ISSN 1808-3765

DOSE AND MODE OF APPLICATION OF THE WATER-ABSORBENT COPOLYMER ON GROWTH OF BERMUDAGRASS

LEANDRO JOSÉ GRAVA DE GODOY[1]; MARCOS RENATO VILLARON XAVIER E BARBOSA[2]; MARCELO VIEIRA FERRAZ[1]; LUIS AUGUSTO SAES[2] E MARCOS VIEIRA FERRAZ[3]

[1]Professor Assistente Doutor do curso de Engenharia Agronômica, Universidade Estadual Paulista, Câmpus Experimental de Registro, Registro, SP, Brasil, legodoy@registro.unesp.br; ferraz@registro.unesp.br.
[2]Graduando do curso de Engenharia Agronômica, Universidade Estadual Paulista, Câmpus Experimental de Registro, Registro, SP, Brasil, marcosvxb@hotmail.com; luis_saes@registro.unesp.br.
[3]Pós-doutorando, Departamento de Horticultura, Faculdade de Ciências Agronômicas, Universidade Estadual Paulista, Câmpus de Botucatu, SP, Brasil, ferrazmarcos@yahoo.com.br.

1 ABSTRACT

The present study aimed to evaluate the effects of water-absorbent copolymer in the growth of Bermudagrass, planted in a sandy substrate and soil medium texture. The treatments consisted of five doses of the copolymer (0, 25, 50, 75 or 100 g m^{-2}), and two application modes (dry and hydrated) in a completely randomized design with five replications. During the experimental period turfs were subjected to a period of 10 days without watering. For the sandy substrate, when subjected to water stress, there was linear increase on dry mater production of clippings (growth) in function doses of water-absorbent copolymer. The major dry mater of roots was achieved by application of the copolymer at a dose of 56 g m^{-2} hydrated. For the soil medium textured copolymer hydrated in doses 50-54 g m^{-2} water-absorbent copolymer showed greater production of dry mater of clippings of Bermudagrass cv. Celebration applied in powder and hydrated forms respectively. For medium textured soil this water-absorbent copolymer did not influence the intensity of green color, not the green coverage rate of the turfgrass. The application of hydrated copolymer reduced the dry matter of roots in the soil of medium texture.

Keywords: Hydrogel, *Cynodon dactylon* (L.) Pers, Maintenance, Turfgrass.

GODOY, L. J. G.; XAVIER E BARBOS, M. R. V.; FERRAZ, M. V.; SAES, L. A.; FERRAZ, M. V.
DOSES E MODOS DE APLICAÇÃO DE COPOLÍMERO HIDROABSORVENTE NO CRESCIMENTO DA GRAMA BERMUDA

2 RESUMO

Com o presente estudo, objetivou-se avaliar os efeitos do copolímero hidroabsorvente no crescimento da grama bermuda, plantada em substrato de areia e solos de textura média. Os tratamentos consistiram da aplicação de cinco doses do copolímero (0; 25; 50; 75; 100 g m^{-2}), e dois modos de aplicação (seco e hidratado), num delineamento inteiramente casualizado com cinco repetições. Durante o período experimental as gramas foram submetidas a um período

Recebido em 25/11/2015 e aprovado para publicação em 15/08/2016

sem irrigação de 10 dias. Para o substrato arenoso quando submetido a estresse hídrico houve efeito linear do copolímero sobre a produção de fitomassa seca de aparas (crescimento). A maior fitomassa de raízes foi alcançada com a aplicação do copolímero na dose de 56 g m^{-2} de forma hidratada. Já para o solo de textura média o copolímero na forma hidratada nas doses de 50 a 54 g m^{-2} do copolímero proporcionou maior produção de fitomassa seca de aparas da grama bermuda cv. Celebration aplicados em pó e de forma hidratada, respectivamente. Para o solo de textura média este copolímero não influenciou a intensidade de cor verde, nem a taxa de cobertura verde do gramado. A aplicação do copolímero hidratado reduziu a fitomassa seca das raízes, em solo de textura média.

Palavras-Chave: Hidrogel, *Cynodon dactylon* (L.) Pers, Manutenção, Gramado.

3 INTRODUCTION

Bermudagrass is recommended for situations where high strength is required to trampling in fields such as sports and recreation environments. According to Lauretti (2003), Bermudagrass is considered a vegetable for the summer cycle, with growth through rhizomes and stolons, aggressive, with a high density of leaves and very strong, with a very fast setting and excellent resilience. Already Gurgel (2003) describes the main problems encountered in this plant are the low tolerance to shaded areas and low temperatures in a highly demanding in nutrition, moisture and maintenance. Golombek (2006) cites the lack of water, light, air and nutrients as factors that negatively affect the optimal physiological functioning of a plant. The positive effect is that hydrophilic polymers, which can absorb a large volume of water or aqueous solution, usually up to a hundred times of their own weight, have been used to aid plant growth in arid soils Shi et al. (2010).

