

Original Research Article

Productivity of Sweet Maize on Spikes under Previous Crops and Cropping Systems in the Coastal Tablelands of Sergipe Brazilian Northeast

ABSTRACT

The level of productivity in the agroecosystems of the Coastal Tablelands can be affected by the management system adopted in the soil, altering its physical, chemical and biological properties, thus compromising the productivity of the harvested crops. This study evaluated the effect of no-tillage systems (no-tillage, minimum tillage and conventional tillage) and previous crops: Peanuts (*Arachis hypogaea*), Crotalaria (*Crotalaria juncea*), Beans (*Phaseolus vulgaris*) and Guandu (*Cajanus cajan*) Under the yield of sweet maize (*Zea mays* L.) in a Ultissol (Argissolo Vermelho Amarelo), aiming to measure the productivity of the agroecosystem studied in the Coastal Tablelands sergipano. The no-tillage system provided better levels of yield of sweet maize, as well as a higher number of plants per hectare, a higher number of spikes per hectare and a higher ratio of plants with spike and total plants. Among the previous crops, sun hemp provided higher productivity of sweet maize in conventional and minimum cultivation systems, while the culture of bean as the previous crop of bean in the no-tillage system, after eight years leading of experiment.

Keywords: Agroecosystems, Agricultural productivity, No-tillage, Minimum tillage, Conventional tillage.

INTRODUCTION

The need to produce food to satisfy population demands, in addition to being concerned with the productivity of agroecosystems, has been aimed at higher levels of environmental sustainability aiming at its maintenance. The way in which this activity is conducted, ie the agricultural practices adopted, affects the environment in which it is inserted at different levels, which can cause direct negative impacts on the soil, for example.

Soil degradation is one of the most serious environmental problems faced by today's society, since soil is often neglected as an integral part of the environment, and essential to the existence of life. It should be noted that the use of soil for agricultural purposes promotes chemical, physical and microbiological changes in its profile, and these should be monitored and evaluated so that preventive or corrective actions can be implemented [1].

The adoption of soil management techniques and crop that guarantee the greater sustainability of agroecosystems has been highlighted, since as pointed out by [2], the importance of soil in the agricultural system is not only a means of maximizing production, but rather of optimizing the use of this resource and sustaining productivity over a long period of time. In this way, its conservation or improvement is vital for sustaining productive activity.

The no-tillage system has been used as a management method to raise or maintain high levels of sustainable soil use. This management interferes in the physical, chemical and microbiological properties of the soil, through its low mobilization, high organic matter input and reduced speed of mineralization and minimization of the soil erosion due to the presence of the vegetal cover, creating an adequate environment for the process of restructuring of the soil indispensable to the sustainability and productivity of the exploited systems. In this way, the productive potential of the soil is ensured over time.

One of the factors essential to the introduction and maintenance of sustainable soil management is the presence of dead vegetation cover to protect it. In this case, the use of plant species in rotation, succession, antecession or consortium with the commercial crops, must present good phytomass production and adaptation to local conditions. These plants will benefit the commercial culture and the

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52 environment, as they control soil erosion, contribute to increase the availability of nutrients to
53 commercial plants, and intervene in the physical, chemical and biological properties of the soil [3].

54 In Brazil, with the expansion of the market for maize for consumption in natura and for the canned,
55 frozen, dehydrated or baby maize industry [4] has provided greater interest in research on the subject.
56 The difference between maize and common is in the sugar and starch content of the endosperm, due
57 to recessive genes. While maize has around 3% sugar and 60 and 70% starch, maize has 9 to 14%
58 sugar and 30 to 35% starch [5].

59 The maize crop has been strongly disseminated in the state of Sergipe, presenting [6] relevance from
60 the food, economic and social perspective.

