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# Growth and development response of *Antirrhinum* to plant growing media

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## Abstract

The seedlings of *Antirrhinum majus* L. cv. 'Orchid Rocket Mixed' at four leaf stage (two cotyledonary leaves and two true leaves) were planted in 15 cm diameter pots containing seven combinations of plant growing media *viz.,* river sand, silt, leaf mold, river sand+silt (1:1), river sand+leaf mold (1:1), silt+leaf mold (1:1) and river sand+silt+leaf mold (1:1:1). The experiment was laid out in 'Randomised Complete Design' while each pot was considered as a replicate. Three equally spaced plants were kept in one pot in one replication and there were three replications in each treatment. Plant growth and development parameters indicated that plant height was significantly ($P$<0.05) affected by growing media and time interval. Plants grown in leaf mold attained maximum height than the other treatments. A linear and significant ($P$<0.05) increase in leaf development was observed in seven growing media such as plants grown in leaf mold media produced maximum number of leaves than the others. Similarly, plants grown in leaf mold media took minimum time to flowering, maximum number of flower buds per spike, maximum number of branches per plant, and maximum stem, leaf and plant fresh and dry weight.

**Key words:** *Antirrhinum majus,* snapdragon, growth and development, growing media

## Introduction

*Antirrhinum* is one of the important bedding plants grown in Europe and USA (Anonymous, 1985). It has been also an important cut-flower crop in USA for many years, although it is only of recent importance as cut-flower in Europe. The whole flowering stem is marketed as a cut-flower and its quality is partly assessed on how many flowers are open (Rogers, 1980). Pakistan exports different flowers and plants to USA, Taiwan and Gulf countries and earn around 2 million dollars as foreign exchange (*per se*). These figures demonstrate tremendous scope of this crop as cut-flower.

Successful production of container-grown plants like *Antirrhinum* is largely dependent on the chemical and physical properties of the growing media (substrates or compost). An ideal potting medium should be free of weeds and diseases, heavy enough to avoid frequent tipping over and yet light enough to facilitate handling and shipping (Böhme *et al.,* 2001). The media should also be well drained (Caron *et al.,* 2001) and yet retain sufficient water to reduce the frequency of watering (Morel and Michel, 2004). Other parameters to consider include cost, availability, consistency between batches and stability in the media over time (Noguera *et al.,* 1997). Selection of the proper media components is also critical for the successful production of plants (Jensen, 1975).

Production of crops involves number of cultural inputs. Among these, perhaps the most important is the type of growing medium used. Due to the relatively shallow depth and limited volume of a container, growing media must be amended to provide the appropriate physical and chemical properties necessary for plant growth. Field soils are generally unsatisfactory for the production of plants in containers. This is primarily because most soil based media do not provide the aeration, drainage and water holding capacity required for plant's growth. To improve this situation several growing media have been developed such as peat and peat-like materials (hypnaceous moss, reed and sedge, humus or muck, sphagnum moss), coir (coconut fiber), wood residues (leaf mold, sawdust, barks), bagasse (waste bi-product of the sugar industry), rice hulls, sand, perlite, vermiculite, garden soil, expanded polystyrene, urea formaldehydes, compost and animal manures (Verdonck, 1998; Reis *et al.,* 1998). The substrate market has considerably developed over the last 20 years in the world. Several factors explain this, including the development of nursery products "ready to plant", mainly grown in containers and the research for precocity and agronomic performance, through the monitoring of most production parameters such as plant growth and development (Rainbow and Wilson, 1998). Composting is also the preferred treatment method for many types of organic wastes from both ecological and economical standpoints. The most common raw materials for composting are plant leaves, twigs, municipal solid waste, sewage sludge, wastes of the timber and food processing industries and animal excreta. Horticulture and especially organic agriculture are using increasing quantities of composts of various types. Compost contributions to the soil-plant system are diverse: (i) Several organic molecules (*e.g.* polysaccharides and humic acid) improve soil texture through their effect on aggregation of clay particles, (ii) As the added organic matter is a substrate for soil microorganisms, it enables, through their activity, enhanced nutrient cycling and weathering of soil minerals and (iii) Composts contain considerable amounts of nutrients that can supplement plant nutrition.

The progressive growers in Pakistan mostly import container-growing media from abroad and spend much foreign exchange. Small growers/nursery owners prepare growing media using plant waste such as leaves, twigs, bark, etc. However, a quantitative research in this area showing the effect of these media components has not been carried out extensively on *Antirrhinum*. Therefore, a research experiment was designed to evaluate seven container based growing media such as leaf mold compost, garden soil, river sand and their combinations with particular reference to *Antirrhinum* plant growth and development.