So that the plant has no problem of development is necessary to use water rationally. According to Giacoia Neto (2003) actually there are many different sensors in the market that monitor applications of water that will be directed on the turfgrass. The irregularity in water supply can lead to poor nutrient absorption, and let them looked terrible. Lopes (2005) cited by Fernandes (2010) reports that excess water can promote the leaching of nutrients, and provide a favorable microclimate for the development of disease. Already Carribeiro (2010) cites that promotes water deficit reduction in the density of shoots, making the turfgrass matt, folded and wrapped in limbo, leaf blades may become bluish color seal until they become brown.

Soil conditioners are used to give the amount of water required for these plants. Water-absorbent polymers can minimize the effects of possible dry spells during the implementation phase, or even problems in the irrigation system. These materials allow the planting of lawns in different situations and soil type. Carribeiro (2010) mentions that for lawns irrigation practices most often are adopted without scientific basis, which does not consider the needs of specific water turfgrass. Tapia (2003) reports that knowing the evapotranspiration is crucial to calculate the replacement of water in a specified period. According to Hafle et al. (2008) water-absorbent polymers have the ability to promote plant growth by slowly releasing nutrients that were once incorporated into the soil releasing them according to the needs of the plant. Arbona et al. (2005) cites that substrates amended with a hydrogel can prevent or, at least, delay the injury caused by drought in young citrus plants. Vale, Carvalho and Paiva (2006) states that the Stocksorb® is an acrylic polymer inert to absorb water shall become a gel and can subsequently releasing the water to the plant gradually. Moraes (2001) defines as products water-absorbent polymers, natural (derived from starch) or synthetic (petroleum), which are valued for their ability to absorb and store water. In Brazil, some water-absorbent synthetic polymers are being used in the production of fruits, vegetables and seedlings of various species as well as the formation of lawns in gardens, soccer fields and golf (OLIVEIRA et al., 2004). According to Azevedo et al. (2002) the use of superabsorbent polymer on coffee plants allows the replacement of water to the soil is more spaced, without the plants showing symptoms of water stress, both in growth and in dry matter accumulation. This effect is proportional to the concentration of the superabsorbent polymer substrate transplanting. Chirino, Vilagrossa and Vallejo (2011) observed that Stocksorb® water-absorbent increasing the water holding capacity of the root plug of *Quercussuber* L., improving seedling water status and increasing seedling survival in the field. The formation of yellow passion fruit seedlings was anticipated in the substrates that had polymer incorporation, achieving adequate size for field planting before those produced without the polymer (CARVALHO; CRUZ; MARTINS, 2013). In some cases, there was no measurable beneficial effect of the addition of hydrogels to soils (HUTTERMANN; ZOMMOROD; REISE, 1999). Saad, Lopez and Santos (2009) used polymer in sandy and clay soil in eucalyptus production and not noticed any difference in increased survival.

The present study aimed to evaluate the effects of water-absorbent copolymer in the development Bermudagrass cv. Celebration sods in sandy substrate and medium textured soils.

4 MATERIALS AND METHODS

The experiment was conducted in a greenhouse at the São Paulo State University, Experimental Campus of Registro, Brazil, with the use of two types of substrate, sand and medium textured soil. Trays used in the experiment were 0.50 m x 0.25 m x 0.12 m. At the bottom of each tray was added a screen to prevent the flow of sand substrate and medium textured soil.

Trays were filled with sandy soil and medium textured soil. The trays were filled with sand 15 dm^3 of sand with the following characteristics: 5 g dm^{-3} MOS, pH ($CaCl_2$) 5.8; 10 mg dm^{-3}, P (resin), 0.3, 10, 4, 22 , 5 $mmol_c dm^{-3}$ of K, Ca, Mg, and CEC, respectively, 55 g kg^{-1}clay, 70 g kg^{-1}silt and 875 g $kg^{-1}$of total sand. In these trays was incorporated organic compound at a dose of 30 g kg^{-1}soil volume at the time of treatment application. For soil texture medium trays were filled with 15 dm^3 of soil with the following characteristics: 23 g dm^{-3} OM, pH ($CaCl_2$) 4.3, 18 mg dm^{-3}, P (resin), 2.2 , 10, 3, 60.4 $mmol_c$ dm^{-3}, K, Ca, Mg, and CEC, respectively, 208 g kg^{-1} clay, 123 g kg^{-1}silt and 669 g $kg^{-1}$of total sand. Correction of soil acidity of the medium textured soil was made with lime, at a dose of 29 g pot^{-1} (V 60%). Organic compound was incorporated into the soil at a dose of 30 g kg^{-1}soil volume at the time of treatment application. %).

