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Full Length Research Paper

Effects of plant density and planting pattern on yield and yield components of Iranian ox-tongue (*Echium amoenum* Fisch and Mey) in North of Iran

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In spite of existing a long history in medicinal plants consumption in Iran, but there has not taken any major step for identification, domestication and mass propagation of these plants. So this study has been accomplished for the purpose of determination the best planting pattern and plant density of the Iranian ox-tongue. A randomized complete block design was used to incorporate factorial combinations of two levels of planting pattern (square and rectangular) and four levels (2, 4, 6 and 8 shrub per m^2) with three replications in agricultural year of 2009 to 2010 in Eshkevarat Region located in the northern part of Iran. The results showed that there was a significant difference between different treatments regarding the effect of plant density on dried flowers weight per shrub ($p<0.01$), dried flowers yield per m^2 ($p<0.05$), dried weight a shrub ($p<0.01$), number of flowers per shrub ($p<0.01$) and number of flowers per inflorescence ($p<0.01$). In general maximum yield of dried flowers of ox-tongue was recorded for the density of 6 shrub per m^2 (709.2kg/ha). The effect of planting pattern on yield and yield components showed that there was no significant difference between the studied treatments ($p>0.05$).

Key word: *Echium amoenum* Fisch and Mey, medicinal plant, Iranian ox-tongue, plant density, planting pattern.

INTRODUCTION

The Iranian ox-tongue is a kind of medicinal plant which is from *Boraginaceae* family, *Echium* genus and *amoenum* species (Zargari, 1996). *Echium amoenum* Fisch and Mey is an herbaceous and perennial plant and has got lint-covered elements. The stem is erected or sometimes curved that has simple leaves (unbranched) with a unique nervure. Its flower consists of a coarse calyx with styloid and perennial structures. The corolla is big and three times higher than calyx that is covered by fuzz. The stamens inside calyx contain floccose filament and have bicorn shape. Also its purple or purplish blue sturdy flower appears on one side of the stem. The pistillate inflorescence is simple and high. All the aerial organs of this plant are covered with uncinate lints that look swollen (white and small) after falling. The fruit is a kind of achene with an acuminate look and is covered with several small bosses. Seeds are brown having swollen lines with length of 3 to 4 mm and width of 2 mm (Amin, 1997; Ghahraman, 1978; Ghassemi et al., 2003; Mehrabani et al., 2005a, b; Gholamzadeh, 2007). The Iranian ox-tongue grows in mountain moderate and Caspian moderate climates (specially tropic and moderate regions of earth) that simultaneously occur during spring rain in mountain moderate and Mediterranean climates. Generally, weather and soil conditions of clammy regions that relatively have continual rain during spring and summer are appropriate for cultivation (Zargari, 1996). This plant is capable to grow and blossom on altitude of 1500 to 2000 m (Ghassemi et al., 2003; Mehrabani, 2005a, b). The Iranian ox-tongue grows wildly on a vast area of northern parts of Iran. Also be cultivated on limited areas in north of Iran (Naderi and Rezaee, 2004; Akbarinia et al., 2007; Akbar zadeh, 2008). The flowers and leaves of ox-tongue with warm temperament traditionally have effects of

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Table 1. Soil test.

pH	6.3
EC (dS/m)	0.17
Percentage of Nitrogen	0.08
Absorbable potassium (mg/kg)	332
Absorbable phosphorus (mg/kg)	13

