

SCIENTIFIC ARTICLE

Soil management in integrated rose production system

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Abstract

Integrated production systems have been used with various crops, and their use in floriculture is innovative. The effects of green fertilization in floriculture and the appropriate fertilization levels are still unknown. The aim was to identify the best dose of chemical fertilizer, with or without green fertilization, for integrated production of 'Carola' roses. The treatments consisted of 4 doses of the chemical fertilization recommended for rose bushes, (25%, 50%, 75%, and 100%), with or without green fertilization (calopo). Plants that were not treated with 100% (or complete) of chemical fertilization were supplemented monthly with Bokashi (16 g/plant, via the soil) and biofertilizer (5% via the leaves). The assessments were conducted 3 times per week for a year. The use of less chemical fertilizer did not affect rose production or quality, whereas the use of green fertilization did not provide a satisfactory outcome. The analyses, biometric, accumulation and nutrient content, and chemical characteristics of the soil, indicated that green fertilization with calopo was not beneficial. Moreover, with the exception of nitrogen and magnesium, there is the possibility of using 75% of the recommended chemical fertilization in rose bushes.

Keywords: *Rosa* sp., sustainability, cut flowers, floriculture, green fertilization

Resumo

Manejo do solo em sistema de produção integrada de rosas

O sistema de produção integrada vem sendo utilizado em várias culturas, sendo inovador o seu uso em floricultura. Nessa atividade ainda são desconhecidos os efeitos de adubação verde ainda como os níveis de adubação fornecidos não são precisos. O objetivo foi identificar a melhor dose de adubo químico associado ou não à adubação verde, em produção integrada de rosas 'Carola'. Os tratamentos consistiram de quatro porcentagens de adubação química, segundo a recomendação para Minas Gerais, (25%, 50%, 75% e 100%) associado ou não à adubação verde (calopogônio). Plantas que não receberam 100% da adubação química receberam a complementação de Bokashi (16 g/planta, via solo) e biofertilizante (5% foliar), em aplicações mensais. As avaliações foram realizadas três vezes por semana em um ano. A redução da adubação química não prejudicou a produção e qualidade das rosas, mas o adubo verde não foi benéfico. Os resultados das análises biométricas, de acúmulo, teor de nutrientes e características químicas do solo indicam que a adubação verde com calopogônio não é eficiente e, exceto para nitrogênio e magnésio, há possibilidade de utilização de até 75% da adubação química recomendada.

Palavras-chave: *Rosa* sp., sustentabilidade, flores de corte, floricultura, adubação verde

Introduction

Rose cultivation presents great relevance in Brazilian agribusiness, and it is conventionally cultivated under intensive production systems (Landgraf and Paiva, 2009a, 2009b). Fertilization is frequently required due to, the nutritional requirements of rose bushes, the continuous harvesting of flowers that is common in commercial cultivation, and consumer market demands for high quality products. However, soil salinization is very common in rose

bush cultivation due to excessive fertilizer applied with the aim of increasing production; in particular, it occurs in protected crops that are not exposed to rain water, which could reduce that damage (Almeida et al., 2014).

The conventional agriculture model presents a number of environmental risks arising from monoculture, mechanization, and the excessive use of insecticides, fungicides, and herbicides (Tarrega et al., 2009). An alternative for flower production that does not affect the environment is the implementation of the Agropecuary

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System of Integrated Production, which seeks to rationalize the use of agrochemical products; monitoring the water supply, soil quality, environment, crop production, and post-harvest conditions; and maintain records in all phases of production to ensure the traceability of the product (Brasil, 2009). Several chemicals have been tested to improve rose quality (Silva et al., 2018), but natural products are rarely researched.

The use of green fertilization follows the global trends of sustainable agriculture, benefitting the soil in chemical, physical, and biological terms and possibility reducing the use of chemical products, minimizing the environmental impact (Calegari et al., 1993; Ferreira et al., 2012). The use of calopo (*Calopogonium mucunoides*) as a green fertilizer is common in large scale crops due to the high degree of green mass production per area and the high rate of nitrogen fixation in the soil (Costa et al., 2009).

Chemical contents and nutrient accumulation in plants are both fundamental of information to understand the nutritional requirements of a crop. This information may then be used as input to estimate the amount of nutrients to give to plants through fertilization (Laviola and Dias, 2008).