The treatments consisted of five doses of the water –absorbent copolymer (0, 25, 50, 75 and 100 g m^{-2}), and two application modes (dry and hydrated) in a completely randomized design with five replications. It used Stockosorb® 660 Micro characterized by the company as an potassium acrylamide/acrylic copolymer, granular white solid density of 605 g dm^{-3}, liquid absorption capacity of distilled water, 280 ml g^{-1} at pH 7.5, CEC of 3.900 $mmol_c$ dm^{-3}. This product is registered in the MAPA (Ministry of Agriculture, Livestock and Food Supply of the Brazilian government) as a soil conditioner (super absorbent polymer).

For the purposes of hydrated copolymer, we used a 100-liter drum to prepare 50 liters with 250 grams of the product (5g L^{-1}). The doses taken per tray were 0, 3.75, 7.5, 11.25; 15g water–absorbent copolymer powder, representing 0, 25, 50, 75 and 100 g m^{-2}, and hydrated the volumes corresponding to: 0, 0.75, 1.5, 2.25 and 3.0 liters of hydrated water –absorbent copolymer. The copolymer, either as hydrated or powder was mixed to the total volume of the sandy soil.

It was acquired 200 sods of Bermudagrass cv. Celebration in CEAGESP, São Paulo (São Paulo General Warehousing and Centers Company). The sods were selected and cut, with the aid of wooden mold, to which fitted trays.

Before planting fertilization was performed using 1.5 g $tray^{-1}$ of simple superphosphate (SS). The remaining nitrogen and potassium applications were made in coverage, by tray, using 1 g of urea and 0.5 g of potassium chloride, where after cutting the leaves.

After planting, irrigation was done to reach field capacity of the soil used. Five days of irrigation that hydration of the copolymer powder was applied to higher possible. For realization of irrigation was necessary to weigh the trays so that the difference in weight over the following days reflected in water loss. In early October was applied a period of 10 days without irrigation to assess tolerance of turfgrass due to drought stress treatments. In late October, the amount of irrigation water applied has become standard for all plots, using an irrigation depth of 5.2mm per day (average obtained from the previous trial).

Six cuts were made during the experiment: at 15 days after planting (DAP), 30, 48, 72, 93 and 100 DAP. For cutting leaves of turfgrass were used electric mower manual, pruning shears and vacuum manual. Before each cut were obtained digital images of each tray with turfgrass for determining the green coverage rate, through analysis of the digital image in photo editor (Corel Photo Paint®). In digital image analysis was also determined the intensity of green color of turfgrass (hue). After each cut, the shavings were aspirated, stored and placed in an oven 65°C for subsequent weighing and determination of dry matter. After the last cut, a sample was taken of each cylindrical portion with an area of 28.3 cm^2 and 12 cm depth in order to determine the dry weight of roots. The samples were washed with distilled water. After drying in an oven at 65°C, the samples were weighed roots.

The results were submitted to analysis of variance by F test at 5 and 1% probability and in the case of results for the doses were adjusted by analysis of linear and quadratic regression, using the program SISVAR version 5.3.