## Materials and methods

The experiment was conducted at Department of Horticulture, Faculty of Agriculture, Gomal University, Dera Ismail Khan. Seeds of *Antirrhinum* cultivar 'Rocket Orchid Mixed' were obtained from the Colegrave Seeds Ltd., Banbury, U.K. Seedlings of this cultivar at four leaf stage (two cotyledonary leaves and two true leaves) were transplanted in 2 litre pot (15 cm in diameter) containing seven different combinations of plant growing media. Three equally spaced plants were kept in one pot in one replication. There were three replications in each treatment. The experiment was laid out in 'Randomised Complete Design' while each pot was considered as replicate. The potting mixtures were as under:

Growing Media 1 (M1): River sand
Growing Media 2 (M2): Silt (garden soil)
Growing Media 3 (M3): Leaf mold
Growing Media 4 (M4): River sand + silt (1 : 1)
Growing Media 5 (M5): River sand + leaf mold (1 : 1)
Growing Media 6 (M6): Silt + leaf mold (1 : 1)
Growing Media 7 (M7): River sand + silt + leaf mmold (1 : 1 : 1)

Plants were observed daily and water was applied manually with the help of hand sprinkler whenever needed. Care was taken not to apply excess water around the root area to minimize the chances of *Pythium*. Special attention was also given to pot spacing in order to reduce plant competition (shade avoidance). Due to organic nature of soil mixtures, weeds were rooted out by hand whenever emerged. Following growth and developmental parameters were measured during the course of experiments: plant height, number of leaves per plant, time of flowering, number of branches per plant, number of flower buds per spike, stem, leaf and plant fresh and dry weights, leaf and stem weight ratio and plant growth ratio.

Experiment was carried out in Completely Randomized Design (CRD) with three replications (9 plants in each replication). Seven plants growing media were used as treatment whereas in case of plant height data (weekly), time interval was also considered as a factor. All means and standard errors were calculated using MS Excel software. However, GENSTAT-5, version 4.2 (Lawes Agricultural Trust, Rothamsted Experimental Station, UK) was used to calculate standard errors of differences between means, regression analysis and ANOVA.

## Results

**Plant height (cm):** Fig. 1a, b indicated a significant ($P<0.05$) increase in the plant height of *Antirrhinum* at different time intervals. Similarly, seven growing media differently but significantly affected the plant height. *Antirrhinum* plants in all media grew slowly during first couple of weeks but then increased linearly. The slowest plant growth was observed in river sand media followed by silt, and river sand+silt. However, the same

