

## COMPARATIVE STUDY OF ORNAMENTAL POTENTIAL OF SIX *Achillea* SPECIES FROM IRAN

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**Abstract.** *Achillea* spp. is one of the most important medicinal genera belonging to Asteraceae family. The potential of this genus as low maintenance and water consuming ground cover species compared with turf grasses can make its application in urban green space planting promising. However, the ornamental potential of the genus yet to be investigated. In this research, in order to determine ornamental potential of six *Achillea* species (*Achillea millefolium*, white and pink flower species), *A. biebersteinii*, *A. santolina*, *A. nobilis* and *A. filipendulina*), the seedling of these species were cultivated on a Horticultural Department Research Field of Ferdowsi University of Mashhad in October 2009. Phenological and morphological characteristic of these species at different growth stages were recorded. This experiment was conducted in a factorial completely randomized design (RCBD) with 6 treatments (*Achillea* species) and 3 replicates. Based on gained results *A. filipendulina*, an imported species to Iran, successfully compatible with green space of different regions of Iran together with *A. millefolium* (white flower), was evaluated as a superior species. These two species had an average height of 90 cm, and their flower lasted for a relatively long period (approximately 60-70 days) and had larger coverage area compared with the other species. These characteristics made these species more suitable than other studied species in this experiment for ornamental and ground cover planting purposes. Other four species were in a moderate level in terms of their ornamental potential.

**Key words:** *Achillea*, Domestication, Morphological characteristic, Native plants, Ornamental plants

## INTRODUCTION

Establishment of green spaces in big cities has always had some limitations such as lack of suitable lands, stable water resources, fertile

soils and finance. Timeworn green spaces in arid regions occasionally need continuous consumption of water, energy, fertilizer and maintenance and these areas are stable by these supporters. Management and maintaining such areas over the time would have enormous financial and environmental costs (Kazemi & Beechham 2008; Jones & Zwar 2003). At the present time, the most important limitation in maintaining and expansion of the existing green spaces or establishment of new green spaces, is accessibility to sustainable water resources (Amiri et al. 2009; Shooshtarian 2010). Such limitations, in particular, cause many problems in arid and semi-arid regions (Shooshtarian & Tehranifar 2010; Rouhollahi et al. 2008). Warm and dry climatic conditions have dominated in most regions in Iran and its low annual precipitation with an uneven spatial and temporal distribution has necessitated supplemental summer irrigation for most plant species used urban green spaces. To tackle this limitation one strategy could be lawn reduction; as high water and nutrient demanding urban green spaces. Using, ground cover plants are the best alternative option for these purpose (Shooshtarian & Tehranifar 2010). Ground cover plants generally are fast growing species having maximum height of 1 meter (Tehranifar 2002). Ground cover plants, in some cases, could be applied in areas where turf grasses have no ability to develop and they basically could provide green spaces with color variability (Nameth & Chattfield 2001). There are few studies showing the application feasibility of this kind of plants in urban green spaces. Shooshtarian (2010) by investigation some capabilities of these plant in quite arid climate of Kish Island (Iran) reported that only four species of *Frankenia thymifolia* Desf., *Carpobrotus acinaciformis* L. Bolus, *Glacium flavum* Crantz. and *Lampranthus spectabilis* Haw. out of ten had the most compatibility in cited situation. Mitroi et al. (2010) investigated variability in decorative morphological characteristics of spontaneous (*Papaver rhoeas*) species in Romania and reported that such variability of characteristics in this plant species indicate a potential usage as dried flowers. Khalil et al. (2006) stated that of six studied species only two species of *Rhagodia spinescens* and *Furcraea gigantea* survived and could develop in Kuwait with severe restrictions on fresh water resources. In a case study on medicinal-ornamental potential of Clary Sage (*Salvia sclarea* L.), Ghani et al. (2010) reported that regarding the leaf and flower beauty, aroma compounds in flowering stage and ease of care, this plant is suitable to be used as an ornamental in urban green space of Mashhad.

Yarrow species (*Achillea spp.* L.) belong to Asteraceae family and are mainly distributed in Europe, Asia and North Africa and also have been introduced in other locations in the world (Zargari 1996; Weyertahl et al.

1997). This plant genus consists of more than 100 species. Nineteen species of the genus have been recognized in Iran; among them seven are endemics (Rechinger 1986; Mozaffarian 2004). Some species of this genus have shown that have the ability to be grown as ground cover plants in urban green spaces (Rahimmalek et al. 2007; Ashoorabadi et al. 2009). The main aim of this study was to determine the application feasibility of some Yarrow species and evaluating their ornamental potential in Mashhad (Iran) climate and similar conditions.