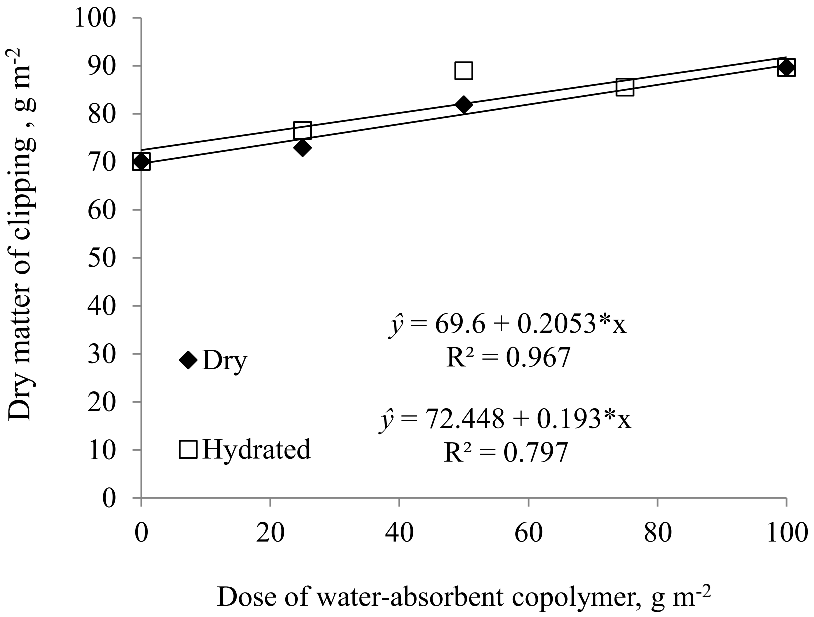
5 RESULTS AND DISCUSSION

5.1 Dry matter of clipping

For the sandy substrate, the effect of water-absorbent copolymer was observed only during under water stress, providing greater growth (dry matter of clipping) with increasing doses when applied hydrated (Figure 1). The ameliorative effect of hydrogels for drought stressed seedlings was demonstrated for *Citrus* (ARBONA et al., 2005). According to Jaminická et al. (2013) an amendment with soil conditioner significantly improved the photosynthetic performance of drought-stressed beech seedlings.

Moreira (2011) obtained promising results when studying the application of hydrogels in the culture of chives. According to the author hydrogels have great importance to have a high capacity to absorb water and nutrients in the form of nutrient solution. Also demonstrate that the plant was ready for consumption in a cycle shorter depending on the conditions provided by the water-absorbent copolymer the greater than that provided amounts of crops and higher profitability at the same time. Already Vallone et al. (2004) obtained opposite results when working with coffee seedlings. The authors noted that in the absence of polymers produced seedlings had higher values as height and leaf area, so the water-absorbent copolymer was not functional.

Figure 1. Clippings dry matter at 48 days after planting (after the stress period), depending on the dose and mode of application of the water-absorbent copolymer, for sandy substrate (UNESP, Registro, 2010/2011). *: significant at the 5% by F test.



The effect was not significant in the treatment with the copolymer applied dry, probably due to some other factor that interfered in plants subjected to a dose of 75 g m^{-2}, whose value was out of trend. Considering the value obtained at this dose as an "out-layer" and eliminating a linear fit was obtained ($p < 0.02$) the dry mass of clippings as a function of the doses of the polymer powder also applied. Even in sandy substrate at 15 days after planting and the total accumulation of dry matter of clippings during the experimental period was not observed effect of water-absorbent copolymer, probably due to irrigation. Sita et al. (2005) to analyze the performance of the polymer in chrysanthemum crops was noted that the sharp decrease in biomass with increasing doses of polymer. The author observed decrease in dry mass of stems and leaves of chrysanthemums, with increasing doses of polymer, which by the description of the author may be due to lower utilization of nutrients by the plant or by a combination between inadequate fertilizer and polymers. Hafle et al. (2008) concluded that the polymer doses were effective in cutting propagation of sweet passion fruit but the author noted that high doses caused negative effects for rooting and seedling development.

For medium textured soil at 15 days after planting, there was no significant effect of the water-absorbent copolymer in dry mass of clippings, probably have been maintained irrigation. In the stress period, 48 DAP, there was a significant effect, and doses of 76 g m^{-2}, in powder form, and the dose of 53 gm^{-2}, hydrated, yielded the highest production of dry matter clipping (Figure 2), showing greater efficiency of the copolymer used in hydrated form, this phase of 10 days without watering.

This difference between the modes of application practically disappeared at the end of the experiment, the maximum dry matter of clippings (total of six cuts) during the experimental period (September-December 2010) was achieved at a dose of 54 g m^{-2}, hydrated and 50 g m^{-2} when applied powder (Figure 3).

Figure 2. Dry matter of clipping at 15 days after planting, depending on the dose and mode of application of the water-absorbent copolymer, in medium textured soil (UNESP, Registro, 2010/2011). *;***: significant at the 5 and 0.1% by F test, respectively.

