils, being widely cultivated in regions less favorable to bean-common (GERRANO *et al*., 2020), have grains rich in proteins, vitamins, and minerals (JAYATHILAKE *et al*., 2018), representing an important food source for world population (KULKARNI *et al*., 2018; OMOMOWO; BABALOLA, 2021) and a promising low-cost protein alternative (WENG *et al*., 2019; ARAÚJO *et al*., 2021) in a short period of time, given the precocity of vegetative cycle (TOMAZ *et al*., 2022).

In Brazil, the cultivation of cowpea is traditional in North and Northeast regions, where it is generally practiced by small and medium-sized family farmers using low technology (SILVA *et al*., 2018a; MELO *et al*., 2020). However, the crop has been expanding to other regions of country (VALERIANO *et al*., 2019), such as the areas of Midwest, North, Northeast and Southeast regions, being cultivated as a second crop by business-based farmers, with use of high technological level and production destined for foreign market (ALVES *et al*., 2020; SORATTO *et al*., 2020).

Brazilian production of cowpea was 632 thousand tons, with the largest producing States being Bahia, Ceará, Tocantins, Piauí, and Mato Grosso (CONAB, 2023). Minas Gerais State produces about 7,700 tons per year in an area of 16,600 hectares, which provides an average productivity of 464 kg ha^{-1}

(CONAB, 2023), considered extremely low compared to those obtained in Brazil by Silva *et al*. (2018b), Alves *et al*. (2020) and Lacerda *et al*. (2020) in which showed grain yields of 2,500, 3,300 and 2,000 kg ha^{-1}, respectively. The low yield in Minas Gerais State is associated with low use of technologies and, mainly, the lack of adapted and recommended cultivars for edaphoclimatic conditions of region.

In Minas Gerais State, there is only one recommendation for a cowpea cultivar, Poços de Caldas cultivar (VIEIRA; VIEIRA; CALDAS, 2000), characterized by being an old genetic material and of low grain yield, additionally, it is no longer found in crop production fields. Thus, the cultivars currently used in Cerrado region are older genetic materials, with low productive potential and little adaptation to mechanized systems, or genetically improved cultivars, recommended for other regions of Brazil.

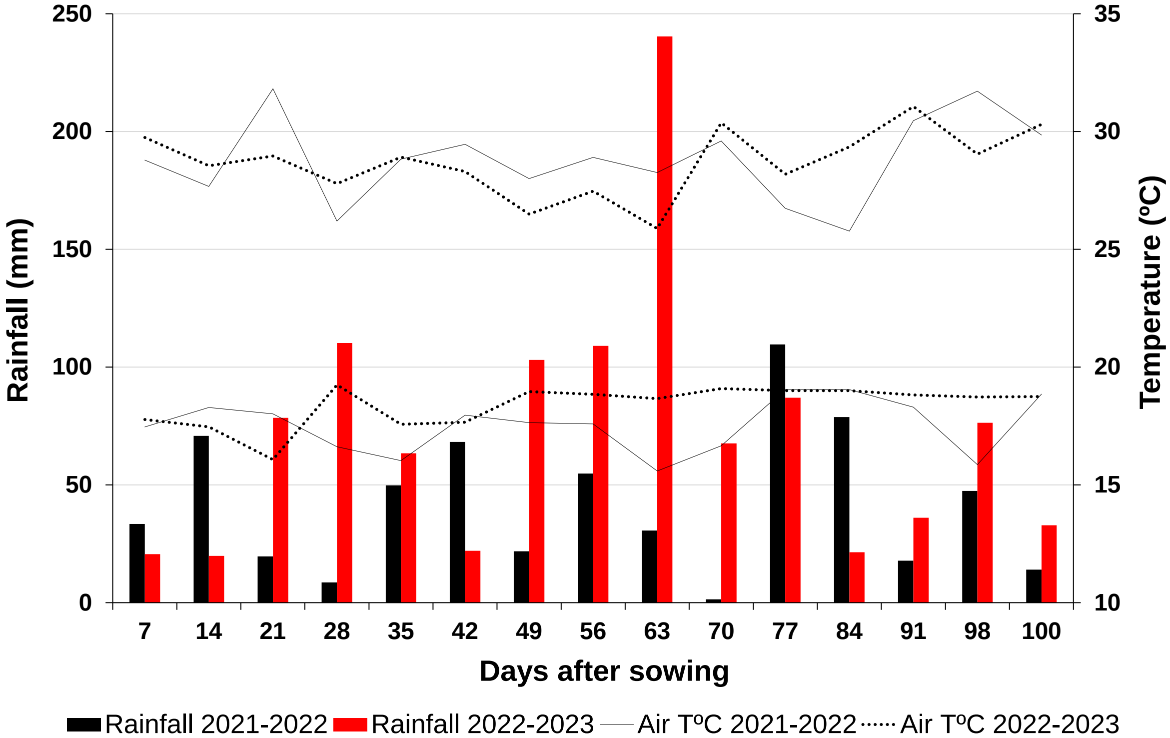
As a result of genotype x environment interaction and great edaphoclimatic variation in Brazil, extremely competitive cultivars in certain places, in others they may not express their potential (GERRANO *et al*., 2020; ARAÚJO *et al*., 2021; CRUZ *et al*., 2021). For this reason, it is essential to know the agronomic performance of cowpea cultivars in most different locations (ALVES *et al*., 2020; TATIS *et al*., 2021; TOMAZ *et al*., 2022) so that agricultural producers have access to to genotypes more adapted to growing conditions (ABIRIGA *et al*., 2020; GERRANO *et al*., 2020).

