

BIOMASSA E EFICIÊNCIA NO USO DA ÁGUA E DA TERRA EM SISTEMAS SOLTEIROS E CONSORCIADOS DE FEIJÃO-CAUPI E MILHO SOB SEQUEIRO, EM DIFERENTES ÉPOCAS DE SEMEADURA

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RESUMO: A produção agrícola em sequeiro no semiárido brasileiro enfrenta o desafio da irregularidade das precipitações. Sistemas consorciados de feijão-caupi e milho, aliados à escolha adequada dos genótipos e das épocas de semeadura, podem aumentar a produtividade e otimizar o uso da água da chuva e da terra. Este estudo avaliou a produção de biomassa e indicadores de eficiência no uso da água e da terra em sistemas solteiros e consorciados de feijão-caupi e dois genótipos de milho (híbrido e variedade), semeados em duas épocas sob condições de sequeiro, no semiárido cearense. O experimento foi realizado entre fevereiro e maio de 2025, em Iguatu (CE), utilizando um delineamento em blocos casualizados com parcelas subdivididas e três repetições. As duas épocas de semeadura foram 20/02 e 21/03/2025. Foram usados os genótipos BRS Pujante, PR27D28 e BRS Caatingueiro. Os resultados mostraram que os consórcios, especialmente os com milho híbrido, geraram maior biomassa e eficiência no uso dos recursos quando plantados na primeira época. A semeadura tardia comprometeu o desempenho dos sistemas. Assim, recomenda-se antecipar a semeadura e priorizar consórcios do feijão-caupi com milho híbrido para melhorar a resiliência da agricultura de sequeiro no semiárido.

Palavras-chave: cultivo múltiplo; *vigna unguiculata* l. walp.; *zea mays* l.

BIOMASS AND EFFICIENCY IN WATER AND LAND USE IN SOLE AND INTERCROPPED SYSTEMS OF COWPEA AND CORN UNDER DRY FIELD, IN DIFFERENT SOWING TIMES

ABSTRACT: Dryland agricultural production in semiarid regions in Brazil faces the challenge of irregular rainfall. Intercropping systems of cowpea and maize, combined with the appropriate choice of genotypes and sowing dates, can increase productivity and optimize the use of rainwater and land. In this study, biomass production and indicators of water and land use efficiency in soil and intercropped systems of cowpea and two maize genotypes (hybrid and variety) sown on two dates

under rainfed conditions in the semiarid region of Ceará were evaluated. The experiment was conducted between February and May 2025 in Iguatu, Ceará, using a randomized block design with split plots and three replications. The two sowing dates were February 20 and March 21, 2025. The genotypes used were BRS Pujante, PR27D28, and BRS Caatingueiro. The results revealed that when planted at the first sowing date, intercropping systems, especially those with hybrid maize, produced greater biomass and higher resource use efficiency. Late sowing compromised system performance. Therefore, early sowing and the prioritization of cowpea–hybrid maize intercropping are recommended to improve the resilience of rainfed agriculture in semiarid regions.

Keywords: multiple cropping; *vigna unguiculata* l. walp.; *zea mays* L.

1 INTRODUCTION

Agricultural production in the semiarid region of Brazil is strongly influenced by climate variability, especially in terms of the irregular distribution and intensity of rainfall. In the municipality of Iguatu, Ceará, precipitation is concentrated between December and May, with frequent dry spells and poorly distributed rainfall, which limits the success of rainfed agriculture (Campos; Andrade, 2021). In this context, the use of intercropping systems, such as cowpea (*Vigna unguiculata*) with maize (*Zea mays*), has emerged as a promising alternative because it enables greater efficiency in the use of water, land, and other productive resources (Ligarreto-Moreno; Arenas-Ochoa, 2023). However, the appropriate choice of genotypes, cropping arrangements, and sowing times can significantly contribute to the sustainability of production in water-restricted environments. Given the above, the objective was to evaluate productive performance, which was based on biomass production and indicators of efficient water and land use, in single and intercropped cropping systems with cowpea and two maize genotypes (hybrid and variety) established at different sowing times under rainfed conditions in the semiarid region of Ceará, with the goal of elucidating the effects of variations in water availability as a determining factor in the production of biomass by the crops.

