

Original Research Article

Effect of Nitrogen Doses and Preculture of Plant Species on Watermelon Culture

ABSTRACT

Aims: The aim of this study was to evaluate the best crop succession strategy and nitrogen dose for irrigated watermelon cultivation in the cerrado of Roraima.

Study design: The experimental design was a randomized complete block design, arranged in split-plot scheme, with four replications.

Place and Duration of Study: Two experiments were conducted (at harvest 2014/2015 and 2015/2016), with the 'Crimson Sweet' watermelon cultivar, grown under different N doses in succession to cover crop species, at the experimental field "Água Boa", belonging to Embrapa Roraima, located in the municipality of Boa Vista, state of Roraima, Brazil.

Methodology: The three plots consisted of cultivating watermelon in succession to: maize intercropped with pigeon pea (*Cajanus cajan*), Brachiaria (*Urochloa ruziziensis*) and a control with spontaneous vegetation. The subplots consisted of four doses of nitrogen (0, 75, 150 and 225 kg ha⁻¹ of N) applied in the watermelon culture. The following variables were evaluated: average mass per fruit, number of fruits per hectare, number of fruits per hectare with mass between 5 and 10 kg, number of fruits per hectare with mass greater than 10 kg, productivity, soluble solids content, pH and titratable acidity.

Results: The pigeon pea provided an increase in the number of fruits per hectare with mass ≥ 10 kg and in productivity. Nitrogen doses between 118 and 124 kg ha⁻¹ provided the highest number of fruits, number of fruits with mass ≥ 10 kg and soluble solids content.

Conclusion: Fruit quality is influenced by the year of cultivation, predecessor cover crop species and by the N doses. Pigeon pea and *U. ruziziensis* favor the availability of nitrogen in the soil for the following crop in succession.

Keywords: Cerrado of Roraima; *Citrullus lanatus*; crop succession; green manure.

1. INTRODUCTION

Watermelon is an economically important crop in Brazil. Besides being a source of income and jobs for the maintenance of man in the rural areas, watermelon is easy to handle and its cultivation presents low production cost. Also, it can be cultivated as an off season crop [1, 2].

26 Growing watermelon at off season negatively interferes in its production, favoring the
27 permanence and incidence of weeds, pests and diseases for subsequent crops [3,4].

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29 Practices such as crop rotation, succession and intercropping interrupt the life cycle of pests
30 and diseases, increase the content of soil organic matter, providing greater availability of
31 nutrients to the plants, favoring nutrient cycling in the soil, increasing land use efficiency, and
32 providing diversification of crop and source of income during the year.

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34 Nitrogen is one of the most important nutrients required for watermelon cultivation. Nitrogen
35 deficiency hinders chlorophyll synthesis, reduces the photosynthetic efficiency in using the
36 sunlight energy, thus interfering in the absorption of nutrients and production of
37 carbohydrates by the plant [5].

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39 The response of watermelon to nitrogen [6] observed that the excess of nitrogen contributed
40 to the decrease of productivity.

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42 However, not all nitrogen fertilizer applied to the soil is absorbed by the plants. Some of it is
43 lost through leaching, when nitrate is moved below the root zone where it cannot be utilized
44 by crops, or by volatilization, among other types of nitrogen loss [7].

45

46 Thus, succession planting, using green manure crops, begins to regain its importance,
47 contributing to the improvement of soil fertility and quality. The plants used for green manure
48 are often cover crops. Cover crops help to preserve the soil, providing greater aggregation of
49 the particles and protecting the soil surface from the direct impact of raindrops [8, 9].

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51 Some characteristics such as high phytomass production, the ability to accumulate N via
52 BNF (Biological Nitrogen Fixation) and high soil nutrient uptake are desirable when choosing
53 a cover crop species [10].

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55 Given the above, the aim of this study was to evaluate the best crop succession strategy and
56 nitrogen dose for irrigated watermelon cultivation in the cerrado of Roraima.

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58 **2. MATERIAL AND METHODS**

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60 **2.1 Location of Study Area**

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62 Two experiments were conducted (at harvest 2014/2015 and 2015/2016), with the 'Crimson
63 Sweet' watermelon cultivar, grown under different N doses in succession of cover crop
64 species, at the experimental field "Água Boa", belonging to Embrapa Roraima, located in the
65 municipality of Boa Vista, state of Roraima, Brazil.

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67 According to Köppen's classification, the climate of the region is classified as Aw (tropical
68 savanna climate), with rainfall, relative humidity and temperature annual averages of 1,667
69 mm, 70% and 27.4 ° C, respectively [11]. The annual mean precipitation and air temperature
70 data, which occurred during the execution of the experiments (2014, 2015 and 2016) are
71 presented in figure 1.

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73 The soil of the experimental area is classified as Dystrophic Yellow Latosol (Ladx), with
74 medium texture [12]. The chemical and physical characteristics of the soil, before the
75 implantation of the experiments, are described in Table 1. Thus, in April 2014, 1,500 kg ha⁻¹
76 of dolomitic limestone (90% TRNP), 100 kg ha⁻¹ of P₂O₅, in the form of single
77 superphosphate (SSP), 50 kg ha⁻¹ of K₂O, in the form of potassium chloride and 50 kg ha⁻¹
78 of FTE BR12, were applied in the soil, incorporated through plowing and harrowing.

