Scientific Article

Green manure affects cut flower yield and quality of 'Vegas' rose bushes[1]

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ABSTRACT

Rose cultivation requires many inputs for satisfactory production, making the process expensive. Nowadays, alternative practices have been used for sustainable crop production. Green manure is an agricultural practice that aims to maintain or improve soil fertility, increasing its yielding capacity. The objective of this research was to evaluate the effect of green manure with legumes on the yield and quality of 'Vegas' roses. Grafted rose seedlings were cultivated in open field for 30 months. Legumes used as green manure and planted intercropped with rose bushes were forage peanut (*Arachis pintoi*) and jack bean (*Canavalia ensiformis*). Pigeon pea (*Cajanus cajan*) was grown in a separate area, cut, macerated, and applied in the rows between rose bushes every 3 months. Plants of control group received no green manure, only mineral fertilizer and cattle manure, as in all other treatments. The experimental design was randomized block with four treatments (three green manure species plus the control) and seven replications. The highest yield and quality of flower stems in 'Vegas' occurred with addition of pigeon pea on the soil surface or chemically treated (control). Forage peanut and jack bean are not suitable for intercropping with 'Vegas' rose bushes due to possible nutrient and water competition.

Keywords: floriculture, legumes, organic fertilization, sustainable production.

RESUMO

Adubação verde influencia produção e qualidade de flores de corte da roseira 'Vegas'

A cultura da roseira demanda a aplicação de diversos insumos agrícolas para uma produção satisfatória, o que torna o processo oneroso. Atualmente, tem-se buscado o uso de manejos alternativos para um cultivo vegetal sustentável. A adubação verde é uma prática agrícola que visa conservar ou melhorar a fertilidade do solo, aumentando sua capacidade produtiva. O objetivo dessa pesquisa foi avaliar o efeito da adubação verde com leguminosas na produção e qualidade de rosas cultivar 'Vegas'. Mudas enxertadas de rosas foram cultivadas a céu aberto durante 30 meses. As leguminosas utilizadas como adubo verde e plantadas em consórcio com as roseiras foram o amendoim forrageiro (*Arachis pintoi*) e feijão de porco (*Canavalia ensiformis*). O feijão guandu (*Cajanus cajan*) foi cultivado em área separada, cortado, triturado e aplicado a cada três meses na superfície do solo na linha de plantio da roseira. As plantas do grupo controle não receberam nenhuma adubação verde, apenas adubação mineral e esterco bovino, como em todos os outros tratamentos. O delineamento experimental foi em blocos casualizados com quatro tratamentos (três espécies de adubo verde mais a testemunha) e sete repetições. A melhor produção de hastes florais de qualidade ocorreu em roseiras 'Vegas' cultivadas com a adição superficial de feijão guandu no solo e no tratamento controle (somente adubação química). O amendoim forrageiro e o feijão de porco não são indicados para serem plantados em consórcio com roseiras 'Vegas' devido à possível competição por água e nutrientes.

Palavras-chave: floricultura, leguminosas, adubação orgânica, produção sustentável.

1. INTRODUCTION

Roses are a challenging culture that require intensive care throughout production in order to obtain a product that meets commercial quality standards. However, one of the barriers of rose cultivation is to reduce the production environmental impact, since this plant requires application of several chemicals for a profitable production. Therefore, alternative practices that contribute to sustainable management of this crop have been sought (ALMEIDA et al., 2014; PIOTROWSKA and WILCZEWSKI, 2012).

An improperly managed cultivation site can result in the loss of natural soil quality. Green manure is a good option for the maintenance and improvement of physical, chemical, and biological properties of the soil because its use reduces nutrient leaching, increases soil fertility, decreases the application of chemical fertilizers, and improves water infiltration and aeration (PADOVAN et al., 2011).

Green manure is considered a sustainable practice in which plants are left after mowing or incorporated into the soil in order to increase the organic matter content. In general, leguminous plants are more frequently used as a green manure because they contain considerable amounts of phosphorus, potassium, calcium, and nitrogen. The roots of legumes are symbiotically associated with bacteria of

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the genus *Rhizobium,* which promote atmospheric N_2 fixation, contributing significantly to increase the amount of nitrogen in the soil-plant system (PERIN et al., 2004; OLIVEIRA et al., 2010).

