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An Evaluation of the Effect of Plow and Fertilizer Types on Qualitative and Quantitative Yields of Fennel (Foeniculum Vulgare M)

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ABSTRACT

Conducting proper operation of tillage and fertilizer use is a very important factor in increasing the yield of any plant. In order to evaluate the effect of plow and fertilizer on the qualitative and quantitative yield of fennel (Foeniculum vulgare M), a factorial experiment was conducted in the form of randomized complete block design with three replications in a personal farm located in Bahabad, Iran. The experiment treatments consisted of the plow type in three levels of complete plow with moldboard plow, disk and trowel, plow with at least one disc and no-plow and fertilizer type in four levels of animal (sheep) manure at the rate of 25 tons per hectare, chemical fertilizer at the rate of 48 kg/ha super phosphate triple, 48 kg/ha sulphate potassium and 60 kg/ha Nitrogen fertilizer of urea and mixed fertilizer based on integrating chemical and animal fertilizers at a rate of 25 tons of manure, 48 kg phosphorus, 48 kg potassium and 60 kg N per hectare and without fertilizer (control). The obtained results indicated that the effect of types of fertilizer and plow on the plant yield was significant at 1% level. So that in the plow treatments, the highest seed yield (896.5), weight of thousand seed (3.60), plant height (86.17) and percentage of essence (3.89) were related to the treatment with complete plow, whereas in the fertilizer treatment, the highest seed yield (963.9) weight of thousand seed (3.68), plant height (100.5) and percentage of essence (4.54) were related to mixed fertilizer. The interaction of fertilizer and plow types was significant on plant height, seed yield and percentage of essence at the probability level of 1%, while it had no significant effect on the weight of thousand seeds. In general, it can be stated that the combined use of complete plow and mixed fertilizer systems could have an effective role in the rate of seed yields, plant height, weight of thousand seeds and active ingredients of seed (essence).

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INTRODUCTION

In order to achieve high yield with desirable quality especially about medicinal plants, one of the major needs in agricultural planning is to evaluate different systems of plant nutrition. In addition to maintain the environment, proper method of plant nutrition and also doing proper operation of tillage, the efficiency of inputs can be increased and through avoiding unnecessary and excessive use of nutrients, the production costs can be reduced up to minimum so that it can be a way towards sustainable agriculture (Hesami *et al*, 2005; Rezaei Nejad *et al*, 2000 and Malanaguda, 1995). Regardless of the economic value of medicinal plants, these plants are adaptable to organic cultivation so it leads to the tendency of producers and consumers to such plants. Lack of sufficient knowledge on growing plants, labor costs in traditional harvest and also mechanized facilities can be pointed out as some of the reasons for the scarcity of yield of medicinal plants in the country (Beigi Omid, 1995).

Perennial fennel (Foeniculum Vulgare Mill) is one of the most important and widely used medicinal plants of Apiaceae family that is mainly cultivated for using its essence in various, pharmacy, food and cosmetic industries. In Iran, area under cultivation for this plant was 1,066 acres in 1999. Currently, in most parts of the world such as South and Central Europe, Asian countries (India, Japan and China), many African countries and also Brazil and Argentina, wide agricultural areas are cultivated by Fennel (Darzi *et al*, 2002).

Many studies have been done on the role of the types of used fertilizer and plow in qualitative and quantitative yields of these plants. In order to investigate the effects of treatments of the chemical fertilizer, manure fertilizer and no-fertilizer on the rate of Proline, soluble sugars, quantitative properties and essence of chamomile, Aramzjo *et al* (2010) concluded that using the manure fertilizer causes to increase the yield and component yield in higher rate compared with the other two treatments.

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In another study, Flavand *et al* (2001) investigated the effect of various methods of soil fertility in terms of using chemical, mixed and organic fertilizers on fennel and concluded that mixed fertilizers cause to increase seed and straw yields in fennel and generally, these fertilizers can be considered as a key factor in modifying chemical and physical soil structure.