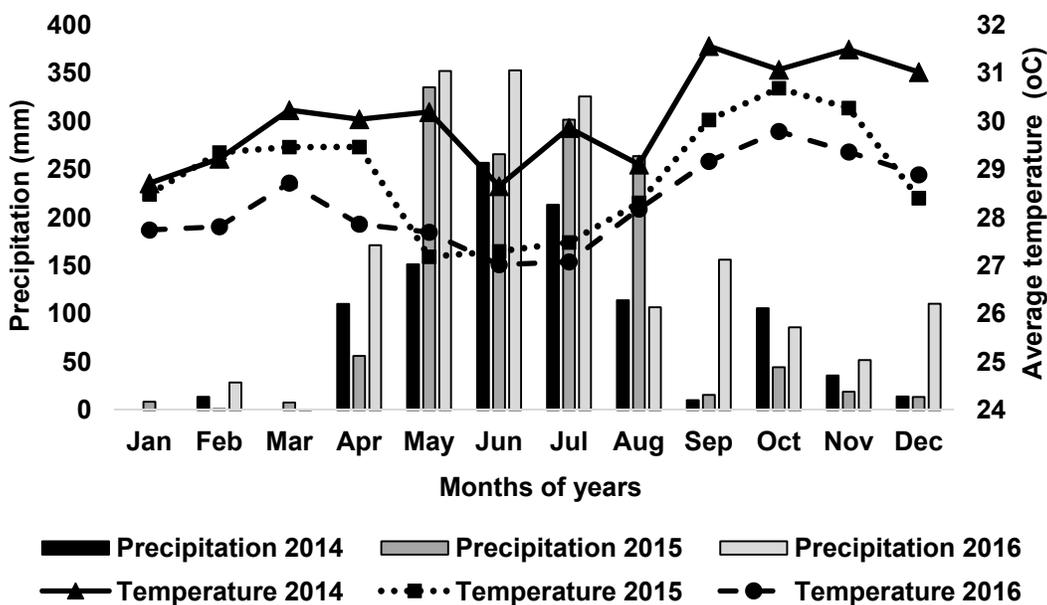


Fig 1. Average monthly data of precipitation and temperature in 2014, 2015 and 2016, obtained from a meteorological station located at the Embrapa Água Boa Experimental Field, Boa Vista, Roraima, Brazil.

Table 1. Chemical and physical characteristics of the soil at the 0-15 cm and 15-30 cm depth layers (Dep.)*.

Years	Dep. (cm)	pH	OM	P	Ca	Mg	Al	H+Al	K
		(water)	g kg ⁻¹	mg dm ⁻³	----- (cmol _c dm ⁻³) -----				
2014	0-15	5.5	10.42	1.11	1.19	0.4	0.42	2.19	0.03
	15-30	4.6	9.26	0.68	0.71	0.4	0.47	1.93	0.02
2015	0-15	5.7	10.03	54.7	1.05	0.27	0.04	2.01	0.09
	15-30	5.4	8.17	14.18	1.28	0.21	0.1	2.62	0.07
2016	0-15	5.6	14.14	60.05	1.23	0.34	0.08	1.91	0.09
	15-30	5.3	10.65	19.7	1.05	0.31	0.01	1.78	0.08
Years	Dep. (cm)	Sand	Silt	Clay	V	M	CEC	CECe	
		----- g kg ⁻¹ -----			----- % -----		----- cmol _c dm ⁻³ -----		
2014	0-15	624.5	78.3	297.2	37	2.5	3.45	1.68	
	15-30	509.7	95.1	395.2	29	3.8	2.7	1.24	
2015	0-15	624.5	78.3	297.2	41	3	3.42	1.41	
	15-30	509.7	95.1	395.2	39	2.6	2.59	1.77	
2016	0-15	624.5	78.3	297.2	58	0	0.01	1.78	
	15-30	509.7	95.1	395.2	36	8	0.08	1.60	

*Analysis performed according to EMBRAPA methodology [12]. O.M. = Organic Matter; V = Base Saturation; M = Saturation by Al³⁺; CEC = Cation Exchange Capacity; CECe = Effective Cation Exchange Capacity.

2.2 Study design

Three systems of crop succession prior to watermelon cultivation were tested: maize intercropped with pigeon pea (*Cajanus cajan*), Brachiaria (*Urochloa ruziziensis*) and a

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94 control with spontaneous vegetation, combined with four doses of nitrogen (0, 75, 150 and
95 225 kg ha⁻¹ of N), using urea as N source, applied in the watermelon culture.

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97 The experimental design was a randomized complete block design, subdivided in a 3 x 4
98 scheme (three succession planting systems and four nitrogen doses), with four replications.
99 The plots corresponded to an area of 256 m² (32 x 8 m), constituted by crop succession
100 systems (maize intercropped with pigeon pea, *U. ruziziensis* and spontaneous vegetation),
101 while the subplots, with an area of 64 m² (8 x 8 m), were constituted by the nitrogen doses
102 applied in the watermelon culture, and the useful area of 24 m².