The aims of study was to evaluate the agronomic performance of cowpea cultivars and to recommend cultivars adapted to cultivation in edaphoclimatic conditions of Southwest Region of Minas Gerais State, Brazil.

2 MATERIAL AND METHODS

The experiments were conducted at Experimental Farm of State University of Minas Gerais, in Passos city, Minas Gerais State, Brazil (geographical coordinates: latitude 20°45'00''S and longitude 46°37'48''W). The region has an approximate altitude of 783 m, temperature and average annual precipitation of 21.4ºC and 1623 mm, respectively. According to Köppen, the climate classification is Cwa, humid subtropical climate with hot summer and dry winter (ALVARES *et al*., 2013). The climatological data referring to cultivation period were obtained at Climatological Station located at UEMG Experimental Farm and are shown in Figure 1.

Figure 1: Rainfall, maximum (TMax) and minimum (TMin) temperatures that occurred during experimental period in 2021/2022 and 2022/2023 years.



Source: Climatological Station located at UEMG Experimental Farm, Passos city (2024)

The soil in experimental area was classified as eutrophic Red-Yellow Latosol (EMBRAPA, 2018), with medium texture (clay: 310 g kg^{-1}; silt: 127 g kg^{-1}; sand: 563 g kg^{-1}). The main chemical characteristics of soil in layers from 0 to 20 cm and 20 to 40 cm are shown in Table 1.

Table 1: Soil chemical analyzes from the 0-20 cm and 20-40 cm depth layers in 2021/2022 and 2022/2023 years.

Chemical characteristics	2021/2022		2022/2023	
	0-20	20-40	0-20	20-40
pH $CaCl_2$	6.3	6.4	5.2	5.3
O.M. (g dm^{-3})	18	15	18	15
P (mg dm^{-3}), Mehlich	25	13	51	14
K^+ ($mmol_c$ dm^{-3}), Mehlich	3.8	2.2	3.7	2.8
Ca^{+2} ($mmol_c$ dm^{-3}), Mehlich	48	39	13	12
Mg^{+2} ($mmol_c$ dm^{-3}), Mehlich	26	16	7	5
S (mg dm^{-3}), Calcium phosphate	4	8	10	13
B (mg dm^{-3}), Hot water	0.12	0.10	0.16	0.12
Cu (mg dm^{-3}), DPTA	0.54	0.58	0.78	0.58
Fe (mg dm^{-3}), DPTA	10	7	14	11
Mn (mg dm^{-3}), DPTA	1.50	0.88	2.48	2.06
Zn (mg dm^{-3}), DPTA	0.90	0.62	0.78	0.46
Al^{+3} ($mmol_c$ dm^{-3}), KCl 1mol L^{-1}	1	1	1	1
H^+ + Al^{+3} ($mmol_c$ dm^{-3}), SMP	10	10	17	14
Sum of bases ($mmol_c$ dm^{-3})	78	57	24	20
Base saturation (%)	89	85	58	59
Cation exchange capacity ($mmol_c$ dm^{-3})	88	67	41	34

