



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

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Authors' contributions

This work was carried out in collaboration among all authors. Author ILGSC collaborated in the projection of the study, implementation, evaluation of the data, statistical analysis and writing of part of the manuscript. Author RDM collaborated in the projection of the study, implementation, evaluation of the data and in the corrections of the manuscript. Authors EAC and EES collaborated in the projection of the study, statistical analysis and in the corrections of the manuscript. Author ESS collaborated in the implementation, data evaluation and statistical analysis. Authors RTS and EMO collaborated in the implementation and evaluation of the data. Author ACMG collaborated on submission and corrections of the manuscript. Authors JAAA and MLG collaborated on the corrections of the manuscript. All authors read and approved the final manuscript.

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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.

Experimental Design: The experimental design was a randomized complete block design,

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arranged in a split-plot scheme, with four replications.

Place and Duration of Study: Two experiments were conducted (2014/2015 and 2015/2016 growing seasons), 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 control with natural 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 fruit weight, number of fruits per hectare, number of fruits per hectare with a 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 produced the highest number of fruits, number of fruits with mass ≥ 10 kg and higher soluble solids content.

Conclusion: Fruit quality was influenced by the year of cultivation, predecessor cover crop species and 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].

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

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

Nitrogen is one of the most essential nutrients required for watermelon cultivation, per increasing the growth and development of the crops, providing photosynthetic rate, productivity, fruit quality and water use efficiency [5]. Nitrogen deficiency hinders chlorophyll synthesis, reduces the photosynthetic efficiency in using the sunlight energy, thus interfering in the absorption of nutrients and production of carbohydrates by the plant [6].

The response of watermelon to nitrogen [7] observed that the excess of nitrogen contributed to the decrease in productivity.

However, not all nitrogen fertilizer applied to the soil is absorbed by the plants. Some of it is lost through leaching, when nitrate is moved below the root zone where it cannot be utilized by crops, or by volatilization, among other types of nitrogen loss [8].

Thus, succession planting, using as a green manure crops, begins to regain its importance, contributing to the improvement of soil fertility and quality. The plants used for green manure are often cover crops. Cover crops help to preserve the soil, providing higher aggregation of the particles and protecting the soil surface from the direct impact of raindrops [9,10].

Some characteristics such as high phytomass production, the ability to accumulate N via BNF (Biological Nitrogen Fixation) and high soil nutrient uptake are desirable when choosing a cover crop species [11].

Given the above, 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.

2. MATERIALS AND METHODS

2.1 Location of Study Area

Two experiments were conducted (2014/2015 and 2015/2016 growing seasons), with the 'Crimson Sweet' watermelon cultivar, grown under different N doses in succession of cover crop species, at the experimental field "Água

Boa”, belonging to Embrapa Roraima, located in the municipality of Boa Vista, state of Roraima, Brazil.

According to Köppen’s classification, the climate of the region is classified as Aw (tropical savanna climate), with rainfall, relative humidity and annual temperature averages of 1,667 mm, 70% and 27.4°C, respectively [12]. The annual mean precipitation and air temperature data, which occurred during the execution of the experiments (2014, 2015 and 2016) are presented in Fig. 1.

The soil of the experimental area is classified as Dystrophic Yellow Latosol (Ladx), with medium texture [13]. The chemical and physical characteristics of the soil, before the implantation of the experiments, are given in Table 1. Thus, in April 2014, 1500 kg ha⁻¹ of dolomitic limestone (90% TRNP), 100 kg ha⁻¹ of P₂O₅, in the form of single superphosphate (SSP), 50 kg ha⁻¹ of K₂O, in the form of potassium chloride and 50 kg ha⁻¹ of FTE BR12, were applied in the soil and incorporated through plowing and harrowing.

