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CHAPTER 25

Productive performance of cowpea lines and cultivars cultivated in the second harvest period in Fernandópolis – SP

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ABSTRACT

The correct choice of strains for a given environment and production system is decisive for obtaining high yields. It is important to carry out regional studies, aiming to select superior lines, both for cultivation and for use in genetic improvement programs. The objective of this study was to evaluate the productive performance and morphological characteristics of fifteen lines and five cowpea cultivars of erect and semi-erect size, identifying the most productive cultivars/lines well adapted to the region of Fernandópolis-SP. The work was conducted at the Teaching and Research Farm of the Universidade Brasil, Fernandópolis Campus/SP. The experiment consisted of 20 treatments, 15 lines and 5 upright and semi-erect cowpea cultivars from the Embrapa Mid-North Breeding Program. The experimental design was in randomized blocks with 20 treatments and four replications. The experimental unit consisted of 4 lines with 5 meters in length each with a spacing of 0.50m between rows, and the two central lines were considered as useful area. The following evaluations were carried out during crop development: flowering, average pod length, pod weight, grain weight, number of grains per pod, grain index and grain yield. The data were submitted to analysis of variance using the SISVAR statistical program and the means were compared by the Scott-Knott test at 5% probability. The lines and cultivars showed high precocity in the study region, which is one of the main characteristics needed for cultivation in the second harvest period. Among the genotypes evaluated, MNC04-792F-146, MNC04-795F-153, MNC04-782F-104, MNC04-769F-48, MNC04-769F-62, MNC04-795F-159, MNC04-762F-9 and MNC04-795F-168 stood out, and the cultivars BRS GUARIBA and BRS CAUAMÉ with the highest values for grain yield. The results obtained suggest that it is possible to select productive lines and cultivars for cultivation in the second harvest period in Fernandópolis – SP.

Keywords: *Vigna unguiculata*, Productivity, Genotype x environment interaction, Plant science.

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INTRODUCTION

Brazilian agriculture has been undergoing major technological changes in recent decades, most of which is due to the globalization of agribusiness, which has caused reflections on the production chain of several crops, especially those that depend on the use of large volumes of pesticides and agricultural fertilizers. Thus, these crops have been presenting a higher production cost every year, and as a result, producers have sought new options for their production arrangements (Freire Filho *et al.*, 2011).

The cowpea crop was long seen as a subsistence crop, in which small farmers and, in a minority of medium-sized farmers, cultivated it in unsuitable environments and, in addition, with restricted use of technological inputs. However, as Damasceno-Silva (2008) describes, the Embrapa Mid-North Cowpea Improvement Program, in recent years, has incessantly sought to reach beyond the small farmer the corporate producer and the results have been favorable.

Research has contributed to improving the productivity and profitability of the crop, which has aroused the interest of medium and large producers (Bezerra *et al*., 2008; Freire Filho *et al.*, 2005;), mainly in the Midwest and Southeast regions, for cultivation in the second harvest period. The market has also been expanding beyond the borders of the North and Northeast regions, including being traded on commodity exchanges in the Southeast region (Freire Filho *et al.*, 2001).

In 2019, the world production of cowpea was 8.9 million tons (FAO, 2020). Brazil exported 46,353 tons of cowpea in 2022, with the United States, Afghanistan, Pakistan, Canada, and China being the main buyers.

In the 2023/24 harvest, 1.3 million hectares of cowpea were cultivated, despite the increase in recent harvests both in cultivated area and productivity, the production values are considered low, not exceeding 600 kg $^{ha-1}$ the national average productivity of cowpea (Conab, 2024). The absence of separation in the statistics of cowpea and common bean production is still an obstacle to Brazilian cowpea exports, as the world is unaware that Brazil produces this crop, since official agencies do not expose the data. However, with the efforts of producers and some companies, cowpea produced in Brazil has been exported in recent years, opening up another marketing alternative for rural producers (Damasceno-Silva, 2009).

The average productivity of cowpea in Brazil, between the years 2005 and 2009, was 369 kg $^{ha-1}$ (Freire Filho *et al*., 2011), and in 2011, it was 525 kg $^{ha-1}$ (CONAC, 2012). It is worth mentioning that states such as Goiás, Mato Grosso do Sul and Mato Grosso have yields greater than 1,000 kg $^{ha-1}$.

