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RESEARCH PAPER

The effect of substrates with compost and nitrogenous fertilization on photosynthesis, precocity and pepper (*Capsicum annuum*) yield

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Abstract

J. De Grazia, P.A. Tittonell, and A. Chiesa. 2007. The effect of substrates with compost and nitrogenous fertilization on photosynthesis, precocity and pepper (*Capsicum annuum*) yield. Cien. Inv. Agr. 34(3):151-160. Fast-growing seedlings have larger immediate nutrient demands as compared with adult plants. A tray experiment was conducted to evaluate the fertilization of sweet pepper transplants growing on different substrates [Control (60% *Sphagnum* peat + 40% perlite), Mix I (45% *Sphagnum* peat + 30% perlite + 25% farmyard compost), Mix II (30% *Sphagnum* peat + 20% perlite + 50% farmyard compost), and Commercial (40% compost + *Sphagnum* peat + perlite + vermiculite)] with weekly applications of nitrogen at rates of 150 and 300 mg·L^{-1}, compared to a control without fertilization. Seedlings were transplanted in a randomized, complete block design with four replications. Leaf area and fresh and dry weights of leaves, stems and roots were measured for the transplants; the leaf weight ratio, specific leaf area, absolute and relative growth rates, leaf expansion rates, leaf area duration, and net assimilation rate were calculated. Precocity, early yield, and total yield were measured for the field crop. The application of nitrogen had positive effects on most growth parameters of seedlings growing on substrates with compost, promoting increased precocity and yield in the transplanted crop. Few benefits from nitrogen fertilization were observed for seedlings growing on substrates without compost. The main effect of the latter is to improve the efficiency of capture of the applied nitrogen, due to better water retention and ion-exchange capacity.

Key words: *Capsicum annuum*, compost, early yield, growing medium, leaf area, nitrogen, seedling.

Introduction

The initial growth stage of pepper seedlings (*Capsicum annuum* L.), as well as other vegetable crops, is critical for good production. The speed and uniformity of emergence and the initial growth rate are essential for obtaining quality seedlings in reasonable periods of time (De Grazia *et al.,* 2004a).

The goal of using substrate mixtures in the production of seedlings of florihorticultural species is to obtain quality plants in the shortest possible period with the lowest possible costs (Buyatte, 2000). For this purpose, *Sphagnum* peat has been the organic matter most frequently used as a substrate component for commercial seedling production. However, as *Sphagnum* peat is not a renewable resource and its price is expected to rise considerably, finding substitutes for *Sphagnum* peat appear to be essential (Subler *et al.*, 1998).

In comparison to adult plants, seedlings have a high demand for mineral nutrients, partly as a result of seedlings' high growth rate (Wien, 1997). In addition to providing nutrients, the substrates to be used for seedling production must allow good water availability and water

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retention, promote efficient gas exchange, and serve as a physical support for the plant (Leskovar and Stoffella, 1995).

Seedlings produced in containers may be exposed to different types of stress (water, nutrition, light, temperature and mechanical resistances), which may cause morphological and/or physiological damage during the initial development of the root and aerial tissues. The physical and chemical properties of the soil or the growth medium in cultivation systems without soil affect root elongation, direction of growth, and the ramification pattern (Feldman, 1984). Any root stress is expressed in the aerial part of the plant, affecting the dry matter partition between roots and shoots. Therefore, stress influences plant productivity (Brouwer and De Wit, 1969). The functional balance between roots and shoots corresponds to an interrelated growth, where changes in the aerial growth rate are expressed in the root and vice versa (Brouwer, 1963).

A short and poorly developed root system explores a lower soil volume to obtain water and nutrients. Low root length per unit of soil volume and/or a low root density requires the rates of water and nutrient absorption to be higher than normal to satisfy the demands of the growing seedlings (Bennie, 1991).

In several studies, materials of organic origin, for example topsoil (remains of herbaceous, shrub-like and arboreal vegetation), chicken and/or hen bedding (mixture of chicken and/or hen manure with materials used as bedding in henhouses), and worm humus, with or without soil, showed satisfactory results as growth substrates for vegetables (Princich *et al*., 1997; Valenzuela and Gallardo, 1997; Subler *et al*., 1998; Atiyeh *et al*., 2000; Rothman *et al*., 2000). However, highly nutritional substrates may be harmful due to their high levels of soluble salts (O'Hallorans *et al*., 1993; Chang *et al*., 1994; Chang and Rinker, 1994; Gómez *et al*., 1996).