In the state of Sergipe, the coastal tablelands and the Coastal zone comprise an area of approximately 7,126 km², of the total 21,910 km², representing about 32% of the area of the state of Sergipe. The importance of the coastal tablelands is related to the significant population that lives on it, occupying about 45% of the Northeast region, as well as the use of the soil for the cultivation of several annual and perennial crops, and animal husbandry, which in turn generate employment and income [7].

Thus, in the agroecosystems of the Sergipe coastal tablelands, where maize is also planted, it is necessary to develop and apply conservation techniques of soil management, so that the physical, chemical and biological properties maintain the same in a level of resilience [8] In the present study, it was found that the water content of the soil was higher than that of the soil. In this way, the present work has the objective of evaluating the influence of cropping systems associated to previous crops on maize productivity in green maize cobs of agroecosystems in the Sergipano coastal tablelands in its eighth year of conduction.

61 MATERIAL AND METHODS

62 The study area was conducted since 2001 in long-term experiment with fifteen years located in the
63 central portion, physiographic region coast, at the experimental station of the agronomy department at
64 the federal university of sergipe, municipality of são cristovão, state of sergipe, geographic
65 coordinates 37°12'00" w, 11°01'00" s, with an altitude of 22 m above level of the sea. According to the
66 Köppen classification, the region's climate type as humid tropical with a dry season in summer, with an
67 average annual temperature of 22 ° c and average annual rainfall of 1200 mm, concentrated in the
68 months from april to september.

69 The soil is classified as argissolo vermelho-amarelo dystrophic tb, a moderate, sandy texture / clay
70 frank, subperenepholia rain forest, gently rolling relief [9]. At the beginning of the experiment, the soil
71 presented the following chemical and physical characteristics in the 0-10 cm layer: ph (h₂o): 5.2;
72 organic matter (om): 7.0 g kg⁻¹; p: 2.4 mg kg⁻¹ and k: 11.2 cmolc kg⁻¹ [9]. The horizons present in the
73 soil profile at the experiment site are: a (0 - 27 cm) and bt (28 - 77 cm), respectively with sandy
74 texture (sand - 82.1%, silt - 12.5% and clay (sand - 15.4%, silt - 24.7% and clay - 59.9%) [10].

75 The experimental design was a randomized block in a 3x4 factorial design, resulting from the adoption
76 of three soil tillage systems: conventional tillage (ct), minimum tillage (mt) and no-tillage (nt); and four
77 crops predecessor to maize were evaluated: beans (*phaseolus vulgaris* L.), peanuts (*arachis*
78 *hypogaeae* L.), guandu (*cajanus cajan* (L.) Millsp.) And crotalaria (*crotalaria juncea*). Twelve
79 experimental plots with an area of 60 m² (6 m x 10 m) were implanted, with three replications, totaling
80 36 experimental plots and space between the plots to allow the maneuver of agricultural machines
81 and implements

82 Annually, before the implantation of the predecessor crops between the months of january to march
83 and the sweet maize 90 days later, the soil preparation was performed according to the management
84 systems adopted.

85 The ct was adopted the sequence: harrowing (grading of mixed discs), plowing (disc plowing) and re-
86 harrowing. In mt, 1 or 2 harrows were used with open disc leveling, depending on the incidence of
87 invasive plants. The nt was applied the non-tillage of the soil, and for the control of invasive we used
88 broad-spectrum action herbicide (glyphosate) at the dosage associated with manual weeding, when
89 necessary.

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After the flowering of the predecessor crops, the biomass generated was cut and fed into each plot. In the fertilization of the previous crops, urea, triple superphosphate and potassium chloride were used, corresponding to 60, 80 and 70 kg ha⁻¹, respectively of n, p and k, n being applied 50% at sowing and 50% at 30 days after germination of the seedlings.

Then, sweet maize (do-005 dow agrosience) was planted with a manual seeder, spacing 0.9 m between rows and 0.2 m between pits. The nutrients applied at the these values were obtained based on the soil analysis and recommendations established for the maize crop, according to [11]. Liming for soil acidity correction and calcium and magnesium supply is carried out according to the chemical analysis of the soil, following the technical recommendations for the maize crop in the state of sergipe [11].