Although green fertilization has been shown to be efficient in several crops (Araújo et al., 2011), we still need more information special for flower production. Research on the integrated production of flowers is also recent, and, therefore, there is a lack of similar results for floriculture.

The objective was to identify the best dose of chemical fertilizer, with or without green fertilization, in order to optimize the production of 'Carola' roses in an Integrated Production System.

Material and Methods

The experiment was conducted in a greenhouse located at 889 m altitude at 21°06'S, 44°15'W. The local climate corresponds to the Cwa group (according to the Köppen classification system), characterized by temperate climate with a humid summer and dry winter (Alvarez et al., 2013). The annual average air temperature is 19.2 °C, with an average minimum of 13.7 °C and an average maximum of 21.6 °C (Brasil, 1969). The soil of the experimental area was originally classified as Ta Eutroferic Haplic Cambisol (Embrapa, 2006).

Physicochemical analysis was initially performed with soil collected at depths of 0-20 cm and 20-40 cm. The soil had a clay texture and a pH of 5.7 (0-20 cm) and 5.4 (20-40 cm). The base saturation (V%) was 37.1% (0-20 cm) and 23.8 (20-40 cm), and the organic matter content was 1.3 dag kg⁻¹ (0-20 cm) and 1.1 dag kg⁻¹ (20-40 cm). After interpreting the analysis, liming was performed 60 days before transplanting the seedlings by applying dolomitic limestone with 95% of effective calcium carbonate equivalent (ECC) to increase base saturation to 70% (Gonçalves et al., 1999).

'Carola' rose seedlings were produced by budding, and when they reached an average height of 40 cm, they were transplanted into 0.15 m high soil beds, with a spacing of

0.20 m between plants and 1.2 m between lines. After 3 months of cultivation, treatments were applied, and plants were managed in a similar way in all the experimental plots in this initial period.

It was evaluated 8 treatments comprising 4 doses of chemical fertilization: 25%, 50%, 75%, and 100% of the fertilization recommended for rose bushes (Gonçalves et al., 1999), with or without calopo (*Calopogonium mucunoides*) cultivated together with rose bushes. The calopo was sown between the planting lines 3 months after the rose bushes were planted, at a distance of 0.5 m from each plant. Pruning was performed every 3 months, and the fresh plant material was left on the soil in the planting lines of the rose bushes, corresponding to an average supply of 480 g of fresh mass (116 g of dry mass) per m². A chemical analysis of calopo leaves revealed macro and micronutrient concentrations (g kg⁻¹): 30.8 N, 3.0 P, 21.2 K, 11.3 Ca, 2.9 Mg, and 2.7 S; and (mg kg⁻¹): 42.7 B, 11.3 Cu, 51.3 Mn, 51.5 Zn, and 313.9 Fe, respectively.

Treatments that did not include complete chemical fertilization (100%) were supplemented with 2 types of biofertilizers applied monthly: Bokashi-Nutri Bokashi® (16 g/plant, as soil fertilization) and foliar feeding biofertilizer (Venzon et al., 2006) at 5%, as leaf fertilization. Plants with complete chemical fertilization (100%) were supplemented with the following (per ha): 80 kg of N, 300 kg of P₂O₅, and 240 kg of K₂O during planting; and 60 kg of N, 35 kg of P₂O₅, and 60 kg of K₂O every 30 days. All treatments were supplemented with 100 t/ha of manure during planting, and this process was repeated every 3 months.

Crop management as irrigation, pest, disease and weed control, was standardized, considering the basic components of Integrated Fruit Production (Fraguas et al., 2001), since there was no information available for Integrated Production of flowers.

It was a randomized block design experiment with spatially subdivided plots. Green fertilization was used in the plots to facilitate the management of the rose bushes, and the subplots corresponded to the different doses of chemical fertilization. The 3.0 m² plots comprised 3 lines with 6 plants, totaling 18 plants per plot and 4 repetitions, with 6 plants being used as useful area.

The number of stems per plant was determined from harvests performed three times a week during a cultivation year, as well as their length from the base to the apex; flower bud length; base of stalk and bud diameters; and fresh mass of leaves, stems, and flower buds. Subsequently, the flower stems were washed in drinking water and distilled water, placed in paper bags, and dried in an oven with an air circulation and renewal system at 65°C until a constant weight was reached, to determine the dry mass and for chemical analysis (Malavolta et al., 1997). For soil analysis, samples were removed according to the different treatments tested, a year after these were applied.