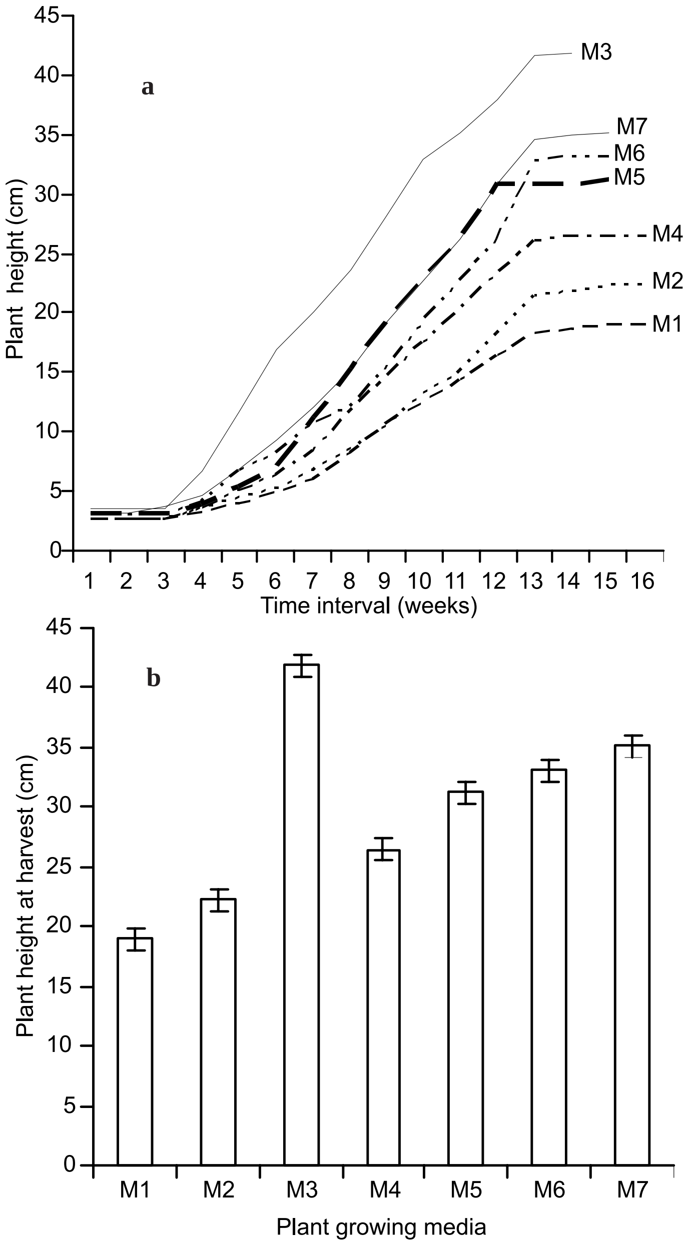


Fig. 1. Effect of different plant growing media *viz*., river sand (M1), silt (M2), leaf mold (M3), river sand + silt (M4), river sand + leaf mold (M5), silt + leaf mold (M6) and river sand + silt + leaf mold (M7) on (a) plant height (cm) of *Antirrhinum* at various time intervals (week 1-16). The data were taken at weekly intervals until the opening of flowers and fitted on normal plant growth curve. (b) general response of plant height at harvest to different plant growing media. Each point represents the mean of the 9 replicate plants whereas vertical bars (where larger than the points in bar graph) represent the standard error of difference.

parameter was significantly different in leaf mold plant growing media or where this media was combined with either river sand or silt or all three components together. For example, after 5 weeks *Antirrhinum* plants in river sand media attained 3.94 cm height followed by silt alone (4.56 cm), river sand+silt (5.09 cm), river sand+leaf mold (5.33 cm), silt+leaf mold (6.67 cm) and river sand+silt+leaf mold (6.89 cm). However, at similar time interval plants grown in leaf mold alone media were measured 11.78 cm in height. Similar trend was noted as the time passed by and at harvest (Fig. 1b), plants grown in river sand alone were 19 cm high (after 16 weeks) followed by silt (22.28 cm), river sand+silt (26.44 cm), river sand+leaf mold (31.22 cm), silt+leaf mold (33.11 cm) and river sand+silt+leaf mold (35.11 cm). However, after 14 weeks time interval plant grown in leaf mold alone media were measured 41.89 cm in height.

**Leaf number per plant:** Fig. 2a, b indicated a significant ($P$<0.05) linear increase in the leaf number of *Antirrhinum* at different time intervals ($r^2$ is shown in Fig. 2a). A similar trend was also observed when seven growing media were compared. Plants grown in river sand or silt based media produced minimum (4) leaves between 1 to 3 weeks of growth however where leaf mold was one of the components of the media plants produced 6 leaves during the same time interval. After the establishment of plants into pots they accelerated the pace of leave development. However, it was again the components of media (availability of nutrient), which played a main role in that process. For example,