Despite the expansion of cowpea when compared to other crops, it is observed that its genetic potential has been very little explored, however, it has already been obtained, under experimental conditions, yields of dry grains above 3,000 kg $^{ha-1}$, and the expectation is that its genetic potential will exceed 6,000 kg $^{ha-1}$ (Bezerra, 1997). However, in order to reach this level of productivity, it is necessary to invest more in research with the crop, in studies related to physiology and ecophysiology, in order to verify the response of this crop to environmental factors in different regions of the country, since most of this information is obtained through work carried out in other countries such as Nigeria and the United States (EMBRAPA mid-north, 2003).

Improved cultivars and elite lines of cowpea have shown yields higher than 2,600 kg $^{ha-1}$ (Bezerra, 1997), demonstrating that the productivity of this crop can be increased through the use of improved cultivars, contributing to reduce production costs and improve product supply (Sponholz *et al.*, 2006). The launch of the first semi-erect cultivar in Brazil, in 2004, BRS Guariba, was the trigger for this change and, a typical northeastern product, produced mainly by the North and Northeast regions, is also being cultivated in extensive areas of the Midwest region (Damasceno-Silva, 2008).

The characteristics that form the plant architecture in cowpea, such as growth habit; length of the hypocotyl, internodes, main and secondary branches; and size of the peduncle can influence for a higher or lower lodging of the plants, as well as allow mechanical harvesting or facilitate manual harvesting. According to Freire Filho *et al.* (1991), the genetic improvement of cowpea has several objectives: to develop resistance to viruses and insects; to develop cultivars with modern architecture, that is, with a more compact, upright size and with a low lodging index; and to develop cultivars for the production of green beans with characteristics for the industrial process.

Cowpea, in relation to other crops, is little improved, however, it has a wide genetic variability for practically all traits of agronomic interest (EMBRAPA, 1990; Freire Filho *et al.*, 1988).

The first studies aimed at improving cowpea began in the Northeast in the sixties and had as their basic objective the increase of productivity (Krutman *et al.*, 1968; Paiva *et al.*, 1970). Local cultivars were collected and characterized, which then went through a process of elimination of atypical plants and were tested in competition trials. Subsequently, introductions were started and rehearsals began to contain materials from different origins.

The correct choice of genotype for a given environment and production system is of great importance to obtain good productivity. However, this alone is not enough for the success of the exploration. It is also necessary that the cultivar has characteristics of grains and pods, which meet the requirements of merchants and consumers (Freire Filho *et al*., 2000).

The second crop, also called "off-season", is characterized by sowing between the months of January, February, March and later in irrigated systems, with predominance in the Midwest region and in the states of Paraná and São Paulo (Esteves *et al*., 1994). The cultivation of corn in the period of the second harvest has gained great importance, as a result of the few viable economic alternatives for the autumn/winter harvest (Shioga *et al*., 2004). However, this type of cultivation has presented a risk of loss of productivity. The main risk factor for loss for off-season corn is prolonged dry spells, which can occur throughout the crop cycle, and can cause losses that can reach 80% to 100% in some years (Clemente Filho; Leão, 2008). In the search for a crop that is more resistant to weather and with greater precocity, cowpea has become in recent years a new crop option, in the second harvest, since it is relatively more tolerant to drought, mainly due to the faster cycle.

Research with cowpea in the southeast region is scarce and the available cultivars are being used without considering their possible differences in behavior and adaptation in the various cultivation regions. It is important that regional studies be carried out in order to select superior genotypes both for cultivation and for use in breeding programs.

The objective of this study was to evaluate the behavior of fifteen lines and five cowpea cultivars of erect and semi-erect size, cultivated in the second agricultural season ("off-season") in Fernandópolis-SP, identifying the most productive and well-adapted cultivars and lines for the region.

MATERIAL AND METHODS

The experiment was conducted at the Teaching and Research Farm of the Universidade Brasil, Fernandópolis/SP Campus, located between the coordinates 20°16'50" south latitude and 50°17'43" west longitude and at an altitude of 520 m.