103
104 In the first year (2014/15), only the pigeon pea, *U. ruziziensis* and spontaneous vegetation
105 (control) were cultivated in the area, which were then desiccated with glyphosate (2 kg ha⁻¹)
106 and the crops in succession planted next.

107
108 After soil correction, during the second week of June 2014, the predecessor plant species
109 were sown in 0.5 m spaced rows. The planting was done using 10 pigeon pea seeds per
110 linear meter and 10 kg ha⁻¹ of *U. ruziziensis* seeds. The aerial parts of the *U. ruziziensis*,
111 pigeon pea and spontaneous vegetation were collected at 100 days after seedling
112 emergence, in an area of 0.25 m², to determine the shoot dry mass, whose means are
113 presented in Table 2.

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Table 2. Shoot dry mass production (kg ha⁻¹) and nitrogen content (g kg⁻¹) of maize, spontaneous vegetation, *U. ruziziensis* and pigeon pea.

Cover crop	Shoot dry mass kg ha ⁻¹			Shoot N content g kg ⁻¹
	2014	2015	2016	
Spontaneous vegetation	1.308	2.025	2.610	22.16
<i>U. ruziziensis</i>	3.508	4.076	5.990	18.43
Pigeon pea	2.354	2.858	3.890	25.43
Maize	-	5.600	6.430	11.58

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In November 2014, 15 days before sowing the watermelon, the soil was fertilized with 120 kg ha⁻¹ of P₂O₅ (single superphosphate), 160 kg ha⁻¹ of K₂O (potassium chloride), 25 kg ha⁻¹ of micronutrients (FTE BR 12), 10,000 L ha⁻¹ of sheep manure and 500 kg ha⁻¹ of dolomitic limestone (200 g per plant). The fertilizers were applied in the planting pits along with the N doses pre-established as treatments.

Irrigation was applied through furrows, with 92 m of length, spaced with 4.0 m, slope of 0.7% and with average flow of 0.7 L seg⁻¹. Irrigation management was monitored using a tensiometer.

Two watermelon seeds were distributed per linear meter at sowing. Thinning was performed at 12 days after seedling emergence, leaving only one plant.

The other cultural treatments consisted of conducting the watermelon branches, manual weed control and control of pests and diseases, which was carried out spraying insecticides or fungicides when necessary, using the specific recommended products for the crop. The watermelon fruits were harvested from 70 to 85 days after seedling emergence.

In the second year (2015/16), after harvesting the watermelon (2014/2015), the maize was cultivated in consortium with pigeon pea, *U. ruziziensis* and spontaneous vegetation. The

139 maize seeds were drilled into unploughed soil (no-tillage system), distributing six seeds of
140 corn per linear meter, placed in the planting lines, succeeding the watermelon spaced at 0.9
141 m.

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143 At 20 and 35 days after planting the corn, fertilization was performed applying N only, at the
144 dose of 50 kg ha⁻¹ of N, to take advantage of the residual effect of fertilizers applied on the
145 watermelon crop. After the second application of N, the chemical control of spontaneous
146 vegetation and sowing of pigeon pea (10 seeds m⁻¹) and *U. ruziziensis* (10 kg of seeds ha⁻¹)
147 were carried out. The pigeon pea and *U. ruziziensis* were sown between the maize planting
148 rows. The maize cultivar used was 30 A 91 PW. At 120 days after emergence (DAE), the
149 maize, *U. ruziziensis*, pigeon pea and spontaneous vegetation were harvested in a randomly
150 selected area of 0.25 m².

151

152 Regarding watermelon cultivation in the second year, the practices performed in the first
153 year/harvest (soil preparation, cultivar, spacing, sowing, irrigation system and water
154 management) were maintained, except for the phosphorus dose applied, which was 100 kg
155 ha⁻¹ of P₂O₅.

156

157 At 66 and 75 days after seedling emergence the watermelon fruits were harvested. Maturity
158 indices for the optimum harvest dates were: observation of the dry vine closest to the fruit,
159 fruit color change (especially in the fruit side in contact with the soil, which goes from white
160 to light yellow) and soluble solids content (at least 9° Brix), determined with a digital
161 refractometer.

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163 **2.3 Data Collection**

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165 All fruits of each useful area of the plots were counted and weighed in the field. The number
166 of fruits per hectare, number of fruits ha⁻¹ with mass between 5 and 10 kg, number of fruits
167 ha⁻¹ with mass greater than 10 kg and productivity were determined. The productivity was
168 obtained by the total mass of fruits, estimated to one hectare.

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170 The fruit quality variables evaluated were: soluble solids content, determined using a
171 refractometer with results expressed as °Brix; pH, analyzed in samples constituted of 10 g of
172 pulp diluted in 100 ml of distilled water, using a @Hanna Instruments pH300 pH meter; and
173 titratable acidity (TA), determined by titration with sodium hydroxide solution (0.1M), with
174 results expressed as percent citric acid.