The parameters of evaluation of maize yield were: number of spikes, number of productive plants, weight of green spikes and relation between number of plants with spikes and total number of plants; being these parameters measured for each systems of preparation of the soil and culture antecedent to the maize.

All data were submitted to analysis of variance and the means were compared by the tukey test at the 5% probability level in the sisvar software [8].

Time of maize sowing consisted of nitrogen in the form of urea (45% of n), phosphorus in the form of triple superphosphate (42% of p₂o₅) and potassium in the form of potassium chloride (58% of k₂o), corresponding to 120, 90 and 110 kg ha⁻¹, respectively n, p and k, with n applied 50% at sowing and 50% at 30 days after seedling germination

RESULTS AND DISCUSSION

In relation maize productivity (Table 1), it was observed that there was a significant statistical difference at the 5% probability level between the cropping systems, as well as between the previous maize crop.

Table 1. Maize productivity in commercial spikes of green maize with straw, under different cropping systems and associated with previous crops

Culture in succession	Productivity (kg ha ⁻¹)		
	CT	MT	NT
Peanuts	2.353,00 d*	6.920,00 b	9.554,00 b
Beans	4.286,00 c	6.174,00 d	9.674,00 a
Crotalaria	5.103,00 a	7.263,00 a	9.004,00 c
Guandu	4.808,00 b	6.473,00 c	8.438,00 d

*Means followed by the same letter do not differ from each other (Tukey test at 5% probability)

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From the data presented in Table 1, it can be observed that the NT system, after eight years, can yield higher yield (kg ha⁻¹) in average terms of commercial spikes of green maize compared to the other cultivated systems studied (over 1/3 higher than the MT and 2.22 times larger than the CT), under the edaphoclimatic conditions of the Sergipano Coastal Board. This superiority is attributed to the benefits inherent to such cultivation practice, for example: because the soil is not mobilized, the conservation of water in the soil profile for a longer period of time and quantity, probably due to the better biological activity observed field, resulting in better soil structuring; lower rate of change of soil temperature; higher fertility of the layer explored by the roots, due to the slower mineralization rate of the previous crops and less occurrence of losses of the layer due to water and wind erosion; greater maintenance of aggregate stability, improving soil structure; and lower subsurface compaction [12],

125 due to the presence of the biological pores of the previous crops, mainly the pigeon pea and the
126 crotalaria.

127 The NT system underwent a great technological evolution, faced with the requirements to ensure
128 productions equivalent to or superior to those of conventional methods of soil preparation. These
129 include the use of soil cover plants (green manures), adapted to local soil and climatic conditions, with
130 nutrient fixation and / or recycling capacity, giving greater protection to the soil and greater
131 productivity of the agronomic crop [13].

132 Thus, in addition to the management system adopted, the choice of the use of soil cover crops -
133 previous crops also affects the productivity of agronomic crops. According to [14], the use of cover
134 crops is an alternative to increase the sustainability of agricultural systems, and can restore
135 considerable nutrients to crops, since these plants absorb nutrients from the subsurface layers of the
136 soil and later release them into the soil. surface layer by the decomposition of its residues.

137 Thus, hedging plants established with a suitable cropping system is a strategy for improving soil
138 quality in agroecosystems and reducing the harmful effects of monoculture. Based on the data in
139 Table 1, it can be observed that all previous crop species, both commercial crops (peanuts and
140 beans) and soil cover crops (pigeon pea and crotalaria) caused statistically significant differences in
141 yield values of maize cobs in each of the cropping systems studied.