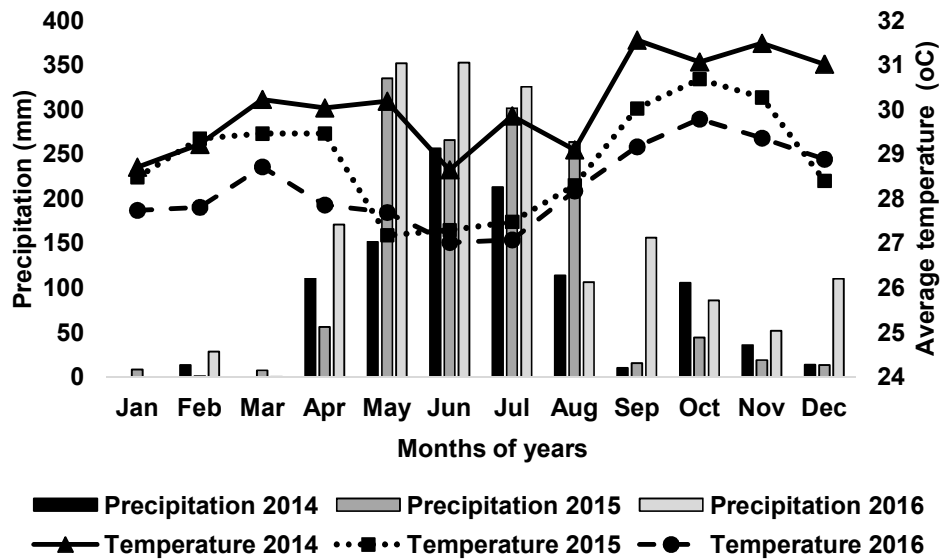


Fig. 1. Average monthly data of precipitation and temperature in 2014, 2015 and 2016, obtained from a meteorological station located at the Embrapa Água Boa experimental field, Boa Vista, Roraima, Brazil

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 (water)	OM g kg ⁻¹	P mg dm ⁻³	Ca	Mg	Al (cmol _c dm ⁻³)		
							H+Al	K	
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 g kg ⁻¹			V %	M	CEC	CECe	
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 Experimental Design

Three systems of crop succession prior to watermelon cultivation were tested: maize intercropped with pigeon pea (*Cajanus cajan*), Brachiaria (*Urochloa ruziziensis*) and a control with natural vegetation, combined with four doses of nitrogen (0, 75, 150 and 225 kg ha⁻¹ of N), using urea as N source, applied in the watermelon culture.

The experimental design was a randomized complete block design, subdivided in a 3 x 4 scheme (three succession planting systems and four nitrogen doses), with four replications. The plots corresponded to an area of 256 m² (32 x 8 m), constituted by crop succession systems (maize intercropped with pigeon pea, *U. ruziziensis* and natural vegetation), while the subplots, with 16 plants and area of 64 m² (8 x 8 m), were constituted by the nitrogen doses applied in the watermelon culture, and the useful area of 24 m².

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

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

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), 10000 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 an 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 natural vegetation. The maize seeds were drilled into unploughed soil (no-tillage system), distributing six seeds of corn per linear meter, placed in the planting lines, succeeding the watermelon spaced at 0.9 m.

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

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

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

2.3 Data Collection

All fruits of each useful area of the plots were counted and weighed in the field. The number of

fruits per hectare, the number of fruits ha^{-1} with a mass between 5 and 10 kg, the number of fruits ha^{-1} with a mass greater than 10 kg and productivity were determined. The productivity was obtained by the total mass of fruits, estimated to one hectare.

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

2.4 Data Analysis

The data were submitted to analysis of variance and F test at 5% probability. The values referring to the effects of the years and the predecessor species (maize x consortia and natural vegetation) were compared by the Tukey test at 5% probability. The data referring to the effects of nitrogen doses were submitted to regression analysis, using the statistical analysis program Sisvar [14].

3. RESULTS AND DISCUSSION

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

3.1 Average Fruit Weight

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

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

Thus, in the first year, there was a 17% increase in the AFW values when compared to the values obtained in the second year. The average fruit weight estimated was 10.55 and $9.80 \text{ kg fruit}^{-1}$, obtained in the first and second year, respectively.

In turn, it was verified that increasing N doses results in the increase of the fruit fresh mass to the detriment of the number of fruits per hectare, since at the end of the plant life cycle the fruit is the organ that accumulates greater dry mass as well as it is the major drain of photosynthetic assimilates [15].

3.2 Fruit Number per Hectare

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

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 ($> 28^\circ\text{C}$) 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) [16] 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 $4.947 \text{ fruits ha}^{-1}$, which was superior to the averages obtained for *U. ruziziensis* ($4218 \text{ fruits ha}^{-1}$) and natural vegetation ($3997 \text{ fruits ha}^{-1}$), which do not differ.