The data obtained were subjected to analysis of variance, and the significant results of the F test (P < 0.05) were subjected to a Tukey test at a probability of 1% and 5% (for the qualitative variables) and to polynomial regression analysis (for quantitative variables) using the

software Sisvar. When significant difference occurred, the regression equations was adjusted based on the greater determination coefficient values (R^2) obtained (Ferreira, 2011).

Results and Discussion

Productivity and growth parameters

There was no interaction between the factors tested for the growth parameters under study. Moreover, there were no differences among the different percentages of chemical fertilization when this factor was analyzed separately.

It was verified that doses of mineral fertilization lower than the level traditionally recommended, when supplemented with organic fertilization, did not affect productivity or the total dry mass of the flower stems. Organic fertilization combined with the lowest mineral fertilization percentage (25%) gave similar results to 100% chemical fertilization. The plants cultivated in an integrated production system produced an average of 7.56 flower stems/year, regardless of the levels of mineral fertilization supplied. Similar results were observed under a conventional production system of 'Kardianal' rose bush (Oki et al., 2001).

The 'Carola' rose bushes produced quality flower stems using the integrated production system with a decrease in chemical fertilization. Regardless of the treatment, all the

flower stems harvested met the standards required for cut roses (Veiling, 2019), showing a flower stem length in the 60 and 70 classes, and a flower bud length classified as big, being considered of excellent quality. Therefore, we may infer that it is possible to manage the 'Carola' rose bush crop and ensure productivity during a year using less chemical fertilizer when supplemented with organic fertilization. Linares-Gabriel et al, (2019), also identified that heliconia (*Heliconia stricta Dwarf Jamaican*) respond positively to low doses of fertilization.

No other similar study has previously been performed with rose bush crops or other ornamental species; however, it was possible to find results similar for other crops. For example, favorable results were obtained with reduced chemical fertilization supplemented with organic fertilization in a bean plant crop (Venturini et al., 2003), and with partial substitution of NPK fertilizer with poultry litter in the production of 'Vera' lettuce (Freitas et al., 2009).

In rose bushes produced without green fertilization, the number of stems produced was 11.45% higher (Table 1) than in plants produced with green fertilization. This could be due to the possible competition between rose bushes and calopo. *In addition, Calopogonium mucunoides* may have an allelopathic effect on rose development as observed in spontaneous plants in flower bed of other flowers species (Pego and Fialho, 2018).

Table 1. Number of stems and dry mass of the aerial shoot system of 'Carola' rose plant, with and without green fertilizer (*C. mucunoides*), regardless of the levels of mineral fertilization.

	Number of stems/plant	Leaf dry mass (g)	Total dry mass of the stem (g)
Green fertilization (calopo)	7.16 b*	4.55 b	12.06 b
No green fertilization	7.98 a	5.01 a	12.90 a

*Averages followed by different letters in columns are significantly different at 5% of probability level by the Tukey test.

Green fertilization with calopo (*C. mucunoides*) affected leaf dry mass and total dry mass of the flower stem. By analyzing the leaf dry mass obtained from plants produced without calopo, we observed an increase of 10.11% when compared to plants produced with green fertilizer (Table 1). In the cultivation of rose bushes without green fertilization, total dry mass production was 6.96% higher than in the crop with green fertilizer. In addition to these altered biometric characteristics of the stems, crop management, including fertilization, pest and disease control, and harvesting, was hampered by the presence of calopo, since this is a species with indeterminate growth. The low efficiency of calopo was also observed by Delarmelinda et al. (2010). According the authors, this green manure did not demonstrate effectiveness in improving the Eutroferric Haplic Cambisol soil conditions.

However, the effects of green fertilization are known to be highly variable, depending on the species used, bio-

mass management, planting and cutting period of the green fertilizer, duration of the residues in the soil, and local conditions, and the interactions between these factors (Fontanetti and Santos, 2010). The beneficial effect of green fertilization has already been identified in the cultivation of sunflowers, mint, 'Pera' oranges, and onions (Wendt et al., 2005; Singh et al., 2010; Azevedo et al., 2012; Souza et al., 2013).

