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Effect of different soil water potential on leaf transpiration and on stomatal conductance in poinsettia.

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Summary

Euphorbia pulcherrima Wild. 'Lilo' was grown in containers in 60% peat, 30% perlite and 10% clay (v/v) mixture, with different irrigation treatments based on soil water potential. Plants were watered at two levels of drought stress: -50 kPa or wilting. The treatments were applied at different stages of plant development for a month or soil was brought to the moisture stress only twice. Additionally, some plants were watered at -50 kPa during the entire cultivation period while the control plants were watered at -5 kPa. Plants were also kept at maximum possible moisture level (watering at -0.5 kPa) or close to it (-1.0 kPa) through the entire growing period. Soil water potential was measured with tensiometer.

Drought stress applied during entire cultivation period or during the flushing stage caused significant reduction in transpiration and conductance of leaves. Stress applied during bract coloration stage had not as great effect on the stomatal conductance and transpiration of leaves as the similar stress applied during the flushing stage. High soil moisture increased stomatal conductance and transpiration rate, respectively by 130% and 52% (flushing stage), and 72% and 150% (bract coloration stage) at maximum, compared to the control.

Key words: water stress, water deficit, drought stress, high soil moisture, leaf transpiration, stomatal conductance

INTRODUCTION

Drought stress and high moisture tension according to many scientist may influence the biochemical and physiological balance of plant (White and Holcomb 1974, Shanks 1976, Drew 1992, Sojka 1992). Among others, water stress decreases the number of stomata (Naik et al. 1993, Younis et al. 1993), reducing the plant growth. Also Net Asymilation Rate can be decreased, resulting in reduced biomass production (Hsiao 1993).

The aim of this study was to investigate the reaction on stomatal conductance and transpiration of leaves of poinsettia plants exposed to water stress at different growth stages.

MATERIAL AND METHODS

Rooted poinsettia (*Euphorbia pulcherrima* Wild.) cv. Lilo cuttings were planted on 12 August, 1987 into 12 cm diameter pots containing a mixture of 60% peat, 30% perlite and 10% clay (v/v), amended with Osmocote Plus 5/6M (15-10-12) - 5 $g.dm^{-3}$. Plants were pinched 2 weeks after potting and provided with natural daylight. One week after potting, when plants established, different irrigation treatments based on soil water potential were introduced. Plants were watered at two levels of drought stress: -50 kPa or wilting. The treatments were applied at different stages of plant development: flushing or bract coloration time - for a month or soil was brought to the moisture stress only twice. Additionally, some plants were watered at -50 kPa during the entire cultivation period while the control plants were watered at -5 kPa. Plants were also kept at a maximum possible moisture level (watering at -0.5 kPa) or they were watered at -1.0 kPa (maintained during entire cultivation). The complete list of all treatments is as follows:

I. Control -- watering at soil water potential -5kPa during the entire cultivation period

II. High moisture level (watering at soil water potential -1.0 kPa) throughout the whole cultivation period

III. Maximal, possible to maintain, moisture level (almost equal to container capacity - with soil water potential -0.5 kPa in the central part of root ball) during the entire cultivation period

IV. Drought stress (watering at -50 kPa) throughout the whole cultivation period

V. Drought stress (watering at -50 kPa) for 1 month during the period of vegetative growth

VI. Short term drought stress during the period of vegetative growth (watering at -50 kPa applied twice)

VII. Drought stress (watering after reaching of wilting point of plants) for 1 month during vegetative growth

VIII. Short term drought stress during vegetative growth: plants brought to the wilting point twice

IX. Drought stress (watering at -50 kPa) for 1 month during the period of bract coloration

X. Short term drought stress during the period of bract coloration (watering at -50 kPa applied twice)

XI. Drought stress (watering after reaching of wilting point of plants) for 1 month during bract coloration

XII. Short term drought stress during bract coloration: plants brought to the wilting point twice

Soil water potential was measured with tensiometer. One tensiometer cup was inserted into one pot of each replication, so that the vertically oriented cup was halfway between the bottom of the pot and the top of the medium. All plants were hand-watered up to full container capacity.

