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Agronomic performance of 'BRS' Itaim cowpea beans at different planting densities under no-tillage and conventional systems¹

Performance do feijão-caupi BRS Itaim em relação à densidade de plantio e sistemas de semeadura convencional e direta

Milton José Cardoso^{2*}, Edson Alves Bastos³, Cândido Athayde Sobrinho⁴ and Francisco de Brito Melo⁵

ABSTRACT - Cowpea beans play an important role in Brazilian farming, mainly in northern and northeastern regions, where it is widely grown among smallholder farmers. In recent years, commercial farmers have expanded its cultivation, mostly to the Midwest. This study aimed at evaluating the planting density of 'BRS Itaim' black-eyed cowpea beans under conventional (CT) and no-tillage (NT), with 75% mulch in the first year. Two experiments (CT and NT) were conducted at Embrapa Meio-Norte in Teresina - PI (Brazil), during the 2014/2015 harvest. Both experiments were carried out in a randomized block design with four replicates, considering the planting densities (PD) 12, 16, 20, 24, and 28 plants m⁻². In both systems, grain yields (GY) and the number of pods per unit area (NPA) responded quadratically to an increase in PD, while a linear decreasing response was observed for the number of pods per unit area. The maximum grain yields (GY) were 1,492 kg ha⁻¹ (23.8 plants m⁻²) and 1,136 kg ha⁻¹ (23.2 plants m⁻²) under CT and NT, respectively. The NPA was most correlated with GY, presenting a value of 0.74 ($P < 0.01$). The survival rate of cowpea seedlings was 94% under CT and 88% under NT. This larger reduction under NT might be attributed to a higher incidence of fungi in the soil under this system (e.g. *Fusarium solani*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Pythium spp.*, *Sclerotium rolfsii* and *Rhizoctonia solani*).

Key words: Yield components. Yield grain. *Vigna unguiculata* (L.) Walp.

RESUMO - O feijão-caupi desempenha importante papel na produção agrícola brasileira, especialmente no Norte e Nordeste, onde é amplamente cultivado por agricultores familiares. Nos últimos anos, a cultura, vem se expandindo principalmente no Centro-Oeste por agricultores empresariais. O objetivo do trabalho foi avaliar a densidade de plantio de feijão-caupi BRS Itaim, tipo fradinho, sob sistemas de plantio convencional (SPC) e direto (SPD) com cobertura do solo de primeiro ano em torno de 75%. Foram conduzidos dois ensaios (um em SC e outro em SD) na Embrapa Meio-Norte, em Teresina, PI, safra 2014/2015. Nos dois ensaios utilizou-se o delineamento experimental de blocos casualizados com quatro repetições, considerando-se as densidades de plantio (DP) de 12; 16; 20; 24 e 28 plantas m⁻². Em ambos os sistemas, as produtividades de grãos (PG) e os componentes de rendimento número de vagens por área (NVA) responderam quadraticamente ao aumento da DP, enquanto a resposta linear decrescente foi observada para o número de vagens por planta. As PG máximas foram de 1.492 kg ha⁻¹ (23,8 plantas m⁻²) e 1.136 kg ha⁻¹ (23,2 plantas m⁻²) nos sistemas de SC e SD, respectivamente. O NVA foi o mais correlacionado com a PG com valor 0,74 ($P < 0,01$). A sobrevivência de plantas de feijão-caupi foi de 94% no sistema de SC e de 88% no sistema de SD, sendo a maior redução observada no sistema de semeadura direta atribuída à maior incidência dos fungos de solo (*Fusarium solani*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Pythium spp.*, *Sclerotium rolfsii* e *Rhizoctonia solani*).

Palavras-chave: Componentes de produção. Produtividade de grãos. *Vigna unguiculata* (L.) Walp.

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INTRODUCTION

One of the major problems in cowpea cultivation regions, mainly in Northeastern and Northern Brazil, is related to rainfall unevenness together with other factors such as sandy soils, high temperatures, and inadequate management measures just as planting density, which contributes to a low yielding of grains, about 0.22 t ha⁻¹ (CONAB, 2016). This values are much lower than those beans grown under a high-tech production system (BRACHTVOGEL *et al.*, 2009; CARDOSO; RIBEIRO, 2006; MAKOI; CHIMPHANGO; DAKORA, 2009; MATOS FILHO *et al.*, 2009; MENDES *et al.*, 2007; NJOKU; MUONEKE, 2008; OLIVEIRA FILHO *et al.*, 2016; OROKA; OMEREGIE, 2007).