In order to investigate the effectiveness of plow system in Chamran wheat yield, Hesami *et al* (2005) carried out two levels of conventional and minimum plows and considered the minimum plow system as the most appropriate cultivation system in controlling weeds cropping to achieve more crops.

In another study conducted by Darzi *et al* in 2006, 2007 and 2008, it was determined that the application of biological phosphate fertilizer causes to increase the number of umbels per plant, biological yield and yield of fennel seed compared to no-use of it.

Given the necessity of plant nutrition management to increase and sustain production, the current study aimed to evaluate the effect of plow type and fertilizer use on the yield of fennel plant.

MATERIALS AND METHODS

Methods:

This study was done as a factorial one in the form of completely random blocks design with 7 treatments and 3 replications in a personal farm in Bahabad, Yazd with geographical coordinates of 55° and 36 minutes east longitude and 31° and 33 minutes to 32° and 29 minutes north latitude and height above sea level of 1390 meters in spring in 2010. In the mentioned area, the mean rainfall and temperature are 153.9 mm per year and 17.2°C, respectively. Before planting, several soil samples were taken from the desired farm from the depth of 0-30cm and their physical and chemical properties were determined (Table 1).

Table 1: Results of physical and chemical soil experiments.

Specifications of the Sample	EC (ds/m)	PH	Phosphorus (mg/kg)	Potash (mg/kg)	Plaster (meg/100gr)	Total Nitrogen	Organic Carbon	Lime
Value	2.73	7.55	9.0	207	0	0.042	0.492	49
Specifications of the Sample	Clay	Loam	Sand	Soil texture	Calcium (meg/l)	Mg (meg/l)	Sodium (meg/l)	SAR
Value	16.3	18	65.7	Sandy loam	12	8.4	12.8	4.00

After preparing appropriate culture, blocking and preparing plots, planting fennel seeds was done at the depth of 1 to 1.5cm of soil and after fertilization and covering seeds by soft sand, the land was immediately irrigated and irrigating was also done regularly and once per nine days during the growth period of the fennel.

The tested treatments consisted of the plow type (A) in three levels of complete plow (a1), no-plow (a2) and minimum plow (a3) and fertilizer type (B) including four levels of animal (sheep) manure (b1), mixed fertilizer (b2), chemical fertilizer (b3) and no-fertilizer (b4).

It should be noted that the complete plow (conventional tillage) included moldboard plow, disk and trowel, minimum plow (minimum tillage) included a disk and no-plow (no-tillage) also included no tillage. The manure treatments were based on 25 tons per hectare rotted manure. Their properties are given in table (2). The treatments of chemical fertilizers were in the rate of 48kg/ha super phosphate triple, 48kg/ha potassium sulphate and 6048kg/ha Nitrogen from urea source that one third of Nitrogen fertilizer was mixed with soil within planting (preparing culture), the other one third at the stage of stem elongation in spring and the remaining one third was used as purity fertilizer in the desired parts at seed stage. The treatments of mixed fertilizer were also based on mixing the chemical and decayed manure fertilizers at the rate of 25 ton of decayed manure fertilizer, 48 kg of phosphorus fertilizer, 48 kg potassium fertilizer and60 kg N per hectare.

Table 2: Results of the test of manure (sheep) fertilizer.

Sample	N	P	K	Ca	O.C	Cl	Mg	Fe	Zn	Cu	Mn	C/N	EC	PH
			(%)							mg/kg			ds/m	
Value	4.0	1.2	0.75	3.2	35	1.2	0.2	554	195	25	156.5	18.9	12.5	7.95

Planting seeds was done at late March in plots with dimensions of 6×3.60m and at a depth of 1 to 1.5m of soil and the tested units included 8-line planting at the distance of 45cm and a length of 6m. Distances of subplots were considered as 60cm and distances of blocks 2m from each other that two rows were omitted as a marginal effect (the first and eighth rows) and measurement of plant traits were done on the remaining lines.

