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Green manure with fabaceous species in monoculture or intercropped with corn in the organic cultivation of pumpkin in succession

Jhonatan M Goulart [1]; José Antonio A Espindola [2]; José Guilherme M Guerra [2]; Janaína RC Rouws [2]; Selenobaldo AC de Sant'Anna [3]; Ednaldo da S Araújo [2]

[1]Universidade Federal Rural do Rio de Janeiro (UFRRJ), Seropédica-RJ, Brasil; marinsgoulart@ymail.com; [2]Embrapa Agrobiologia, Seropédica-RJ, Brasil; jose.espindola@embrapa.br; guilherme.guerra@embrapa.br; janaina.rouws@embrapa.br; ednaldo.araujo@embrapa.br; [3]Centro Universitário Cesmac, Maceió-AL, Brasil; selenobaldo.santanna@cesmac.edu.br

ABSTRACT

The aim of this study was to evaluate, in three consecutive cycles, the phytotechnical performance of herbaceous fabaceous plants cultivated in monocropping or intercropped with corn and the pumpkin productivity in succession. The statistical design was of randomized blocks in a factorial arrangement 2 (monocropping or intercropping) x 3 (fabaceous species) + 1 (corn monocropping). The treatments consisted of gray velvet bean monocropping; gray velvet bean intercropped with corn; sunn hemp monocropping; sunn hemp intercropped with corn; jack bean monocropping; jack bean intercropped with corn and corn monocropping. After cutting the fabaceous and corn, Itapuã 301 pumpkin cultivar was planted. The authors verified that fabaceous monocropping reached higher dry biomass productivities, especially sunn hemp in the first and second years and provided greater accumulation of N, P and K. In the first year, fabaceous pre-cropping, regardless of the arrangement, provided an increase in pumpkin productivity up to 165.87% higher comparing with corn pre-cropping, whereas in the second and third years, no pumpkin production associated with corn monocropping was observed. The three Fabaceae species showed potential to be used as green manure in pumpkin growing when compared with corn pre-cropping.

Keywords: *Cucurbita moschata*, *Crotalaria juncea*, *Canavalia ensiformis*, *Mucuna pruriens*, *Zea mays*.

RESUMO

Adubação verde com espécies de fabáceas em monocultivo ou consorciadas ao milho no cultivo orgânico de abóbora

Objetivou-se avaliar em três ciclos consecutivos o desempenho fitotécnico de fabáceas herbáceas cultivadas em monocultivo ou consorciadas ao milho e a produtividade de abóbora em sucessão. O delineamento estatístico foi em blocos casualizados em arranjo fatorial 2 (monocultivo ou consórcio) x 3 (espécies fabáceas) + 1 (monocultivo de milho). Os tratamentos consistiram em mucuna cinza em monocultivo; mucuna cinza consorciada ao milho; crotalária juncea em monocultivo; crotalária juncea consorciada ao milho; feijão-de-porco em monocultivo; feijão-de-porco consorciado ao milho; e milho em monocultivo. Após o corte das fabáceas e do milho, realizou-se o plantio de abóbora Itapuã 301. Constatou-se que os monocultivos das fabáceas alcançaram as maiores produtividades de biomassa seca, com destaque para a crotalária no primeiro e segundo ano e proporcionaram os maiores acúmulos de N, P e K. No primeiro ano, os pré-cultivos das fabáceas, independentemente do arranjo, proporcionaram um aumento de produtividade de abóbora superior em até 165,87% em relação ao pré-cultivo de milho, ao passo que, no segundo e terceiro anos não ocorreu a produção de abóbora associada ao monocultivo de milho. As três espécies de fabáceas apresentam potencial como adubo verde no cultivo de abóbora, quando comparadas com o pré-cultivo com milho.

Palavras-chave: *Cucurbita moschata*, *Crotalaria juncea*, *Canavalia ensiformis*, *Mucuna pruriens*, *Zea mays*.

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Green manure is a management technique that contributes to soil fertility improvement. The species used in this technique present peculiar characteristics to guarantee the benefits generated after the cutting management. These characteristics are associated with a high biomass production, voluminous root system which favors the recycling of nutrients from deep soil layers and the fixation of atmospheric nitrogen (Pereira *et al*., 2012), through mutualistic association between the fabaceous root system and N-fixing bacteria.

