Journal of Fruit and Ornamental Plant Research Vol. 18(2) 2010: 349-360

CHANGES OF PHYSICAL PROPERTIES IN ROCKWOOL AND GLASSWOOL SLABS DURING HYDROPONIC CULTIVATION OF ROSES

Jacek S. Nowak

Research Institute of Pomology and Floriculture
Pomologiczna 18, 96-100 Skierniewice, POLAND
e-mail: Jacek.Nowak@insad.pl

(Received September 7, 2010/Accepted October 7, 2010)

ABSTRACT

Roses cv. 'Trixx' were grown in 4 different slabs of mineral wool (100 cm length, 15 cm width and 7.5 cm height), which were placed on specially constructed racks in a greenhouse. The cultivation method using bent shoots was used. The studied growth media were: rockwool slabs – Master and Pargro which had a horizontal fibrous structure, Bomat slabs with a homogeneous structure and glasswool Cultilene slabs with a homogeneous structure. The physical properties of mineral wool slabs were obtained from 15 cm long and 15 cm width samples. The samples were taken from slabs before cultivation, and periodically from a greenhouse during the 2.5 year growing period (6, 12, 18, 24 and 30 months after planting). The bulk density increased and total porosity decreased in the Master and Cultilene slabs as early as after six months of cultivation. Other changes in the remaining slabs were not evident until the end of the cultivation stage. The air-water properties depended on the cultivation time and were very different at -4 cm H_2O. More stable values of air-water properties were observed at -10 cm H_2O. Usually in the beginning of the cultivation period, water content was lower – especially at the -10 to -50 cm H_2O range of water potential.

Key words: growing medium, rockwool, glasswool, inert media, slabs, water, porosity, bulk density, shrinkage, water holding capacity

INTRODUCTION

The physical properties of growing media are very important, especially in hydroponic cultivation of plants. In these conditions plants are grown at full water capacity. For this reason, even small physical property changes cause appreciable deterioration of air-water properties on the root environment. Some researchers look for good methods for determining physical properties, on mineral wool slabs (Wever and Kipp, 1998; Wever, 2000ab, 2002) but there is no information in scientific literature about the determination of those properties during the cultivation period. Determining the physical properties on mineral wool slabs is related to the difficulty in determining air-water properties in slabs.

The aim of this study was to estimate the changes in the physical properties of mineral wool used in the hydroponic cultivation of roses.

MATERIAL AND METHODS

The experiments were conducted from 2002 to 2005 in the greenhouse of the Research Institute of Pomology and Floriculture in Poland. Roses cv. 'Trixx' were grown in 4 different mineral wool slabs (100 cm length, 15 cm width and 7.5 cm height). Slabs were placed on racks in a greenhouse. The shoots are bent in this cultivation method. The studied growth media (slabs) were:

1. Grodan – rockwool with a horizontal fibrous structure,
2. Pargro – rockwool with a horizontal fibrous structure,
3. Cultilene – glasswool, homogeneous,
4. Bomat – rockwool, homogeneous.

The growing system, fertilization, watering and plant protection were conducted in agreement with the principles of rose cultivation.

The physical properties of slabs were determined before cultivation as well as periodically during the 2.5 year growing period (6, 12, 18, 24 and 30 months after planting) in a greenhouse. Various physical parameters of the slabs were determined using the method described by the Research Station in Naaldwijk, the Netherlands. The 15 cm long and 15 cm wide sample was formed by cutting the slab with a knife. The sample was placed on a grid in an empty bath. A constant, slow flow of distilled water filled the bath until the level reached c.a. 1 cm above the top of the sample. The sample was made thoroughly wet for up to 24 h (±2 h), after which the water was removed from the bath for 3 h, and again filled with distilled water to 1 cm above the top of the sample for 30 min. After that, the sample was removed from the water bath and transferred to a sandbox ensuring good contact between the bottom of the sample and the sand. Then,100 cm pressure head was applied for 30 min. Next, the distilled water was poured into the sandbox containing the sample, until the water level reached 3 cm above the top of sample. The sample was kept thoroughly wet for up to 24 h (±2 h), after which, the first level of water suction was applied.