In general, the use of composted materials allows the replacement of renewable resources (e.g. peat) and transforms organic wastes into usable substrates instead of environmental pollutants. Moreover, the seedlings' growth is promoted by the supply of micro- and macronutrients, which would otherwise be provided through fertilization (Prieto, 2005).

The addition of mineral nutrients to the substrate mixtures may improve the nutrients' immediate availability, limiting the temporary immobilization effect caused by the organic components of the substrate (C:N, C:P). Moreover, this practice may decrease or eliminate the need to add compost or soil. The objective of this work was to evaluate the effect of the addition of nutrients to substrates used in pepper seedling production, through the characterization of the photosynthetic apparatus, precocity, and early and total yields.

Materials and methods

This work was done in greenhouses for the commercial production of pepper seedlings (*C. annuum*) in Las Colonias, Florencio Varela, located in the horticultural belt of Buenos Aires, between August of 2004 and March of 2005. A chapel-type greenhouse, consisting of a wooden structure and an LDT polyethylene cover (150 µm thick) for the roof and lateral walls, was used. The greenhouse was 30 m^2 (nursery), with a ridge purlin height of 2.9 m and lateral ventilation. Heating was supplied via resistance electric radiators.

Saxo F1 hybrid pepper was used (Clause Semences International Inc.). The seeds were pre-germinated in a chamber at 25ºC and were sown, with 1.5 mm of the root emerged, on August 13th, 2004. The seeded trays were put on 1.10 m-high tables and watered by means of microaspersion. The trays were disinfected with sodium hypochlorite (2 $mL \cdot L^{-1}$) before being filled with sterile substrate. Later, neutral oxiquinolein sulphate (0.3 $g \cdot L^{-1}$) was applied every week, and captan (2.5 $g \cdot L^{-1}$) every two weeks.

Treatments

The substrates used were: 1. Control substrate (To), consisting of 60% (v/v) *Sphagnum* peat and 40% pearlite; 2. Substrate mixture I (MI), composed of 45% (v/v) *Sphagnum* peat, 30% pearlite and 25% composted plant materials; 3.

Substrate mixture II (MII), composed of 30% (v/v) *Sphagnum* peat, 20% pearlite, and 50% composted plant materials; and 4. Commercial substrate (Co) (Grow Mix S1, Terrafertil S.A.), composed of *Sphagnum* peat, organic compost, pearlite and vermiculite. Each substrate was fertilized every week with urea at a ratio of 150 $mg \cdot L^{-1}$ of nitrogen (F1) or 300 $mg \cdot L^{-1}$ of nitrogen (F2); in addition, a control substrate was left unfertilized (F0). These treatments were made along with the watering during four successive weeks. The electric conductivity of a saturated extract (1:2.5 v/v) of every substrate was determined at 25°C.

Measurements and determinations

The samples for the characterization of the seedlings' photosynthetic apparatus were obtained at the beginning of the fertilization treatments, 27 days after sowing (dah) and when, in most of the treatments, the transplanting size had been reached (7-8 true leaves), at 57 days. Each sample consisted on five complete plants per repetition. The leaf area (LA) and the fresh weights of leaves (LFW), stems (SFW) and roots (RFW) were determined. The dry weights of leaves (incubated at 65°C for 72 h) (LDW), stems (SDW) and roots (RDW) were also determined.

Growth analysis

For this analysis, the results obtained were processed according to Hunt (1978, 1982). The leaf area ratio [$LAR = LA \cdot (LDW + SDW)^{-1}$], a specific leaf area ($SLA = LA = LA \cdot LDW^{-1}$), the absolute growth rate (AGR) and the leaf expansion rate in absolute terms (ALER) were calculated.

The photosynthetically active surface present in the plant in the different samplings was integrated to estimate the leaf area duration (LAD). The relative growth rate (RGR) was calculated in relation to the fresh and dry matter: RRG ($mg \cdot day^{-1}$) = $(\ln P_2 - \ln P_1)\,(t_2 - t_1)^{-1}$, with P_2 and P_1 being the values of the weights at times t_2 and t_1, respectively (Venus and Causton, 1979).

