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Broccoli production depending on the seed production system and organic and mineral fertilizer

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ABSTRACT

The experiment was conducted in a greenhouse at the Universidade Federal do Espirito Santo, in Alegre, Espirito Santo state, Brazil, to evaluate the broccoli production depending on the seed production system and organic and mineral fertilization. Seeds of the broccoli cultivar Ramoso Piracicaba were originated from lots of seed obtained in an organic and conventional production system. The experimental design was of randomized blocks, with four replications in a factorial arrangement combination of the lots, 2x5 (organic and mineral fertilized seeds) and substrates [S1 (soil + sand + manure), S2 (soil + sand + manure + NPK), S3 (soil + sand + manure + Fertium® 10 g L^{-1}), S4 (soil + sand + manure + Fertium® 30 g L^{-1}) and S5 (soil + sand + manure + Fertium® 50 g L^{-1}]. The analyzed variables were emergency, fresh and dry mass of aerial part, emergency speed and height of seedlings after 28 days of sowing, and plant diameter, leaf area, number of leaves, fresh and dry mass of aerial part, plant height, root volume, fresh and dry root mass, absolute and relative growth rates and increment to leaf area and plant height after 104 days. The emergency was similar in the different substrates; great vigor occurred on conventional seeds; the mineral fertilization increased the production of fresh mass of aerial part; the use of substrate containing soil, sand soil conditioner Fertium (30 to 50 g L^{-1}) increased the volume, fresh and dry mass of roots and rate of increase in these variables.

Keywords: *Brassica oleracea* var. *italica*, emergence, productivity, plant nutrition, substrate.

RESUMO

Produção de brócolos em função do sistema de produção da semente e do tipo de substrato

O experimento foi conduzido em casa de vegetação na UFES--CCA, em Alegre-ES, objetivando avaliar a produção de brócolos em função do sistema de produção da semente e do tipo de substrato. Utilizaram-se sementes de brócolos da cultivar Ramoso Piracicaba. O delineamento foi em blocos ao acaso, com quatro repetições, em arranjo fatorial 2x5, compreendendo lotes (sementes de cultivo orgânico e convencional) e substratos [S1 (solo + areia + esterco); S2 (solo + areia + esterco + NPK); S3 (solo + areia + esterco + Fertium® 10 g L^{-1}); S4 (solo + areia + esterco + Fertium® 30 g L^{-1}) e S5 (solo + areia + esterco + Fertium® 50 g L^{-1})]. Foram avaliados a emergência, massa fresca e seca da parte aérea, IVE e altura de plântulas após 28 dias da semeadura; e diâmetro do colo, área foliar, número de folhas, massa fresca e seca da parte aérea, altura das plantas, volume de raiz, massa fresca e seca da raiz, taxas de crescimento absoluto e relativo e incremento para área foliar e altura das plantas após 104 dias. A emergência foi similar nos diferentes substratos. As sementes de sistemas convencionais apresentaram maior vigor; a adubação mineral aumentou a produção de massa fresca da parte aérea; a utilização de substrato contendo solo, areia, esterco e o condicionador de solo Fertium (30 a 50 g L^{-1}) aumentou o volume, massa fresca e seca da raiz das plantas e a taxa de incremento nestas variáveis.

Palavras-chave: *Brassica oleracea* var. *italica*, emergência, produtividade, nutrição de plantas, substratos.

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The broccoli (*Brassica oleracea* var. *italica*), from the family Brassicaceae, is a shrub-kind annual vegetable of great importance in human food and in the production of vegetable oils and fats. This plant presents thick inflorescences, succulent stem, with tufts of flower buds of color varying from dark green to bluish, less compact than those of the cauliflower. These shoots and buds are the edible part of the plant (Filgueira, 2003).

The broccoli propagation is carried out through seeds, which can be sown directly to the field or upon trays with individual cells for the obtainment of seedlings and the following transplantation to the field. The later is the method most utilized by the vegetable producers, due to the higher operational efficiency, lower quantity of seeds, better plantlet standardization, easier handling at field, improved pest and disease control and earlier harvesting (Filgueira, 2003, Lopes *et al*., 2005, Laviola *et al*., 2006). In this system, the adoption of high quality seeds is imperative, since evidences show that the low seed quality affects the vigor of the plantlets, reducing productivity (Andreoli *et al*., 2002; Kikuti & Marco Filho, 2007; Malone *et al.,* 2008). The emergency of plantlets in field may present variation depending on the seed vigor, even in a lot with high germinative capacity. Kikuti & Marcos Filho (2007), when studying the physiologic potential of cauliflower seeds and comparing them to the development of the plants in field, verified that the initial development of the plantlets is variable according to the difference in the quality of the lot of the seed. Different lots may present different behavior depending on the climatic conditions prevailing in the period of the experiment in the field (Lopes *et al.,* 2002), on the seed water content, according to what is stated to chinese cabbage by Lopes & Macedo (2008), and on the substrate (Zucareli *et al.,* 2008).