2 MATERIALS AND METHODS

The experiment was conducted between February and May 2025 in the experimental area of the Federal Institute of Ceará–Iguatu Campus in Iguatu, Ceará (6°39' S, 39°26' W; 218 m), in a sandy loam Argisol (0–0.20 m),

under a hot semiarid climate (BSh). A randomized block design was adopted in split plots (2 × 7), with three replications, totaling 42 experimental units (15 m² each). The plots corresponded to two sowing dates (February 20 and March 21, 2025), and the subplots corresponded to seven cropping systems: (1) cowpea alone; (2) hybrid maize alone; (3) maize variety alone; (4) hybrid maize intercropped with cowpea; (5) maize variety intercropped with cowpea; (6) cowpea intercropped with hybrid maize; and (7) cowpea intercropped with variety maize. The genotypes BRS Pujante (cowpea), PR27D28 (hybrid maize) and BRS Caatingueiro (variety maize), recommended by the Hora de Plantar 2025 program, were used.

The soil was prepared by plowing and harrowing, followed by manual sowing. Fertilization followed the recommendations for soil analysis. Cultural practices included manual weeding and phytosanitary control according to local practices. The dry biomass (DB) of the crops was determined 69 days after sowing by collecting four plants per plot for the maize genotypes. For cowpea, a 0.25 m² template was used. In both cases, the samples were dried at 65 °C in a forced-air oven, with DB expressed in kg ha⁻¹. Rainwater productivity (PABS) was calculated as the ratio between the DB and accumulated precipitation (kg m⁻³) according to Gebremedhin. *et al.* (2023), and land use efficiency (UETBS), according to Willey (1979). Crop evapotranspiration (ETc) was estimated by multiplying the reference evapotranspiration (ETo) calculated by the FAO Penman–Monteith method and the crop coefficients (Kc) according to the Kc suggestions of Souza, Bezerra and Teófilo (2005) and Santos *et al.*

(2014) for cowpea and maize, respectively. The supplemental water requirement (SWR) was calculated as the difference between the ET_c and effective precipitation (P_e), and the relative water satisfaction (RWS) was calculated as the ratio between the P_e and ET_c , according to Gebremedhin. *et al.* (2023). *The data on the crop response variables were subjected to analysis of variance, and when significant effects were noted, Tukey's test was adopted for comparison of means using ASSISTAT software.*

3 RESULTS AND DISCUSSION

Analysis of variance (data not shown) revealed a significant effect of sowing time only on UETBS. The cropping system significantly influenced all the variables (BS, PABS, and UETBS), as did the interaction between sowing time and treatment, indicating

that the responses differed depending on the local water seasonality provided by crop establishment at different times.

During the cowpea and maize cycles, both sowing periods resulted in effective rainfall above evapotranspiration, generating a water surplus (negative ANS). In green maize, period 1 presented a total ANS of -82.08 mm, and period 2 presented a total ANS of -14.94 mm, with the SAR always above 100%, except during flowering in period 2 (68.78%), indicating possible water restriction at this stage. The total supplemental requirements were -128.13 mm (Period 1) and -76.33 mm (Period 2), with a greater deficit during flowering in Period 2 (ANS 43.36 mm and SAR 76.03%), indicating greater water stress at that time. There was excess water in the early stages in both periods, with SRA above 200% at this stage, suggesting a risk of soil saturation and likely adverse effects on the plants (Table 1).

Table 1. Water indicators (PPT, ETc, NSA and SRA) in different phenological stages of cowpea and green corn during the two growing seasons.

Cowpea						
Stadium	OF	Era	PPT (mm per-1)	ETc (mm per-1)	NSA (mm per-1)	SRA (%)
Vegetative	0 – 34	1	145.20	127.42	-17.78	113.95
		2	151.93	119.43	-32.50	127.21
Flowering	35 – 50	1	110.93	92.53	-18.40	119.88
		2	63.71	92.63	28.92	68.78
Pod filling	5 – 64	1	110.34	58.77	-51.57	187.75
		2	116.96	94.93	-22.03	123.21
Maturation	65 – 69	1	0.00	5.67	5.67	0.00
		2	0.00	10.67	10.67	0.00
Totals	(-)	1	366.47	284.39	-82.08	128.86
		2	332.60	317.66	-14.94	104.70
Sweet corn						
Home	0 – 16	1	109.90	39.93	-69.97	275.25
		2	115.34	39.04	-76.30	295.40
Development	17 – 37	1	131.81	61.33	-70.48	214.93
		2	108.70	56.38	-52.32	192.81
Flowering	38 – 65	1	130.44	138.18	7.74	94.40
		2	137.55	180.91	43.36	76.03
Physiological Maturation	66 – 69	1	0.00	4.58	4.58	0.00
		2	0.00	8.92	8.92	0.00
Totals	(-)	1	372.15	244.02	-128.13	152.51
		2	361.59	285.26	-76.33	126.76

Effective precipitation (PPT, mm period⁻¹), crop evapotranspiration (ETc, mm period⁻¹), supplemental water requirements (NSA, mm period⁻¹) and relative water satisfaction (SRA, %) at different phenological stages in cowpea and maize genotypes (hybrid and variety) in two sowing times, i.e., during the rainy season of 2025, in Iguatu, Ceará.