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176 **2.4 Data Analysis**

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178 The data were submitted to analysis of variance and F test at 5% probability. The values
179 referring to the effects of the years and the predecessor species (maize x consortia and
180 spontaneous vegetation) were compared by the Tukey test at 5% probability. The data
181 referring to the effects of nitrogen doses were submitted to regression analysis, using the
182 statistical analysis program Sisvar [13].

183

184 **3. RESULTS AND DISCUSSION**

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186 There was influence of the years of cultivation, the predecessor plants and the N doses on
187 most of the evaluated variables, as well as a significant effect of the interaction “N doses x
188 year” on the average mass per fruit, number of fruits with mass greater than 10 kg and fruit
189 yield. For the interaction between “years x predecessor plants” there was significant effect
190 only for titratable acidity. However, the variables did not suffer interference from the triple
191 interaction between the tested factors, showing that the means obtained in these variables

192 are independent of the combination of the predecessor plants, the N doses and the year of
193 cultivation.

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195 **3.1 Average mass per fruit**

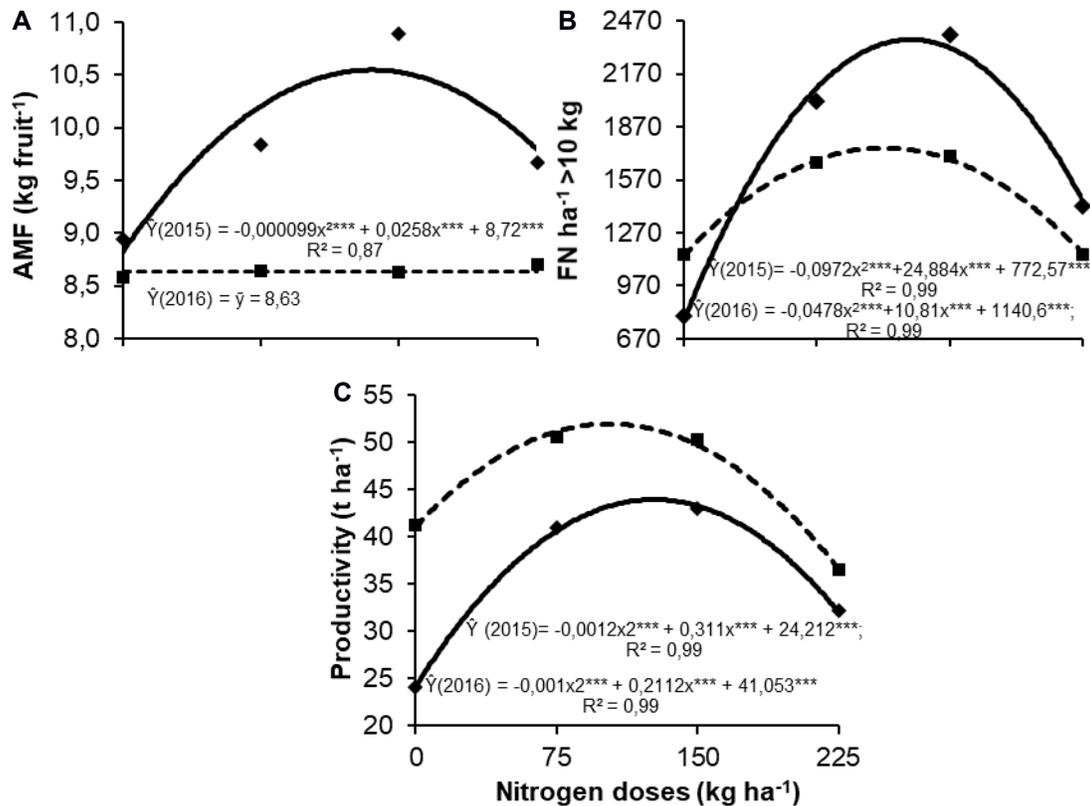
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197 The average mass per fruit (AMF) was not influenced by the plant species cultivated before
198 the watermelon, obtaining $9.22 \text{ kg fruit}^{-1}$, a value considered normal for the studied cultivar
199 (Table 3). However, the AMF was affected by the interaction “year x N dose” (Figure 2A). It
200 was observed that the AMF obtained at the first year was higher than that obtained in the
201 second year in all doses of N tested.

202

203 Figure 2A shows that in the first year of cultivation, the AMF was favored by increasing N
204 levels, adjusting to the quadratic polynomial regression model, obtaining the highest value
205 ($10.55 \text{ kg fruit}^{-1}$) at the N dose of $135.55 \text{ kg ha}^{-1}$. However, in the second year of cultivation
206 there were no differences between the masses per fruit, obtaining a mean value of 9.8 kg
207 fruit^{-1} .