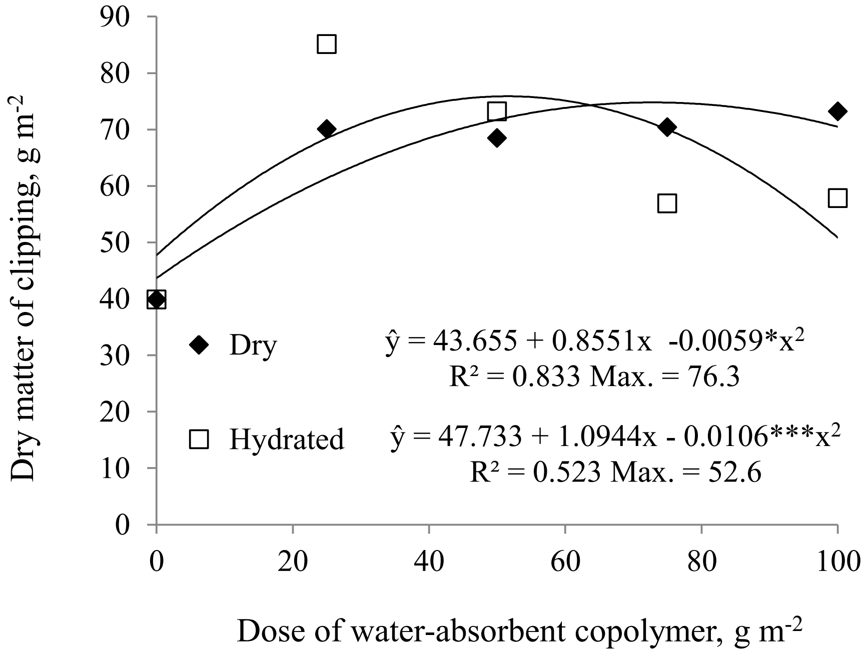
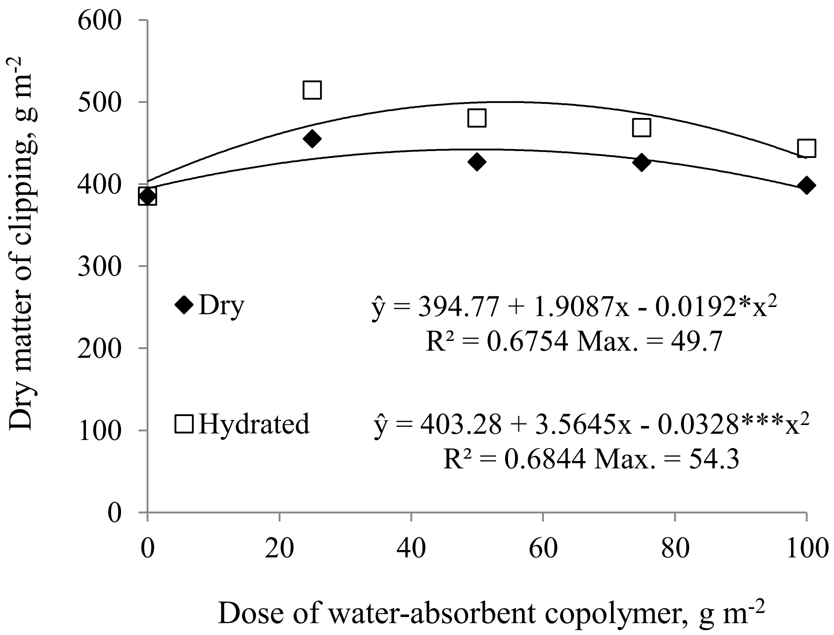


Figure 3. Dry matter of clippings, 48 days after transplanting (after the stress period) as a function of dose and mode application of the water-absorbent copolymer, in medium textured soil (UNESP, Registro, 2010/2011). *;***: significant at the 5 and 0.1% by F test, respectively.



Averaged across treatments, the total dry matter of the clippings produced from September to December 2010 was higher in turfgrasses receiving hydrated product (458 g m^{-2}) than applied as a powder (418.4 g m^{-2}). This can be explained as to receive the product initially retained hydrated water in the product can be promoted further development of seedlings each having more water than the non-hydrated product. This initial amount of water may allow further development of the seedlings at the end of the experiment, since the quantity and availability of water in the substrate are critical to survival and subsequent formation of the seedlings. The use of 0.5 L of a 7.0 g L^{-1} of hydrogel directly into the planting hole favored significantly the establishment of physic nut seedling and formulations above the suggested concentration reduced seedling growth in western Paraná (DRANSKI et al., 2013). Oliveira et al. (2004) observed that as the polymer concentration in the soil increased, there was also higher water retention, especially in matrix potentials higher.