Green manures contribute to increasing soil organic matter content (Cardoso *et al*., 2014), minimizing the effects of compaction caused by the intensive use of agricultural machinery (Valicheski *et al*., 2012), helping soil protection, reducing losses through processes such as leaching and transport of particles by erosion (Teodoro *et al*., 2011). For pre-cropping crops, this manure can contribute to increasing productivities of crops grown in succession (Oliveira *et al*., 2015; Batista *et al*., 2016; Cordeiro *et al*., 2018; Goulart *et al*., 2021). In vegetable cultivation, green manure can be used in different ways, such as rotation, intercropping, inter-stripping and mulching (Guerra *et al*., 2014).

Considering the organic systems, the use of Fabaceae as green manures is of great importance for nitrogen introduction in the system, since the fertilizer sources allowed for this macronutrient is limited and, when available, are of high market value. Espindola *et al*. (2005) reported that biological nitrogen fixation carried out by fabaceae contributes significantly to supplying this nutrient, which can result in N self-sufficiency in agroecosystems.

Intercropping with crops of economic interest is a good way to optimize fabaceae cultivation, mainly in family-labor managed areas. In this case, corn, which is a crop with erect growth habit combined with high dry biomass production, is a frequently used intercropping species. Moreover, this crop produces green cobs and grains.

Even with all the positive aspects reported concerning the use of green manures, still few studies describing the benefits of this technique in successive crops with vegetables in different agricultural years can be found in literature. This occurs mainly in the organic pumpkin growing, which is a vegetable crop widely cultivated in Brazil at different technological levels and with high market demand. Considering the above, we believe that the remaining biomass of the green manure contributes to increasing pumpkin productivity. In this context, this study aimed to evaluate the phytotechnical performance of herbaceous Fabaceae grown in monocropping and intercropped with corn and pumpkin productivity under organic system in three consecutive cycles.

MATERIAL AND METHODS

The experiment was carried out at Fazendinha Agroecológica km 47, located in the municipality of Seropédica, Metropolitan Region in Rio de Janeiro (22°46'S, 43°41'W, 33 m altitude), for three consecutive years (2015, 2016 and 2017). The experimental design used was randomized blocks, with three replicates, in a factorial scheme 3 (Fabaceae species) x 2 (monocropping or intercropping) + 1 (corn monocropping). The treatments consisted of gray velvet bean (*Mucuna pruriens*) monocropping; gray velvet bean intercropped with corn; monocropping sunn hemp (*Crotalaria juncea*); sunn hemp intercropped with corn; jack beans (*Canavalia ensiformis*) monocropping; jack beans intercropped with corn and corn BRS Eldorado monocropping.

The experimental plots consisted of 16 m^2 area (4 x 4 m). The soil was classified as Red Yellow Latosol (Santos *et al*., 2018a); the chemical properties in 0 to 20 cm layer (before the experiment installment) were: pH = 6.2; Ca = 3.3 $cmol_c/dm^3$; Mg = 1.4 $cmolc/dm^3$; Al = 0.0 $cmolc/dm^3$; available P = 18.6 mg/dm^3; K = 53.7 mg/dm^3, analyzed using the methodology proposed by Nogueira & Souza (2005). Green fertilizers (Fabaceae and corn) were manually sown simultaneously in December in the three agricultural years, except the velvet bean intercropped with corn which was sown 35 days after sowing the other treatments. This procedure was adopted in order to reduce the effect of competition between the velvet bean and corn. The values of average temperatures and rainfall in the three agricultural years are described in Figure 1.