Water-air properties were established with the sand apparatus 'Eijkelkamp', at a negative pressure range of 0-50 hPa. For each of 4 negative pressure levels (-3.2, -10, -32 and -50 cm H_2O) 24 h were allowed to reach water equilibrium. After measurements with the sand apparatus, the samples were dried at 103 ^{o}C. Shrinkage of the substrates was assessed by volume reduction measurement. Organic matter and ash content were also determined. Porosity was calculated according to the EN 13041 method (1999).

Measurements were conducted in 6 replicates. Results were analysed statistically with ANOVA. Significance of differences between means was established with Duncan's multiple range test, at the probability level of 95%.

RESULTS AND DISCUSSION

The changes in the air-water properties of the investigated media are presented in Figure 1-7. Significant increase in bulk density (Fig. 1) and decrease of total porosity (Fig. 2) of the Master and Cultilene slabs was observed as early as after six months of cultivation. Other changes in the remaining slabs were not evident until the end of the cultivation stage.

Considerable degree of interdependence between some of the physical properties of the investigated slabs was ascertained. These studies confirmed other authors' information concerning a high correlation between total porosity and bulk density of substrates (Fig. 8). The substrate's pore content is inversely proportional to its density (Beardsell et al., 1979; Hanan et al., 1981; Bunt, 1983; Nowak and Strojny, 2004). When bulk density of the substrate decreases, the porosity increases.

In the case of organic media, porosity and bulk density were essentialy influenced by air and water content. The smaller the porosity and the greater the density, meant greater water content and smaller air content (Nowak and Strojny, 2004). This correlation was not affirmed in this experiment. The special structure of the mineral wool slab are its variable density, and arrangement of fibres. These structures probably permit it to uphold stable air-water properties during the whole cultivation period. The decrease in total porosity in organic medium is connected with a decrease in air content – at the cost of water (Nowak and Strojny, 2003). In the case of mineral wool slabs this dependence was not observed. A decrease in total porosity caused water content to decrease, especially at -4 cm H_2O water potential.

The water and air content values, at the -4 cm H_2O water potential, were very different depending on the cultivation time (Fig. 3-4). More stable values of air-water properties were observed at a -10 cm H_2O water potential, where water and air content in particular slabs remained on a similar level till the end of cultivation (Fig. 5-6). The best air-water properties at this pressure head were observed in Pargro slabs. These properties could positively affect better yield of roses cultivated on the Pargro mineral wool slab (Tab. 1). However, a significant influence of particular slabs on the remaining biometric features of plants (amount of flowers, flower bud diameter, flower bud height, flower shoot length and weight of flowers) was not affirmed. Nevertheless, analysis of linear correlation showed that when using Pargro slabs in rose cultivation, the physical properties of

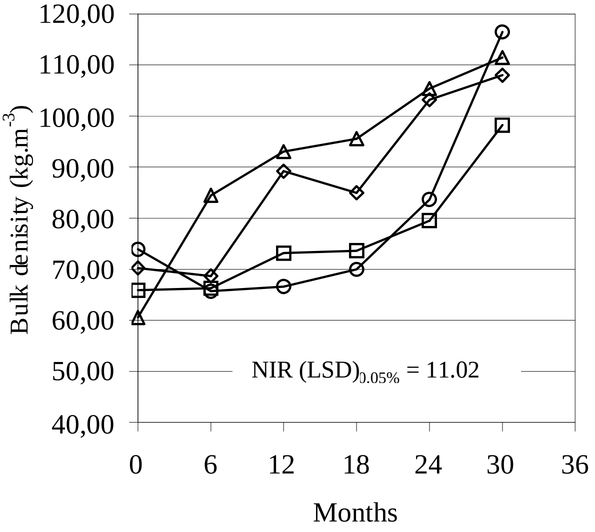

Figure 1. Effect of the length of the cultivation period on the bulk density of slabs: Grodan Master (◊), Pargro (□), Cultilene (Δ) and Bomat (○). Each point represents the mean of 6 replications. Means are separated by LSD, 5% level