The volume of substrate and seedling age may influence the development of the crop, as observed in cauliflower (Godoy & Cardoso, 2005), although Kano *et al*. (2008) have not confirmed this trend. The composition of the substrate, is responsible for maintaining the mechanical stability of the root system, the stability of the plant in the germination phase (radicle protrusion) and initial development and provide suitable conditions for the growth and production of the plants, with constant supply of water, oxygen and nutrients, besides the handling facility (Figliola *et al*., 1993; Lopes *et al.,* 2005). Therefore, depending on each species, it is important to evaluate what is the best substrate or combination of substrates which provide the seedling production of the best quality (Laviola *et al.,* 2006).

The absorption of soil nutrients by plants during the development phase makes necessary their restitution through fertilization. Organic fertilizers can provide the nutrients necessary for growing plants, and in the production of vegetables, the organic fertilizers have gained prominence as sources of nutrients best suited economically, providing persistent development and reaching levels of competitiveness and high standard marketable products, especially in places where its acquisition is facilitated (Rodigues & Casali, 2000; Lopes *et al*., 2005; Souza & Resende, 2006).

This study aimed to evaluate the production of broccoli depending on the seed production system and the type of substrate.

MATERIAL AND METHODS

Seeds of broccoli, Ramoso Piracicaba cultivar, season 2007, from organic and conventional systems were used. The seeds from the organic crop system were obtained from the field of seed production of the Cooperativa dos Agricultores do Movimento Sem Terra-Cooperal, located in the municipality of Santa Fé das Missões, Rio Grande do Sul state, Brazil, and the seeds from the conventional system were produced by the company AGRISTAR, located in the municipality of Jaíba, Minas Gerais State, Brazil. In the execution of the experiment, the seeds were homogenized separately and reduced to two groups: organic and conventional.

The experiment was carried out in a greenhouse without temperature control, whose temperature and relative humidity were measured daily with the aid of a psychrometer. Each plot consisted of a 6 L vessel coated internally and externally with black polyethylene bags to prevent the loss of water and substrate.

The soil was an Oxisol, medium texture, collected in the layer B, at a depth of 20-40 cm at the site of the Escola Agrotécnica Federal de Alegre (EAFA) in the district of Rive in the municipality of Alegre, Espírito Santo State, Brazil. The soil was dried in the shade, loose and sieved through a mesh of 2 mm diameter and its chemical analysis showed: pH= 6.6, P= 3.0 mg dm^{-3}, K= 144.0 mg dm^{-3}, Ca= 4.3 $cmol_c$ dm^{-3}, Mg= 1.9 $cmol_c$ dm^{-3}, Na= 5.0 $cmol_c$ dm^{-3}, Al= 0.0 $cmol_c$ dm^{-3}; H+Al= 2.1 $cmol_c$ dm^{-3}, sum of basis= 6.6 $cmol_c$ dm^{-3}, CEC= 8.7 $cmol_c$ dm^{-3}, effective CEC= 6.6 $cmol_c$ dm^{-3}, basis saturation= 75.4%, aluminum saturation= 0,0%, K/CEC= 4.2%, Ca/CEC= 49.2, Mg/CEC= 21.7%, Na/CEC= 0.2%, Al/CEC= 0.0%, H+Al/CEC= 24.6, Ca/Mg= 2.3, Ca/K= 11.6, Mg/K= 5.1, and organic matter= 6.9 g kg^{-1}, and the physical analysis: coarse sand (g kg^{-1}) = 293.72, fine sand (g kg^{-1}) = 84.45, silt (g kg^{-1}) = 136.71, clay (g kg^{-1}) = 485.12, and soil density (kg dm^{-3}) = 1.13.

