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Organic cabbage growth using green manure in pre-cultivation and organic top dressing fertilization

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ABSTRACT

The experiment was conducted in (Integrated Agroecological Production System in Seropédica-RJ) Sistema Integrado de Produção Agroecológica (SIPA), Seropédica-RJ, to evaluate the effect of two maize populations in relation to baby corn productivity and shoot mass, to determine the contribution of pre-cultivated maize, green velvet and organic topdressing fertilization in the agronomic performance of cabbage (*Brassica oleracea* var. capitata). The experimental design consisted of randomized blocks with three treatments (maize population of 100,000 and 200,000 plants ha⁻¹ and green velvet at 100,000 plants ha⁻¹) and eight replicates. After that, cabbage was transplanted in the straw of these species, adopting a randomized block design allocated in split plots, totalizing six treatments, being three pre-cultivation practices and two organic topdressing fertilization doses (with or without 50 g fermented organic compost per planting hole). Considering “baby corn” productivity, no differences were observed compared to maize populations, with an average productivity of 822.5 kg ha⁻¹. Green velvet pre-cultivation obtained the highest shoot dry mass (8.4 t ha⁻¹). Cabbage crop was improved by green velvet pre-cultivation, reaching 60.7 t ha⁻¹ and organic topdressing fertilization, reaching 60.4 t ha⁻¹; however, in the presence of green velvet straw, topdressing fertilization did not promote additional yield benefit of this crop. Thus, we noticed that green manure using green velvet increased cabbage productivity, submitted to organic management, when compared to maize pre-cultivation, making it able to replace organic topdressing fertilization.

Keywords: *Brassica oleracea* var. capitata, agroecology, minimum tillage, baby corn, corn stigmas, velvet green.

RESUMO

Cultivo orgânico de repolho com adubação verde em pré-cultivo e adubação orgânica em cobertura

O experimento foi conduzido na área do Sistema Integrado de Produção Agroecológica (SIPA), Seropédica-RJ, objetivando avaliar o efeito de duas populações de milho quanto à produtividade de minimilho e de massa de parte aérea, determinar a contribuição dos pré-cultivos de milho, da mucuna verde e da adubação orgânica de cobertura, no desempenho agrônômico do repolho. O delineamento adotado foi constituído de blocos casualizados, com três tratamentos (milho nas densidades de 100.000 e 200.000 plantas ha⁻¹ e mucuna verde na densidade de 100.000 plantas ha⁻¹) e oito repetições. Na sucessão, realizou-se o transplante do repolho na palhada destas espécies, adotando-se o delineamento de blocos casualizados distribuídos em parcelas subdivididas, totalizando seis tratamentos, sendo três pré-cultivos e duas doses de adubação orgânica de cobertura (ausência e presença de 50 g de composto orgânico fermentado por cova). Considerando a produtividade de “minimilho”, não foram observadas diferenças em decorrência das populações de milho, com produtividade média de 822,5 kg ha⁻¹. A maior produtividade de massa seca de parte aérea dos pré-cultivos foi obtida com mucuna verde (8,4 t ha⁻¹). A cultura do repolho foi beneficiada pelo pré-cultivo com a mucuna verde, alcançando 60,7 t ha⁻¹ e pela adubação orgânica de cobertura, alcançando 60,4 t ha⁻¹, todavia, na presença da palhada de mucuna verde, a adubação de cobertura não promoveu benefício adicional no rendimento desta hortaliça. Desta forma, evidenciou-se que a adubação verde utilizando a leguminosa mucuna verde proporciona aumento de produtividade de repolho, submetido ao manejo orgânico, quando comparado ao pré-cultivo de milho e é capaz de substituir a adubação orgânica de cobertura.

Palavras-chave: *Brassica oleracea* var. capitata, agroecologia, cultivo mínimo, minimilho, estigmas de milho, mucuna verde.