Cowpea beans have been intensely researched in recent years, which have been leading to improvements in both crop yield and its profitability. This scrutiny has aroused the interest of medium and large farmers (FREIRE FILHO *et al.*, 2011; OLIVEIRA FILHO *et al.*, 2016). Among the agricultural practices being studied, planting density (PD) and cropping system (CS), both conventional (CT) and no-tillage (NT), have stood out. The first refers to plant spatial arrangements and is the most important to optimize crop yield since influences the leaf area index, foliar insertion angle, and the interception of incident light by plants, particularly in lower canopy layers. Therefore, PD directly affects solar radiation interception, being one of the most defining factors of GY. While studying BRS Guariba, Bezerra *et al.* (2012) observed a 63.8% reduction in the number of pods per plant (NPP), and 67.6% decrease in grain yield per plant (GY), by raising PD in 100 and 500 thousand plants ha⁻¹, respectively. For BRS Novaera, Bezerra *et al.* (2014) reported declines of 66.5% and 59.53% in NPP and GY, respectively. Naim, Jabereldar, and Mohamed (2011), while investigating the PDs of 6, 12, 18, and 24 kg ha⁻¹, observed an increase in the number of grains per area, as well as reductions in NPP, 100-grain weight, GYP, and harvest index.

NT might be considered promising to the detriment of CT when growing cowpeas by the soil mulching effect that maintain moisture and contribute to weed control. This system may also be taken as an alternative to reduce water deficit risks in crops and improve water use efficiency. Since soil temperatures are very high in Northeastern Brazil, a further advantage of an NT relies on the reduction of soil temperature by mulching, as a protection against the sunrays, what also would minimize the drastic climatic effects unfavorable to a crop development (SIMIDU *et al.*, 2010).

Fontes, Oliveira and Rocha (2013) have already tested the feasibility of growing cowpeas under NT; they proved that this system showed compatibility with the regional-recommended CT in terms of both PD and GY.

Furthermore, in a study of irrigated NT, Locatelli *et al.* (2014) pointed the lack of influence on BRS Pajeú yield components; the same authors reported that BRS Guariba and BRS Novaera obtained maximum GYs of 1.28 and 1.51 t ha⁻¹ using water depths of 74.3 and 94.0% ET_o, respectively.

The objective of this study was to evaluate the planting density for 'BRS Itaim' cowpea beans under conventional tillage and no-till with 75% soil mulching in the first year.

MATERIAL AND METHODS

The study was conducted in a Yellow Argisol (JACOMINE *et al.*, 2013; MELO, ANDRADE JÚNIOR; PESSOA, 2014) in a rainfed area during the 2014/2015 harvest (March to May of 2015). This area is located at a property belonging to the Embrapa Meio-Norte, in Teresina microregion (PI), Brazil. The local geographical coordinates are 05°02'09.9" S, 42°47'544" W, and 69.0-m altitude. Soil chemical analysis of samples collected at 20 cm depth was carried out at the Laboratory of Soil Fertility (Embrapa Meio-Norte). The analysis showed the following results: pH (H₂O 1: 2.5) = 5.4; phosphorus (mg dm⁻³) = 4.0; potassium (cmol_c dm⁻³) = 0.14; calcium (cmol_c dm⁻³) = 3.1; magnesium (cmol_c dm⁻³) = 1.4; aluminum (cmol_c dm⁻³) = 0.1, and organic matter (g kg⁻¹) = 30.1.

Two experiments with cowpea beans (BRS Itaim cultivar, erect black-eyed) were installed side by side in a randomized block design with four replicates. One experiment was carried out under CT and the other under NT with 75% soil mulching in the first year (Figure 1). Treatments consisted of five planting densities (12, 16, 20, 24, and 28 plants m⁻²).