Table 2. Shoot dry mass production (kg ha⁻¹) and nitrogen content (g kg⁻¹) of maize, natural 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	1308	2025	2610	22.16
<i>U. ruziziensis</i>	3508	4076	5990	18.43
Pigeon pea	2354	2858	3890	25.43
Maize	-	5600	6430	11.58

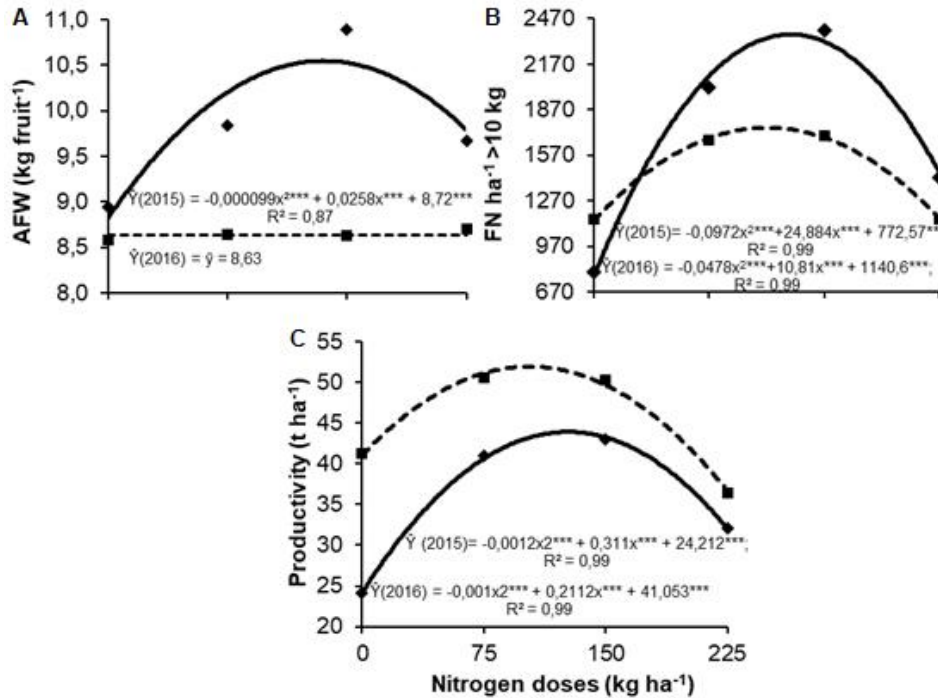


Fig. 2. Average mass per fruit (A), fruit number per hectare (FN ha⁻¹ > 10 Kg) (B) and productivity (C) of watermelon obtained as a function of the interaction year [2015 (—◆—) 2016 (---■---)] and doses of N

Table 3. Average fruit weight (AFW), fruit number per hectare (FN ha⁻¹), fruit number per hectare with mass between 5 and 10 kg [FN ha⁻¹ (5 - 10 Kg)], productivity [PROD (t ha⁻¹)], soluble solids (SS) and potential of hydrogen (pH) of watermelon grown in succession at different years

Factors	AFW (Kg)	FN ha ⁻¹	FN ha ⁻¹ (5 - 10 Kg)	PROD (t ha ⁻¹)	SS (°Brix)	pH
Year of 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