142 In average terms, commercial crops promoted higher maize productivity compared to soil cover crops,
143 when conventional (50% higher) and minimum (5% higher) cultivation systems were adopted. On the
144 other hand, when the PD system was adopted, commercial crops (peanuts and beans), which when
145 used prior to maize, provided higher yields (10% higher) of maize. Probably this result is due to the
146 fact that the PD conservation system offers better soil conditions for the potential expression of the
147 commercial crops that leave more significant benefits, and potentially more useful for the subsequent
148 maize crop (Table 1).

149 In this sense one of the main challenges for the implementation of conservationist systems in the
150 Coastal Tablelands Sergipano is the definition of species of plants of cover of the ground adapted to
151 the local edaphoclimatic conditions. These plants must at the same time have as outstanding
152 characteristics, rapidity of establishment and phytomass production; ease of management [15];
153 aggressive and abundant root system with high biomass production contributing to reduce the effects
154 of soil compaction a common problem in CT crops [3] possibility of commercial use; and potential of
155 not hosting pests and diseases that attack the crop of agronomic interest, as well as support to soils
156 with medium to low fertility, as is the average condition of the horizons A of the Argissolos coming
157 from the barreiras sediments present in the coastal tablelands.

158 The advantage of the use of cover crops of the Fabaceae family, such as those used in this study, is
159 linked to their biomass accumulation potential and their ability to supply nitrogen to the successor crop
160 [16]. [17] report that crops in precession to maize with low nitrogen availability compromise the
161 development and yield of grains, due to the high carbon to nitrogen ratio (C/N), immobilizing a good
162 part of the nitrogen present in the soil. This observation should also be taken into account for maize
163 cultivation, aiming at an acceptable productivity, translating into nitrogen fertilizer economy by the
164 rapid decomposition and utilization by the residual N maize available to the soil by the biological
165 fixation.

166 In this sense, the forage of legume crops to maize within a system of conservationist cultivation like
167 the NT favors the increase of the productivity, due to the improvement of the physical properties of the
168 soil due to the effect of its root system and biomass; and improvement of its chemical behavior, due to
169 the higher nitrogen input to the soil, since the crop is very demanding about this nutrient, translating
170 into higher productivity, as obtained in the present experiment (Table 1).

171 Thus, it is observed that crotalaria when grown in succession to maize provided higher maize
172 productivity in relation to commercial crops such as beans and peanuts in the cropping system in
173 which there is soil revolving (CT and MT), characterizing itself as a plant of important coverage for the
174 agroecosystems of the Sergipe coastal tablelands, that adopt these systems of soil management [18]
175 in a work carried out under Latossolo Vermelho Distroférico, cultivated in NT, involving crop rotation
176 systems with seven different cover crops, identified that crop rotation positively influences the
177 productivity of maize grown under NT when cultivated after sunbathing and vetch.

178 At the end of the eighth year of conduction, the NT system associated with the bean predecessor crop
179 provided better maize yield, the peanut crop associated with the MT system occupied the second
180 position in terms of the production of green maize in spikes (Table 1). Beans are among the plant
181 species most associated with maize planting (in precession, succession and consortium), because
182 they provide a positive economic income, thus being economically viable for income generation and
183 with this, making it easier to acquire the technological package of maize.

184 In a study conducted under Latossolo Vermelho distroférrico, [19] found that there is interaction
185 between soil management and crop rotation under maize productivity, when adopted NT, considering
186 two complete cycles of crop rotation (maize / common bean / maize / common bean). The authors
187 observed relatively higher yields of maize and beans in relation to the other associations, which leads
188 to higher gross income per hectare, corroborating with the results found in this study.

189 Differing from the results found in an experiment conducted by [20], conducted in Latossolo Vermelho
190 distroférrico in the experimental farm of Embrapa in Santo Antônio de Goiás-Go, aiming to determine
191 how much soil preparation systems and crop rotations (bean), affect the yield of maize, soybean and
192 wheat grains, it was verified that there was no effect of crop rotation on maize yield.