Source: Soil and Leaf Analysis Laboratory of UEMG, Passos city (2024)

The experiments occurred during the period of first crop, in 2021/2022 (sowing: October 21, 2021 and harvest: January 28, 2022) and 2022/2023 years (sowing: November 11, 2022 and harvest: February 18, 2023).

The experimental design adopted was randomized complete blocks, with five replications, in which 10 commercial cultivars of cowpea were evaluated, as specified: BRS Xique-Xique, BRS Tumucumaque, BRS Novaera, BRS Imponente, BRS Marataoã, BRS Rouxinol, BRS Pajeú, BRS Itaim, BRS Cauamé and BRS Guariba. The experimental plots consisted of 5 lines with 5.0 m in length and spacing of 0.5 m, totaling 12.5 m^2 of area.

Soil preparation was carried out with plowing and two harrowing. Subsequently, furrows spaced 0.50 m apart were opened, in which the seeds were manually deposited for a population density of 10 plants m^{-1}.

Fertilization was carried out based on soil analyzes and on recommendations indicated by Ribeiro, Guimarães and Alvarez (1999) and cultural practices and pest and disease controls were carried out in accordance with recommendations adopted for crop (VALE; BERTINI; BORÉM, 2017). Weeding was carried out manually between 20 and 35 days after sowing.

The characteristics evaluated in pre-harvest were size, lodging, cultivation value and disease tolerance, as described in Table 2.

Table 2: Scale of morphophysiological assessments (size, lodging, cultivation value and disease tolerance) in cowpea cultivars.

Scale for classifying the size of cowpea plants			
1 Erect	Short main and secondary branches, with insertion of secondary branches forming a right angle with main branch.		
2 Semi erect	Short main and secondary branches, with insertion of secondary branches approximately perpendicular to main branch. They generally do not touch the ground.		
3 Semi prostrate	Medium-sized main and secondary branches, with lower secondary branches touching the ground and tending to lean on vertical supports.		
4 Prostate	Long main and secondary branches, with lower secondary branches touching the ground and tending to lean on vertical supports.		
Scale for classifying the degree of lodging of cowpea plants			
1	No lodging or with the main branch broken		
2	From 1 to 5% lodging or with a broken main branch.		
3	From 6 to 10% lodging or with a broken main branch.		
4	From 11 to 20% lodging or with a broken main branch.		
5	Above 20% lodging or with a broken main branch.		
Scale for classifying the cultivation value of cowpea plants			
1	Lines/cultivar without suitable characteristics for commercial cultivation.		
2	Plants with few characteristics suitable for commercial cultivation.		
3	Plants with most of characteristics suitable for commercial cultivation.		
4	Plants with all the characteristics suitable for commercial cultivation.		
5	Plants with excellent characteristics for commercial cultivation.		
Scale for classification of cowpea plant diseases			
1	0% infected plants	6	20-40% infected plants
2	1% infected plants	7	40-60% infected plants
3	1-5% infected plants	8	60-80% infected plants
4	5-10% infected plants	9	80-100% infected plants
5	10-20% infected plants		

Source: Embrapa Mid-North (Trial monitoring worksheet, 2017).

At the time of harvest were evaluated pod length, number of grains per pod, grain index, mass of a thousand seeds, and grain yield. Grain yield was estimated by useful area of each plot, with moisture corrected to 13%, and expressed in kg ha^{-1}.

