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Performance of roquette crop fertilized with cattle and green manure using two planting densities

Desempenho da cultura de rúcula submetida a adubação verde e esterco bovino utilizando duas densidades de plantio

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ABSTRACT

This research was conducted to study the direct fertilization combining 0 and 160 kg N ha^{-1} of cattle manure and green manure as branches of pigeon pea (*Cajanus cajan* L.) and their residual effects on two population densities of roquette (*Eruca sativa* Miller) crop, in Seropédica, Rio de Janeiro, Brazil. Yield, number of leaves plant^{-1}, leaf area index, shoot fresh weight, stems dry matter, roots dry matter, leaves dry matter, total dry matter and plant height were measured. The experiment was a randomized block design set as a factorial 2 x 2 x 2, and three replications: 0 and 160 kg N ha^{-1} of cattle manure, 0 and 160 kg N ha^{-1} of branches of pigeon pea and 500,000 and 1,000,000 plants ha^{-1}. The results indicate that the population density of 500,000 plants ha^{-1} showed, in general, better results in terms of yield per plant. However, 1,000,000 plants ha^{-1} had significantly higher yield per hectare. It was observed that there was no significant difference between the use of cattle manure and branches of pigeon pea on the yield of roquette under directly fertilization and residual effect of fertilization. The replacement of cattle manure by branches of pigeon pea associated with 1,000,000 plants ha^{-1} showed less loss of roquette yield under the residual effect of fertilization.

Keywords: *Eruca sativa*, Pigeon pea, Cattle Manure, Population, Residual Effect.

RESUMO

Investigou-se a adubação orgânica direta combinando esterco bovino, ramas de guandu (*Cajanus cajan* L.) e seu efeito residual na cultura da rúcula (*Eruca sativa* Miller) cultivada em duas densidades populacionais no Município de Seropédica, RJ, sobre produtividade, índice de área foliar, número de folhas planta^{-1}, matéria fresca parte aérea, matéria seca de ramos, raízes e folhas, matéria seca total e altura de planta. O delineamento experimental adotado foi blocos ao acaso em ensaio fatorial 2 x 2 x 2 e três repetições: 0 e 160 kg N ha^{-1} de esterco bovino, 0 e 160 kg N ha^{-1} de ramas de guandu e 500.000 e 1.000.000 plantas ha^{-1}. Os resultados indicam que a densidade populacional de 500.000 plantas ha^{-1} apresentou, em geral, melhores resultados em termos de rendimento por planta. No entanto, 1.000.000 plantas ha^{-1} apresentou produtividade significativamente maior. Observou-se que não houve diferença significativa entre o uso de esterco bovino e ramas de guandu na produtividade de rúcula sob adubação direta e seu efeito residual. Sob efeito residual, a substituição do esterco de gado por ramas de guandu utilizando 1.000.000 plantas ha^{-1} apresentou menor perda de produtividade.

Palavras-chave: *Eruca sativa*, Guandu, Esterco Bovino, População, Efeito Residual.

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Introduction

The culture of roquette (*Eruca sativa* Miller) is gaining space in the marketplace since the late 90`s (SILVA, 2004), being preferably grown by small producers close to consumer centers (GRANJEIRO et al., 2007). According to the Companhia de Entrepostos e Armazéns Gerais do Estado de São Paulo (General Warehouses Society of São Paulo), the marketing of roquette had a 78% growth from 1997 to 2003 (SILVA, 2004).

The growth of commercial quantity of roquette and its recovery in the price are indicators that it is a profitable crop. In general, vegetables are highly demand crops for soluble nitrogen fertilizers and high yields depend on the application of high doses of mineral fertilizers, which are derived from energy-intensive industrial processes (PERIN et al., 2004). Also, few studies are directed to a better understanding of nutritional management of roquette (PURQUERIO et al., 2007). When it comes to organic sources, there are even fewer reported works using residues for the production of high fresh roquette yield, such as the work by Zarate et al. (2006).