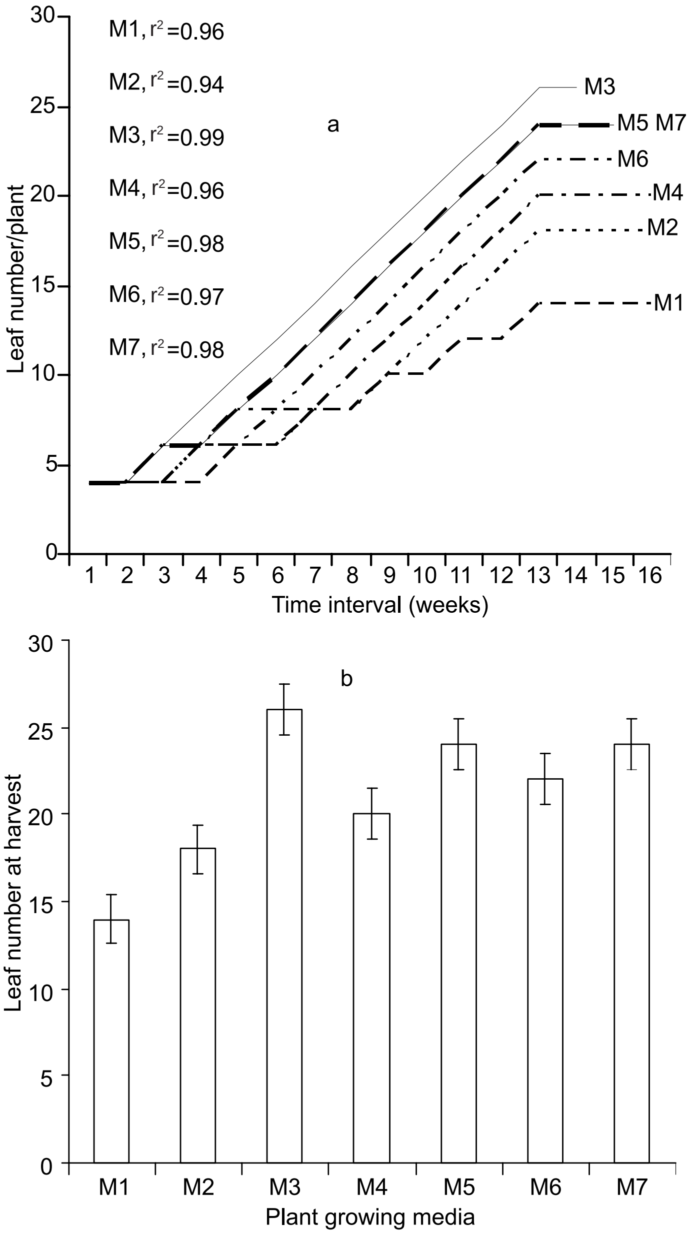


Fig. 2. Effect of different plant growing media *viz.,* river sand (M1), silt (M2), leaf mold (M3), river sand + silt (M4), river sand + leaf mold (M5), silt + leaf mold (M6) and river sand + silt + leaf mold (M7) on (a) leaf number per plant of *Antirrhinum* at various time intervals (week 1-16). The data were taken at weekly intervals until the opening of flowers and fitted on regression analysis according to its linear nature. (b) total number of leaves at harvest. Each point represents the mean of the 9 replicate plants whereas vertical bars (where larger than the points in bar graph) represent the standard error of difference.

plants grown in river sand produced 14 leaves at harvest (Fig. 2b) followed by silt media (18 leaves) and river sand+silt (20 leaves). Again like plant height parameter, plants grown in leaf mold or leaf mold based media produced maximum number of leaves *i.e.* plants in leaf mold media alone produced 26 leaves followed by river sand+leaf mold and river sand+silt+leaf mold media (24 leaves each) and silt+leaf mold media (22 leaves).

**Days to flowering:** Fig. 3a showed a significant ($P$<0.05) difference among time to flowering means of plants grown in seven different growing media particularly compared to leaf mold media. Plants took more time to flower where the nutrients availability was restricted *i.e.* in river sand, silt and river sand+silt (102 days each) media. On the other hand, plants grown in nutrient enriched media took less time to flower *i.e.* in leaf mold (92 days), river sand+leaf mold (94 days), silt+leaf mold (93 days), river sand+silt+leaf mold (94 days).

**Number of flower buds per spike**: Data regarding number of flower buds per spike (Fig. 3b) showed a significant ($P$<0.05) difference between means of seven growing media. Maximum number of flower buds (16) were counted in leaf mold alone grown plants followed by river sand+silt+leaf mold (15), river sand+leaf mold and silt+leaf mold (14 buds each). However, minimum number of flower buds (6) were obtained by the plants grown in river sand followed by silt and river sand+silt (8 buds each) media.

**Number of branches per plant:** Number of branches per plant data presented in Fig. 3c depicted a significant ($P$<0.05) difference among means of seven growing media. No side branches were produced by the plants grown in either river sand or silt alone or combined with each other media. However, plants grown in leaf mold or leaf mold based media produced side branches *i.e.* maximum number of branches per plant (4) were observed in plants grown in leaf mold alone media followed by river sand+silt+leaf mold (3), river sand+leaf mold and silt+leaf mold (2 side branches each).

**Stem fresh and dry weight (g):** Stem fresh and dry weight (g) data in Fig. 4a indicated a significant ($P$<0.05) difference among means of seven growing media. Plants grown under more nutrient available media (leaf mold or leaf mold based media) were more efficient to produce a good quality plants *i.e.* maximum stem fresh weight (52.27 g) was recorded in leaf mold alone media followed by river sand+silt+leaf mold (31.40 g), silt+leaf mold (29.77 g) and river sand+leaf mold (26.31 g). Whilst minimum stem fresh weight (9.96 g) was recorded in river sand, silt (15.73 g) or in the combination of both media (12.27 g). Maximum stem dry weight (5.64 g) was recorded in plants grown in leaf mold alone media followed by leaf mold based media *i.e.* 2.53 g (river sand+silt+leaf mold), 2.48 g (silt+leaf mold) and 2.08 g (river sand+leaf mold). However, plants grown in constraint nutrient media produced limited photosynthetic materials (assimilates) hence stem dry weight was minimum such as in river sand (1.00 g), silt (1.58 g), and river sand+silt (1.19 g) media.