Through an analogous procedure, the rate of leaf expansion rate was calculated in relative terms (RLER). The efficiency of the photosynthetic apparatus was indirectly determined through the net assimilation rate (NAR), estimated based on the relationship NAR ($g \cdot cm^{-2} \cdot day^{-1}$) = $(TDW_{final} / LA_{final} - TDW_{initial} / LA_{initial})$ x $(\alpha / \alpha - 1) / das_{1.2}$, where $\alpha = (\ln TDW_{final} - \ln TDW_{initial}) \cdot (\ln LA_{final} - \ln LA_{initial})^{-1}$, and $das_{1.2}$ is between the first and the second sampling, indicated as initial and final in the equation (Evans, 1972).

After transplanting, the precocity in days was determined for each transplanted plant (dat), and the weight of the harvested fruits was recorded for the first raceme (the fruit of the first dichotomic ramification was collected prior to its development); the moment of the beginning of harvest was considered to be when 50% of the plants on every farm reached that condition. The yield throughout the entire production cycle was determined.

Transplanting and cultivation

Each transplant was cultivated separately in a 1200 m^2 greenhouse with a parabolic roof whose maximum height was 3.50 m and whose walls were at 2.10 m. The greenhouse had a metallic structure with a 150 μm-thick roof and 100 μm-thick LTD polyethylene curtains, which allowed frontal and lateral ventilation. The socles were made of 60 cm of polyethylene, 100 μm thick.

The greenhouse soil was treated with 10 $g \cdot m^{-2}$ of dazomet 20 days before the transplanting. A fertilization base with diamomic phosphate was applied (18:46:0) at a ratio of 150 $kg \cdot ha^{-1}$, a week before the transplanting. A second, identical application was made on October 23rd of 2004 for all the treatments, using a frame plantation of 1.0 m between the lines with 0.3 m between plants inside each line. The greenhouse was not heated and it was drip-watered.

Starting from the blooming of the first flower, 100 $kg \cdot ha^{-1}$ of urea was applied (46:0:0) along with the watering in four biweekly applications. The phytosanitary program consisted of preventive applications of systemic fungicides, benomyl (0.9 $g \cdot L^{-1}$) and carbendazim (0.3 $g \cdot L^{-1}$), and of contact insecticides, captan (1.2 $g \cdot L^{-1}$)

and mancozeb (2.0 g·L^{-1}) and endosulfan (1.5 L·ha^{-1}) and deltametrine (0.2 cm^3·L^{-1}). The weeds were manually controlled.

Design and statistical analysis

During the stage of seedling production, the experimental design consisted of a completely randomized arrangement, with four repetitions in a factorial combination of 3 x 2 factors (three levels of nitrogenous fertilization x four substrate mixtures), considering each 91-cell-tray as an experimental unit. The treatments for the transplanted seedlings were distributed according to a completely randomized block design with four repetitions; the experimental unit was represented by farm plots of 4.2 m^2. The results obtained were subjected to an analysis of variance and the averages were separated, according to Tukey ($p < 0.05$). The relationship between the experimental variables and the response was studied via an analysis of linear regression.

Results and discussion

At 27 days after sowing, for the different types of substrates, statistically significant differences were obtained ($p < 0.05$) for all the parameters related to the characteristics of the photosynthetic apparatus (Table 1). The seedlings cultivated on the control substrate showed the lowest LA, SLA, LAR and ALER values. These values were significantly different ($p < 0.05$) from those for seedlings on the remaining substrates (Table 1). In comparison to the average across treatments, these control seedlings had 55.4% of the LA, 71.9% of the SLA, 79.3% of the LAR, and 55.7% of the ALER. This demonstrated the beneficial effects of the addition of composed materials to the substrate mixture for the parameters related to the photosynthetic apparatus. The commercial substrate was not statistically different from mixture I with regard to the resulting leaf area and absolute leaf expansion rate. Mixture II, which was not differentiated in terms of the specific leaf area and leaf area ratio, gave higher values than the Control mixture (Table 1).

With regard to the absolute growth rate on fresh weight basis, the commercial substrate was not statistically different from Mixture I, but resulted in a higher absolute growth rate than Mixture II ($p < 0.05$) and the control substrate ($p < 0.01$). The control mixture produced seedlings with a lower speed of initial growth than the rest ($p < 0.01$), reaching only 56.8% of the average AGR on fresh weight basis (Table 1). This behavior was different from what was previously observed by Tittonell *et al*. (2003) and Rouphael (2004). According to these authors, the substrates with composted materials or worm humus produced seedlings with lower initial growth speeds. This is possibly due to the highest minimun temperature of the Mixtures composed of peat and pearlite. The absolute growth rate on dry weight basis, on the basis of dry weight, showed a different behavior, as the seedlings cultivated on the commercial substrate exhibited the highest values ($p < 0.01$) and the values for mixture I were intermediate ($p < 0.01$) between those for seedlings on commercial substrate and those for seedlings grown on mixture II or the control substrate (Table 1).