In the first agricultural year, the soil was plowed followed by one harrowing. Then, furrows were opened, spaced 0.5 m for Fabaceae monocropping and 1.0 m for corn. In the second and third years, the species were sown after furrow openings in the respective experimental plots. When intercropped, Fabaceae was sown between rows of

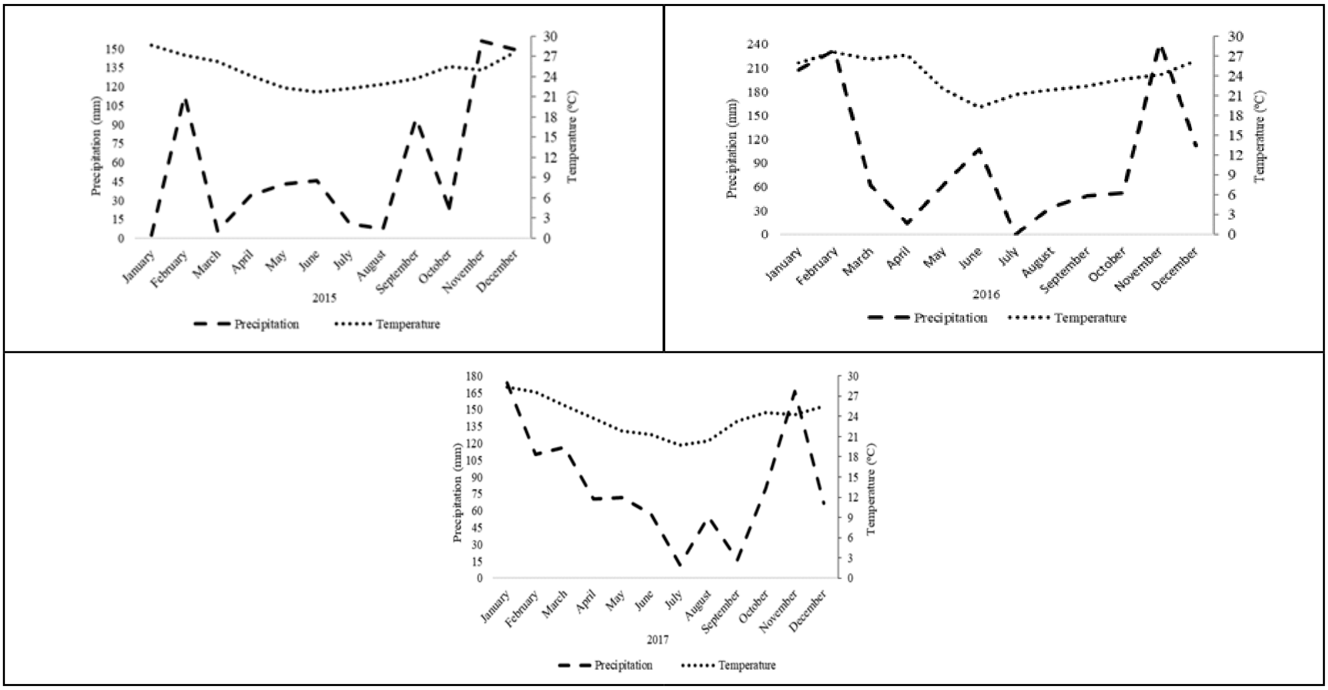

Figure 1. Average temperatures and rainfall during the experiments. Seropédica, 2015, 2016 and 2017. Seropédica, Fazendinha Agroecológica km 47, 2015-2017.

the corn crop, totalizing a population corresponding to half the number of plants in monocropping system. Fabaceae seeds were sown at densities of eight, thirty and six seeds/linear meter for velvet bean, sunn hemp and jack bean, respectively. Corn was sown at density of ten plants per linear meter; afterwards, thinning was performed for five plants, obtaining a final stand corresponding to 50,000 plants/ha. Planting fertilization for pre-croppings consisted of 80 kg/ha P_2O_5, using thermophosphate and 60 kg/ha K_2O, using potassium sulfate.

Topdressing fertilization was only performed for corn, using 100 kg/ha of N, according to recommended by Freire *et al*. (2013), using castor bean cake, split in two applications: 50 kg/ha of N at 15 days and 50 kg/ha of N, 30 days after sowing.

120 days after sowing, when Fabacea species started flowering, samples were collected in a 2 m^2 area per plot (intercropping and monocropping) to determine the fresh biomass. Then, a 300 g (approximately) subsample was collected and taken to a forced ventilation oven at 65°C to quantify the dry biomass. Afterwards, these samples were ground and taken to the laboratory to evaluate the nutrient contents. We evaluated N in biomass according to Kjedahl method, P through colorimetric method, K through flame photometry, Ca and Mg by atomic absorption method, according to the procedures described by Nogueira & Souza (2005). After removing the samples, the pre-croppings were cut using a crusher 160 coupled to the tractor, keeping the biomass on the soil surface.