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A strong appeal for sustainable Agriculture has forced the search for new production systems, which include the replacement of synthetic fertilizers by organic ones. This practice promotes benefits to chemical, physical and

biological soil characteristics, resulting in higher productivities (Sediyama *et al.*, 2014). The evolution of the production process led to the substitution of agricultural management practices, in which plant and animal farms were

integrated, for specialized systems. That is the reason why local availability of organic matter for fertilization had been reduced.

Alternatively to manures, the use of fermented “Bokashi” compost,

a fermented mixture of wheat bran and castor oil cake, inoculated with effective microorganisms (EM), has been widely used (Mata *et al.*, 2016). The predominant fermentation process is lactic, however, acetic, alcoholic, propionic and butyric fermentation also occur (Siqueira & Siqueira, 2013).

In tropical conditions, few scientific studies are related to the benefits of these fermented composts for plant mineral nutrition, though. Oliveira (2015) observed that the application of this compost resulted in an increase in number of leaves and fresh mass production of lettuce shoots (cv. Vera).

Another alternative to soil fertilization is the green manure. Silva *et al.* (2011b), studying succession of organic maize and kale cultivations under no-tillage system, verified that kale showed higher productivity, when intercropped with vegetables *Crotalaria spectabilis* and *Mucuna deeringiana*. Silva *et al.* (2011a) estimated that, in average, 67% of N in green velvet tissues is derived from the biological nitrogen fixation (BNF).

Using grass mulch has many advantages such as high capacity of mass production and nutrient cycling, mainly K. Decomposition of the mulching with grass straw is lower than the mulching with vegetables (Silva, 2002). The decomposition rate of straw, in general, is inversely proportional to the C/N ratio (Doneda, 2010), favoring the maintenance of mulching for a longer period of time.

Considering the maize shoot production, this species presents potential to be used as mulching. One alternative is producing straw and mini corn (baby corn) *in situ*. Baby corn is the female inflorescence harvested prior to fertilization (Barbosa, 2009), being processed as industrialized food, being source of additional cash income. Stigma (corn hair) is recommended by popular medicine to treat edema, cystitis, gout and kidney stones (Li & Yu, 2009). However, no results in relation to stigma production in maize fields in Brazil were found.

Many studies on management of Brassicacea in organic farming

production have been carried out (Santos, 2009; Corrêa *et al.* 2014). This botanical family is a widely consumed food and has great socioeconomic importance (Filgueira, 2008) and also presents high nutrient extraction capacity (Silva *et al.*, 2012). In conventional management, cabbage (*Brassica oleracea* var. *capitata*) is generally fertilized using high doses of soluble fertilizers (Aquino *et al.*, 2005); however, in organic cultivation the green manure associated with organic fertilization provides good productivity levels for this vegetables (Pereira, 2007).

The aim of this study was to evaluate the effect of green manure, in pre-cultivation with green velvet and corn in two population densities, associated with fermented organic compost “bokashi”, on agronomic performance of cabbage submitted to organic cultivation.

MATERIAL AND METHODS

The experiment was installed at Sistema Integrado de Pesquisa em Produção Agroecológica (SIPA) “Fazendinha Agroecológica km 47”, Seropédica, Rio de Janeiro State (22°45'S, 43°41'W, 33 m altitude).

The soil is classified as Argisol. Soil chemical analysis in the 0-20 cm layer, showed pH (water)= 6.1; Al⁺⁺⁺= 0.0 cmol_cdm⁻³; Ca⁺⁺= 1.9 cmol_cdm⁻³; Mg⁺⁺= 0.93 cmol_cdm⁻³; available P= 64 mg dm⁻³; K⁺= 50.0 mg dm⁻³; organic matter = 1.41 g kg⁻¹.

Cover crops were sown on February 22, 2011. Maize, cultivar Eldorado, was grown in a 1.0-m spacing between furrows and 10 plants per linear meter (100,000 plants ha⁻¹), 0.5 m between furrows and 10 plants per linear meter (200,000 plants ha⁻¹). The green velvet (*Mucuna pruriens* cv. Utilis) was planted in 0.5-m spacing between furrows and 5 plants per linear meter (100,000 plants ha⁻¹). The useful area consisted of 4 m² of central green velvet plots, for corn (100,000 plants ha⁻¹) 2 central rows measuring 2 meters long were delimited and for maize (200,000 plants ha⁻¹) 4 central rows measuring 2 meters long were delimited.

