

PACLOBUTRAZOL AND CATTLE MANURE USE IMPROVES THE QUALITY OF PEPPER SEEDLINGS

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ABSTRACT - The use of high quality seedlings is a key factor for the success of vegetable production. A high quality seedling may be obtained with the use of appropriate substrates and adequate nutritional and hormonal balance of the plants. An experiment was conducted to investigate the effects of foliar application of nitrogen and paclobutrazol and the use of cattle manure on production of pepper seedlings. Pepper seedlings (*Capssicum frutescens* cv. Malagueta) were grown in a seedling nursery with shadow protection at 50%. Treatments were arranged in a completely randomized design in a 2x3 factorial: two types of substrates [commercial substrate (Bioplant[®]) and alternative substrate composed of 50% cattle manure and 50% vermiculite] and three foliar treatments [10000 mg L⁻¹ nitrogen (N); 50 mg L⁻¹ paclobutrazol (PBZ); and 10000 mg L⁻¹ N + 50 mg L⁻¹ PBZ], with six replications. Foliar applications were performed at 21 days after sowing. Three categories of morphological indicators were measured, i.e., plant dimensions (height and diameter), plant dry matter (shoot, root and total dry matter) and indices (sturdiness quotient “SQ”, shoot:root dry matter ratio “SRR” and Dickson quality index “DQI”). The use of paclobutrazol, associated or not with nitrogen, and the use of alternative substrate consisting of 50% cattle manure and 50% vermiculite improved the quality of pepper seedlings, indicating they are excellent management strategies for the vegetable seedling production.

Palavras-chave: *Capssicum frutescens*, organic substrate, plant growth regulator.

USO DE PACLOBUTRAZOL E ESTERCO BOVINO MELHORA A QUALIDADE DAS MUDAS DE PIMENTA

RESUMO - O uso de mudas de alta qualidade é um dos principais fatores para o sucesso da produção de hortaliças. Mudas de qualidade podem ser obtidas com a utilização de substratos apropriados e com adequado balanço nutricional e hormonal das plantas. Desse modo, objetivou-se com este trabalho investigar os efeitos da aplicação foliar de nitrogênio e paclobutrazol e do uso de esterco bovino na produção de mudas de pimenta. Mudas de pimenta (*Capssicum frutescens* cv. Malagueta) foram cultivadas em um viveiro com tela de sombrite de 50%. Os tratamentos foram dispostos em um delineamento experimental inteiramente casualizado em esquema fatorial 2x3: dois tipos de substratos [substrato comercial (Bioplant[®]) e substrato alternativo composto de 50% de esterco bovino e 50% de vermiculita] e três tratamentos foliares [10.000 mg L⁻¹ de nitrogênio (N); 50 mg L⁻¹ de paclobutrazol (PBZ); e 10.000 mg L⁻¹ de N + 50 mg L⁻¹ de PBZ], com seis repetições. As aplicações foliares foram realizadas 21 dias após a semeadura. Três categorias de indicadores morfológicos foram mesurados, ou seja, as dimensões da planta (altura e diâmetro de caule), matéria seca das mudas (parte aérea, raiz e matéria seca total) e índices de qualidade (quociente de robustez “SQ”, razão da matéria seca da parte aérea:raízes “RPAR” e índice de qualidade de Dickson “IQD”). O uso do paclobutrazol, associado ou não com a aplicação de nitrogênio, e o uso de substrato alternativo constituído de 50% de esterco bovino e 50% de vermiculita melhorou a qualidade de mudas de pimenta ‘Malagueta’, indicando serem excelentes estratégias de manejo para a produção de mudas de hortaliças.

Key words: *Capssicum frutescens*, substrato orgânico, regulador de crescimento.

INTRODUCTION

Malagueta pepper (*Capssicum frutescens* – Solanaceae) is a type of chilli widely used in Brazil, Portugal, Mozambique and Caribbean (FILGUEIRA, 2008). Currently, the pepper cultivation has taken important position in Brazil due to growing external demand of the consumer market. However, the quality of seedlings transplanted is a major factor that determines the success of pepper production. The survival of seedlings,

growth performance, length of production period, and yield and quality of vegetables produced are greatly influenced by the quality of seedlings used (CARMELLO, 1995; SOUZA et al., 2008; MEDEIROS et al., 2008). Thus, the production of seedlings can be considered as one of the most important stages in the cultivation of vegetables.