The experimental residues were submitted to Shapiro-Wilk ($p>0.01$) and Levene ($p>0.01$) tests to verify normality and homoscedasticity, respectively. Subsequently, individually in each experiment, the analysis of variance ($p<0.05$) was performed (Steel and Torrie, 1960), to verify the relationships between the residual mean squares were lower than 7:1 (BANZATTO; KRONKA, 2006). Given this assumption, it became possible to work with joint analysis of data, adding the year factor as a source of variation in analysis of variance.

In joint analysis, the developments were used that proved to be necessary, regardless of whether the interaction between factors was significant or not

(PERECIN; CARGNELUTTI FILHO, 2008; BARBIN, 2013). This procedure was adopted because the individual analysis of variance presents an average "F" test, and often, although interaction is not significant, in unfolding of one factor within other (deeper analysis), significance can be detected that provides important results from a practical point of view (PERECIN; CARGNELUTTI FILHO, 2008; BARBIN, 2013).

The effects of cultivars were compared by Scott-Knott test at 5% significance and effects of years were studied by F test ($p<0.05$) of analysis of variance, since for two levels of factor it is conclusive. All statistical procedures were performed using Sisvar computational program (FERREIRA, 2019).

3 RESULTS AND DISCUSSIONS

The joint analysis of variance for main factors, tested separately, showed that cultivar factor was significant ($P<0.05$) for agronomic characteristics (Table 3). The year factor was not significant ($P>0.05$) for number of grains per pod, grain index and size (Table 3). While, the cultivar x year interaction showed dependence ($P<0.05$) between the factors for most of characteristics evaluated, except for lodging, size and cultivation value (Table 3).

Table 3: Summary of analysis of variance, coefficient of variation (CV) and overall mean involving ten cowpea cultivars, cultivated in two years, for yield (YIELD), thousand seed mass (TSM), pod length (PL), number of grains per pod (GP), grain index (GI), lodging (LOD), size, diseases and cultivation value (CULT).

Source of variation	GL	QUADRADOS MÉDIOS								
		YIELD	TSM	PL	GP	GI	LOD	Size	Diseases	CULT
		kg ha^{-1}	g	cm	un	%	------------------- note -------------------			
Cultivars (C)	9	1899446*	1257*	2.80*	15.81*	42.08*	4.82*	1.31*	2.34*	1.63*
Years (Y)	1	9684855*	1226*	21.07*	1.96^{ns}	6.86^{ns}	10.24*	0.04^{ns}	16.00*	1.93*
C x Y	9	782556*	836*	2.02*	3.15*	12.38*	0.46^{ns}	0.08^{ns}	2.04*	0.21^{ns}
Block	4	167902*	101^{ns}	6.85*	4.41*	3.11^{ns}	1.36*	0.46^{ns}	0.84	0.94*
Residue	76	57600	177	0.92	1.36	4.84	0.38	0.26	0.48	0.18
Average		1336	157	18.14	12.02	75.80	3.32	3.12	4.36	2.28
CV (%)		17.96	8.43	5.27	9.72	2.90	18.45	16.50	15.84	18.76

*Significant ($p<0.05$); ns – not significant ($p>0.05$), by F test.
Source: own authorship (2024)

The tested genotypes showed interaction with existing edaphoclimatic conditions in period of first crop in Southwest Region of Minas Gerais, Brazil. Additionally, climate variation, mainly rainfall distribution (Figure 1), significantly influenced most morphophysiological and phytotechnical parameters in years (Table 3). Distinct agronomic performance among cowpea cultivars were also identified and several studies conducted in Brazil (ABIRIGA *et al.,* 2020; ALVES *et al.,* 2020; MELO *et al.,* 2020; CRUZ *et al.,* 2021; TATIS *et al.,* 2021; TOMAZ *et al.,* 2022).