## MATERIAL AND METHODS

This experiment was conducted in 2009 - 2010, in one of the Horticultural Department Research Fields of Ferdowsi University of Mashhad. *A. nobilis*, *A. millefolium* (white flower) and *A. biebersteinii* transplants were propagated from wild plants which had been used in earlier domestication program. The other three species were collected from green spaces of other cities in Iran. These plants were transplanted to main plots with 1.5×1.5 dimension and 30×40 cm intervals. Statistical design was a factorial completely randomized design (RCBD) with 6 treatments (6 species of Yarrow) and three replicates. Soil characteristics, environmental conditions and meteorological parameters of the experimental plots were described in Table 1 and 2.

Table 1. Soil conditions and geographical situation of the experiment field (Mashhad, Iran).

| Place of experiment | pH   | EC   | N (ppm) | P (ppm) | K (ppm) | Soil Texture | Altitude (m) | Latitude                           |
|---------------------|------|------|---------|---------|---------|--------------|--------------|------------------------------------|
| Mashhad             | 7.28 | 2.28 | 735     | 15.3    | 150     | Loam         | 1037         | 36° 18' 20" (N)<br>59° 31' 44" (E) |

Farming operations such as irrigation and weeding were conducted similarly for all treatments. All phenological and morphological characters of plants including bolting (coming out of rosette form), flowering period and its stems number, auxiliary inflorescence number, inflorescence and plant height in flowering time were measured in the end of each growth stage. Plant's growth and development rates were measured by the amount of plant growth in a specified time period and were calculated by the following formula:

$$\text{Growth Rate Index (GRI)} = \text{difference of initial and final growth status}$$

Table 2. Monthly means of meteorological parameters in cultivation region (Mashhad from Dec 2009 to Aug 2010).

| Month Index                   | Dec   | Jan   | Feb   | Mar   | April | May   | June  | July  | Aug   | Sept  |
|-------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| Precipitation <sub>(mm)</sub> | 13.71 | 15.93 | 19.46 | 47.92 | 27.64 | 37.35 | 7.21  | 2.31  | 0     | 2.4   |
| Temperature <sub>(C°)</sub>   | 6.30  | 6.20  | 5.87  | 11.80 | 14.22 | 20.14 | 26.09 | 29.35 | 26.66 | 22.60 |
| Relative humidity (%)         | 69    | 63    | 68    | 63    | 58    | 53    | 30    | 23    | 22    | 25    |

### Visual assessment

The visual assessment of plants was done by 4 evaluators (consist of 2 specialists in horticulture and 2 ordinary persons) and were given scores from 1 to 5 for each plant species. This method was developed by several researchers (Ghani et al. 2010; Shooshtarian. 2010).

These scores indicated visual quality of plants as follows:

Grade 5: suggests very good, indicating very good ornamental features and great compatibility

Grade 4: suggests good

Grade 3: suggest moderate, acceptable for cultivation in green space

Grade 2: suggest weak

Grade 1: suggest very weak

Plants assessed to have a visual quality score less than moderate were supposed not to be offered for green space plantation.

### Proline and chlorophyll analysis

Based on previous research demonstrating correlation between environmental resistance and biochemical factors (Thomas 1990; Selahvarzi et al. 2008; Shooshtarian 2010), the above characters were measured. In fact the principle role of proline probably is not to reduce the osmotic potential, but to protect enzymes against dehydration and salt accumulation (Thomas 1990). Extraction and determination of proline was performed according to the method of Bates et al. (1973) with little modifications. Leaf samples (1 g) were extracted with 3% sulphosalicylic acid. Extracts (2 ml) were held for 1h in boiling water by adding 2 ml ninhydrin and 2 ml glacial acetic acid, after which cold toluene (4 ml) was added. Proline content was measured by a spectrophotometer (Shimadzu 1601) at 520 nm and calculated as  $\mu\text{mol g}^{-1}$  DW against standard proline. Photosynthetic pigments like chlorophyll were estimated by the methods of Saini et al. 0.5 g of plant material was taken in a pestle and mortar and homogenized with 10ml of 80% acetone. The extract was centrifuged at  $8000 \times g$  for 10min and the supernatant was made up to 25ml with 80% acetone and was used for the estimation of Chlorophyll contents.

absorbance read at 645 and 663 nm in spectrophotometer (model Shimadzu UV-120-02, Japan) and the quantity of read chlorophyll was calculate by standard formula and expressed as mg g<sup>-1</sup> FW. Total Chlorophyll (mg /g F.W.) = 20.2(A<sub>645</sub>) +8.02(A<sub>663</sub>) × v/w×1000, A= absorbance rate in length wave of exposed, V=final volume of acetone and extract and W is fresh weight of samples.