hilarity, general nutrient and can cause face to be more cheerful. Flowers, leaves and floriferous branches have medicinal use. The leaves of ox-tongue smell flavorless surely. The extract of ox-tongue has anti-inflammatory and anti-depression feature (Sayyah et al., 2006; Akbarinia et al., 2007). In Iranian traditional medicine; the flowers of ox-tongue are also used by people so as to abate the symptoms of sniffle and common cold, multiplier of blood pressure, calmative and diaphoretic. Accordingly, this plant shall be considered as an Iranian purebred medicinal plant (Amin, 1997, 2005; Ghassemi et al., 2003; Mehrabani et al., 2005a, b; Gholamzadeh et al., 2007). Ox-tongue can increase the potency of body immunity system too (Amirghofran et al., 2000). This plant has a range of substances such pyrrolizidine which have antimicrobial and disinfectant effects (Mehrabani, 2005a, 2005b). Numerous researches have been accomplished during past a few years on therapeutic impacts of *E. amoenum.* The antibacterial effects survey (Mansouri, 1999; Abolhassani, 2004), the study of petals essence constitutive components (Ghassemi, 2003), the study of pyrrolizidine alkaloids (Mehrabani et al., 2006) and phenolic ingredients (Mehrabani, 2005a), the study of anti-nervousness effects (Rabbani et al., 2004), the study of narcotic (Heidari et al., 2006a) and anticonvulsive effects (Heidari et al., 2006b), on animals and the antioxidant effects survey (Ranjbar et al., 2006), treatment of mild to moderate major depressive disorder (Amirghofran et al., 2000; Saiiah et al., 2004), treatment of mild to moderate obsessive-compulsive disorder (Saiiah et al., 2005) and psychopathy cure on human patients (Saiiah et al., 2004, 2005) can be implied.

In general accomplished researches were mainly related to the seed components and petals and seed medicinal effects and no considerable study has been performed in order to determine suitable cultivation methods in Iran yet. Principally, the increase of agricultural production is possible through the enhancement of cultivated areas or increase of yield per area unit. As regards that the cultivable areas in Iran is limited, the increase of yield per area unit by the means of revisory methods is the best solution to enhance the ox-tongue production (Alizadeh and Koochaki, 1996). The ox-tongue plant is a row crop (Amin, 1997) so assigning suitable row spaces and planting pattern can influence the increase of yield. Choosing a desirable plant density as for the continental conditions of region cause better gemmule establishment, more effective use of light, nutrients and environmental factors, better competition against weeds and finally more yield increase (Fathi, 1999). In this matter, this study was accomplished for assessing the effects of planting pattern and plant density on yield and yield components of the Iranian ox-tongue in Latmahalleh valage, north of Iran.

MATERIALS AND METHODS

This study was accomplished in Latmahalleh village of Eshkevarat Region located in the northern part of Iran, in the point of 36°50´ N latitude and 50°10´ E longitude in an area in scale of 300 Km^2 and in 2009 to 2010 agricultural years. Average annual precipitation is 662 to 1202 mm; altitude is 1400 to 2000 m, minimal temperature is 5°C and maximum is 35°C. The results of soil experiment indicated that the soil texture is a kind of sandy-clay texture (39% clay, 50% sand and 11% silt). The parameters such as pH, EC and amounts of nitrogen, potassium and phosphorus were experimented and the results are shown in Table 1.

In this study, the experiment was done as a factorial in a completely random blocks plan with three replications. The first factor was planting pattern in two levels (square and rectangular) and the second factor was plant density in four levels (2, 4, 6 and 8 plant per m^2). Thus, four treatments with square shape planting pattern in 35.5 x 35.5, 41 x 41, 50 x 50 and 70 x 70 cm and four treatments with rectangular shape planting pattern in 25 x 50, 27.5 x 60, 35 x 70 and 60 x 80 cm were created. So the plant density was equated in both square shape pattern and rectangular shape pattern.

Farm preparation accomplished in the end of March 2009 then it was created some plots in 3 x 4 m in order to perform design plan. It was specified 70 cm distance between the plots and one meter between the blocks. It was utilized a kind of furrow irrigation system for planting ox-tongue. The planting process started on 5th May of 2009. Used seed was type of native subspecies and it was planted in the depth of 2 to 3 cm of soil level. According to the soil analysis results, the farm was fertilized by amount of 4.5 Kg of 46% triple super phosphate and 4.5 Kg of 50% 2-potassium sulfate used in the form of stripes between planting rows (in 300 m^2). It was also added 3 Kg of 46% urea manure on the planting time and 3 Kg of urea manure in the form of dividing over a period of time after the first weeding (in 300 m^2). Weed control process was implemented in the mechanical way with the aid of hands on 6th June and 6th August of 2009. In order to apply the sampling process properly and deletion of marginal effects, the herbs located in coastal rows and also ones that were in the outset and end of the plots were not identified.

