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Identification of superior cowpea varieties in competition with weeds[1]

Identificação de variedades superiores de feijão-caupi em competição com plantas daninhas

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ABSTRACT – Cowpea varieties that are more competitive against weeds are, by themselves, not enough to control the weeds. However, the adoption of more-competitive varieties, together with other cropping practices, including planting density and weeding, can provide greater weed control in addition to affording the farmer more time to carry out this control. This study had the following objectives: a) to identify, in a preliminary evaluation (E-1), varieties that are the most competitive against weeds, based on dry grain yield; b) among the most-competitive varieties, identify the most productive in terms of green and dry grain yield (E-2). The seeds used for E-1 were obtained from producers chosen at random from each of 48 districts in the State of Rio Grande do Norte. A randomized block design with five replications was used. In E-2, the twelve varieties presenting the highest grain yield in E-1 were evaluated in a randomized block design with five replications. In both evaluations, only one weeding was carried out, 30 days after sowing. In E-1, the Umarizal, Itaú, Upanema, Lagoa de Pedras, José da Penha and São Tomé varieties were superior. The second experiment demonstrated that Umarizal is the most productive variety in terms of pod yield and green grain. There is no difference between the varieties for dry grain yield. The Umarizal variety has potential for use in the production of green pods and grains, and of dry grains. The preliminary evaluation is effective in identifying superior varieties.

Key words: *Vigna unguiculata*. Landraces. Immature grain. Ripe grain. Macassar beans.

RESUMO – Variedades de feijão-caupi mais competitivas com plantas daninhas, isoladamente, não serão suficientes para controlar plantas daninhas. Entretanto, a adoção de variedades mais competitivas, juntamente com outras práticas culturais, incluindo densidade de plantio e capinas, propiciará maior controle das plantas daninhas, além de permitir mais tempo ao agricultor para efetuar esse controle. Este trabalho teve os objetivos: a) identificar, em avaliação preliminar (E-1), variedades mais competitivas com plantas daninhas, com base no rendimento de grãos secos; b) dentre as variedades mais competitivas identificadas, distinguir as mais produtivas em termos dos rendimentos de grãos verdes e secos (E-2). As sementes utilizadas em E-1 foram obtidas de produtores, tomados aleatoriamente, em cada um de 48 municípios do Estado do Rio Grande do Norte. Utilizou-se o delineamento de blocos ao acaso com cinco repetições. Em E-2, foram avaliadas, no delineamento de blocos ao acaso com cinco repetições, as doze variedades que apresentaram os maiores rendimentos de grãos em E-1. Nas duas avaliações, uma só capina foi realizada, aos 30 dias após a semeadura. Em E-1, são superiores as variedades Umarizal, Itaú, Upanema, Lagoa de Pedras, José da Penha e São Tomé. O segundo experimento indicou que a variedade Umarizal é a mais produtiva em termos dos rendimentos de vagens e de grãos verdes. As variedades não diferem quanto ao rendimento de grãos secos. A variedade Umarizal possui potencial para ser utilizada para produção de vagens e grãos verdes e grãos secos. A avaliação preliminar é eficiente em discriminar variedades superiores.

Palavras-chave: *Vigna unguiculata*. Variedades tradicionais. Grãos imaturos. Grãos maduros. Feijão-macassar.

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INTRODUCTION

The Northeast of Brazil covers an area of 1,561,178 km^2 (18.3% of the country). Of this area, 62% corresponds to the semi-arid region, with 56,760,780 inhabitants (27.2% of the total population) (BNB, 2018). The cowpea [*Vigna unguiculata* (L.) Walp.] is one of the most important crops in the semi-arid region, where it is grown as a subsistence crop in every municipality.

In the semi-arid region, weed management in the cowpea is by hoeing, which is arduous, time-consuming and expensive. Two weedings, each requiring the work of one man over ten days, would currently cost at least BRL 1,000.00 (MEKONNEN *et al*., 2017). This activity, made more difficult on rainy days, is often carried out by poor and undernourished people. The adoption of cowpea varieties with greater competitive ability against weeds can help reduce the work of the farmer and maintain higher yields.