The general average of grain yield obtained in experiments, considering the two years and ten cultivars, was 1336 kg ha^{-1}. The average yields of cowpea in Brazil and Minas Gerais in 2021/2022 harvest were 491 and 464 kg ha^{-1}, respectively (CONAB, 2023), lower than general average obtained in present study (Table 3). In period of the first crop, the Southwest Region of Minas Gerais satisfactorily provides the edaphoclimatic needs required by cowpea, representing one more option for crops that can be inserted in a rotation scheme, with a view to better agricultural diversification. In addition, there are the beneficial effects that legume provides to the soil (GERRANO *et al.,* 2020), since it has been recommended as a green manure (IQBAL *et al.,* 2018; KULKARNI *et al.,* 2018; AIOSA *et al.,* 2020).

In years, regardless of cultivars, the cultivation cycle (sowing - harvesting) was 100 days (Figure 1), showing insensitivity to genetic variation, as cowpea has little sensitivity to photoperiod, thus, regardless of region, season of planting and genotypes, variations in the cycle are not very pronounced (SANTOS *et al.,* 2014; CORREA *et al.,* 2015).

In morphophysiological evaluations, it was verified that the cultivars that had shorter and more erect branches provided healthier and less bedridden plants, and, therefore, a more adequate cultivation value (Table 4). In general, superiority was observed for BRS Novaera, BRS Guariba, BRS Xique-Xique, and BRS Tumucumaque cultivars and inferiority for BRS Marataoã (Table 4).

Table 4: Morphophysiological evaluations (LOD - lodging, SIZE, DISEASES and CULT - cultivation value) of ten cowpea cultivars grown in Southwest of Minas Gerais, Brazil, in the first crop, in 2021/2022 and 2022/2023 years.

Cultivars	LOD	SIZE	DISEASES	CULT
BRS Novaera	2.9 c*	2.9 c	4.1 b	2.5 c
BRS Guariba	3.1 c	2.9 c	4.2 b	2.6 c
BRS Xique-Xique	2.3 d	2.7 c	3.9 b	3.0 d
BRS Tumucumaque	2.8 c	2.8 c	4.1 b	2.4 b
BRS Pajeú	3.9 b	3.4 b	4.0 b	2.3 b
BRS Imponente	2.8 c	3.1 c	4.4 b	2.3 b
BRS Rouxinol	4.5 a	3.3 b	4.4 b	2.1 b
BRS Cauamé	3.7 b	3.3 b	4.3 b	2.0 b
BRS Itaim	3.1 c	2.9 c	4.6 b	2.2 b
BRS Marataoã	4.1 b	3.9 a	5.6 a	1.5 a
Years	Morphophysiological evaluations			
2021-2022	3.0 b	3.14 a	3.93 b	2.4 a
2022-2023	3.6 a	3.10 a	4.76 a	2.1 b

* Means followed by different letters in columns differ from each other (p > 0.05) by Scott-Knott test.

Source: own authorship (2024)

The thousand seed mass and grain index correlated directly with grain yield, verifying that the cultivars with highest grain density and participation of grains in grain/pod (grain index) were the most productive (Table 5).

The variables number of grains per pod and pod length were inversely proportional to grain yield (Table 5). The least productive cultivars were those with greatest pod lengths and, therefore, the highest number of grains per pod. Thus, a tendency towards a compensation effect is evident, although the increase was not sufficient to match the productive performance (Table 5). The relationship between grain yield, number of pods per plant, grain index and thousand seed mass are preponderant factors to be considered in genetic improvement programs and relevant during the process of recommending cowpea cultivars (TOMAZ *et al.* 2022).

Tomaz *et al.* (2022) studying twelve cowpea genotypes in five environments in Ceará State, Brazil, observed that the number of pods per plant and grain index showed the highest correlations with grain yield, and negative correlations between grain yield and pod length and number of grains per pod. According to Passos *et al.* (2007) the characteristic “production per pod” is associated with morphophysiological factors of cultivar, in such a way that prostrate genotypes tend to produce more grains per pod than erect and semi-erect ones. In general, the cultivars with highest number of grains per pod obtained in study (Table 5) were those with highest size scores, that is, the most prostrate (Table 4).