193 However, the antecedent culture of guandu did not provide high levels of maize production regardless
194 of the management system adopted (Table 1). However, it stands out for its phytomass production, its
195 cultivation on the Sergipe coastal tablelands being culturally very important for the exploitation of
196 agroecosystems mainly in crops for family agriculture, reinforcing the potential of this crop in this
197 agricultural region.

198 Therefore, maize cultivation, in succession to leguminous plants in conservationist systems such as
199 NT and MT, can provide improvement in soil quality, translating into higher productivity, increasing the
200 profitability and sustainability level of agricultural activity. Thus, the relative high yield of maize
201 reached in this study by the NT (9.2 ton ha^{-1}), followed by the MT (6.7 ton ha^{-1}), is justified, although
202 limitations exist in the Sergipe coastal tablelands as presence of a cohesive layer of pedogenetic
203 character and irregular rainfall distribution (spatial and temporal variability), where 70% of the
204 precipitation is concentrated in a continuous period of 5 to 6 months.

205 Linked to plant residues of cover crops, the cultural remains left by maize on the soil surface can be of
206 great importance to the conservation of soil moisture, improving the microbiological activity of the soil,
207 especially in the tropical regions. These residues also decrease soil losses due to erosion, since
208 maize straw has a slower decomposition than legumes due to high C/N ratio, contributing to the
209 reduction of decomposition rate and slower release of nutrients in the soil [21], with physical
210 protection of soil, both radiation and raindrops.

211 The intense oxidation rate of organic matter, conditioned by high humidity and temperature for a good
212 part of the year, typical conditions in the Sergipe coastal tablelands, provide the most transient
213 "umbrella" effect of plant residues and the positive effects of organic matter on the soil by the rapid
214 decomposition of the deposited phytomass, releasing nutrients that can be harvested by maize. Thus,
215 the legume consortium as covers plants and antecedents (low C/N ratio), with the residues of maize
216 (high C/N ratio), condition of the present experiment, can reconcile soil protection and fertilization, as
217 well as the greater perennality of these conditions [22]. In this way, the agroecosystem is established
218 at an adequate level of resilience, thus promoting higher levels of sustainability without compromising
219 the productive potential of the agronomic crops.

220 This improved balance of the agroecosystem in the NT has provided a lower incidence of
221 spontaneous plants, pests and diseases, while the CT system, where there was intense soil rotation,
222 besides providing lower maize productivity, showed a higher incidence of pests and spontaneous
223 plants, probably due to the more stressful conditions for the maize crop [23] in a study under the
224 influence of the bean culture on the dynamics of spontaneous plants during the cycle of cultivation of
225 organic maize under NT and CT systems, under Argissolo Vermelho Amarelo, verified different effects
226 of the bean straw and other antecedent crops under the quantity and variability of the population of
227 spontaneous plants, as well as in the control of these plants. This is probably due to the selective
228 character of the allelopathic effects of the residues of the previous cultures on the invasive ones,
229 providing positive effects for the subsequent maize crop, reducing its population and consequent
230 competition with the maize plants, as observed in the present study.

231 It is worth noting that maize productivity is determined among other factors by the number of plants,
 232 number of spikes per plant, accumulation of green mass in the spikes measured by weight (kg) and
 233 the relation between.

234 Number of plants with spikes and the total number of plants. This last parameter shows that although
 235 some crops may present a greater number of plants, which translates into greater phytomass
 236 production, this higher quantity will not always indicate a higher yield of spikes or grains.

237 Thus, when evaluating the potential of maize plants to produce commercial spikes of green maize at
 238 average ha per hectare under different cropping systems and after the succession of the four previous
 239 crops studied (Table 2) indicates that there were sensible numerical differences NT in relation to the
 240 other cultivation systems studied (5% between NT and MT and 4% between NT and CT). This was a
 241 result of the number of plants per hectare and number of plants with commercial spikes, showing that
 242 the NT provides better conditions for the development of the plants, resulting in a better stand, as
 243 these plants were able to express higher production of commercial spikes, translated by their
 244 statistically significant differences between their superior means for NT.