The stomatal conductance and transpiration of leaves was determined during whole irrigation cycle after water stress was applied (from one till next watering) in 3 plants and 3 fully developed leaves per each plant using portable porometer (LICOR, 1600M, Nebraska, USA). The measurements were taken every day between 10-12 a.m.. The results were shown on graphs and the differences between treatments were evaluated using standard error.

RESULTS

Effect of different water potential on transpiration and stomatal conductance of poinsettia leaves at flushing stage.

Analysing stomatal conductance and leaf transpiration measurements carried out every day during the whole irrigation cycle (from one watering till another) it was found that immediately after watering both parameters gradually increased. After reaching the maximum as the water stress increased the stomatal conductance and the leaf transpiration fell down (fig. 1 and 2). The maximal stomatal conductance of control plants was noted on the third day after watering while for other plants it was observed two days after watering. Also transpiration rate was the highest on the second day after watering except for plants treated with -50kPa stress for entire cultivation period or for a month during flushing. In these two treatments maximum transpiration occurred already on the next day after watering. The maximal rates of stomatal conductance and leaf transpiration depended on the method of stress induction and were generally lower in plants where the stress was defined by soil water potential (-50 kPa) than in these watered at wilting. I was found that also rates of stomatal conductance and leaf transpiration reduction depended on stress induction method. In plants watered at soil water potential -50 kPa significant decrease in stomatal conductance and transpiration occurred already on the third day after watering, while in plants watered at wilting after 5 days. The strongest reduction of stomatal conductance and leaf transpiration was observed in plants for which -50 kPa water stress was applied during entire cultivation. Generous watering at soil water potential of -0.5kPa during entire cultivation increased stomatal conductance and leaf transpiration, respectively, by 130% and 52% compared to control plants (fig. 3 and 4).

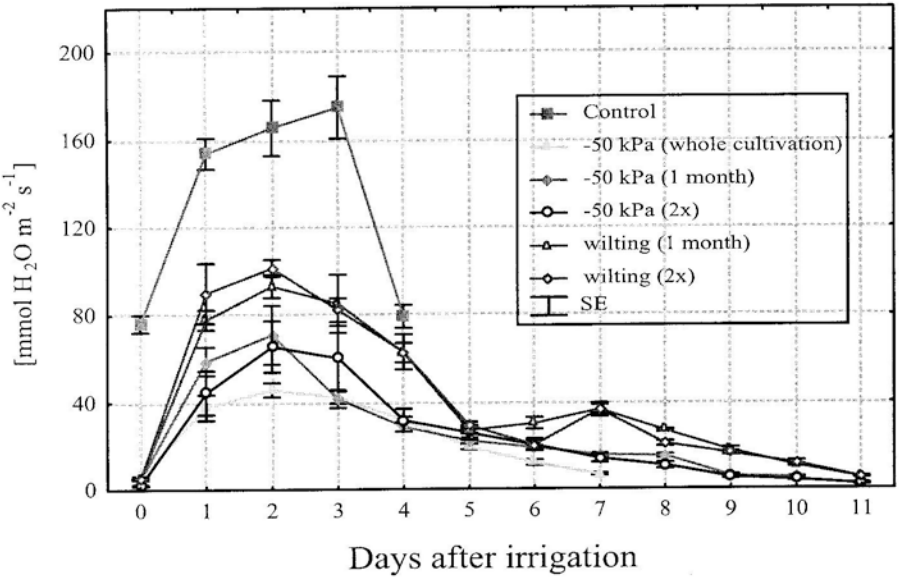

Fig. 1. Stomatal conductance of poinsettia at flushing stage.