Total nutrient content

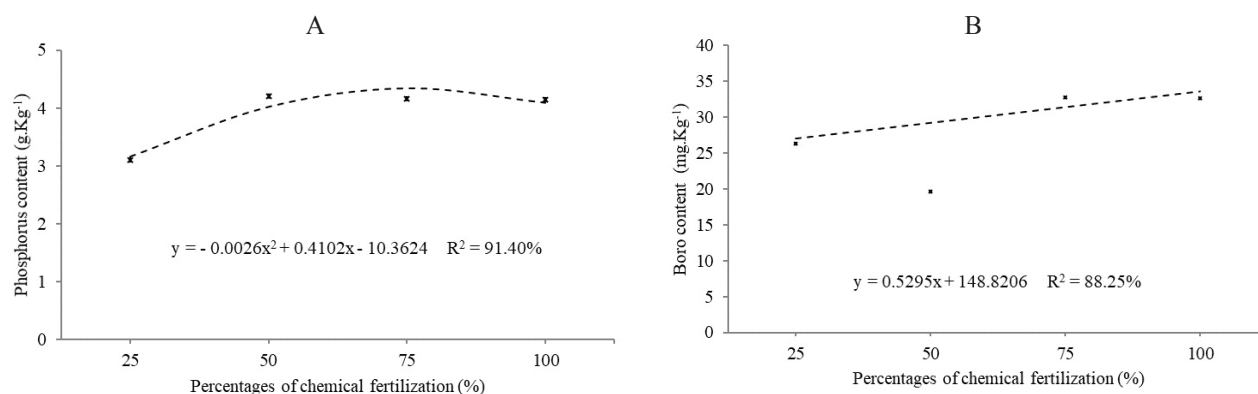
When assessing the levels of chemical fertilization applied to the 'Carola' rose bush, was observed that the levels of nitrogen, potassium, calcium, sulfur, copper, manganese, zinc, and iron did not alter at the end of one year period (Table 2). Meanwhile, regardless of the treatment, the N and Mg levels were below the reference values for the interpretation of rose tissue analysis results (Martinez, et al., 1999).

Table 2. Macronutrient and micronutrient contents in flower stems of ‘Carola’ roses according to the different percentages of chemical fertilization, regardless of the presence of green fertilization

Chemical fertilizer (%)	Macronutrient (g kg ⁻¹)				
	N	K	Ca	Mg	S
25	20.71	14.25	12.15	1.8	1.36
50	22.03	15.36	12.15	1.92	1.49
75	22.04	15.51	11.30	1.89	1.42
100	22.98	16.43	11.81	1.94	1.45
Chemical fertilizer (%)	Micronutrient (mg kg ⁻¹)				
	Cu	Mn	Zn	Fe	
25	60.47	50.97	36.32	98.64	
50	55.13	52.10	40.99	101.88	
75	60.37	55.91	39.61	106.94	
100	66.60	59.19	37.90	113.84	

It was possible to observe a quadratic equation of plant phosphorus content according to fertilization tested, and the estimated maximum point occurred at 76.46% of the recommended fertilization. A linear equation was observed for boron with better response when 100% of

recommended fertilization was provided (Figure 1). Although boron is involved in many of the physiological processes of plants (Marschner, 1995), information on boron requirements for most plants for cut flowers, such as roses, is still scarce.

**Figure 1.** A - Phosphorus (g.kg⁻¹) and B - boron (mg.kg⁻¹) content in flower stems of ‘Carola’ roses at different percentages of chemical fertilization, regardless of the presence or absence of green fertilizer.

The nutrients nitrogen, calcium, magnesium, sulfur, boron, copper, and zinc were not influenced by green fertilization, which did not change the content of these nutrients at the end of the first year of harvesting ‘Carola’ rose bushes (Table 3). By analyzing the K, Mn, and Fe contents, was observed

that the use of green fertilizer with *C. mucunoides* provided a lower content of those element compared to treatments without green fertilizer. However, in the analysis of P, we observed that management with calopo green fertilization was favorable, increasing the content of this nutrient (Table 3).

