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GRAIN YIELD OF MAIZE GROWN AFTER COWPEA[1]

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ABSTRACT

Under irrigation, maize can be grown throughout the year in northeastern Brazil, resulting in soil degradation in many areas. The renewed interest in the study of crop rotations with legumes is targeted at reducing this degradation. The objective of this work was to evaluate growth and grain yield in three maize cultivars (AG 8080, AG 9010 and DKB 333B), after growing the Sempre Verde cowpea cultivar, incorporated at three different moments. The following treatments were applied, in a randomized complete-block design with ten replications: without cowpea cultivation; cowpea cultivation and incorporation into the soil at bloom time; or after four green bean harvests; or after three mature bean harvests (dry grains). The maize cultivars were grown in each of the four areas of each block in the cowpea experiment following a split-plot scheme with treatments arranged in a randomized complete-block design with ten replications. The incorporation of cowpea, regardless of timing, does not have beneficial effects on maize growth or grain yield. Cultivars AG 8080 and DKB 333B do not differ, but both are superior to cultivar AG 9090 with regard to grain yield.

Key words: *Zea mays, Vigna unguiculata*, green bean.

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RESUMO

RENDIMENTO DO MILHO CULTIVADO DEPOIS DO CAUPI

Com irrigação, o milho pode ser cultivado durante todo o ano no Nordeste Brasileiro resultando na degradação do solo de várias áreas. O renovado interesse pelo estudo da rotação cultural com leguminosas visa reduzir essa degradação. Este trabalho teve como objetivo avaliar o crescimento e o rendimento de grãos de três cultivares de milho (AG 8080, AG 9010 e DKB 333B), após o cultivo do cultivar Sempre Verde de caupí incorporado em três épocas. Foram aplicados os seguintes tratamentos, no delineamento de blocos ao acaso com dez repetições: sem cultivo de caupí e cultivo de caupi, incorporado ao solo por ocasião da floração ou após quatro colheitas de feijão verde ou após três colheitas de feijão maduro (grãos secos). Os cultivares de milho foram cultivados em cada uma das quatro áreas de cada bloco do experimento com caupi. Portanto, o experimento com milho obedeceu ao delineamento de parcelas subdivididas em blocos ao acaso, com dez repetições. A incorporação do caupi, independentemente da época, não beneficia o crescimento ou o rendimento de grãos do milho. Os cultivares AG 8080 e DKB 333B não diferem entre si, mas ambos são superiores ao cultivar AG 9090, quanto ao rendimento de grãos.

Palavras-chave: *Zea mays, Vigna unguiculata*, feijão verde

INTRODUCTION

Maize (*Zea mays* L) and cowpea (*Vigna unguiculata* (L) Walp.) are grown in the State of Rio Grande do Norte for green or dry grain yield. The green maize grains show a moisture content ranging between 70% and 80%, while cowpea grains have a moisture content between 60% and 80%. Green and dry grains of both crops are very popular products in the diet of the Brazilian northeastern population.

Repeated maize cultivations, which are made possible under irrigation and with the intensive use of chemical products, result in physical, chemical, and biological soil degradation (*11*) in several areas. Physical degradation results in deterioration of soil properties that influence water infiltration and plant growth. Chemical degradation implies a rapid decline in soil quality. Nutrient depletion, acidification, and salinization are processes that reduce crop yields. Biological degradation includes reductions in organic matter content, decreases in the amount of carbon in the biomass, and decreased soil fauna activity and diversity. Biological degradation is perhaps the most serious form of soil degradation because it affects soil life and because organic matter affects the physical and chemical properties of the soil. It is usually more serious in semiarid regions because of high soil and air temperatures (*16*).

Soil degradation maintains a close relationship with agroecosystem sustainability, i.e., the ability of an agroecosystem has to maintain productivity when subjected to salinity, toxicity, erosion, etc. Soil organic matter conservation in semiarid regions is one of the most important limiting factors for sustainable development (*16*).