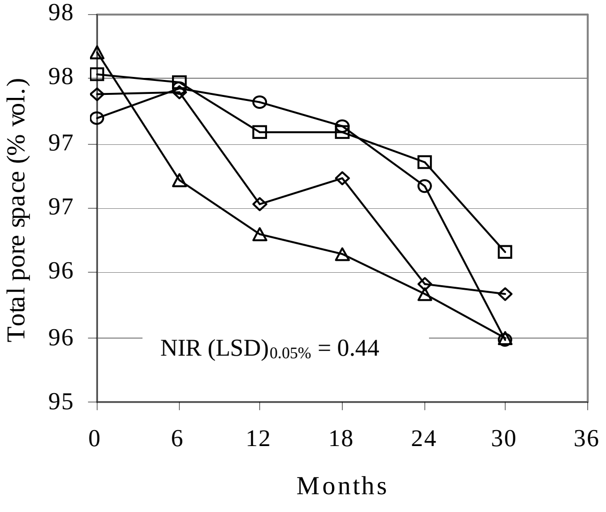

Figure 2. Effect of the length of the cultivation period on the total pore space of slabs: Grodan Master (◊), Pargro (□), Cultilene (Δ) and Bomat (○). Each point represents the mean of 6 replications. Means are separated by LSD, 5% level

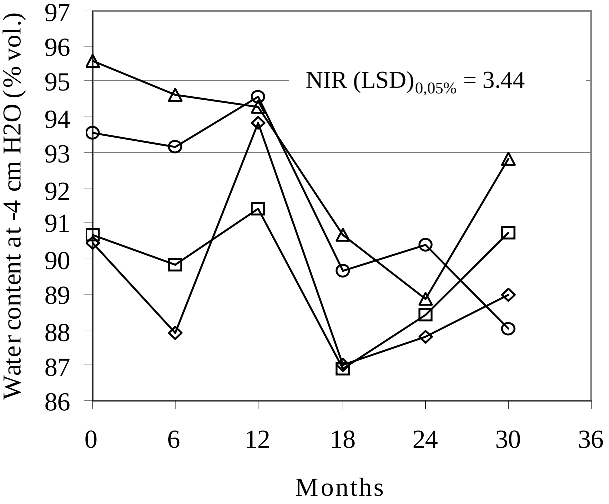

Figure 3. Effect of the length of the cultivation period on the water content at -4 cm H_2O of slabs: Grodan Master (◊), Pargro (□), Cultilene (Δ) and Bomat (○). Each point represents the mean of 6 replications. Means are separated by LSD, 5% level

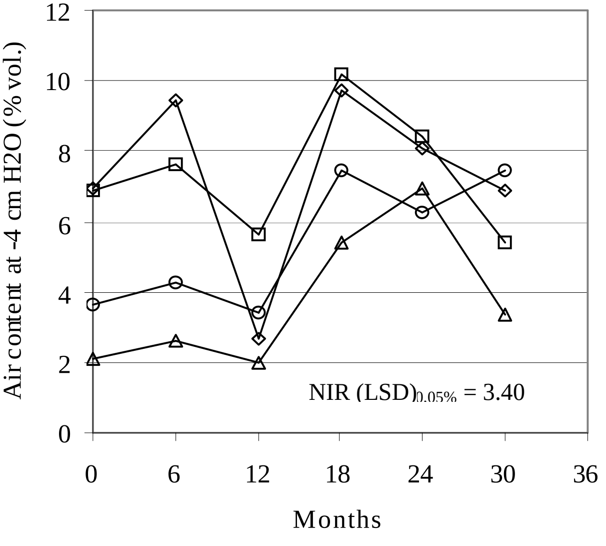

Figure 4. Effect of the length of the cultivation period on the air content at -4 cm H_2O of slabs: Grodan Master (◊), Pargro (□), Cultilene (Δ) and Bomat (○). Each point represents the mean of 6 replications. Means are separated by LSD, 5% level

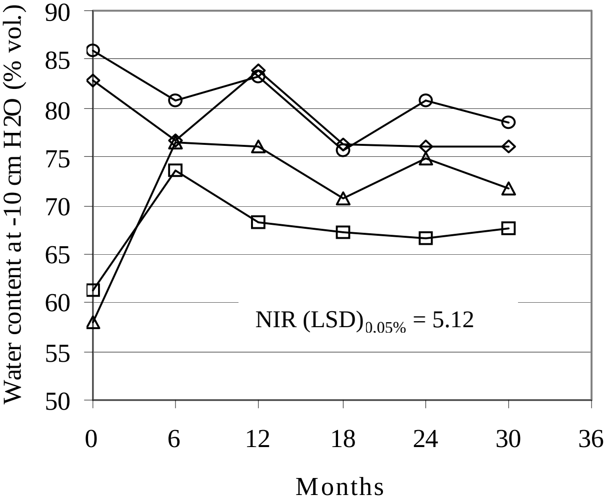

Figure 5. Effect of the length of the cultivation period on the water content at -10 cm H_2O of slabs: Grodan Master (◊), Pargro (□), Cultilene (Δ) i Bomat (○). Each point represents the mean of 6 replications. Means are separated by LSD, 5% level