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209
 210 **Fig 2. Average mass per fruit (A), Fruit number with mass greater than 10 kg per**
 211 **hectare**
 212 **(FN ha⁻¹ > 10 Kg) (B) and productivity (C) of watermelon obtained as a function of the**
 213 **interaction year [2015 (—◆—) 2016 (---■---)] and doses of N.**

214 Thus, in the first year, there was a 17% increase in the AMF values when compared to the
 215 values obtained in the second year. The average mass per fruit estimated was 10.55 and
 216 9.80 kg fruit⁻¹, obtained in the first and second year, respectively.

217
 218 In turn, it was verified that increasing N doses results in the increase of the fruit fresh mass
 219 to the detriment of the number of fruits per hectare, since at the end of the plant life cycle the
 220 fruit is the organ that accumulates greater dry mass as well as it is the major drain of
 221 photoassimilates [14].
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223 **3.2 Fruit number per hectare**

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 225 The number of fruits was influenced only by the isolated factors: year of cultivation,
 226 predecessor plant species and N doses, whose means are presented in Table 3 and figure
 227 3A, respectively.
 228

229 **Table 3. Average mass per fruit (AMF), fruit number per hectare (FN ha⁻¹), fruit number**
 230 **per hectare with mass between 5 and 10 kg [FN ha⁻¹ (5 - 10 Kg)], productivity [PROD (t**
 231 **ha⁻¹)], soluble solids (SS) and potential of hydrogen (pH) of watermelon grown in**
 232 **succession at different years.**
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FACTORS	AMF	FN ha ⁻¹	FN ha ⁻¹	PROD	SS	pH
YEAR OF	(Kg)		(5 - 10 Kg)	(t ha ⁻¹)	(°Brix)	

CULTIVATION						
2015	9.8 a*	3593.3 b	1935.8 b	35.03 b	12.21 a	5.44 a
2016	8.6 b	5181.9 a	3758.7 a	44.64 a	10.73 b	5.22 b
CV (%)	10.5	26.2	34.0	32.11	5.07	3.32
PREVIOUS PLANTS						
Spontaneous vegetation	8.9 a	3997.0 b	2747.4 a	34.8 b	11.13 a	5.39 a
<i>U. ruziziensis</i>	9.4 a	4218.3 b	2591.2 a	38.8 b	11.19 a	5.36 a
Pigeon pea	9.3 a	4947.6 a	3203.1 a	45.8 a	12.09 a	5.25 b
CV (%)	16.4	21.5	45.6	20.26	8.23	2.32

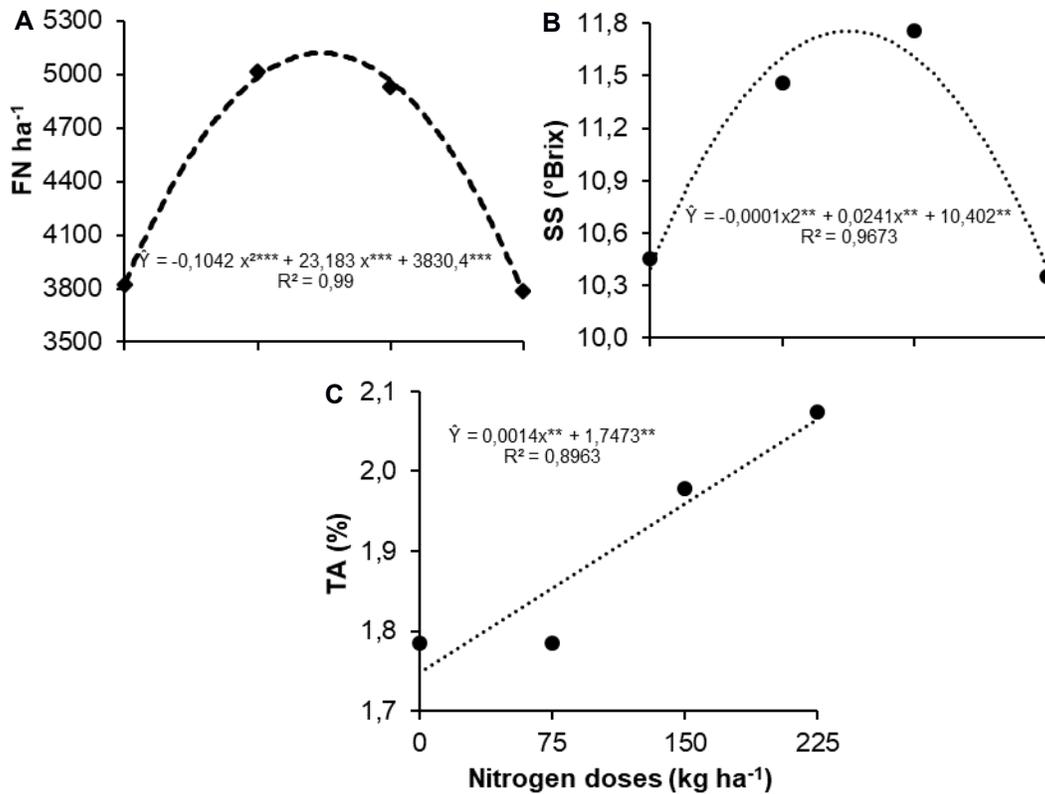
* Means followed by the same letter in the columns, for the same factor, do not differ among themselves by the Tukey test at 5% probability.