Crop rotations involving legume-maize or legume-other crops were common in the past in several regions. Studies have shown that maize rotation or intercropping with legumes provided positive effects on yield (*8*), with economic benefits as well (*9*). Such positive effects were due to improvement in the physical (*5*) and chemical (*4*) properties of the soil. Those results indicated that the effect of legumes is excellent in repeatedly cultivated soils and that the practice of green fertilization is highly viable (*6*). The renewed interest (*4, 17*) in the study of crop rotation with legumes is a result of factors related to agriculture sustainability (*12*): degradation of agricultural resources, cost reduction, interest in obtaining better quality foods, and preventing quality of life deterioration in rural communities.

This work aimed to evaluate plant and ear insertion heights, as well as grain yield and its components in three maize cultivars, after cultivation of cowpea incorporated at three different moments.

MATERIAL AND METHODS

Two sprinkler-irrigated experiments (one involving cowpea and the other with maize) were conducted at Fazenda Experimental "Rafael Fernandes", of Escola Superior de Agricultura de Mossoró (ESAM), located 20 km from the municipal seat of Mossoró-RN, Brazil. Informations on the region's climate were summarized by Carmo Filho and Oliveira (*3*).

The physical analysis of a soil sample from the experiment area, a Red-Yellow Argisol, cultivated for over ten years with maize, indicated moisture retentions of 12.48 (at 0.01 Mpa) and 3.59 (at 1.5 Mpa) and an apparent density of 1.32 Mg m^{-3}, and the following granulometric fractions (g kg^{-1}): 522 coarse sand, 338 fine sand, 84 silt, and 56 clay. The chemical analysis of the same sample showed: pH, in water = 6.9; P = 37 mg kg^{-1} soil; K^{+} = 0.42 $_{c}mol_{c}dm^{-3}$; Ca^{2+} = 3.9 $_{c}mol_{c}dm^{-3}$; Mg^{2+} = 2.1 cmolcdm^{-3}; Al^{3+} = 0.0 cmolcdm^{-3}; Na+ = 0.27 cmolcdm^{-3}; and 9.4 g kg-1 organic matter.

The following treatments were applied to the cowpea experiment, in a randomized complete-block design with ten replications: no cowpea cultivation; cowpea cultivation and incorporation into the soil at bloom time; or after four green bean harvests; or after three mature bean harvests (dry grains). The cowpea cultivar utilized was Sempre Verde, of indeterminate growth, and incorporation was made with a hoe. The treatments were evaluated in 12 m × 7 m plots. The soil was tilled by means of two harrowings and was not fertilized. Planting was done on 8/15/01, with four seeds/pit, at a 1 m × 1 m row spacing. Thinning was performed 30 days after planting, leaving the two more vigorous plants in each pit. The crop was hoed for weeds at 25 and 45 days after planting. The green and dry kernel harvests were done manually as the grain reached the "ideal harvest time". Before incorporation, eight plants were cut even with the ground and weighed for fresh and dry matter yield evaluation. Dry matter evaluation was performed by the oven method, utilizing a 500 g sample of crushed material. After evaluation, the material was returned to the experimental area where it had been removed from. A soil sample from each plot cultivated with cowpea was removed one day after the soil had been tilled to be planted with maize.

Soil tillage for maize consisted of two harrowings, and was performed one month after incorporation of the cowpea plants that yielded green or dry kernels. Fertilization at planting consisted of the application of 30 kg N, 60 kg P_2O_5 and 30 kg K_2O, per hectare, in furrows located beside and below the seeding furrows. The sources of nitrogen, phosphorus and potassium were ammonium sulfate, single superphosphate and potassium chloride, respectively. Planting was performed with four seeds per pit, at a 1.0 m × 0.4 m row spacing, on 1/4/02. Three cultivars (AG 8080, AG 9010 and DKB 333B) were grown in each of the four areas of each block in the cowpea experiment. Therefore, split-plots were used for the maize experiment with treatments arranged as a randomized complete-block design with ten replications. Each plot consisted of three 6.0 m long rows. The usable area was the area occupied by the central row, with the elimination of one pit at each end. A thinning operation was performed 28 days after planting, leaving two plants/pit. Pest control was achieved with two deltamethrin sprays (250 ml/ha), at 25 and 30 days after planting. Weeds were controlled by means of two hoeings, performed 20 and 45 days after planting. Sidedressing with 30 kg N/ha was done after the first hoeing.

