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Use of nanocomposite hydrogel with N-urea in the production of eggplant seedlings

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ABSTRACT

The use of quality seedlings of eggplant is directly related to the success of their production, with polymers added to the substrate, which work as water conditioners, increase the water retention capacity, and provide better seedling quality. The study aimed to evaluate the use of nanocomposite hydrogel enriched with different proportions of N-urea in the production of eggplant seedlings. The experiment was conducted at the State University of Mato Grosso do Sul, Cassilândia, MS, Brazil, from June to August 2019, under sombrite® 30%. Five treatments were evaluated, using the commercial substrate, Carolina Soil®: 1) commercial substrate without hydrogel; 2) commercial substrate with 0.075g of pure hydrogel (0.00g of N-urea)/15 mL of a substrate; 3) commercial substrate with 0.075g of hydrogel and 10% N-urea/15 mL of a substrate; 4) commercial substrate with 0.075g of hydrogel and 20% N-urea/15 mL of a substrate, and 5) commercial substrate with 0.075g of hydrogel and 40% N-urea/15 mL of a substrate. The experiment was conducted with four replications of 25 seedlings. The emergence speed index, percentage of emergence, height, number of leaves, stem diameter, shoot dry matter, root dry matter, and total dry matter were evaluated, as well as the Dickson Quality Index. The data were subjected to analysis of variance (SPEEDSTAT statistical software) and grouping test of means. A regression analysis was performed to adjust equations for some of the variables. The best seedlings can be obtained using the dosage of 28.83% N-urea with 0.075g of hydrogel per 15 ml of the substrate, according to the DQI adjustment, which includes several traits of the seedlings, thus reflecting on its quality.

Keywords: *Solanum melongena*, hydroretentor, seedling quality, nutrition.

Uso de hidrogel nanocompósito com N-ureia na produção de mudas de berinjela

RESUMO

A utilização de mudas de qualidade de berinjela está diretamente relacionada ao êxito de sua produção, sendo que polímeros adicionados ao substrato, que funcionam como condicionadores hídricos, aumentam a capacidade de retenção de água e propiciam uma melhor qualidade de plântulas. O trabalho teve como objetivo avaliar o uso de hidrogel nanocompósito enriquecido com diferentes proporções de N-ureia na produção de mudas de berinjela. O experimento foi conduzido na Universidade Estadual do Mato Grosso do Sul, Cassilândia, MS, de junho a agosto de 2019, em sombrite 30%. Foram avaliados cinco tratamentos, usando como substrato comercial a marca Carolina Soil®: 1)substrato comercial sem hidrogel; 2)substrato comercial com 0,075g de hidrogel puro (0,00g de N-ureia)/15 mL de substrato; 3) substrato comercial com 0,075g de hidrogel com 10% de N-ureia/15 mL de substrato; 4) substrato comercial com 0,075g de hidrogel com 20% de N-ureia/15 mL de substrato e 5) substrato comercial com 0,075g de hidrogel com 40% de N-ureia/15 mL de substrato. O experimento foi conduzido com quatro repetições de 25 plântulas. Foram avaliados o índice de velocidade de emergência, porcentagem de emergência, altura, número de folhas, diâmetro do colo, fitomassas secas da parte aérea, sistema radicular e total, bem como o Índice de Qualidade de Dickson. Os dados foram submetidos à análise de variância (programa estatístico SPEEDSTAT), teste de agrupamento de médias e foi realizada análise de regressão para ajuste de equações referentes a algumas das variáveis. As melhores mudas podem ser obtidas utilizando a dosagem de 28,83% de N-ureia na combinação 0,075g de hidrogel 15 ml^{-1} de substrato, em função do ajuste do IQD, que engloba diversas características das plântulas, refletindo, assim, na sua qualidade.

Palavras-chave: *Solanum melongena*, hidroretentor, qualidade de mudas, nutrição.