**Leaf fresh and dry weight (g):** Fig. 4b regarding leaf fresh and dry weight (g) indicated a significant ($P$<0.05) difference among means of seven growing media. Plants grown in leaf mold media have maximum leaf fresh weight (15.38 g) followed by river sand+silt+leaf mold (10.04 g), silt+leaf mold (9.73 g) and

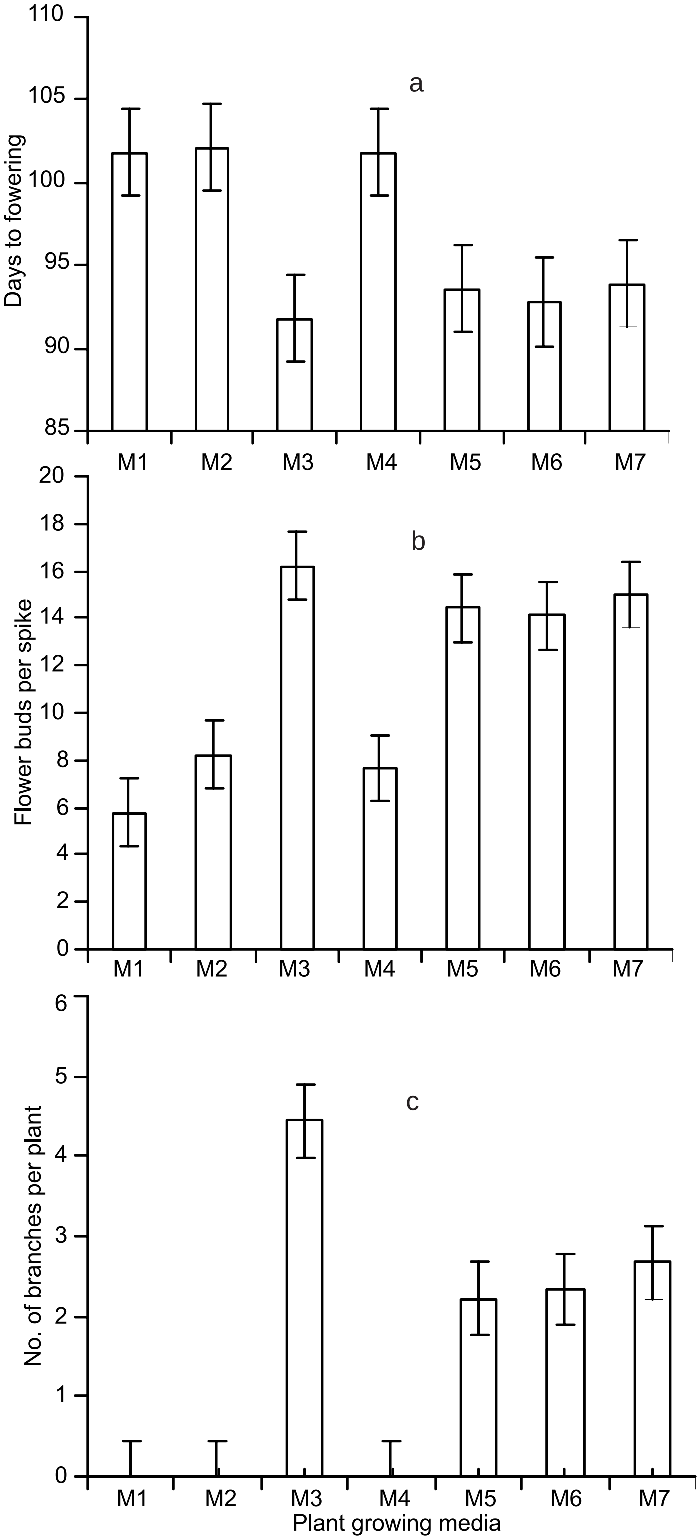


Fig. 3. Effect of different plant growing media *viz.,* river sand (M1), silt (M2), leaf mold (M3), river sand + silt (M4), river sand + leaf mold (M5), silt + leaf mold (M6) and river sand + silt + leaf mold (M7) on (a) days taken to flowering, (b) number of flower buds/spike and (c) number of branches/plant of *Antirrhinum* Each bar represents the mean of the 9 replicate plants whereas vertical bars (where larger than the points) represent the standard error of difference.