Source: Authors (2025)

Dry biomass (DB) production was greater in Period 1 for cowpea alone (7,802 kg ha⁻¹) and for hybrid maize intercropped with cowpea (13,169 kg ha⁻¹), reflecting the better relative water supply (RWS) during the vegetative and reproductive stages of the bean. Hybrid maize and the variety alone maintained high DB during both periods, with hybrid maize standing out in Period 2 (11,886 kg ha⁻¹). The decrease in DB of the bean intercropped with the maize variety in Period 2 (4,669 kg ha⁻¹) is associated with lower water availability during cowpea flowering. Water productivity in the BS (PABS) followed the BS pattern but showed greater sensitivity to water supply, with gains for single hybrid maize and intercropping in Season 2, even with lower rainfall, and a decrease for single cowpea and cowpea intercropped with variety maize, due to water

restriction (SRA < 70%). Land use efficiency (UETBS) was high and similar among the intercropping systems in season 1, with cowpea with a variety of maize standing out (2.80). In Season 2, UETBS decreased significantly in intercropping systems with beans, especially with a variety of maize (0.44), indicating lower efficiency under water restriction during the reproductive phase of the bean. In summary, in Season 1, all intercropping systems presented UETBS > 1, indicating a productive advantage over monocultures with a good water supply. In Period 2, only corn intercropping maintained this advantage (UETBS = 2.13), whereas cowpea intercropping had UETBS < 1, highlighting the disadvantage of crop production under water restriction, especially when it occurred during flowering (Table 2).

Table 2. Average values of dry biomass, water productivity, and efficient land use for cowpea and maize.

Treatment	BS (kg ha ⁻¹)		PABS (kg m ⁻³)		UETBS (-)	
	Ep . Semester 1	Ep . Semester 2	Ep . Sem. 1	Ep . Sem. 2	Ep . Sem. 1	Ep . Sem. 2
Single cowpea	7,801.94 _{aABC}	5.119,12 _{aBC}	1.51 _{aABC}	1.02 _{aBC}	—	—
Single hybrid corn	11,488.74 _{aAB}	11,885.55 _{aA}	2.22 _{aAB}	2.39 _{aA}	—	—
Single variety corn	7,011.62 _{aBC}	9,020.43 _{aABC}	1.35 _{aBC}	1.81 _{aABC}	—	—
Hybrid corn combined with cowpea	13,169.39 _{aA}	13,088.41 _{aA}	2.54 _{aA}	2.63 _{aA}	2.13 _{aA}	2.13 _{aA}
Corn var. cons. cowpea	4,767.08 _{BC}	10,575.56 _{aAB}	0.92 _{BC}	2.12 _{aAB}	1.79 _{aA}	1.60 _{aAB}
Cowpea (convertible corn) hybrid	7,490.01 _{aBC}	5,267.36 _{aBC}	1.44 _{aABC}	1.05 _{aBC}	1.66 _{aA}	0.40 _{BB}
Cowpea (cons. maize var.)	8,305.09 _{aABC}	4,668.69 _{BC}	1.60 _{aABC}	0.93 _{BC}	2.80 _{aA}	0.44 _{BB}

Average values of dry biomass production (BS, kg ha⁻¹), water productivity in dry biomass production (PABS, kg m⁻³) and efficient land use in dry biomass production (UETBS) of cowpea plants and maize genotypes (hybrid and variety) grown in single and intercropped systems under rainfed conditions at two sowing times (Ep. Sem.), corresponding to the first (1) and second (2) growing seasons, during the rainy season of 2025, in the municipality of Iguatu, Ceará. Intercropping (cons.); Variety (var.). Means followed by the same uppercase letter in rows and a different lowercase letter in columns do not differ statistically from each other according to Tukey's test at the 5% probability level; LSD: least significant difference.

Source: Authors (2025)

4 CONCLUSIONS

Intercropping systems between cowpea and corn, especially with hybrid corn, resulted in greater biomass production and efficiency in terms of water and land use when they were sown at the beginning of the rainy season. The second sowing time, with water restriction during cowpea flowering, reduced the performance of the intercropping systems. Therefore, the adoption of intercropping with corn, preferably hybrids, which are sown earlier, is recommended as an efficient strategy for rainfed agriculture in semiarid regions.

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