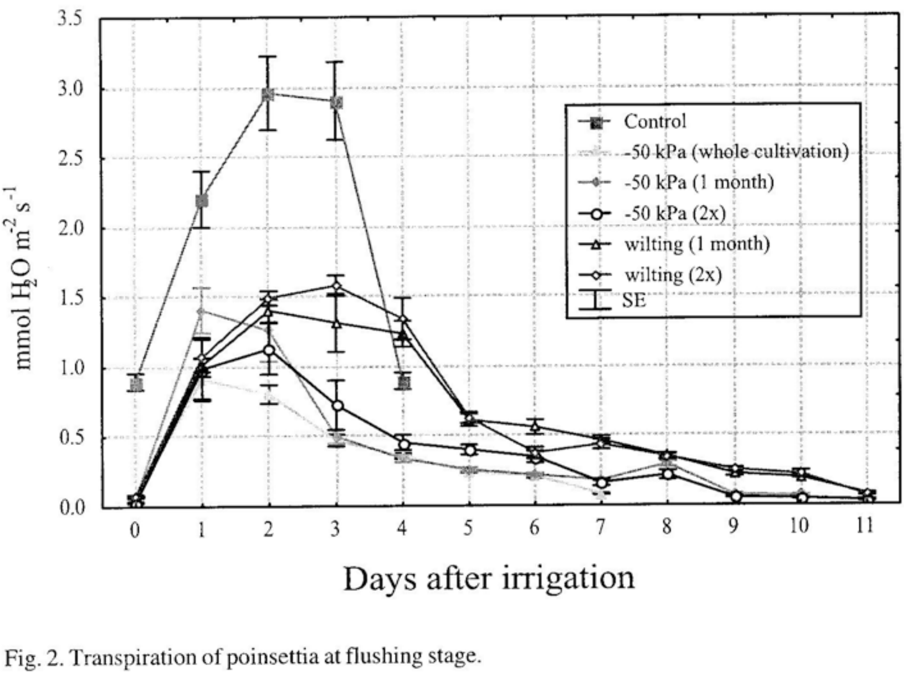

Fig. 2. Transpiration of poinsettia at flushing stage.

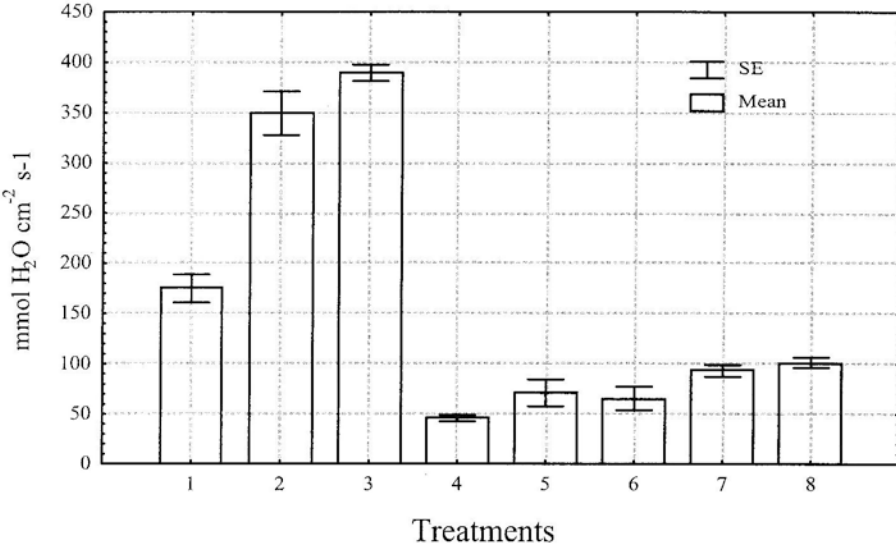

Fig. 3. Maximum stomatal conductance of poinsettia at flushing stage. From the left: 1 – Control; 2 – -1.0 kPa (whole cultivation); 3 – -0,5 kPa (whole cultivation); 4 – - 50 kPa (whole cultivation); 5 – -50 kPa (1 month); 6 – -50 kPa (2x); 7 – Wilting (1 month); 8 – Wilting (2x).