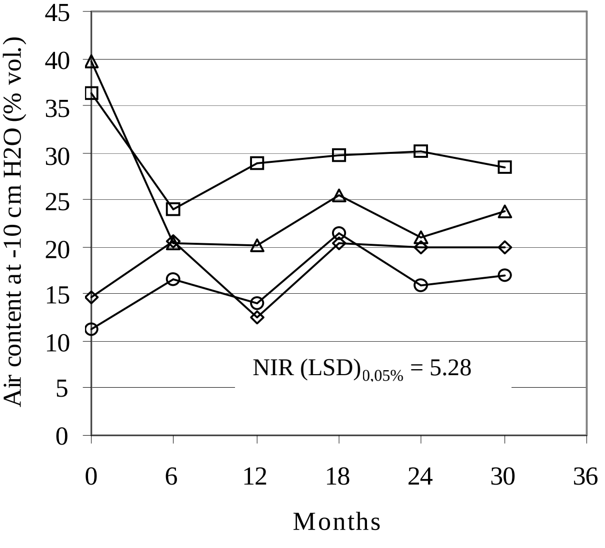

Figure 6. Effect of the length of the cultivation period on the air content at -10 cm H_2O of slabs: Grodan Master (◊), Pargro (□), Cultilene (Δ) i Bomat (○). Each point represents the mean of 6 replications. Means are separated by LSD, 5% level

Table 1. Effect of different rockwool and glasswool slabs on the yield, bud flower diameter, bud flower height, stem length and fresh weight of rose flowers ’Trixx’

Mineral wool	Flower yield (number per plant)[1]	Bud flower diameter [cm]	Bud flower height [cm]	Length of flower stem [cm]	Weight of flowers [g]
Grodan Master	67.0 ab*	2.8 a	3.6 a	49.8 a	25.7 a
Pargro	81.1 b	2.8 a	3.5 a	50.0 a	26.7 a
Cultilene	67.9 ab	2.8 a	3.5 a	48.6 a	24.8 a
Bomat	51.2 a	2.9 a	3.4 a	46.5 a	22.9 a

[1] Flower yield from a 2.5 year cultivation time

*Mean values followed by the same letter within columns are not significantly different at a 5% level according to Duncans’s t-test

the Pargro slabs significantly influenced flower bud height, flower shoot length and fresh mass of flowers (Nowak and Kunka, 2008). Water capacity and air capacity had the biggest influence in this instance.

A very unfavourable characteristic of some growing media is shrinkage. This should not be a feature when using slabs. However, the shrinkage of all the slabs in the experiment, after being used for 6 months for rose cultivation, did gradually increase (Fig. 7). A similar dependence was observed in organic growing media in container cultivation of plants. In container cultivation this problem was caused by mineralization and compact organic media, as well as strongly developed root systems (Nowak and Strojny, 2003). A decrease in the volume of the investigated growing media was caused by settlement. This was presumably influenced by the strongly developed root system, and pressure of plants on the top of slabs. High shrinkage of slabs is considered unfavourable. Such shrinkage generates problems with watering, hydration, and generally leads to worsen the air-water relations. Shrinkage and compaction tend to decrease the amount of coarse pores and increase that of fine pores. This action further affects the characteristics of the growing media (Langerud, 1986).

The effects of the cultivation period on the change of water retention of the 4 mineral wool slabs are shown in Figure 9-12. The water retention curve shows that water content changed significantly during the cultivation. At the beginning of cultivation, water content was usually low, but later water retention increased. This change was mainly observed in water retained between -10 to -50 cm H_2O. These fluctuation were caused by the root system and settlement of slabs. The opposite effect on water retention was observed in the organic growing media (Nowak and Strojny, 2003).