#### **Statistical analysis**

For measurement of morphological and biochemical features, 5 samples of each replicates in each species were taken. Statistical analysis of variance (ANOVA) was performed by MINITAB 13 software. Means were separated by Duncan's multiple range test at 5% level of probability by MSTATC software.

## **RESULTS**

Analysis of Variance (Table 3), showed significant differences in morphological and biochemical characteristics of plant species as follow:

#### **Time from cultivation to bolting and flowering**

The earliest bolting time (105 days after planting) belonged to *A. filipendulina* which had significant difference with other species. In contrary, the latest time (121 days after planting) was recorded for white flower *A. millefolium* (White flower) (Table 4). Furthermore, and as well as above results, the earliest and latest flowering time referred to *A. filipendulina* and *A. millefolium* respectively. These figures showed significant difference with other species (Table 4).

#### **Plant height and growth rate index of plant height**

The largest plant height at flowering time (93.10 cm) was related to *A. filipendulina* species and the shortest (55 cm) was for pink flower *A. millefolium*. Later and former species had no significant differences with others and a significant difference with *A. millefolium* (white flower) respectively. Furthermore, the maximum and minimum GRI were recorded for *A. biebersteinii* and *A. santolina* respectively which had significant difference compared with others (Table 4).

#### **Height and diameter of the main inflorescence**

As seen in Table 4, maximum inflorescence height (5.07 cm) was for *A. bibersteinii* while the minimum height (1.63 cm) was recorded for *A. santolina*. The mentioned species had significant difference regarding other species. In addition, the maximum and minimum inflorescence diameter was observed in *A. bibersteinii* and *A. santolina* with average of 7 cm and

1.1 cm, respectively and both of which had significant difference compared with others.

Table 3. Analysis of variance (mean square) of 6 Yarrow Species in Mashhad's (Iran) climate.

|                   | DAP to bolting | DAP to flowering | Plant height | Plant height G.R.I. | Inflorescence height | Inflorescence diameter |
|-------------------|----------------|------------------|--------------|---------------------|----------------------|------------------------|
| Means Square (MS) | 107.7          | 73.8             | 1632         | 188.5               | 81.5                 | 12.26                  |
| F                 | 68             | 9.6              | 204.7        | 37.9                | 3017.4               | 381.3                  |
| P value           | 0.0001         | 0.001            | 0.0001       | 0                   | 0.0001               | 0.0001                 |

|                   | Inflorescence number | Number of Flowers on main inflorescence | Number of flowers on lateral inflorescence | Cover diameter |
|-------------------|----------------------|---|--|----------------|
| Means Square (MS) | 845.4                | 24.75                                   | 10760                                      | 601.1          |
| F                 | 47.1                 | 91.2                                    | 501.1                                      | 23             |
| P value           | 0.0001               | 0                                       | 0.0001                                     | 0.001          |

|                   | Leaf number | Shoot number | Chlorophyll A | Chlorophyll B |
|-------------------|-------------|--------------|---------------|---------------|
| Means Square (MS) | 2420193     | 1759.6       | 0.53          | 0.095         |
| F                 | 2444        | 1261.8       | 70.5          | 12.73         |
| P value           | 0           | 0            | 0             | 0             |

|                   | Fresh weight | Dry weight | Flowering period | Coverage surface |
|-------------------|--------------|------------|------------------|------------------|
| Means Square (MS) | 10110        | 2127       | 168              | 90.4             |
| F                 | 1486         | 405.3      | 62.4             | 12.14            |
| P value           | 0.0001       | 0.001      | 0                | 0.001            |

|                   | Cover surface G.R.I | Total chlorophyll | Proline content | Visual score |
|-------------------|---------------------|-------------------|-----------------|--------------|
| Means Square (MS) | 1.45                | 0.85              | 2.84            | 0.95         |
| F                 | 10.17               | 44.82             | 65.2            | 7.57         |
| P value           | 0.001               | 0                 | 0               | 0.004        |

DAP: Days After Planting.