Seven days after cutting the pre-croppings, we opened the pits, spaced 1.3 m between lines and 1.0 m between pits in the lines, totalizing twelve pits per plot to sow pumpkin (*Cucurbita moschata*) Itapuã 301 (Jacarezinho type), which is a globular and flatten-shaped cultivar, showing earliness and fruits weighing 1.3 kg average. The pits were fertilized seven days before sowing corresponding to 80 kg/ha of P_2O_5, using thermophosphate and 60 kg/ha of K_2O from potassium sulfate. Nitrogen fertilization was not carried out for the pumpkin crop due to N supplied by the biomass of green manures remained in soil. Pumpkin was grown sowing three seeds per pit, being later thinned to one plant. The plants were harvested gradually during three weeks, according to maturation. In average, this period corresponded to approximately 90 days after sowing, when the green fruits turned to orange, and the peduncle got dry.

Cultural practices were carried out during the experiment: weeding between lines, pruning of the sunn hemp intercropped with corn at 35 days after sowing, in order to interrupt the growth of fabaceae, with subsequent regrowth, allowing corn to grow without light competition. We highlight that the management was carried out with the aid of pruning shears, at 50 cm high from the soil, being the pruned material returned to the soil surface of the experimental area. At the same time, samples were collected in an area equivalent to 2 m^2 per plot, in order to evaluate the productivity of sunn hemp biomass obtained after cutting and summed to the total productivity at the end of the cycle. Moreover, the authors used the biological insecticide *Bacillus thuringiensis* to control fall armyworm (*Spodoptera frugiperda*) in corn crop, fruit borer (*Diaphania nitidalis*) and cucurbit borer (*Diaphania hyalinata)*, both found in pumpkin crop, whenever these insects were detected in the experimental area.

The basic assumptions were verified prior to performing the analysis of variance (ANOVA). When significant differences between the factors, evaluated by F test of ANOVA, were noticed, the averages were compared between the management levels using F test and between Fabaceae levels by Scott-Knott test, at 5% probability of significance. The data were evaluated with the aid of the R program (R Core Team, 2021).

RESULTS AND DISCUSSION

The interaction between management

Table 1. Average production of the shoot dry biomass of fabaceous plants and corn (t/ha) in relation to monocropping and intercropping, in three consecutive years. Seropédica, Fazendinha Agroecológica km 47, 2015-2017.

Management	Fabaceous plant's shoot dry biomass		
	1st year	2nd year	3rd year
Monocropping	11.037 A	6.106 A	10.796 A
Intercropping	5.279 B	4.182 B	3.160 B
Fabaceous			
Sunn hemp	11.908 A	9.071 A	8.092 A
Jack bean	6.828 B	3.428 B	8.114 A
Gray velvet bean	5.737 B	2.934 B	4.727 B
Interaction M x F	0.6031	0.2112	0.8801
CV (%)	18.75	18.20	27.00
	Corn plant's dry biomass		
Monocropping	4.922 A	2.810 A	3.272 A
C. Sunn hemp	4.523 A	2.443 A	2.391 A
C. Jack bean	5.359 A	2.714 A	2.807 A
C. Gray velvet bean	3.680 A	2.475 A	1.863 A
CV (%)	42.19	19.35	30.70

C = intercropping. Averages followed by same letters in the same column do not differ from each other by F test. Analysis of variance, for management and Scott-Knott test for fabaceous plants, at 5% probability.

(monocropping and intercropping) and fabaceous was not significant (p>0.05) for dry biomass production of fabaceous plants (Table 1). However, regardless of the year of evaluation, fabaceous monocroppings showed average dry biomass productivites superior to their corresponding intercroppings. The reduction of the dry biomass productivity of fabaceous plants in intercroppings can be associated with light competition exercised by corn and lower plant density.

