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Research Paper

Assessment on adaptation of some selected medicinal and aromatic plants to the northern parts of Turkey: Agricultural and chemical property based evaluation

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Abstract. Studies concerned with adaptation and cultivation of the medicine and economy-based plants consumed in all countries must be conducted in order to determine the appropriate plant species demonstrating higher yield and producing potent metabolite in harmony with agro-ecological conditions of the region. In this context, an adaptation study was carried out to investigate the agricultural and oil yield performance of some medicinally and economically important plants in the northern parts of Turkey. The trials were laid out in the randomized complete block design with three replicates. Plant height (cm), branch number per plant, capsule number per plant, number of umbrella per plant, biological yield (kg/da), seed yield (kg/da), harvest index (%), fixed oil ratio (%), essential oil ratio (%) were examined for each plant. As a result, yield for each plant was as follows: *Nigella sativa* (96.6 kg/da), *Coriandrum sativum* (100.35 kg/da), *Foeniculum vulgare* (77.26 kg/da), *Anethum graveolens* (93.55 kg/da) and *Trigonella foenum-graecum* (93.5 kg/da).

Keywords: Medicinal and aromatic plants, adaptation, yield, quality

INTRODUCTION

Medicinal and aromatic plants (MAPs) are of interest for human uses from the prehistoric times to the present day. Importance and demand for medicinal and aromatic plants are associated with plant-based drugs, health products, pharmaceuticals, food additives, cosmetics in addition to the economic value chain for developing countries. Priority in selection of some elite plants has gained importance with respect to the conservation, cultivation, processing, and standardization concerned with the chemical constituents extracted from the plants collected from wild and cultivated ones; since the activity-induction of MAPs are directly associated with the standard content of potent metabolites. There is no homogeneity in potent metabolite in MAPs, which results from noticeable impacts of climatic, ecological and other concerned phenomena. For this reason, in many parts of Anatolia (Turkey), there have been many attempts in relation to the evaluation, cultivation, conservation and adaptation of medicinally and economically useful plants within traditional cultivation systems. However, a few plants from MAPs are cultivated and the production of these plants is usually carried out in western and central Anatolia. Especially, cumin, dill, coriander, anise, fennel and black cumin stand out for agricultural activities. Export values were estimated for black cumin (32 t), fenugreek (195 t), fennel (1994 t), and coriander (1 t) (Anonymous, 2014). Fennel (*Foeniculum vulgare* (Apiaceae)) is a Mediterranean medicinal and aromatic plant, of which fruits are used in the treatment of digestive disorders in addition to the bitter fennel usages as food flavor, in liqueurs and in the perfumery industry (Tanira et al., 1996). Anti-inflammatory, antispasmodic, carminative, diuretic, expectorant, laxative, analgesic and stimulant of gastrointestinal mobility potential of fennel

extracts have been reported in addition to the uses in treatment for nervous disturbances (Choi and Hwang, 2004). Moreover, essential oil was proven to have potent showed antioxidant, antimicrobial, and hepatoprotective activity (Ruberto et al., 2000). *Anethum graveolens* L. (dill) (Apiaceae) seeds have medicinal and aromatic values with respect to the antimicrobial, antispasmodic, antidiabetic, antihypercholesteromic, and anti-inflammatory activities and flavour to cakes and pastries, soups, salads, potatoes, meats, and pickles (Orhan et al., 2013). *Nigella sativa* (black cumin) (Ranunculaceae) seeds are great of interest and importance in relation to the role in human nutrition and health. Essential fatty acids, glycolipids, phospholipids, and bioactive phytosterols are important metabolites of the black cumin crude fixed seed oil (Ramadan, 2007 and Ramadan and Wahdan, 2012) in addition to antitumor activity, antioxidant activity, anti-inflammatory activity, antibacterial activity and a stimulatory effect on the immune system. *Coriandrum sativum* L. (Apiaceae) has been proven to possess role and activities concerned with the treatment of cough, dysentery, sore throat, convulsion, insomnia and anxiety (Grieve, 1971). *Trigonella foenum-graecum* L. (Fabaceae) seeds known as fenugreek, has also been reported to possess antioxidant, hypocholesterolaemic activity and anti-cataract activity in alloxan diabetic rats (Hadriche et al., 2010; Vats et al., 2004).