1. Introduction

Eggplant is a widely cultivated species from the Solanaceae family, being among the most consumed vegetables (Chapman, 2019). The Brazilian consumer prefers eggplants with a more elongated shape and a bright dark purple color. Cultivars with rounded fruits, purple or pink color, with sweet pulp, and few seeds are known as Italian type eggplants (Marouelli et al., 2014). Between 2016 and 2018, the fruit was traded, on average, for R$ 3.00 per kilogram in the wholesale of the State of São Paulo and is among the vegetables with the highest revenues obtained from sales of fruit and vegetables in the country's CEASAS during this period. At the São Paulo Terminal Warehouse (ETSP), in 2018, about 28,597 tons of the product were sold, mainly from the cities of Elias Fausto-SP, Mogi Guaçu-SP, Pouso Alegre-MG, Estiva Gerbi-SP, Itatiba-SP, and Mogi Mirim-SP (CEAGESP, 2019). Its production costs are low, and, as a result, it generates adequate income for producers (HFBrasil, 2019). The production of seedlings represents about 3% of the total inputs and services used in the production of the eggplant (Emater-DF, 2019).

Although it represents a small part of the costs for obtaining productive plants in the field or protected cultivation, the production of quality seedlings is directly related to the success of the vegetable production (Jorge et al., 2016). Therefore, using substrates with adequate characteristics that result in efficiency in the management of water and nutrition is fundamental (Gruda et al., 2013).

Among the several technologies adopted in the seedling production system in multicellular trays (Jorge et al., 2019a), the addition of polymers to the substrate, which acts as water conditioners, increase the water retention capacity and provide a better seedling quality (Melo et al., 2019b). These polymers, which can be natural or synthetic, are capable of absorbing large amounts of water in their three-dimensional structure, without dissolving completely, forming hydrogels. In trays for seedlings filled with different substrates, the leaching of nutrients caused by excess water resulting from the irrigation process often carried out empirically or in excess, is one of the reasons why complementation by fertigation is carried out frequently (Lima et al., 2012; Jorge et al., 2020). The use of slow or controlled nutrient release fertilizers is an alternative to increase the efficiency of these applications, as they are also called "smart fertilizers", as they are materials prepared to release their nutrient content gradually, coinciding, if possible, with the nutritional demand by plants throughout their cycle (Hanafi et al., 2000).

Among the nutrients that can be incorporated into hydrogels, there is nitrogen, whose losses are mainly caused by the management of nutrition and water, justifying the interest in developing alternatives to improve their availability in a controlled manner. Bortolin et al. (2016) synthesized a new series of hydrogels composed of polyacrylamide, methylcellulose and 50% montmorillonite type clay, in which the presence of mineral clay, can improving some material properties, reduces costs and allows an efficient and more controlled release concerning pure hydrogel, almost 200 times more gradual than pure urea. This innovative hydrogel formulation has shown positive results in several seedlings (Jorge et al., 2019b, Melo et al., 2018, 2019a, 2019b). Specifically, for eggplant, there is a need to define dosages of this hydrogel for formulation with substrates.

Given the above, this study aimed to evaluate the use of nanocomposite hydrogel (NC-MMt) with different proportions of N-urea incorporated in the development of eggplant seedlings.

2. Material and Methods

The experiment was conducted at the State University of Mato Grosso do Sul (UEMS), University Unit of Cassilândia, MS. The location has a latitude of -19.1225º (= 19º07'21” S), a longitude of -51.7208º (= 51º43'15” W) and an altitude of 516 m (Automatic station CASSILANDIA-A742). A protected environment, called an agricultural screen, was used, with a galvanized steel structure, 8.00 m wide by 18.00 m long and 3.50 m high, closing at 45º of inclination, with monofilament screen in its entire length, mesh with 30% shading.

A completely randomized design with four replications and 25 plants per plot was used, from June to August 2019. Five treatments were evaluated, using the commercial substrate: 1) commercial substrate without hydrogel; 2) commercial substrate with 0.075g of pure hydrogel (0.00g of N-urea)/15 mL of a substrate; 3) commercial substrate with 0.075g of hydrogel and 10% N-urea/15 mL of a substrate; 4) commercial substrate with 0.075g of hydrogel and 20% N-urea/15 mL of a substrate, and 5) commercial substrate with 0.075g of hydrogel and 40% N-urea/15 mL of a substrate. Multicellular black plastic trays with 200 cells of 15 ml each were used. The substrate used in the test was Carolina Soil®, based on sphagnum peat, with the following characteristics: pH = 5.5±0.5; EC = 0.4±0.3 mS/cm; WRC = 55%; Density = 145 kg/cm^3.