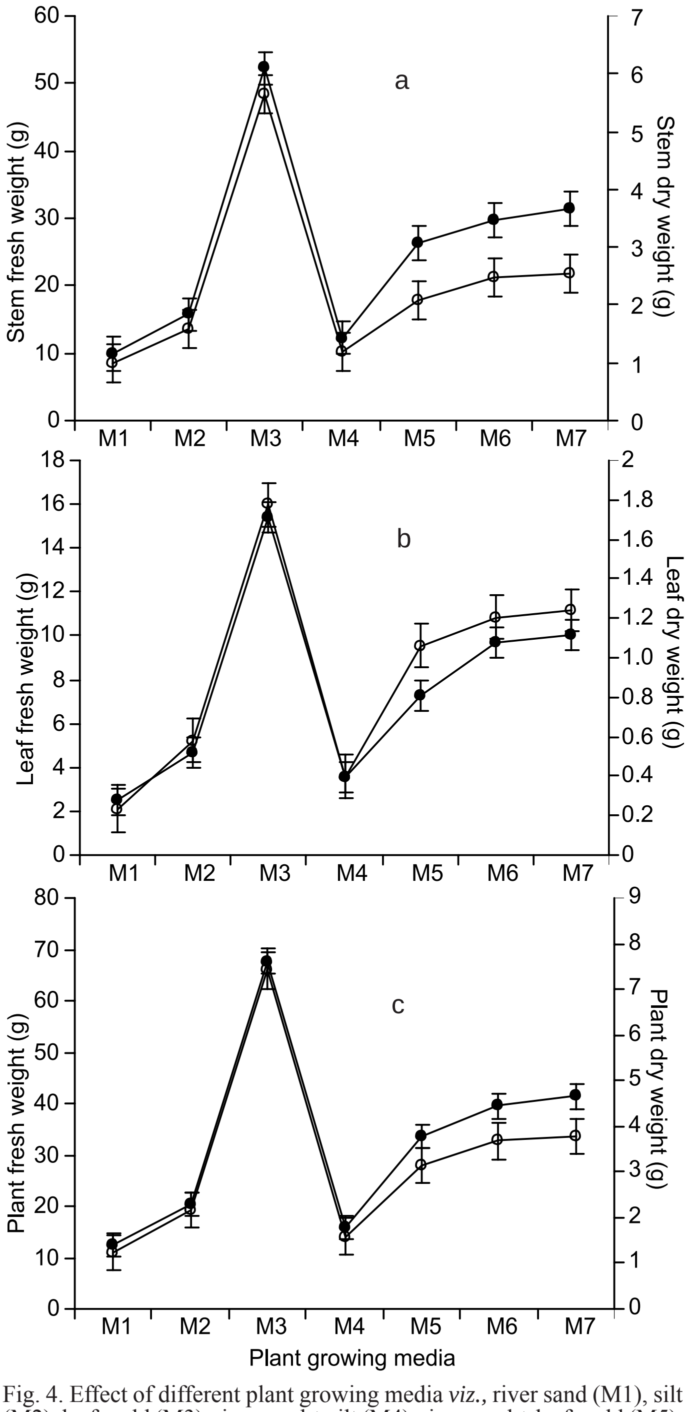


Fig. 4. Effect of different plant growing media *viz.,* river sand (M1), silt (M2), leaf mold (M3), river sand + silt (M4), river sand + leaf mold (M5), silt + leaf mold (M6) and river sand + silt + leaf mold (M7) on (a) stem fresh (●) and dry weight (○), (b) leaf fresh (●) and dry weight (○) and (c) plant fresh (●) and dry weight (○) of *Antirrhinum*. Each point represents the mean of the 9 replicate plants whereas vertical bars (where larger than the points) represent the standard error of difference.

river sand+leaf mold (7.26 g). Minimum leaf fresh weight was recorded in plants grown in river sand (2.51 g) followed by river sand+silt media (3.57 g) and silt media (4.65 g). It was observed that plants in leaf mold media produced maximum leaf dry weight (1.78 g) followed by plants grown in leaf mold based media *i.e.* river sand+silt+leaf mold (1.24 g), silt+leaf mold (1.20 g) and river sand+leaf mold (1.06 g). However, river sand (0.23 g), silt (0.58 g) and river sand+silt media (0.40 g) produced minimum leaf dry weights.