Baby corn ears were harvested

between 56 and 75 days after sowing. Those ears, measuring diameters from 0.8 to 1.8 cm (desired diameter) and with no deformations, were classified as marketable; the ones which were out of the desired diameter were classified as unmarketable (Pereira Filho & Cruz, 2001) and mini corn with deformations were classified as unmarketable due to deformation. After determining fresh mass, subsamples of baby corn and stigmas were taken to be dried in forced air circulation at 65°C for 72 hours. Then, dry mass was quantified, ground and taken to Laboratório de Química Agrícola of Embrapa Agrobiologia to determine N, P, K, Ca and Mg contents.

Cutting of corn and green velvet plants, in order to make straw mulch, was carried out during the green velvet flowering, at 144 days after sowing and kept on the soil. We quantified phytomass samples and took subsamples, then dry mass was quantified and macronutrients contents were analyzed, as it was done for baby corn.

Non-leguminous species were used as reference for natural abundance of ¹⁵N in soil. False-milkweed (*Emilia sonchifolia*), wandering-jew (*Commelina erecta*) and maize (*Zea mays*) were collected in the experiment area and analyzed, showing the following δ¹⁵N values: 10.60; 9.32 and 8.06, respectively. The contribution of BNF was estimated using ¹⁵N or δ¹⁵N abundance technique (Shearer & Kohl, 1988), with the aid of a mass spectrometer (Finnigan MAT, model Delta Plus). The percentage contribution of N derived from BNF was calculated using the formula: % BNF = 100 (δ¹⁵N of control plant - δ¹⁵N of fixing plant) / (δ¹⁵N of control plant - B), being B = -1.54, value corresponding to the isotopic discrimination of δ¹⁵N by *Mucuna pruriens*, according to that described by Okito *et al.* (2004), adopted to estimate all the other species.

Five days after the mulching species cutting, cabbage seedlings, cultivar Seicho, 32-day old, were transplanted into no-tillage system. The holes were arranged in double rows, spaced 0.4x0.3x0.7 m, totalizing 64 plants per subplot and were fertilized using planting fertilizer at a rate of 6.536 t ha⁻¹

of tanned bovine manure presenting the following chemical analysis: 15.0; 3.5; 12.0; 14.4 and 6.2 g kg⁻¹, respectively of N, P, K, Ca and Mg.

The experiment design was in randomized blocks, with four replicates, arranged in split plot scheme, consisting of six treatments; plots consisted of three pre-cultivations (mulching species) and subplots with and without organic topdressing made from fermented compost (0 t ha⁻¹ and 2.28 t ha⁻¹, and the last dose equivalent to 100.0 kg ha⁻¹ N). This compost was prepared using a mixture of wheat bran (60%) and castor cake (40%), 200 L of water, 2 L of effective microorganisms solution and 1.5 kg of crystal sugar; the compost was kept in plastic buckets and hermetically sealed and left to stand for 1 month for fermentation. Chemical analysis showed: 44.3; 4.2; 11.5; 3.3 and 3.5 g kg⁻¹, respectively N, P, K, Ca and Mg.

Cabbage harvest was performed on October 20, 2011, at 89 days after transplanting. The following agronomic traits were evaluated: whole plant fresh mass, head fresh mass, head weight. Then, subsamples of each subplot were taken. These subsamples have undergone the same steps cover crop mass has (as it was mentioned above), in order to determine dry mass and the chemical analysis of plant material.

The obtained results were submitted to statistical analysis using F test, with the aid of SAEG Program and Scott-Knott test at 5% significance level.

RESULTS AND DISCUSSION

No significant differences were observed for baby corn productivity in population densities from 100,000 to 200,000 plants ha⁻¹ (Table 1). Average values for marketable baby corn productivity were 822.5 kg ha⁻¹. Similar values for mass of marketable fresh baby corn were found by Corrêa *et al.* (2014) in the same experimental area and by Jesus (2009) in the North Fluminense Region.

