Effect of Watering Frequencies on the Growth and Survival of Petunia Axillaris in a Controlled Environment

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Petunia axillaris is a very important economically cherished plant because of its ability to produce beautiful fragrant flowers that come in different colors, which invariably gives an aesthetic value. However, it is important to deepen the understanding for possible culture improvement. This study examined the effect of three watering frequencies on the growth and survival of Petunia from juveniles. The treatments consist of low water application (once in a week), normal application (twice per week) and high-water application (thrice per week). The following data were collected from the seedlings; plant height, number of flowers, number of dead plants. Also, destructive sampling was carried out to assess length and width of leaf, root depth, as well as number of leaves and number of dead leaves. Statistical analysis was performed with R-studio software. Growth and survival rate performances were significantly (p < 0.05) affected by watering frequencies. The multivariate analyses of principal component (PCA), showed that, all growth parameters except the number of dead leaves were correlated positively to each other. The results indicated that high flexibility of the species to be cultured with minimum requirements of water supply equating to reduction in production costs.

Key words: culture, management, ornamentals, plant performance.

INTRODUCTION

Petunia axillaris is an annual plant in the family Solanaceae. The plants are grown solely for their aesthetic value. In other words, they are ornamental plants grown for decorative purposes in gardens and landscape design projects, as household plants, for cut flowers and specimen display (Cantor et al., 2015). The aesthetic features displayed by the plant includes; the stem, bark and most importantly the flowers which occur in different colours depending on the species gene. It has been reported that Petunias can tolerate relatively harsh conditions and hot climates (Brown and Moncada, 2018). Water is one of the most important factors that affects the biological make up of plant growth and health; it is essential for many plant processes like photosynthesis, nutrient transport, and cell expansion and development (McElrone et al., 2013). Irrigated agriculture is the leading use of water by humanity (Shortle and Griffin, 2001). Generally, plants respond to water stress in different ways ranging from adaptive changes and/or deleterious effects (Chaves et al., 2002). For ornamental plants, they may become smaller and look less appealing resulting in lower revenue or a longer growing period even in a nursery setting (Jones and Tardieu, 1998). The irrigation of farms has made it possible for crops to be grown in the deserts, greenhouses and other normal natural unsuitable conditions.

Physiological responses of plants are frequently used as accurate indicators of plant water stress (Bhattacharjee and Saha, 2014), which usually involve tissue size measurements as an indicator. These are done using appropriate equipment and the variability due to growth compared. Assessment of petunia plant growth to determine the actual quantity of water required to save and minimise labour cost, was done in this work. This attempt
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to study the effects of different watering frequencies on this valuable plant’s (*Petunia axillaris*) seedling growth in the nursery will provide the much-desired practical information for accurate culture practice. This information will invariably assist the farmers and growers to be able to maximize the benefits inherent in the processes involved given a similar condition. Therefore, this research was formulated with the specific objective of determining the best watering frequency (irrigation) for petunia plant seedling raised in the nursery at juvenile stage from sowing date to first six weeks of growth.

**MATERIALS AND METHODS**

**Location**

The plants were grown at the greenhouse (Plant Environment Laboratory) of Higher Technical School of Agricultural Engineering, University of Valladolid, Palencia campus, Spain (42°02'25"N, 4°30'1"W). The greenhouse was maintained at constant temperature and humidity throughout the period of the experiment. Potted media containers with great surface for optimal stability during cultivation and transportation were used. The media was ‘Sustrato 28®’; a plant season substrate produced by Pindstrup-Mosebrug SAE. E-09140 Sotopalacios, Burgos, Spain. It was supplied in bags of 100 litres with the following composition: 70% peat 5-20 mm, 30% black peat 0-10 mm, approximately pH 6.0 (aqueous solution), wetting agent, an aqueous detergent which facilitates the absorption of water, microelements and a compound of nitrogen, phosphorus and potassium enough for the first 20-30 days. The container was ‘Maceta Termoformada Desch 10.5cm L Baja®’ produced by Projar Grupo Inspiring Green Technology, Spain

**Experimental treatments and irrigated crop studies**

The treatments consist of low water application (200ml of water once in a week-1x), normal application (200ml of water twice in a week-2x) and high-water application (200ml of water three times in a week-3x). Twenty containers filled with the media were potted having seven days from sowing *Petunia axillaris* seedlings for each of the treatments (total number of 60 plants i.e. 20 x 3). An overtrop sprinkler irrigation system was used for the experiment. The potted plants were separated from each other for all the treatments. The setups were observed for five weeks’ period of the experimentation at a uniform climatic condition in the greenhouse.