To measure the plant height at full flowering stage in each plot, 10 plants were selected and they were measured from the ground to the main umbel and its mean was considered as the plant height. By weighing all seeds produced per plot, the rate of seed yield was measured. Also, to measure the weight of thousand seeds at the stage of maturity, each plot was sampled and the number of thousand seeds was counted by the seed counter and then weighed with an accurate balance. In order to extract its essence and measure its percentage, 100 g fennel seeds was also taken and after powdering, its percentage of essence was calculated through the distillation method with water vapor by Clevenger device,.

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Finally, the obtained data was analyzed using MSTAT-C software and the mean of treatments was compared using Duncan test (DMRT) and the correlation coefficients of traits were obtained using SPSS software.

Findings:

Plant height:

The results obtained from the analysis of variances showed that the plant height at 1% level is influenced by the plow and fertilizer types (Table 3). According to the results of comparing the means, using mixed fertilizer had significantly the highest height (the mean of plant height 100.5cm) and lack of using fertilizer had the lowest height (the mean of plant height 41.29cm). However, the height difference was negligible in the two treatments of chemical fertilizer and lack of use of fertilizer and they had no significant difference with each other (Table 4). Also, minimum height of plant (the mean of plant height 43.24cm) was related to the treatment without plowing and maximum height (the mean of plant height 86.17cm) to the treatment with complete plow (Table 5).

Comparing the interaction means of plow and fertilizer had significant difference at 1% level so that the minimum height of plant was related to the treatment without plow and fertilizer (with the mean plant height of 30.39cm) and the maximum height of plant was related to the treatment with complete plow and mixed fertilizer (with the mean plant height of 127.7cm) (Figure 1).

Weight of thousands seeds:

Results of variance analysis showed that the type of fertilizer and plow had significant effect on the weight of thousand seeds of fennel at 1% statistical level. The lowest weight of thousand seeds was related to the treatment without fertilizer (the weight mean of thousand seeds 2.661g) and the highest weight of thousand seeds was related to the treatment with the mixed fertilizer (the mean weight of thousand seeds 3.677g) (Table 4). Also, minimum weight of thousand seeds was related to the treatment without plow with the weight mean thousand seeds of 2.707g and its maximum weight was related to the treatment with complete plow with the weight mean thousand seeds of 3.592g. There was no significant difference in terms of the interaction of fertilizer and plow on the weight of thousand seeds of fennel at 1% level.

Seed yield:

The fertilizer and plow types had significant effect on seed yield at 1% statistical level (Table 3). Minimum seed yield was related to the treatment without fertilizer (control) (the mean seed yield of 543.7 kg per ha) and maximum seed yield was related to the treatment with the mixed fertilizer (the mean seed yield of 963.9 kg per ha) (Table 4). Also, minimum seed yield was related to the treatment without plow with the mean seed yield of 547.0 kg per ha and maximum seed yield was related to the treatment with complete plow with the mean seed yield of 896.5kg per ha (Table 5).

Results of variance analysis indicated that there is a significant difference between interaction between the fertilizer and plow types on seed yield in fennel at 1% level (Table 3). Thus, minimum seed yield was related to the treatment without plow and fertilizer with the mean seed yield of 464.3 kg per hectare and maximum seed yield was related to the treatment with complete plow and mixed fertilizer with the mean seed yield of 1169.0 kg per hectare. Results of comparing means revealed that there is a significant difference between all treatments in the interaction of the type of plow and fertilizer on seed yield (Table 2).

Table 3: The variance analysis of studied traits of fennel.