At 57 days after sowing, the evaluated characteristics of the photosynthetic apparatus were not significantly affected by the level of applied nitrogenous fertilizer (Table 1). With regard to the Mixtures used as substrates, significant differences were observed at 27 days for all the parameters associated with the photosynthetic apparatus. However, after transplanting, there were statistically significant differences only between the leaf areas ($p < 0.01$) for the control and mixture I, between the LAD for the control substrate and the rest of the substrates ($p < 0.01$), and between the RLER, where the control substrate produced higher values than the commercial substrate. The other substrate mixtures exhibited an intermediate level without differences between them (Table 1). As indicated in Figure 1, a ALER decrease for cultivated seedlings was observed on the commercial substrate in the later stages of the cultivation cycle, conditioning the rest of the related variables.

The leaf area ratio (LAR) did not differ significantly with the increase in the compost proportion (Table 1); the effect that was expressed in the photosynthetic efficiency,

Table 1. Characteristics of the parameters related to the leafiness and fresh and dry absolute growth rates of pepper seedlings (*Capsicum annuum*) at the beginning of the fertilization treatments, and characteristics of the parameters related to the "leafness" of pepper seedlings at the time of transplanting.

Treatments	Leaf area cm^2	Specific leaf area $cm^2 \cdot g^{-1}$	Leaf area ratio $cm^2 \cdot g^{-1}$	Absolute leaf expansion rate $cm^2 \cdot day^{-1}$		Absolute growth rate, $mg \cdot day^{-1}$	
						fresh	dry
27 days after sowing:							
Substrates[1]:							
Control	1.319 c[2]	489.5 c[2]	337.2 c[2]	0.049 c[2]		1.97 c[2]	0.23 c[2]
Mixture I	2.795 ab	625.1 b	415.5 b	0.104 ab		4.25 a	0.32 b
Mixture II	2.478 b	844.9 a	481.0 a	0.092 b		3.49 b	0.25 c
Commercial	2.925 a	762.5 a	466.9 a	0.108 a		4.18 a	0.40 a
					Relative leaf expansion rate $cm^2 \cdot day^{-1}$	Leaf area duration $cm^2 \cdot day$	Net assimilation rate $mg \cdot cm^{-2} \cdot day^{-1}$
57 days after emergence:							
Substrates[1]:							
Control	7.214 a[2]	1105.1 a[2]	907.0 a[2]	0.196 a[2]	0.0530 a[2]	102.30 b[2]	0.028 a[2]
Mixture I	11.126 a	1180.2 a	855.1 a	0.278 a	0.0451 a	178.50 a	0.028 a
Mixture II	9.759 a	1048.1 a	775.7 a	0.243 a	0.0442 a	157.52 a	0.036 a
Commercial	9.158 a	1019.9 a	717.4 a	0.208 a	0.0367 a	162.91 a	0.032 a
Fertilization:							
Nitrogen, $mg \cdot L^{-1}$							
0	8.902 a[2]	1159.6 a[2]	880.4 a[2]	0.217 a[2]	0.0432 a[2]	146.35 a[2]	0.026 a[2]
150	10.024 a	1088.7 a	794.7 a	0.255 a	0.0473 a	156.76 a	0.035 a
300	9.017 a	1016.8 a	766.4 a	0.221 a	0.0437 a	147.82 a	0.032 a
Interaction F x S	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*

[1]Control (To) = 60% (v/v) *Sphagnum* peat and 40% pearlite. Substrate mixture I (MI) = 45% (v/v) *Sphagnum* peat, 30% pearlite and 25% composted plant materials. Substrate mixture II (MII) = 30% (v/v) *Sphagnum* peat, 20% pearlite, and 50% composted plant materials, and Commercial substrate (Co) = Grow Mix S1 (Terrafertil S.A.) composed of *Sphagnum* peat, organic compost, pearlite and vermiculite.
[2]Means for five seedlings per replicate followed by different letters are significantly different according to Tukey ($p < 0.05$).

as the net assimilation rate (NAR), was not statistically significant. This behavior was different from what was described in previous work (De Grazia *et al*., 2001). Unlike what was observed in such work, where the LAD increased linearly with the increase in the proportion of compost present in the cultivation mixture, in this work the relationship between increasing compost content and the leaf area duration fit a negative quadratic function with a maximum value between mixture I and the commercial substrate (Figure 2).