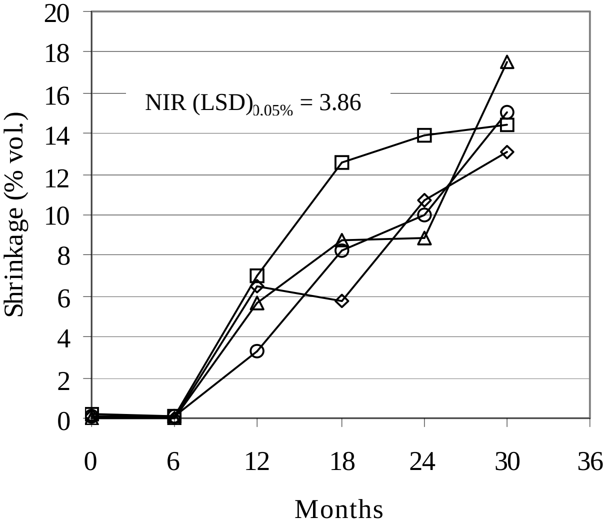

Figure 7. Effect of the length of the cultivation period on the shrinkage of slabs: Grodan Master (◊), Pargro (□), Cultilene (Δ) i Bomat (○). Each point represents the mean of 6 replications. Means are separated by LSD, 5% level

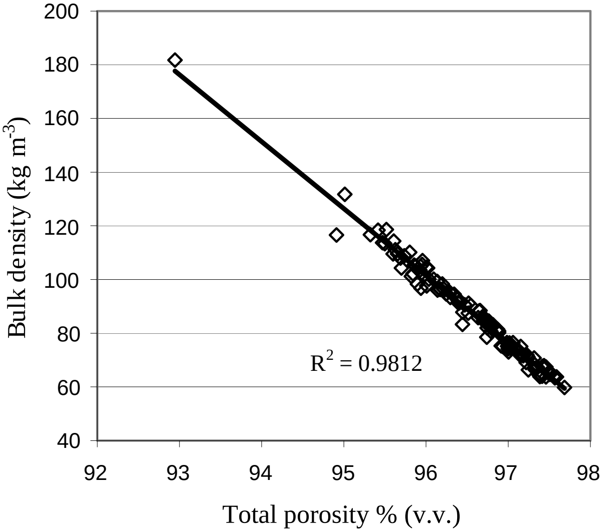

Figure 8. Linear correlation between total porosity and bulk density of rockwool and glasswool slabs (for all kind of mineral wool slabs)

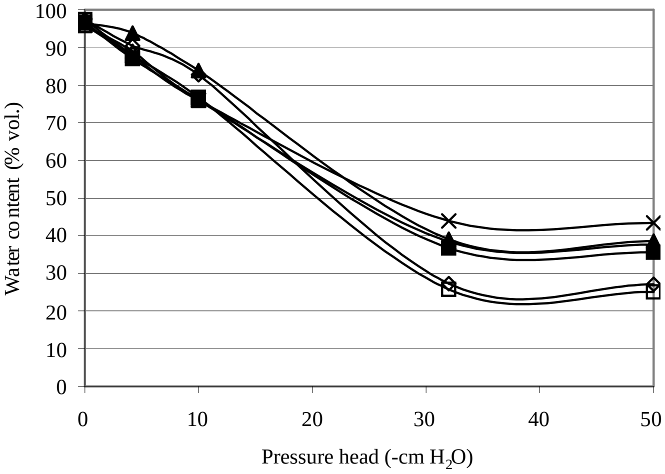

Figure 9. Effect of cultivation time on the change of water retention characteristics of Grodan Master slabs. Each point represents the mean of 6 replications. Measurements after: 0 (◊), 6 (□), 12 (▲), 18 (■), 24 (x) and 30 (Δ) months of cultivation

