Effects of Two Methods of Mechanical Stress on Snapdragon and Wallflower Plants Growth Responses

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ABSTRACT

This investigation was conducted in two separate experiments. In the first experiment, seedlings of wallflower (Cheiranthus cheiri L.) were selected for treatment at 8-cm-height stage. Seedlings were shook mechanically in three diurnal times (6AM, 2PM and 10PM) for 4, 8, 12 and 16 min using ‘Impactor’ device along with control plants. In the second experiment, seedlings of snapdragon (Antirrhinum majus L.) were selected for treatment at 5-cm height stage. Seedlings were shook 6, 12 and 18 min for 5 days, 3, 6 and 9 min for 10 days and 2, 4 and 6 min for 15 days using a rotary shaker. Results showed that in wallflower at 3 diurnal times, with increasing the time of shaking the length decreased. Shaking for 4 and 8 min at 6 PM much more decreased the length than the other diurnal times. At 3 diurnal times with increasing the time of shaking the shoot fresh weight decreased. However, the means were not significantly different among 3 diurnal treatments with the same time of impacting. In snapdragon, the length of shoots was not significantly different when treated for 5 and 10 days in 3 different shaking times. However, in shaking for 15 days treatment with increasing the time of shaking the shoot length get more dwarfs.

Key words: Impactor, Mechanical stress, Shaking; snapdragon, Wallflower.

Introduction

Some effects of mechanically stress induce on the growth of plants are visible in the natural world [22], for example plants subjected to wind action often have shorter stem, smaller leaf, lower fresh and dry weights than wind-protected plants [2, 6, 14, 16, 18, 30, 35]. Wind induced growth changes have been associated with enhanced respiration and transpiration, as well as with decreased photosynthesis and water content [3, 10, 11, 12, 26, 33, 34]. The mechanical aspect of wind action on plant development has investigated using a variety of mechanical stress induced treatments including air current, shaking, flexing and water spray [11,13, 19, 27, 31, 35]. Controlled mechanical stress in the form of shaking (seismic stress) or stem flexing or rubbing (thigmic stress) generally inhibits growth in mass and dimension of major plant part [6, 16, 28, 29], compare to undisturbed control plants. Mechanical stress also has been used to strengthen stem and to control height of greenhouse bench crops [6]. However, many methods are used to control transplant height including plant growth regulators, withholding water or nutrient, temperature control and clipping the shoots. These methods require high levels of management often have long-term effects on plant growth and may delay early yield [1, 15, 17, 21, 25]. Therefore, mechanical stimulation is, in principle, an excellent means of limiting undesirable stem elongation and it also can increase stem strength. There are some reports on using mechanical stress treatments in several plants. However, in most of them only the plant growth is evaluated. There are a few reports on investigation the best diurnal time or duration of the mechanical stress treatment.

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Shaking and brushing are the popular mechanical stress techniques [6, 23]. Most studies on mechanical stress have been conducted with annual plants [2, 6, 16, 30] and there is no report on the responses of biennial plants to mechanical stress. In this investigation the best diurnal time and duration of mechanical stress treatment are studied using ‘Impactor’ and shaker devices on wallflower and snapdragon seedlings (as biennial plants), respectively.

Materials and Methods

Plant material and environmental condition:

Wallflower (Cheiranthus cheiri L.) and snapdragon (Antirrhinum majus L.) seeds were sown five in each pot. Seedlings were grown in 7-cm diameter plastic pots containing soil, peat and perlite (1:2:1 by volume). Then, the seedlings were thinned to one per pot. Plants were fertilized with a balanced nutrient solution (Ghatreh Tala™, Tehran, Iran) at least one time a week in irrigation water. Water was used from bottom of the pots. Experiments were conducted under the natural photoperiods during November 2006 to April 2007 months (9/5 to 11/5 hr day'). Diurnal temperature regime in the greenhouse during winter was 20 °C and 13 °C for day and night times, respectively.

Mechanical stress treatment:

In the first experiment, seedlings of wallflower were selected for treatment at 8-cm-height stage. Seedlings were shaken mechanically in three diurnal times (6AM, 2PM and 10PM, corresponding to the beginning and middle of the light period, and the beginning of the dark period.) for 4, 8, 12 and 16 min using ‘Impactor’ device (own-made) along with control plants. This device was used to make 20 impacts per min on the first above the soil 3-cm length of the seedling stem for 15 days. The impact force did the stems bend to the angle of 15° to 25° (Fig. 1).

Fig.1: ‘Impactor’ is shaking the seedlings.

In the second experiment, seedlings of snapdragon were selected for treatment at 5-cm height stage. Seedling were shook 6(t1), 12(t2) and 18(t3) min for 5 days; 3(t4), 6(t5) and 9(t6) min for 10 days; and 2(t7), 4(t8) and 6(t9) min for 15 days with shaker along with control plants. Time of shaking in groups of t1, t8 and t; t2, t5 and t3, t9 and t, t and t were equal but were divided in 5, 10 and 15 days, respectively.