Unlike what was reported in previous studies (Tittonell *et al*., 2002), where the RGR in dry weight was mainly explained by the growth in leaf area instead of by a higher net assimilation rate, in this test the behavior observed for RGR in dry weight would be associated with a higher intensity of photosynthesis ($y = 0.6751x - 0.004$; $r^2 = 0.65$; $p < 0.05$), characterized by NAR, rather than with increased development of the leaf area ($y = 0.0022x - 0.0033$; $r^2 = 0.41$; $p < 0.05$). However, this difference could be conditioned by the weak relationship existing between LA and RGR in dry weight for the unfertilized seedlings (Figure 3).

The absolute growth rate, based on fresh weight as well as on dry weight, was not significantly affected by either the level of nitrogenous fertilization or the type of substrate used (Table 2). This differs from the results previously obtained, where the AGR based on dry weight of the seedlings increased with augmentation of the proportion of composted materials in the growth environment (De Grazia *et al*., 2004b). The RGR in fresh weight was not significantly

Table 2. Fresh and dry absolute and relative growth rates of pepper seedlings (*Capsicum annuum*) at the time of transplanting (57 days after the sowing date).

Treatments	Absolute growth rate		Relative growth rate	
	fresh mg·day[1]	dry $mg \cdot day^{-1}$	fresh $mg \cdot day^{-1}$	dry $mg \cdot day^{-1}$
Nitrogen fertilization (N), $mg \cdot L^{-1}$				
0	3.96 a[1]	0.15 a[1]	0.0266 a[1]	0.0138 a[1]
150	6.05 a	0.23 a	0.0349 a	0.0193 a
300	5.45 a	0.21 a	0.0336 a	0.0182 a
Type of substrate (S)				
Control	3.94 a[1]	0.12 a[1]	0.0363 a[1]	0.0132 ab[1]
Mixture I	5.63 a	0.23 a	0.0294 a	0.0182 ab
Mixture II	6.13 a	0.27 a	0.0348 a	0.0257 a
Commercial	4.93 a	0.16 a	0.0263 a	0.0113 b
Interaction F x S	*ns*	*ns*	*ns*	*ns*

[1]Means for five plants per replicate followed by different letters within the groups for nitrogen fertilization and type of substrate are significantly different according to Tukey ($p < 0.05$). A non-significant (ns) interaction between nitrogen fertilization and type of substrate was observed.

different for the various fertilization levels or the different mixtures used. On the contrary, the RGR based on the dry weight was higher for the mixture with a larger compost component (MII), consistent with what was observed in other studies (De Grazia *et al*., 2001).

Regardless of the substrate mixtures used, the seedlings' precocity was not significantly affected by the addition of nitrogen to the substrate; neither the precocious yield nor the total yield was affected (Table 3). The seedlings on the control mixture took 3.55 days more than the average across treatments for the first fruits to develop to a marketable size. This result was significantly different ($p < 0.05$) from the results for substrates with composted materials. The precocious yield was significantly lower for the control in comparison to MI and MII. The level of production attained in the first

Table 3. Precocity, early yield and total yield of pepper plants (*Capsicum annuum*).

Treatments	Precocity dat	Fruit yield (fresh weight) early $t \cdot ha^{-1}$	total $t \cdot ha^{-1}$
Nitrogen fertilization (N), $mg \cdot kg^{-1}$			
0	80.92 a[1]	7.27 a[1]	25.45 a[1]
150	79.33 a	7.19 a	26.10 a
300	78.75 a	7.01 a	26.00 a
Type of substrate (S)			
Control	83.22 a[1]	5.26 b[1]	23.19 a[1]
Mixture I	77.11 b	8.44 a	28.40 a
Mixture II	78.67 b	7.64 a	26.78 a
Commercial	79.67 b	7.27 ab	25.01 a
Interaction F x S	*ns*	*ns*	*ns*

[1]Means for five plants per replicate followed by different letters within the groups for nitrogen fertilization and type of substrate are statistically significant according to Tukey ($p < 0.05$). A non-significant (ns) interaction between nitrogen fertilization and type of substrate was observed. dft, days from transplanting.