Table 3. Macronutrient and micronutrient contents in the dry mass of flower stems of ‘Carola’ roses according to the presence or absence of calopo (*C. mucunoides*), regardless of chemical fertilization levels.

	Micronutrient (mg kg ⁻¹)					
	N	P	K	Ca	Mg	S
Green fertilization	21.29 a*	5.40 a	14.81 b	11.60 a	1.81 a	1.40 a
No green fertilization	22.59 a	2.40 b	15.96 a	12.10 a	1.96 a	1.46 a
	Micronutrient (mg kg ⁻¹)					
	B	Cu	Mn	Zn	Fe	
Green fertilization	29.63 a	56.29 a	49.95 b	38.04 a	100.10 b	
No green fertilization	31.00 a	64.99 a	59.41 a	39.37 a	110.55 a	

*Averages followed by the same letters in columns are not significantly different at 5% of probability level by the Tukey test.

Therefore, we observed that green fertilization performed with calopo did not favor contents of most nutrients in the ‘Carola’ rose bush.

Total nutrient accumulation

In all treatments, the accumulation of macronutrients in the flower stems during 1 year of cultivation was in the order: N > K > Ca > P > Mg > S (Table 4). The order of

accumulation of micronutrients in the flower stems showed differences only for the treatments with 100% fertilization + green fertilization, and 25% fertilization: Fe > Mn > Cu > Zn > B. For the other treatments, the accumulation was Fe > Cu > Mn > Zn > B (Table 5). Information about rose bushes nutrient uptake is essential for rose growers, as it is possible to understand the nutritional needs of plants and establish a fertilization program (Taniguchi et al., 2018).

Table 4. Accumulation of macronutrients in flower stems of the ‘Carola’ rose

Fertilization (%)*	Green fertilization	Supplement	Macronutrient (g kg ⁻¹)					
			N	P	K	Ca	Mg	S
100	X	-	0.28	0.06	0.20	0.13	0.02	0.02
75	X	Bokashi + Foliar feeding	0.28	0.07	0.20	0.14	0.02	0.02
50	X	Bokashi + Foliar feeding	0.24	0.06	0.17	0.13	0.02	0.02
25	X	Bokashi + Foliar feeding	0.25	0.04	0.17	0.14	0.02	0.02
100	-	-	0.28	0.03	0.21	0.14	0.02	0.02
75	-	Bokashi + Foliar feeding	0.31	0.04	0.22	0.15	0.03	0.02
50	-	Bokashi + Foliar feeding	0.29	0.03	0.20	0.15	0.03	0.02
25	-	Bokashi + Foliar feeding	0.31	0.03	0.22	0.17	0.03	0.02

* Gonçalves et al., (1999)

Table 5. Accumulation of micronutrients in flower stems of the ‘Carola’ rose

Fertilization (%)*	Green fertilization	Supplement	Micronutrient (mg plant ⁻¹)				
			B	Cu	Mn	Zn	Fe
100	x	-	0.35	0.66	0.68	0.48	1.38
75	x	Bokashi + Foliar feeding	0.46	0.71	0.67	0.51	1.31
50	x	Bokashi + Foliar feeding	0.33	0.59	0.57	0.45	1.13
25	x	Bokashi + Foliar feeding	0.33	0.85	0.57	0.45	1.19
100	-	-	0.43	1.04	0.77	0.45	1.45
75	-	Bokashi + Foliar feeding	0.45	0.91	0.85	0.57	1.63
50	-	Bokashi + Foliar feeding	0.37	0.73	0.69	0.53	1.39
25	-	Bokashi + Foliar feeding	0.36	0.71	0.80	0.52	1.50

* Gonçalves et al., (1999)

The plants accumulated higher amounts of phosphorus (0.050 g plant⁻¹) when they received 75.01% of the recommended chemical fertilizer compared to the other percentages tested (Figure 2). This confirms that ‘Carola’ rose bushes did not respond to the higher supply of nutrients

within a year, indicating that it is possible to decrease phosphate fertilization by 25%, which may decrease production costs and minimize environmental problems, such as soil salinization.