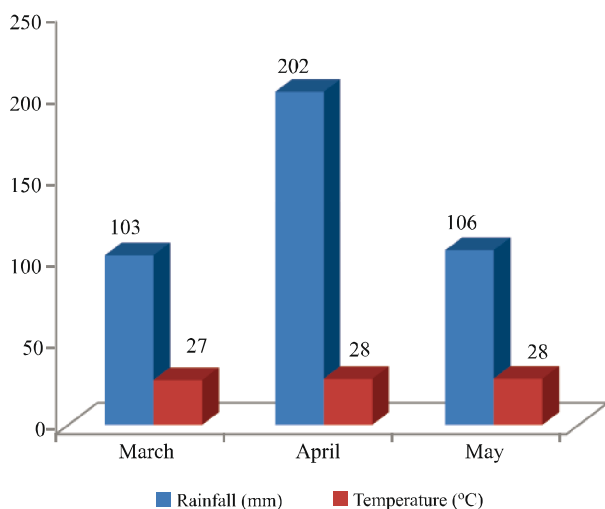
The plots were 5-m long and consisted of four 0.5-m rows. The useful area was composed of the two central rows. During sowing, on March 25, 2015, surplus amounts of seeds were sown in the rows and, by occasion of thinning out, the right amount of plants was maintained according to the density to be tested. Basal dressing consisted of 60 kg P₂O₅ ha⁻¹ (simple superphosphate) and 50 kg K₂O ha⁻¹ (potassium chloride), and N topdressing of 20 kg ha⁻¹ (simple superphosphate), being applied on the fifteenth day of sowing. Figure 2 shows the monthly rainfall (mm) and means of air temperature recorded during the evaluated crop cycle.

The agronomic traits assessed were pod length (PL), number of pods per plant (NPP), number of pods per unit area (NPA), 100-grain weight (100-GW; in grams), seedling survival (ratio between the initial and final plant stand), and grain weight (GW; in kg per useful area unit), and weight corrected to 13% moisture (CGW). The latter

Figure 1 - BRS Itaim cowpea beans under conventional tillage (left) and under no-tillage (right). Teresina, PI. 2014/2015 harvest season. (Photo by Milton José Cardoso)



Figure 2 - Monthly rainfall (mm) and means of air temperature during the evaluated crop cycle (March-May 2015) of 'BRS Itaim' cowpea beans. Teresina, Piauí. Data source: an agrometeorological station located 300 m away from the experimental area



was estimated by the following equation: $CGW = [(100 - Mi) \times GY] / (100 - Mf)$; wherein, CGW is the corrected grain weight, Mi is the grain moisture by a moisture meter (Gehaka, G600i), Mf is the grain moisture to be corrected (13%). The first four trains were analyzed for ten pods chosen at random from the useful area of each treatment. Grain yield (GYHA; kg ha^{-1}) was determined by the equation: $GYHA = (10,000 \text{ m}^2 \times CGW \text{ kg}) / (\text{useful m}^2)$. The incidence of diseases, characterized as root and stem rot, was inspected by counting the number of symptomatic plants in each plot, thus confirming etiology at the Laboratory of Plant Pathology, Embrapa Meio-Norte, Piauí State (Brazil).

First- and second-degree regressions on variance analysis data were performed for plant densities following the method described by Pimentel-Gomes (2009) and Zimmermann (2014). Considering the t-test, the best model was selected by the significance of each parameter, accepting a significance level up to 15% probability (CONAGIN, JORGE, 1982).

The method developed by Alvarez V. and Alvarez (2003) was also followed, in which an equation is significant regardless the significance of coefficients. Nonetheless, the model significance must be explicit in the equation (for regression coefficient), besides showing an R^2 significance. All statistical analyses were performed using SAS software (SAS INSTITUTE, 2015).

RESULTS AND DISCUSSION

The variance analysis showed significant effects from planting densities on the number of pods per plant, number of pods per area, and grain yield (Table 1). The same trend was registered for the cropping system for the same traits (Table 2).

By analyzing the interaction between CS x PD, we noticed an effect ($P < 0.01$) on the yield components NPP, NPA, and GY. While NPP showed a linear decreasing response, NPA presented a quadratic response when increasing PD (Figure 3). We observed that by increasing NPA in one, there was a decrease of 0.181 and 0.073 pods per plant in CT and NT, respectively. It was a quadratic response to PD increase, which reached a maximum of 94.72 pods/ m^2 (CT with 22.27 plants/ m^2) and 64.68 pods/ m^2 (NT with 25.4 plants/ m^2). (Figure 3).