5.2 Intensity of green color turfgrass (IGG)

For the sandy substrate was significant difference between treatments, however it was not possible to adjust the linear or quadratic regression. This effect of the copolymer in the sand substrate is due to which turfgrasses transplanted without the copolymer had a hue of 123 degrees, while all other treatments showed value of 101-106 degrees (green low intensity). After the stress period and at the end of the experiment there were no effects of copolymers in the intensity of green color turfgrass (IGG) of Bermudagrass. These data are similar to those observed by Vale, Carvalho and Paiva (2006) where the dry copolymer applied to the planting of coffee did not affect plant development.

In medium textured soil did not affect the water–absorbent copolymer intensity of green color of the turfgrass in any of the three evaluations. IGG values were similar to those observed by Lima et al. (2010) for Bermudagrass cv. Celebration subjected to high doses of N.

5.3 Rate of green cover of soil (RGC)

For the sandy substrate there was no significant effect of the polymer in RGC, shortly after planting. After the stress period and at the end of the experiment, the polymer was no effect on the RGC, however no adjustment linear or quadratic regression, ie, there was no a clear effect of the copolymer on the RGC. In the medium textured soil at 15 days after planting, there was no dose adjustment water-absorbent copolymer, which, in a way, showed uniformity of sod selected. The sods due transport coverage does not have 100% green, and application in the form of powder provided greater green cover rate (79.1%) than in hydrated form (75.4%). The product hydrated, especially at higher doses may have caused early in an excess of water, hindering the maintenance of green leaves.

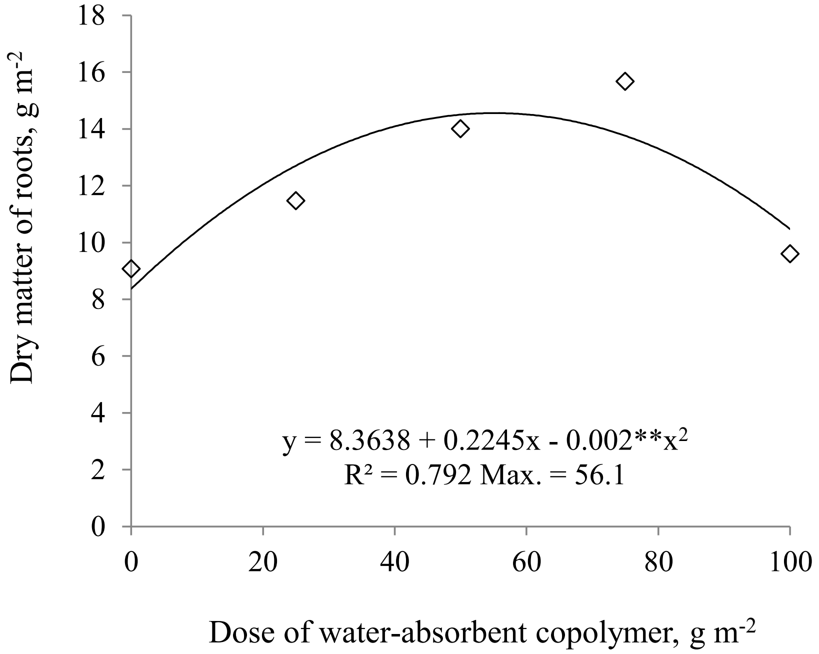
In medium textured soil, after the stress period, there was no effect of dose on the water-absorbent copolymer in the RGC. Despite the stress after green coverage rate remained higher than at 15 DAP. The difference between the RGC of turfgrasses that receiving powder (88.9%) or hydrated (85.7%) was no longer significant.

At the end of the experiment, in December, there was also no effect of dose or application mode in RGC for medium textured soil.

5.4 Dry matter of roots (DMR)

A dose estimated of 56 g m^{-2} of copolymer in the hydrated form, provided the highest root dry matter at the end of the experiment, in sandy substrate (Figure 4).

Figure 4. Dry matter of roots as a function of the water–absorbent copolymer dose, hydrated, at the end of the experiment - 100 days after transplanting, in sandy substrate (UNESP, Registro, 2010/2011). **: significant at 1% by F test.



Turfgrasses subjected to doses of 50 and 75 g m^{-2} copolymer applied in the hydrated form had higher root dry matter than when applied dry, at the same doses.

In sandy substrate, with 3% organic material, the application of hydrated copolymer, the average doses provided greater dry matter of roots of Bermudagrass cv. Celebration (11.9 g m^{-2}) which is applied powder (9.4 g m^{-2}).

For medium textured soil, average dry matter of roots was higher, when the copolymer was applied as a powder (13.5 g m^{-2}) which hydrated (9.7 g m^{-2}).

Increasing doses of the copolymer hydrated reduced the dry matter of roots at the end of the experiment.