A high quality seedling may be obtained with the use of trays and appropriate substrates, and with adequate

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nutritional and hormonal balance of the seedlings. A substrate for the production of seedlings has the purpose of ensuring quality plant growth in a short time and at low cost (FILGUEIRA, 2008). Silva-Júnior and Visconti (1991) describe how a good substrate should have the ability to retain nutrients and water, good aeration, low resistance to root penetration and good resistance to loss of the structure of the root ball, which is essential for success when transplanting. Castoldi et al. (2014) reported that alternative substrates, based on vermicompost, sterilized sand, rice husks and basalt powder, were efficient in the production of lettuce seedlings, producing better seedlings and in less time than the traditional substrate.

In this context, the formulation of substrates by the farmer can be very advantageous, by allowing the use of residues of other activities and reduce the cost of production of seedlings. However, the formulation of an alternative substrate which would be more sustainable from a socio-economic and environmental view point, is dependent on the availability of quality material for its composition, this characteristic varying with the region. An excellent alternative is to use regional substrates that can be easily obtained (CASTOLDI et al., 2014). The use of animal manure as substrates has been an excellent strategy for the improve the quality of vegetable seedlings. The efficiency of alternative substrates formulated from cattle manure has been reported in seedlings of other vegetable species, such as lettuce (SILVA et al., 2008; VIANA; VASCONCELOS, 2008), eggplant (COSTA et al., 2012), and cherry tomato (COSTA et al., 2015a). However, the effectiveness of the use of cattle manure on production of pepper seedlings are still incipient and inconclusive (COSTA et al., 2015b).

Another alternative to improve the quality of pepper seedlings is with the use of nutrients and plant growth regulators. Paclobutrazol (PBZ), a substance of the triazole group, is a well-known plant growth retardant. It is applied to the soil or foliar spray (JUNGKLANG; SAENGNIL, 2012; BENETT et al., 2014). Paclobutrazol functions by inhibiting cytochrome P-450, which mediates oxidative dimethylation reactions, including those which are necessary for the synthesis of ergosterol and the conversion of kaurene to kaurenoic acid in the gibberellins biosynthetic pathway (FLETCHER et al., 2000). From this function, PBZ has been used to reduce plant height for potted plant production (FLETCHER et al., 2000; WANDERLEY et al., 2014) and for enhance the quality of seedlings produced (BENETT et al., 2014). Using 2 to 6 mg L⁻¹ PBZ was reported reduction in the plant height, without affecting the quality of the inflorescence potted sunflower plants (WANDERLEY et al., 2014). An increase in the PBZ concentration to 150 mg L⁻¹ reduced plant height and shoot dry matter, increased root dry matter and improved the quality of tomato seedlings (BENETT et al., 2014). However, there is no information in the literature that indicates whether the PBZ has beneficial effects on the quality of pepper seedlings. Plant response to PBZ varies with the method of application, rate applied, developmental stage and plant species (WANDERLEY et al., 2014).

This research was carried out to investigate the effects of foliar application of nitrogen and paclobutrazol on production of pepper seedlings (*Capssicum frutescens* cv. Malagueta) grown in commercial substrate (Bioplant[®]) and alternative substrate composed of 50% cattle manure and 50% vermiculite.

MATERIAL AND METHODS

The experiment was conducted in a seedling nursery at the Horticultural Department of the Mato Grosso do Sul State University (UEMS), in Cassilândia, Mato Grosso do Sul, Brazil (19° 05' 20" S, 51° 48' 24" W, and altitude of 470 m). Pepper seeds of the cultivar Malagueta were planted on March 14th, 2015, in 128-cell expanded polystyrene trays filled with commercial substrate composed of coconut fiber (Bioplant[®]) or alternative substrate composed of 50% cattle manure and 50% vermiculite. Three seeds were sown per cell, and eighteen days after sowing, they were thinned to one seedling per cell. Pepper seedlings were grown in a seedling nursery with shadow protection of 50% for 40 days [at 20 to 29 °C, with relative air humidity of 68 ± 17% and light fluence of 550 ± 220 μmol m⁻² s⁻¹ photosynthetic photon flux density (PPFD)].