When used as vegetation cover, green manure reduces the fluctuations in temperature and moisture in the topsoil layer, which favors plant development. In addition to increasing the soil quality, this practice has an antagonistic effect on pathogens, pests, and weeds, promoting a more sustainable plant production (ANDRADE NETO et al., 2008).

To the best of our knowledge, there have been no studies on the use of green manure in the cultivation of roses. Therefore, the objective of this study was to evaluate legume green manure in the yield and quality of 'Vegas' roses.

2. MATERIAL AND METHODS

The experiment was conducted in Minas Gerais State, at an altitude of 889 m and geographical coordinates 21°06' S and 44°15' W. The local climate is temperate (Cwa, according to the Köppen classification), characterized by wet summers and dry winters. The average annual 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 in the experimental field was originally classified as Ta Eutroferric haplic cambisol (EMBRAPA, 2006). Grafted rosebush seedlings (*Rosa sp.*), 'Vegas' cultivar, were planted in 10 × 15 m open field area, at a depth of 0.25 m and spacing of 1.20 m between rows and 0.20 m between plants. The experiment was carried out for 30 months.

The experiment was carried out in a randomized block design with four treatments, three species of legumes: perennial forage peanut (*Arachis pintoi*), the annual jack bean (*Canavalia ensiformis* 'Comum') and the pigeon pea (*Cajanus cajan*) and a control without the application of green manure, with seven replications. Each experimental plot comprised a row containing five plants.

The green manure used was planted fifteen days after rosebushes planting. The forage peanut and jack bean were planted with a spacing of 10 cm between plants, along with the roses, and were prevented from spreading in the rows. These two green manure species were cut every 3 months and the fresh biomass was kept between rows as a source of supplementary fertilization, which corresponded to 360 and 180 g of dry matter of jack bean and forage peanut, respectively, for each plant in each application.

The pigeon pea was grown in a separate area with spacing of 1.5 m between rows and 15 cm between plants, as this green manure specie can reach substantial height and interfere with the rose plantation growth by unwanted shading. Before ripening of the seeds, pigeon pea plants were mown, the fresh biomass macerated and placed between rose bush rows every 3 months in the corresponding amount of 300 g of dry mass per plant per application.

All experimental plants, including control, were fertilizer with chemical fertilizers and cattle manure. Chemical fertilization was performed based on soil analysis and applied according to the recommendations for lime and fertilizer use in Minas Gerais (RIBEIRO et al., 1999). According to these recommendations, each plant received the following water-soluble fertilizers via nutrient solution in monthly applications: 0.41 g of NPK 13:40:13 (nitrogen, phosphorus, and potassium), (Yara, Oslo, Norway), 0.51 g of potassium nitrate (Yara, Oslo, Norway), 0.61 g of calcium nitrate (Yara, Oslo, Norway), 0.51 g of magnesium sulphate (Yara, Oslo, Norway), 0.15 g of urea (Heringer, Viana, Brazil), and 3.15 mg YaraVita Rexolin APN (Yara, Oslo, Norway). The roses were fertilized every 4 months with 10 L of dry cow manure per linear meter that was applied to the soil in the planting row (Table 1). The results of chemical analysis of the top 0–20-cm soil layer before the planting of seedlings and after 30 months of different treatments with green manure are presented in Table 2.

Table 1. Chemical analysis of bovine manure used in the experiment

pH*		**C/N ratio****		**Organic carbon**	**Organic matter**		**Humidity*****		**Total N**
7.5		37.1		33.8	58.2		77.6		0.91
P_2O_5	**K_2O**	**Ca**	**Mg**	**S**	**B**	**Zn**	**Fe**	**Mn**	**Cu**
1.05	1.88	1.46	0.47	0.17	0.002	0.02	0.98	0.03	0.005

* in $CaCl_2$ 0.01 mol L^{-1}; ** Values expressed as % dry matter for C/N ratio, organic carbon, organic matter, total N, P_2O_5, K_2O, Ca, Mg, S, B, Zn, Fe, Mn and Cu; *** at 65 ºC.