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Table 3 shows that the number of fruits increased in the second year of cultivation, exceeding the average obtained in the first year by 40%. This can be attributed to the greater nutrients availability in the area at the second year of cultivation provided by the residual effect of the fertilization applied on the watermelon crop and by the cultural remains of the plant species cultivated the previous year. In addition, the occurrence of high temperatures (> 28 °C) during the first year of cultivation presumably favored the production of male flowers, while in the second year, when the average temperature was 27 °C, the percentage of female flowers was greater. RUDICH and HALEVY (1974) [15] observed that high temperatures favor the production of male flowers, while low temperatures stimulate female flowers occurrence in cucumber and some cucurbits.

Regarding the effect of previous plant species cultivation, the pigeon pea favored the number of watermelon fruits, providing an average of 4.947 fruits ha⁻¹, which was superior to the averages obtained for *U. ruziziensis* (4.218 fruits ha⁻¹) and spontaneous vegetation (3.997 fruits ha⁻¹), which do not differ.

The N dose factor (Figure 3A) affected the number of fruits per hectare. The means adjusted to the quadratic polynomial regression model, reaching the maximum value (5,119.5 fruits ha⁻¹) at the N level of 111.2 kg ha⁻¹, and decreasing from this dose on. Araújo et al. (2011) [1] & Barros et al. (2012) [16] observed that the excess of nitrogen in the plant leads to nutritional imbalance and, consequently, negatively affects the number of fruits per hectare.



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261 **Fig 3. Fruit number per hectare (A), soluble solids (B) and titratable acidity (C) of fruits**
262 **of watermelon obtained under nitrogen doses, considering the average of two years**
263 **of cultivation.**

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3.3 Fruit Number per hectare with Mass between 5 and 10 kg

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The number of fruits per hectare with mass between 5 and 10 kg was not influenced by the predecessor cover crops and doses of N tested. The pigeon pea provided an average of 3,203.1 fruits ha⁻¹, in comparison to the means obtained with the other species of cover crops (Table 3).

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Regarding the year of cultivation, there was a simple effect response, with an average of 3,758.7 fruits ha⁻¹ in the second year, exceeding the average obtained in 2014 by 51% (1).

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This increase may have occurred because the cover crops previously grown in the area produced dry matter and provided satisfactory amounts of N to the soil [10]. The values of the averages obtained may supply not only the consumer's market of Roraima, but also that of the whole North region, which demands medium to large size fruits, weighing between 6 and 15 kg [17,18].

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3.4 Fruit number with mass greater than 10 kg per hectare

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The number of fruits per hectare with mass greater than 10 kg was not influenced by the year of cultivation, obtaining a mean value of 1,536.7 fruit ha⁻¹. However, it was affected by the predecessor plant species and by the interaction between "year of cultivation x N doses". The averages obtained under previously cultivated plant species are presented in Table 4

287 and those reached as a function of the interaction between year and doses of N are shown
288 in Figure 2B.

289

290 The previous cultivation of pigeon pea provided an increase in the number of watermelon
291 fruits over 10 kg. The mean fruit number with mass greater than 10 kg under pigeon pea
292 (1,744.8 fruits ha⁻¹) was statistically equal to the number of fruits obtained under *U.*
293 *ruziziensis* and higher than the average obtained under spontaneous vegetation, which, in
294 turn, does not differ from the number of fruits obtained under *U. ruziziensis*.

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296 As for the effect of the interaction “year of cultivation x doses of N” (Figure 2B), it was
297 verified that in both years the number of fruits with mass greater than 10 kg increased with
298 increasing N doses. The means adjusted to the quadratic polynomial regression model,
299 reaching the maximum values of 2,364 fruits ha⁻¹ (first year) and 1,750 fruits ha⁻¹ (second
300 year) under the N doses of 124.4 and 108.1 kg ha⁻¹, respectively. Thus, the number of fruits
301 weighing more than 10 kg in the first year (2014/2015) was higher than that obtained in the
302 second year (2015/2016), in practically all N doses tested.

303

304 Nitrogen is an essential nutrient for watermelon plants, but in large quantities, the plant
305 assimilates only the necessary amount, and directs it to the vegetative structure [19].

306

307 **Table 4. Fruit number per hectare with mass greater than 10 kg, of watermelon plants**
308 **grown in succession.**

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PREVIOUS PLANTS	FN ha ⁻¹ > 10 kg
Spontaneous vegetation	1,249.9 b*
<i>Urochloa ruziziensis</i>	1,614.5 ab
Pigeon pea	1,744.8 a
AVERAGE	1,536.4

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* Averages followed by the same letter, in the columns, do not differ by Tukey's test ($p \geq 0.05$).

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312 3.5 Productivity

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314 The averages of fruit productivity obtained under different predecessor plant species, year of
315 cultivation and the interaction between year of cultivation and doses of N, are presented in
316 table 3 and figure 2C, respectively.