G.R.I.: Growth Rate Index.

Table 4. Comparative analysis of some morphological characteristics in 6 Yarrow Species.

| Yarrow Species                       | DAP to bolting       | DAP to flowering | Plant height | Plant height G.R.I. |
|--------------------------------------|----------------------|------------------|--------------|---------------------|
| <i>A. millefolium</i> (white flower) | 121.30a <sup>†</sup> | 152.00a          | 88.67a       | 14.33b              |
| <i>A. millefolium</i> (pink flower)  | 116.70b              | 139.40cd         | 55.00d       | 8.03c               |
| <i>A. nobilis</i>                    | 120.00a              | 144.00bc         | 71.00b       | 16.73b              |
| <i>A. biebersteinii</i>              | 120.00a              | 142.3bcd         | 65.27c       | 24.17a              |
| <i>A. santolina</i>                  | 119.7a               | 145.00b          | 29.50e       | 0.87d               |
| <i>A. filipendulina</i>              | 105.3c               | 138.00d          | 93.10a       | 14.37b              |

| Yarrow Species                       | Inflorescence height (cm) | Inflorescence diameter (cm) | Inflorescence number | Number of Flowers on main inflorescence |
|--------------------------------------|---------------------------|-----------------------------|----------------------|---|
| <i>A. millefolium</i> (white flower) | 4.63b                     | 5.70b                       | 36.00b               | 234.50b                                 |
| <i>A. millefolium</i> (pink flower)  | 4.13b                     | 5.60b                       | 38.50b               | 169.00c                                 |
| <i>A. nobilis</i>                    | 2.13c                     | 5.40b                       | 32.27b               | 260.60b                                 |
| <i>A. biebersteinii</i>              | 5.07a                     | 7.00a                       | 24.77b               | 248.30b                                 |
| <i>A. santolina</i>                  | 1.63d                     | 1.10c                       | 66.50a               | 89.27d                                  |
| <i>A. filipendulina</i>              | 2.50c                     | 5.47b                       | 17.77b               | 348.50a                                 |

DAP: Days After Planting. G.R.I.: Growth Rate Index.

<sup>†</sup>Means with similar letters are not significantly different by Duncan's test at 5% level.

### Number of inflorescences and number of flowers in main and lateral inflorescence

The highest number of inflorescence (66.5) was for *A. santolina*. This was not significantly different from the related figures on other plant species. Maximum and minimum numbers of flowers in main inflorescence were observed on *A. filipendulina* and *A. santolina*, with 354.8 and 89.3 numbers of flowers respectively (Table 4). In terms of number of flowers in lateral inflorescence, also the above species were distinguished by possessing the largest and the smallest numbers, with average of 182.20 and 25, respectively and had significant differences compared with others (Table 5).

### Flowering period

Maximum flowering period (70.67 days) was for *A. filipendulina* species which in this case, just had no significant difference with *A. millefolium* (pink flower) and the minimum figure (50 days) was for *A. santolina* which had significant difference in comparison with others (Figure 1).

### Coverage diameter & area and related growth rate indices

The uttermost coverage of diameter and surface was for *A. filipendulina* with an average of 77.1 cm and 4685 cm<sup>2</sup>, respectively and the least was related to *A. santolina* with 38.2 cm and 1146 cm<sup>2</sup> (Table 5 and Figure 2). Furthermore, the highest and the lowest rates for coverage area of GRI were recorded for *A. filipendulina* and *A. millefolium* white flower respectively (Table 5). *A. filipendulina*, in mentioned cases, had significant differences with other studied plants.

Table 5. Comparative analysis of some characteristics in 6 Yarrow Species.

| Yarrow Species                       | Number of flowers on lateral inflorescence | Cover diameter (cm <sup>2</sup> ) | Cover surface G.R.I. |
|--------------------------------------|--|-----------------------------------|----------------------|
| <i>A. millefolium</i> (white flower) | 71.05c <sup>†</sup>                        | 46.77bc                           | 1.87c                |
| <i>A. millefolium</i> (pink flower)  | 66.50c                                     | 52.03b                            | 2.37bc               |
| <i>A. nobilis</i>                    | 96.77b                                     | 43.67bc                           | 2.27bc               |
| <i>A. biebersteinii</i>              | 88.50b                                     | 41.47c                            | 2.43bc               |
| <i>A. santolina</i>                  | 25.00d                                     | 38.17c                            | 2.63b                |
| <i>A. filipendulina</i>              | 185.20a                                    | 77.10a                            | 3.90a                |