**Measurements and Data collection**

The following parameters were measured from all the seedlings in the nursery and compared among the treatments: plant height (at the third and fifth weeks), number of flowers (at the third and fifth weeks), percentage mortality for the plants (at the fifth week).

Destructive sampling after the fifth week of treatments application were carried out for assessment of the following: length of leaf (cm), width of leaf (cm), root depth (cm) and shoot height (cm), as well as number of leaves and number of dead leaves.

**Statistical Analyses**

Collected data were expressed as mean. Analysis of variance (ANOVA) was used to determine differences among the watering frequencies, using R-Studio version 3.6.1 scientific graphing data analysis software (R, 2019). The differences were considered to be significant at 0.05 (P < 0.05). Tukey multiple comparison test was used to determine the level of significant among the treatment means. The multivariate analyses of principal component (PCA) was also performed among all the variables measured.

**RESULTS AND DISCUSSION**

There was a significant (p < 0.05) effect due to the watering frequencies on the number of dead leaves produced by the plants. Petunia plants with the lowest watering application treatments (1x) had the highest number of dead leaves. This showed that less the frequency of water application on Petunia plants in nursery the more the leaves die off. Significant (p < 0.05) differences were observed among the treatments on number of leaves produced by the Petunia plants. Plants with thrice per week water applications (3x) had the highest number of leaves. The twice per week (2x) and once a week (1x) treated plants had similar number of leaves (Figure 1).

![Figure 1: The effects of the different watering frequencies on some measured parameters of the petunia plants.](image-url)
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highest values. However, from the analysis of variance (ANOVA) result and means comparison using Tukey test, it was observed that there was no significant difference in leaf length and width between the 3x and 2x treated plants. Results of this experiment indicated substantial sensitivity of Petunia plants leaf to water stress and this was similar to the observations of Pallardy and Rhoads (1999) on *Populus* clones, Shawquat *et al.* (2014) on soybeans; and also, on Petunia plants by Klock-Moore and Broschat (2001) under subirrigation systems.

No significant effect was detected among the three watering frequencies on the root depth. This suggested that the plants roots developments were not altered by the treatments. However, the water frequencies application affected the shoot height of the Petunia plants significantly (p < 0.05) as seen in Figure 1. The 1x treated plants had the tallest shoots. Boutraa *et al.* (2010) had reported that water application can influence the plant shoot height on some cultivated wheat plants. The development of plant root and shoot system is strongly influenced by growing conditions such as water stress (Franco, 2011). However, just as observed in this experiment, root growth can be less affected when compared to shoot growth. A similar result was observed on *Lonicera implexa* (Navarro *et al.*, 2008), *Lotus creticus* (Franco *et al.*, 2001), *Nerium oleander* L. (oleander) (Banon *et al.*, 2006), and *Silene vulgaris* (Arreola *et al.*, 2006).

The Petunia plants are basically grown for its wide range of flower colours, sizes and the plant architecture in general. A mature organ of petunia flower is organized in four concentric whorls. There are five sepals, five petals, five stamens; and a blobbed carpel in the inner whorl (Krol and Chua, 1993). The line graph for the number of flowers as affected by the different water applications on the Petunia plants are given in Figure 2. Comparable differences were observed among the treatments at the fifth week of application. The Petunia plants with 1x treatments had higher number of flowers than others. This effect was in a negative form because, lesser the water application level the higher number of flowers. This observation was in accordance with the submission of Katsoulis *et al.* (2006) that irrigation (watering) frequency negatively affects rose flower production. However, Petunia plants under 3x treatments started growing significantly (p < 0.05) taller than others from the third week and this trend continued to the fifth week (Figure 3). Our work also agreed with similar finding of Scheiber and Beeson (2006), who observed quality negative response due to reduced irrigation volumes of *Petunia ×hybrida* ‘Rose Madness’ on flowers and shoot mass.