The air temperature, relative humidity of the air, and rainfall in the experimental period were 19°C, 76 %, and 1574 mm, respectively. Irrigation was performed daily up to field capacity by a drip system. The plants were grown with *agobio* method and pests and disease control occurred using the rules of the Integrated Production System (FRÁGUAS et al., 2001)

The assessments, which began 90 days after planting, were conducted three times a week. Rose stems were harvested in the commercial standard and evaluated by observing the number of stems produced per plant, the number of leaves per stem, the length and diameter of the stem, the length and diameter of the flower bud, and the fresh and dry matter of the stem, leaves, and flower buds. After 30 months of cultivation, the third leaf from the shoot apex with five leaflets was collected for chemical analysis (five leafs per plot to assessed separately according treatments). The leaf macro- and micronutrient contents were measured according to the methodology described by Malavolta et al. (1997). The leaf nutrient contents were compared according to the method described by Mastalerz and Lanchans (1969). The data were submitted to analysis of variance and the means were compared using the Scott-Knott test ($P < 0.05$).

3. RESULTS AND DISCUSSION

According to the interpretation of soil analysis based on the *5th Aproximação* (RIBEIRO et al., 1999) and given that soils with 70% base saturation are considered suitable for cultivation of roses (ALMEIDA et al., 2014), the soils treated with or without green manure showed a satisfactory percentage of base saturation after the treatment (Table 2). However, this soil property was classified as fair before planting of the roses, thus confirming a significant improvement in base saturation. The organic matter content before planting of the seedlings was considered low; it improved after the fertilization in the treatments with or without the application of green manure, as indicated by the similar average levels of organic content in all treatments (Table 2).

Table 2 Chemical analysis of soil for active acidity (pH), base saturation (V), organic matter (O.M.), macro- and micronutrients in the top 0 - 20 cm layer before planting of the seedlings and after 30 months of cultivation of rose 'Vegas' bushes with the application of green manures.

Property*	Before planting	Treatment			
		Without green manure	Forage peanut	Pigeon pea	Jack bean
pH	5.7	6.3	6.6	6.6	6.9
V %	46.50	78.16	81.36	81.78	82.44
O.M. dag kg^{-1}	1.30	2.36	2.36	2.74	2.11
Macronutrients*					
P (mg dm^{-3})	0.80	20.25	14.09	19.68	19.68
K (mg dm^{-3})	20.00	56.00	52.00	104.00	68.00
Ca ($cmol_c$ dm^{-3})	1.90	5.50	6.00	6.00	5.70
Mg ($cmol_c$ dm^{-3})	0.40	1.00	1.10	1.20	1.10
S (mg dm^{-3})	24.40	12.61	10.34	11.23	11.23
Micronutrients*					
B (mg dm^{-3})	0.00	0.26	0.26	0.38	0.31
Cu (mg dm^{-3})	5.50	7.20	6.86	7.26	7.78
Fe (mg dm^{-3})	52.70	140.74	69.62	94.10	81.81
Mn (mg dm^{-3})	14.50	45.20	40.85	49.43	44.40
Zn (mg dm^{-3})	2.70	20.92	13.64	13.92	14.24

* Units of measure: % for V; dag kg^{-1} for O.M.; mg dm^{-3} for P, K, S, B, Cu, Fe, Mn, and Zn; and $cmol_c$ dm^{-3} for Ca and Mg.

According to the interpretation of the analyses based on the *5th Aproximação* (RIBEIRO et al., 1999), the availability of macronutrients in soils treated with or without green manure was considered good, with significant increase in potassium after the addition of pigeon pea. The availability of nutrients in the soil before planting of the seedlings was very low for phosphorus, low for potassium and magnesium, average for calcium, and very good for sulfur. Hence, the management practices applied in soil fertilization increased the levels of these nutrients, with the exception of sulfur. However, the availability of boron was low, with the exception of soil containing pigeon pea, which was classified as the average level. The level of boron before planting was zero; thus, the application of

chemical and organic fertilizers later increased availability of this nutrient (Table 2). It is noteworthy that one of the benefits of using green manure is the cycling of nutrients that were added to the soil through mineral fertilization but not used by the crops, or those that were released by mineralization of organic matter (TORRES et al., 2008).

