AGRÁRIA
Revista Brasileira de Ciências Agrárias
v.4, n.3, p.283-288, jul.-set., 2009
Recife, PE, UFRPE. www.agraria.ufrpe.br
Protocolo 519 - 02/03/2009 • Aprovado em 01/06/2009

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Agronomic performance of lettuce and carrot, in monoculture and associated with medicinal plants, under organic systems[1]

ABSTRACT

The purpose of this study was to evaluate the agronomic performance of intercropping between lettuce, carrots, mint and basil in the organic system of production. The experiment was conducted from May to September of 2007, in the field, at the Universidade Federal de Minas Gerais - Montes Claros, Minas Gerais. There were two experiments: one with lettuce (*Lactuca sativa* L.) and other with carrot (*Daucus carota* L.) as main crops. Each one of them was conducted in a randomized block design, with seven treatments and six repetitions. The treatments were: single lettuce and in a group with basil (*Ocimum basilicum* L.) or mint (*Mentha x villosa* H.), single carrot and in a group with basil or mint, lettuce and carrot intercropping, and monoculture of basil and mint. The lettuce had two consecutive crops. In the first crop of lettuce only the variable fresh part of the aerial part was influenced by clustered culture. The form of cultivation did not affect the agronomic characteristics of the carrot. In the second crop of lettuce, there were better results in single growing. The highest productivity of the vegetables was observed in consortium cultivation.

Key words: *Lactuca sativa*, *Daucus carota*, *Mentha x villosa*, *Ocimum basilicum*, intercropping

Desempenho agronômico de alface e cenoura, solteiras e consorciadas com plantas medicinais, em sistema orgânico

RESUMO

O objetivo deste trabalho foi avaliar o desempenho agronômico dos consórcios entre alface, cenoura, hortelã e manjericão, em sistema orgânico de produção. O experimento foi realizado de maio a setembro de 2007, em campo, na Universidade Federal de Minas Gerais – Montes Claros, MG. Foram realizados dois experimentos: um com a alface (*Lactuca sativa* L.) e outro com a cenoura (*Daucus carota* L.) como culturas principais. Cada um deles foi realizado no delineamento de blocos ao acaso, com sete tratamentos e seis repetições. Os tratamentos consistiram em: alface solteira e em consórcio com manjericão (*Ocimum basilicum* L.) ou com hortelã (*Mentha x villosa* H.), cenoura solteira e consorciada com manjericão ou com hortelã, consórcio alface e cenoura, e monocultivo de manjericão e hortelã. A alface teve dois cultivos consecutivos. No primeiro cultivo da alface apenas a variável massa fresca da parte aérea foi influenciada pelo cultivo consorciado. A forma de cultivo não influenciou as características agronômicas da cenoura. No segundo cultivo da alface foram observados melhores resultados no cultivo solteiro. As maiores produtividades das hortaliças foram observadas no cultivo em consórcio.

Palavras-chave: *Lactuca sativa, Daucus carota, Mentha x villosa, Ocimum basilcum*, associação de culturas

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INTRODUCTION

The association between cultures with different cycles reduces the development of spontaneous herbs and soil temperature, better controls erosion and optimizes the use of agricultural inputs (Olasantan et al., 1996). Besides that, this association improves the labor force, resulting in higher seasons with better profitability for the producer (Goncalves, 1981).

Aspects like arrangements, densities, sowing seasons, among others, are being intensively studied in intercropping of vegetables. Bezerra Neto et al. (2005), in a study with intercropping of carrot and lettuce, noted that greater population density of carrot increased plant height and decreased the dry portion of aerial part and roots. In multidimensional analysis of carrot-lettuce intercropping under different combinations of densities, the authors discovered that there was no significant interaction between the population densities of the involved cultures in relation to productive efficiency. However, significant effects of the main factors were observed. With the increase in population densities of carrot and lettuce from 40 to 100% of the recommended population in mono-cropping system, we found an increase of 24 and 12.5% respectively, in production capacity (Bezerra Neto et al., 2007).

High levels of productivity of carrot in monoculture and in intercropping with lettuce were observed, but the lettuce had higher single crop productivity. (Salgado et al., 2006). In evaluating the intercropping carrot - lettuce in the organic system, Sudo et al. (1997) didn't observe significant differences in single lettuce and in a consortium within two years of cultivation.