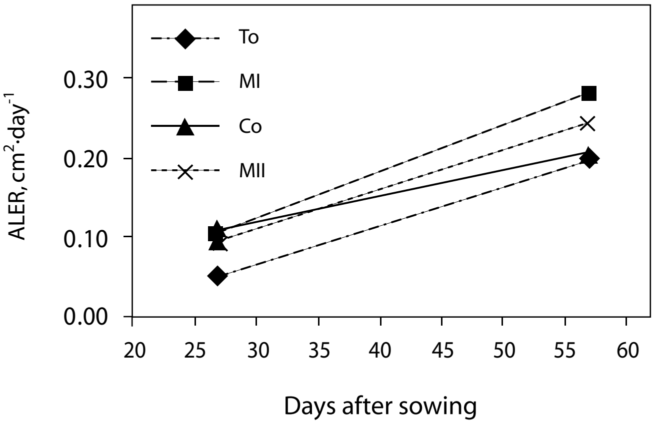

Figure 1. Characterization of the absolute leaf expansion rate (ALER) of pepper seedlings (*Capsicum annuum*) on different substrate mixtures: To = Control substrate, Co = Commercial substrate, MI = Substrate mixture I, and MII = Substrate mixture II. Each point is the mean for five seedlings per replicate.

harvest from the seedlings cultivated on the control mixture only reached 73.6% of the average across treatments, showing the effect the addition of composted material had on this parameter. However, this effect did not mean significant differences with respect to the yield reached throughout the entire production cycle for any of the evaluated substrates (Table 3).

The nitrogenous fertilization of the control substrate mixture was insufficient for the seedlings to reach the values obtained when cultivated on the compost substrate mixtures. Therefore, the main beneficial effect of the compost materials may be to decrease the nutrients' leaching from the matrix substrate due to higher water retention and the increased ionic exchange capacity (De Grazia *et al*., 2004a).

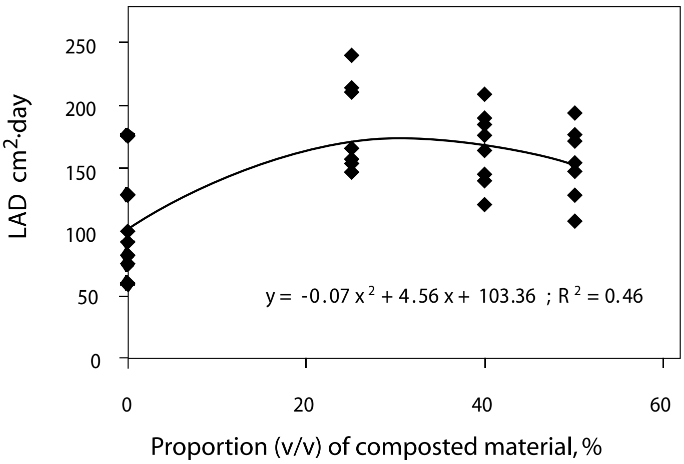

Figure 2. Relationship between leaf area duration (LAD) at the time of transplanting and the proportion of composted materials in the growth substrate of pepper seedlings (*Capsicum annuum*). Each value represents the means for five seedlings per replicate.