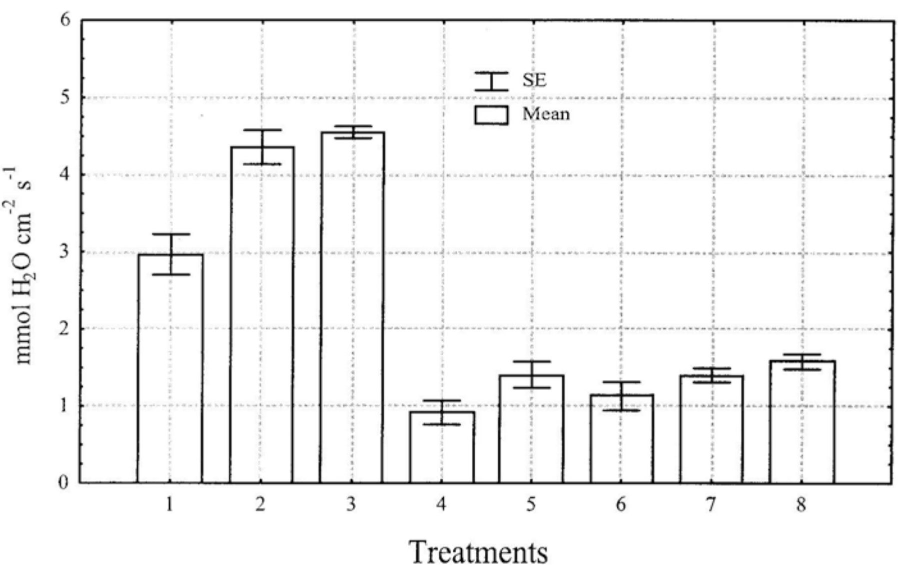

Fig. 4. Maximum transpiration of poinsettia at flushing stage. From the left: 1 – Control; 2 – -1.0 kPa (whole cultivation); 3 – -0,5 kPa (whole cultivation); 4 – -50 kPa (whole cultivation); 5 – -50 kPa (1 month); 6 – -50 kPa (2x); 7 – Wilting (1 month); 8 – Wilting (2x).

The effect of different soil water potential on transpiration and stomatal conductance of poinsettia at bract coloration stage.

Drought stress applied during bract coloration had less effect on stomatal conductance and leaf transpiration than during flushing. Daily measurements of these parameters during entire irrigation cycle demonstrated that water stress determined by either soil water potential of -50kPa or plant wilting resulted in decrease in stomatal conductance and leaf transpiration compared to control plants. The -50kPa stress applied for 1 month stronger influenced plants than similar stress induced during two waterings only (fig. 5, 6). Stomatal conductance was the highest on the third day after watering except for the plants where drought stress was maintained from the beginning of cultivation. In the latter the maximal stomatal conductance was observed 4 days after watering. Transpiration of non-stressed plants was maximal on the third day after watering why for stressed plants after four days. Plants stressed twice up to the wilting point exhibited the highest transpiration on the fifth day after watering. At this growth stage the strongest reduction of stomatal conductance and leaf transpiration was noted in plants stressed for the entire cultivation. Their maximal levels were by, respectively, 72 and 64% lower than in control plants (fig. 7, 8). Generous watering (at soil water potential -0.5 kPa) during entire cultivation resulted in increased stomatal conductance and leaf transpiration in this stage maximally by 72 and 150%, respectively, compared to the control (fig. 7, 8).