Vegetative practices, such as those involving soil cover, are simple, help erosion control and, in most cases, improving the availability of nutrients for subsequent crops (ANDREOLI et al., 2000). According to Oliveira et al. (2006), one can build more efficient fertilization process through cultural practices such as crop rotation and successional green manuring with legumes in order to exploit the residual effect. Thus, the succession of cultures can increase the efficiency of the use of fertilizer, and diversifying the production system as well.

When crop residues are managed for soil fertilization, a cover crop should be of easily established, rapidly growing plant, with a high biomass production, disease resistant, and economically viable (REEVES, 1994). In ecological management systems, maximum soil coverage is used to protect the soil surface, reducing temperature range, allowing the addition of nitrogen through biological nitrogen fixation (NBNF), and organic manure as well (FEIDEN, 2001). Therefore, the inclusion of the NBNF, through green manures that are growing into the system is a desirable practice in agricultural production.

Whereas the culture of roquette is a leaf-harvesting crop, nitrogen becomes very important to yield. In Brazil, there is little information on nutrition and management practices in the cultivation of organic roquette. The objective of this study was to evaluate the effect of cattle manure and branches of pigeon pea as green manure on yield, number of leaves plant-1, leaf area index, shoot fresh weight, stem dry matter, leaves dry matter, root dry matter, total dry matter and plant height under two planting densities.

Methods

In the area of SIPA - Sistema Integrado de Produção Agroecológica (Integrated System of Agroecological Production), technical cooperation project among Embrapa (Empresa Brasileira de Pesquisa Agropecuária) Agrobiology Center and Embrapa Soil Center, Pesagro-Rio (Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro) and Universidade Federal Rural do Rio de Janeiro were developed in 2001, two successive plantings of roquette to assess the effect of direct fertilization and residual effect from the use of cattle manure and branches of pigeon pea (*Cajanus cajan* L.) as source of nitrogen. This work was part of the cooperation project of the Third World countries, an agreement between TWAS (The Academy of Sciences for the Developing World, formally the Third World Academy of Sciences), UNESCO (United Nations Educational, Scientific and Cultural Organization) and CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico).

The region is located at 22°46' South latitude and 43°41' West longitude, at an altitude of 33 m. According to the Köppen climate classification, the climate is AW, characterized by heavy rainfall in summer and a dry winter season. The average annual rainfall is of 1275 mm with average annual temperature of 23.5° C. Soil tillage was carried out with a hoe in an Ultisol of sandy clay loam soil. Chemical analysis of soil in accordance with Claessen (1997), presented the following results: pH (water) 7.3, 4.5 $cmol_c$ dm^{-3} Ca, 1.4 $cmol_c$ dm^{-3} Mg, 165.7 mg kg^{-1} of P, 195.0 mg kg^{-1} K, 0.9 g kg^{-1} total N.

The experimental design was a randomized block design set as a factorial 2 x 2 x 2, with three replications, with 0 and 160 kg manure N ha^{-1} (M_0 and M_{160}), 0 and 160 kg N ha^{-1} branches of pigeon pea (G_0 and G_{160}) and 500,000 and 1,000,000 plants ha^{-1} (P_1 and P_2). Two rows of pigeon pea were planted as alleys around the experimental area. On 07/02/01, the pigeon pea plants were pruned and their remains were placed on the plots of 2 m^2, while the cattle manure was applied to the soil on 26/07/01. Roquette seeds were sown directly in trays with 128 cells and the transplanted directly on the field on 08/03/01, at one and two plants per pit at spacing 0.20 x 0.10 m, given a plant population densities of 500,000 (one plant per hole) and 1,000,000 plants ha^{-1} (two plants per hole), respectively, and were harvested 27 days after transplantation. The second planting of roquette to evaluate the residual effect of fertilization with manure and pigeon pea residues was carried out on the same plots of the first experiment. Seeds of roquette were sown directly on 09/27/01 and samples were taken 34 days after sowing (about ninety days after fertilization with cattle manure and 120 days after green manured with pigeon pea).