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318 Pigeon pea provided the highest average for fruit yield (45.80 t ha⁻¹), surpassing in 31% and
319 18% the means obtained under spontaneous vegetation and *U. ruziziensis*, respectively,
320 which did not differ among them (Table 3).

321

322 This result can be attributed to the greater availability of nutrients provided by the pigeon
323 pea, which presents a lower C:N ratio as well as a greater N accumulation in its aerial part
324 (25.43 g kg⁻¹ of N), exceeding in 13% and 27% the accumulation of N in *Urochloa ruziziensis*
325 (18.43 g kg⁻¹ N) and spontaneous vegetation (22.16 g kg⁻¹ N) aerial parts, respectively
326 (Table 2).

327

328 When studying the effect of *Mucuna aterrima* and spontaneous vegetation as predecessor
329 crops on watermelon cultivated under different N doses, Monteiro Neto et al. (2011) verified
330 that *Mucuna aterrima* favored the fruit yield (56 t ha⁻¹), surpassing in 15% the mean obtained
331 under spontaneous vegetation (49 t ha⁻¹).

332

333 The N provided by leguminous cover crops is of great importance for subsequent crops, and
334 can replace chemical nitrogen fertilizers. On the other hand, the fast decomposition of

335 legume residues, due to low C:N ratio, does not allow good soil cover after drying and
336 brushing [20].

337

338 One of the primary uses of cover crops is to increase soil fertility. The use of cover crops in
339 the off-season has a great potential to absorb nutrients from the subsurface layer, and then
340 to transport them to the surface layers through decomposition and mineralization of the
341 residues, which contributes to an efficient use of fertilizers by the cash crops grown in
342 succession [8, 21].

343

344 Regarding the effect of the interaction between “year of cultivation x doses of N” (Figure 2C),
345 it was observed that in both years fruit yields increased with increasing N doses. The means
346 obtained adjusted to quadratic polynomial regression equations.

347

348 The fruit yield in the second year was higher than the means obtained in the first year,
349 regardless of the N doses tested. Thus, maximum fruit yields (44.2 t ha^{-1} and 52.2 t ha^{-1})
350 were reached in years 1 and 2 under the N levels of 129 and 106 kg ha^{-1} , respectively. This
351 represents an 18% increase in fruit yield, obtained in the second year of cultivation, using
352 the N dose of 106 kg ha^{-1} . However, considering the average obtained in the two years of
353 cultivation, this corresponds to an estimated average productivity of 48.7 t ha^{-1} , reached with
354 the N dose of 118 kg ha^{-1} .

355

356 The increased fruit productivity achieved in the second year is mainly due to the greater
357 availability of nutrients provided by the residual effect of fertilizers and cultural remains from
358 the previous year's cultivation (first year of cultivation).

359

360 The means obtained in the first year of cultivation were similar to those found by Barros et al.
361 (2012) [16] when testing the effect of different N doses on watermelon productivity. These
362 authors verified a maximum fruit yield of 40.42 t ha^{-1} at the N dose of $144.76 \text{ kg ha}^{-1}$. Araújo
363 et al. (2019) [22] registered higher commercial yields of watermelon at N levels of 253 and
364 209 kg ha^{-1} .

365

366 Thus, the increase of nitrogen doses up to a certain limit favors leaf area expansion,
367 boosting photoassimilates production and, consequently, the production of fruits in cucurbits
368 [23].

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370 **3.6 Soluble Solids**

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372 The soluble solids content was not influenced by the previously cultivated plant species nor
373 by the interactions between the tested factors, obtaining an average of $11.05 \text{ }^\circ\text{Brix}$.
374 However, it was observed effects for year of cultivation and N doses, whose means are
375 shown in table 3 and figure 3B.

376

377 In the first year of cultivation it was verified a mean soluble solids content of $12.21 \text{ }^\circ\text{Brix}$,
378 surpassing in 12% the value found in the second year ($10.73 \text{ }^\circ\text{Brix}$). This occurred,
379 presumably, due to the climatic conditions. The lower rainfall and higher temperature and
380 luminosity registered in 2014/2015 (Figure 1), in relation to the means occurred in the
381 second year, favored the SS content in watermelon fruits. According to Azevedo et al. (2014)
382 [24] high temperature and luminosity provide ideal conditions for satisfactory crop yield and
383 excellent fruit quality.

384

385 Figure 3B shows that the SS values were adjusted to the quadratic polynomial regression
386 model. Maximum SS content ($11.85 \text{ }^\circ\text{Brix}$) was registered at the N dose of 120.5 kg ha^{-1} ,
387 from which a reduction occurred in these contents.

388

389 Araújo et al. (2001) [1], when studying the effect of different N doses (50, 100, 150, 200 and
390 250 kg ha⁻¹) on 'Crimson Sweet' watermelon plants, registered the highest SS content
391 (12.23 °Brix) at 162.7 kg ha⁻¹ of N.

392

393 According to Monteiro Neto et al. (2016) [25], excess nitrogen affects fruiting and can make
394 the fruit pulp watery. Thus, we can infer that the lowest sugar concentration comes from the
395 excessive water accumulation in the watermelon fruit. The fruits evaluated in the present
396 study present satisfactory SS levels, once they meet the preference of the national and / or
397 international consumers.