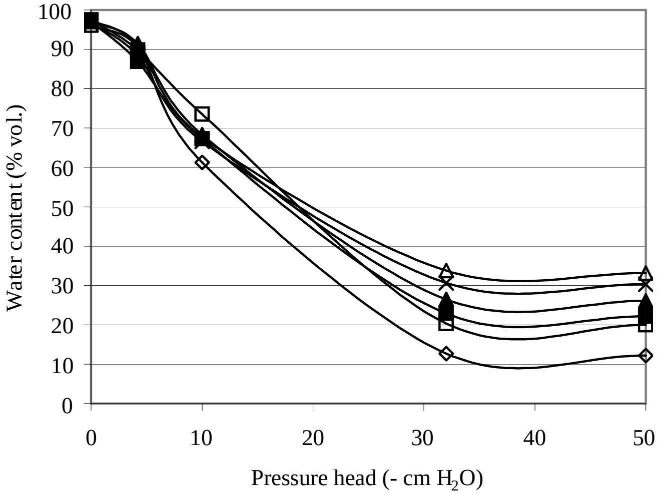

Figure 10. Effect of cultivation time on the change of water retention characteristics of Pargro slabs. Each point represents the mean of 6 replications. Measurements after: 0 (◊), 6 (□), 12 (▲), 18 (■), 24 (x) and 30 (Δ) months of cultivation

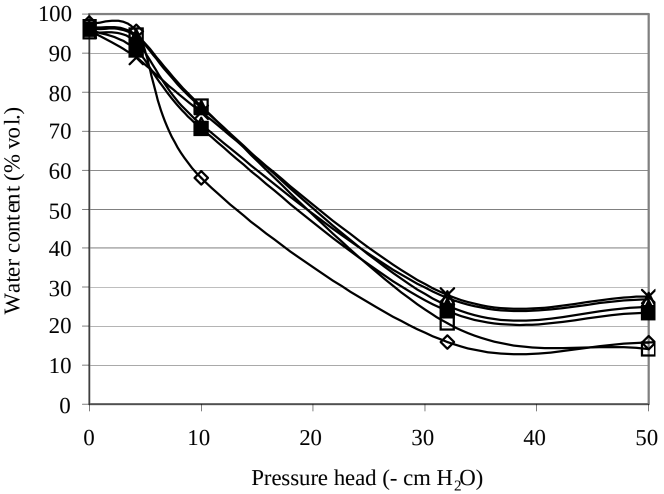

Figure 11. Effect of cultivation time on the change of water retention characteristics of Cultilene slabs. Each point represents the mean of 6 replications. Measurements after: 0 (◊), 6 (□), 12 (▲), 18 (■), 24 (x) and 30 (Δ) months of cultivation

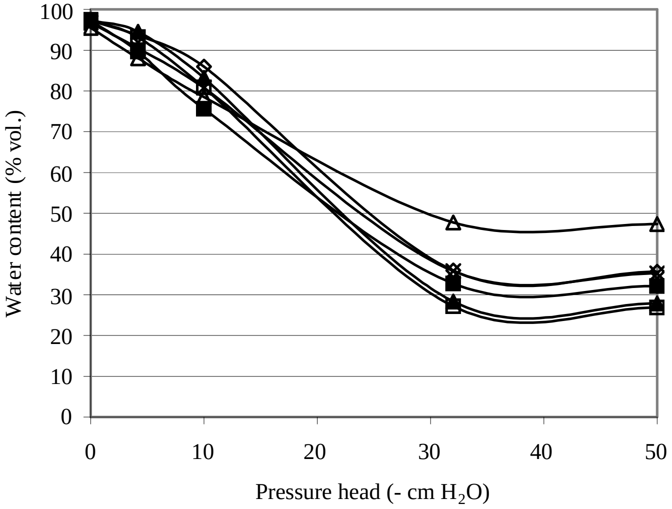

Figure 12. Effect of cultivation time on the change of water retention characteristics of Bomat slabs. Each point represents the mean of 6 replications. Measurements after: 0 (◊), 6 (□), 12 (▲), 18 (■), 24 (x) and 30 (Δ) months of cultivation

CONCLUSION

The data indicate that all 4 mineral wool slabs, as media, provided adequate moisture holding capacities for rose production. The Pargro slab, however, can maintain favourable physical conditions over longer periods than other slabs. The selection of mineral wool slabs for rose cultivation should be based on stability of water retention characteristics and general physical properties throughout the entire growing time of the crop.

REFERENCES

Beardsell D.V., Nichols D.G., Jones D.L. 1979. Physical properties of nursery potting-mixtures. SCI. HORT. 11: 9-17.