In relation to baby corn stigmas, the authors did not observe any significant difference between the two plant population densities (Table 1). The

average productivity reached 66 kg ha⁻¹; despite of the fact that yield was not high, the high monetary value added to this by-product of baby corn harvest should be highlighted. Experimental results on stigma production were not found in literature, so that no discussion in relation to productivity reached using the adopted organic management was possible.

Productivity of shoot dry mass of green velvet was superior and was different from shoot dry mass of maize (Table 2). Productivity of shoot dry mass equivalent to 6.0 t ha⁻¹ is considered an appropriate amount of straw for mulching, in no-tillage system (Darolt, 1998), in tropical conditions. On the other hand, in the Atlantic forest biome, this shoot productivity cannot be found.

Shoot dry mass of green velvet in this study was higher than the one found by Silva *et al.* (2011a) in similar weather conditions. However, in spite of producing greater amount of shoot phytomass, equivalent to 8.4 t ha⁻¹, this leguminous plant has a low C/N ratio, decomposing faster. Oliveira *et al.* (2008), analyzing different mulching decomposition, observed that C/N ratios were lower in leguminous *C. juncea*, velvet bean (*Mucuna pruriens*) and gliricidia (*Gliricidia sepium*) comparing with sugar cane grass (bagasse) and Cameroon grass. Percentage value of dry mass remaining in grass was superior to leguminous plants, which showed low contents of remaining N, showing faster release of this nutrient.

The authors observed that the

population density of 100,000 maize plants ha⁻¹ was higher and different from the population density of 200,000 corn plants ha⁻¹ when analyzing mass productivities of maize shoots. In the lowest population density, productivity was similar to the value found, in similar weather conditions, by Corrêa *et al.* (2014) with the same cultivar. The lowest productivity reached in the highest population density allowed to verify a possible occurrence of intraspecific competition (Table 2), which did not influence in baby corn productivity, since the ears were early-harvested. For Andrade *et al.* (1999), this crop show low plasticity of growth when compared to other species of Poaceae family, due to its limited capacity of leaf expansion and prolificity. This botanical family produces a mass with high quality and volume (Andreola *et al.*, 2000) and usually presents a decomposition rate inversely proportional to its C/N ratio (Doneda, 2010), favoring the establishment of mulching.

Some studies suggest that the efficiency of grass cultivation intercropped with leguminous plants produces straw with C/N ratio intermediate to that of the species in isolated crops, resulting in the lowest decomposition rate in relation to the phytomass when using leguminous plants exclusively, favoring the maintenance of mulching longer and synchronizing the supply stages and increased demand for N by crops (Corrêa *et al.*, 2014).

The amount of N, K, Ca and

Table 1. Fresh and dry mass (kg ha⁻¹) of marketable and non-marketable husked baby corn per diameter and by deformations, dry straw mass and corn stigma dry mass, in two corn population densities. Seropédica, UFRRJ, 2011.

Treatment	MDC	NCBCD	MDNDef	EEC
	Fresh mass		Dry mass	
M100	809.25 A	504.78 A	55.93 A	67.5 A
M200	836.12 A	436.70 A	67.86 A	65.8 A
CV (%)	9	28	36	12

Averages followed by same letter in the column do not differ from each other by Scott-Knott test, 5% probability level; MDC= marketable husked baby corn; NCBCD= Non-marketable baby corn by diameter; MDNDef= Non-marketable husked baby corn, by deformations; EEC= Stigmas of harvested ears; M100 and M200= Respectively, maize grown in the density population of 100,000 and 200,000 plants ha⁻¹.