The effect of crops on weeds is known as interference. Zystro *et al*. (2012), called these effects suppressive ability. Such effects should be distinguished from the effects of weeds on crops, which are known as crop responses, and are different between cultivars, i.e., a cultivar might be more or less tolerant to weeds. As such, the competitiveness of a cultivar comprises two components: suppressive ability and tolerance (ZYSTRO *et al*., 2012). Increasing the competitive ability of the cowpea in the semi-arid region of Brazil is of great interest.

Increasing the competitiveness of cowpea varieties alone will not be enough to control the weeds. However, the adoption of more-competitive varieties together with other cropping practices, including planting density and weeding, can provide greater weed control, in addition to affording the farmer more time to carry out this control. This has been verified for several crops in various countries (ALI *et al*., 2017; BAJWA; WALSH; CHAUAN, 2017; DASS *et al*., 2017; JHA *et al*., 2017).

In general, genetic improvement reduces competitiveness because selection is often carried out together with good weed control, sometimes with the use of herbicides (ZHAI *et al*., 2016). However, there are differences in the competitive ability of corn hybrids (CARVALHO *et al*., 2011), showing that even among improved material, it is possible to find materials with greater competitive ability against weeds. In the cowpea, differences have been found between varieties against *Alectra vogelii*, and between cultivars against *Striga gesnerioides*, two required parasitic species (SALIFOU *et al*., 2017).

Traditional varieties are grown over several generations, often without efficient weed control, which favors the selection of more competitive types. Vandeleur and Gill (2004) found that traditional varieties of wheat not only gave greater weed suppression but were also more tolerant to the weeds.

The aims of this study were a) to identify, in a preliminary evaluation based on grain yield, traditional varieties that are more competitive against weeds; and b) among the most competitive varieties, identify the most productive in terms of green grain and dry grain yield.

MATERIAL AND METHODS

Two experiments were carried out at different times but in the same area: a preliminary selection of traditional cowpea varieties for competitiveness against weeds (experiment-1), and an additional evaluation of the varieties that proved to be superior in the preliminary evaluation (experiment-2).

Methodology common to both experiments

The experiments were carried out on the Rafael Fernandes Experimental Farm of the Federal Rural University of the Semi-Arid (UFERSA), located 20 km from the capital of the district of Mossoró, Rio Grande do Norte (RN) (5º11' S, 37º20' W, at an altitude of 18 m). The soil in the experimental area is classified as a Red Yellow Argisol (PVA), according to the Brazilian System of Soil Classification (SANTOS *et al*., 2018). The results of the analysis of a soil sample from each experiment are shown in Table 1.

According to the Köppen classification (1948), the climate in the region is type BSwh', i.e., very dry, with a mean annual rainfall of 825 mm and greater rainfall during the summer. The experiments were irrigated by sprinkler, with the experimental plots parallel to the lines of sprinklers. The amount of water needed was calculated considering the effective depth of the root system to be 40 cm. Irrigation was carried out every two days and was based on the amount of water retained in the soil at a pressure of 0.40 Mpa. Irrigation began after sowing and was suspended 15 days after the first dry-pod harvest.

The soil was prepared by cross harrowing. The cowpea received 10 kg of N, 80 kg of P_2O_5 and 40 kg of K_2O per hectare as fertilizer when planting. The fertilizers were applied manually in furrows below and to the side of the seeds. The experiments were sown on December 5, 2014, and October 29, 2015, respectively. Four seeds were sown per hole, and the plants thinned out 20 days after sowing, leaving the two largest plants in each hole. Thirty days after sowing, 10 kg of N ha^{-1} were applied as top dressing. The sources of nitrogen, phosphorus and potassium were ammonium sulfate, single superphosphate and potassium chloride, respectively.