The studied characteristics consist of dried flowers weight per shrub, dried flowers yield per m^2, dried weight a shrub, number of flowers per inflorescence and number of flowers per shrub. The flower harvest process was accomplished on May (2010) in five times, on 13th, 16th, 19th, 22nd and 25th. Number of flowers per inflorescence and number of flowers per shrub were counted and dried weight a shrub and dried flowers yield per m^2 were measured with hundredth accuracy after drying on 35 to 40°C. Five shrubs from every harvest time were selected quite randomly for determining the yield components of every plot. The average weights of five shrubs were counted in every plot and every harvest time. Then, received average was recorded as their yield components (every plot from every harvest term). The yields of all five harvest times were added together for obtaining the yield components of single shrub of every plot in current agricultural season. The yield of dried flowers a shrub multiplied in the number

Table 2. Variance analysis for effects of plant density and plant pattern on yield and yield components of Iranian ox-tongue.

Source of variation	df	Mean squares				
		Dried flowers weight per shrub (g)	Dried flowers yield per m^2 (g)	Dried weight a shrub (g)	Number of flowers per shrub	Number of flowers per inflorescence
Block	2	14.37^{ns}	451.76^{ns}	1530.63^{ns}	3332.16^{ns}	29.62^{ns}
Plant pattern	1	39.52^{ns}	493.13^{ns}	2418.23^{ns}	715.04^{ns}	0.37^{ns}
Plant density	3	206.77^{**}	1256.00^{*}	149281.66^{**}	462545.37^{**}	2061.04^{**}
Reciprocal effect	3	15.25^{ns}	428.27^{ns}	15456.81^{ns}	8387.15^{ns}	51.04^{ns}
Error	14	12.32	352.55	5147.51	23185.92	166.62
C.V (%)		23.61	28.49	13.55	18.85	19.85

^{ns} Non significant, *significant at $p<0.05$ and **significant at $p<0.01$.

of shrubs in different densities for measuring the dried flowers yield per m^2. EXCEL and SPSS (16) softwares were used for the means comparison, drawing the charts and variance analysis (Table 1).

RESULTS AND DISCUSSION

Dried flowers weight per shrub

In this study, results from the variance analysis of the effect of planting pattern on dried flowers weight in a shrub of ox-tongue showed that there was no significant difference ($p>0.05$) between the studied treatments (Table 2). The effect of plant density on dried flowers weight in a shrub of ox-tongue indicated that there was a significant difference ($p<0.01$) between different treatments (Table 2). Data in Table 3 also indicated that maximum average was in density of 2 shrubs per meter square (23.17 g) and the minimum average obtained in 8 shrubs per meter square (9.26 g). In other words, dried flowers weight in a shrub was increased with decreasing the plant density. Similar results were reported by Omidbeygi and Hasani (2007), Behnia (2008), Seghat and Mousavi (2008), Xian-Qing et al. (2009), El-Hendawy et al. (2008), Pryor and Russel (1985). While, this result did not correspond with Francescangeli et al. (2006). Decrease of competition among the bushes and increase of the space allocated to each bush was seemed its reason. Nevertheless, result of variance analysis of interactions between planting pattern and plant density showed that there was no significant difference ($p>0.05$) between different treatments regarding dried flowers weight in a shrub of ox-tongue (Table 2).