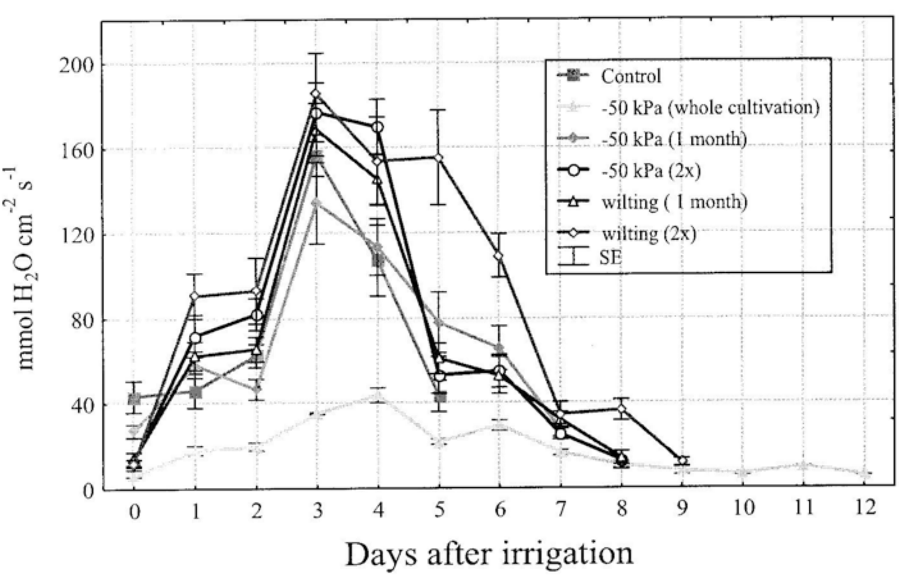

Fig. 5. Stomatal conductance of poinsettia at bract coloration stage.

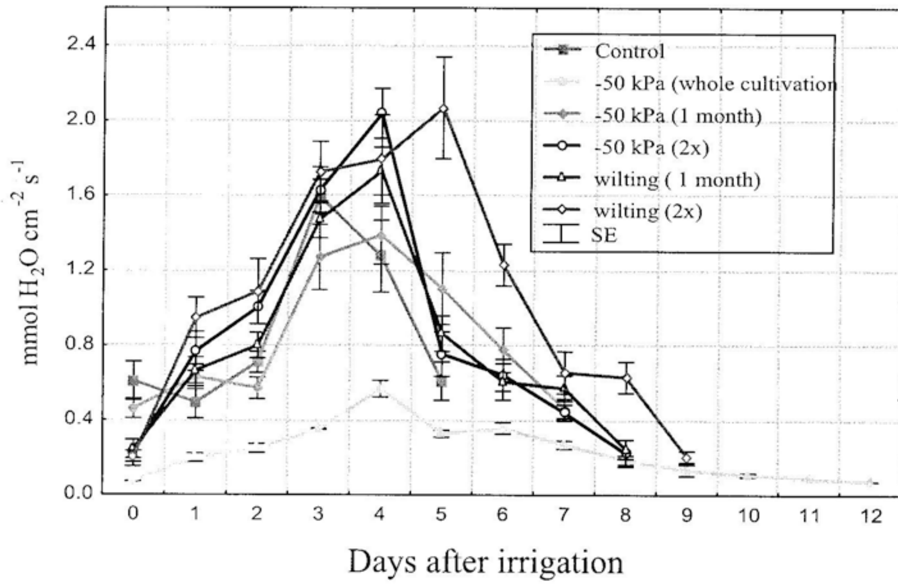

Fig. 6. Transpiration of poinsettia at bract coloration stage.