Table 1 - Results of the chemical analysis of the soil from two experiments used to evaluate traditional varieties of cowpea for competitiveness against weeds. Mossoró, RN, 2018

Characteristic	Evaluation	
	Preliminary (experiment-1)	Additional (experiment-2)
pH in water	7.00	7.60
Phosphorus (mg dm^{-3})	9.50	21.00
Poassium (mg dm^{-3})	110.40	56.70
Sodium (mg dm^{-3})	10.40	71.20
Calcium ($cmol_c$ dm^{-3})	3.20	2.10
Magnesium ($cmol_c$ dm^{-3})	2.20	0.60
Exchangeable acidity ($cmol_c$ dm^{-3})	0.00	0.00
Potential acidity ($cmol_c$ dm^{-3})	0.08	0.00
Sum of bases ($cmol_c$ dm^{-3})	5.73	3.15
Cation exchange capacity ($cmol_c$ dm^{-3})	5.73	3.15
Cation exchange capacity (pH = 7) ($cmol_c$ dm^{-3})	5.81	3.15
Base saturation (%)	99.00	100.00
Aluminum saturation (%)	0.00	0.00
Exchangeable sodium percentage (%)	1.00	10.00

In both experiments, chlorantraniliprole, bifenthrin and methomyl as active principles were applied using a backpack sprayer, with the aim of controlling the black cutworm (*Agrotis ipsilon* Hufnagel) and cowpea aphid (*Aphis craccivora* Kock).

To determine shoot dry weight in the cowpea, the plants from one hole were cut close to the ground and crushed in a forage cutter. A sample of approximately 100 g was then dried in a forced air circulation oven at 70 ºC to constant weight.

The incidence of weeds in the experimental area was evaluated after the final bean harvest. The weeds were cut close to the ground, identified and weighed. A procedure similar to that adopted to determine dry matter in the cowpea, was used to estimate shoot dry matter in the weeds.

The data were subjected to analysis of variance using the SISVAR v5.3 software developed by the Federal University of Lavras (FERREIRA, 2010). Prior to the analysis of variance, the data were subjected to Bartlett's test for homogeneity of variances (NOGUEIRA; PEREIRA, 2013).

Experiment-1

The seeds used in experiment-1 were obtained from one producer chosen at random from each of the districts in the State of Rio Grande do Norte listed in Table 6. The varieties were identified according to the name of the district where they were collected. When collecting the seeds, a brief interview was held with each producer with the aim of guaranteeing that the seeds came from a traditional variety.

A randomized block design was used with five replications, where the treatments corresponded to the 48 traditional varieties mentioned above. The varieties were weeded once, 30 days after sowing; it was considered that this procedure would cause moderate competitive stress against weeds in each variety, considering that, in this region, the cowpea is generally weeded twice (approximately 20 and 40 days after sowing).

The plots consisted of one row, 6.0 m in length, containing ten holes (each of two plants). The spacing between rows was 1.0 m, with 0.6 m between holes in the same row. The plants in the holes at each end of the rows were considered borders. The plants in each row grown to the side of each block with the same variety of cowpea were also considered borders.

At flowering, the plants from one hole in each row were cut close to the ground and evaluated for length of the main branch, the number of secondary branches, the number of leaves, and the fresh and dry weight of the plant. The remaining plants in each plot were used to evaluate the dry grain yield. The pods were collected 95, 97 and 100 days after sowing, left in the sun to dry, and threshed manually.

To evaluate dry matter in the above-ground part of the weeds, plants were collected from two randomly chosen areas of 0.6 m^2 in each block.

The mean values were compared at 5% probability using the Scott-Knott test (1974) whenever the value for the F-test in the analysis of variance was significant.

Experiment-2

In experiment-2, the 12 varieties that presented the highest grain yields in the preliminary evaluation for competitiveness against weeds were evaluated in a randomized block design with five replications (Umarizal, Itaú, Upanema, Lagoa de Pedra, José da Penha, São Tomé, Baraúna, Campo Grande, Luiz Gomes, Angicos, Jaçanã and Macaíba). These varieties were subjected to moderate weed stress by being weeded once, 30 days after sowing.

Each plot consisted of four rows, 6.0 m in length, with the area occupied by the two central rows considered the working area; the plants from one hole at each end of the two central rows were disregarded in all the evaluations. One of the rows of the working area was used to evaluate green grain yield and the other to evaluate dry grain yield. A spacing of 1.0 m x 1.0 m was used, with two plants per hole. As such, eight plants were used to evaluate the green grain and dry grain yield.