The agronomic indexes used were yield, number of leaves $plant^{-1}$, leaf area index (LAI), shoot fresh weight, stems dry matter, roots dry matter, leaves dry matter, total dry matter and plant height from the measurement of central plot, corresponding to 10% of the plot (0.2 m^2). For the measurements, the fresh plant material was divided into stems and leaves (the shoot) and roots. They were then weighed to obtain the fresh weights and then placed in a ventilated oven at a temperature of 65° C for 72h, (until the sample weight became constant). The LAI was calculated from the direct measurement of 16 plants per sub-plot, using a leaf area meter (LI-COR).

Statistical analysis was performed by considering the analysis of variance of the 2x2x2 factorial combinations as following: $P_1M_0G_0$ - 500,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_1M_0G_{160}$ - 500,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea; $P_1M_{160}G_0$ - 500,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_1M_{160}G_{160}$ - 500,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea; $P_2M_0G_0$ - 1,000,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_2M_0G_{160}$ - 1,000,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea ; $P_2M_{160}G_0$ - 1,000,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_2M_{160}G_{160}$ - 1,000,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea. Before the analysis of variance, data were tested for normality and/or homogeneity of the error model. F-test and mean comparison by Tukey test (5%) was performed by SAS program for direct fertilization and SISVAR program for residual effect.

Results and discussion

Table 1 shows the analysis of variance for the effect of direct fertilization using 0 and 160 kg N ha of cattle manure and 0 and 160 kg N ha of branches of pigeon pea on two densities of roquette (500,000 plants ha^{-1} and 1,000,000 plants ha^{-1}). There was interaction between cattle manure, branches of pigeon pea and plant density only for root dry matter. For the effects of two by two factors, there were interactions between plant density with cattle manure and between cattle manure with branches of pigeon pea that showed response to four indexes: number of leaves, root dry matter, leaves dry matter and total dry matter and stem dry matter, leaves dry matter, total dry matter and plant height, respectively, while the effect between plant density and branches of pigeon pea, was effective for stem dry matter, leaves dry matter and plant height.

It was observed that in terms of agronomic indexes (Table 2), the yield was statistically higher in $P_2M_{160}G_0$ compared to $P_1M_0G_0$, being equal in other combinations. The number of leaves plant $^{-1}$, and shoot fresh weight were higher, especially in $P_1M_{160}G_0$ and $P_1M_{160}G_{160}$ than combinations containing P2. In general, the combinations of P_1 to P_2 stood out, like stem dry matter ($P_1M_{160}G_{160}$), leaves dry matter ($P_1M_0G_0$), total dry matter ($P_1M_0G_0$ and $P_1M_0G_{160}$) and plant height ($P_1M_0G_{160}$ and $P_1M_{160}G_{160}$). It was not observed significant difference between the other indexes.

Thus, the combinations with P_1 presented, in general, better results in terms of yield per plant than P_2. The yield of $P_2M_{160}G_0$ stands out quantitatively to the others combinations, but it was significantly higher only in the more restrictive combination, i.e., received no fertilization ($P_1M_0G_0$). The combination of M_{160} with P_1 significantly increased the number of leaves plant $^{-1}$ and shoot fresh weight, while that was not significantly affected by green manure on the performance of roquette, regardless of plant density (Table 2).

The results indicate that the combination of factors (cattle manure, pigeon pea and plant density) showed differential response to

Table 1. Mean square values of the effect of cattle and green manures on yield, number of leaves plant^{-1} (NL), leaf area index (LAI), shoot fresh weight (SFW), stems dry matter (SDM), roots dry matter (RDM), leaves dry matter (LDM), total dry matter (TDM) and plant height (PH) of *Eruca sativa* under two population densities.