For the dry biomass production of fabaceous, the authors observed that sunn hemp obtained the highest averages of production, differing significantly from the other species in the first and second cultivation years. In the third year, the highest biomass productivities were obtained with jack beans and sunn hemp, showing similar performance among each other. We highlight that, in the beginning of the third year, we noticed the presence of white mold (*Sclerotinia sclerotiorum*) and *Fusarium spp.* associated with sunn hemp under monocropping and intercropped with corn. This might have happened due to successive cultivation of this vegetable in the same area that might become a limiting factor for growing this species under systems which do not use crop rotation. This fact may have contributed to decreasing productivity comparing with previous cultivations.

The high biomass production showed by sunn hemp under the conditions in this study is due to the fact that

Table 2. Average nutrient contents (g/kg) in shoot biomass of fabaceous plants in relation to monocropping or intercropping with corn, in three consecutive years. Seropédica, Fazendinha Agroecológica km 47, 2015-2017.

Management	Fabaceous plant's nutrient contents				
	1st year				
	N	P	K	Ca	Mg
Monocropping	28.4 A	2.44 A	14.97A	9.63 A	3.01 A
Intercropping	28.5 A	2.24 A	14.71A	10.06 A	2.72 A
Fabaceous					
Sunn hemp	19.4 C	2.00 A	12.29 B	7.20 B	3.23 A
Jack bean	30.5 B	2.42 A	16.97 A	16.13 A	3.28 A
Gray velvet bean	37.0 A	2.59 A	15.26 A	6.21 B	2.08 B
Interaction M x F	0.1982	0.6022	0.5642	0.8211	0.5711
CV (%)	13.00	25.30	15.20	36.00	23.80
	2nd year				
Monocropping	31.8A	2.21A	14.85A	15.19B	4.53 A
Intercropping	33.9A	2.46A	16.20A	17.74A	4.16 A
Fabaceous					
Sunn hemp	23.1 B	2.09 B	16.04 A	7.42 B	4.26 B
Jack bean	35.2 A	2.06 B	15.31 A	32.50 A	5.70 A
Gray velvet bean	40.2 A	2.86 A	15.22 A	9.52 B	3.07 B
Interaction M x F	0.4144	0.6565	0.5174	0.1690	0.2917
CV (%)	13.90	13.30	15.90	13.10	22.90
	3rd year				
Monocropping	33.0 A	2.19 A	13.63 A	10.31 A	4.25 A
Intercropping	30.4 A	2.28 A	10.97 A	10.11 A	2.66 B
Fabaceous					
Sunn hemp	24.0 C	1.89 B	12.50 A	7.82 B	3.34 A
Jack bean	31.2 B	2.02 B	12.32 A	15.01 A	4.49 A
Gray velvet bean	39.8 A	2.81 A	12.09 A	7.79 B	2.53 A
Interaction M x F	0.5497	0.1326	0.0589	0.0557	0.0947
CV (%)	9.60	15.05	24.70	21.05	33.00

Averages followed by same letters in the same column do not differ from each other by F test, analysis of variance, for management and Scott-Knott test for fabaceous plants, at 5% probability.

cultivation was during spring-summer, seasons when this species shows higher vegetative development associated with long photoperiod (Leal *et al*., 2012), high temperatures and high rainfall frequency. Under similar climatic conditions, Goulart *et al*. (2021) verified for sunn hemp, in spring-summer, dry biomass productivities up to 15.84 t/ha. Moreira *et al*. (2016) reported the same for jack beans dry biomass productivities of 14.37 t/ha and Cordeiro *et al*. (2018) reported 8.4 t/ha for velvet beans. Such biomass input shows fabaceous cultivation potential, being an appropriate management technique to supply biomass in production of agricultural systems.

The corn dry biomass productions were similar in the three cultivation years (Table 1), regardless of management and intercroppings studied. This fact shows that insertion of vegetables in the corn growing system does not result in a decrease of corn dry biomass and allows to supply biomass to both species.

Concerning the nutrient contents in shoot biomass of green manures, the authors did not observe significant interactive effects either ($p>0.05$), between management and fabaceous (Table 2). In the first cultivation year, the averages of the nutrient contents were similar between monocroppings and intercroppings; in the second and third years, higher Ca contents were observed in intercroppings and magnesium contents in monocropping, respectively, though.