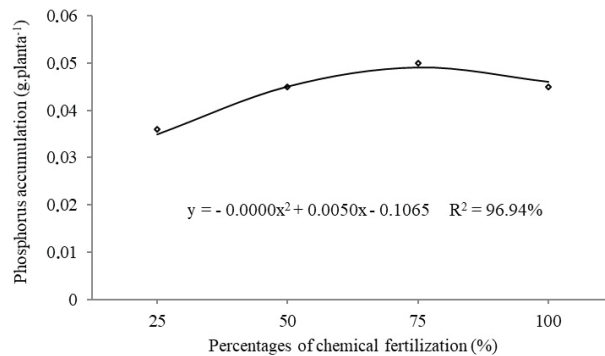


Figure 2. Accumulation of phosphorus (g plant⁻¹) in flower stems of ‘Carola’ roses according to the different percentages of chemical fertilization, regardless of the presence or absence of green fertilization.

For the remaining nutrients (N, K, Ca, Mg, S, B, Cu, Mn, Zn, and Fe), differences in accumulation depending on the fertilization rates were not observed (Table 6). Therefore, we may infer that ‘Carola’ rose bushes accumulate the same amount of macronutrients and micronutrients, with the exception of P, when submitted to different doses of

chemical fertilizer, indicating that the use of high amounts of fertilizers is not necessary for the production of ‘Carola’ rose stems within a year. In addition, nutrient accumulation may differ in other types of roses under the same experimental conditions, as detected in gerberas (Ludwig et al., 2019)

Table 6. Macronutrient and micronutrient accumulation in flower stems of ‘Carola’ roses according to the different percentages of chemical fertilization, regardless of the presence or absence of green fertilization.

Chemical fertilization (%)	Macronutrient (g plant ⁻¹)				
	N	K	Ca	Mg	S
25	0.28	0.19	0.15	0.02	0.02
50	0.26	0.18	0.14	0.02	0.02
75	0.29	0.21	0.15	0.03	0.02
100	0.28	0.20	0.14	0.02	0.02
Chemical fertilization (%)	Micronutrient (mg plant ⁻¹)				
	B	Cu	Mn	Zn	Fe
25	0.35	0.78	0.68	0.48	1.34
50	0.35	0.66	0.63	0.49	1.26
75	0.45	0.81	0.76	0.54	1.47
100	0.39	0.85	0.73	0.47	1.42

Table 7. Macronutrient and micronutrient accumulation in flower stems of ‘Carola’ roses according to the presence or absence of calopo (*C. mucunoides*) regardless of the different levels of mineral fertilization.

	Macronutrient (g plant ⁻¹)					
	N	P	K	Ca	Mg	S
Green fertilization	0.26 b*	0.06 a	0.18 b	0.14 a	0.02 b	0.02 a
No green fertilization	0.30 a	0.03 b	0.21 a	0.15 a	0.03 a	0.02 a
	Micronutrient (mg plant ⁻¹)					
	B	Cu	Mn	Zn	Fe	
Green fertilization	0.37 a	0.70 a	0.62 b	0.47 a	1.26 b	
No green fertilization	0.40 a	0.85 a	0.78 a	0.51 a	1.49 a	

*Averages followed by the same letters in columns are not significantly different at 5% of probability level by the Tukey test.

When cultivated without calopo, the plants showed higher accumulation of the nutrients N, K, Mg, Mn, and Fe (Table 7). However, association with calopo favored a higher accumulation of P but did not influence the remaining nutrients.

Although the species used as green fertilizer are able to immobilize a great amount of nutrients in their biomass, this does not mean that these nutrients are readily available for the associated crop (Alvarenga et al., 1995). Overall, the association of green fertilizer (*C. mucunoides*) with rose bushes did not favor the accumulation of macronutrients or micronutrients in ‘Carola’ rose stems at the end of one year of cultivation. The association with calopo was less efficient in terms of both production

of dry mass and absorption and accumulation of most nutrients by the rose bushes. In the absence of calopo, there was a higher production of dry mass (Table 1) and greater accumulation of nutrients, except for P (Table 7).

Soil characterization according to the treatments applied

The potassium (Figure 3A) and boron (Figure 3B) concentrations in the soil increased as the percentage of chemical fertilization given to the plants increased. There was a similar behavior between the average B content in the dry mass of the flower stems and the levels of B in the soil, which means that every increase in boron in the soil increased B content in the plants (Figure 1 and Figure 3B).