The three cultivars that showed the highest yield in average years (Table 5 - BRS Novaera, BRS Guariba, and BRS Xique-Xique) were the ones that obtained the lowest scores of aerial part architecture, less lodging, healthier and with higher averages of cultivation value (Table 4). At the other extreme, the least productive cultivar (Table 5 - BRS Marataoã) showed the worst results for morphophysiological characteristics (Table 4), verifying that the morphophysiological variables collaborated directly with cultivars yield.

Table 5: Average values of YIELD – yield in kg ha^{-1}, TSM – thousand seed mass in g, PL – pod length in cm, GP – number of grains per pod, and GI – grain index in %, of ten cowpea cultivars cultivated in Southwest of Minas Gerais, Brazil, in first crop of 2021/2022 and 2022/2023 years.

Cultivars	YIELD			TSM			PL			GP			GI		
	21/22	22/23	Average	21/22	22/23	Average	21/22	22/23	Average	21/22	22/23	Average	21/22	22/23	Average
BRS Novaera	2587 Aa*	1058 Ab	1823 A	186 Aa	166 Ab	176 A	19.2 Aa	16.2 Ba	17.7 B	11.1 Ba	10.3 Ca	10.7 B	78.2 Aa	75.4 Ab	76.8 A
BRS Guariba	2509 Aa	1089 Ab	1799 A	190 Aa	152 Ab	171 A	18.5 Aa	17.5 Ba	18.0 B	10.6 Ba	11.7 Ba	11.2 B	78.6 Aa	76.7 Aa	77.6 A
BRS Xique-Xique	2149 Ba	1234 Ab	1691 A	150 Ca	160 Aa	155 C	18.1 Aa	17.4 Ba	17.7 B	10.8 Ba	10.5 Ca	10.7 B	75.8 Aa	76.2 Aa	76.0 B
BRS Tumucumaque	1996 Ba	1194 Ab	1595 B	168 Ba	149 Ab	159 B	19.7 Aa	18.3 Ab	19.0 A	11.2 Ba	12.0 Ba	11.6 B	76.3 Aa	77.2 Aa	76.7 A
BRS Pajeú	1839 Ba	1021 Ab	1430 B	150 Ca	138 Aa	144 C	18.0 Aa	17.5 Ba	17.8 B	11.8 Ba	12.3 Ba	12.1 B	77.1 Aa	76.5 Aa	76.8 A
BRS Imponente	1452 Ca	1130 Ab	1291 C	166 Ba	162 Aa	164 B	18.3 Aa	18.2 Aa	18.3 B	11.1 Ba	11.9 Ba	11.5 B	76.2 Aa	74.8 Aa	75.5 B
BRS Rouxinol	1214 Ca	1070 Aa	1142 C	134 Cb	152 Aa	143 C	18.9 Aa	18.3 Aa	18.6 A	14.3 Aa	13.5 Aa	13.9 B	71.2 Ba	70.7 Ba	71.0 C
BRS Cauamé	1205 Ca	1089 Aa	1147 C	145 Ca	154 Aa	149 C	18.8 Aa	18.9 Aa	18.8 A	12.2 Bb	14.7 Aa	13.4 A	72.7 Bb	77.4 Aa	75.0 B
BRS Itaim	1021 Ca	1081 Aa	1051 C	176 Ba	153 Ab	164 B	17.7 Aa	17.2 Ba	17.5 B	11.1 Ba	11.5 Ba	11.3 B	78.7 Aa	77.5 Aa	78.1 A
BRS Marataoã	497 Da	279 Ba	388 D	145 Ca	155 Aa	150 C	18.9 Aa	17.2 Bb	18.0 B	14.5 Aa	13.2 Aa	13.9 B	75.7 Aa	72.8 Bb	74.2 B
Average	1647 a	1025 b		161 a	154 b		18.6 b	17.7 a		11.9 a	12.2 a		76.0 a	76.0 a	

* Means followed by distinct uppercase letters in column and lowercase in row differ from each other (p>0.05) by Scott-Knott test.
Source: own authorship (2024)

The experiment carried out in 2021/2022 year provided the best morphophysiological parameters for cowpea (Table 4), with direct and pronounced effects on yield, which was 38% higher than the grain yield obtained in 2022/2023 year.