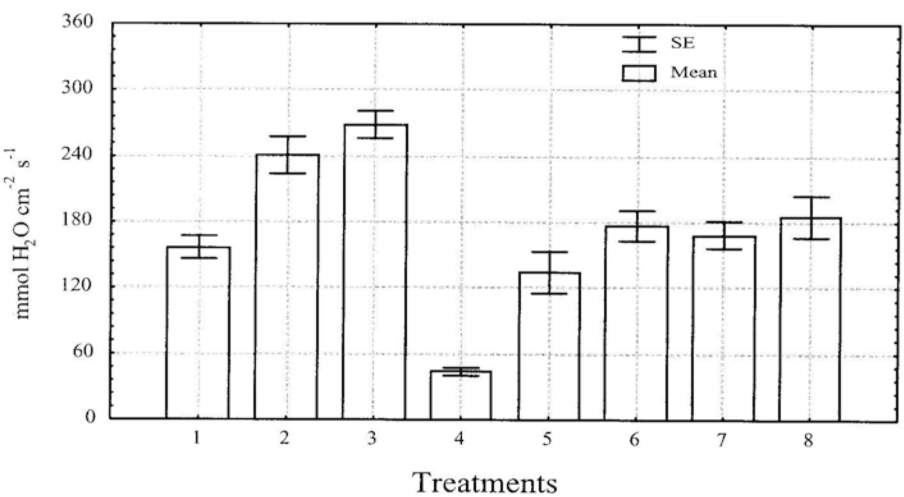

Fig. 7. Maximum stomatal conductance of poinsettia at bract coloration stage. From the left: 1 – Control; 2 – -1.0 kPa (whole cultivation); 3 – -0,5 kPa (whole cultivation); 4 – -50 kPa (whole cultivation); 5 – -50 kPa (1 month); 6 – -50 kPa (2x); 7 – Wilting (1 month); 8 – Wilting (2x).

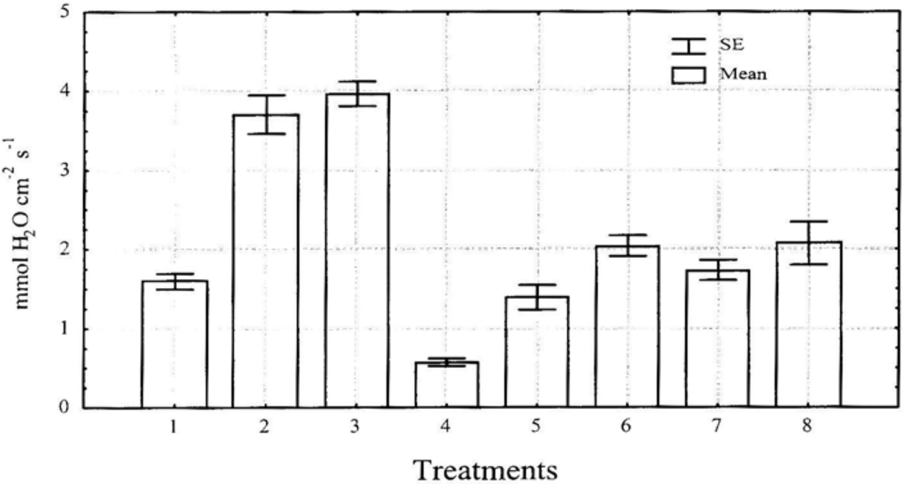

Fig. 8. Maximum transpiration of poinsettia at bract coloration stage. From the left: 1 – Control; 2 – -1.0 kPa (whole cultivation); 3 – -0,5 kPa (whole cultivation); 4 – - 50 kPa (whole cultivation); 5 – -50 kPa (1 month); 6 – -50 kPa (2x); 7 – Wilting (1 month); 8 – Wilting (2x).

DISCUSSION

Drought stress had strong effect on stomatal conductance and leaf transpiration of poinsettia plants during flushing stage. This was especially true when water stress was maintained from the beginning of cultivation which resulted in dramatic decrease in these parameters. However, no plant wilting was observed in this treatment and plants stayed turgid even at the deepest water stress. Thus reduction of stomatal conductance and leaf transpiration may be seen as a plant self-defence system minimising water losses. Similar reactions were observed by Bansal and Nagrajan (1992). But lower stomatal conductance and leaf transpiration lead to reduction of photosynthetic efficiency (Hsiao, 1993) which was presumably the main reason for decreased growth of plants. The results obtained by Nowak and Strojny (1997, 1998, 2001) also support this thesis, as these authors noted that poinsettia reaction to water stress depended both on its depth and method of induction. In presented research drought stress maintained during entire cultivation and induced by reducing soil water potential to -50 kPa caused growth retardation just from the very beginning. Short time (applied twice) or longer (for a month) drought stress induced during vegetative phase and indicated by low soil water potential of -50 kPa or by wilting also resulted in significant growth reduction. The stress controlled by soil water potential was more evident than one determined by wilting. This agrees with results of Gilbertz et al. (1984).