Bunt A.C. 1983. Physical properties of mixtures of peats and minerals of different particle size and bulk density for potting substrates. ACTA HORT. 150: 143-153.

Hanan Joe J., Olympios Ch., Pittas Ch. 1981. Bulk density, porosity, percolation and salinity control in shallow, freely draining, potting soils. J. AMER. SOC. HORT. SCI. 106(6): 742-746.

Langerud B.R. 1986. A simple in situ method for the characterization of porosity in growth media. PLANT SOIL 93: 413-425.

Nowak J.S., Strojny Z. 2003. Effect of different container media on the growth of gerbera. ACTA HORT. 608: 59-63.

Nowak J.S., Strojny Z. 2004. The effect of physical properties of organic growing media on cut flower yield of gerbera. FOLIA UNIV. AGRIC. STETIN. AGRICULTURA 236(94): 133-138.

Nowak J.S., Kunka M. 2008. The effect of physical properties of mineral wool slabs on yield and flower quality of roses. ZESZ. POST. NAUK ROL. 525: 283-292 (in Polish).

EN 13041 1999. Soil improvers and growing media – Determination of physical properties – Dry bulk density, air volume, water volume, shrinkage value and total pore space.

Wever G. 2000a. Aangepast beperkt fisisch onderzoek vaste substraten. Analysereeks PBG, Naaldwijk.

Wever G. 2000b. Determination of dry matter content (KIWA). Analysereeks PBG, Naaldwijk.

Wever G., Kipp J.A. 1998. Characterisation of the hydrophysical behaviour of stonewool. Proc. 16th World Congress of Soil Science.

Wever G. 2002. Set of appendices on analytical methods. BRL-K10001 Substrate materials (*for the Kiwa product certificate for Substrate materials)*. Kiwa N.V., Rijswijk.

ZMIANY WŁAŚCIWOŚCI FIZYCZNYCH PODŁOŻY Z WEŁNY MINERALNEJ I SZKLANEJ W HYDROPONICZNEJ UPRAWIE RÓŻ

Jacek S. Nowak

STRESZCZENIE

Róże odmiany ’Trixx’ uprawiano w czterech podłożach z wełny mineralnej (matach dł. 100 cm, szer. 15 cm, wys. 7,5 cm), ustawionych na odpowiednim stelażu w szklarni – uprawa na zagonach wzniesionych umożliwiających przyginanie pędów. W doświadczeniu zastosowano maty – z wełny mineralnej: Grodan Master, Pargro i Bomat oraz matę z włókien szklanych Cultilene. Właściwości fizyczne badanych mat oznaczono metodą opracowaną w stacji doświadczalnej w Naaldwijk (Holandia). Do oznaczeń pobierano próby z mat o rozmiarach 15 cm x 15 cm przed uprawą oraz w ciągu 2,5-letniego okresu uprawy co 6 miesięcy (6, 12, 18, 24 i 30 miesięcy od posadzenia roślin).

W matach Grodan Master i Cultilene obserwowano znaczny wzrost gęstości objętościowej, a zarazem spadek porowatości ogólnej już po 6 miesiącach uprawy. W pozostałych matach zmiany te były bardziej widoczne dopiero w końcowej fazie uprawy. Zawartość wody i powietrza przy potencjale wody –4 cm H_2O, a więc po odcieknięciu wody grawitacyjnej była bardzo zróżnicowana w poszczególnych miesiącach uprawy. Bardziej stabilne właściwości powietrzno-wodne obserwowano przy potencjale wody –10 cm H_2O, przy którym zawartość wody i powietrza w poszczególnych matach utrzymywała się na podobnym poziome aż do końca uprawy. Najbardziej korzystne warunki powietrzno-wodne przy tym potencjale stwierdzono w macie Pargro. Krzywa retencji wodnej wskazuje, że zawartość wody zmieniała się znacznie w poszczególnych etapach uprawy. Zwykle w początkowym okresie uprawy zawartość wody była niższa, w późniejszym – wyższa. Dotyczyło to głównie zakresu potencjału wodnego od –10 cm H_2O do –50 cm H_2O.

Słowa kluczowe: wełna mineralna, wełna szklana, podłoża inertne, maty uprawowe, porowatość, gęstość, pojemność wodna