**Plant fresh and dry weight (g):** A significant ($P<0.05$) difference among means of seven growing media was observed (Fig. 4c) regarding plant fresh and dry weight data. Plants grown in leaf mold alone media produced more fresh weight (67.62 g) than the rest of treatments. In other treatments where leaf mold was used as one of the constituent, plant fresh weight was recorded

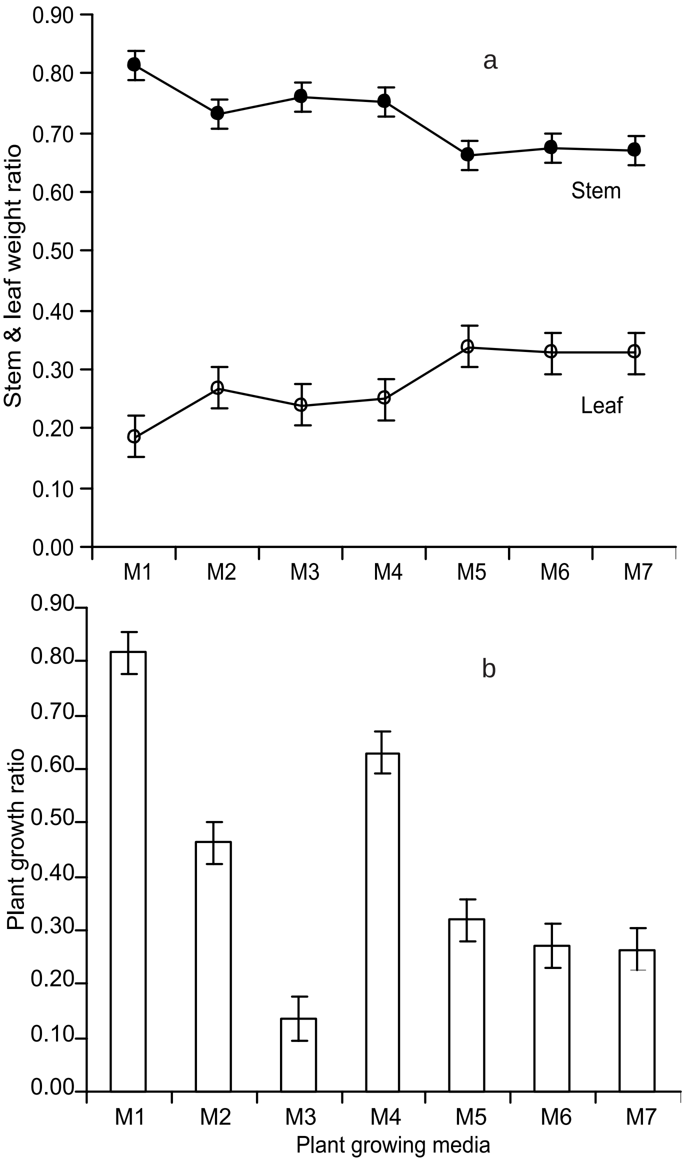


Fig. 5. Effect of different plant growing media *viz.,* river sand (M1), silt (M2), leaf mold (M3), river sand + silt (M4), river sand + leaf mold (M5), silt + leaf mold (M6) and river sand + silt + leaf mold (M7) on (a) stem and leaf weight ratio and (b) plant growth ratio of *Antirrhinum*. Each point or bar represents the mean of the 9 replicate plants whereas vertical bars (where larger than the points) represent the standard error of difference.

as 41.44 g (river sand+silt+leaf mold), 39.49 g (silt+leaf mold) and 33.57 g (river sand+leaf mold). A minimal plant fresh weight response was noted in rest of the media (without leaf mold as an ingredient) *i.e.* river sand media (12.47 g), river sand+silt media (15.85 g) and silt media (20.39 g). Maximum plant dry weight was recorded in plants grown in leaf mold alone media (7.41 g) followed by leaf mold based media *i.e.* 3.77 g (river sand+silt+leaf mold), 3.68 g (silt+leaf mold) and 3.14 g (river sand+leaf mold). However, plants grown in very limited nutrient media produced minimum assimilates which eventually decreased plant dry weight such as in river sand (1.23 g), silt (2.16 g) and river sand+silt (1.59 g) media.

**Derived parameters:** Leaf and stem ratio (Fig. 5a) indicated that plants grown in river sand media accumulated 19% photosynthates in leaves and 81% in stem followed by silt alone (27 and 73% assimilates in leaves and stem, respectively). Similarly, plants grown in leaf mold media had up 24 and 76% assimilates in leaves and stem, respectively. On the other side, by examining the inverse of plant dry weight (Fig. 5b) it was revealed that maximum plant growth ratio (0.82) was observed in plants grown in river sand media followed by river sand+silt media (0.63). However, minimum plant growth ratio was estimated in plants grown in leaf mold media (0.13) followed by silt+leaf mold and river sand+silt+leaf mold media (0.27 each).