Dried flowers yield per m^2

Results of variance analysis presented in Table 2 indicated that there was no significant difference ($p>0.05$) between different treatments regarding the planting pattern effect on dried flowers yield of ox-tongue per m^2. The effect of plant density on dried flowers yield of ox-tongue per m^2 indicated that there was a significant difference ($p<0.05$) between different treatments (Table 2). Mean analogy (Table 3) showed that the maximum average was in density of 6 bushes per m^2 (79.12 g) and the minimum average obtained in density of 2 bushes per m^2 (46.35 g). In other words, dried flowers yield per m^2 discovered increases with the plant density decreases. In general maximum yield of dried flowers of ox-tongue (709.2 kg/ha) was recorded for the density of 6 shrub per m^2 (Figure 1). This result is consistent with Wiley and Heath (1970), But, different results reported by Najafpour et al. (2008), Pezeshkpour et al. (2008), Mohammadi et al. (2009), Sadeghi and Choukan (2008), Akbarinia et al. (2007), Gokmen et al. (2001), Konuskan (2000), Turgut (2000), Sabagh and Razmjoo (2007), Saberali et al. (2007), Yadavi et al. (2006), Yadvi et al. (2007), Tahmasbi and Rashed (2009), Sabeti and Jafarzadeh (2006). The reason of yield increase per m^2 along with plant density decreases can be related to more efficient coverage of bushes and optimum use of environmental factors. Nevertheless, the interactions between planting pattern and plant density indicated that there was no significant difference ($p>0.05$) between different treatments regarding dried flowers yield per m^2 (Table 2).

Dried weight a shrub

Results from the variance analysis in Table 2 indicated that there was no significant difference ($p>0.05$) between treatments of planting pattern regarding dried weight a shrub of ox-tongue. The effect of plant density on dried weight a shrub of ox-tongue indicated that there was a significant difference ($p<0.01$) between different treatments (Table 2). The effect of plant density showed that maximum average of dried weight a shrub ($M=726.07$ g) was in density of 2 bushes per m^2 and the minimum average ($M=377.75$ g) was in density of 8 bushes per m^2 (Table 3). In other words, dried weight a shrub discovered increases with the plant density decreases. The interactions between planting pattern and plant density indicated that there was no significant

Table 3. Mean analogy by Duncan test.

Source	Dried flowers weight per shrub (g)	Dried flowers yield per m^2 (g)	Dried weight a shrub (g)	Number of flowers per shrub	Number of flowers per inflorescence
Plant pattern					
Square	16.69[a]	70.44[a]	519.20[a]	813.00[a]	64.75[a]
Oblong	14.12[a]	61.73[a]	539.27[a]	802.08[a]	65.00[a]
Plant density					
2	23.17[c]	46.35[ab]	726.07[c]	1165.2c	91.00[b]
4	16.00[b]	64.02[ab]	583.78[b]	875.17[b]	64.16[a]
6	13.18[ab]	79.12[b]	429.36[a]	659.67[a]	55.66[a]
8	9.26[a]	74.13[b]	377.75[a]	530.17[a]	48.66[a]
Reciprocal effect					
Square - 2	25.63[d]	51.26[ab]	779.05[e]	1213.00[d]	94.66[c]
Oblong - 2	20.72[cd]	41.53[a]	685.06[de]	1117.30[cd]	87.33[bc]
Square - 4	16.72[bc]	66.88[abc]	556.01[c]	877.00[bc]	64.33[ab]
Oblong - 4	15.29[abc]	61.17[abc]	611.54[cd]	873.33[bc]	64.00[ab]
Square - 6	15.86[bc]	95.20[c]	397/21[ab]	674.33[ab]	54.66[a]
Oblong - 6	10.50[ab]	63.04[abc]	358.30[a]	645.00[ab]	56.66[a]
Square - 8	8.55[a]	68.42[abc]	356.87[a]	487.67[a]	45.33[a]
Oblong - 8	7.98[ab]	79.84[abc]	502.17[bc]	572.67[a]	52.00[a]

