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Growth and Flowering Response of *Gaillardia pulchella* Foug. to Different Plant Growing Substrates

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ABSTRACT
Landscaping is gaining momentum in and around main cities of Saudi Arabia to provide recreational facilities to the community. The agricultural scientists are growing different types of flowering plants in different seasons to cope with this situation. In order to facilitate healthy landscaping, samplings of *Gaillardia* cultivar Arizona Sun were planted in pots containing seven different combinations of plant growing media viz., sand, garden soil, organic compost, sand+garden soil (1:1), sand+organic compost (1:1), garden soil+organic compost (1:1) and sand+garden soil+organic compost (1:1:1). The experiment was laid out by following a complete randomized design where each pot was considered as a replicate. All the plant growth and flowering parameters were significantly ($p \leq 0.05$) affected by growing media apart from days to 50% flowering. Plants grown in sand+garden soil+organic compost (1:1:1) media showed maximum plant height, plant spread, number of leaves per plant, number of branches per plant, flower size, disc size and number of rays per flower. Since, the floral induction in *Gaillardia* responded well to photoperiod, temperature or both, therefore it did not show significant influence of any media combination. In conclusion, combination of compost with garden soil (1:1) showed promising potential for optimal growth of *Gaillardia* cultivar Arizona Sun under local conditions.

Key words: *Gaillardia pulchella* Foug, fire-wheel, blanket flower, growth, flowering, growing media

INTRODUCTION

Gaillardia pulchella, also known as blanket flower or fire-wheel is one of the important bedding and cut flower plants grown across the globe. It is hardy, short-lived perennial and grown under a variety of soil and climatic conditions. The genera has over two dozen species which are mostly native to North America (Bailey, 1947). As a bedding plant, it is grown in pots, mixed containers and borders for short time display while the whole flowering stem is marketed as a cut flower for bouquets (Armitage, 1992). *Gaillardia* provides sizzling summer color to the garden with striking blooms in combinations of red, yellow and orange offset by deep brown centers.

The global bedding plants and cut flower industry is a highly vibrant industry. Flower varieties, the region of production, production media and cultural techniques, markets availability and retailing arrangements are all undergoing continuous change which are also few biggest challenges for the growers of this industry. In a steadily growing global bedding plants and cut flower markets, the new developing country exporters are gaining significant market share (Anonymous, 2013). The government of Saudi Arabia launched an extensive program to encourage modern farming technology to establish rural roads, irrigation networks and storage and export facilities and to promote agricultural research and training institutions. The result has been a phenomenal growth not only in the production of all basic foods but also exports of wheat, dates, dairy products, eggs, fish, poultry, vegetables and flowers to markets around the world (Baig and Straquadine, 2014). For an instant, fresh cut flowers are exported to Netherlands (Strategic Media, 2009). These studies demonstrate tremendous scope for this crop as cut flower.

Successful production of pot-grown plants such as *Gaillardia* largely depends on the chemical and physical

properties of the growing media. 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 (Bohme *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 be considered include cost, availability, consistency between batches and stability in the media over time (Noguera *et al*., 1997). Therefore, selection of the proper media components is critical to the successful production of plants (Jensen, 1975). The progressive growers in Kingdom of Saudi Arabia mostly import pot-growing media from abroad and spend much foreign exchange. However, small nursery owners prepare growing media using plant waste etc. In Al-Ahsa region nurserymen often prepare media using sand, garden soil and organic compost. However, a quantitative research on the effect of these substrates was not carried out on *Gaillardia*. Therefore, a research experiment was designed to evaluate three pot based growing media such as sand, garden soil and organic compost and their combinations with particular reference to plant growth and development.

MATERIALS AND METHODS

Present study was conducted at Agricultural Research and Veterinary Experimental Station, King Faisal University, Al-Ahsa, Saudi Arabia. After 4 weeks of germination, seedlings of *Gaillardia pulchella* Foug (cultivar Arizona Sun) were transplanted into 20 cm diameter pots contained seven different combinations of plant growing media. The experiment was laid out by following the completely randomized design having ten replications in each treatment. The potting mixtures were prepared according to the following composition:

- Growing media 1: Sand
- Growing media 2: Garden soil
- Growing media 3: Organic compost
- Growing media 4: Sand+garden soil (1:1)
- Growing media 5: Sand+organic compost (1:1)
- Growing media 6: Garden soil+organic compost (1:1)
- Growing media 7: Sand+garden soil+organic compost (1:1:1)

Plants were observed daily and water was applied manually with the help of sprinkler whenever needed. However, precaution was taken to avoid over irrigation around the root area to minimize the chances of root rot disease. A recommended dose of NPK (150:80:60 kg ha^{-1}) was applied to all treatments. 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 eradicated by hand whenever required. The growth and development parameters measured were: Plant height, plant spread, number of leaves per plant, number of branches per plant, days to 50% flowering, flower head size, central disk size and number of rays per flower. All the means and standard errors were calculated using MS-Excel 2010 software. However, MSTAT-C (Michigan State University, USA) data analysis software was used to calculate standard errors of differences between means and ANOVA.