Experimental design and data analyses:

Experiments were conducted as complete randomized design with 8 replications for wallflower and 4 replications for snapdragon. Parameters measured including stem length and shoot fresh weight for wallflower (4 out of 8 replications) 20 days after the treatments. The same parameters were not measured for snapdragon at the same time. The parameters were measured including shoot length, shoot fresh weights and time of flowering for both plants at the end of experiments. Data were analyzed using MSTAT-C program and the mean comparisons were made following Duncan’s Multiple Range Test (DMRT) at P= 0.01.

Results and Discussion

Experiment 1:

Twenty days after treatment length of wallflower’s shoots were measured and results showed that at 3 diurnal times (6AM, 2PM, 10PM) with increasing time of treatments the length decreasing (Table 1) also data are not significantly between 3 diurnal in like time of Impacting and mechanical stress can reduce plant height by 48% compared to untreated plants (Table 1). The weight of wallflower’s shoot 20 days after treatment showed no significant difference between 3 diurnal times. Furthermore, increasing the time of shaking decreased the weight (Table 1).

The length of wallflower’s shoots at the end of experiment showed that at 3 diurnal times with increasing the time of treatments the length decreased; and shaking for 4 or 8 min at 6PM was more effective than the other diurnal times (Table 2). Shaking for 16 min resulted in weak plants with chlorosis and epinasty symptoms in leaves.

The fresh weight of wallflower’s shoots at the end of experiment showed that at all diurnal times with increasing the time of treatments the weight decreased; however, weight changes were not significantly different in 3 diurnal times in the same times of impacting (Table 2). Results showed that diurnal times of shaking did not affect the time of flowering. In the plants were shaken for 4 and 8 min
Auxins and gibberellins are two important plant growth regulators that affected by mechanical stress. Therefore, by decreasing these hormones level the growth will retarded. For example, depending on the point of mechanical stress application, elongation of the cells in the growth zone is inhibited because the growth hormone auxin is either depleted or supraoptimal within those cells [23].

The results of experiment with wallflower showed that shaking in 6AM is more effective than the other times. Growth in herbaceous plants is usually highest at the end of the light period [5, 6]. However, the plants were more responsive to shaking in 6AM than the other times when it would have suppressed the peak of growth. In similar experiment with Seismic stress, tomatoes were unaffected by the time of day that they were shaken [16] but shaken chrysanthemums [6] and brushed tomato [9] were more sensitive in the morning. The reduction may have been due to mechanical stress causing stomatal closure because photosynthesis would be reduced only in the morning treatment. At the end of experiment the length and fresh weight of shaking wallflower shoots were lesser than those of the untreated plants. However, results indicating that some of the growth suppression was lost with increasing the time after the shaking. For example, brushed tomato transplants growth was equal to those of control plants after impedance ended [22].

With increasing the time of shaking the length and fresh weight of shoots decreased. A graded response to varying stimulation intensities has been described in many species. The response has occurred in growth and in the expression of touch-induced genes that regulate growth. In studies using several levels of stimulation, there was a graded increase in growth inhibition with increased mechanical stimulation in aster [Callistephus chinesis (L.) Nees], dusty miller [Senecio bicolor (Willd.) Todaro] [4] and tomato [16]. In Arabidopsis, expression of the TCH genes that code for regulatory proteins is greater and lasts longer with increasing dose of mechanical stimulation [7].
The optimum dose for treatment appears to be a board range. There appears to be an increment of growth that is eliminated by the mild mechanical stimulation reported here and that this response is easily saturated. Of course, more intense treatment will stress the plant to ultimately reduce growth to zero and cause clorosis.

One of the effects of mechanical stress on wallflower plants was epinasty; cause of this phenomenon is increasing of ethylene. Ethylene, the so-called “stress hormone” has received the most attention of all phytohormones with respect to mechanical stress growth regulation. Increased activity of the enzyme 1-aminocyclopropane-1-carboxylic acid (ACC) synthase, which catalyzes production of the immediate precursor of ethylene, begins within 30 min of stress episode [27].

Mechanical stress caused at most only a few days delay in the appearance of floral bud of wallflower and no effect on time of flowering of snapdragon plants. This delay in flowering maybe is depended to decreasing the gibberellins content.

Although mechanical stress alone may not attain the ultimate goal of conditioning, to control transplant growth during production and enhance post transplant productivity, it generally does provide good to excellent growth control with no detrimental effects on transplant establishment or crop productivity. Further experiments with the other plants are needed to better understanding the exact effect of mechanical stress on different parts and tissues of horticultural crops, specially the ornamentals.

References


Table 3: Length and fresh weight of snapdragon’s shoots at the end of experiment

<table>
<thead>
<tr>
<th>Parameters</th>
<th>5 days</th>
<th>10 days</th>
<th>15 days</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6(t)</td>
<td>12(t)</td>
<td>18(t)</td>
<td>24(t)</td>
</tr>
<tr>
<td>L</td>
<td>21.75ab</td>
<td>18.25ab</td>
<td>16.75ab</td>
<td>17.25ab</td>
</tr>
<tr>
<td>FW</td>
<td>8.54a</td>
<td>8.32a</td>
<td>8.34a</td>
<td>6.86b</td>
</tr>
</tbody>
</table>

† In each row, means followed by the same letters are not significantly different according to DMRT at 1% level.