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Determine the best density and appropriate planting time of *Achillea millefolium*

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Abstract

In order to investigate the effect of planting time and density of *Achillea millefolium* under field condition, this project was performed at Forest and Rangelands Research Institute, Karaj, Iran in 2011. The experiment was conducted as split plot in the form of a randomized complete block design with three replications. The main factor was four planting times (6 March, 26 March, 14 April and 5 May) and the sub factor was three density included 100 plants per square meter (10×10cm), 25 plants per square meter (20×20cm) and 11 plants per square meter (30×30cm). The analysis of variance showed that the effect of planting time, density and their interaction significantly affected all measured traits. The highest plant fresh weight (161.23g), inflorescence (4.75cm) and stem height (57.77cm) was observed in the second planting time. The highest number of sub stem (14.83n/p) and canopy diameter (22.58cm) belonged to planting spaces of 30×30cm. The highest plant weight (139.33g), root length (20cm), inflorescence (4.06cm) and stem height (54.75cm) was observed in treatment 20×20cm. The results indicated that among the four planting times, the first and second planting time provide more opportunities for growth and density of 30×30cm provides sufficient space for plant growth. So, For high production in the first year of planting, it's recommended from 15 March to late April. Spacing of 30×30cm was detected the best planting interval for the first year. And considering that *Achillea millefolium* is a perennial plant, planting intervals greater than 30×30cm may be more suitable for the next years.

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Introduction

Planting at the right time makes the collection of appropriate environmental factors for plant germination, establishment and survival. As much as possible, the plant at every stages of its growth encounter with optimum growing condition (Nezami *et al*., 2009). Different planting time adapted plant vegetative and reproductive period of growth with temperature, length of day and different solar radiation and in this way, affect plant development, producing foliage and yield (Heydarizadeh *et al*., 2007). The best planting time is when the crop able to finish its growth with minimal stress (Morteza *et al*., 2009) and the plant had enough time for vegetative growth before flower creation. Inadequate vegetative growth make decrease in food supply, flowers number, small grain and loss of quality and quantity yield. In the other hand, prolonged growth causes loss of soil moisture and vegetative and reproductive organs competition for food (Bagheri *et al*., 2008).

Ram and his colleagues (Ram *et al*., 2010) investigated the effect of four planting time (25 August, 9 September, 24 September and 9 October) on *withania somnifera* Dunal in India. Their results indicated that planting on 25 August had the highest plant height, main and sub stem number, root length and width. With delay in planting, trend of decline was observed in the traits. So that the planting on 9 October reached to the lowest value. Dadkhah and his colleagues studied two planting times (spring and autumn) on *Matricaria* in Shirvan, Iran. They concluded that planting time had significant effect on growth traits of *Matricaria chamomilla*. So measured traits like bush height, main and sub stem number, length of flowering period and flower number per bush in the fall planting was higher than spring planting (Dadkhah *et al*., 2009).

Optimal density is one of the success factors in the production. If the plant density be more than optimal, environmental factors availability such as moisture, light and nutrients is not optimum for per plant. If the plant density be less than optimal, environmental resources not used effectively and reduce the production (Norouzpur *et al*., 2006).

Investigation effect of three density (8,12 and 16 plant per square meter) on *Mentha piperita* indicated that the highest nodes number on the main stem, leaf number per bush and LAI per bush was observed in the lowest density but the highest stem height belonged to third density (Izadi *et al*., 2010). Study three density (6×50, 8×50 and 12×50cm) on morphological traits of *Calendula officinalis* in Sistan and Baluchistan, Iran stated that the highest petal number, flower diameter and sub stem number belonged to third density. The highest sub stem length and leaf number was observed in the first and third density and the highest stem diameter, stem weight and root weight belonged to the second and third density. The first density showed the highest flower fresh weight (Ganjali *et al*., 2010).