RESULTS AND DISCUSSION

Table 1 indicated a significant ($p \leq 0.05$) increase in the plant height of *Gaillardia* in different growing media. All the plants in all media grew slowly during first couple of weeks but then increased linearly. Minimum plant height was observed in sand media (25.17 cm) followed by garden soil (28.50 cm) and sand+garden soil (31.83 cm). However, the same parameter was significantly different in leaf mold plant growing media (37.83 cm) or where this media was combined with either sand (36.33 cm) or garden soil (37.17 cm) or together (40.50 cm). A similar trend was also observed regarding plant spread parameter (Table 1). Plants grown in sand (749.50 cm^2), garden soil (974.17 cm^2) or the combination of both (1170.83 cm^2) covered minimum soil surface area. However, organic compost alone (1481.67 cm^2) or combined with either sand (1547.50 cm^2), garden soil (1834.17 cm^2) or with both (2317.33 cm^2) produced more dense plant canopy. Maximum number of leaves per plant were counted when organic compost was combined with sand and garden soil (413.67) followed by garden soil+organic compost (389.17), sand+organic compost (345.83) and organic compost alone media (314). However, minimum leaves were noted in sand media (210.67) followed by garden soil (247.33) and sand+garden soil media (280.67). A very similar trend was observed regarding the number of branches per plant i.e.,

Table 1: Effect of different plant growing media of growth and flowering characteristics of *Gaillardia pulchella*

Growing media	Plant height (cm)	Plant spread (cm^2)	No. of leaves per plant	No. of branches per plant	Days to 50% flowering	Flower size (cm)	Disc size (cm)	No. of rays per flower
GM1	25.17±1.51	749.50±81.67	210.67±12.06	15.83±0.70	84.00±1.77	4.33±0.42	1.52±0.11	9.00±0.73
GM2	28.50±2.96	974.17±204.06	247.33±17.78	18.17±1.25	83.67±1.56	5.67±0.42	1.72±0.10	9.83±0.75
GM3	37.83±1.68	1481.67±124.32	314.00±22.47	20.33±1.05	79.83±2.14	6.83±0.65	2.02±0.12	13.33±1.23
GM4	31.83±2.29	1170.83±166.62	280.67±11.67	18.17±1.40	83.67±1.56	5.50±0.43	1.73±0.11	10.00±0.73
GM5	36.33±1.56	1547.50±129.70	345.83±18.10	21.33±0.88	80.00±2.29	6.83±0.65	2.02±0.12	12.33±1.20
GM6	37.17±1.64	1834.17±197.97	389.17±17.63	22.00±1.29	79.83±1.05	7.33±0.56	2.17±0.14	13.83±1.51
GM7	40.50±2.36	2317.33±162.09	413.67±10.96	23.50±1.28	79.67±2.01	8.00±0.52	3.17±0.17	16.00±1.06
SED	3.05	227.90	20.64	1.50	2.35	0.70	0.16	1.50
$LSD_{(0.05)}$	6.23**	465.40**	42.15**	3.06**	4.81^{NS}	1.43**	0.33**	3.05**

Growing media GM1: Sand, GM2: Garden soil, GM3: Organic compost, GM4: Sand+garden soil (1:1), GM5: Sand+organic compost (1:1), GM6: Garden soil+organic compost (1:1), GM7: Sand+garden soil+organic compost (1:1:1), values are given with Mean ±SED. LSD: Least significant difference among means. **Highly significant difference among treatments

maximum number of branches were counted when organic compost was combined with sand and garden soil (23.50) followed by garden soil+organic compost (22), sand+organic compost (21.33) and organic compost alone media (20.33) whereas minimum branches were produced in sand media (15.83) followed by garden soil (18.17) and sand+garden soil media (18.17).

The data regarding days to 50% flowering was statistically non-significant ($p \leq 0.05$) as none of the media influenced that parameter. However, plants grown in sand took 84 days to flower followed by plants in garden soil and the combination of both (83.67 days). Similarly, plants grown in organic compost and its various combinations with sand and garden soil flowered few days earlier such as 19.67 (sand+garden soil+organic compost), 79.83 (garden soil+organic compost and organic compost alone) and 80 days (sand+organic compost). Other flower related parameters such as flower size, disc size and number of rays per flower were significantly different ($p \leq 0.05$) when grown in various media. Maximum flower size of 8 cm was observed in sand+garden soil+organic compost media followed by 7.33 cm (garden soil+organic compost) and 6.83 cm (organic compost alone and sand+organic compost). Similarly, maximum flower disc size (3.17 cm) was measured when sand+garden soil+organic compost media was used followed by garden soil+organic compost (2.17 cm) and organic compost alone and sand+organic compost media (2.02 cm). Minimum disk size was observed in sand media (1.52 cm) followed by garden soil (1.72 cm) and sand+garden soil media (1.73 cm). More or less similar trend was noted regarding number of rays per flower. Maximum number of rays were counted when plants were grown in sand+garden soil+organic compost media (16) followed by garden soil+organic compost (13.83), organic compost alone (13.33) and sand+organic compost (12.33), however sand, garden soil and mixture of both produced minimum number of rays i.e., 9, 9.83 and 10, respectively.