6 CONCLUSIONS

The copolymer did not influence the intensity of green color, nor the green cover rate of the turfgrass.

The application of copolymer influenced dry matter of clippings (growth) and dry matter of roots.

7 THANKS

Thanks to the company Evonik Degussa Brasil LTDA. designed for financial support.

8 REFERENCES

ARBONA, V.; IGLESIAS, D. J.; PRIMO-MILLO, E.; TALON, M.; GOMEZ-CARDENAS, A. Hydrogel substrate amendment alleviates drought effects on young citrus plants. **Plant and Soil,** Crawley, v. 270, p. 73-82, 2005.

AZEVEDO, T. L. F.; BERTONHA, A.; GONÇALVES, A. C. A.; FREITAS, P. S. L.; RESENDE, R.; FRIZZONE, J. A. Níveis de polímero superabsorvente, frequências de irrigação e crescimento de mudas de café. **Acta Scientiarum,** Maringá, v. 24, n. 5, p. 1239-1243, 2002.

CARRIBEIRO, L. S. **Potencial de água no solo e níveis de compactação para o cultivo de grama esmeralda.** 2010. 79 f. Dissertação (Mestrado em Agronomia) – Faculdade de Ciências Agronômicas, Universidade Estadual Paulista, Botucatu, 2010.

CARVALHO, R. P.; CRUZ, M. C. M.; MARTINS, L. M. Irrigation frequency using hydro-absorvent polymer in seedling of yellow passion fruit. **Revista Brasileira de Fruticultura**, Jaboticabal, v. 35, n. 2, p. 518-526, 2013.

CHIRINO, E.; VILAGROSSA, A.; VALLEJO, R. V. Using hydrogel and clay to improve the water status of seedlings for dryland restoration. **Plant and Soil**, Crawley, v. 344, p. 99-110, 2011.

DRANSKI, J. A. L.; PINTO JUNIOR, A. S.; CAMPAGNOLO, M. A.; MALAVASI, U. C.; MALAVASI, M. M. Survival and seedling growth of physic nut as a function of method of application and hydrogel formulations. **Revista Brasileira Engenharia Agrícola e Ambiental,** Campina Grande, v. 17, n. 5, p. 537-542, 2013.

FERNANDES, E. R. P. **Hidrogel e turno de rega no crescimento inicial de eucalipto.** 2010. 35 f. Dissertação (Mestrado em Agronomia) - Universidade Federal dos Vales do Jequitinhonha e Mucuri, Diamantina, 2010.

GIACOIA NETO, J. **Sistemas de irrigação para gramados.** In: GODOY, L. J. G.; OLIVEIRA, M. V. A. M.; VILLAS BÔAS, R. L. (Org.). SIMPÓSIO SOBRE GRAMADOS – SIGRA, 1, 2003, Botucatu. **Anais...** Botucatu: UNESP/FCA, 2003. 1 CD-ROM.

GOLOMBEK, C. H. A. **Estresse em gramados e fatores fisiológicos correlatos.** In: GODOY, L. J. G.; BACKES, C.; OLIVEIRA, M. V. A. M.; VILLAS BÔAS, R.L. (Org.) SIMPÓSIO SOBRE GRAMADOS – SIGRA, 3, 2006, Botucatu. **Anais...** Botucatu: UNESP/FCA, 2006. 1 CD-ROM.

GURGEL, R. G. A. **Principais espécies e variedades de gramas**. In: GODOY, L. J. G.; OLIVEIRA, M. V. A. M.; VILLAS BÔAS, R.L. (Org.). SIMPÓSIO SOBRE GRAMADOS – SIGRA, 1, 2003, Botucatu. **Anais...** Botucatu: UNESP/FCA, 2003. 1 CD-ROM.

HAFLE, O. M.; CRUZ, M. C. M.; RAMOS, J. D.; RAMOS, P. S.; SANTOS, V. A. Produção de mudas de maracujazeiro doce através da estaquia utilizando polímero hidrorretentor. **Revista Brasileira de Ciências Agrárias**, Recife, v. 3, p. 232-236, 2008.

HUTTERMANN, A.; ZOMMORODI, M.; REISE, K. Addition of hydrogels to soil for prolonging the survival of *Pinus halepensis* subjected to drought. **Soil & Tillage Research**, Amsterdam, v. 50, p. 295-304, 1999.

JAMINICKÁ, G.; DITAMAROVÁ, L.; KURJAK, D.; KMET, J.; PSIDOVÁ, E.; MACKOVÁ, M.; GOMORY, D. E.; STRELCOVÁ, K. The soil hydrogel improved photosynthetic performance of beech seedlings treated under drought. **Plant, Soil and Environment,** Prague, v. 59, n. 10, p. 446-451, 2013.