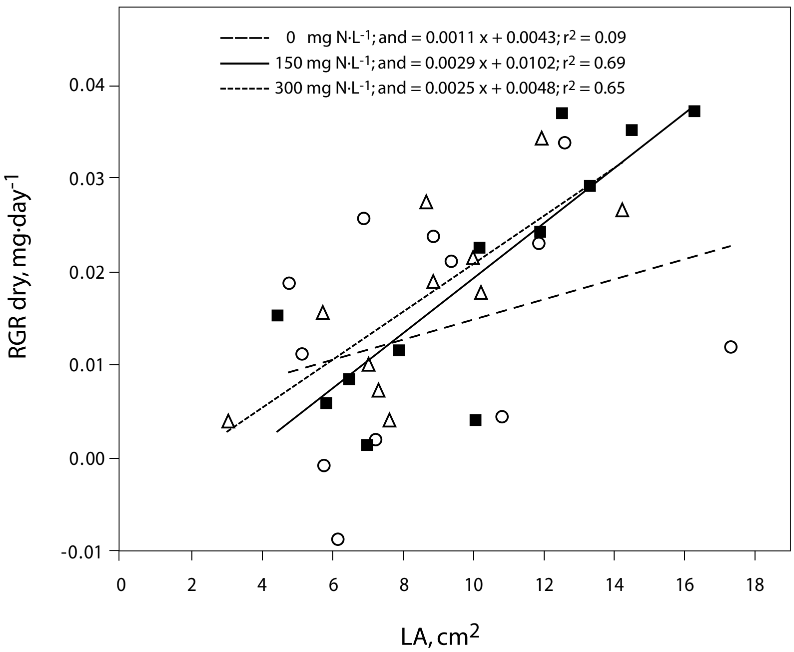

Figure 3. Relationship between relative growth rate (RGR) (on dry weight basis) and leaf area (LA) of pepper seedlings (*Capsicum annuum*) at transplanting for each nitrogen fertilization level. (○: 0 mg·L^{-1}; ■: 150 mg·L^{-1}; △: 300 mg·L^{-1}). Each point is the mean for five seedlings per replicate.

Resumen

Los plantines presentan elevada demanda de nutrientes como resultado de su alta tasa de crecimiento en relación a las plantas adultas. Para evaluar la adición de nitrógeno a sustratos preparados con y sin materiales compostados en la producción de pimiento, se realizó un ensayo fertilizando plantines cultivados en diferentes sustratos: Testigo (60% turba de *Sphagnum* + 40% perlita), Mezcla I (45% turba de *Sphagnum* + 30% perlita + 25% material vegetal compostado), Mezcla II (30% turba de *Sphagnum* + 20% perlita + 50% material vegetal compostado) y un sustrato Comercial (turba de *Sphagnum* + 40% compost + perlita + vermiculita) con 150 y 300 mg□L^{-1} de nitrógeno por semana, manteniendo un testigo sin fertilizar. Los plantines fueron transplantados en invernadero según un diseño de bloques completos aleatorizados con cuatro repeticiones. Previo al transplante se determinó área foliar, pesos fresco y seco de hoja, tallo y raíz, se calculó la proporción areal de hojas, área foliar específica, tasas de crecimiento absolutas y relativas en fresco y en seco, tasa de expansión foliar absoluta y relativa, duración del área foliar y tasa de asimilación neta de los plantines. En el cultivo se determinó precocidad, rendimiento precoz y total. La fertilización nitrogenada de la mezcla de sustrato testigo fue insuficiente para que los plantínes alcanzaran los valores obtenidos al cultivarlos en las mezclas de sustratos con compost. Por lo tanto, es posible que el principal efecto benéfico de los materiales compostados sea disminuir la lixiviación de nutrientes desde la matriz del sustrato gracias a la mayor retención hídrica y al aumento de la capacidad de intercambio de iones.

Palabras clave: Area foliar, *Capsicum annuum*, compost, medio de crecimiento, nitrógeno, rendimiento precoz, transplante.

References

Atiyeh, R.M., C.A. Edwards, S. Subler, and J.D. Metzger. 2000. Earthworm-processed organic wastes as components of horticultural potting media for growing marigold and vegetable seedlings. Compost Science and Utilization 8:215-223.

Bennie, A.T. 1991. Growth and mechanical impedance. Pages 393-416. In: Y. Waisel, A. Eshel, and U. Kafkafi (eds.). Plants Roots: The Hidden Half. Marcel Dekker, New York, USA.

Brouwer, R. 1963. Some aspects of the equilibrium between overground and underground plant parts. Jaarb, I.B.S. Wageningen, The Netherlands 213, 31-39.

Brouwer, R., and C.T. de Wit. 1969. A simulation model for plant growth with special attention to root growth and its consequences. Pages 224-244. In: W.J. Whittington (ed.). Root Growth. Butterworths, London, UK.

Buyatti, M. 2000. Evaluación del comportamiento agronómico del aserrín de salicáceas compostado en mezcla con perlita para la producción de plantines florales. Horticultura Argentina 19:94 (Resumen 310).

Chang, C., and D.L. Rinker. 1994. Use of spent mushroom substrate for growing containerized woody ornamentals: an overview. Compost Science and Utilization 2:45-53.

Chang, C., R.A. Clinc, and D.L. Rinker. 1994. Bark and peat amended spent mushroom compost for containerized culture of shrubs. HortScience 29:781-784.