In recent years, an increase in demand for therapeutic potential of plants has been observed (Hulin et al., 1998; Calixto, 2000, Suzuki et al., 2002). Moraes et al. (2005), studying the production of cabbage and capuchin, single and intercropped with two or three rows per bedding, noted larger production of cabbage in consortium plots. On the other hand, Moreira et al. (2006) found no advantage for the vegetables when it was assessed the crop's production in single cultivation and associated with carrot in two spatial arrangements of plants. Basil and mint are two plants of great therapeutic potential (Potenza et al., 2004; Guedes et al., 2004). In Brazil, it is common the use of these species as a therapy source or as seasoning, which makes plants with considerable market potential. However, further studies are needed on the adequacy to the consortium of medicinal plants.

The purpose of this study was to evaluate the agronomic performance of consortium between lettuce, carrots, mint and basil under an organic system of production, in relation to their respective single cultures.

MATERIAL AND METHODS

The experiment was conducted in the experimental area at the Institute for Agricultural Sciences (IAS), Universidade Federal de Minas Gerais, Campus Regional of Montes Claros, Brazil, from May to September of 2007. By Köppen classification, the prevailing climate in the region is Aw – tropical of Savanna, with dry winter and rainy summer. The original vegetation is the savannah and the soil, according to analysis made in the soil laboratory of IAS, it is Cambisol Haplic (Embrapa, 2006) with the following characteristics: pH = 7.3 in water, organic material = 3.39 g dm^{-3}, P = 33.8 mg dm^{-3}, K = 240 mg dm^{-3}; Al = 0.00 $cmol_c$ dm-3; Ca = 7.40 $cmol_c$ dm^{-3} and Mg = 2.0 cmolc dm^{-3}.

Two experiments were carried out in parallel, one with the lettuce (*Lactuca sativa* L.) "Grand Rapids" and other with the carrot (*Daucus carota* L.) "Brasilia" as main crops. In each experiment, the experimental design randomized blocks were used, with seven treatments and six repetitions. The lettuce and carrot "Brasilia" were planted with four rows per bedding in the mono-cropping system, and with two lines alternating with the herbal little - mint (*Mentha x villosa* H.) and basil (*Ocimum basilicum* L.) in the intercropping cultivation. The plots were 1.0 meter wide and 1.5 meter in length, and the useful plot was consisted of an area of 1.20 x 0.90 meters (Figure 1). The spacing was 0.30 meter between plants and 0.30 meter between rows for all species, since for the carrot, after thinning, it was around 0.05 meter between plants.

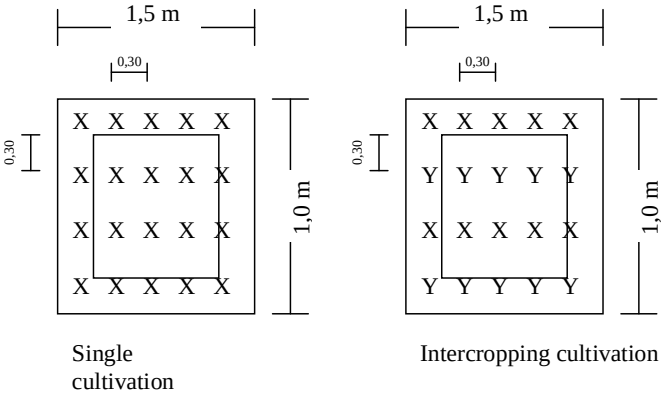

Figure 1. Spatial arrangement of plants in monoculture and consortium

Figura 1. *Arranjo espacial de plantas em monocultivo e consorciadas*

The lettuce was grown in two cycles during the developed experiment when the other plants of the consortium were already in advanced stages of development. The seedlings were produced in seed beds with a mixture of soil, manure and sand in the proportion of 2:1:0,5, being transplanted at 21 days after sowing. The seedlings of mint and basil were grown in a greenhouse, by cutting, with commercial substrate, 30 days before transplanting to the field. The carrot had direct seeding, and it was accompanied by seedlings of lettuce, basil and mint, in the country, a week later. The seedlings' transplant of the second crop of lettuce was conducted a week after the first harvest of lettuce.

The soil preparation was carried out by a tractor a week before sowing, with plowing and harrowing, lifting up the beds right after. It was held only organic fertilizer with 35 t ha^{-1} of cattle manure (Ribeiro et al., 1999). During the trial period,

manual weeding was made and irrigation was performed by micro-sprinklers.

The first harvest of lettuce happened to complete the cycle of 60 days after sowing and the second harvest was held on September 18 of 2007, also with 60 days of its cycle. We evaluated the fresh and dry mass, the number of leaves and length of the stalk of lettuce plants. The carrot was harvested on August 18 of that year, with cycle of 90 days, and the length, diameter, the fresh and dried masses of the roots. The plants of basil and mint were harvested at 150 days after transplantation.