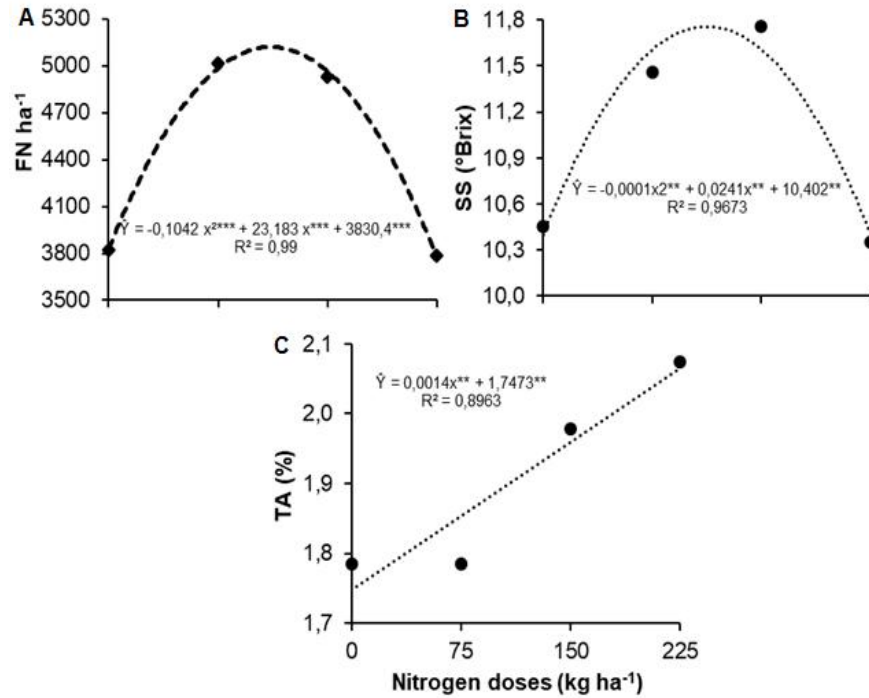


Fig. 3. Fruit number per hectare (A), soluble solids (B) and titratable acidity (C) of fruits of watermelon obtained under nitrogen doses, considering the average of two years of cultivation

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

Previous plants	FN ha ⁻¹ > 10 kg
Natural vegetation	1249.9 b*
<i>Urochloa ruziziensis</i>	1614.5 ab
Pigeon pea	1744.8 a
Average	1536.4

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

Table 5. Averages of watermelon fruits Titratable Acidity (TA) as a function of the interaction between year x predecessor plant species

Previous plants	TA (% citric acid)		
	2015	2016	Average
Natural 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	

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

The N dose factor (Fig. 3A) affected the number of fruits per hectare. The means adjusted to the quadratic polynomial regression model, reaching the maximum value (5119.5 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) [17] observed that the excess of nitrogen in the plant leads to nutritional imbalance and, consequently, negatively affects the number of fruits per hectare.

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

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 3203.1 fruits ha⁻¹, in comparison to the means obtained with the other species of cover crops (Table 3).

Regarding the year of cultivation, there was a simple effect response, with an average of 3758.7 fruits ha⁻¹ in the second year, exceeding the average obtained in 2014 by 51%.

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 [11]. 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 [18,19].

3.4 Fruit Number with Mass Greater than 10 kg per Hectare

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

The previous cultivation of pigeon pea provided an increase in the number of watermelon fruits over 10 kg. The mean fruit number with mass greater than 10 kg under pigeon pea (1744.8 fruits ha⁻¹) was statistically equal to the number of fruits obtained under *U. ruziziensis* and higher than the average obtained under natural vegetation, which, in turn, does not differ from the number of fruits obtained under *U. ruziziensis*.

As for the effect of the interaction "year of cultivation x doses of N" (Fig. 2B), it was verified that in both years the number of fruits with mass greater than 10 kg increased with increasing N doses. The means adjusted to the quadratic polynomial regression model, reaching the

maximum values of 2,364 fruits ha⁻¹ (first year) and 1,750 fruits ha⁻¹ (second year) under the N doses of 124.4 and 108.1 kg ha⁻¹, respectively. Thus, the number of fruits weighing more than 10 kg in the first year (2014/2015) was higher than that obtained in the second year (2015/2016), in practically all N doses tested.

Nitrogen is an essential nutrient for watermelon plants, but in large quantities, the plant assimilates only the necessary amount, and directs it to the vegetative structure [20].

3.5 Productivity

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

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

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

When studying the effect of *Mucuna aterrima* and natural vegetation as predecessor crops on watermelon cultivated under different N doses, Monteiro Neto et al. (2016) [21] verified that *M. aterrima* favored the fruit yield (56 t ha⁻¹), surpassing in 15% the mean obtained under natural vegetation (49 t ha⁻¹).

The N provided by leguminous cover crops is of great importance for subsequent crops, and can replace chemical nitrogen fertilizers. On the other hand, the fast decomposition of legume residues, due to low C:N ratio, does not allow good soil cover after drying and brushing [22].