Bezerra *et al.* (2009), Cardoso; Ribeiro and Bastos (2015), and Naim; Jabereldar (2010) also

Table 1 - Variance analysis for pod length (PL); number of grains per pod (NGP), grain yield per hectare (GYHA), 100-grain weight (100-GW), number of pods per plant (NPP), number of pods per area (NPA), and seedling survival (SUR) in 'BRS Itaim' cowpea beans. Teresina, PI, 2014/2015 harvest season

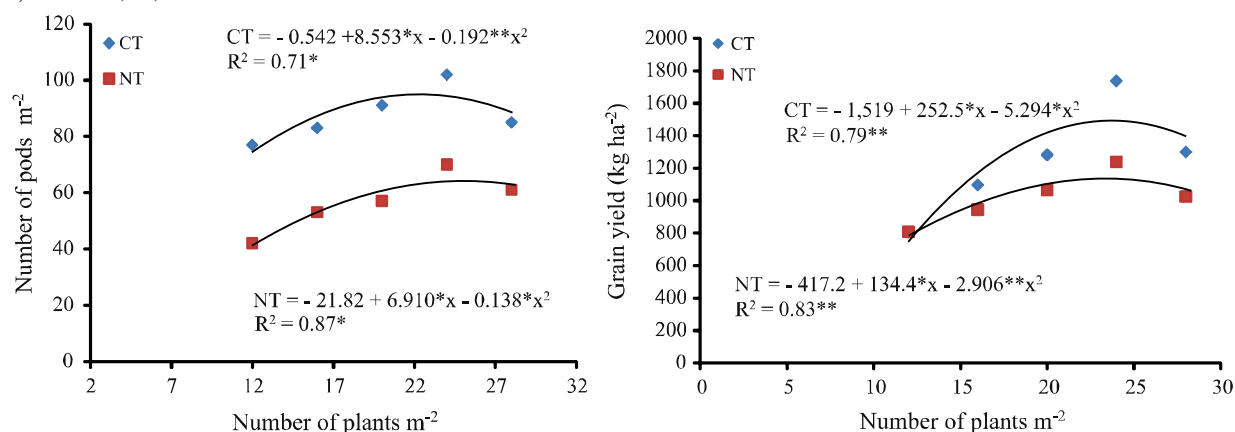
VF	Mean squares							
	GL	PL	NGP	GYHA	100-GW	NPP	NPA	SUR
CS	1	0.3423	0.0018	522,808.23**	1.2250	1.3127*	34.9917**	0.0353**
BL	6	0.5366	0.0177	73,203.73**	0.4417	0.1254**	3.6094**	0.0064**
PD	4	0.7854	0.0348	49,502.866**	1.4625	0.3937**	2.6912**	0.0044*
CS*PD	4	0.4066	0.0131	67,145.29**	1.2875	0.0429**	0.2325**	0.0007
Residue	24	0.5670	0.0109	5,535.06	0.5667	0.0034	0.0402	0.0012
CV%		4.36	3.11	6.59	3.43	3.22	2.38	3.76
Mean		17.26	3.36	1,129.83	21.98	1.81	8.42	0.91

** (p<0.01) and * (P<0.05), respectively, significant at 1% and 5% level, F- test. CS: cropping system; BL blocks; PD: planting density; CV: coefficient variation

Table 2 - Means of pod length (PL), number of grains per pod (NGP), 100-grain weight (100-GW), number of pods per plant (NPP), number of pods per square meter per area (NPA), seedling survival (SUR), and grain yield (GYHA) in 'BRS Itaim' cowpea beans under conventional tillage (CT) and no-tillage (NT). Teresina, PI, 2014/2015 harvest season

System	PL	NGP	GYHA	100-GW	NPP	NPA	SUR
CT	17.35	11.2	1,244	22.15	3.98	87.36	0.94
NT	17.17	11.3	1,015	21.80	2.64	56.07	0.87
F-Test	ns	ns	**	ns	**	**	ns

** (P<0.01) and ns: significant at 1% and 5% level by the F- test and non-significant, respectively

Figure 3 - Number of pods.m⁻² and number of pods.plant⁻¹ of 'BRS Itaim' cowpea beans under conventional tillage (CT) and no-tillage (NT). Teresina, PI, 2014/2015 harvest season