Mean for groups in homogeneous subsets are displayed

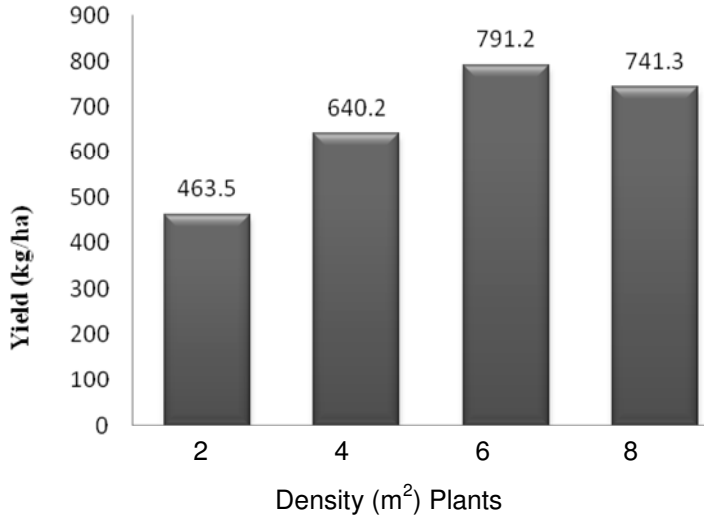

Figure 1. Effect of plant density on dried flowers yield (kg/ha).

difference (p>0.05) between different treatments regarding variable of dried weight a shrub (Table 2).

Number of flowers per shrub

Results of variance analysis presented in Table 2 showed that there was no significant difference (p>0.05) between different treatments regarding effect of planting pattern on number of flowers per shrub. The effect of plant density on number of ox-tongue flowers per shrub indicated that there was a significant difference (p<0.01) between different treatments (Table 2). Data in Table 3 indicated that the maximum average of flowers number per shrub was in

density 2 bushes per m^2 (about 1165) and the minimum average obtained in density of 8 bushes per m^2 (about 530) and whatever the plant density decreases per meter square, number of flowers per bush increases. This result was similar with Omidbeygi and Hasani (2007), Seghat and Mousavi (2008). Decrease of competition among the bushes and increase of the space allocated to bushes seemed its reason. Furthermore, the results of variance analysis of interactions between planting pattern and plant density indicated that there was no significant difference ($p>0.05$) between different treatments regarding number of ox-tongue flowers per shrub (Table 2).

Number of flowers per inflorescence

Results of variance analysis indicated that there was no significant difference ($p>0.05$) between different treatments regarding of planting pattern effect on number of flowers per inflorescence (Table 2). The plant density had a significant effect ($p<0.01$) on the number of flowers per inflorescence (Table 2). Mean analogy by Duncan Test (Table 3) indicated that the maximum average of flowers number per inflorescence was in density of 2 bushes per m^2 (M=91) and the minimum average obtained in density of 8 bushes per m^2 (about 48). Nevertheless, the interactions between planting pattern and plant density showed that there was no significant difference ($p>0.05$) between different treatments regarding number of flowers per inflorescence (Table 2).

Conclusion

In general, the results of this study indicated that density of 6 shrubs per m^2 was the most desirable of density for medicinal plant of Iranian ox-tongue that the maximum yield of dried flowers of ox-tongue was recorded for the density of 6 shrub per m^2 (709.2 kg/ha). Reasons of these results were the decrease in competition among the plants and increase of the space allocated for every plant in comparison with higher densities. It can be said that available resources from soil and the air are not utilized in maximum rate in comparison with lower densities and current resources such nutrition and light have enough potential to feed more plants per m^2. In addition, despite flower yield in square shape planting pattern was more than rectangular shape but the results of variance analysis indicated that there was no significant difference between the square shape and rectangular shape planting pattern. The little difference between the yields of square shape and rectangular shape of planting pattern could be explained that whatever planting pattern changes from rectangular shape to square shape, (1) The plants use available resources (nutrition and light) more efficiently. (2) The plants competition in square shape planting pattern comes later. (3) There will be more spaces for plants during the whole growth period. (4) They will make more yields finally. The results of this study recommended that it would be better to use the square shape planting pattern with six shrubs per m^2 for increasing yield per area unit. Also as regards the hazel is now cultivated in studied region and the spaces between trees are useless, study of effective factors on adoption of the medicinal plants cultivation such “ox-tongue” among mentioned trees and study of accessibility to the best yield of “ox-tongue” between the trees in sequence of that are among researching needs.

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