Soil and sand (sieved through 2 mm mesh), manure (sieved through 4 mm mesh) and the soil conditioner Fertium® were used to make the substrates. The substrates were prepared as follows: (1:1:1): S1 (soil + sand + manure), S2 (soil + sand + manure + NPK*), S3 (soil + sand + manure + Fertium® 10 g L^{-1}), S4 (soil + sand + manure + Fertium® 30 g L^{-1}) and S5 (soil + sand + manure + Fertium® 50 g L^{-1}); and *NPK: 40 kg ha^{-1} of N in the form of ammonium sulfate, 400 kg ha^{-1} of P_2O_5 in the form of triple superphosphate and 100 kg ha^{-1} K_2O in the form of potassium chloride (Dadalto & Fullin, 2001). The recommendation was based on a population of 20.000 plants ha^{-1} (Camargo, 1992), and on the soil chemical analysis (Silva, 1999).

For irrigation, we determined the moisture retention in the tension of 0.010 MPa for field capacity (CC) in the Richards pressure chamber, with porous plate (Embrapa, 1997) maintained at 70% (Filgueira, 2003). For control of irrigation, the change in the mass of the pots was measured daily on an electronic scale with accuracy of 0.01 g. We carried out the pest control following the crop necessity, spraying with a solution of 1% Bioneen (Indian neem oil) following the product technical recommendation.

For sowing, 20 seeds were sown in each pot, to the depth of 0.2 cm. The experiment was carried out in two stages:

First stage - in order to evaluate the seed quality, we carried out a daily evaluation of the plantlet emergence until the 28th day after sowing, when we evaluated: **emergence (E) –** percentage of normal plantlets (BRASIL, 2009), **fresh and dry mass aerial part of plants –** measured with analytical scale (accuracy of 0,0001 g), the dry mass being obtained after drying the plantlets into a stove with forced air circulation at 80±3 ºC, for 72 hours. The results were expressed in mg $plant^{-1}$, **emergence speed index (IVE) –** determined according to Maguire (1962), **plantlet height (AP) –** determined with a millimeter ruler, obtained through the measure, in centimeters, of the distance between the plant base (soil) and the insertion point of the first leaf pair, **leaf area** – determined in five plantlets, randomly chosen, through the following equation (Grimes & Carter, 1969): $Y = 0{,}4322x^{2{,}3002}$, in which: Y = leaf area $leaf^{-1}$ and x = length of the leaf central vein.

Second stage - in order to evaluate the plant development and the production, the thinning was carried out 28 days after sowing, retaining one plant in each pot. The chemical composition of the substrates was determined and the top dressing was carried out with ammonium sulfate, following the recommendation for the crop. Afterwards, the evaluations were carried out each seven days, until the harvest (104 days after sowing) and we evaluated: **diameter of the base –** measured close to the soil, with a caliper rule, and the results were expressed in centimeters, **leaf area –** evaluated each 30 days, according to what was previously described, **number of leaves –** the plants were cut close to the soil 76 after thinning, separated into aboveground part and roots and the number of leaves being evaluated, **plant height –** measured each seven days, through a millimeter ruler from the plant base (soil) to the apical end of the main stem, **fresh and dry mass aerial part of plants** -determined using an analytical scale (accuracy 0.001 g), dry mass being obtained after drying the aboveground part in the stove with forced air circulation, 80±3°C for 72 hours, and the results expressed in mg plant^{-1}, **volume, fresh and dry mass of roots** - roots were washed in water containers, with the aid of a sieve of 2 mm, the detached roots being collected. Volume was determined with a graduate cylinder and fresh and dry weight were determined on an analytical scale (accuracy 0.001 g), and the dry mass was obtained in a stove with forced air circulation at 80±3°C for 72 hours. The results were expressed in mg plant^{-1}.

At the stage of development and production of broccoli, we used the absolute growth rate, to identify the average speed of growth (Benincasa, 2003). The **absolute growth rate, relative growth rate and increment** were determined for leaf area and plant height in both cropping systems (Benincasa, 2003). The experimental design was randomized complete block design (DBC) with six replications and plots consisting of 20 seeds in each pot for the evaluated characteristics until the stage of plant development. After trimming, the most vigorous plants were kept in each pot.

In the final stage of production, we evaluated four replications per treatment, with the remaining two retained for seed production. To standardize the number of replications in the different phases of the experiment, we detected the four replications used from the initial phase and we eliminated the other two. The treatments were in a factorial arrangement 2x5 (two lots of seeds and five substrates) in a randomized block design with four replications.

The data were subjected to analysis of variance, and when significant difference was observed, the means of qualitative factors were compared by Tukey test (p≤0.05). For the effects of the quantitative factors, we proceeded to the regression analysis.