Based on the results obtained was verified that most productive cultivars in 2021/2022 year (BRS Novaera, and BRS Guariba) showed a 58% reduction in yield in 2022/2023 year (Table 5). While the cultivars with the lowest yield (BRS Rouxinol, BRS Cauamé, BRS Itaim, and BRS Marataoã), regardless of years, did not differ statistically for grain yield, thus, although less productive, the cultivars were the most stable, providing greater security for agricultural producers.

In present study, the genotypes showed different behaviors in edaphoclimatic conditions of Southwest Region of Minas Gerais, Brazil. According to Borém, Miranda e Fritsche Neto *et al.* (2017), genotypes with wide adaptation present predictable behaviors, even when subjected to different environmental conditions, while adapted genotypes take advantage of environmental variations, which shows the need to carry out studies aimed at knowledge of genotype x environment interactions (SOUSA *et al.,* 2018; PESSOA *et al.,* 2023).

The evaluated characteristics differed statistically within the years (Table 4 and 5) promoted by accumulation of precipitation during the crop cycle (2021/2022: 627mm and 2022/2023: 1088 mm) (Figure 1). In last year of study, excessive rainfall impaired the morphophysiological and phytotechnical performance of cultivars, especially at harvest time (Figure 1). It is worth noting that in last three weeks of cultivation, the final third of grain filling, the accumulated precipitation in 2022/2023 year was 145 mm, practically twice the amount obtained in same period for 2021/2022 year (Figure 1). After the harvest, in processing, the discounts were very pronounced, which justifies the enormous productive discrepancy between the years.

Alves *et al.* (2020) evaluating fifteen lines and five commercial cowpea in five environments in of Mato Grosso State, Brazil, observed low yields of cultivars sown in Sinop city, due to excessive rainfall, mainly at harvest. The authors associated the low yields with a very intense vegetative growth and, mainly, due to intense severity of pod rot.

The average yield of cultivars were 2,549 and 1,108 kg ha^{-1} in growing of 2021/2022 and 2022/2023 years, respectively (Table 5). Based on quotation made in April/2024 (AGROLINK), the price of cowpea paid on property was R$ 240.00 per 60 kg bag. Based on information it was verified that in first year of study the producer would have gross income of R$ 10,196 and in second year of R$ 4,432. Although the economic analysis was not the primary object of research was observed that in agricultural of 2022/2023 year, due to excessive rainfall during the harvest, the producer would not be economically viable in cultivation of cowpea during the first crop in Southwest Region of Minas Gerais, Brazil.

The cultivation of cowpea can constitute a source of income, in a relatively short period of time, becoming an alternative for agricultural diversification. However, part of the farmer's profit, if not the total, can be lost, due to sensitivity of most productive cultivars to rainfall at harvest, recommending that in regions with a productive arrangement characterized by two grain crops, position the cowpea planting in the second crop, can be an interesting strategy, since, in off-season crops, there is no significant amount of rain in harvest.

Grain yields in mean years of BRS Novaera, BRS Guariba, and BRS Xique-Xique cultivars did not differ statistically from each other ($p>0.05$), with superiority compared to other cultivars. BRS Marataoã, BRS Itaim, BRS Cauamé, BRS Rouxinol, and BRS Imponente, regardless of year of cultivation, were the ones that showed the lowest agronomic potential in harvest conditions of the Southwest Region of Minas Gerais, Brazil (Table 5).

4 CONCLUSIONS

The most recommended cowpea cultivars for first crop cultivation in the Southwest Region of Minas Gerais, Brazil are: BRS Novaera, BRS Guariba and BRS Xique-Xique.

The cowpea cultivar least indicated for sowing in the first crop in the Southwest Region of Minas Gerais is BRS Marataoã.

The cultivars BRS Novaera, BRS Guariba, BRS Xique-Xique, BRS Tumucumaque, BRS Pajeú and BRS Imponente are those with the greatest productive variability.

More studies are needed to consolidate cowpea cultivation in the Southwest Region of Minas Gerais, in first crop and mainly in off-seasom crops.

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