Treatments were arranged in a completely randomized design in a 2x3 factorial: two substrates [commercial substrate (Bioplant[®]) and alternative substrate composed of 50% cattle manure and 50% vermiculite] and three foliar treatments [10000 mg L⁻¹ nitrogen (N); 50 mg L⁻¹ paclobutrazol (PBZ); and 10000 mg L⁻¹ N + 50 mg L⁻¹ PBZ], with six replications. Twenty plants per trays represented one replicate.

The main physicochemical characteristics of cattle manure used in the experiment are shown in Table 1. Foliar applications were performed at 21 days after sowing using a CO₂ pressurized sprayer with 0.8 MPa working pressure capacities, equipped with flat fan nozzle, adjusted to spray volume equivalent to 250 L ha⁻¹.

Pepper seedlings were evaluated at 40 days after sowing. Seedlings in all treatments were removed from the trays and washed with water to remove substrate adhered to the roots. Posteriorly, the seedlings were separated into roots and shoots, dried in a forced air circulation oven for three days at 65 °C, and then weighed. The results were expressed in grams per seedling. The shoot length (SL, in cm) was measured using meter scale. Collar diameter (CD, in mm) was measured by using a digital caliper with accuracy of 0.01 mm. From these measurements were calculated total dry matter (TDM), shoot: root dry matter ratio [SRR; shoot dry matter (g)/root dry matter (g)], sturdiness quotient [SQ; shoot length (cm)/collar diameter (mm)] and Dickson Quality Index [DQI = TDM/(SRR + SQ)] (DICKSON et al., 1960).

The normality of data was previously tested by the Kolmogorov-Smirnov test and then data were submitted to analysis of variance (ANOVA), and means of treatments were compared by the Tukey test at the 0.05 level of confidence. All analyses were performed using Sisvar version 5.3 software for Windows (Statistical Analysis Software, UFPA, Lavras, MG, Brazil).

TABLE 1. Physical and chemical characteristics of cattle manure used in the experiment.

Characteristic	Cattle manure
pH in water	6.5
Dry matter (g kg ⁻¹)	971.0
Carbon organic (g kg ⁻¹)	96.5
Total nitrogen (g kg ⁻¹)	10.6
Total phosphorus (g kg ⁻¹)	3.7
Potassium (g kg ⁻¹)	1.0
Calcium (g kg ⁻¹)	9.8
Magnesium (g kg ⁻¹)	1.7
Sulfur (g kg ⁻¹)	1.8
Copper (mg kg ⁻¹)	17.5
Iron (mg kg ⁻¹)	7800.0
Manganese (mg kg ⁻¹)	310.0
Zinc (mg kg ⁻¹)	75.0
Boron (mg kg ⁻¹)	11.5

RESULTS AND DISCUSSION

The substrates and foliar application of nitrogen (N) and paclobutrazol (PBZ) significantly affected ($p \leq 0.05$) on all the measured traits (Figures 1 and 2). In general, alternative substrate consisting of cattle manure (50%) plus vermiculite (50%) resulted in pepper seedlings with the highest values for the majority of investigated traits except shoot length (Figure 1A) and sturdiness quotient (Figure 2C). The use of cattle manure as substrate can promote greater availability of nutrients for seedlings and improves the physical condition of the medium (RODRIGUES et al., 2010), resulting therefore in vigorous seedlings and good quality. The appropriate proportion of organic matter in the substrate improves the gas exchange of the roots due to good aeration (GOMES et al., 2003), and combined with the addition of vermiculite, which allows higher porosity of the substrate, enabling a better development of the seedlings (COSTA et al., 2015b).

The efficiency of alternative substrates in the production of vegetable seedlings has also been reported by other authors. Costa et al. (2015a) evaluating the use of different organic residues as substrates, reported the efficiency of alternative substrates produced from 50% cassava foliage + 50% commercial substrate (Vida Verde[®]) and 25% cassava foliage + 25% poultry manure + 25% cattle manure + 25% commercial substrate (Vida Verde[®]) on production of cherry tomato seedlings. Costa et al. (2015b) found that the substrate consists from 30% cattle manure plus 70% vermiculite resulted in ornamental pepper seedlings of higher quality. Castoldi et al. (2014), comparing the development of lettuce seedlings in different substrates, showed the possibility of producing lettuce seedlings using substrates of organic origin, easily made by the producer.