RESULTS AND DISCUSSION

The seedling emergence did not differ significantly among the used substrates, independently on the origin of the seeds (Table 1A). The same way, Pires *et al*. (2003), evaluating seed germination and early development of broccoli seedlings in different substrates, treated with different soil conditioners, did not find differences among the substrates.

Fresh and dry mass of the aboveground part of the seedlings were superior in the substrate containing soil + sand + manure conditioned with Fertium® 10 (S3), 30 (S4) and 50 (S5) g L^{-1} (Table 1A). The seedling growth in the initial phase was proportional to the concentration of the soil conditioner Fertium® in the substrates with mineral fertilization, probably because of the higher cation exchange capacity (CEC) and, consequently, the greater availability of nutrients. Similar results were observed in growth of broccoli sprouts in mining soil, organic fertilizer and NPK substrate (Lopes *et al*., 2004).

For all the evaluated substrates, the coefficient of emergence speed (IVE) was higher for conventional seeds in relation to organic seeds (Table 2A). However, higher dose of soil conditioner (50 g L^{-1}) did not increase the IVE, independently of the origin of the seeds (Table 2A).

Although the soil conditioner has the function to improve the substrate structure, it is possible that higher concentrations increased the concentrations of some elements, interfering negatively in the uptake of water and in the seed germination speed. These results were observed in substrates with Fertium® S3, S4 and S5 showing higher values of sodium 3.1; 2.9 and 2.8 (Na/CTC (%) respectively,

Table 1. Evaluated broccoli characteristics depending on seed origin and substrates (características avaliadas em plantas de brócolo (*Brassica oleracea* L. var. *italica*)*,* em função da origem da semente e substratos). Alegre, UFES, 2009.

Characteristics	Substrates				
	S1	S2	S3	S4	S5
(A) 28 days after seeding					
E (%)	86 a	87 a	81 a	87 a	79 a
MFPA (g)	204.12 c	265.74 c	1787.48 b	2394.95 a	2477.25 a
MSPA (g)	30.46 b	30.21 b	221.10 a	271.60 a	278.72 a
(B) 104 days after seeding					
D (mm)	11.75 ab	15.00 a	13.62 ab	10.75 b	12.75 ab
AF (dm^2)	37.43 c	95.24 a	57.80 b	50.81 b	52.55 b
V (mL)	19.37 c	29.87 b	45.87 a	18.12 c	19.37 c
NF	13.00 b	17.50 a	14.88 ab	15.13 ab	16.88 a
MSPA	13.56 c	44.22 a	25.45 b	15.07 c	25.02 b

Means followed by the same letter in the line, do not differ by Tukey test, p<0,05 (médias seguidas da mesma letra na linha, não diferem entre si pelo teste de Tukey, p<0,05). After 28 days: E= emergency; MFPA= fresh mass of the aerial part; MSPA= dry mass of the aerial part. After 104 days: D= stem diameter; AF= leaf area; V= root volume; NF= leaf number; MSPA= dry mass of the aerial part (após 28 dias da semeadura (A): E= emergência; MFPA= massas fresca da parte aérea; MSPA= massa seca da parte aérea. Após 104 dias da semeadura: D= diâmetro do colo; AF= área foliar; V= volume da raiz; NF= número de folhas; MSPA= massa seca da parte aérea).

Table 2. Unfolding of the significant interaction between the seed origin and substrates after 28 days (A) for emergency speed index (IVE). height (A) and leaf area (AF) and 104 days (B) for height (A). leaf area (AF). fresh mass of the aerial part (MFPA). root fresh mass (MFR) and root dry mass of the broccoli plants (*Brassica oleracea* L. var. *itálica*) (desdobramento da interação entre origem da semente e substratos após 28 dias (A) para índice de velocidade de emergência (IVE). altura (A) e área foliar (AF); e 104 dias (B) para altura (A). área foliar (AF). massa fresca da parte aérea (MFPA). massa fresca da raiz (MFR) e massa seca da raiz (MSR) de plantas de brócolos (*Brassica oleracea* L. var. *italica*). Alegre. UFES. 2009.