One of the primary uses of cover crops is to increase soil fertility. The use of cover crops in the off-season has a great potential to absorb nutrients from the subsurface layer, and then to transport them to the surface layers through decomposition and mineralization of the

residues, which contributes to an efficient use of fertilizers by the cash crops grown in succession [9,23].

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

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

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

The means obtained in the first year of cultivation were similar to those found by Barros et al. (2012) [17] when testing the effect of different N doses on watermelon productivity. These authors verified a maximum fruit yield of 40.42 t ha^{-1} at the N dose of $144.76 \text{ kg ha}^{-1}$. Araújo et al. (2019) [24] registered higher commercial yields of watermelon at N levels of 253 and 209 kg ha^{-1} .

Thus, the increase of nitrogen doses up to a certain limit favors leaf area expansion, boosting photosynthetic assimilates production and, consequently, the production of fruits in cucurbits [25].

3.6 Soluble Solids

The soluble solids content was not influenced by the previously cultivated plant species nor by the interactions between the tested factors, obtaining an average of 11.05 °Brix . However, it was observed effects for year of cultivation and N doses, whose means are shown in Table 3 and Fig. 3B.

In the first year of cultivation, it was verified a mean soluble solids content of 12.21 °Brix ,

surpassing in 12% the value found in the second year (10.73 °Brix). This occurred, presumably, due to the climatic conditions. The lower rainfall and higher temperature and luminosity registered in 2014/2015 (Fig. 1), in relation to the means occurred in the second year, favored the SS content in watermelon fruits. According to Azevedo et al. (2014) [26] high temperature and luminosity provide ideal conditions for satisfactory crop yield and excellent fruit quality.

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

When Araújo et al. (2001) [1] studying the effect of different N doses (50, 100, 150, 200 and 250 kg ha^{-1}) on ‘Crimson Sweet’ watermelon plants, registered the highest SS content (12.23 °Brix) at 162.7 kg ha^{-1} of N.

According to Monteiro Neto et al. (2016) [21], excess nitrogen affects fruiting and can make the fruit pulp juicy. Thus, we can infer that the lowest sugar concentration comes from the excessive water accumulation in the watermelon fruit. The fruits evaluated in the present study present satisfactory SS levels, once they meet the preference of the national and / or international consumers.

3.7 Potential of Hydrogen

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

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

It can be verified in Table 3 that the pH values obtained under natural vegetation (5.39) and *U. ruziziensis* (5.36) are equal and higher than the mean found for the fruits cultivated in succession to pigeon pea (5.25). This possibly occurred due

to the ability of pigeon pea to increase soil nitrogen content, thus providing the best pH. The acidity, the lower the value presented in the fruits, more attractive to the consumers. The mean maximum pH value observed meets the consumer's preferences and is within the range registered in other studies [27]. However, high pH values do not negatively affect fruit quality, given that watermelon is intended for raw consumption.

3.8 Titratable Acidity

It was observed an increase in titratable acidity (TA) as the N doses increased, adjusting to the increasing linear regression model. The maximum value (2.06 g of citric acid per 100 g⁻¹ of pulp) was verified at the N dose of 225.0 kg ha⁻¹ (Fig. 3C). The results found in the present study corroborate in part with those found by Purquerio and Cecilio Filho (2005) [28]. These authors found that increasing nitrogen concentrations in the nutrient solution promoted the increase of melon fruits titratable acidity, thus causing delay in fruit maturation. Similar result was observed by Queiroga et al. (2007) [25], who also obtained an increasing linear response in TA.

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

In pear orange production, fruits that receive a higher incidence of solar radiation present decreased acid content. After reaching the maximum temperature, the concentration of this acid decreases, prevailing the respiratory demand of the fruits [29].

The titratable acidity provided by the pigeon pea in both years was inferior to the means obtained under the other predecessor plant species, which in turn did not differ from each other. In the first year, the natural vegetation and *U. ruziziensis* were statistically different. In the second year of cultivation, the means obtained under the pigeon pea were inferior to those obtained under *U. ruziziensis*, which in turn did not differ from the

average obtained under natural vegetation. This may be related to higher nitrogen availability provided by pigeon pea cultivation.

4. CONCLUSION

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

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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