As expected the largest shoot length of pepper seedlings was verified with the foliar application of

nitrogen (N), while the application of paclobutrazol (PBZ) resulted in seedlings of lower height, regardless of the N application (Figure 1A). Nitrogen is an essential nutrient for growth and development of the plants. It is constituting many biologically important organic molecules in plant cell components, including proteins, nucleic acids, purines, pyrimidines, coenzymes (vitamins) and many other compounds (BARKER; PILBEAM, 2007). Nitrogen supply increases shoot height of squash seedlings (*Cucurbita moschata*) (HIGUTI et al., 2010). On the other hand, the PBZ has been used to reduce plant height by inhibiting gibberellin biosynthesis (FLETCHER et al., 2000), a plant growth hormone. These results are close to those obtained by Benett et al. (2014), who reported reduced plant height of tomato seedlings with increase of PBZ concentration to 150 mg L⁻¹.

The foliar application of PBZ in pepper seedlings grown in alternative substrate provided greater collar diameter (Figure 1B), which resulted in lower sturdiness quotient - shoot length/collar diameter ratio (Figure 2C). The increase in stem diameter is important for providing greater robustness to the seedlings. Benett et al. (2014) reported that the foliar application of PBZ increased the collar diameter of tomato plants resulting in better quality seedlings. The stem diameter has been appointed as the best and most practical characteristics for classification and identification of high quality seedlings, and therefore can be considered a good predictor of out-planting survival. Ivetić et al. (2013) reported that stem diameter was the most important grading characteristic, followed by shoot height and root development. In general, a high quality seedling should have a value of sturdiness quotient ranging from 2.5 to 3.5, and a robustness quotient greater than 4.0 can be indicative of etiolating of seedlings.

In general, PBZ resulted in pepper seedlings with higher dry matter values of the shoots (Figure 1C), roots

(Figure 1D) and total dry matter (Figure 2A). Contrary results were reported by other authors. Nascimento et al. (2003) found that the PBZ reduced the dry matter of shoots and roots in tomato seedlings. Benett et al. (2014) measured a reduction of shoot dry matter, and increased root dry matter of tomato seedlings with foliar applications of PBZ.

The shoot:root dry matter ratio (SRR) was lower with the PBZ application on pepper seedlings grown in commercial substrate (Figure 2B). These results indicate that there was a higher photoassimilate partition from shoot to the roots. Pacllobutrazol was shown to shift assimilate partitioning from leaves to roots, increase carbohydrates in all parts of apple seedlings, increase chlorophyll content, soluble protein, and mineral element concentration in leaf tissue, increase root respiration and reduce water use (WANG; STEFFENS, 1985).

The foliar application of PBZ resulted in better quality pepper seedlings as reported by values greater Dickson quality index - DQI (from 0.032 to 0.049) (Figure

2D). Dickson quality index can be considered one of the most comprehensive indicators of assessment of seedling quality (BINOTTO, 2010). On the other hand, the foliar application of N resulted in lower quality pepper seedlings (DQI from 0.023 to 0.029) and therefore should not be a management option adopted for the production of pepper seedlings. Nitrogen is related to many factors that control the various processes of growth and development of plants (BARKER; PILBEAM, 2007), which may have resulted in an imbalance in production and dry matter partitioning.

In summary, the use of pacllobutrazol, associated or not with nitrogen, and the use of alternative substrate consisting of 50% cattle manure and 50% vermiculite improved the quality of pepper seedlings, indicating they are excellent management strategies for the vegetable seedling production. The use of alternative substrates is very important to the producer, since the combination of manure and vermiculite has a lower cost compared to the use of commercial substrate, and cattle manure can be obtained on the farm.