The data obtained in the evaluation of variables fresh and dry masses of the aerial part, leaf number and length of plant lettuce stalk, fresh and dry mass, length and diameter of the roots of carrot, and production per area unit were statistically analyzed using the technique of orthogonal contrasts and F test, which organized contrasts were as follows:

Y1 = single lettuce vs consortium lettuce and basil, consortium mint and lettuce, consortium lettuce and carrot;

Y2 = consortium lettuce and basil vs consortium lettuce and mint, consortium lettuce and carrot;

Y3 = consortium lettuce and mint vs consortium lettuce and carrot;

Y4 = single carrot vs consortium carrot and basil, consortium carrot and mint, consortium lettuce and carrot;

Y5 = consortium carrot and basil vs consortium carrot and mint, consortium lettuce and carrot;

Y6 = consortium carrot and mint vs consortium lettuce and carrot;

Y7 = single lettuce vs consortium lettuce and basil, consortium mint and lettuce, consortium lettuce and carrot in the second crop;

Y8 = consortium lettuce and basil vs consortium lettuce and mint, consortium lettuce and carrot in the second crop;

Y9 = consortium lettuce and mint vs consortium lettuce and carrot in the second cultivation.

RESULTS AND DISCUSSION

The average for the variables fresh and dry mass in the aerial part, number of leafs, and length of the stalk of lettuce plants in the first under monoculture and intercropped, can be seen in Table 1. It is observed that, for the lettuce, only the variable fresh mass of the aerial part (FMAP) showed significant difference among treatments, in which the highest averages are observed when the vegetables were associated with basil and mint. These results agree of Moraes et al. (2005) who observed significant effect in the production vegetable in the cultivation in consortium between cabbage and capuchin.

The values of orthogonal contrast between averages of treatments can be found in Table 2. In contrast Y1, only the variable number of leaves was significant, showing better response to the lettuce when using the consortium system. Similar benefits to the lettuce one were observed by Cecílio Filho et al. (2002) that in assessing the productivity of lettuce and radish depending on the time of establishment of the

Table 1. Average values obtained, by plant, in assessing the characteristics fresh and dry mass of the aerial part (FMAP and DMAP), number of leaves (NL) and stalk length (SL) of lettuce the first in intercropping and monoculture

Tabela 1. *Valores médios obtidos, por planta, na avaliação das características massa fresca e seca da parte aérea (MFPA e MSPA), número de folhas (NFA) e comprimento de caule(CC) de alface no primeiro em cultivo consorciado e monocultivo*

Treatments[1]	FMAP (g)	DMAP (g)	NL	SL (cm)
A	186,34 bc	8,48 a	16,60 a	10,54 a
A e M	240,05 ab	10,15 a	19,50 a	10,70 a
A e H	259,47 a	11,74 a	21,39 a	11,79 a
A e C	183,22 c	8,28 a	18,72 a	11,22 a
C.V(%)	15,53	40,23	11,82	31,76

[1] Treatments: A – single lettuce, A and M - lettuce associated with basil; A and H - lettuce associated with mint; A and C - lettuce intercropped to carrot; Medium followed by the same letter do not differ by Tukey test, at 5% probability

Table 2. Values of orthogonal contrast between averages of treatments, by plants, into the variables: fresh and dry mass of the aerial part (FMAP and DMAP), number of leaves (NL) and stalk length (SL) in the first lettuce cultivation, in consortium and monoculture

Tabela 2. *Valores dos contrastes ortogonais entre médias de tratamentos, por plantas, paras as variáveis massa fresca e seca da parte aérea (MFPA e MSPA), número de folhas (NFA) e comprimento de caule (CCA) de alface no primeiro em cultivo consorciado e monocultivo*

Contrasts[1]	FMAP (g)	DMAP (g)	NL	SL (cm)
Y1 = (A) vs (A e M, A e H, A e C)	-123,72 ^{ns}	-4,73 ^{ns}	-9,81 *	-2,09 ^{ns}
Y2 = (A e M) vs (A e H, A e C)	37,41 ^{ns}	0,01 ***	-1,11 *	-1,61 ^{ns}
Y3 = (A e H) vs (A e C)	76,25 ^{ns}	3,46 ^{ns}	2,7 ***	0,50 ^{ns}

[1] Treatments: A – single lettuce, A and M - lettuce associated with basil; A and H - lettuce associated with mint; A and C - lettuce intercropped of carrot; ns, *, **, *** - values not significant, significant at 5%, 1% and 10% respectively by the F test

consortium, noted agronomic benefits in associated lettuce, since the largest accumulation of fresh vegetables was observed in this consortium when the sowing of radish was realized up to seven days after transplanting (133.25 g m^{-2}).