Mg accumulated in shoot area of green velvet was higher compared to treatments with maize, which shows the high capacity of this leguminous plant for nutrient cycling (Table 2). Close values, except for Ca, were found by Lima *et al.* (2010) in velvet bean, reporting average values of 196.6; 14.4; 100.7; 41.9 and 13.9 kg ha⁻¹, for N, P, K, Ca and Mg, respectively. The amount of N, P and Mg accumulated in maize shoots, in population density of 200,000 plants ha⁻¹ was lower than that of the accumulated quantity on density of 100,000 plants ha⁻¹, due to the lower productivity observed in the highest population density (Table 2). In maize population of 200,000 plants ha⁻¹ Corrêa *et al.* (2014) verified values similar to the ones found in this study, except for the quantity accumulated in the shoots of N and Ca.

In organic cabbage cultivation, the authors did not verify interactive effects related to the studied variation sources

(pre-cultivation and dose of fermented organic compost), in relation to any analyzed variables. However, positive and independent effects were detected analyzing pre-cultivation with green velvet and topdressing using fermented organic compost on cabbage productive performance (Table 3).

In this context, pre-cultivation with green velvet provided an increase in production and, consequently, in productivity of cabbage “heads” in t ha⁻¹, when compared to pre-cultivations with different maize population densities. This increase reached about 15 and 22%, corresponding to gains in productivity of heads, from 9 to 13 t ha⁻¹, respectively, in relation to pre-cultivations equivalent to maize densities from 100,000 to 200,000 plants ha⁻¹. This fact is possibly due to the benefits resulting from the greater cycling of nutrients provided by the green velvet straw, comparing to maize, mainly the cycling of nitrogen (Table 3).

Average cabbage head weight in

the adopted organic management, both in pre-cultivation with green velvet and in the presence of mulching, was similar to the observed by Moreira *et al.* (2011). Analyzing cabbage production in relation to synthetic-N fertilizer, Moreira *et al.* (2011) obtained the maximum estimated value of 1.13 kg of head fresh mass, applying 278 kg N ha⁻¹.

Values of cabbage productivity, using green velvet straw and maize straw, reached levels similar to the ones found by Vargas *et al.* (2011), under conventional cultivation with *C. juncea* and *C. ensiformis* straw, and using nitrogen fertilization with 75 kg of N ha⁻¹, yield was between 47.0 to 58.0 t ha⁻¹. Oliveira *et al.* (2003) reached productivity of 34.7 t ha⁻¹, under organic cultivation with *C. juncea* straw, in population density of 27,778 plants ha⁻¹. Under the same weather conditions, Santos (2009) found productivity ranging from 62 to 74 t ha⁻¹, growing cabbage with *C. juncea* straw, under mono and intercropping system with either sunflower or sorghum, under the same edaphoclimatic conditions.

Higher accumulations of N, P and Mg in cabbage shoots were provided by pre-cultivation with green velvet, differing statistically from the other treatments (Figure 1). These values are close to the ones found by Pereira (2007), evaluating nutrient accumulation in cabbage mass, under no-tillage on *C. juncea* straw; Pereira (2007) found 99.6; 11.6; 131.8; 16.7; 6.0 kg ha⁻¹ of N, P, K, Ca and Mg, respectively.

In relation to BNF through the use of green velvet, the amount of N from the atmosphere, estimated by natural abundance of ¹⁵N technique, was 62% similar to the value found by Silva *et al.* (2011a), which is the accumulated amount of 114.32 kg ha⁻¹ of N in the shoots. Considering the equivalence, disregarding soil N recovery efficiency by the cabbage from decomposition process of green velvet straw, this value corresponds to an application of 254 kg ha⁻¹ of a concentrated synthetic fertilizer (urea). Considering the N fertilization recommended by Filgueira (2008), the amount of N derived from accumulated BNF only in green velvet shoots, is a value close to what is recommended for

Table 2. Mass productivity of mulching and amount of macronutrients accumulated in plant tissues. Seropédica, UFRRJ, 2011.