Source of changes	df	Plant height	Weight of thousand seeds	Seed yield	Percentage of the essence
Replication	2	0.765^{ns}	0.104^{ns}	9.529^{ns}	0.09^{ns}
Treatment of plow type (a)	2	5554.647**	2.384**	366341.474**	1.72**
Treatment of fertilizer type (b)	3	6972.022**	2.547**	299482.572**	2.54**
Interaction of plow and fertilizer types (ab)	6	674.451**	0.096^{ns}	31691.950**	0.26**
Error of experiment	22	3.495	0.107	16.897	0.08
Coefficient of variations		2.85	10.26	0.57	2.35

ns and **are respectively non-significant and significant at levels of 1% probability

Percentage of the essence:

As it is given in Table 3, the fertilizer and plow types have had a significant effect on the percentage of the essence at 1% statistical level. Accordingly, minimum percentage of essence was related to the treatment

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without fertilizer (control) with the percentage mean of 2.717% and its maximum was related to the treatment with mixed fertilizer with the percentage mean of 4.536% (Table 4).

Also, the minimum percentage of essence was related to the treatment without plow with the percentage mean of the essence of 2.901% and the maximum percentage of essence was related to the treatment with complete plow with the percentage mean of essence of 3.887% (Table 5).

The results of the analysis of variance showed that there is a significant difference between the interaction of the fertilizer and plow types on the percentage of the fennel essence at 1% level (Table 3). So that the minimum percentage of the essence was related to the treatment without plow and fertilizer with the mean percentage essence of 2.310% and its maximum was related to the treatment with complete plow and mixed fertilizer with the percentage mean of essence of 4.913% (Figure 3).

Table 4: Comparing the effect of fertilizer type on the studied properties of fennel.

Treatment of fertilizer type	Plant height	Weight of thousand seeds	Seed yield	Essence of the seed
	(cm)	(gr)	(kg/ha)	(%)
manure	75.28b	3.603a	748.8b	3.626b
Mixed fertilizer	100.5a	3.677a	963.9a	4.536a
Chemical fertilizer	45.10c	2.788b	628.2c	2.817c
Without fertilizer (control)	41.29c	2.661b	543.7d	2.717c

Table 5: Comparing the mean effect of plow type on the studied traits of fennel.

Treatment of the plow type	Plant height	Weight of thousand seed	Seed yield	Essence of the seed
	(cm)	(gr)	(kg/ha)	(%)
Complete plow	86.17a	3.592a	896.5a	3.877a
No plow	43.24c	2.707	547.0c	2.901c
Half plow	67.23b	3.247ab	720.0b	3.483b

Table 6: Correlation coefficients between the studied traits.

Treatment	Plant height	Weight of thousand seed	Seed yield	Essence of the seed
Plant height	1			
Weight of thousand seed	0.947**	1		
Seed yield	0.966**	0.909**	1	
Percentage of the essence	0.928**	0.940**	0.899**	1

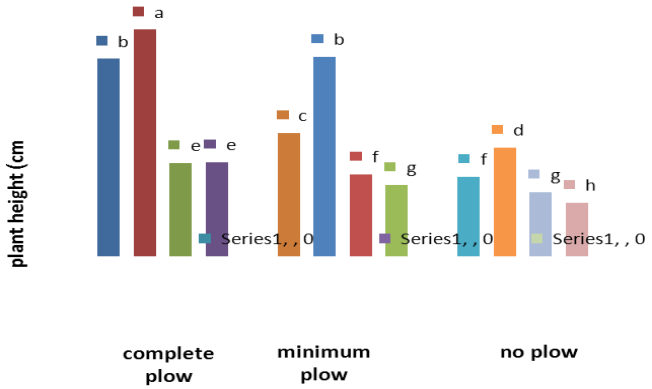

Fig. 1: Comparing the mean interactions of the fertilizer and plow types on the fennel height.

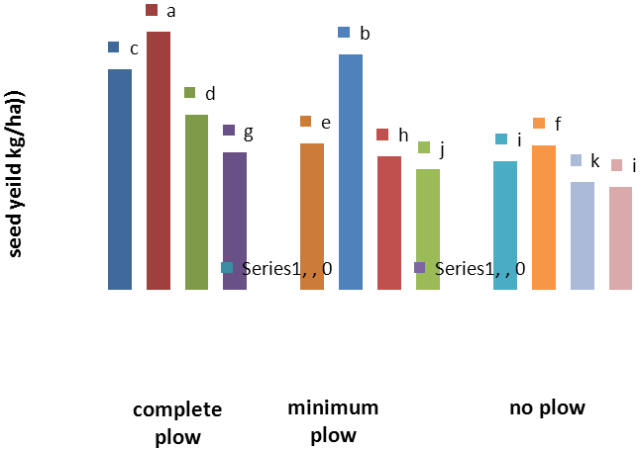

Fig. 2: Comparing the mean interactions of the fertilizer and plow types on seed yield in fennel.