Sunn hemp showed lower N contents in shoot biomass in the three years of evaluation. On the other hand, velvet beans showed higher N contents in the first and third cultivation years; in the second year the average of this content was as high as in jack beans. Lower N contents of sunn hemp can be associated with higher stem production reflecting directly in an increase in C/N ratio in this species when compared with jack beans and velvet beans. Rodrigues *et al*. (2012) also reported lower N contents in dry biomass of sunn hemp when compared with jack beans, black velvet beans and pigeon pea beans. In relation to P, the average contents were similar ($p>0.05$) for monocroppings and intercroppings, regardless the cultivaton year. Velvet beans showed higher P average contents, differing in relation to the other two leguminous only in the first and third cultivation years.

For Ca, in the second year, the authors observed higher contents in intercroppings when compared with monocroppings, considering that jack beans showed the highest contents of this nutrient in the three consecutive years, showing the Ca cycling potential when compared with sunn hemp and velvet beans. Pereira *et al*. (2017) reported that jack beans showed higher Ca contents comparing with other green manures, corroborating the results found in this study.

Interaction between management and fabaceous concerning nutrient accumulation was not significant either

Table 3. Accumulation of N, P and K in shoot biomass (kg/ha) of fabaceous plants in relation to monocropping and intercropping with corn, in three consecutive years. Seropédica, Fazendinha Agroecológica km 47, 2015-2017.

Management	Nutrients accumulation in biomass of fabaceous plants		
	1st year		
	N	P	K
Monocropping	307.93 A	26.53 A	162.18 A
Intercropping	127.60 B	10.61 B	71.40 B
Fabaceous			
Sunn hemp	229.20 A	24.15 A	148.37 A
Jack bean	214.18 A	16.69 A	116.15 B
Gray velvet bean	209.92 A	14.71 A	85.85 B
Interaction M x F	0.0966	0.9541	0.7761
CV (%)	25.70	39.70	24.36
	2nd year		
Monocropping	175.55 A	13.01 A	93.61 A
Intercropping	120.39 B	9.64 B	66.66 B
Fabaceous			
Sunn hemp	210.68 A	18.89 A	145.70 A
Jack bean	118.83 B	6.80 B	49.62 B
Gray velvet bean	114.90 B	8.29 B	45.09 B
Interaction M x F	0.1339	0.1312	0.1247
CV (%)	18.35	14.65	21.07
	3rd year		
Monocropping	348.96 A	23.39 A	149.07 A
Intercropping	86.12 B	6.37 B	35.77 B
Fabaceous			
Sunn hemp	201.46 A	16.07 A	113.16 A
Jack bean	256.41 A	26.02 A	97.35 A
Gray velvet bean	194.76 A	12.55 A	66.76 A
Interaction M x F	0.1972	0.2931	0.1718
CV (%)	28.35	30.80	35.60

Averages followed by same letters in the same column do not differ from each other by F test, analysis of variance, for management and Scott-Knott test for fabaceous plants, at 5% probability.

(p>0.05) for N, P and K (Table 3). We highlight that fabaceous monocropping showed higher accumulation of these macronutrients, in general average, when compared with corresponding intercroppings in the three cultivation years. Higher amounts of nutrient accumulation in monocroppings, to the detriment of intercroppings, can be associated with higher shoot biomass production in single-species cultivation. In relation to fabaceous performance, in the first and third years, the average accumulated amounts of N and P were similar using any of the three green manures; in the second year, the authors observed higher macronutrient accumulations in the shoot dry biomass of sunn hemp, differing (p≤0.05) from the other species. In relation to K, higher accumulations were also observed in sunn hemp biomass, in the first and second cultivation years, and no significant differences in K averages in the third year was observed.

Interaction between management and fabaceous was significant (p≤0.05) for Ca and Mg accumulation in the three consecutive years (Table 4). The average amounts of Ca accumulation in the three years were significantly greater in jack beans in relation to velvet beans and sunn hemp for these green manures under monocropping. When they are intercropped with corn, the amounts of Ca accumulation in the treatments with sunn hemp and jack beans in the first and second years were greater than velvet bean accumulation, though. Other results found in studies had already shown calcium accumulation potential by jack bean when compared to other green manures (Almeida & Camara, 2011; Brito *et al*., 2017; Goulart *et al*., 2021).