398

399 **3.7 Potential of Hydrogen**

400

401 The fruit pulp pH was affected by the year of cultivation and by the predecessor plant
402 species (Table 3). However, it was not influenced by the N doses nor by the interactions
403 between the tested factors, presenting an average of 5.33.

404

405 The fruit pulp pH in the first year of cultivation (5.44) was higher than that observed in the
406 second year (5.22). This can be attributed to the number of days to harvest. In the first year,
407 the fruits remained attached to the plant for a longer period when compared to the second
408 year, which enabled further development of the fruits and, consequently, longer maturation
409 time, generating higher pH values.

410

411 It can be verified in table 3 that the pH values obtained under spontaneous vegetation (5.39)
412 and *U. ruziziensis* (5.36) are equal and higher than the mean found for the fruits cultivated in
413 succession to pigeon pea (5.25). This possibly occurred due to the ability of pigeon pea to
414 increase soil nitrogen content, thus providing the best pH. The acidity, the lower the value
415 presented in the fruits, more attractive to the consumers. The mean maximum pH value
416 observed meets the consumer's preferences and is within the range registered in other
417 studies [26]. However, high pH values do not negatively affect fruit quality, given that
418 watermelon is intended for raw consumption.

419

420 **3.8 Titratable Acidity**

421

422 It was observed an increase in titratable acidity (TA) as the N doses increased, adjusting to
423 the increasing linear regression model. The maximum value (2.06 g of citric acid per 100 g⁻¹
424 of pulp) was verified at the N dose of 225.0 kg ha⁻¹ (Figure 3C). The results found in the
425 present study corroborate in part with those found by Purquerio and Cecílio Filho (2005)
426 [27]. These authors found that increasing nitrogen concentrations in the nutrient solution
427 promoted the increase of melon fruits titratable acidity, thus causing delay in fruit maturation.
428 Similar result was observed by Queiroga et al. (2007) [23], who also obtained an increasing
429 linear response in TA.

430

431 The titratable acidity results for the interaction between "year of cultivation x predecessor
432 plant species" are presented in table 5. The years 2015 and 2016 showed a significant
433 difference, presenting the averages 1.70% and 2.11%, respectively. Comparing the values,
434 there is an increase in titratable acidity. The fruit quality was probably influenced by the
435 prevailing temperature in each year, as can be observed in soluble solids content and
436 titratable acidity. In the first year, the mean temperature was 31 °C while in the second year
437 the mean temperature was 27 °C (Figure 1).

438

439

440 In pear orange production, fruits that receive a higher incidence of solar radiation present
441 decreased acid content. After reaching the maximum temperature, the concentration of this
442 acid decreases, prevailing the respiratory demand of the fruits [28].

443
444 **Table 5. Averages of watermelon fruits titratable acidity (TA) as a function of the**
445 **interaction between year x predecessor plant species.**
446

PREVIOUS PLANTS	TA (% citric acid)		
	2015	2016	AVERAGE
Spontaneous vegetation	1.84 Ba	2.10 Aab	1.97
<i>U. ruziziensis</i>	1.73 Ba	2.18 Aa	1.95
Pigeon pea	1.54 Bb	2.05 Ab	1.79
AVERAGE	1.70	2.11	

447 *Averages followed by the same uppercase letter in the rows and lowercase letter in the columns, do
448 not differ by Tukey test ($p \geq 0.05$).
449

450 The titratable acidity provided by the pigeon pea in both years was inferior to the means
451 obtained under the other predecessor plant species, which in turn did not differ from each
452 other. In the first year, the spontaneous vegetation and *U. ruziziensis* were statistically
453 different. In the second year of cultivation, the means obtained under the pigeon pea were
454 inferior to those obtained under *U. ruziziensis*, which in turn did not differ from the average
455 obtained under spontaneous vegetation. This may be related to higher nitrogen availability
456 provided by pigeon pea cultivation.

457

458 **4. CONCLUSION**

459

460 The components of production and quality of watermelon fruits are affected by the year of
461 cultivation, predecessor plant species and by the doses of nitrogen. Nitrogen doses ranging
462 from 118 to 124 kg ha⁻¹ provide greater number of fruits per hectare, number of fruits per
463 hectare with mass > 10 kg and soluble solids in the fruit pulp. The fruit yield, average mass
464 per fruit and fruit number per hectare are influenced by the interaction “year of cultivation x
465 doses of N”. The previous cultivation of pigeon pea increases the number of fruits per
466 hectare, the number of fruits per hectare with mass > 10 kg and the productivity of
467 watermelon. The cultivation of pigeon pea and *U. ruziziensis* favor the nitrogen availability in
468 the soil for the next crop.

469

470 **COMPETING INTERESTS**

471

472 Authors have declared that no competing interests exist.

473

474 **AUTHORS' CONTRIBUTIONS**

475

476 This work was carried out in collaboration between all authors. All authors read and
477 approved the final manuscript.

478

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