The climate of the region, according to the Koppen classification, is humid tropical, Aw, with a dry and mild winter and a hot and rainy summer (Rolim *et al.*, 2007). The region is characterized by a period of 6 months of the year with water deficit and an average temperature of 23.5°C.

According to Oliveira *et. al.* (1999) the soil of the experimental area is of the PVA1 group, that is, Ultisols Yellow Red Yellow Ultisols eutrophic abruptic A moderate sandy/medium relief smooth and undulating

Before the installation of the experiment, soil samples from the experimental area of the 0-10 and 10-20 cm layer were collected and analyzed for chemical characteristics. The experiment was carried out in a minimum cultivation area previously occupied with corn, in which desiccation was carried out 15 days before the implementation of the experiment with the use of the herbicide glyphosate (1,560 g of the active ingredient (a.i.) $^{ha-1}$).

A total of 16 lines were evaluated (MNC04-762F-3, MNC04-762F-9, MNC04-769F-30, MNC04-769F-48, MNC04-792F-146, MNC04-769F-62, MNC04-782F-104, MNC04-792F-143, MNC04-792F-144, MNC04-792F-144, MNC04-792F-144 48, MNC04-795F-153, MNC04-795F-154, MNC04-795F-155, MNC04-795F-159 and MNC04-795F-168) and 4 cowpea cultivars (BRS GUARIBA, BRS TUMUCUMAQUE, BRS NOVAERA, BRS ITAIM, BRS CAUAMÉ) from the Embrapa Mid-North Improvement Program, located in Teresina, PI. The lines were selected in the Preliminary Yield Assay – EPR.

The experimental design was randomized blocks with four replications. The experimental plots consisted of 4 rows with 5 meters in length using a spacing of 0.50m between rows with the two central rows as useful area.

Sowing was carried out on March 12, 2015, a three-row no-tillage seeder was used, where it opened the sowing furrows and deposition of fertilizer, the sowing and covering of seeds was carried out manually, thirteen seeds were sown per meter of row. At 15 days after sowing (DAS), manual thinning was performed, leaving eight plants per meter of row, totaling a population of 160 thousand plants per $^{ha-1}$.

By means of soil chemical analysis (Table 1), implantation fertilization was performed manually in the planting furrow, the equivalent of 290 kg $^{ha-1}$ of fertilizer formulated 08-28-16 (N, P2O5 and K2O) was applied, and top dressing was carried out at 15 days after plant emergence (DAE), applying the equivalent of 60 kg $^{ha-1}$ of nitrogen, using urea as a source, even in the case of a legume, it was necessary to top dress, because the inoculation of the bean seeds was not performed.

Table 1. Chemical characteristics of the soil, in the 0-10 and 10-20 cm layer, before the installation of the experiments.

Layer	pH(CaCl2)	M.O	Presina	H+Al	K	Ca	Mg	CTC	V
		(g dm^{-3})	(mg dm^{-3})	(mmolc dm^{-3})					(%)
0-10	5,3	18	13	21	1,2	17	6	45,2	53,54
10-20	5,1	15	11	26	1,0	13	5	45,0	42,22

Source: From the authors, 2015.

During the development of the plants, two manual weeds were carried out, with the objective of eliminating invasive plants, for ant control baits were distributed in the experiment area, for pest control was carried out the application with insecticides (S-methylcarbamate oxime), 160 g of the active ingredient (a.i.) $^{ha-1}$ at 30 DAE and (N-nitroimidazolidim-2-ilidineamino), 105 g of the active ingredient (a.i.) $^{ha-1}$ at 50 DAE, in the same period for disease control, the fungicide (N-methoxy) was applied, 75 g of the active ingredient (a.i.) $^{ha-1}$ at 51 DAE.