Achillea millefolium is the plant of Asteraceae and its active substances are appetizing and make food digestion. The essential oil is anti-bacterial and anti-inflammatory (Benedek and Kopp, 2007; Vasinauskiene *et al*., 2006). *Achillea millefolium* planting time and spaces has not been reported up to now, Therefore this study was conducted to investigate the agronomic characteristics and effects of planting time and density in Iran.

Material and method

In order to investigate the effect of planting time and density of *Achillea millefolium* under field condition, this project was performed at Forest and Rangelands Research Institute, Karaj, Iran in 2011.

The experiment was conducted as split plot in the form of a randomized complete block design with three replications. The main factor was four planting times included 6 March, 26 March, 14 April and 5 May. The sub factor was three densities included 100 plants per square meter (10×10cm), 25 plants per square meter (20×20cm) and 11 plants per square meter (30×30cm).

Indirect cultivation but mentioned planting times was performed in cultivation trays. After enough growth, plants of each planting times and spaces were transferred to the respective plots. Amounts of nitrogen (40kg/ha), phosphorus (30kg/ha) and potassium (32kg/ha) were mixed with soil while cultivation in all treatments. In order to facilitate the establishment of seedlings, watering was performed from planting time every three days for the first week and then every five to seven days depending on the weather condition.

In this project any herbicides, pesticides and manure was not used. In complete flowering stage and after removing marginal effect, morphological characteristics were recorded of the lines between plots. Traits which were evaluated in this study include plant fresh weight, root length, root width, inflorescence height, stem height, sub stem number, canopy diameter, chlorophyll a, chlorophyll b and total chlorophyll.

Data were analyzed by the SPSS 16 software and analysis of variance was performed with MSTAT-C. Comparison of means was performed by the Duncan's multiple range test at the level of 5%.

Results and discussion

Analysis of variance indicated (Table 1) that the planting times and spaces significantly affected all measured traits. The interaction effect of main and sub factor were different for plant fresh weight, root length, inflorescence height, sub stem number, canopy diameter, chlorophyll b and total chlorophyll ($\alpha \leq 0.05$).

Table 1. Analysis of variance of the effect of planting times and spaces on morphological and physiology traits of *Achillea millefolium*.

						Mean Squares (MS)					
SOV	Df	Plant fresh weight	Root length	Root width	Inflorescence height	Stem height	Sub stem number	Canopy diameter	Chlorophyll a	Chlorophyll b	Total chlorophyll
Block	2	546.3**	60.93**	7.46**	1.72**	168.7**	0.7ns	78.08**	0.02**	0.09**	0.04**
Planting time (A)	3	16566.56**	129.56**	25.6**	12.46**	703.43**	106.91**	194.91**	0.05**	0.02**	0.2**
Error (A)	6	22.42	11.47	0.09	0.28	1.87	5.91	2.86	0.001	0.002	0.002
Planting spaces (B)	2	15918.2**	197.35**	19.66**	4.99**	1353.02**	152.52**	117.25**	0.22**	0.3**	1.02**
(A) × (B)	6	673.51**	10.05**	0.37ns	0.26*	6.54ns	6.19**	8.02**	0.001ns	0.01**	0.009**
Error	16	11.12	1.74	0.16	0.08	4.16	0.44	1	0.001	0.001	0.001
CV(%)	-	3.17	8.007	7.11	8.74	4.4	5.78	5.15	2.87	2.91	1.44

ns, non significant; *, significant at P≤0.05; **, significant at P≤0.01.

Table 2. Effect of planting times on morphological and physiology traits of *Achillea millefolium*.