Evaluating the dry biomass and nutrient accumulation in the shoot area of jack bean, Padovan *et al*. (2011) reported that, even after formation of the first pods, this leguminous still accumulates expressive amounts of biomass and nutrients, mainly N, K and Ca. Considering management, for jack bean, the authors observed greater and significant accumulation of this macronutrient in the cultivation of this species in the three consecutive years. For velvet beans monocropping, the authors observed significant Ca accumulation only in the third year comparing with the intercropping; for sunn hemp the average amounts accumulated between monocropping and intercroppings were similar in the three consecutive years, though.

Concerning Mg accumulation in the

Table 4. Accumulation of Ca and Mg (kg/ha) in shoot biomass of fabaceous plants in relation to monocropping and intercropping with corn, in three consecutive years. Seropédica, Fazendinha Agroecológica km 47, 2015-2017.

Management	Gray velvet bean	Sunn hemp	Jack bean	General average
	Ca accumulation			
	1st year			
Monocropping	45.29 Ac	95.68 Ab	159.83 Aa	120.27 A
Intercropping	16.78 Ab	71.66 Aa	58.33 Ba	48.92 B
General average	31.04 c	83.67 b	109.08 a	
CV (%)		23.80		
	2nd year			
Monocropping	31.28 Ac	64.65 Ab	132.69 Aa	76.20A
Intercropping	24.14 Ab	64.82 Aa	83.32 Ba	57.43 B
General average	27.71 c	64.74 b	108.01 a	
CV (%)		24.66		
	3rd year			
Monocropping	82.57 Ab	72.39 Ab	182.20 Aa	112.39 A
Intercropping	3.87 Ba	44.09 Aa	65.45 Ba	37.80 B
General average	43.22 b	58.24 b	123.82 a	
CV (%)		35.75		
	Mg accumulation			
	1st year			
Monocropping	19.24 Ab	46.19 Aa	35.61 Aa	38.68 A
Intercropping	4.66 Bb	30.57 Ba	10.93 Bb	15.38 B
General average	11.95 c	38.38 a	23.27 b	
CV (%)		27.70		
	2nd year			
Monocropping	10.51 Ac	42.28 Aa	28.41 Ab	27.06 A
Intercropping	7.56 Ab	33.90 Aa	11.62 Bb	17.69 B
General average	9.04 c	38.09 a	20.01 b	
CV (%)		26.25		
	3rd year			
Monocropping	25.13 Ac	43.49 Ab	66.21 Aa	44.95 A
Intercropping	1.33 Ba	13.72 Ba	12.52 Ba	9.19 B
General average	13.24 c	28.60 b	39.37 a	
CV (%)		28.95		

Averages followed by same lowercase letters in the line, and uppercase in the column, do not differ from each other by F test, analysis of variance, for management and Scott-Knott test for fabaceous plants, at 5% probability.

shoot biomass of fabaceous plants (Table 4), we observed that, in monocropping, in the first year, the average amounts accumulated in the biomass of sunn hemp and jack bean were superior to the ones accumulated in the dry biomass in the shoot area of velvet bean; in the second year sunn hemp provided greater Mg accumulation when compared with the other treatments, though. In the third year, jack bean showed superior averages of Mg in relation to the other green manures. Sunn hemp intercropped with corn showed average accumulation significantly superior to the other fabaceous plants in the first and second year, not showing statistical differences among the three green manures in the third year.

In relation to accumulated amount of nutrients in corn biomass, the authors observed that for N, P and Mg no difference was noticed between treatments in different cultivation years, accumulating average values for N (49.85;18.07; and 32.14 kg/ha), P (8.83; 10.32; and 8.98 kg/ha) and Mg (13.78; 6.29; and 4.48 kg/ha), respectively, for 2015, 2016 and 2017. In relation to K, no difference concerning accumulated amounts in the first cultivation year was noticed; in the second and third years, monocropping corn reached greater accumulation of this nutrient, though (49.10 and 55.98 kg/ha of K, respectively, in 2016 and 2017). The amount of Ca accumulation was similar in the first year, smaller accumulations were detected in the intercropping with jack bean in the second year, whereas in the third year, greater accumulations were observed in the corn biomass in monocropping, 8.7 kg/ha of Ca.