![Figure 2](image-url) Average plant height for different watering frequencies treated plants at 3rd and 5th week of the experiment

![Figure 3](image-url) Average number of flowers observed in the different watering frequencies treated petunia plants at the 3rd and 5th week of the experiment.

Highest mortality rates were observed on the petunia plants treated with 1x. This was followed by those that received 2x. However, very few dead plants were observed on the 3x treated plants (Figure 4). The multivariate analysis of Principal components (PCA) of the parameters measured in the experiment (Figure 5 and Table 1) showed that length of leaf had positive direct effect on the number of leaves, shoot height and width of leaf. This implies that the longer the leaf the more widely developed it is, and also the taller the plant shoots system becomes. Furthermore, this indicates that those petunia plants with larger leaves are the tall ones. The explanation will be that the production of larger leaves (per leaf area of the plant) supports the petunia plant shoot growth. The large leaf area so produced will directly correlate with more photosynthesis and the plant will consequently grow taller (Reich, 2004). In accordance, King (1998) reported that as the larger leaves give advantage to an increased light interception capacity of the plant for photosynthesis; there is a resultant increase in the overall height of the plant shoot.
Table 1: Principal component analysis values of parameters measured

<table>
<thead>
<tr>
<th></th>
<th>number of leaves</th>
<th>number of dead leaves</th>
<th>length of leaf</th>
<th>width of leaf</th>
<th>shoot height</th>
<th>root height</th>
</tr>
</thead>
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<tr>
<td>number of leaves</td>
<td>1</td>
<td>-0.3753</td>
<td>0.32923</td>
<td>0.3288</td>
<td>0.09194</td>
<td>0.18347</td>
</tr>
<tr>
<td>number of dead leaves</td>
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<td>1</td>
<td>-0.04643</td>
<td>0.09919</td>
<td>0.24665</td>
<td>-0.3483</td>
</tr>
<tr>
<td>length of leaf</td>
<td>0.32923</td>
<td>-0.04643</td>
<td>1</td>
<td>0.82595</td>
<td>0.66171</td>
<td>-0.0225</td>
</tr>
<tr>
<td>width of leaf</td>
<td>0.3288</td>
<td>0.09919</td>
<td>0.82595</td>
<td>1</td>
<td>0.74306</td>
<td>0.07188</td>
</tr>
<tr>
<td>shoot height</td>
<td>0.09194</td>
<td>0.24665</td>
<td>0.66171</td>
<td>0.74306</td>
<td>1</td>
<td>0.11743</td>
</tr>
<tr>
<td>root depth</td>
<td>0.18347</td>
<td>-0.34836</td>
<td>-0.0225</td>
<td>0.07188</td>
<td>0.11743</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 4: Percentage mortality of the petunia plants at different watering frequencies.

Figure 5: Principal component analysis chart of parameters measured.

Petunia axillaris plants during their vegetative growth stage

A flower of the Petunia axillaris plant

CONCLUSION

Changes in climate and demand for water resources are likely to cause an increased pressure to reduce water use, especially for domestic home garden nursery growers. Rather than give up on the process because of the enormous challenge imposed by water scarcity in developing countries like Nigeria, the data presented by this investigation indicates that acceptable results can be achieved in a plant like Petunia. Its production in the nursery with once a week water application of 200 ml can give plants with tall shoots and high number of flowers. Because of the overriding importance of water to plant growth, managing water application (irrigation) is the most critical cultural operation in farm nurseries.
Further research is required to investigate this irrigation frequency effect on petunia plants in the nursery for a longer period of time and possible with genetically different species. More research is also needed in the traditional nursery setting. This right water application frequency when discovered and adopted will save time, labour and money for maximum benefit in petunia plant production. And also ensures continuous production as a feature of urban landscape and aesthetic, despite restrictions and challenges of water supplies in most developing countries of the world.

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