| Yarrow Species                       | Leaf number | Shoot number | Chlorophyll A (µgr/ml) |
|--------------------------------------|-------------|--------------|------------------------|
| <i>A. millefolium</i> (white flower) | 452.00d     | 6.6cd        | 1.13b                  |
| <i>A. millefolium</i> (pink flower)  | 487.5c      | 12.00b       | 1.52a                  |
| <i>A. nobilis</i>                    | 573.5b      | 11.40b       | 0.61d                  |
| <i>A. biebersteinii</i>              | 305.00f     | 7.77c        | 0.97c                  |
| <i>A. santolina</i>                  | 7390.00a    | 67.5a        | 0.31e                  |
| <i>A. filipendulina</i>              | 363.00e     | 5.00d        | 0.96c                  |

| Yarrow Species                       | Chlorophyll B (µgr/ml) | Fresh weight (g) | Dry weight (g) |
|--------------------------------------|------------------------|------------------|----------------|
| <i>A. millefolium</i> (white flower) | 0.37bc                 | 256.00a          | 11.37c         |
| <i>A. millefolium</i> (pink flower)  | 0.85a                  | 157.50d          | 12.60c         |
| <i>A. nobilis</i>                    | 0.52ab                 | 127.00e          | 8.70c          |
| <i>A. biebersteinii</i>              | 0.32cd                 | 93.47f           | 11.77c         |
| <i>A. santolina</i>                  | 0.18d                  | 209.70b          | 35.93b         |
| <i>A. filipendulina</i>              | 0.66a                  | 173.80c          | 70.09a         |

DAP: Days After Planting. G.R.I.: Growth Rate Index.

<sup>†</sup>Means with similar letters are not significantly different by Duncan's test at 5% level.



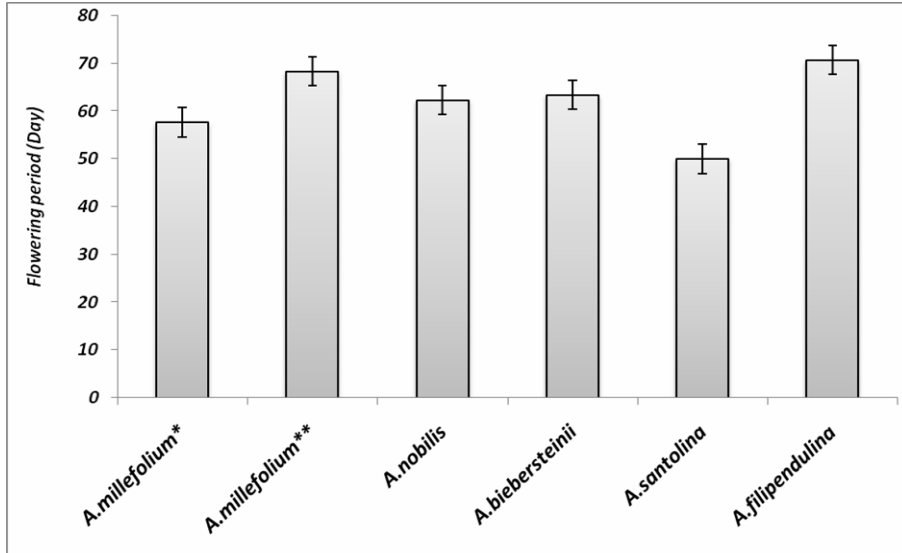


Figure 1. Flowering period of different *Achillea* species (\*: white flower and \*\*: pink flower)