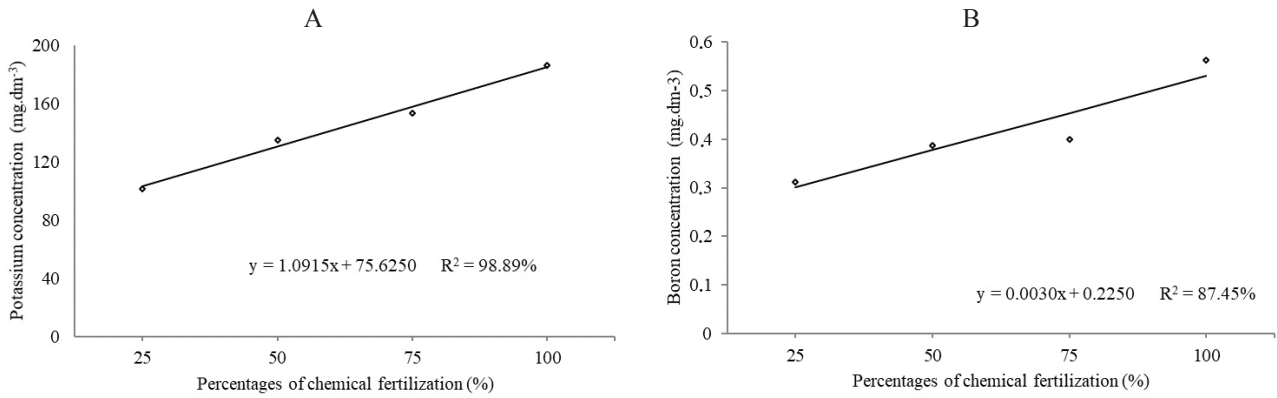


Figure 3. A - Potassium and B - boron concentrations in soil cultivated with ‘Carola’ rose bushes, according to the different percentages of chemical fertilization, regardless of the presence or absence of green fertilization.

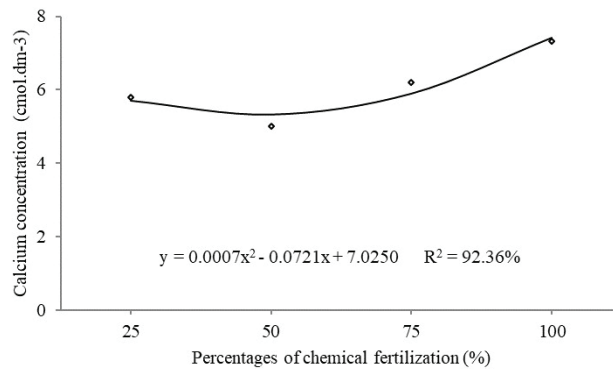


Figure 4. Calcium concentrations in soil cultivated with ‘Carola’ rose bushes, according to the different percentages of chemical fertilization, regardless of the presence or absence of green fertilization.

Calcium concentration in the soil had the estimated minimum point when the percentage of chemical fertilization was 51.5%, with tendency to increase as the doses were increased (Figure 4).

There was no effect on the other nutrients in the soil according to the amount of chemical fertilizer used over a period of one year of cultivation of the ‘Carola’ rose and the general averages can be observed in table 8.

Table 8. Chemical characteristics of soil cultivated with ‘Carola’ rose bushes according to the different percentages of chemical fertilization

Chemical fertilization (%)		Macronutrient				
		P	S		Mg	
		mg dm ⁻³			cmol dm ⁻³	
25		39.03	14.41		1.45	
50		68.02	13.52		1.56	
75		76.06	17.97		1.17	
100		102.31	29.72		1.80	
Chemical fertilization (%)		Micronutrient				OM (dag kg ⁻¹)
		Cu	Fe	Mn	Zn	
		mg dm ⁻³				
25		9.66	54.65	48.62	13.07	2.25
50		9.08	55.41	57.88	16.98	2.25
75			54.88	59.90	24.38	2.31
100			64.08	51.57	26.36	2.76

The pH of the soil was influenced by the use of green fertilization, being more alkaline in the absence of green fertilization (Table 9). The calcium content in the soil was also higher when plants were grown in the absence of green fertilization, compared to treatment with green manure. On

the other hand, B, Cu and Zn contents in the soil were higher when the rose bushes were grown with green fertilization, which promoted the recycling of nutrients, making them available to the rose bushes.