Treatment	Dry mass (t ha ⁻¹)	N	P	K	Ca	Mg
M100	4.9 B	61.3 B	16.4 A	65.1 B	9.65 B	11.0 B
M200	3.3 C	43.5 C	12.1 B	52.1 B	6.42 B	7.7 C
MV100	8.4 A	184.6 A	11.9 B	91.0 A	145.40 A	20.0 A
CV (%)	16	20	26	20	20	28

Averages followed by same letters in the column do not differ from each other by Scott-Knott test, 5% probability; M100 and M200= Maize grown in the population density of 100,000 and 200,000 plants ha⁻¹, respectively; MV100= Green velvet cultivated in the population density of 200,000 plants ha⁻¹.

Table 3. Fresh mass of the whole plant, cabbage “head” average weight and N content of cabbage, cultivated in no-tillage system, on mulching mass with and without organic fertilization. Seropédica, UFRRJ, 2011.

Kind of straw	Whole plant mass (t ha ⁻¹)	Head mass (kg per plant)	Head productivity (t ha ⁻¹)	N content
M100	78.93 B	1.03 B	51.46 B	22.9 B
M200	72.44 B	0.94 B	47.14 B	21.8 B
MV100	87.29 A	1.21 A	60.77 A	28.2 A
Organic compost				
0N	72.05 B	0.92B	46.22 B	22.5 B
100N	87.4 A	1.20 A	60.44 A	26.0 A

Averages followed by same letters in the column do not differ from each other by Scott-Knott test, 5% probability; M100 and M200= Maize grown in the population density of 100,000 and 200,000 plants ha⁻¹, respectively; MV100= Green velvet cultivated in the population density of 200,000 plants ha⁻¹; 0N= 0.0 kg ha⁻¹ N; 100N= 100.0 kg ha⁻¹ N.

this crop. In this context, considering organic management, pre-cultivation with green velvet shows potential to provide significant amount of N to reach productivity levels similar to the ones obtained under conventional management.

Evaluating N contents in cabbage heads (Table 3), the authors observed that in green velvet straw cultivation N content was higher, differing significantly from the other treatments. This is due to the fact that this species

performs biological fixation with atmospheric N_2 fixing bacteria.

Using the results, the authors concluded that cabbage which had been organically cultivated, under no-tillage system using green velvet, in the absence of topdressing application, with fermented organic compost, did not show any mass productivity decrease when compared with organic fertilized treatment (Table 3). These results show the contribution of BNF through the use of green velvet, after straw

decomposition, as an effective source of N supply for the crop. Thus, organic topdressing can be replaced by pre-cultivation with this leguminous plant, showing advantage of soil protection and, also monetary-cost benefits. Thus, this system can be an alternative for organic production systems, in which the use of synthetic N fertilizers is not allowed, as well as in conventional production systems.

In this context, Pereira (2007) suggests replace supplementary organic fertilization by pre-cultivation with *C. juncea*, since the productivity of cabbage grown on the straw of this leguminous plant, without topdressing application, did not differ from the productivity of cabbage with poultry litter, 200 kg ha⁻¹ N.

In relation to the amount of nutrients accumulated in cabbage shoots, the authors observed that the topdressing with fermented organic compost resulted in an increase of N, P, K and Ca (Figure 2) when compared to the absence of this organic fertilization. Similarly, Oliveira *et al.* (2003) reported that supplementary topdressing with poultry litter, in cabbage cultivation, provided an increase in nutrient accumulation in the shoot area.

The authors concluded that population density of 100,000 maize plants ha⁻¹ provided the same productivity of baby corn fresh mass and maize stigma dry mass, as density of 200,000 maize plants ha⁻¹. However, in the lower population density, shoot productivity is higher than the productivity found in the higher density, making it the best alternative, considering productivity indexes, seed economy and ease of crop management.

Pre-cultivations with maize and green velvet resulted in high productivity of dry shoot phytomass, which shows that a strategy favoring the use of these species can provide the production of straw produced *in situ* aiming to cabbage minimal cultivation under organic production systems.