Green bean yield was determined from the weight of the pods and grain, collected in ten harvests from 53 to 82 days after sowing. The green grain yield was corrected for a moisture content of 65% (mean value of the grain moisture content of each variety). Also evaluated were the number of pods plant^{-1}, the number of beans pod^{-1} (in 10 pods), the 100-grain weight (in five samples), and the length, width, and thickness of 10 pods and 10 grains. The dry grain yield was determined from the dry grain weight, collected in four harvests from 70 to 82 days after sowing. In addition to yield (corrected for a moisture content of 15.5%.), the following were evaluated: the number of pods plant^{-1}; the number of beans pod^{-1} (in 10 pods); the 100-grain weight (in five samples); and the length, width and thickness of 10 grains. After the final harvest of dry grains, the plants from a randomly chosen hole were cut close to the ground, weighed and ground. A sample of the ground material, weighing approximately 100 g, was placed in a forced air circulation oven at 70 ºC to constant weight. This made it possible to estimate shoot dry weight in the cowpea.

Ninety-one days after sowing, the weeds from an area of 1.0 m^2 in each plot were collected to determine the weight of the shoots.

The mean values of the treatments were compared using Tukey's test (BRAUN, 1994), at 5% probability.

RESULTS AND DISCUSSION

Weeds

Experiment-1

The weed species occurring during experiment-1 were: *Adenocalymma* sp. (80), *Alternanthera tenella* Colla (40), *Borreria verticillata* L. (40), *Cenchrus echinatus* L. (100), *Commelina benghalensis* L. (20), *Dactyloctenium aegyptium* (L.) Willd. (20), *Digitaria* sp. (100), *Panicum maximum* Jacq. (20) and *Turnera subulata* Sm. (40). The numbers in parentheses indicate the percentage rate of occurrence, i.e., the ratio between the number of plots in which a particular species occurred and the total number of plots. The most frequent species, i.e., *Adenocalymma* sp., *Cenchrus echinatus* L. and *Digitaria* sp. are considered difficult to control (ARRUDA *et al*., 2015; PEREIRA *et al*., 2015).

Experiment-2

Table 2 shows the list of weed species that occurred during the experiment after the final bean harvest. The most frequent species were *Cenchrus equinatus*, *Dactyloctenium aegyptium* and *Digitaria* sp. Yadav *et al*. (2017), related the weed species that generally occur in the cowpea to genotypic and environmental factors. Genotypic factors include the variety of cowpea, weed species and biotic agents (fauna). Among the environmental factors can be included variations in soil and climate that, although relatively small, occur in the experimental environment (blocks and plots). The distribution of weed species in the experimental area was not uniform (Table 3). Weed species occur individually as aggregates; their distribution depends on the properties of the soil and is specific to each area (METCALFE *et al*., 2016).

There was no effect from the treatments on weed growth (Table 4), determined from the fresh and dry weight of the shoots. The fresh matter weight ranged from 923 g m^{-2} (weeds associated with the Luiz Gomes variety) to 1517 g m^{-2} (weeds associated with the Itaú variety). The experimental coefficient of variation (CV) was 38.9%. The dry matter weight ranged from 130 to 267 g m^{-2} in weeds associated with the same cowpea varieties, and the CV was 36.7%.

Cowpea

Experiment-1

Of the six characteristics used to evaluate growth in the cowpea, the treatments influenced the number of leaves only (not indicated by the F-test but revealed by Tukey's test) (Table 5). The varieties Itaú, José da Penha, Campo Grande, Alexandria, Pedro Velho, Monte Alegre, Pedra Preta, Felipe Guerra, Santana do Matos, Apodi, Senador Eloi de Souza, São José do Mipibu and São Gonçalo do Amarante did not differ from each other and were superior to the other varieties

Table 2 - Occurrence index for weed species in experiment-2.[1]

Number	Species	Occurrence index[1] (%)
1	*Adenocalymma* sp.	13
2	*Alternanthera tenella* Colla	8
3	*Amaranthus viridis* L.	37
4	*Borreria verticillata* L.	2
5	*Cenchrus echinatus* L.	100
6	*Citrullus lanatus* Thunb	3
7	*Commelina benghalensis* L.	48
8	*Dactyloctenium aegyptium* (L.) Willd.	80
9	*Digitaria* sp.	55
10	*Euphorbia hyssopifolia* L.	23
11	*Jacquemontia* sp.	10
12	*Neojobertia candolleana* (Mart. ex DC.) Bureau & K. Schum	2
13	*Portulaca oleracea* L.	40
14	*Turnera subulata* Sm.	5