Characteristics	System	Substrates				
		S1	S2	S3	S4	S5
(A) After 28 days of seeding						
IVE	ORG	3.30 Ba	3.52 Ba	2.80 Bb	3.30 Ba	2.60 Bb
	CONV	4.17 Aab	4.15 Aab	4.17 Aab	4.51 Aa	4.00 Ab
A (mm)	ORG	4.37 Ab	5.52 Ab	8.25 Aa	9.15 Aa	10.25 Ba
	CONV	3.20 Ac	4.80 Ac	9.45 Ab	9.20 Ab	13.12 Aa
AF (dm^2)	ORG	34.67 Bc	90.62 Ba	62.29 Ab	55.26 Ab	56.14 Ab
	CONV	40.61 Ac	97.62 Aa	49.78 Bb	46.35 Bbc	44.17 Bbc
(B) After 104 days of seeding						
A (mm)	ORG	241.25 Aa	310.00 Aa	303.75 Aa	270.00 Aa	255.62 Ba
	CONV	222.50 Ac	305.00 Ab	298.75 Abc	263.75Abc	512.50 Aa
AF (dm^2)	ORG	35.77 Ac	90.62 Ba	62.29 Ab	55.26 Ab	56.14 Ab
	CONV	39.10 Ac	99.86 Aa	53.31 Ab	46.35 Abc	48.97 Abc
MFPA (g)	ORG	138.63 Ac	253.59 Ba	197.34 Ab	127.68 Ac	162.54 Abc
	CONV	117.69 Ab	300.70 Aa	154.80 Bb	131.70 Ab	136.90 Ab
MFR (g)	ORG	36.10 Ac	48.71 Bb	80.00 Aa	20.93 Bd	44.80 Abc
	CONV	41.61 Ab	86.00 Aa	83.55 Aa	37.30 Ab	42.20 Ab
MSR (g)	ORG	8.57 Ac	14.15 Bb	24.20 Aa	8.26 Ac	11.78 Abc
	CONV	8.48 Ac	25.11 Aa	23.97 Aa	10.00 Abc	12.29 Ab

Means followed by the same letter. lowercase in the line or uppercase in the column. do not differ by Tukey test. $p<0.05$ (médias seguidas da mesma letra. minúscula na linha ou maiúscula na coluna. não diferem entre si pelo teste de Tukey. $p<0.05$).

than in used substrates with no Fertium®. The sensibility to higher or lower salt concentrations in the soil is typical of each kind of plant and the effects in the yield of the crop can be influenced by other factors like the osmotic, toxic and nutritional potentials (Viana *et al*., 2004), according to the evaluated factors in *Brassica pekinensis* cv. Granat (Chinese cabbage) (Lopes & Macedo, 2008).

On the other hand, no matter the substrate used, the height of the broccoli seedlings did not differ in relation to the origin of seeds, the exception was the substrate S5, in which a higher height of the seedlings was observed in conventional seeds (Table 2A).

S2 substrate showed higher values for leaf area for conventional, as well as, for organic seeds. For organic seeds, the substrates S1, S2 and S4 showed higher values for IVE, and the substrates S3, S4 and S5, in the highest height of seedlings (Table 2A). For conventional seeds, the IVE did not differ in substrates S1, S2, S3 and S4, and for the height, only the substrate S5 stood out. Alves *et al*. (2005), working on coriander, reported that the IVE increased with the increase of doses of bovine manure in the absence of NPK.

In general, in the initial phase of growth, the seedlings grown in substrate enriched with soil conditioner showed appropriate growth. For organic seeds, no significant coefficient value of regression in absolute growth rate of leaf area (Figure 1A) and height (Figure 1B) was observed in the different used substrates, except for substrate S5, in which the absolute growth of leaf area showed higher value, after 90 days of sowing. The relative growth rate of leaf area (Figure 1C) did not show significant effect for the regression coefficient in any of the evaluated substrates. However, for height (Figure 1D), in the substrate S2, the relative growth rate was higher, on the 62nd day.

In the evaluation of the increase of the leaf area (Figure 1E), no significant coefficient of regression was noticed in all the evaluated substrates. For the increase of the height of the plants (Figure 1F), the higher increase was noticed in plants cultivated in substrate S2, after 62 days of sowing. During this period, the plants possibly demand more nutrients in comparison to the earlier period in order to achieve a higher level of yield.