The sowing of the Preta comprida cultivar (germination = 98% and purity = 100%) occurred on June 26, 2019, with the emergence observed at nine days after sowing (DAS) and stabilizing at 23 DAS. During this period, the evaluations of the emergence speed index (ESI) proposed by Maguire (1962) and the emergence percentage (EP) were carried out. Daily irrigation was manually performed, trying not to soak the substrates.

At 40 DAS, the seedling height (SH) was measured with the aid of a ruler. Stem diameter (SD) was measured with a digital caliper. Shoot (SDM) and root (RDM) dry matter were measured on an analytical scale after drying in an air forced circulation oven at a constant temperature of 65 ºC for 72 hours. Subsequently, the relationship between seedling height and shoot diameter (HDR), total dry matter (TDM), the ratio between shoot and root dry matter (SRR), the ratio between the root and total dry matter (RTR) were evaluated. Also, according to Dickson et al. (1960), the Dickson quality index (DQI) was assessed, as follows:

DQI = [TDM/(HDR + SRR)].

The data were submitted to analysis of variance using the SPEEDSTAT statistical software (Carvalho et al., 2020), and the means, when significant, were grouped by the Scott-Knott test, at 5% probability. Regression analysis was performed for hydrogel doses, excluding treatment without hydrogel and pure hydrogel (controls), to adjust the equations that determine the best responses for different variables.

3. Results and Discussion

There were significant differences between the means of hydrogel treatments compared to the control for all variables evaluated. The emergence speed index (ESI) of the eggplant seedlings showed a root-type adjustment, with treatment with a hydrogel containing 10% N-urea as the best response (Figure 1). Adjustment of the quadratic type was observed for the emergence percentage, and the best dosage estimated by the regression model was 12.12% N-urea, which may have provided better humidity conditions for the seeds to hydrate and start the germination process. The highest concentration of N-urea (40%) showed lower rates of emergence, with a possible interference of this nutrient in the salinity of the substrate, as demonstrated by Almeida et al. (2019). However, the germination values for intermediate dosages are considered adequate and are following different treatments used in eggplant seeds (Domingues Neto et al., 2017).