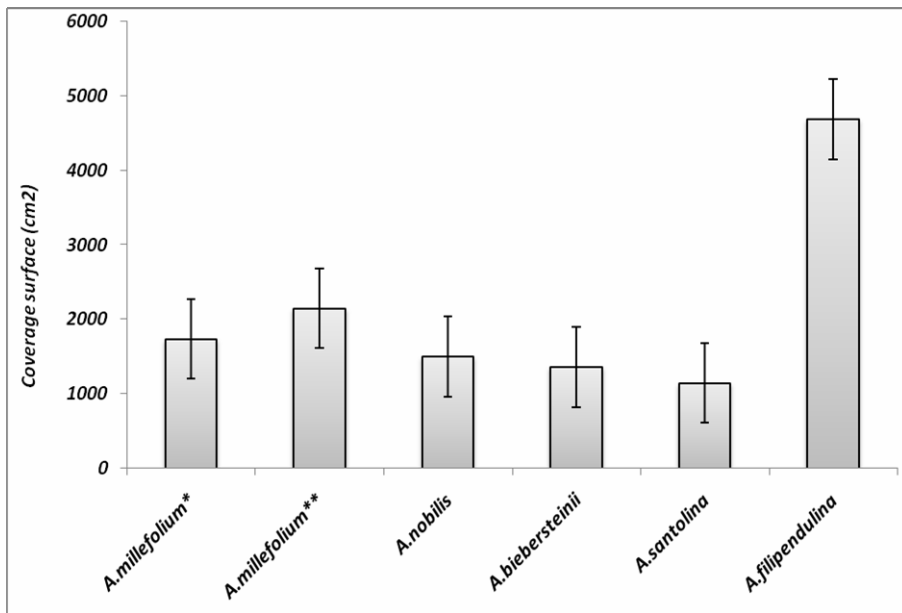


Figure 2. Coverage surface of different *Achillea* species (\*: white flower and \*\*: pink flower)

### Number of leaves and flowering stems

The highest number of leaves (7390) belonged to *A. santolina* and the lowest number (305) was related to *A. biebersteinii*. The above species had significant differences with other species. For number of flowering stems, maximum and minimum numbers (67.5 and 5) were recorded for *A. filipendulina* and *A. santolina*, respectively and both of which differed significantly in comparison with others (Table 5).

### Biochemical factors (chlorophyll a, b and total chlorophyll and Proline content)

*A. santolina* had the lowest amount of chlorophyll a, b and total chlorophyll and *A. millefolium* pink flower had the uttermost content of chlorophyll a, and total chlorophyll (Table 5 and Figure 3). The maximum amount of chlorophyll b was found in *A. filipendulina*.

Reviewing literature has revealed a various range of proline amino acid among different plant species (Selahvarzi 2008; Shoohtarian 2010). In this research, maximum amount was found in *A. santolina* (3.04  $\mu\text{mol/g}$ ) and the minimum amount was in pink flower *A. millefolium* (0.66  $\mu\text{mol/g}$ ) (Figure 4).

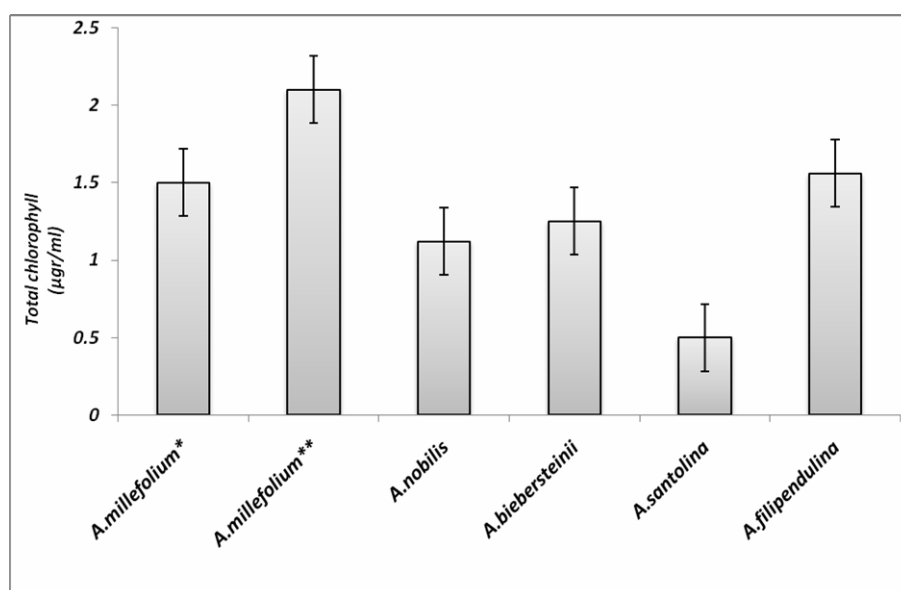


Figure 3. Total chlorophyll on different species of *Achillea*  
(\*: white flower and \*\*: pink flower)