The behavior of relative growth rate in relation to time (Figure 1D) showed a decrease in the development of the broccoli crop cycle, experiencing rapid accumulation of material, followed by a lower increment phase.The results obtained suggest that Fertium® improves soil structure. This effect was observed in a faster way, showed through absolute growth rate (Figure 1A), in comparison

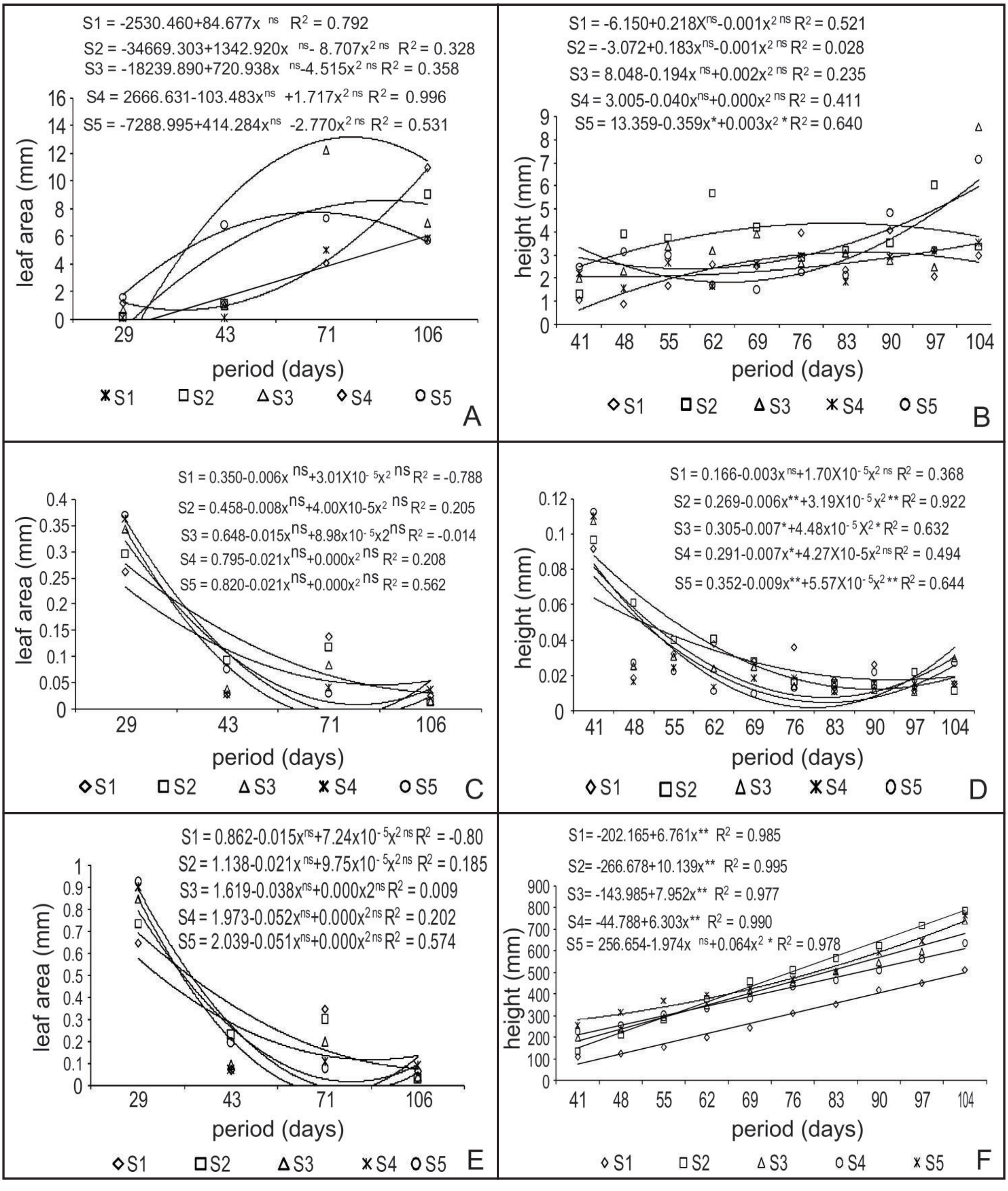

Figure 1. Absolute growth rate (mm): leaf area (A) and height (B); relative growth rate (mm): leaf area (C) and height (D); and increment (mm): leaf area (E) and height (F) of seeds of *Brassica oleracea* var. *italica* obtained from organic cultivation system (taxa de crescimento absoluto (mm): área foliar (A) e altura (B); taxa de crescimento relativo (mm): área foliar (C) e altura (D); e incremento (mm): área foliar (E) e altura (F) de sementes de *Brassica oleracea* var. *italica* provenientes de sistema de cultivo orgânico). Alegre, UFES, 2009.

to the mineral fertilizer containing NPK, which showed better availability in yield phase, noticed in relative growth rate (Figure 1D).