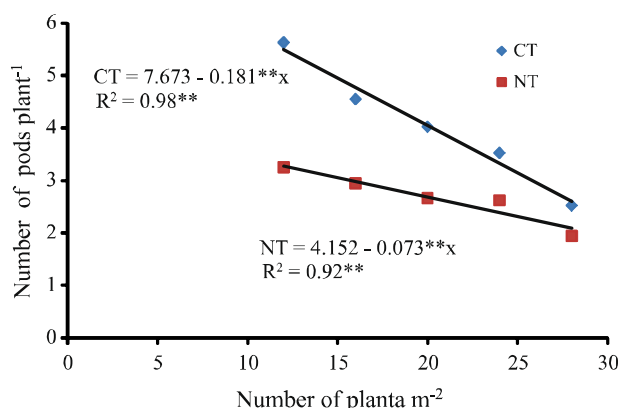
**and *: significant at 1% and 5% level by the F-test, respectively

observed similar behavior for the same traits when increasing NPA. One of the reasons for these scenarios might have been caused by intraspecific competition, probably due to a lower blossoming, which could have been aggravated by water stress during flourishing

and pod filling stages. Similar results were observed by Likewise, Bezerra *et al.* (2008), Cardoso, Ribeiro and Bastos (2015), Lemma, Worku and Woldemichael (2009), Naim and Jabereldar (2010), and Távora, Nogueira and Pinho (2001).

Quadratic response of GY by increasing PD (Figure 4) was observed, with maximum GY values of 1,492 kg ha⁻¹ (23.8 plants m⁻²) and 1,136 kg ha⁻¹ (23.2 plants m⁻²) under CT and NT, respectively. In addition, the same trend was observed by Cardoso and Ribeiro (2006), Naim and Jabereldar (2010), Bezerra *et al.* (2014), and Cardoso, Ribeiro and Bastos (2015). Distinctly, Jallow and Ferguson (1985) observed linear effects by varying PD from 4 to 25 plants m⁻² in eight cultivars of cowpea beans.

Figure 4 - Grain yield of 'BRS Itaim' cowpea beans under conventional tillage (CT) and no-tillage (NT). Teresina, PI, 2014/2015 harvest season



**and *: significant at 1% and 5% level by the F-test, respectively

Table 3 highlights that NPA was the yield component mostly correlated ($P < 0.01$) with grain yield, presenting an average of 0.74.

Table 3 - Pearson's Correlation for grain yield per hectare (GYHA), pod length (PL), number of grains per pod (NGP), 100-grain weight (100-GW), number of pods per plant (NPP), number of pods per area (NPA), and seedling survival (SUR) of 'BRS Itaim' cowpea beans under conventional tillage (CT) and no-tillage (NT). Teresina, PI, 2014/2015 harvest season

Yield Component	GYHA
PL	0.0937
NGP	- 0.2735
GYHA	1.0000
100-GW	0.1374
NPP	0.0292
NPA	0.7423**
SUR	0.2420

** : significant at 1% level by the F-test

Additionally, a higher incidence of soil fungi was observed in plants under NT when compared to CT (*Fusarium solani*, *Fusarium oxysporum*, *Macrophomina phaseolina*, *Pythium spp.*, *Sclerotium rolfsii* and *Rhizoctonia solani*), affecting the plant survival, which was 94% under CT and 88% under NT.

CONCLUSIONS

1. Under a no-tillage system with first year mulching, increasing plant densities cause a reduction in grain yield of 'BRS Itaim' cowpea beans as well as it favors soil fungi attack compared to a conventional tillage system;
2. Grain yield response to planting density is quadratic, reaching maximum values of 1,492 kg ha⁻¹ (23.8 plants m⁻²) and 1,136 kg ha⁻¹ (23.2 plants m⁻²) under conventional and no-tillage systems, respectively. The yield component mostly correlated with grain yield was the number of pods per area, with a significant value of 0.74;
3. With the increase of planting density, the yield components number of pod per plant and number of pods per area are majorly affected in a no-tillage if compared to a conventional tillage system;
4. Under both conventional and no-tillage systems, the number of pods per area is the component mostly correlated with grain yield.

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