Productivity of cabbage on green velvet straw was higher than the productivity of cabbage grown on maize straw, considering that topdressing with the compost did not result in

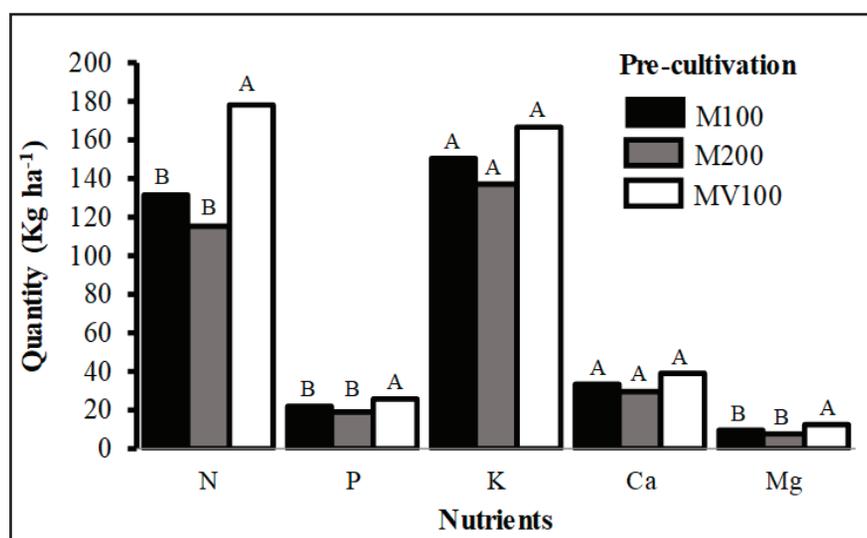


Figure 1. Accumulated amount of nutrients in shoots of cabbage, cultivated on the mulching straw; ¹Bars with the same letters do not differ among themselves by Scott-Knott test, 5% probability; M100 and M200= Maize grown in the population density of 100,000 and 200,000 plants ha⁻¹, respectively; MV100= Green velvet cultivated in the population density of 200,000 plants ha⁻¹. Seropédica, UFRRJ, 2011.

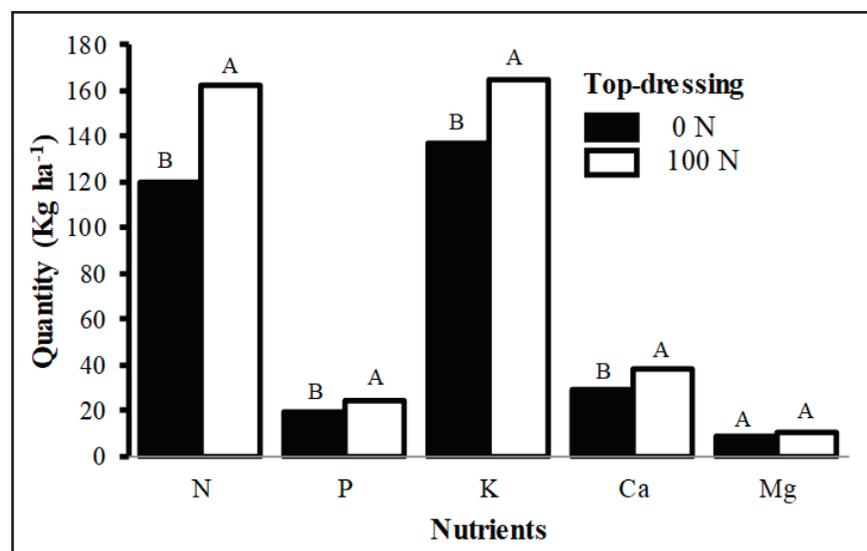


Figure 2. Amount of nutrients accumulated in shoot of cabbage using topdressing with organic compost; ¹Bars with the same letters do not differ among themselves by Scott-Knott test, 5% probability; 0N= 0.0 kg ha⁻¹ N; 100N= 100.0 kg ha⁻¹ N. Seropédica, UFRRJ, 2011.

an additional gain in relation to this vegetable yield, this system showed to be unnecessary. Even cabbage being cultivated on the maize straw showed satisfactory productivity, above national average, and increased in the presence of topdressing fertilization with the organic compost “bokashi” obtained from wheat fermentation and cake.

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