[1]Occurrence index = ratio between the number of plots in which a particular weed species occurred and the total number of experimental plots

Table 3 - Distribution of weed species in plots of traditional varieties of cowpea in experiment-2. The numbers correspond to the species identified in Table 2. Mossoró, RN, 2018

Traditional variety	Blocks					Total species
	1	2	3	4	5	
Umarizal	3-5-9-13	5-7-9-13	5-7-8-9	5-7-8-9	3-5-7-8-9-10	7
Itaú	1-3-5-6-11	5-7-8-13	5-7-8-9	5-7-9	5-8-9	9
Upanema	5-6-7	5-8-9-10-11-13	5-8-9-13	5-7-8-9	5-7-8-9-10	8
Lagoa de Pedra	5-8-13	1-5-7-8-13	3-5-9-10	3-5-8-13	3-5-8-10	8
José da Penha	1-3-5-7-8-9-13	1-5-7-8-13	5-7-8-9-13	3-5-7-8-9	3-5-8-9	7
São Tomé	2-5-7-9	5-7-8-13	3-5-8-9-10-11	3-5-8	5-8-10	9
Baraúna	1-5-11	1-3-5-8-11-13	3-5-7-8-9-13	5-8	3-5-8-13-14	9
Campo Grande	3-5-8-13	1-5-8-9-13	3-5-7-8	3-5-7-9	5-8-9-13	7
Luiz Gomes	5-13	5-7-8-13	5-8-9-10	5-9-10	3-5-9	7
Angicos	1-2-5-7-8-9-13	2-5-8-10	5-7-8-9	3-4-5-8-12	3-5-8-14	12
Jaçanã	3-5-7-8-13	2-5-7-8	5-8-10-14	5-8-10	3-5-7-8-9	9
Macaíba	5-7-8-9-13	1-2-5-8-10-13	5-7-8-9	5-7-8-9	5-8-9-10-11	9

Table 4 - Summary of the analysis of variance for fresh and dry weight in weed shoots in a cultivation of cowpea varieties in experiment-2.[1]

Source of variation	Degrees of freedom	Mean Square			
		Shoot matter			
		Weeds (g m^{-2})		Cowpea (g $plant^{-1}$)	
		Fresh	Dry	Fresh	Dry
Blocks	4	557,714.61*	4,865.78^{ns}	33,710.55^{ns}	1,129.35^{ns}
Varieties	11	179,979.94^{ns}	6,529.28^{ns}	57,974.62^{ns}	1,346.83^{ns}
Residual	44	189,860.37	4,651.71	42,728.85	1,262.81

[1] ^{ns}; *: not significant, and significant at 5% respectively by F-test

in terms of the number of leaves per plant (Table 6). Despite the effect of the varieties on the number of leaves, which contributes to shoot matter, the varieties did not differ in terms of fresh or dry shoot matter. Shoot fresh matter per plant ranged from 41.4 g (Santa Cruz) to 72.4 g (Campo Grande), with a mean value of 53.4 g and CV of 36.0%. Shoot dry matter per plant ranged from 4.9 g (Carnaúba dos Dantas and Lagoa Salgada) to 8.7 g (Campo Grande), with a mean value of 6.5 g and CV equal to 36.0%. Differences in the weight of the leaves and branches (not evaluated in the present study) must have compensated for the differences seen in the number of leaves.

Table 5 - Summary of the analysis of variance for growth characteristics and grain yield in traditional varieties of cowpea initially evaluated for competitiveness against weeds (experiment-1).[1]

Source of Variation	Degrees of freedom	Mean square					
		Total plant fresh matter (g)	Total plant dry matter (g)	Number of secondary branches	Number of leaves	Length of the main branch (cm)	Dry grain yield (kg ha^{-1})
Blocks	4	3,462.89**	53.67**	105.77**	879.89**	462.83**	241,790.67**
Varieties	47	383.01^{ns}	4.43^{ns}	12.19^{ns}	120.50^{ns}	27.77^{ns}	295,797.54**
Residual	188	368.71	4.21	9.93	87.58	23.73	51,851.59