Rose bushes grown in soil treated with the surface addition of pigeon pea, and those grown in control with soil that did not receive green manure (but only chemical fertilization), produced more stems than the roses intercropped with jack bean and forage peanut during the 30 months of cultivation (Figure 1A). These data were contrary to those reported by Almeida et al. (2015) who observed higher productivity of lettuce and arugula when green manure was applied. The greatest number of roses of control shows that the intercropping with green manures was not favorable for the development of plants, as may have been competition between rosebushes and legumes.

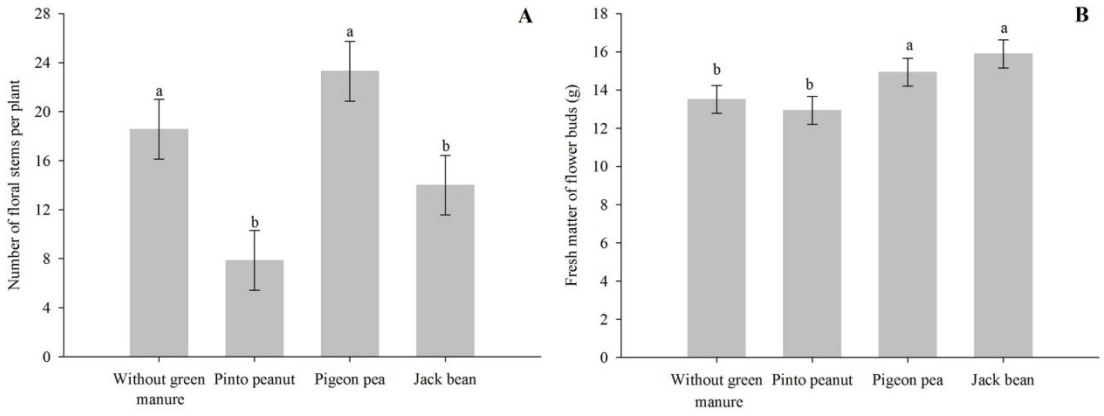

Figure 1. Number of flower stems produced by rose 'Vegas' bushes during 30 months of cultivation with or without green manures (A), and fresh matter of flower buds of rose 'Vegas' bushes cultivated with or without green manures (B). Means followed by the same letter do not differ according to the Scott-Knott test ($P < 0.05$) and bars represent standard error deviation about average (2.42 to number of floral stems per plant and 1.49 to fresh matter of flower buds).

There were no significant differences in the number of leaves per stem (8.01), stem length (56.30 cm), and stem diameter (7.14 mm) as well as the fresh (15.53 g) and dry matter (4.24 g) of stems between all four treatments. The flower stems from all treatments fit the Veiling class 60 of quality standard for cut roses, successfully meeting the requirements for commercial quality (VEILING, 2014). The fresh (10.06 g) and dried matter (2.68 g) of leaves and the length (48.81 mm) and diameter (33.36 mm) of flower buds did not differ statistically.

It was observed that the roses cultivated with green manure - jack bean and pigeon pea, accumulated more fresh matter of flower buds compared to the rose bushes intercropped with forage peanut and the control (Figure 1B). The dry matter of flower buds was not significantly different between the treatments; its average value was 2.34 g. The dry weight of flowers topped the classical average of 1.88 g for roses (TAMINI and MATSUYAMA, 1999).

The concentrations of nitrogen, potassium, and magnesium in leaves were low, according to the scale for roses provided by Mastalerz and Lanchans (1969). The rose bushes contained normal levels of phosphorus and calcium in the leaves (Table 3). Leaves from rose bushes grown together with jack bean and those that did not receive green manure contained more calcium than the leaves from rose bushes intercropped with forage peanut or cultivated with surface application of pigeon pea.