Present study showed a positive effect of different plant growing media on plant height as taller plants were observed when they were grown in 1:1:1 ratio combination of sand+garden soil+organic compost media. However, plant height is thought to be attained through biological, physical and chemical methods (Khattak and Pearson, 2005; Barrett and Erwin, 1994; Tayama *et al*., 1992; Baloch *et al*., 2009). Increase in height of chrysanthemum plants was also obtained by Soltanzad *et al.* (1982) with the application of filtered pressmud media. Similarly, maximum plant height (68.6 cm) was obtained in the pot filled with soil+coco peat, in case of Liliums (Rani *et al*., 2005). Nethra (1996) obtained the tallest potted China aster plants, which received 10 t ha^{-1} of vermicompost and recommended dose of N, P_2O_5 and K_2O. Therefore, present study suggested a cost effect method to manipulate that parameter using a proper media combination. As the same growing media enhanced other growth and flowering characteristics as well such as plant spread, number of leaves per plant, number of branches per plant, flower size, disc size and number of rays per flower, which is assumed to be the best media for growing *Gaillardia*. The garden soil and organic compost in the above-mentioned media provided more essential plant nutrients and was well aerated due to the presence of sand, therefore it is assumed that plants utilized most of the available nutrients to produce maximum assimilates (Kellogg *et al*., 2000). Similarly, media prepared from green waste significantly enhanced growth of snapdragon, stock and tomato plants (Rainbow and Wilson, 1998). In oriental lily, plant growth was significantly influenced by sandy loam media than coir, peat or combination of both (Merhaut and Newman, 2005). The best *Calathea insignis* growth was achieved when the composted green waste was amended with the combination of 20% biochar and 0.7% humic acid (Zhang *et al*., 2014). Results of present study also showed that plants grown in different media did not show any significant influence on days to 50% flowered. Flowering time is mostly affected by photoperiod, temperature (Adams *et al*., 1997, 1998) or GA_3 (Bradley *et al*., 1996). It could be therefore, assumed that four days flowering difference among treatments is not due to the difference in media but could be the early response of plant growth in organic compost based media which led to competency of apex size and in result the environmental signal (photoperiod) induced the stimulus (McDaniel *et al*., 1992; Hackett and Srinivasani, 1985). However, nutrient enriched media significantly increased flower size, disc size and number of rays per flower. These results are in agreement with Mokashi and Nalawadi (2012). Similarly, nutrient addition significantly increased corolla width in *Ipomopsis aggregate* (Burkle and Irwin, 2009). However, Wang (2007) obtained largest flowers of *Phalaenopsis* when applied 300 mg L^{-1} K with high N and high P regardless of the Douglas fir bark+perlite+coarse Canadian sphagnum peat or Chilean sphagnum moss media. The difference could be due to the variation in the substrates. From these results a conclusion can be drawn that to obtain best quality *Gaillardia* plants they should be grown in nutrient enriched media (Laghari *et al*., 2004; Hahn *et al*., 2001; Lopez *et al*., 1998).

CONCLUSION

The study showed a significant ($p \leq 0.05$) increase in the plant height of *Gaillardia* in different growing media. Minimum plant height was in sand media (25.17 cm) followed by garden soil (28.50 cm) and sand+garden soil (31.83 cm). The plants grown in sand (749.50 cm^2), garden soil (974.17 cm^2) or in combination of both (1170.83 cm^2) covered minimum soil surface area. The plant canopy was dense in organic compost alone (1481.67 cm^2) or combined with either sand (1547.50 cm^2), garden soil (1834.17 cm^2) or with combination of both (2317.33 cm^2). None of the media influenced the days to 50% flowering. However, the difference in other flower parameters such as flower size, disc size and number of rays per flower was significant among the different growing media treatments at 5% level of confidence. The descending order of minimum disk size was in sand media (1.52 cm) <garden soil (1.72 cm) <sand+garden soil media

(1.73 cm). Maximum number of rays were in plants grown in sand+garden soil+organic compost media (16) followed by garden soil+organic compost (13.83), organic compost alone (13.33) and sand+organic compost (12.33). But the sand, garden soil and mixture of both produced minimum number of rays as 9, 9.83 and 10, respectively. In conclusion, combination of compost with garden soil (1:1) showed promising potential for optimal growth of *Gaillardia* cultivar Arizona Sun under local conditions.

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