Source of variation	DF	Yield	NL	LAI	SFW	SDM	RDM	LDM	TDM	PH
Rep	2	0.63^{NS}	28.07^{*}	0.11^{NS}	126.36^{*}	0.05^{*}	0.06^{NS}	0.04^{NS}	0.07^{NS}	1.80^{NS}
P	1	1.10^{*}	481.51^{*}	1.13^{NS}	3453.60^{*}	0.39^{*}	0.85^{*}	11.87^{*}	22.78^{*}	0.51^{NS}
M	1	3.21^{*}	47.04^{*}	2.59^{*}	619.86^{*}	0.01^{NS}	0.01^{NS}	0.01^{NS}	0.04^{NS}	12.76^{*}
G	1	0.07^{NS}	0.40^{NS}	0.64^{NS}	30.90^{NS}	0.01^{NS}	0.03^{NS}	0.16^{NS}	0.00^{NS}	37.75^{*}
P x M	1	0.16^{NS}	29.48^{*}	0.00^{NS}	8.87^{NS}	0.00^{NS}	0.11^{*}	0.69^{*}	1.90^{*}	0.94^{NS}
P x G	1	0.09^{NS}	0.09^{NS}	0.00^{NS}	33.54^{NS}	0.01^{*}	0.18^{*}	0.01^{NS}	0.01^{NS}	3.45^{*}
M x G	1	0.12^{NS}	1.31^{NS}	0.51^{NS}	26.17^{NS}	0.02^{*}	0.06^{NS}	0.33^{*}	0.52^{*}	3.30^{*}
P x M x G	1	0.00^{NS}	0.60^{NS}	0.22^{NS}	1.37^{NS}	0.00^{NS}	0.11^{*}	0.01^{NS}	0.00^{NS}	0.57^{NS}
Error	14	0.22	0.34	0.34	29.44	0.01	0.12	0.21	0.59	54.09

* = Significant at P = 0.05

DF = Degrees of freedom

NS = Not significant at P= 0.05

P = Plant population density

M = Cattle manure

G = Green manure (*C. cajan*)

Table 2. Effect of cattle manure 0 and 160 kg N ha^{-1} (M_0 e M_{160}) and green manure e 0 e 160 kg N ha^{-1} of pigeon pea prunnings (G_0 e G_{160}), under two population densities (P_1 and P_2) on yield, number of leaves $plant^{-1}$ (NL), leaf area index (LAI), shoot fresh weight (SFW), stems dry matter (SDM), roots dry matter (RDM), leaves dry matter (LDM), total dry matter (TDM) and plant height (PH) in Seropédica, Rio de Janeiro, Brazil.

Treat	Yield	NL	LAI	SFW	SDM	RDM	LDM	TDM	PH
	t ha^{-1}		cm^2			g $plant^{-1}$			cm
$P_1M_0G_0$	23.628b	17.433ab	2.747a	56.847ab	0.446ab	1.240a	3.361a	5.045a	20.333b
$P_1M_0G_{160}$	27.228ab	17.033abc	3.193a	63.870ab	0.456ab	1.026a	3.262ab	4.744a	24.033a
$P_1M_{160}G_0$	30.602ab	21.667a	3.530a	74.997a	0.394ab	1.178a	2.701abc	4.271abc	22.100ab
$P_1M_{160}G_{160}$	31.635ab	22.833a	3.780a	69.747a	0.519a	0.891a	3.147ab	4.555ab	29.933a
$P_2M_0G_0$	27.332ab	10.500d	3.037a	31.283c	0.225ab	0.686a	1.587c	2.498bc	20.367b
$P_2M_0G_{160}$	28.838ab	10.483d	3.827a	33.167c	0.172b	0.551a	1.544c	2.267c	23.167ab
$P_2M_{160}G_0$	37.882a	10.933cd	4.150a	43.897bc	0.203ab	0.627a	2.018abc	2.848abc	23.000ab
$P_2M_{160}G_{160}$	31.18ab	11.217bcd	3.970a	43.915bc	0.219ab	0.960a	2.027bc	3.206abc	23.700ab

$P_1M_0G_0$ - 500,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_1M_0G_{160}$ - 500,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea; $P_1M_{160}G_0$ - 500,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_1M_{160}G_{160}$ - 500,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea; $P_2M_0G_0$ - 1,000,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_2M_0G_{160}$ - 1,000,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea ; $P_2M_{160}G_0$ - 1,000,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_2M_{160}G_{160}$ - 1,000,000 plants ha^{-1}, 160 kg N ha^{-1} cattle manure, 160 kg N ha^{-1} of branches of pigeon pea

agronomic indexes studied when under direct fertilization. For the farmers, the main concern is for crop yield, and in this respect, yields were the same between the combinations, except for $P_2M_{160}G_0$ and $P_1M_0G_0$, where the first was superior to the second.