Tea cultivation is the primary economical way in the current research area, where 90% of local inhabitants deals with tea cultivation, which consequently causes monoculture farming in the region. However, the cultivation is not implemented within the planned appropriate agricultural techniques with respect to the soil type and fertilization based applications. The inappropriate practices in the region causes degradation soil and consequently decrease the total yield or production of tea per unit area year by year. Hence, local farmers should be advised and encouraged to attempt new crop pattern cultivation in order to prevent soil degradation and monoculture farming. Studies concerned with adaptation and cultivation of the medicine and economy-based plants consumed in all countries must be conducted in order to determine the appropriate plant species demonstrating higher yield and producing potent metabolite in harmony with agro-ecological conditions of the region. Hence, the current study deals with increasing or ascertain the plants which have a great market demand as an alternative or supportive crop, in addition to the contribute to the crop diversity, for traditional tea production, of which total yield and economic interest have decreased. Within the frame of this study, black cumin, dill, fenugreek, coriander, and fennel were under research to determine agricultural properties and herein, it was targeted to determine promising plants suitable to agro-ecological conditions to the region with respect to the yield and standard quality.

MATERIALS AND METHODS

Research material

Experimental materials were provided from different research institutions in Turkey. Then, they were sown in violas under greenhouse conditions on 24.03.2010 and 18.03.2011 for both experimental years, respectively. First seedling emerged in fenugreek in the following 3rd and 5th days. The other plants germinated after one week or ten days. They were regularly and daily irrigated.

Properties of experimental soil

Testing was prepared in 3 replications such that inter row was 30 cm and above row was 10 cm according to the testing design of the randomized blocks, and conducted in the research and practice area of the Rize-Pazar Vocational School. Seedlings were transplanted to the experimental soil on 11/05/2010 and 05/20/2011. The soils of the experiment area had a the texture of sandy clay loam, and was acidic at medium range (pH = 5.2), had poor amounts of lime (2.02%), medium amounts of nitrogen (0.14%), medium amounts of salt (0.56%), medium amounts of phosphorus coverage (1.86 ppm), rich in potassium (250 ppm), and low amounts of organic material (1.25%). The experiment area in the vegetation period (May-August) between 2010 and 2011 had an average temperature as 23.4°C, 22.8°C, respectively, total rainfall amount was 680.9 and 518.3 mm, respectively, and the average humidity amount was 71.2 and 73.5%, respectively (Anonymous, 2012).

The required amount of nitrogen fertilizer was applied to the experimental plots according to soil analysis. 4 kg/da DAP (18 46 0) was applied for bottom fertilizer every two years. For upper fertilizer, 8 kg/da CAN (26% N) was totally performed twice during the dates 27.05/15.06.2010 and 27.05/20.06.2011 for both experimental years. Then, harvests were made on 16.07.2010 and 29.07.2011.

Essential oil isolation

After each harvest, above ground parts were dried at 35°C and essential oils from aerial parts after each harvest were extracted using 30 g of dried material, a 1000 ml round-bottomed flask by hydro distillation (4 h) with Neo-Clevenger apparatus.

Crude oil isolation

Seed yield was calculated on the basis of 91% dry matter. The content of oil was determined using the Soxhalet method: the seed samples were finely ground in

Table 1. Changes in agricultural and chemical properties of black cumin in two-experimental years.

Agricultural and chemical properties	Experimental years		
	2010	2011	Mean
Plant height (cm)	48.4	58.4	53.4
Branch number per plant	4.1	4.3	4.2
Capsule number per plant	4.9[b]	5.9[a]	5.4
Seed number in capsule per plant	63.8	68.0	65.9
1000-seed weight (g)	1.9	2.4	2.2
Yield (kg/da	94.6	98.6	96.6
Biological Yield (kg/da)	282.3	311.9	297.1
Harvest Index (%)	27.9	29.0	28.5
Essential oil (%)	0.2	0.1	0.17
Fixed oil (%)	28.1	29.3	28.7

LSD (%5): Plant height**:**12.46; Branch number: 26.46; Capsule number: 0.76; Seed number in capsule: 28.69; 1000-seed weight: 9.96; Yield: 6.99; Biological Yield: 5.03; Harvest Index: 4.23; Essential oil: 70.98; Fixed oil: 10.25.
Means in the same column by the same letter are not significantly different to the test of Duncan (α = 0.05).

a coffee grinder (manufactured by Bran) and extracted with *n*-hexane with in a Soxhalet apparatus for 8 h at a constant temperature of 80°C (James, 1995).

Statistical analysis

The experiments were arranged as a split plot design with three replications. MSTAT-C statistical program was used to determine statistical significance levels and the differences between individual averages were considered to be statistically important at $p < 0.05$.

RESULTS AND DISCUSSION

In the current study, black cumin, dill, fenugreek, coriander, and fennel were under research to determine agricultural properties and herein, it was targeted to determine promising plants suitable to agro-ecological conditions to the region with respect to the yield and standard quality. In this context, the plants were separately evaluated.