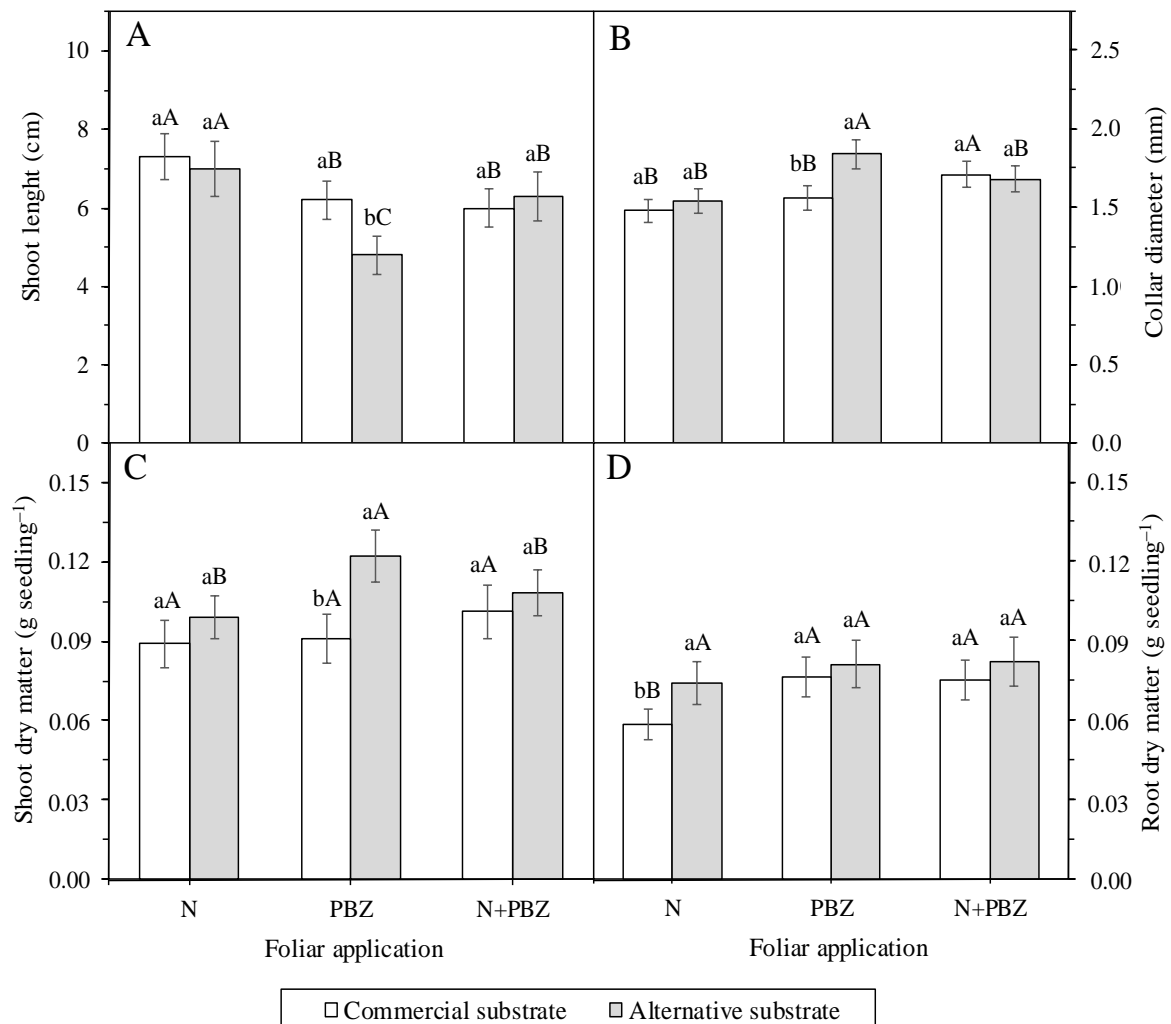


FIGURE 1 - Effects of foliar application of nitrogen (N) and pacllobutrazol (PBZ) on shoot length (SL, in A), collar diameter (CD, in B), shoot dry matter (SDM, in C) and root dry matter (RDM, in D) of pepper seedlings (*Capssicum frutescens* cv. Malagueta) grown in commercial substrate (Bioplant[®]) and alternative substrate composed of 50% cattle manure and 50% vermiculite. Bars followed by the same lower case letters, between the substrate types or same upper case letters, for the foliar applications are not significantly different by Tukey test at the 0.05 level of confidence. Data refer to mean values (n = 6) ± standard error.