In relation to the Y2 contrast, there was better response from the lettuce when associated with basil, for the characteristics dry mass of aerial part, and in a consortium with mint and carrot, for variable number of leafs, showing an adaptability between these cultures. Rezende (2004), when assessing the productivity of pepper crop, cabbage, rocket, lettuce and radish in consortium cultivation, noted that the greater fresh mass of lettuce was observed when the lettuce was intercropped with pepper, demonstrating a greater adaptation to this culture rather than the other two vegetables. Regarding the Y3 contrast, better answers for the variable fresh mass of the aerial part of lettuce in the intercropping lettuce – mint was observed, for the characteristic number of leafs.

The averages obtained in the carrot evaluation did not show significant difference between the treatments (Table 3), which agrees with Bezerra Neto et al. (2003) who also did not observe significant effects among the factors' cultivation system when analyzing the performance of the agro-economic consortium carrot and smooth lettuce in two cropping systems on track.

In the orthogonal contrasts evaluated for the carrot (Table 4), it is noted that no one showed significant differences, indicating that the same agronomic quality obtained on mono-

Table 3. Average values obtained by plant, in assessing the following characteristics: length (CR), diameter (RD), fresh and dry mass of carrot roots (FMR and DMR), in consortium and monoculture cultivation

Tabela 3. *Valores médios obtidos, por planta, na avaliação das características comprimento(CR), diâmetro(DR), massa fresca e seca de raízes de cenoura (MFR e MSR); em cultivo consorciado e monocultivo*

Treatments[1]	CR (cm)	DR (cm)	FMR (g)	DMR (g)
C	15,29 a	3,43 a	96,17 a	11,12 a
C e M	16,27 a	3,51 a	113,24 a	12,01 a
C e H	29,78 a	16,61 a	120,41 a	12,32 a
C e A	15,13 a	3,32 a	93,79 a	9,89 a
C.V(%)	11,81	10,01	30,11	31,71

[1]Treatment: C - single carrot, C and M - carrot associated with basil, C and H - carrot associated with mint, C and A - carrot intercropped with lettuce; Averages followed by the same letter do not differ between each other by Tukey test, to 5% probability

Table 4. Values of orthogonal contrast between averages of treatments, with plants for variable lengths (RL), diameter (DR), fresh and dry mass of roots of carrot (FMR and DMR) in a consortium and monoculture cultivation

Tabela 4. *Valores dos contrastes ortogonais entre médias de tratamentos, por plantas, para as variáveis comprimento (CR), diâmetro (DR), massa fresca e seca de raízes de cenoura (MFR e MSR) em cultivo consorciado e monocultivo*

Contrasts[1]	RL (cm)	DR (cm)	FMR (g)	DMR (g)
Y4 = (C) vs (C e M, C e H, C e A)	-15,31 ns	-13,15 ns	-38,93 ns	-0,86 ns
Y5 = (C e M) vs (C e H, C e A)	-12,37 ns	-12,91 ns	12,28 ns	-1,81 ns
Y6 = (C e H) vs (C e A)	14,65 ns	13,29 ns	26,62 ns	2,43 ns

[1] Treatment: C - single carrot, C and M - carrot associated with basil, C and H - carrot associated with mint, C and A - carrot intercropped with lettuce; ns - no significant values

cropping system, can be obtained from cultivation in a consortium. These results disagree with Caetano et al. (1999), which noticed damage to the carrot from the consortium system when it was associated to the cultivated lettuce "Marisa". The adaptation between the involved species may be related to the fact that ecological systems are capable of self-regulation, especially in the consortium systems, where the roots explore the depths of soil, or compete for light in different ways (Santos, 1998).

In the second crop of lettuce, for all variables, the obtained averages were significant, being the better results in single growing (Table 5). This shows that in intercropped systems, plants are subject to various types of interactions (Vieira et al., 2003), they are also related to the maintenance of efficiency in the absorption and use of water, nutrients and CO_2, which can put at risk the productivity of crops (Silva, 1983). The installation of the second crop of lettuce was performed when the other plants of the system were already in advanced stages of development, with higher length, showing that the competition between the plants in systems of multiple cultures is for light rather than water and nutrients (Portes, 1984), a fact noted by the advantage of monoculture on the consortium.