In the physiological maturation of each genotype, phylotechnical evaluations were carried out on the two central lines, with 0.5m from each end of the lines being disregarded. The following evaluations were carried out:

a) **Cycle:** Number of days elapsed from emergence to physiological maturity of the plants in each plot.
b) **Flowering:** The number of days for flowering was evaluated considering the number of days elapsed from plant emergence to full flowering of the treatments.
c) **Average pod length (CPMV):** Determined in centimeters, by averaging five pods per plot taken at random. In the case of curved pods, the longest straight line from the base of

the pod to its end was measured. The pods were evaluated at the Seed Laboratory of the University of Brazil.

d) **Pod weight (PVG):** Evaluated by weighing 5 pods, these pods being the same as those referred to in item c.

e) **Grain weight (PGR):** Evaluated by weighing the total number of grains of 5 pods, these pods being the same as those referred to in item c.

f) **Number of grains per pod (NGV):** Determined by the ratio between the total number of grains in 5 pods, these pods being the same as those referred to in item c.

g) **Grain index (GI):** It was obtained by the ratio between grain weight/pod weight, harvested at the maturity stage of the pods, taking five pods per plot at random and calculating the index according to the expression: GI (%) = (PG5V/P5V).100 where, PG5V = grain weight of 5 pods and P5V = weight of 5 pods.

h) **Grain yield:** All pods contained in the two central rows of each plot were harvested manually, disregarding 0.5 meters from the end of each row. After harvest, the grains were manually threshed and weighed, transforming the grain mass to kg $^{ha-1}$, corrected to 13% moisture (wet basis).

The data were submitted to analysis of variance using the SISVAR statistical program (Ferreira, 2000) and the means were compared by the Scott-Knott test at 5% probability.

RESULTS AND DISCUSSION

The average plant population of the experiment was 73,850 plants $^{ha-1}$. Among the genotypes studied, the cultivars BRS Cauamé, BRS GUARIBA and BRS TUMUCUMAQUE presented the lowest final plant establishment, while the highest populations were observed in the cultivars BRS NOVAERA and BRS ITAIM. Among the strains, the smallest populations were: MNC04-762F-9, MNC04-792F-146, MNC04-782F-104, MNC04-792F-144, MNC04-795F-159 and MNC04-795F-168 (Table 02).

Table 2. Final plant population (plants ha-1), flowering (DAE) and cycle (DAE) of cowpea lines and cultivars, in Fernandópolis -SP, 2015.[(1)]

Genotypes	Plant Population	Flowering
MNC04-762F-3	79.242a	40,0c
MNC04-762F-9	66.333b	39,0b
MNC04-769F-30	78.750a	42.5d
MNC04-769F-48	78.750a	42.0d
MNC04-792F-146	64.167b	40,5c
MNC04-769F-62	78.833a	41.5d
MNC04-782F-104	67.083b	40,8c
MNC04-792F-143	75.833a	37,5a
MNC04-792F-144	66.667b	41,0c
MNC04-792F-148	80.833a	42.3D
MNC04-795F-153	83.750a	42.0d
MNC04-795F-154	85.500a	39,0b
MNC04-795F-155	76.583a	38,5b
MNC04-795F-159	69.417b	38,5b
MNC04-795F-168	66.250b	36,5a
BRS GUARIBA	61.833b	38,5b
BRS TUMUCUMAQUE	65.834b	38,0b
BRS NOVAERA	90.833a	37,3a
BRS ITAIM	75.417a	37,5a
BRS CAUAMÉ	65.083b	38,8b
Average	73.850	39,6
C.V. (%)	13,1	2,4

[(1)] Means followed by distinct, lowercase letters in the column, differ statistically by the Scott-Knott test at 5% probability. Source: From the authors, 2015.

The low final plant population was due to failures in seed germination. The low germination was possibly caused by the low vigor of the seeds that presented weevil attack. In the initial phase of plant germination, some plots suffered attacks by birds, which fed on the apical buds of the seedlings, leading to their death.

In the edaphoclimatic conditions of Fernandópolis, SP, the cultivars showed different behavior regarding flowering and maturation. For all the lines evaluated, the plants emerged between 7 and 9 days after sowing, flowering occurred at 37 to 43 DAE (days after emergence) (Table 2).

The average flowering of the evaluated lines was 39.6 DAE, and the earliest flowering lines were: MNC04-795F-168, BRS NOVAERA, BRS ITAIM, MNC04-792F-143. According to Matoso (2014), the shorter cycle of the crop sown in the off-season is economically interesting for the rural producer, because after the cowpea harvest it is possible to sow another crop, in the winter period, such as wheat or triticale in irrigated conditions for the study region. In addition, cowpea cultivars that reach maturity within 90 days after sowing are less subject to water deficits, common to the second harvest, because the greatest water requirement of the crop is until flowering.