Table 9. Chemical characteristics of soil cultivated with ‘Carola’ rose bushes according to the presence or absence of calopo (*C. mucunoides*), regardless of the different levels of chemical fertilization.

	pH H ₂ O (1:2.5)	Macronutrient					
		P	K	S	Ca	Mg	
		mg dm ⁻³			cmol dm ⁻³		
Green fertilization	7.14 b*	71.98 a	144.56 a	22.38 a	5.55 b	1.58 a	
No green fertilization	7.36 a	70.73 a	143.12 a	15.43 a	6.60 a	1.67 a	
		Micronutrient				MO (dag kg ⁻¹)	
		B	Cu	Mn	Zn		Fe
		mg dm ⁻³					
Green fertilization	0.48 a	12.85 a	51.12 a	23.26 a	60.76 a	2.45 a	
No green fertilization	0.35 b	8.23 b	57.86 a	17.13 b	53.75 a	2.33 a	

*Averages followed by the same letters in columns are not significantly different at 5% of probability level by the Tukey test.

The initial chemical analysis was performed with soil collected at depths of 0 to 20 cm and 20 to 40 cm. After interpretation of the analysis, liming was performed 60 days before transplanting the seedlings by applying dolomitic limestone with 95% of PRNT to increase base saturation to 70%, according to the recommendations for

the rose bush crop offered by the Soil (Gonçalves et al., 1999). However, at the end of the cultivation cycle, the pH was above that recommended for crop development. The soil solution was shown to be more alkaline in the absence of green fertilization than when green fertilizer was used (Table 9).

Nutrient recycling, making significant amounts of nutrients available in the soil, in particular N, K, Ca, and P, made it possible to replace or reduce the amount of nitrogen fertilizers used in a plot when leguminosae species were associated with citrus (Silva et al., 2002). A lower content of organic matter, Ca content, and sum of base values in the superficial soil layer were obtained in a traditional cultivation system when compared to the use of cover plants with different doses of nitrogen fertilization (Andrioli and Prado, 2012).

The use of green fertilization in the soil is a practice that supplies plants with organic matter and the nutrients they require, which makes it possible to decrease the amount of chemical fertilizers used (Buzinaro et al., 2009), decreasing production costs. Green fertilizers add organic compounds to the soil, such as root exudates, root and leaf biomass, organic acids, and several elaborated compounds such as amino acids and phytohormones (Delarmelinda et al., 2010). Among the expected effects of the planting system in association with species suitable for green fertilization, the increase of organic matter in the soil should be highlighted (Calegari et al., 1993).

The chemical attributes of the soil were affected, except for exchangeable K, available P, and values of saturation of the cation exchange capacity $CEC_{pH7.0}$ of bases, by the cultivation of cover plants for green manure in a direct planting system (Souza et al., 2013). Green fertilization improves the chemical, physical, and biological characteristics of the soil. The use of legumes as green manure provided an increase in organic matter content, sum of bases and saturation percentage by bases, in particular *Pueraria phaseoloides*, *C. juncea*, and *C. spectabilis* (Delarmelinda et al., 2010). However, the results presented in the cultivation of rose associated with green manure were different from those observed by these authors.

Conclusions

It is possible to manage rose bush crops and ensure production quality when using the Integrated Production System. In the first year of harvest evaluation, it was possible to cultivate 'Carola' roses under an Integrated Production System with a 75% of the recommended chemical fertilization (except for N and Mg) when associated with organic fertilization.

Green fertilization with *C. mucunoides* associated with the rose bushes is not recommended, since it reduced the quality of flower stems, besides increasing the difficulties in managing the crop.

Author Contribution

J.C.V.B.: Conduction and evaluation of the experiment; tabulation and statistical analysis of data; writing of the manuscript. **E.F.A.A.:** Experimental planning, conduction and evaluation of the experiment and standardization of the according to the journal. **P.D.O.P.** 0000-0001-7997-8420: Preparation of the text and important contribution in the final version of the manuscript.

M.A.L.: Experimental planning, conduction and evaluation of the experiment; data collection, analysis and article writing. **S.N.R.:** Experimental planning, conduction and evaluation of the experiment. **L.M.C.:** Experimental planning, conduction and evaluation of the experiment.

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