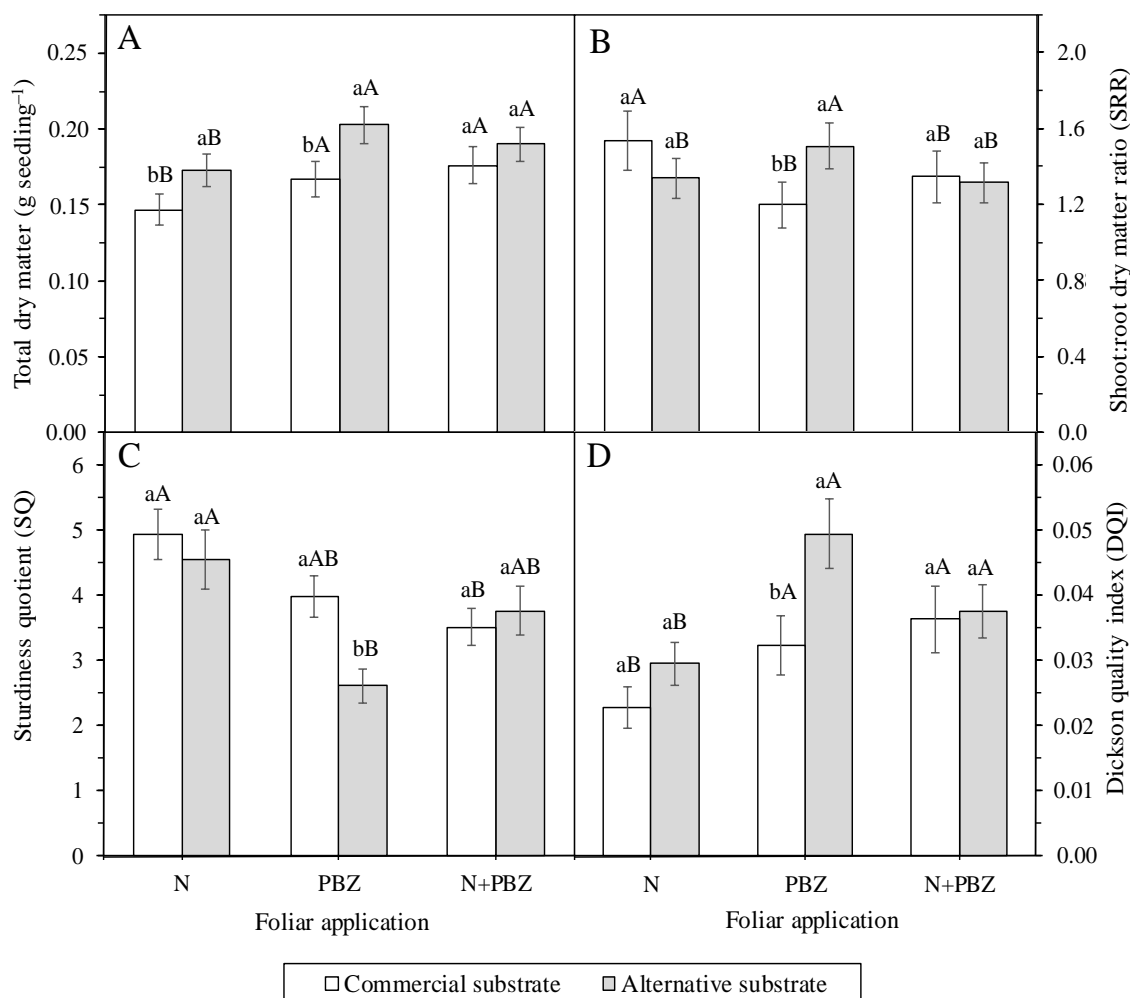


FIGURE 2 - Effects of foliar application of nitrogen (N) and paclobutrazol (PBZ) on total dry matter (TDM, in A), shoot: root dry matter ratio (SRR, in B), sturdiness quotient (SQ, in C) and Dickson quality index (DQI, in D) of pepper seedlings (*Capssicum frutescens* cv. Malagueta) grown in commercial substrate (Bioplant[®]) and alternative substrate composed of 50% cattle manure and 50% vermiculite. Bars followed by the same lower case letters, between the substrate types or same upper case letters, for the foliar applications are not significantly different by Tukey test at the 0.05 level of confidence. Data refer to mean values (n = 6) ± standard error.

CONCLUSIONS

Foliar application of paclobutrazol and alternative substrate use consisting of 50% cattle manure and 50% vermiculite improved the quality of pepper seedlings.

Foliar application of N resulted in lower quality pepper seedlings, and therefore should not be a management option adopted for the production of pepper seedlings.

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