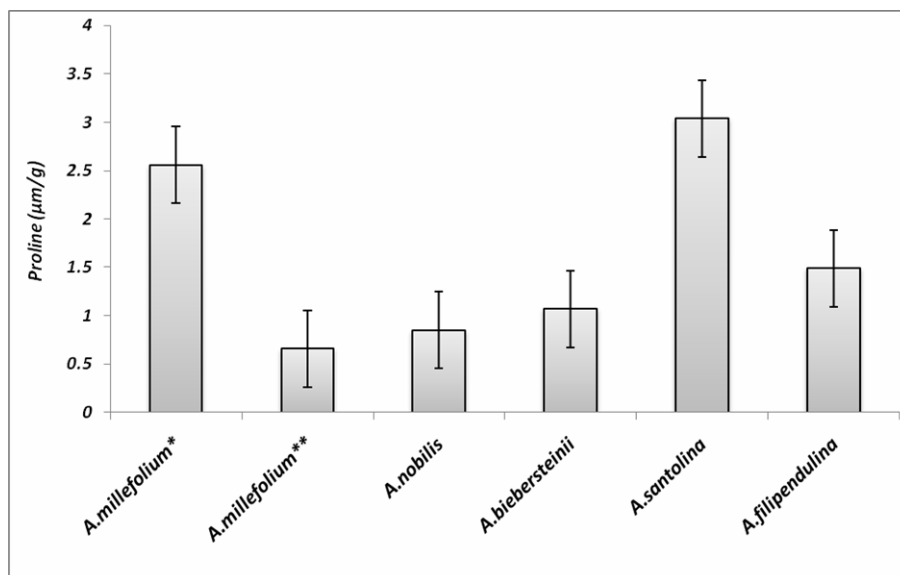


Figure 4. Proline content on different species of *Achillea* (\*: white flower and \*\*: pink flower)

#### Fresh and dry weight and growth rate index

Species with the lowest and highest fresh weight, *A. millefolium* (white flower) and *A. biebersteinii* respectively, had significant difference with other species. Whilst, *A. filipendulina* and *A. nobilis* had the highest and lowest amount of dry weight respectively. The former species with 70.09 g had significant difference in comparison with other species.

#### Visual assessment

The maximum visual score (4.70) pertained to *A. filipendulina*, which had some superior characters. The lowest score (3) related to *A. millefolium* pink flower (Figure 5). Both mentioned species had significant differences with other species.

#### DISCUSSION

According to the results of this study, *Achillea* species proved their capability to be used as a ground cover plant, due to their own

characteristic features. Subsequently the traits of each species are discussed in details.

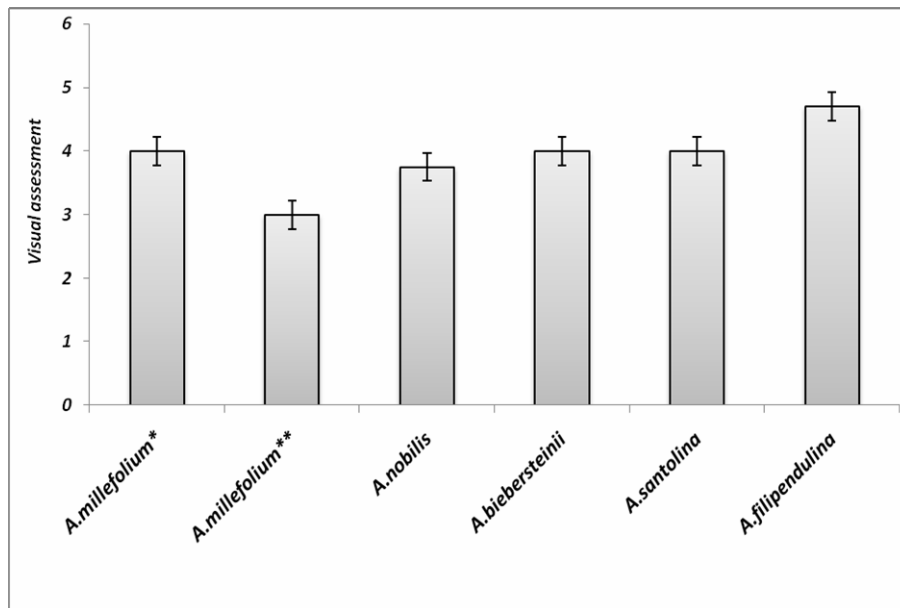


Figure 5. Visual assessment on different species of *Achillea* (\*: white flower and \*\*: pink flower)

White Yarrow (*Achillea millefolium*), species is considered as the most popular species, and in some countries cut and dried flower of this species are used. In addition, this species has been used as one of the most suitable plants for cultivation in green space for many years (Borgmann et al. 2002; Chimmondou-Pavlidou 2004). This species in comparison with others, flowered late, had tall height (approximately 90 cm) and produces white and approximately huge inflorescences. Its flowering period was relatively long (about 60 days). Total chlorophyll content of this species was modest, and the amount of proline was rather high. It had a decent coverage area and coverage diameter, but in terms of coverage area GRI it was low. This species presented a high ornamental potential. Another considerable point about this species is the beauty of its leaves and the appearance of this plant in preflowering stage, and also average visual scoring for this species was 4, mainly due to the decent coverage features of this species (Figure 6).