LAURETTI, L. R. **Implantação de gramados por sementes**. In: GODOY, L. J. G.; OLIVEIRA, M. V. A. M.; VILLAS BÔAS, R. L. (Org.). SIMPÓSIO SOBRE GRAMADOS – SIGRA, 1, 2003, Botucatu. **Anais...** Botucatu: UNESP/FCA, 2003. 1 CD-ROM.

LIMA, C. P.; BACKES, C.; VILLAS BÔAS, R. L.; OLIVEIRA, M. R.; KIIH, T. A. M.; FREITAG, E. E. Bermudagrass sod production as related to nitrogen rates. **Revista Brasileira de Ciência do Solo**, Viçosa, v. 34, n. 2, p. 371-378, 2010.

LOPES, J. L. W. et al. Efeitos da irrigação na sobrevivência, transpiração e no teor relativo de água na folha em mudas de *Eucalyptus grandis* em diferentes tratos. **Scientia Forestalis**, Piracicaba, v.68, p.97-106, 2005.

MORAES, O. **Efeito do uso de polímero hidroretentor no solo sobre o intervalo de irrigação na cultura da alface (*Lactuca sativa* L.).** 2001. 73 f. Tese (Doutorado em Agronomia) - Escola Superior de Agricultura Luiz de Queiroz, Universidade de São Paulo, Piracicaba, 2001.

MOREIRA, K. D. **Efeito do polímero hidratassolo sobre propriedades físico-químicas em solução nutritiva no desenvolvimento da cebolinha (*Allium fistulosum* L.).** 2011. 36 f. Monografia (Graduação em Química) - Centro de Estudos Superiores de Caixas, CESC/UEMA, Caxias, 2011.

SAAD, J. C. C.; LOPEZ, J. L. W.; SANTOS, T. A. Manejo hídrico em viveiro e uso de hydrogel na sobrevivência pós-plantio de *Eucalyptus urograndis* em dois solos diferentes. **Engenharia Agrícola,** Jaboticabal, v. 29, n. 3, p. 404-411, 2009.

SHI, Y.; LIA, J.; SHAOA, J.; DENGA, S.; WANGA, R.; LIA, N.; SUNA, J.; ZHANGA, H.; ZHUA, H.; ZHANGA, Y.; ZHENGB, X.; ZHOUB, D.; HÜTTERMANNC, A.; CHENA, S. Effects of stockosorb and luquasorb polymers on salt and drought tolerance of *Populus popularis*. **Scientia Horticulture**, Amsterdam, v. 124, n. 2, p. 268-273, 2010.

SITA, R. C. M.; REISSMANN, C. B.; MARQUES, R.; OLIVEIRA, E.; TAFFAREL, A. D. Effect of polymers associated with n and k fertilizer sources on *Dendrathema grandiflorum* growth and K, Ca and Mg relations. **Brazilian Archives of Biology and Technology**, Curitiba, v. 48, n. 3, p. 335-342, 2005.

OLIVEIRA, A. R.; REZENDE, L. S.; MARTINEZ, M. A.; MIRANDA, G. V. Influência de um polímero hidroabsorvente sobre a retenção de água no solo. **Revista Brasileira de Engenharia Agrícola e Ambiental,** Campina Grande, v. 8, n. 1, p. 160-163, 2004.

TAPIA, D. **Implantação e manejo de gramados esportivos**. In: GODOY, L. J. G.; OLIVEIRA, M. V. A. M.; VILLAS BÔAS, R. L. (Org.). SIMPÓSIO SOBRE GRAMADOS – SIGRA, 1. 2003, Botucatu. **Anais...** Botucatu: UNESP/FCA, 2003. 1 CD-ROM.

VALE, G.; CARVALHO, S.; PAIVA, L. Avaliação da eficiência de polímeros hidrorretentores no desenvolvimento do cafeeiro em pós-plantio. **Coffee Science**, Lavras, v. 1, n. 1, p. 7-13, 2006.

VALLONE, H. S.; GUIMARÃES, R. J.; SOUZA, C. A. S.; CARVALHO, J. A.; FERREIRA, R. S. E.; OLIVEIRA, S. Substituição do substrato comercial por casa de arroz carbonizada para produção de mudas de cafeeiro em tubetes na presença de polímeros hidrorretentores. **Ciência e Agrotecnologia,** Lavras, v. 28, n. 3, p. 593-599, 2004.