For pumpkin productivity (Table 5), no significant interaction between management and fabaceous was noticed. In the first year, fabaceous pre-cropping, regardless of the arrangement, provided a higher pumpkin productivity, up to 165,87%, compared with corn pre-cropping. In relation to the second year, fabaceous monocropping provided higher pumpkin productivities when compared to the corresponding intercroppings, no differences between management in the third year was verified. Corn monocropping provided low pumpkin productivity in the first cultivation year when compared with the other treatments; in the second and third years no pumpkin production associated with corn monocropping was verified, due to plant development deficit, resulting in plants with small stems and leaves and no fruiting (Table 6). This can be related to a reduced nitrogen availability, since no nitrogen source was applied at the time of pumpkin sowing. Grasses, in general, have a high C/N ratio, and their addition to the soil can lead to the immobilization of this macronutrient by microorganisms present in soil (Teixeira *et al*., 2010).

Resende *et al*. (2013) reported that cultivar Jacarezinho reached productivity of 12.2 t/ha, using fertilizer formulation 6-24-12 at 200 kg/ha, and two mulchings at 20 and 45 days after transplanting, 50 kg/ha N and 60 kg/ha K_2O, using urea and potassium chloride as sources, respectively. This productivity was reached in this study with the use of green manures. Santos *et al*. (2018b) also reported productivity of the cultivar Jacarezinho of 21.53 t/ha, using urea as nitrogen source. This confirms the potential of green manure

Table 5. Average production of pumpkin (t/ha) obtained in the field experiment, in three consecutive years. Seropédica, Fazendinha Agroecológica km 47, 2015-2017.

Management	Pumpkin production		
	1st year	2nd year	3rd year
Monocropping	17.631 A	20.490 A	8.331 A
Intercropping	17.403 A	14.422 B	8.002 A
Fabaceous			
Sunn hemp	16.999 A	19.980 A	6.451 A
Jack bean	19.163 A	15.073 A	10.596 A
Gray velvet bean	13.389 A	17.316 A	7.452 A
Interaction M x F	0.8345	0.1093	0.6711
CV (%)	23.70	17.00	36.20

Averages followed by same letters in the same column do not differ from each other by F test, analysis of variance, for management and Scott-Knott test for fabaceous plants, at 5% probability.

Table 6. Comparison between the average of each treatment and average of the control (corn monocropping) for the pumpkin production (t/ha) obtained in the field experiment conducted in Seropédica evaluated in three consecutive years. Seropédica, Fazendinha Agroecológica km 47, 2015-2017.

Pre-cropping	Pumpkin production		
	1st year	2nd year	3rd year
Gray velvet bean	16.124&	22.602***	8.499*
Sunn hemp	17.951*	21.313***	6.038&
Jack bean	18.816*	17.557***	10.455**
Gray velvet bean + corn	16.653&	12.031***	6.403&
Crotalaria+corn	16.047&	18.647***	6.865*
J. bean +corn	19.508*	12.589***	10.737**
Corn monocropping	7.077	0.00	0.00
CV (%)	25.39	18.27	40.26

&, *, ** and ***Significant average in relation to corn monocropping by Dunnet test, at 10%, 5%, 1% and 0,1% probability, respectively.

as pre-cropping in pumpkin production systems, with emphasis on the nitrogen supply derived from biological fixation. According to the results described by Sant'Anna *et al*. (2018), sunn hemp, velvet bean and jack bean in mutualistic association with bacteria can enter the system, respectively, up to 58, 61 and 85% of the total nitrogen accumulated in the dry biomass.

The authors concluded that fabaceous monocropping reached higher dry biomass production, mainly for sunn hemp in the first and second years and provided greater accumulations of N, P and K. In the first year, fabaceous pre-croppings, regardless of arrangement, provided an increase in pumpkin production, up to 165.87%, in relation to corn pre-cropping, whereas in the second and third years no pumpkin production associated with corn monocropping was verified. The three different fabaceous species showed potential to be used as green manure in pumpkin cultivation, when compared with corn pre-cropping.

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