The earliest genotypes represent a rich source of genes for the development of early and medium-early cultivars. Precocity is an important characteristic, as it represents the possibility of carrying out up to three crops per year, including rainfed and irrigated crops; favoring the increase and/or stabilization of production and in regions with long periods of drought (Cisse *et al.*, 1995; Machado *et al*., 2008).

The genotypes evaluated differed from each other for CMV (average pod length), and the highest values for this trait were observed in the lines MNC04-762F-3, MNC04-762F-9, MNC04-792F-146, MNC04-782F-104, MNC04-792F-143, MNC04-792F-148, MNC04-795F-153, MNC04-795F-154, MNC04-795F-155, MNC04-795F-159 and in the cultivar BRS TUMUCUMAQUE (Table 3).

Table 3. (CMV) Average pod length (cm) and (NGV) number of grains per pods of cowpea lines and cultivars, in Fernandópolis -SP, 2015.(1)

Genotypes	**Average Pod Length**	**Mass pod**	**Number of grains per pod**
MNC04-762F-3	20,1a	2,62a	12,2a
MNC04-762F-9	20,4a	2,72a	12,1a
MNC04-769F-30	18,3b	2,44a	13,0a
MNC04-769F-48	18,7b	2,10a	11,0a
MNC04-792F-146	19,3a	2,62a	12,0a
MNC04-769F-62	18,6b	2,69a	13,5a
MNC04-782F-104	19,5a	2,40a	12,2a
MNC04-792F-143	19,6a	2,55a	11,4a
MNC04-792F-144	18,7b	2,00a	9,9b
MNC04-792F-148	19,1a	2,40a	11,6a
MNC04-795F-153	19,2a	2,80a	13,5a
MNC04-795F-154	21,2a	2,33a	12,6a
MNC04-795F-155	20,2a	2,64a	12,1a
MNC04-795F-159	19,1a	2,54a	11,7a
MNC04-795F-168	17,9b	2,26a	9,9b
BRS GUARIBA	16,8b	1,83a	9,0b
BRS TUMUCUMAQUE	21,2a	2,54a	11,6a
BRS NOVAERA	16,6b	2,39a	8,9b
BRS ITAIM	16,8b	1,89a	8,7b
BRS CAUAMÉ	18,1b	2,28a	11,5a
Average	19,0	2,4	11,4
C.V. (%)	8,5	17,3	13,6

(1) Means followed by distinct, lowercase letters in the column, differ statistically by the Scott-Knott test at 5% probability. Source: From the authors, 2015.

The cultivar BRS TUMUCUMAQUE and the lines MNC04-795F-154, MNC04-762F-9, MNC04-795F-155 and MNC04-762F-3, presented CMV equal to or greater than 20 cm, a value considered within commercial standards, for the commercialization of green pods (Silva; Oliveira, 1993), (Table 3). According to Freire Filho (2011), the green bean market requires large and attractive pods. It is worth mentioning that large pods are one of the desirable characteristics for manual harvesting, as it facilitates manual plucking.

Currently, for mechanized harvesting, smaller pods with fewer grains and, consequently, lighter, are preferred, as they allow better support, reducing the possibility of bending and breaking the stalk. Because they are lighter, the pods are less likely to touch the ground, which reduces the possibility of losses due to rot (Silva; Neves, 2011).

The pod mass did not present significant difference between the genotypes evaluated, the average obtained by the genotypes for this trait was 2.4 grams (Table 3).

For the number of grains per pods, the average was 11.4 grains, where the lines BRS ITAIM, BRS NOVAERA, BRS GUARIBA, MNC04-795F-168, MNC04-792F-144 presented the lowest values for NGV, being a consequence of a lower CMV.

NGV has high genetic heritability, being little influenced by the environment, in addition, this trait generally does not correlate with productivity (Andrade *et al.*, 1998), in this experiment this was observed in the MNC04-769F-30 lineage, which presented one of the highest values for NGV, but was one of the least productive (Table 3 and 4). Sampaio *et al.* (2006) observed that the semi-erect and erect lines presented an average of 15 to 11 grains per pod, values similar to those found in this study. Teixeira, *et al.* (2007); Bevilaqua, *et al*, (2007) evaluating 22 genotypes, observed that the lines that stood out in number of grains per pod were TVX5059-09C-02 and IT82G-9, both with values of 11.