Evaluations included plant and ear heights from ten plants chosen at random from the plot's usable area, as well as grain yield and its components. The distance from ground level to the insertion point of the highest foliar blade was considered as plant height. The distance from ground level to the ear insertion node was considered as ear insertion height. Grain yield (corrected for a moisture content of 15.5 %) and the number of ears/ha were estimated based on usable plant yield. The number of kernels/ear and the 100-grain weight were estimated in samples consisting of ten and five sample units, respectively. The statistical analysis of the data was done according to recommendations by Zar (*19*).

RESULTS AND DISCUSSION

The green beans were harvested in the period from 60 to 69 days after planting. The dry grain were harvested in the period from 69 to 76 days after planting. The mean cowpea green pod, green kernel and dry grain yields (mean ± standard deviation of the mean) were, respectively: 2,632 ± 281, 1,621 ± 174, and 1,262 ± 136 kg ha^{-1}. The pod and green kernel yields were lower than those obtained by other authors; however, dry grain yield was comparable (*14*).

The mean fresh matter mass values in the above-ground part of the cowpea plants incorporated at flowering, after green bean harvesting, and after mature bean harvesting, were 11,800 kg ha^{-1}, 19,600 kg ha^{-1} and 20,160 kg ha^{-1}, respectively. There were no differences between fresh matter mass values after green bean or mature bean harvesting, but both surpassed fresh matter mass at flowering. Similar behavior occurred with regard to dry matter mass. The mean dry matter mass yield values for the above-ground part of incorporated cowpea plants at flowering and after green bean, or mature bean harvesting were, respectively, 1,557 kg ha^{-1}, 3,529 kg ha^{-1} and 3,786 kg ha^{-1}. Since the cowpea cultivar utilized has indeterminate growth, after flowering the plants continue to grow, even more so because they were irrigated, which explains the greater fresh and dry matter yields in the above-ground part of the plants, after green bean or dry bean harvesting. The analysis of a sample from the above-ground part of the cowpea plants at flowering indicated, in percentages: 0.76 P, 2.31 K, 0.06 Na, 3.92 Ca, and 0.37 Mg. The corresponding values for plants after green bean harvesting were: 0.80, 2.41, 0.04, 1.44, and 1.95. In plants harvested after mature bean harvesting, values were 0.76, 2.03, 0.03, 4.08, and 0.34, respectively. These values are higher than those determined by Calegari (2) and by Ferreira (*7*) in several legumes.

In spite of the differences between the amounts of cowpea matter turned under, there were no differences between the chemical characteristics of the soil at maize planting (Table 1). Probably the differences in time at which cowpea incorporation was performed contributed to explain this observation. Alcântara et al. (*1*) made evaluations of soil samples at three different times (90, 120 and 150 days after management) to determine the performance of pigeon pea (*Cajanus cajan* (L.) Millsp.) and sunn hemp (*Crotalaria juncea* L.) for soil recovery. They verified that pigeon pea had a better performance on the first evaluation and sunn hemp performed better on the second. On the third evaluation no beneficial green fertilizer effects were found in the chemical properties of the soil. The chemical compositions of most crops are subject to great alterations during their growth period. When the plant matures, its protein contents and water-soluble constituents decrease, while its amounts of hemicellulose, cellulose and lignin increase. In general, the water-soluble fractions are degraded first, followed by structural polysaccharides, and then by lignin. The residues from immature plants are more rapidly decomposed than residues from older plants, releasing more nutrients (*10*). From this point of view, cowpea incorporation at flowering would be more advantageous, but the continued irrigation might have contributed, at least in part, to leach the released nutrients. In addition, plants incorporated at a later time grew more, thus accumulating more organic matter. Results from experiments that study the effects of plant residue management on crop yields are many times conflicting, since many factors related to residue quality, cropping and soil practices are involved (*13*).

Despite the fact that cowpea incorporation after the mature grain was harvested yielded a higher number of kernels/ear, there were no differences between plant height, ear insertion height, grain yield, number of ears/ha , and 100-grain weight in maize grown without or after cowpea incorporation at different times (Table 2).