Planting time	Plant fresh weight (g)	Root length (cm)	Root width (cm)	Inflorescence height (cm)	Stem height (cm)	Sub stem number (n/p)	Canopy diameter (cm)	Chlorophyll a (mg/l)	Chlorophyll b (mg/l)	Total chlorophyll (mg/l)
6 March	119.14b	21.22a	4.27c	3.93b	47.88b	14.88a	25.11a	1.02c	1.14c	2.67c
26 March	161.23a	17.55b	4.33c	4.75a	57.77a	14.11b	21b	1.11b	1.2b	2.84b
14 April	72.77c	14.77c	6.23b	2.53c	43.55c	8.55c	17.11c	1.21a	1.27a	3.04a
5 May	66.85d	12.4d	7.78a	2.26c	36.66d	8.55c	14.44d	1.11b	1.22b	2.85b

Means in a column followed by the same letter are not significantly different at P≤0.01.

Results showed that the second planting time (26 March) had the highest plant fresh weight (161.23g), inflorescence height (4.75cm) and stem height (57.77cm). It seems that the second planting time had the highest height and growing period because of more favorable environmental conditions. The highest root length (21.22cm), sub stem number

(14.18n/p) and canopy diameter (25.11cm) belonged to the first planting time (Table 2).

Generally, plant encounter with hot weather and moisture stress could reduce canopy and sub stem number. Perhaps the first planting time had high root penetration into the soil due to longer growing season and soft soil in early spring. So the roots were more able to penetrate in soil. In the fourth planting time because of decreased growing period, roots did not had enough time for growing and penetration. This results were consistent with the others (Dadkhah *et al.*, 2009; Ram *et al.*, 2010).

Table 3. Effect of planting spaces on morphological and physiology traits of *Achillea millefolium*.

Planting spaces	Plant fresh weight (g)	Root length (cm)	Root width (cm)	Inflorescence height (cm)	Stem height (cm)	Sub stem number (n/p)	Canopy diameter (cm)	Chlorophyll a (mg/l)	Chlorophyll b (mg/l)	Total chlorophyll (mg/l)
30*30cm	66.8c	17.41b	6.9a	3.25b	50.16b	14.83a	22.58a	1.24a	1.37a	3.14a
20*20cm	139.33a	20a	5.71b	4.06a	54.75a	12b	19.33b	1.13b	1.18b	2.84b
15*15cm	108.87b	12.05c	4.35c	2.79c	34.5c	7.75c	16.33c	0.97c	1.06c	2.56c

Means in a column followed by the same letter are not significantly different at P≤0.01.

Evaluation the traits in the three planting spaces indicated that spacing of 20×20cm had the highest plant fresh weight, root length, inflorescence height and stem height with 139.33g, 20cm, 4.06cm and 54.75cm, respectively (Table 3). In the spacing of 30×30cm, roots had sufficient space to absorb water and had not a particular competition for deep penetration. Intense competition may be reduced a part of roots energy in the density of 15×15cm. It's also possible that problem of roots high density and tangled penetration is another factor in preventing root penetration in the density of 15×15cm. Food and water need of the plant is another question. In addition to the enough space in the density of 20×20cm, more shoots increase the need to water absorption. Therefore, roots penetration to the soil increased and root length of the treatment was grater. This results matched with the others (Izadi *et al.*, 2011).

The density of 30×30cm had the highest sub branches number (14.83n/p) and canopy diameter (22.58cm). In this density, more sub branches and having enough space for their aerial expand have been led to increase canopy diameter (Table 3). The third planting time (14 April) showed the highest amount of chlorophyll a, chlorophyll b and total chlorophyll with 1.21mg/l, 1.27mg/l and 3.04mg/l, respectively (Table 2). The highest amount of chlorophyll a (1.24mg/l), chlorophyll b (1.37mg/l) and total chlorophyll (3.14mg/l) was observed in density of 30×30cm (Table 3). The high amount of chlorophyll a, b and total chlorophyll in the third planting time is related to time of plant growing period. At the sampling time, herbs of the first and second planting time were somewhat closer to old age. It is natural that the plant is much younger and greener, chlorophyll is as much more. One of the reasons for higher chlorophyll in the spacing of 30×03cm related to lack of intense competition between plants and nutrient uptake such as iron, manganese and nitrogen. This elements are effective in making chlorophyll.

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