[1] ns; *; **: not significant, significant at 5%, and significant at 1% respectively by F-test

Table 6 - Mean values for growth characteristics and grain yield in traditional varieties of cowpea evaluated in competition with weeds (experiment-1).[1]

Variety	Number of leaves per plant	Grain yield (kg ha^{-1})	Variety	Number of leaves per plant	Grain yield (kg ha^{-1})
Umarizal	29.3 b	945 a	Ceará Mirim	29.0 b	329 c
Itaú	39.0 a	937 a	Carnaúba dos Dantas	24.7 b	320 c
Upanema	28.7 b	863 a	Serrinha	33.7 b	319 c
Lagoa de Pedras	28.9 b	822 a	Felipe Guerra	42.0 a	303 c
José da Penha	42.7 a	817 a	Lagoa d'anta	33.4 b	293 c
São Tomé	31.2 b	765 a	Lagoa Salgada	25.3 b	267 c
Baraúna	29.6 b	689 b	Boa Saúde	32.4 b	251 c
Campo Grande	44.8 a	683 b	Nova Cruz	31.0 b	241 c
Luiz Gomes	33.6 b	668 b	Vera Cruz	31.1 b	241 c
Angicos	32.7 b	655 b	Santana do Matos	41.3 a	239 c
Jaçanã	27.7 b	649 b	Lajes	29.9 b	231 c
Macaíba	30.6 b	615 b	Tenente Ananias	28.9 b	229 c
Japi	30.8 b	612 b	Tangará	28.1 b	228 c
Tenente Laurentino Cruz	34.2 b	563 b	Apodi	40.3 a	225 c
Carnaubais	31.5 b	562 b	São Bento do Trairi	29.2 b	225 c
Alexandria	40.2 a	544 b	Currais Novos	34.2 b	223 c
Pedro Velho	36.4 a	490 b	Senador Elói de Souza	40.6 a	181 c
Monte Alegre	39.4 a	450 c	São José do Mipibu	35.8 a	179 c
Pedra Preta	37.3 a	449 c	Mossoró	34.1 b	169 c
Passa e Fica	27.3 b	438 c	Santa Cruz	27.8 b	150 c
Campo Redondo	32.3 b	375 c	Serra do Mel	25.6 b	112 c
Bodó	34.0 b	368 c	São Gonçalo do Amarante	38.3 a	97 c
São José do Campestre	32.1 b	367 c	São Miguel	33.2 b	63 c
São Paulo do Potengi	34.0 b	334 c	Martins	33.5 b	57 c
Coefficient of variation for the number of leaves per plant: 28.2%					
Coefficient of variation for grain yield: 55.1%					

[1]Mean values followed by the same letter within each characteristic do not differ at 5% probability by Scott-Knott test

Similar results to those found in the present study regarding cowpea growth were seen by various authors who also demonstrated the effect of the variety x environment interaction on characteristics associated with growth (MFEKA; MULIDZI; LEWU, 2019). The fact that no effect from variety was detected on some of the component characteristics of vegetative growth may be related, at least in some cases, to experimental error. The loss of plant material with senescence, especially the leaves, can lead to experimental error; but even characteristics like the number of secondary branches and length of the main branch are subject to experimental error. As all the varieties under evaluation in the present study are of indeterminate growth, branches from the plants in each plot were not restricted to the areas of the plots in which they originated. As a result, during each harvest, branches were broken, and material was lost.

It is important to remember that the survey of weed species was carried out at the end of the cowpea cycle in both experiments. Surveys taken at different times will produce different results for the floristic composition of the weeds (LIMA *et al*., 2016). This is due to the dynamic nature of the emergence and disappearance of weeds in experimental areas. For example, Lima *et al*. (2016), carried out a survey of the number of plants of species occurring in the cowpea from 7 to 63 days after crop emergence. They found that in some species the number of plants was high at the beginning of the cycle and decreased progressively; in other species, the opposite occurred. In yet other species, the number of individuals was high at the beginning, decreased until the middle of the cycle and then increased until the end of the cycle. In addition, individuals of some species were found at each collection, but in other species, the occurrence was sporadic.