It is important to note that the crops were irrigated. Therefore, in plots where cowpea was not cultivated, the weeds must have grown bigger than in plots containing cowpea plants. Hoeing obviously represents a way of incorporating diversified plant material to the soil. According to Magdoff et al. (*13*), when several sources of plant residues are turned under, they promote greater biodiversity in terms of soil organisms, which could be beneficial to the crop. In addition, Vasquez et al. (*18*) verified that weed decomposition was slower than crop residue decomposition. Similarly as in this work, Ferreira (*7*) also did not find grain yield differences in maize grown without or after incorporation of several legumes. Santos and Lhamby (*15*) also did not observe any effects of crop rotation on maize grain yield.

Cultivar DKB 333B was superior to the other cultivars with regard to plant height and ear insertion height (Table 3). This cultivar did not differ from cultivar AG 8080, and both were superior to the other cultivar, with respect to grain yield. This superiority was due to higher values for number of kernels/ear and 100-grain weight, since the cultivars being evaluated did not differ as to their numbers of ears/ha (Table 3).

CONCLUSIONS

1) The incorporation of cowpea, regardless of timing, does not have beneficial effects on maize growth or grain yield.

2) Maize cultivars AG 8080 and DKB 33B do not differ, but are both superior to cultivar AG 9090 with regard to grain yield.

TABLE 1 - Soil chemical analysis results without or with cowpea incorporation at three different moments[1]

Cowpea incorporation	pH (1:2.5)			Ca	Mg	K	Na	Al	P	Sorptive complex (S)	Organic matter
	Water	KCl	$CaCl_2$	----------	----------	$cmol_c\ dm^{-3}$	----------	----------	($mg\ dm^{-3}$)		(%)
Without	7.8	6.6	7.1	5.4	2.2	0.61	0.40	0.0	104	8.60	20.1
After flowering	7.7	6.5	7.0	5.5	2.3	0.64	0.38	0.0	110	8.78	21.2
After green bean production	7.7	6.5	7.0	5.7	2.3	0.62	0.34	0.0	117	8.90	17.1
After mature bean production	7.7	6.5	7.0	5.4	2.3	0.58	0.36	0.0	112	8.63	25.5
Means	7.7	6.5	7.0	5.5	2.3	0.61	0.37	0.0	111	8.73	21.0
Coefficient of variation, %.	2	3	2	15	20	17	21	0.0	20	13	35

[1]There were no significant differences between treatments ($P > 0.05$).

TABLE 2 – Means of plant height, ear height, grain yield, ear number/ha, grain number/ear and 100 grains weight in three maize cultivars grown without or with cowpea incorporation at three different moments[1]

Cowpea incorporation	Plant height (cm)[1]	Ear height (cm)[1]	Grain yield (kg/ha)[1]	Ear number/ha[1]	Grain number/ear[2]	100- grain weight (g)[1]
Without	157	71	6,637	49,589	426 a	33.5
After flowering	159	72	6,666	49,081	429 a	33.7
After green bean production	162	76	6,825	49,265	415 a	34.2
After mature bean production	160	74	6,801	49,667	443 b	33.9
Coeff. variation, % (plots)	7	11	12	4	9	4

[1]There were no significant differences ($P > 0.05$).

[2]There were significant difference, at 5% probability, by Tukey's test.

TABLE 3 - Means of plant height, ear height, grain yield, ear number/ha, grain nuıd 100 grains weight of the maize cultivars grown without or with cowpea incorporation at thremoments[1].

Cultivars	Plant height(cm)[1]	Ear height (cm)[1]	Grain yield (kg/ha)[1]	EaGrain numbenber/ear[1]	100- grain weight (g)[1]
AG 9010	136 c	81 b	6,221 b	49,0391 c	44.4 b
AG 8080	169 b	98 b	7,055 a	49,7465 a	43.8 b
DKB 333B	174 a	114 a	6,921 a	49,4430 b	47.0 a
Coeff. variation, % (subplots)	4	8	10	8	6

[1]There were significant differences, at 5% probability, by Tukey's test.

[2]There were no significant differences ($P > 0.05$).

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