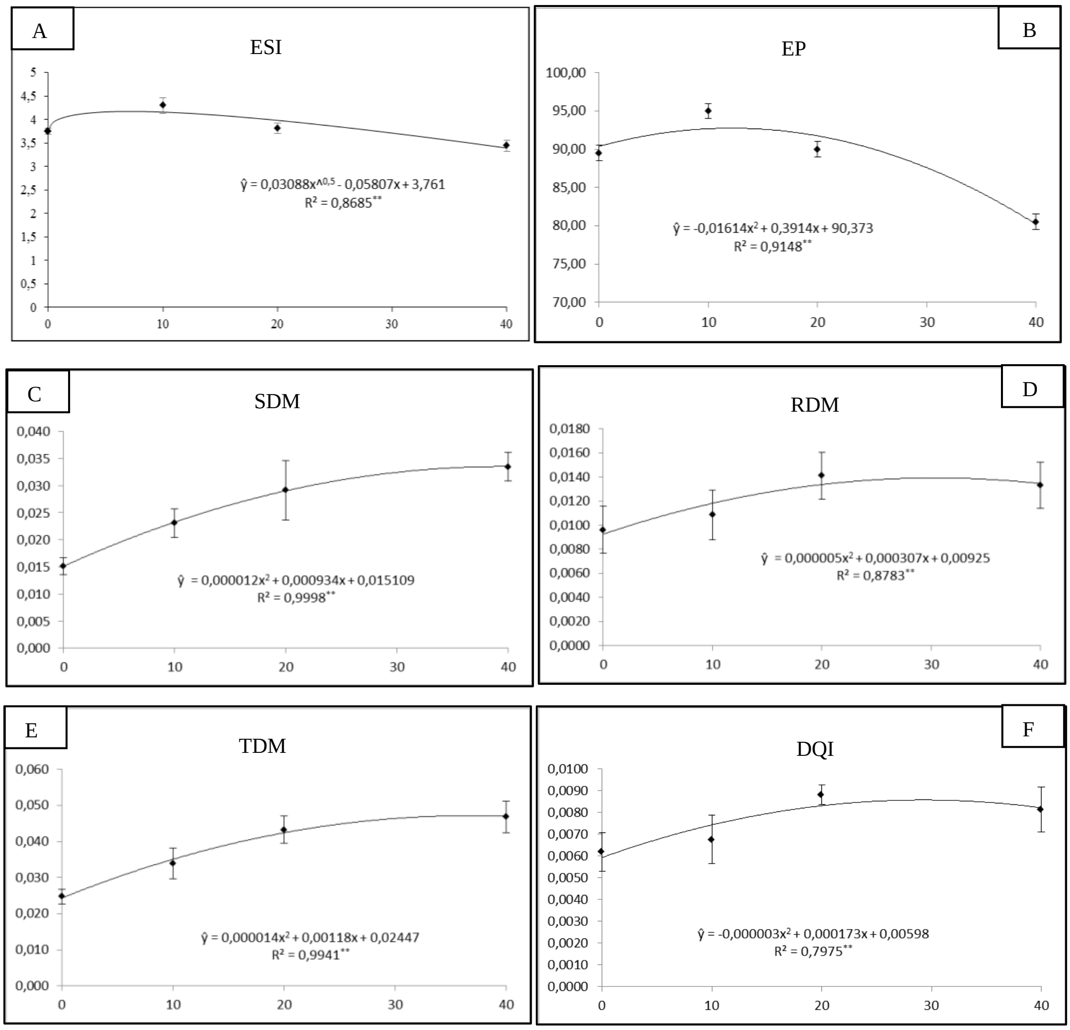

Figure 1. Regression adjustments: A – Emergence speed index (ESI, CV=6.29%, root model), B – Emergence percentage (EP, CV=4.62%, quadratic model), C – Shoot dry matter (SDM, CV=13.54%, quadratic model), D – Root dry matter (RDM, CV=16.41%, quadratic model), E – Total dry matter (TDM, VC=9.96%, quadratic model) and F – Dickson quality index (DQI, V=12.15%, quadratic model) of eggplants seedlings produced in substrates containing hydrogel at doses of 00% of N-urea/15 mL of substrate (0); 10% of N-urea/15 mL of substrate (10); 20% of N-urea/15 mL de substrate (20); and 40% of N-urea/15 mL of substrate (40). Embrapa Hortaliças (2020).

The treatments containing nitrogen differed from the controls in the number of leaves, seedling height, and stem diameter (Table 1). For the number of leaves, the best development of eggplant seedlings was evidenced with the incorporation of N to the polymer, since all treatments containing N were significantly superior to the control. Similar results were also obtained by Melo et al. (2019a), who also got an increase in the number of leaves with increasing doses of N in the hydrogel in peppers.

Higher seedling heights were verified in treatments containing hydrogel with N-urea. This growth stimulus is favorable; however, it must be observed, depending on the demand for commercial seedlings from nurseries in different regions, which is quite variable, that is, the pattern required by producers depends exclusively on the planting schedule and management in the field. Jorge et al. (2019b) observed that this factor is predominant in the production of tomato and pepper seedlings in two high-tech nurseries in the Distrito Federal (DF) region.

For the stem diameter, a significant trait for the establishment of seedlings after transplanting, so that they do not bend with the action of the wind or may come to resist abiotic stresses during this stage (Luna et al., 2014; Melo et al., 2019b), there was no adjustment of a model that establishes a better dosage. For the ratio between seedling height and stem diameter (HDR), there is the same trend of the superiority of treatments with hydrogel with N-urea compared to controls. However, higher doses of N-urea may incur seedlings that are isolated and susceptible to the problems mentioned above, as seen in the treatment with 40% (3.74), which were higher (2.50) than verified by Costa et al. (2011) and Costa et al. (2013) on different substrates.

The shoot (SDM) and root (RDM) dry matter in the regressions referring to the dosages of N-urea showed quadratic adjustment, with values of 38.91% and 30.7% of N-urea, respectively, as the best responses (Figure 1D). These variables are indicators of seedling development and their quality status, being used to describe the proportion of shoot morphological benefit and the metabolic cost related to the development of the root system (Oztekin et al., 2009). In this way, intermediate dosages can be adjusted so that there is no growth of the aerial part to the detriment of the root system, causing imbalances, with consequences in the stages of transplantation and development.