Table 2. Number of maize plants, spikes per hectare and percentage of plants with commercial spikes in the different cropping systems.

Cultivation system	Number plants ha-1	Number spikes ha-1	Number plants with spikes /Total plants (%)
CT	28683 c*	24632 c	85
MT	42559 b	35679 b	84
NT	44382 a	39679 a	89

*Means followed by the same letter do not differ from each other (Tukey test at 5% probability).

248 In this way, it was observed that the NT system presented, in addition to a larger number of plants, a
 249 higher number of commercial spikes, in relation to the other cultivation systems (CT and MT), and in
 250 the CT resulted in the lower quantitative of both plants like spikes per hectare. These results are in
 251 agreement with the results obtained in the third year of cultivation of the experiment, a situation of
 252 behavior that has been repeated, confirming that NT for providing conditions for better maize
 253 development, translates into higher productivity and efficiency of the plants in this variable.

254 The data observed in this study are also in agreement with the results found by [24], who affirm that
 255 NT provides larger plant populations and number of spikes per hectare when compared to the other
 256 cultivation systems. It is also worth noting that the NT increased production of 5,030.00 kg ha⁻¹ of
 257 maize in relation to the CT and 2,460.00 kg ha⁻¹ in relation to the MT, corresponding to an increase of
 258 54.86 and 26.83% respectively, in relation to ND.

259 The average productivity achieved in this study, even for conservation systems, is considered low in
 260 relation to the national average (12 ton ha⁻¹), according to [25]. When comparing the data obtained in
 261 the study with the results obtained by [5], in Latossolo Vermelho Eutrofico in Uberlândia-MG, when
 262 evaluating the yield of spikes with straw and yield of eight hybrids of common and green maize as a
 263 function of harvest intervals with average productivity of 20,15 ton ha⁻¹ (26 days after flowering),
 264 confirm that the data in this study are below a potential level. It is worth mentioning that the markedly
 265 coastal soil conditions are of low fertility and drainage difficult in the period of intense rains (due to the
 266 presence of the textural B horizon) and in small summer, making water retention difficult (due to
 267 texture horizon A sandy), translating into low productivity.

268 Similar results were also found by [26], that also, studying green maize hybrids, obtained average
 269 yield of spikes with straw of 12 ton ha⁻¹; and by [27], which also evaluated thirty six maize cultivars in
 270 Ijaci-MG, obtaining on average a yield of 13.03 ton ha⁻¹ of green maize cobs. It is understood that this
 271 difference is due to the local edaphoclimatic characteristics (of the Sergipe coastal tablelands), which
 272 as emphasized by [28], are responsible for 60% of the maize production, associated with the genetic
 273 characteristics of the hybrids studied, responsible for 40% of the productivity achieved.

274 In this way, the NT system, in addition to contributing to soil conservation, can guarantee a real
 275 possibility of profitability for farmers, with long-term cultivation, increasing maize productivity both for

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276 phytomass (for soil cover maintenance or production (Tables 1 and 2), without raising the cost of
277 production, evidencing the efficiency of this management system under the soil and climate conditions
278 of the Sergipe coastal tablelands. It should be noted that crop productivity and consequently its
279 financials profitability is one of the main determining factors for susceptibility in the adoption of new
280 technologies.

281 282 CONCLUSIONS

283 Conservation management systems: NT followed by MT provide higher yields of maize when
284 compared to conventional cultivation, when associated with the presence of predecessor crops. From
285 the predecessor crops studied for maize cultivation, crotalaria cultivation provides higher yields of
286 maize in commercial spikes of green maize, under the systems of minimum cultivation and
287 conventional cultivation. The NT system, the bean's predecessor crop, provides a bigger stand, maize
288 productivity and efficiency per plant of the production of commercial spikes of green maize, markedly
289 when compared to MT and mainly CT.

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