There was no significant difference for the genotypes evaluated for grain mass by MGV pods, the lowest MGV value was obtained in the line MNC04-792F-144 and the highest by the line MNC04-795F-153 (Table 4).

The grain index, determined by the grain weight/pod weight ratio, is a very important trait in cultivars intended for the production of green and/or dry grains, since it measures the efficiency of the cultivar in the allocation of photoassimilates to the grains (Freire Filho *et al.*, 2005). Silva and Oliveira (1993) obtained values ranging from 42.8 to 71.7% for this character. In the present study, the values found ranged from 62.6% for the MNC04-792F-144 lineage to 76.6% for the MNC04-795F-154 lineage (Table 4).

Table 4. (MGV) Grain mass per pod (grams), grain index (%) and grain yield (kg ha-1) in Fernandópolis -SP, 2015.[1]

Genotypes	Grain Mass Per Pod	Grain index	Grain productivity
MNC04-762F-3	1,86a	70,2b	815,1b
MNC04-762F-9	1,88a	68,9b	1024,4a
MNC04-769F-30	1,65a	67,1b	754,7b
MNC04-769F-48	1,41a	66,3b	1065,5a
MNC04-792F-146	1,85a	70,4b	1165,4a
MNC04-769F-62	1,92a	71,1a	1059,0a
MNC04-782F-104	1,60a	66,1b	1080,9a
MNC04-792F-143	1,80a	69,9b	930,3b
MNC04-792F-144	1,27a	62,6b	863,0b
MNC04-792F-148	1,72a	71,1a	931,9b
MNC04-795F-153	2,14a	76,4a	1124,8a
MNC04-795F-154	1,79a	76,6a	935,3b
MNC04-795F-155	1,84a	69,4b	910,8b
MNC04-795F-159	1,85a	72,9a	1047,5a
MNC04-795F-168	1,66a	73,3a	990,2a
BRS GUARIBA	1,33a	72,3a	989,2a
BRS TUMUCUMAQUE	1,77a	69,3b	912,5b
BRS NOVAERA	1,73a	72,2a	952,9b
BRS ITAIM	1,41a	74,1a	754,5b
BRS CAUAMÉ	1,66a	72,4a	975,8a
Average	1,7	70,6	964,2
C.V. (%)	20,5	6,2	13,5

[1] Means followed by distinct, lowercase letters in the column, differ statistically by the Scott-Knott test at 5% probability. Source: From the authors, 2015.

Grain yield ranged from 755 to 1165 kg ha-1, forming two groups, one with grain yield above 1000 kg ha-1 and the other below, and it was also possible to verify that of the twenty genotypes evaluated, ten presented productivity above 1000 kg ha-1.

The genotypes with the best yield performance were: MNC04-792F-146, MNC04-795F-153, MNC04-782F-104, MNC04-769F-48, MNC04-769F-62, MNC04-795F-159, MNC04-762F-9, MNC04-795F-168, BRS GUARIBA and BRS CAUAMÉ.

All the genotypes studied showed satisfactory development and productivity in the study region, since the productivity obtained is higher than the national average production.

Productivity is an important criterion when choosing a cultivar, but it is not the only one, at the time of its choice, the cost/benefit ratio must also be considered, based on the price of seeds, productivity, the efficiency of technology in pest control, tolerance to diseases of regional occurrence and, of course, the technological level that the producer uses in the crop.

CONCLUSIONS

The lines and cultivars showed high precocity in the study region, which is one of the main characteristics needed for cultivation in the second harvest period. Among the genotypes evaluated, the lines MNC04-792F-146, MNC04-795F-153, MNC04-782F-104, MNC04-769F-48, MNC04-769F-62, MNC04-795F-159, MNC04-762F-9 and MNC04-795F-168, and the cultivars BRS

GUARIBA and BRS CAUAMÉ, obtained the highest values for the production components. The results obtained suggest that it is possible to select productive lines and cultivars for cultivation in the second harvest period in Fernandópolis – SP

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