The TDM also presented a quadratic adjustment, with a better response to a dosage of 42.12% N-urea. The treatments with higher concentrations of N-urea showed plants with a higher dry matter of shoot by the absorption of NH_4 from urea, one of the main elements responsible for the growth and development of higher plants (Marschner, 1995), which was incorporated into the polymer that gradually releases it. It was also observed that RTR (amount of RDM concerning TDM) resulted in lower values at dosages equal to or above 10% N-urea, a demonstration that the roots may not have accompanied the rapid growth and development of the aerial part, given the ready availability of the nutrient, even using a substrate with adequate composition and electrical conductivity, such as the presence of phosphorus, boron and other elements associated with root development.

The shoot dry matter, root dry matter, total dry matter, seedling height, and stem diameter are fundamental to evaluate the quality of seedlings, resulting in the index known as DQI - Dickson Quality Index (Dickson et al., 1960). Although the index was developed using forest species, Lima et al. (2019), evaluating eggplant seedlings of the Comprida Roxa cultivar, claim that the DQI has a significant and positive correlation with the growth responses evidenced in this vegetable.

The ratio between seedling height and stem diameter was the factor that, in calculating the DQI, caused a slight decrease in the value of the treatment with 40% N-urea (Table 2). Thus, better values associated with this seedling quality index were obtained at the dosage of 28.83% N-urea and, as reported by Costa et al. (2011), the DQI is an adequate indicator to determine the quality pattern of eggplant seedlings, which, in a study with different substrates under a 50% shade screen, found values similar to those of the present study.

Table 1. Emergence speed index (ESI), emergence percentage (EP), number of leaves (NL), seedling height (SH), stem diameter (SD), and the ratio between seedling height and stem diameter (HDR) of eggplant seedlings.

	ESI	EP (%)	NL	SH (cm)	SD (mm)	HDR
Control	3.49 b	84.5 b	3.24 b	2.59 d	1.06 b	2.44 c
Hydrogel + 00%N	3.74 b	89.5 a	3.36 b	2.63 d	1.10 b	2.40 c
Hydrogel + 10%N	4.29 a	95.0 a	3.72 a	3.64 a	1.26 a	2.89 b
Hydrogel + 20%N	3.81 b	90.0 a	3.51 a	2.97 c	1.07 b	2.79 b
Hydrogel + 40%N	3.44 b	80.5 b	3.65 a	3.32 b	1.03 b	3.24 a
CV (%)	7.7	6.2	6.2	5.5	4.6	3.4

Means followed by equal letters belong to the same group by the Scott-Knott test, at 5% probability. N = nitrogen. CV = coefficient of variation.

Table 2. Shoot dry matter (SDM), root dry matter (RDM), total dry matter (TDM), the ratio between shoot and root dry matter (SRR), the ratio between the root and total dry matter (RTR), and Dickson quality index (DQI) of eggplant seedlings.

	SDM (g)	RDM (g)	TDM (g)	SRR	RTR	DQI
Control	0.016 c	0.011 b	0.027 c	1.47 b	0.41 a	0.0069 b
Hydrogel + 00%N	0.015 c	0.010 b	0.025 c	1.64 b	0.39 a	0.0062 b
Hydrogel + 10%N	0.023 b	0.011 b	0.034 b	2.16 a	0.32 b	0.0068 b
Hydrogel + 20%N	0.029 a	0.014 a	0.043 a	2.14 a	0.33 b	0.0088 a
Hydrogel + 40%N	0.033 a	0.013 a	0.047 a	2.54 a	0.28 b	0.0081 a
CV (%)	13.2	18.3	10.4	22.2	15.0	14.0

Means followed by equal letters belong to the same group by the Scott-Knott test, at 5% probability. N = nitrogen. CV = coefficient of variation.

4. Conclusions

Based on the results, better seedlings can be obtained using the dosage of 28.83% N-urea in combination with 0.075g of hydrogel 15 ml^{-1} of the substrate, according to the DQI adjustment, which includes several seedling traits, thus reflecting on its quality.

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