De Grazia, J., P.A. Tittonell, y A. Chiesa. 2001. Calidad y precocidad del plantín de pimiento (*Capsicum annuum* L.) en función de la proporción de materiales compostados presentes en el medio de cultivo. En: Actas de la II Reunión de Producción Vegetal del NOA. San Miguel de Tucumán, Tucumán, Argentina.

De Grazia, J., P.A. Tittonell, and A. Chiesa. 2004a. Growth and quality of sweet pepper (*Capsicum annuum* L.) transplants as affected by substrate properties and irrigation frequency. Advances in Horticultural Sciences 18:181-187.

De Grazia, J., P.A. Tittonell, y A. Chiesa. 2004b. Eficiencia en el uso de agua en la producción de plantines de pimiento (*Capsicum annuum* L.) cultivados en sustratos adicionados con polímeros superabsorbentes. Horticultura Argentina 23:22-28.

Evans, G.C. 1972. The Quantitative Analysis of Plant Growth. Blackwell Scientific Publications, Oxford, UK. 734 pp.

Feldman, L.J. 1984. Regulation of root development. Annual Review of Plant Physiology 35:223-242.

Gómez, I., J. Navarro Pedreño, R. Moral, M.R. Iborra, G. Palacios, and J. Mataix. 1996. Salinity and nitrogen fertilization affecting the macronutrient content and yield of sweet pepper plants. Journal of Plant Nutrition 19:353-359.

Hunt, R. 1978. Plant Growth Analysis. Edward Arnold, London, UK. 67 pp.

Hunt, R. 1982. Plant Growth Curves. The Functional Approach to Plant Growth Analysis. Edward Arnold, London, UK. 248 pp.

Leskovar, D.I., and P.J. Stoffella. 1995. Vegetable seedling root systems: Morphology, development, and importance. HortScience 30:1153-1159.

O'Hallorans, J., M. Muñoz, and O. Colberg. 1993. Effect of chicken manure on chemical properties of a Mollisol and tomato production. Journal Agriculture of the University of Puerto Rico 77:181-191.

Prieto, F.S. 2005. Calidad del plantín de tomate (*Lycopersicon esculentum* Mill.) cultivado en sustratos adicionados con lombricompuesto. Tesis de grado. Facultad de Agronomía, Universidad de Buenos Aires, Buenos Aires, Argentina. 14 pp.

Princich, F.R., C.S. Gallardo, y O.R. Valenzuela. 1997. Empleo de lombricompuesto como sustrato de crecimiento para plantines de pimiento (Híbrido Elisa). En: Actas del XX Congreso Argentino de Horticultura. Bahía Blanca, Buenos Aires, Argentina (Resumen 23).

Rothman, S., B. Tonelli, O. Valenzuela, y M. del C. Lallana. 2000. Cultivo de plantines de tomate con sustratos basados en humus de lombriz. Horticultura Argentina 19:45 (Resumen 119).

Rouphael, Y. 2004. Yield, water requirement, nutrient uptake and fruit quality of zucchini squash grown in soil and closed soilless culture. The Journal of Horticultural Science and Biotechnology 79:423-430.

Subler, S., C. Edwards, and J. Metzger. 1998. Comparing vermicomposts and composts. BioCycle 39:63-66.

Tittonell, P.A., J. De Grazia, y A. Chiesa. 2002. Adición de polímeros superabsorbentes en el medio de crecimiento para la producción de plantines de pimiento (*Capsicum annum* L.). Horticultura Brasileira 20:641-645.

Tittonell, P.A., J. De Grazia, y A. Chiesa. 2003. Emergencia y tasa de crecimiento inicial en plantines de pimiento (*Capsicum annuum* L.) cultivados en sustratos adicionados con polímeros superabsorbentes. Revista Ceres 50:659-668.

Valenzuela, O.R., y C.S. Gallardo. 1997. Uso de lombricompuesto como medio de crecimiento para plantines de tomate (cv. Platense). Revista Científica Agropecuaria 1:15-21.

Venus, J.C., and D.R. Causton. 1979. Plant growth analysis: a re-examination of the methods of calculation of relative growth and net assimilation rates without using fitted functions. Annals of Botany 43:633-638.

Wien, H.C. 1997. Transplanting. Pages 37-67. In: The Physiology of Vegetable Crops. H.C. Wien (ed.). CAB International, Oxon, UK.