Black cumin (*Nigella sativa* L.)

Black cumin is used as a spice in Indian and Middle Eastern cuisine (Sharma et al., 2009). Multi-year-trials did not elicit any statistically significant changes in relation to the yield and quality properties except capsule number but they reached the highest values in 2011 (Table 1). Seed yield (96.6 kg/da), fixed oil (28.7%) and essential oil content (0.2%) are determined in terms of average values obtained from both experimental years. In the study conducted in Şanlıurfa (Turkey), seed yield (140.63 to 248.23 kg/da), seed number per plant (53.07 to 89.40), essential oil content (0.24 to 0.43%), 1000-seed weight (2.07 to 2.40 g), branch number per plant (2.30 to 4.43), capsule number per plant (2.27 to 15.97) and plant height (69.07 to 88.50 cm) were reported by Özel et al. (2008). Fixed oil (35 to 38%), essential oil content (0.3 to 0.6 %) in seeds, seed yield (75 to 150 kg/da) in Isparta were disseminated by Baydar (2007). The current results comply with previous reports.

Fenugreek (*Trigonella foenum-graecum* L.)

There were no statistically significant differences concerned with experimental year's interaction with agronomical properties but highest values were determined in 2011. Herein, yield **(**93.5 kg/da), legume number per plant (8.9), 1000-seed weight (17.85 g) and fixed oil content (4.24 %) were mean valued for both experimental years. Plant height (107.3 cm), branch number per plant (5.44), seed number in legume (14.76), 1000-seed weight (18.03 g) and seed yield (121.65 kg/da) were determined by Ayanoğlu and Mert (1999). Yılmaz and Telci (1999) cultivated fenugreek in winter and summer periods and plant height (53.4 to 47.8 cm), branch number (3.0 to 2.0), legume number (12.2 to 7.3), seed number in legume (10.4 to 2.8), 1000-seed weight (17.60 to 16.65 g) and seed yield (128.60 to 19.69 kg/da) were disseminated parameters for winter and summer, respectively. The highest seed yield (355.0 to 366.0 kg/da) were determined under different sowing time and row spacing by Tokbay and Arabacı (2011). The highest biological yield (340.0 kg/da), plant height (38.3 cm), legume number (6.5), seed yield (82.0 kg/da) were reported

Table 2. Changes in agricultural and chemical properties of fenugreek in two-experimental years

Agricultural an chemical properties	Experimental years		
	2010	2011	Mean
Plant height (cm)	33.0	34.68	33.84
Branch number per plant	2.6	2.8	2.7
Legume number per plant	8.6	9.3	8.9
Seed number in legume per plant	11.3	12.8	12.05
1000-seed weight (g)	17.2	18.5	17.85
Yield (kg/da)	93.4	93.6	93.5
Biological yield (kg/da)	294.7	308.3	301.5
Harvest index (%)	26.37	29.13	27.75
Fixed oil (%)	4.23	4.27	4.24

LSD (5%): Plant height: 3.31; Branch number: 25.86; Legume number: 15.30; Seed number in legume: 11.76; 1000-seed weight: 14.07; Yield: 19.21; Biological Yield: 8.46; Harvest Index: 0.73; Fixed oil: 35.07.
Means in the same column by the same letter are not significantly different to the test of Duncan (α = 0.05).

when exposed to the sewage sludge application (6 t /da) by Tunçtürk et al.(2011 b). The average biological yields were reported as 399.3 to 741.8 kg/da by Özdemir (1999), and 236.72 to 472.03 kg/da by Başbağ and Tonçer (2005). The average plant height (48.22 to 50.96 cm), number of fruit (11.28 to 16.08 each), in fruit seed number (9.58 to 10.26), number of branches (2.8 to 3.23 each), thousand seed weight of 19.71 to 10.20 g, biological yield 638.28 to 729.30 kg/da, seed yield 176.03 to 194.30 kg/da and harvest index showed variation between 26.32 and 28.48% were reported when exposed to the applied fertilizer doses (0, 3, 6, 9 and 12 kg/da) by Beyzi (2011)

Fixed oil content (6.22 to 6.42%) under Tekirdağ ecological conditions were reported by Yaver et al. (2011). There are similar or different results with previously reported studies, which may be attributed to ecological conditions and cultivation systems or techniques. (Table 2).

Coriander (*Coriandrum sativum* L.)