Figure 6. Six species of *Achillea* studied in this research.

Pink Yarrow (*A. millefolium*), had the highest amount of chlorophyll a, b and total chlorophyll while in terms of proline it had the lowest amount, and moderate coverage area and diameter and coverage area index. This species had an inflorescence with rather huge size and a long flowering period (about 70 days). In terms of the period from cultivation to flowering, it stood in middle of other species. It had moderate height but regarding its visual evaluation it failed to attract attention of the evaluators (Figure 6).

*A.nobilis* and *A.biebersteinii* are the wild species of Khorasan Razavi Province which have been cultivated to investigate domestication properties of these species in Ferdowsi University of Mashhad for 4 years (Ghani et al. 2010). These species in most morphological measurements possessed the middle values in comparison with other species. The most important observed features in *A. nobilis* species was production of several leaves (after *A. santolina* species it had the most number of leaves), having a moderate height (71 cm), having quite low amount of proline and total chlorophyll. This species was a relatively late flowering plant with creamish white flowers and a considerable size of main inflorescence. Inflorescence is mostly seen as a single flower in this plant species, it has rather long flowering period (62 days), and the most important feature of this species is its beauty in the preflowering stage (Figure 6).

The most important traits of *A. biebersteinii* were having huge inflorescence in terms of diameter and height, and the lowest number of leaves in comparison with other species. This species had the highest growth rate index of height that showed fast growth of this species. A single plant sucker or rhizome can cover a square meter plot one year after cultivation (Figure 6). Hence, it is considered an ideal plant for massive planting. Its leaves greatly attract insects; therefore, several bee hives could be seen in its natural ecosystem.

*A. santolina*, doesn't widely grow in Iran, and in recent years it has been introduced into Iran as covering plant for cultivation in green space. The most important traits of this species are its slow and compact growth habit with a low height nearly 30 cm. This species does not have a main inflorescence and it had several inflorescences with low diameter and length. In terms of physiological characteristics, this species had the lowest amount of chlorophyll (a, b and total) and the highest amount of proline. Its leaves were wormlike, small, numerous and silverish green in color (Figure 6). Due to dense growth habit, the spread coverage area and diameter of this plant species was low. Its flowering period was short and about 50 days. Low number of flowers in inflorescence and small size of inflorescence, low height growth rate index, quite late flowering time were among the characteristics of this plant species. It also had a great number of flowering stalks. In observer's view, visual quality of this species was assessed to be suitable. The considerable point about this species was that several plants were dried and mortality rate was high during the growing season.

*A. filipendulina*, is an imported plants to Iran that has been properly adapted to green space environments in most climatic conditions of Iran. Also this species has been widely grown in some area of Iran but no report

exists about its domestication to date. This species had some good properties including the maximum amount of coverage diameter, coverage surface, and growth rate index of coverage surface. The longest period flowering (about 71 days), big inflorescence and the highest plant height (93 cm). This species compared with other species, flowered early, and had low number but big size leaves. Also maximum visual score belonged to this species (Figure 6).

Generally it seems that each of these species has some features and superiorities compared with others and based on these features can be selected for special purposes. For instance if plants with huge inflorescence and relatively long period of flowering are needed; species like *A. filipendulina*, *A. millefolium* (white flower) and *A. biebersteinii* are appropriate options. *A. biebersteinii* due to producing a large number of rhizomes is suitable as a ground cover plant. *A. santolina*, seems to be suitable if it is cultivated among coverage plants like turfgrasses or if it is cultivated as coverage borders in turf areas.

## CONCLUSION

Based on compatibility rate and ornamental factors assessment of the species in Mashhad climatic conditions, the priority of these species for cultivation is suggested as following: *A. millefolium* (white flower), *A. filipendulina* > *A. nobilis*, *A. biebersteinii* > *A. millefolium* (pink flower), *A. santolina*

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