Table 3 shows the analysis of variance for the residual effect in roquette. Unlike the direct fertilization, there was no interaction between the combinations of factors cattle manure, pigeon pea and plant density. The significance was only observed for yield, stem dry matter, root dry matter, leaves dry matter and total dry matter using plant density as isolated factor, as well as, for the factor cattle manure with plant height.

Table 4 shows, in general, no difference

Table 3. Mean square values of residual effects of cattle and green manures on yield, number of leaves plant^{-1} (NL), leaf area index (LAI), shoot fresh weight (SFW), stems dry matter (SDM), roots dry matter (RDM), leaves dry matter (LDM), total dry matter (TDM) and plant height (PH) of *Eruca sativa* under two population densities.

Source of variation	DF	Yield	NL	LAI	SFW	SDW	RDW	LDW	TDM	PH
Rep	2	0.25^{NS}	1.21^{NS}	0.57^{NS}	0.13^{NS}	0.26^{NS}	0.56^{NS}	0.09^{NS}	0.03^{NS}	6.15^{*}
P	1	19.49^{**}	4.32^{NS}	0.36^{NS}	0.50^{NS}	31.82^{**}	130.87^{**}	4.76^{*}	13.57^{**}	1.43^{NS}
M	1	0.09^{NS}	0.68^{NS}	0.20^{NS}	0.01^{NS}	0.72^{NS}	1.16^{NS}	0.01^{NS}	0.11^{NS}	6.62^{*}
G	1	3.93^{NS}	2.15^{NS}	4.38^{NS}	4.07^{NS}	0.73^{NS}	0.58^{NS}	2.68^{NS}	2.24^{NS}	0.15^{NS}
P x M	1	0.79^{NS}	1.67^{NS}	0.68^{NS}	0.73^{NS}	0.71^{NS}	0.99^{NS}	0.58^{NS}	0.70^{NS}	0.19^{NS}
P x G	1	1.34^{NS}	0.58^{NS}	0.16^{NS}	0.49^{NS}	0.12^{NS}	0.41^{NS}	0.03^{NS}	0.03^{NS}	0.03^{NS}
M x G	1	1.29^{NS}	1.65^{NS}	2.05^{NS}	1.64^{NS}	0.00^{NS}	0.00^{NS}	1.09^{NS}	0.63^{NS}	1.53^{NS}
P x M x G	1	0.09^{NS}	0.00^{NS}	0.02^{NS}	0.00^{NS}	0.87^{NS}	1.14^{NS}	0.24^{NS}	0.01^{NS}	0.63^{NS}
Error	14	0.25	1.21	0.57	0.13	0.26	0.56	0.09	0.03	6.15

* = Significant at P = 0.05

DF = Degrees of freedom

NS = Not significant at P= 0.05

P = Plant population density

M = Cattle manure

G = Green manure (*C. cajan*)

between the combinations for all indexes used, except root dry matter, when the combinations P_1 were higher to P_2 and stem dry matter, where $P_1M_0G_0$ $P_1M_0G_{160}$ were statistically superior to $P_2M_0G_0$. Once again, special attention should be given to yield. Even thought without significant difference, the results show that, quantitatively, the combinations of $P_2M_0G_{160}$ and $P_2M_{160}G_{160}$ gave higher values than other combinations. In this case, the correct management of green manure may have contributed to this result possibly due to slower release of N from the deposition of branches of pigeon pea into the soil.