In the observation of the values of orthogonal contrasts between treatments in the second crop of lettuce (Table 6), it appears that in all contrasts, for all characteristics, the results showed no significant differences, indicating that the competitive pressure exerted by plants cultivation in intercropping was not sufficient to establish differences (Negreiros et al., 2002).

Table 5. Average values obtained by plant, in assessing the characteristics of a fresh and dry mass of aerial part (FMAP and DMAE), number of leaves (NL) and stalk length (SL) in the second crop of lettuce, in a consortium and monoculture

Tabela 5*. Valores médios obtidos, por planta, na avaliação das características massa fresca e seca da parte aérea (MFPA e MSPA), número de folhas (NFA) e comprimento de caule(CC) de alface no segundo cultivo, em consórcio e monocultivo*

Tratamentos[1]	FMAP (g)	DMAE (g)	NL	SL (cm)
A	113,32 a	11,59 a	28,15 a	12,46 a
A e M	61,39 ab	4,08 b	19,8 ab	8,84 ab
A e H	34,9 2b	3,44 b	9,21 b	3,75 b
A e C	4,89 b	0,98 b	8,5 b	3,4 b
C.V(%)	58,19	23,71	50,13	64,51

[1] Treatment: A – single lettuce, A and M - lettuce associated with basil; A and H - lettuce associated with mint; A and C - lettuce intercropped with carrot; Averages followed by the same letter do not differ between each other by Tukey test, to 5% probability

Table 6. Values of orthogonal contrast between averages of treatments, for plants, to the variables of a fresh and dry mass of aerial part (FMAP and DMAP), number of leaves (NL) and stalk length (SL) of lettuce in the second intercropping and monoculture

Tabela 6. *Valores dos contrastes ortogonais entre médias de tratamentos, por plantas, paras as variáveis massa fresca e seca da parte aérea (MFPA e MSPA), número de folhas (NFA) e comprimento de caule (CCA) de alface no segundo consorciado e monocultivo*

Contrasts[1]	FMAP (g)	DMAP (g)	NL	SL (cm)
Y7 = (A) vs (A and M, A and H, A and C)	238,76 ns	26,27 ns	46,94 ns	21,39 ns
Y8 = (A and M) vs (A and H, A and C)	82,97 ns	3,74 ns	21,89 ns	10,53 ns
Y9 = (A and H) vs (A and C)	30,03 ns	2,46 ns	0,71 ns	0,35 ns

[1] Treatment: A – single lettuce, A and M - lettuce associated with basil; A and H - lettuce associated with mint; Aand C – lettuceintercropped with carrot; ns - no significant values

The averages obtained in the production of biomass per area showed higher values in productivity in a consortium, except for the single carrot, demonstrating that for this vegetable cultivation it did not influence in the biomass produced. However, it showed superiority in relation to the others single and in consortium cultures (Table 7). These results agree with those obtained by Bezerra Neto et al. (2003) found higher values in the single crop system, for total productivity, business, relationship consortium/single crop and classified productivity of roots. There were significant differences, for lettuce, between the two cropping systems analyzed. In the presence of medicinal plants, the averages differ among the cultivation system and among the vegetables used. Bezerra Neto et al. (2003) observed increased productivity of leaves of lettuce plants in the system of mono-cropping system, which is not in accordance with the obtained results.

The conditions of the area, the way to lead the culture, choice of culture, besides the particularities of each region and the preferences of the market (Heredia Zárate, 1990; Oliveira et al., 2005a,b) are factors that must be observed when choosing to establish systems of association, since the spe-

Table 7. Average values obtained by plant, measuring the production per area unit in a consortium and monoculture cultivation

Tabela 7. *Valores médios obtidos, por planta, na avaliação da produção por unidade de área em cultivo consorciado e monocultivo*

Treatments	Production (g m^{-2})
Single lettuce	359,08 c
Lettuce intercropped with basil	708,11 b
Lettuce intercropped with mint	594,67 b
Lettuce in consortium with carrot	1531,22 a
Single carrot	1189,28 a
Carrot intercropped with basil	1360,44 a
Carrot intercropped with mint	1167,50 a
Single basil	97,11 c
Single mint	177,55 c
C.V(%)	39,26

Averages followed by the same letter do not differ by Tukey test, to 5% probability

cies involved should establish a mutual cooperation, for the use of all factors of production involved, with maximum benefits for each crop.

CONCLUSIONS

Only in the first crop of lettuce, the variable fresh mass of aerial part was influenced by the consortium culture. The form of cultivation did not affect the agronomic characteristics of the carrot. In the second crop of lettuce, there were better results in single growing. The highest production was observed in the cultivation in consortium.

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