Stress induced during bract coloration did not have so strong effect on stomatal conductance and leaf transpiration as the one during flushing. At this stage vegetative growth was already terminated and plant reaction was not so evident. The strongest decrease in these parameters was again caused by -50 kPa drought stress maintained during entire cultivation. Similarly as at flushing stage, levels of stomatal conductance and leaf transpiration were strictly correlated with biomass accumulation. Water stress induced during generative phase did not influence the height of poinsettia plants, both when measured immediately after stress or at the end of cultivation (Nowak and Strojny, 1997, 1998). However it did reduced area and slightly also number of leaves and bracts. Thus, lower fresh and dry shoot weight of stressed plants resulted presumably from smaller area of leaves and bracts. The same was observed on chrysanthemums by Lieth and Burger (1989). This proves that short-time or even a slightly longer drought stress during bract coloration stage has no great effect on poinsettia growth.

Generous watering increased stomatal conductance and leaf transpiration compared to control plants, both in flushing and bract coloration stages. This agrees with experiments of Bradford and Hsiao (1982), though there are also data suggesting that short-time or longer overwatering may negatively affect stomatal conductance and leaf transpiration (Zhang and Davis, 1986, 1987; Smith et al., 1989). In our experiments poinsettia grew very well at high soil water potential (-0.5 kPa) and in this treatment the highest levels of stomatal conductance and leaf transpiration were noted. It was probably because of very good physical properties of the growing medium which provided good aeration of root environment even in the high moisture level.

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Wpływ zróżnicowanego potencjału wody w podłożu na transpirację i przewodność szparkową poinsecji.

Streszczenie

Poinsecję (*Euphorbia pulcherrima* Wild.) 'Lilo' uprawiano w mieszaninie 60% torfu, 30% perlitu i 10 % ziemi gliniastej, stosując zróżnicowane nawadnianie oparte na pomiarze potencjału wodnego podłoża. Zastosowano dwa sposoby określania stresu suszy: potencjał wody w podłożu -50 kPa lub początkowe objawy więdnięcia roślin. Rośliny poddano 2-krotnemu przesuszeniu albo stres utrzymywano przez 1 miesiąc, zarówno w fazie krzewienia jak i wybarwiania. Dodatkowo część roślin nawadniano przy -50 kPa przez cały czas uprawy. Rośliny kontrolne nawadniano przy -5 kPa. Ponadto zastosowano poziomy wilgotności: maksymalny - zbliżony do pojemnikowej pojemności wodnej (nawadnianie przy -0,5 kPa) przez cały czas uprawy oraz zbliżony do maksymalnego (nawadnianie przy -1,0 kPa) utrzymywany przez cały czas uprawy. Potencjał wody w podłożu mierzono przy pomocy tensjometrów.

Stres suszy indukowany w fazie krzewienia zmniejszył drastycznie przewodnictwo szparkowe i transpirację liści, zwłaszcza utrzymywany od początku uprawy. Natomiast stres suszy wywołany w czasie wybarwiania przykwiatków nie wpłynął na tak wyraźny spadek przewodnictwa szparkowego i transpirację liści. Najsilniej na obniżenie powyższych wskaźników wpływał stres suszy -50 kPa utrzymywany przez cały czas uprawy. Intensywne nawadnianie, zarówno w fazie krzewienia się, jak i wybarwiania przykwiatków, wpłynęło na zwiększenie intensywności przewodnictwa szparkowego i transpiracji liści powodując ich wzrost w porównaniu do wartości kontrolnych, przy maksymalnie uzyskanych poziomach odpowiednio o: 130% i 52% (krzewienie się) i 72% i 150% (wybarwianie).