The treatments had an influence on grain yield (Table 5). The Scott-Knott test (1974) separated the varieties under evaluation grown under weed stress into three groups for grain yield (Table 6). The Umarizal, Itaú, Upanema, Lagoa de Pedras, José da Penha and São Tomé varieties stood out as superior (Table 6).

Experiment-2

There was also no effect from the treatments (Table 4) or differences between the cowpea varieties in terms of the shoot fresh and dry matter evaluated in experiment-2. Shoot fresh matter ranged from 363.0 to 679.5 g plant^{-1}, while dry matter ranged from 60.3 to 115.9 g plant^{-1} in the José da Penha and Angicos varieties, respectively. The value for CV was 40.0% for both characteristics.

The treatments influenced green bean yield, determined from the green pod and green grain yield (Table 7). The response of the varieties in terms of green pod and green grain yield were different (Table 8). For both characteristics, Tukey's test identified three groups of varieties: the most productive varieties, the least productive varieties, and one group with intermediate yields. The Umarizal variety was the most productive in terms of green pod and green grain yield; this finding is interesting, as green beans are sold in the form of pods or green grain. The Baraúna, Campo Grande and Upanema varieties showed intermediate pod yields, while in the other varieties, the pod yield was lower. In terms of green grain yield, the Lagoa de Pedras, Jaçanã and José da Penha varieties had the lowest productivity, with the other varieties presenting intermediate behavior. Differences between varieties in terms of green pod and green grain yield indicate a difference in pericarp yield.

There was no difference between varieties in terms of dry grain yield, although they differed for 100-grain weight and the number of grains per pod (Table 9).

The Campo Grande and Itaú varieties had the highest grain weight, while the Baraúna and Jaçanã varieties had the highest number of grains per pod (Table 10).

As seen above, there was no difference between cowpea varieties in terms of the growth of the associated weeds (Table 5). On the other hand, there were differences between the varieties in terms of dry grain yield in experiment-1 (Table 5), and in terms of green bean (Table 7) and dry grain yield (Table 9) in experiment-2. These differences show that cowpea varieties differ in their competitive ability against weeds.

The differences between cultivars in terms of competitive ability against weeds are due to differences in the ability to access light, nutrients and water, as well as differences in allelopathic activity (WORTHINGTON *et al*., 2015). There

Table 7 - Summary of the analysis of variance for green pod and green bean yield and their components in traditional varieties of cowpea in experiment-2.[1]

Source of variation	Degrees of freedom	Mean square[1]				
		100-grain weight (g)	Number of pods per plant	Number of grains per pod	Pod yield (kg ha^{-1})	Green grain yield (kg ha^{-1})
Blocks	4	9.09^{ns}	17.80^{ns}	0.59^{ns}	98,428.11^{ns}	159,929.98^{ns}
Varieties	11	12.29**	108.92**	2.33**	2,898,681.76**	875,199.81*
Residual	44	9.93	29.40	0.46	837,028.55	340,055.52

[1] ns; *; **: not significant, significant at 5%, and significant at 1% respectively by F-test

were no differences between the cowpea varieties in terms of shoot growth in either experiment (Table 5). Therefore, to explain the differences between the competitive abilities of the varieties under study, there remain the differences between the root systems and between allelopathic activity, neither evaluated in the experiments on which the present

Table 8 - Mean values for green pod and green grain yield and the components of green grain production in traditional varieties of cowpea in experiment-2.[1]

Traditional variety	100-grain weight (g)	Number of pods per plant	Pod weight (kg)	Pod weight (kg)	Green grain yield (kg ha^{-1})
Umarizal	36.5 bc	35.5 a	15.7 abc	5845 a	3476 a
Baraúna	38.1 bc	26.4 ab	16.9 a	4428 ab	2901 ab
Campo Grande	47.3 a	19.9 b	15.6 abc	4504 ab	2586 ab
Macaíba	32.7 cd	26.0 ab	16.1 ab	3751 b	2579 ab
São Tomé	32.1 cd	27.4 ab	15.8 abc	3763 b	2523 ab
Luiz Gomes	34.7 bc	23.3 b	15.0 bc	3649 b	2508 ab
Upanema	35.9 bc	24.2 ab	16.1 abc	3939 ab	2507 ab
Angicos	27.7 d	29.1 ab	16.9 a	3321 b	2266 ab
Itaú	40.8 ab	19.8 b	16.3 ab	3536 b	2234 ab
Lagoa de Pedras	35.8 bc	23.1 b	14.6 c	3239 b	2168 b
Jaçanã	32.0 cd	23.0 b	15.9 abc	3159 b	2007 b
José da Penha	36.7 bc	18.7 b	15.4 bc	3263 b	1923 b
CV (%)	8.8	22.0	4.3	23.7	23.6