About the interactions between plant density and two sources of nitrogen (cattle manure and branches of pigeon pea), it was observed that only in the direct fertilization it occurred interaction between the factors used as agronomic indexes, while for the residual effect did not occurred (Tables 1 and 3). When it was used direct fertilization, plant density affected yield, number of leaves plant^{-1}, shoot fresh weight, stem dry matter, root dry matter, leaves dry matter and total dry matter; the factor cattle manure was significant for yield, number of leaves plant^{-1}, LAI, shoot fresh weight and plant height, while the branches of pigeon pea factor was significant only for plant height (Table 1). While for residual effects, generally, the differences were small, except for planting density factor which was significant for yield, stem dry matter, root dry matter, leaves dry matter and total dry matter (Table 3).

The results show that there were no significant differences on the yield of roquette when it was

Table 4. Residual effect of cattle manure (E1 e E2) e 0 e 160 kg N ha^{-1} of pigeon pea prunnings (G1 e G2), respectively, yield, number of leaves plant^{-1} (NL), leaf area index (LAI), shoot fresh weight (SFW), stems dry matter (SDM), roots dry matter (RDM), leaves dry matter (LDM), total dry matter (TDM) and plant height (PH) in Seropédica, Rio de Janeiro, Brazil.

Treat	Yield	NL	LAI	SFW	SDM	RDM	LDM	TDM	PH
	t ha^{-1}		cm^2			g plant^{-1}			cm
$P_1M_0G_0$	8.561 a	10.666 a	2.738 a	19.290 a	1.622 a	0.807 a	2.411 a	4.840 a	20.056 a
$P_1M_0G_{160}$	11.605 a	12.839 a	3.720 a	25.967 a	1.585 a	0.814 a	3.240 a	5.640 a	20.247 a
$P_1M_{160}G_0$	9.014 a	10.155 a	2.743 a	20.215 a	1.407 ab	0.733 a	2.602 a	4.743 a	22.325 a
$P_1M_{160}G_{160}$	9.005 a	10.733 a	2.875 a	20.242 a	1.527 ab	0.791 a	2.581 a	4.899 a	21.743 a
$P_2M_0G_0$	12.358 a	9.060 a	2.092 a	13.582 a	0.993 b	0.506 b	1.686 a	3.185 a	20.178 a
$P_2M_0G_{160}$	20.770 a	10.283 a	3.429 a	23.720 a	1.163 ab	0.534 b	2.339 a	4.036 a	21.473 a
$P_2M_{160}G_0$	17.181 a	10.133 a	2.733 a	18.749 a	1.065 ab	0.529 b	2.024 a	3.619 a	24.600 a
$P_2M_{160}G_{160}$	20.308 a	9.783 a	3.034 a	22.473 a	1.090 ab	0.507 b	2.372 a	3.969 a	22.328 a

$P_1M_0G_0$ - 500,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_1M_0G_{160}$ - 500,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea; $P_1M_{160}G_0$ - 500,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_1M_{160}G_{160}$ - 500,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea; $P_2M_0G_0$ - 1,000,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_2M_0G_{160}$ - 1,000,000 plants ha^{-1}, 0 kg N ha^{-1} of cattle manure, 160 kg N ha^{-1} of branches of pigeon pea ; $P_2M_{160}G_0$ - 1,000,000 plants ha^{-1}, 160 kg N ha^{-1} of cattle manure, 0 kg N ha^{-1} of branches of pigeon pea; $P_2M_{160}G_{160}$ - 1,000,000 plants ha^{-1}, 160 kg N ha^{-1} cattle manure, 160 kg N ha^{-1} of branches of pigeon pea.

used the combinations of cattle manure and branches of pigeon pea as a nitrogen source (Tables 2 and 4). However, the use of combination $P_2M_{160}G_0$ was significantly higher than the $P_1M_0G_0$. Marin et al. (2007), evaluating the effect of fertilization with cattle manure and Gliricidia sepium pruning on maize yield, observed that despite the yield of maize did not differ between plots fertilized with manure or Gliricidia, these two organic significantly increased yield when compared to control, similar result were observed in this work.