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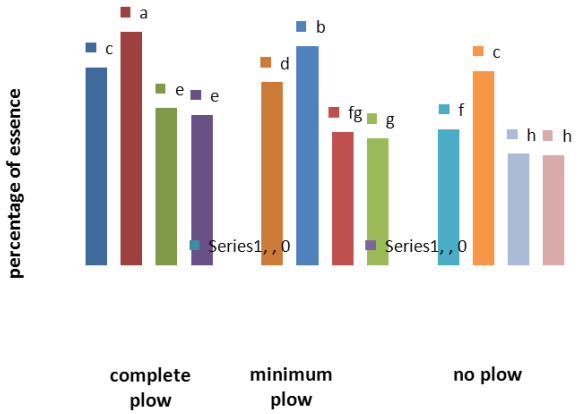

Fig. 3: Comparing the mean interactions of the fertilizer and plow types on the percentage of the essence of fennel.

Discussion:

Given that in terms of the mean elements (NPK), the initial soil is able to supply the plant need in low yields, adding these elements as fertilizer at the mode of complete plow could not have a significant effect on plant height. Although in the mode of minimum and without plows, the effect was significant, it is not comparable with other treatments. Complete plow caused soil conditioner to be better (Gajeri *et al* 1997) and also more depth of soil become naturally available and the plant can supply its basic needs. The study results conducted by Mohammadi *et al* (2009) based on the positive effect of complete plow on increasing the height of wheat plant confirms this issue. Then, by the use of manure, the physical condition of soil was improved and increasing maintaining water in soil and micronutrients cause to highly increase plant height and biomass. As a result of this increase, the plant need to macronutrients (NPK) also naturally increases. Since soil is naturally failed to satisfy this requirement, along with improving the physical properties of soil, the combined use of manure and chemical fertilizers causes to increase production via efficient use of water and nutrients (Bhattacharya, 2008) and as a result, it can have more impact compared with the use of each lonely (Brsz *et al*, 2005; Mentmoro, 2009). The result of the study by Malanagod (1995) who investigated the effect of fertilizer treatments on cilantro, expresses the same issue too. On the effect of mixed fertilizers on seed yield, it can also be stated that this relationship is through increasing photosynthesis in plants (Rezaei Nejad and Afuoni, 2000). In this regard, Akbarinia *et al* (2003) also obtained similar results. Given that the soil texture is relatively light, while using the chemical fertilizers, the possibility of leaching nitrate ions from fertilizer source is more and will be out of reach of the plant. Thus, the plant need is not fully supplied (Malakoti, 1996; Sharifi Ashorabadi, 1999). If the presence of organic matter and micronutrients in manure is effective on improving the physicochemical properties and fertility of soil, then leaching becomes less. Therefore, within the growing period, through gradual liberalization of nutrient elements, the nitrogen concentration increases and becomes more in the treatments with manure fertilizer and then, mixed fertilizer. The positive impact of organic fertilizers on improving the quality of chemical plants has also been reported by (Blaga *et al*, 1989; Burin and Sartori, 1989 and Malangoda, 1995). Also, since plow causes to increase the soil conditioner, it can have a positive impact on seed germination. In mixed fertilizers, because phosphorus is considered as a vital element in germination and also, organic materials provide necessary heat for germination, this type of fertilizers can have an important role in seed germination.

Conclusion:

This research is shown that using the system of complete plow and mixed fertilizer can have an effective role at the rate of seed yields, the plant height, weight of thousand seeds and seed ingredients (essence).

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