[1]Mean values followed by the same letter within each characteristic do not differ at 5% probability by Tukey's test

Table 9 - Summary of the analysis of variance for dry grain yield and its components in traditional varieties of cowpea in experiment-2. Mossoró, RN, 2018.[1]

Source of variation	Degrees of freedon	Mean square			
		100-grain weight (g)	Number of pods per plant	Number of grains per pod	Grain yield (kg ha^{-1})
Blocks	4	0.05^{ns}	55.00^{ns}	2.59**	147,048.18^{ns}
Varieties	11	36.21**	83.08^{ns}	6.78**	256,836.65^{ns}
Residual	44	1.20	60.53	0.56	144,743.11

[1] ^{ns}; *; **: not significant, significant at 5%, and significant at 1% respectively by F-test

Table 10 - Mean values for dry grain yield and its components in traditional varieties of cowpea in experiment-2[1]

Traditional variety	100-grain weight	Number of pods per plant	Number of grains per pod	Grain yield (kg ha^{-1})
Upanema	21.2 bc	26.6 a	16,2 abcd	1525 a
Umarizal	20.4 bcd	25.8 a	14,6 d	1388 a
Jaçanã	17.2 g	27.7 a	16,8 ab	1386 a
Campo Grande	25.0 a	18.5 a	15,8 abcd	1356 a
Itaú	22.3 b	18.4 a	16,0 abcd	1254 a
Baraúna	20.1 bcde	18.3 a	17,3 a	1249 a
São Tomé	17.7 fg	24.4 a	15,6 bcd	1188 a
Lagoa de Pedra	18.7 defg	21.7 a	15,1 cd	1116 a
Angicos	14.4 h	25.8 a	16,3 abc	1061 a
José da Penha	19.3 cdefg	17.8 a	15,0 cd	960 a
Luiz Gomes	19.6 cdef	16.6 a	15,0 cd	865 a
Macaíba	17.9 efg	18.8 a	14,6 d	789 a
CV (%)	5.2	35.8	4.8	32.3

[1]Mean values followed by the same letter within each characteristic do not differ at 5% probability by Tukey's test

study was based. However, it should be noted that there is a possibility of varieties with similar growth but with different leaf and branch architecture showing different competitiveness against weeds.

Competition between root systems generally results in less biomass than competition between the shoots of the competitors involved (KIAER *et al*., 2013). Furthermore, the competition between root systems is greater when one of the competitors is a grass (KIAER *et al*., 2013). In the present study, the most common weeds were grasses (Table 2). Another aspect that can influence crop yields, but which is generally not considered in studies of weed management, is the occurrence of pathogens and pests. The presence or absence of certain weeds can reduce the attack of certain pests (TAKIM; UDDIN II, 2010).

There were differences between the behavior of the varieties for green grain yield (Table 8) and dry grain yield (Table 10). There are three possible causes for these differences. First, there is evidence that harvesting the green pods determines a greater number of pods per plant (ALIKO *et al*., 2013). Second, plants grown for dry grain production spend more time in the field than those grown for green grain production, suggesting that they suffer the effects of abiotic and biotic factors (including weeds) for longer. Finally, it should be remembered that green grain and dry grain are products that are harvested and evaluated differently. For example, the ideal time for harvesting green pods is decided by the harvester, while for dry grain, the ideal time is less subjective.

CONCLUSIONS

1. In the preliminary experiment, the Umarizal, Itaú, Upanema, Lagoa de Pedras, José da Penha and São Tomé varieties were superior in terms of grain yield. The preliminary evaluation is effective in identifying superior varieties;
2. In the additional evaluation, the Umarizal variety is the most productive in terms of pod yield and green grain yield. There is no difference between the varieties for dry grain yield. The Umarizal variety has potential for the production of green pods and grains, and of dry grains.

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