In conventional system (Figure 2), absolute growth rate of leaf area (Figure 2A) was higher in substrate S5, reaching higher value on the 71st day after sowing. The release of nutrients by the soil conditioner Fertium® was probably the reason of a higher absolute growth rate, keeping the growth in a gradual way without large decrease in growth. Absolute growth rate of the height (Figure 2B), in substrate S1 showed a significant increase, higher values after 62 days. In relation to relative growth rate of leaf area (Figure 2C), no difference among the substrates was observed. However, in relative growth rate of height (Figure 2D),

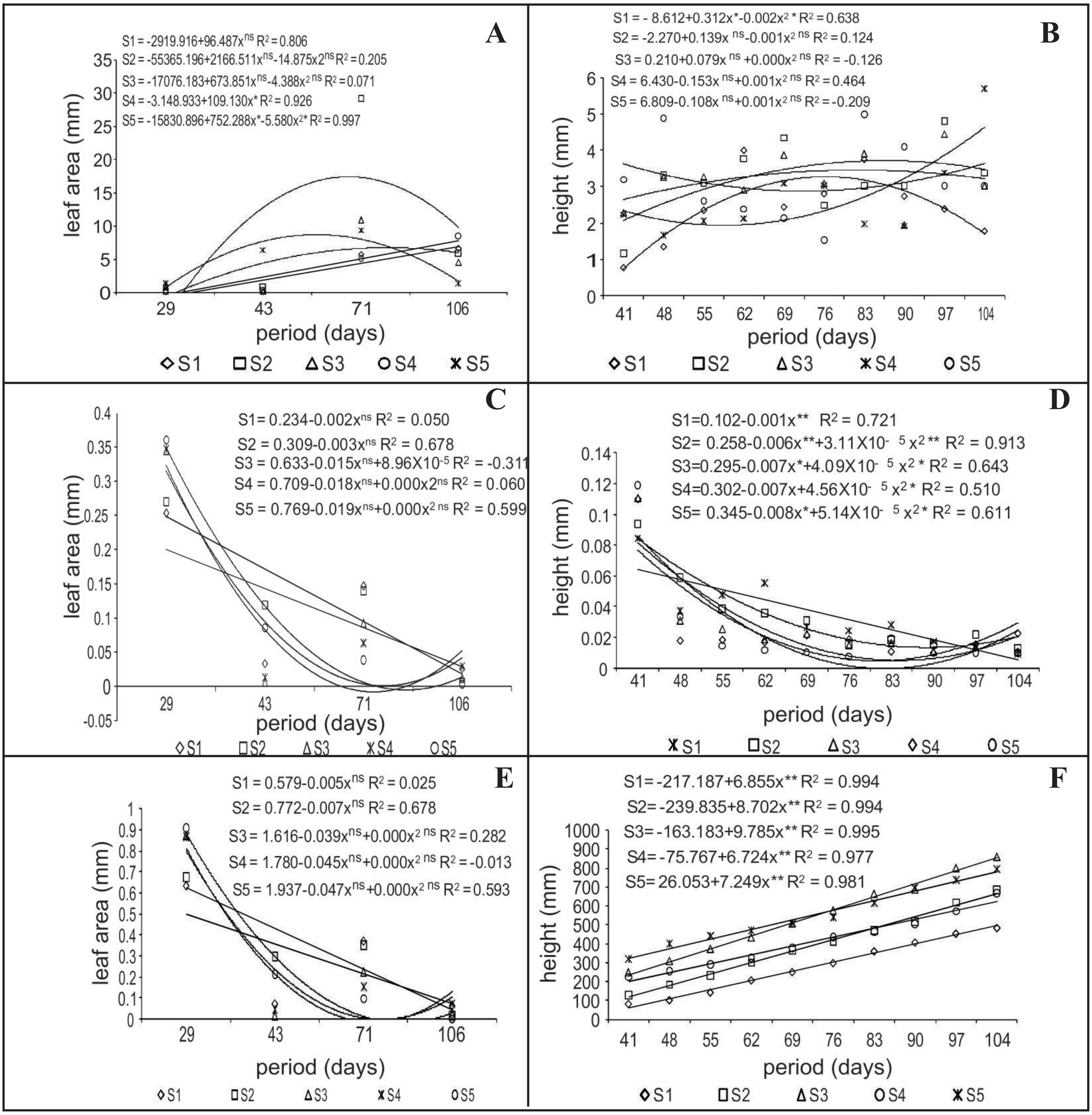

Figure 2. Absolute growth rate (mm): leaf area (A) and height (B); relative growth rate (mm): leaf area (C) and height (D); and increment (mm): leaf area (E) and height (F) of seeds of *Brassica oleracea* var. *italica* obtained from conventional cultivation system (taxa de crescimento absoluto (mm): área foliar (A) e altura (B); taxa de crescimento relativo (mm): área foliar (C) e altura (D); e incremento (mm): área foliar (E) e altura (F) de sementes de *Brassica oleracea* var. *italica* provenientes de sistema de cultivo convencional). Alegre, UFES, 2009.

the results were higher in substrates S2 and S1, after 48 and 62 days, respectively. For the increase of leaf area, no significant difference among substrates was observed.