Table 3. Leaf contents of macro- and micronutrients in rose 'Vegas' bushes after 30 months of cultivation with or without green manures.

Treatment	Macronutrients					
	N (ns)	P (ns)	Ca **	K (ns)	Mg (ns)	S (ns)
	g kg^{-1}					
Without green manure	28.18	2.40	8.20	12.80 a	2.00	2.00
Forage peanut	27.08	2.00	7.40	11.00 b	2.00	2.00
Pigeon pea	28.32	2.20	9.00	11.60 b	2.00	2.00
Jack bean	26.56	2.16	8.10	12.94 a	2.10	2.00
Treatment	Micronutrients					
	B (ns)	Cu (ns)	Mn (ns)	Zn **	Fe (ns)	
	mg kg^{-1}					
Without green manure	31.96	8.84	33.50	24.52 a	144.56	
Forage peanut	34.04	6.46	31.76	21.68 b	129.04	
Pigeon pea	33.22	6.64	31.66	25.82 a	127.92	
Jack bean	39.54	5.72	31.26	21.26 b	129.72	

(ns) and ** indicate not significant and significant, respectively, according to the F-test.
The means followed by the same letter do not differ according to the Scott-Knott test ($p < 0.05$).

Levels of boron, copper, manganese, zinc, and iron in the rose leaves were classified as normal (Table 3). The leaves of roses grown with the surface application of pigeon pea and those that were not treated with green manure contained more zinc than the leaves of roses intercropped with forage peanut or jack bean.

Nitrogen, phosphorus, calcium, magnesium, and iron are needed in higher quantities during the rose vegetative growth phase, and their accumulation serves as a reserve for new sprouts; however, in the development and pigmentation phase of the petals and leaves, rose bushes require larger quantities of potassium (CASARINI and FOLEGATTI, 2006). The nitrogen, potassium, and magnesium available for 'Vegas' rose bushes may not have been sufficient to meet the demands of the plants, which can be noted by the low levels of these nutrients in leaves, regardless the treatment. During the experimental period, no symptoms of nutrient deficiency were observed; however, with the exception of plants that were treated with pigeon pea, the number of rose flowers per plant was below the average of eight flower stems per plant per year (ALMEIDA et al., 2013).

Green manure promotes distinct effects in the soil-plant systems which are related to the species used, the management of the biomass, the planting and cutting season of green manure, the period in which the waste from these fertilizers remains in the soil, the climatic conditions of the site, and the interaction between these factors (ALCÂNTARA et al., 2000). The use of jack bean as green manure favored the quality of flower buds by increasing their fresh matter; however, its application reduced the number of flower stems. Similarly, intercropping with forage peanut was not beneficial for any of the parameters analyzed.

One of the limitations of the use of green manure in commercial crops is the management, whereas intercropping may reduce the loss of income for producers (PERIN et al., 2007). However, the production of roses intercropped with jack bean and forage peanut was lower, possibly because of competition between the intercropped species. Forage peanut aggressively spreads along the rose bush rows, hindering its management, whereas jack bean may compete with the rose plant for water and nutrients.

In a similar manner to that observed in the treatment with jack bean, the rose 'Vegas' bush grown with the surface addition of pigeon pea to the soil also accumulated more fresh matter of flower bud than those grown under other treatments, which is a characteristic that indicates a better quality of rose. This treatment increased the number of flower stems in comparison with the intercropping of roses with jack bean or forage peanut; however, no application of green manure (control) resulted in similar effect to that after the treatment with pigeon pea. Thus, green manure

with pigeon pea applied to soil surface can provide several medium- and long-term benefits to the soil-plant system such as reduced impact of erosion, increased organic matter content, decreased temperature and moisture oscillations on soil surface, and recycling of nutrients (ANDRADE NETO et al., 2008).

4. CONCLUSIONS

Green manure with pigeon pea applied on soil surface every 3 months is equivalent as chemical fertilization in cultivation of 'Vegas' rose bushes under the conditions investigated in this study.

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