## Discussion

Desirable plant height is acquired through biological (genetics and plant breeding methods), physical (container size, water stress, nutrient stress, wind, vibrations or touching, light intensity, photoperiod, light quality and temperature) and chemicals (such as ancymidol, daminozide, paclobutrazol, chlormequat-chloride, ethephon, uniconazole) methods (Tayama *et al.,* 1992; Barrett and Erwin, 1994; Khattak and Pearson, 2005). When deciding on the best control method, growers have to consider the cost of the method (including equipment, labour and other expenses encountered such as fuel). They have to also consider how the method will affect crop timing and plant quality, the retail outlet price (bouquets in case of cut-flowers like *Antirrhinum*). To study plant height was one of the objectives of present research. Therefore, it was observed that plant growing media (nutrient stress; a physical method to control plant height) significantly control plant height. However, a slow initial growth was recorded in almost all plants due to low prevailing temperature (4.52°C in December) when plants were getting established after transplantation. In leaf mold media (nutrient enriched media) plants were much taller than the other treatments. Comparing leaf mold media with river sand or silt media the difference in plant height was almost double (23 and 19 cm, respectively). Plant height data recorded at different time intervals (weeks) also endorsed the similar trend at all stages of growth. Similarly, Rainbow and Wilson (1998) used a media obtained from green wastes and treated it with 50 mL phosphoric acid (to add P and reduce pH) and 1.7 to 3 g of ammonium nitrate (to add N), followed by dilution using a low-nutrient substrate such as coir in a ratio of between 1 and 5 parts by volume to 1 part by volume of compost. They reported that the media prepared from green waste significantly enhanced growth of *Antirrhinum* and stock and tomato plants. However, Jamal *et al.* (1997) obtained contrary results of plant height in *Lagerstroemia*. The contradictory findings in *Lagerstroemia* could be due the difference in genera as *Antirrhinum* is a small annual growing plant whereas *Lagerstroemia* is a semi-dwarf shrub.

Leaf number findings also showed a significant difference between the growing media as plants grown in leaf mold media produced 12 or 10 additional leaves than the plants in river sand and silt media, respectively. It has been reported in petunia, pansy and *Antirrhinum* that leaf development is the response to the environment such as temperature and photoperiod (Adams *et al.,* 1996; Adams *et al.,* 1997a,b; Adams *et al.,* 1998; Munir, 2003). However, no evidence is reported in recent literature that growing media can affect the number of leaves. The only assumption could be drawn that as the nutrient availability was highest in the leaf mold media, therefore, plants utilized much of the nutrients to produce maximum assimilates. This assumption seems sensible whilst looking at the plant fresh weight data.

Plants grown in nutrient enriched media flowered only 10 days earlier than the river sand, silt or combination of both media. As already known flowering time is mostly affected by photoperiod, temperature (Adams *et al.,* 1996; Adams *et al.,* 1997a,b; Adams *et al.,* 1998; Munir, 2003) or $GA_3$ (Bradley *et al.,* 1996). It could be, therefore, assumed that early flowering was not due to the difference in media but could be the early response of plant growth in leaf mold based media which led to competency of apex size and in result the environmental signal (photoperiod) induced the stimulus (Hackett and Srinivasani, 1985; McDaniel *et al.,* 1992) and eventually early floral initiation took place.

As the research experiment was aimed to study the most appropriate nutrient enrichment media for *Antirrhinum*, it was significant to record the stem, leaf and plant fresh and dry weight along with leaf and stem ratio and plant growth ratio which could lead to study that how much assimilates were required by the plants to complete the juvenile phase and to use these assimilates during reproductive phase when floral parts are incapable to do photosynthesis. The data regarding fresh and dry weight clearly indicated that the variation in the nutrient availability in the tested media had profound effects on the plant assimilates availability which eventually affect almost all growth and developmental process significantly. It was concluded from the dry matter partitioning data that plants grown in nutrients enriched media (leaf mold or leaf mold based media) produced maximum assimilates as compared to media where nutrients availability was restricted such as river sand, silt or the combination of both. Leaf and stem ratio data also depicted a balanced distribution of assimilates in leaf mold media whereas maximum plant growth ration in river sand pointed towards the stunted plant height and leaf numbers. From these results, a conclusion can be drawn that to obtain best quality of *Antirrhinum* plants they should be grown in nutrient enriched media such as leaf mold or leaf mold based media.

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