Height increase (Figure 2F) was higher in substrate S5, up to 69 days after sowing. After, higher value was observed in substrate S3. Probably, a higher availability of nutrients of the substrates containing organic fertilizer occurred, due to the process of mineralization in the substrate. Diniz *et al*. (2008) showed that higher levels of organic compost in the cultivation of broccoli provide higher relative growth rates.

Root volume, plant diameter, number of leaves and dry mass of aerial part of the plants were also influenced by the kind of substrate used (Table 1B). Lower level of soil conditioner in the substrate (S3) determined the higher effect of root volume (Table 1B). This may have happened because of a higher moisture retention and aeration, provided by the soil conditioner and, consequently, the reduction of temperature, resulting in higher development of root system of plants. Considering number of leaves in relation to substrates, higher values were observed in substrates S2, S3, S4 and S5, which showed similar results. However, in the evaluation of dry mass of aboveground part, a higher accumulation in developed plants was observed in substrate S2 (Table 1B).

Data analyses showed a significant interaction among the variables seed origin x the type of substrate for the variables total height of the plant, leaf area, fresh mass of aerial part and fresh and dry mass of root (Table 2B). No significant difference was observed in relation to the type of substrate used, for height of conventional or organic seeds, except in substrate S5, in which conventional seed plants showed higher height. For organic seed plants, no significant difference was observed for height, independently of the type of substrate used. However, for conventional seed plants, higher height was observed in substrate S5.

Substrate S2 provided plants with higher leaf area and higher fresh mass of aboveground part, for conventional and organic seeds (Table 2B). In both cases, however, conventional seed plants showed higher vigor. For substrates S1, S4 and S5, no difference was observed in fresh mass of the aerial part of organic or conventional seeds and, in substrate S3, the aboveground part of organic seeds accumulated higher fresh mass. Ototumi *et al*. (2001) showed higher values of fresh mass of broccoli when cultivated in conventional system.

Considering the marketable mass of broccoli Ramoso Piracicaba, in average, 600 to 800 grams per plant, the average yield obtained, in this work, showed lower values to the marketable standard of the cultivar. It is possible that high temperatures in the greenhouse (higher than 30^0C) during the crop cycle interfered in the development of the productivity of the plants, even broccoli being an adapted crop for the summer weather (Björkman & Pearson, 1998).

In relation to fresh mass of roots of both seed systems, the plants cultivated in substrates S2 and S3, showed higher values (Table 2B). Possibly, the use of substrate containing lower dose of soil conditioner or mineral fertilizer provide better development in root system through making available higher quantity of nutrients of substrate for the plant, which show higher quantities of phosphorus in its composition. Besides, it is a fact that pH values between 6.0 to 7.0 increase availability of nutrients in mineral and organic substrates. In this study, these values were between 5.2 and 5.5 and only the mineral substrate (S2) showed pH 6.5, whereas in the organic ones the pH was higher than 7.0, above recommended. Besides, K, Ca, P and Mg contents were above recommended values for these used substrates: K= 0.28 to 0.46 $cmol_c\ dm^{-3}$, Ca= 0.7 to 1.2 $cmol_c\ dm^{-3}$, P= 8.0 to 13 mg L^{-3} and Mg= 0.5 to 0.83 $cmol_c\ dm^{-3}$ (Camargo, 1992; Silva, 1999; Dadalto & Fullin, 2001). It is possible that, the substrate composition, associated to the temperature oscillation observed in the greenhouse, interfered in the availability of nutrients for the plants, interfering in the broccoli productivity.

This study showed that the quality of seeds is fundamental for the crop establishment and for the increase of productivity. The germination of seeds was similar in different substrates, however, higher vigor was observed in conventional seed. Although the mineral fertilizer increase fresh mass of the aerial part, the use of the substrate containing soil, sand, manure and soil conditioner Fertium in levels of 30 to 50 g L^{-1}, provide an increase in volume, fresh and dry mass of root and rate of increment in these variables.

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