The use of different plant density can be adopted according to the interest of the producer, because plants with larger leaves and shoots fresh weight were observed using P_1, occurring the same behavior, in general, to stem dry matter, leaves dry matter and total dry matter. However, according to the results achieved in this work the adoption of P_2 is quantitatively advantageous with the use of residual fertilizer, especially from the branches of pigeon pea. This perhaps reflects the slower release of nutrients resulting from decomposition of branches of pigeon pea, as well as, the replacement of cattle manure for branches of pigeon pea associated with P_2 showed less loss of yield under there sidual effect of fertilization (Table 4).

It was consistent that the standard commercial roquette was affect by fertilization, since the treatments without fertilization showed higher dry matter, indicating that the reduction of water content in the plant was related to the absence of fertilization (Tables 2 and 3). The residual effect of direct fertilization has diminished over time, when the index to show differences between treatments were root dry matter and stem dry matter. However, when one plant was used per pit, yield was lower and the use of P_2 offset the lower weight of individual plants as compared to plots with treatments P_1. Special attention should be given in Table 3, when the root dry matter were significantly higher in P_1, which can be explained by intra-specific competition where plants invested in bigger roots to absorb more nutrients, but without this effort been reflected in higher yield.

Thus, it was possible to conclude that the intra-specific competition using P_2 caused a reduction of shoot fresh weight, leaves dry matter and stem dry matter and number of leaves plant^{-1}. Furthermore, P_2 offset the lower weight of individual plants as compared to combinations with P_1. Contrary to the indexes number of leaves plant^{-1}, stem dry matter, leaves dry matter and total dry matter, LAI was quantitatively greater under direct fertilization using P_2 (Table 2), which did not occur with the residual effect of fertilization (Table 4).

The benefits of branches of pigeon pea as green manure are supported by Oliveira et al. (2006), investigating the growth and yield of yam (taro) observed that branches of pigeon pea contributed to the improvement of soil fertility by the input of 6.58 t ha^{-1} dry biomass and 159 kg ha^{-1} N and further allowed the cycling of P, K, Ca and Mg, in the order of 20.0, 136.0, 64.0 and 16.0 kg ha-1 respectively.

This behavior reveals that even without significant differences between them, the replacement of cattle manure by branches of pigeon pea as a source of nitrogen for growing roquette can be an alternative for the producer. The results obtained in this study are similar to those obtained by Perin et al. (2004), which evaluated the residual effect of the cultivation of sunnhemp (Crotalaria) and millet on the production of broccoli, in succession to corn, found no residual effect of green manure on dry matter production of broccoli.

The results about the comparison between cattle manure and branches of pigeon pea reinforce the hypothesis that fertilization with remains of pruning woody green manure can be an alternative for small producers with a view to replacing animal manure, that are often expensive. We must consider that the supply of manure is a problem for producers, because, according to Fernandes et al. (2007), the low concentration of nutrients in organic fertilizers, resulting in the necessity of using large quantities to meet crop needs, plus the cost of distribution of manure to crops due to the higher volume to be applied per unit of area and the lack agricultural equipment suited to this type of fertilization (MARTINS et al., 2002).

It is vital therefore to optimize available resources and protect the soil with successive crops with the use of material of slow decomposition, since it is not recommended the use of organic materials for rapid degradation in tropical regions, where it is most important to reduce the rate of decomposition of organic matter (KHATOUNIAN, 1994). Therefore, the results of this study demonstrate the technical feasibility of producing roquette using two plants per pit as a strategy to be adopted by farmers to increase crop productivity, whether using manure, whether using branches of pigeon pea as a source of nitrogen.

Conclusion

1. There was no significant difference between the use of cattle manure and branches of pigeon pea on the yield of roquette under directly fertilization and residual effect of fertilization.

2. The replacement of cattle manure by branches of pigeon pea associated with P2 showed less loss of yield under the residual effect of fertilization.

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