Seed yield was higher in the second experimental year than first one but essential oil and fixed oil content were higher in first experimental year than the second one. In the previous reports, plant height was 48.5 to 73.2 cm (Kaya et al., 2000), 40.8 to 58.5 cm (Kan and İpek, 2004) and 41.24 to 47.22 cm (Pehluvan et al., 2007) and the current study is an agreement with the literatures given concerned with plant height. Similarly, the present results in relation to the branch number per plant comply with 4.5 to 6.2 (Kaya et al., 2000), 3.8 to 5.8 (Kan and İpek, 2004), 5.67 (İnan et al., 2007), and 6.20 to 7.73 (Tonçer, 2007). Number of umbrellas (35.13) herein did not comply with 11.4 to 13.6 (Kan and İpek, 2004), and 4.7 to 7.9 (Kaya et al., 2000) but it coincided with 35.13 (İnan et al., 2007). Biological yield was 265.2 to 400.7 kg/da (Gümüşçü et al., 2007), 228.3 to 348.3 kg/da (Kaya et al., 2000), 207.8 to 447.3 kg/da (Arabacı and Bayram, 2005) and the current study is in agreement with the literatures with regards to plant height. Seed yield coincided with 7.46 to 7.66 g (Kaya et al., 2000), 5.59 g (İnan et al., 2007), and 13.59 to 14.48 g (Tonçer, 2007) and yield values were in parallel with 86.6 to 124.3 kg/da (Kan and İpek, 2004), 90.57 to 112.42 kg/da (Avcı et al. 2005), 67.8 to 91.1 kg/da (Kaya et al., 2000), and 79.51 to 107.16 kg/da (Pehluvan et al., 2007) but yield values were higher in the studies by 142.0 to 171.2 kg/da (Kırıcı et al., 1997), 179.39 kg/da (İnan et al., 2007) and 237.36-249.43 kg/da (Tonçer, 2007). (Table 3).

Fennel (*Foeniculum vulgare* L.)

Changes in plant height in relation to the both experimental years were statistically significant but other tested parameters were not important. Seed yield was 72.50 to 129.60 kg/da (Coşge et al., 2007), 89.5 to 266.8 kg/da (Arabacı and Bayram, 2005), 56.97 to 167.05 kg/da (Kızıl et al., 2001), and 39.2 to 67.1 kg/da (Avcı and Amir Nia, 2007) 47.4 to 73.3 kg/da (Tunçtürk and Çiftçi, 2011) in the previous reports. In the present study, seed yield was 74.63 to 79.88 kg/da, of which value was lower than the study proposed by Arabacı and Bayram (2005) but the current result complied with the other results. Essential oil content was 1.513 to 1.694 % (Arabacı and Bayram, 2005), 2.08 to 2.45% (Avcı and Amir Nia, 2007), 1.750 to 2.512% (Çoşge et al., 2007), and 1.87 to 2.17% (Kızıl et al., 2001). Fennels that originated from Denizli had 2.32% and Hatay-originated fennels had 2.43% essential oil (Karaca and Kevseroğlu, 1999). Essential oil

Table 3. Changes in agricultural and chemical properties of coriander in two-experimental years.

Agricultural and chemical properties	Experimental years		
	2010	2011	Mean
Plant height (cm)	37.97[b]	64.67[a]	51.32
Branch number per plant	4.67	7.67	6.17
Umbrella number per plant	7.73	8.57	8.15
Seed number in umbrella per plant	34.5	37.2	35.9
1000-seed weight (g)	8.63[b]	11.37[a]	10.0
Yield (kg/da)	97.57	103.13	100.35
Biological Yield (kg/da)	296.4	317.4	306.88
Harvest Index (%)	30.5	31.47	31.0
Essential oil (%)	1.13	0.87	1.0
Fixed oil (%)	1.27[a]	1.17[b]	1.22

LSD (5%): Plant height: 4.30; Branch number : 21.88; Umbrella number: 11.65; Seed number in umbrella: 4.84; 1000-seed weight: 8.44; Yield: 7.84; Biological Yield: 10.83; Harvest Index: 14.81; Essential oil: 31.89; Fixed oil: 0.0.
Means in the same column by the same letter are not significantly different to the test of Duncan (α = 0.05).

Table 4. Changes in agricultural and chemical properties of fennel in two-experimental years.

Agricultural and chemical properties	Experimental years		
	2010	2011	Mean
Plant height (cm)	45.1[b]	53.1[a]	49.1
Branch number per plant	6.5	8.0	7.3
Umbrella number per plant	6.7	7.1	6.9
Seed number in umbrella per plant	46.7	55.0	50.8
1000-seed weight (g)	6.8	7.2	6.9
Yield (kg/da)	74.6	79.9	77.3
Biological yield (kg/da)	463.9	530.4	497.2
Harvest index (%)	20.8	22.7	21.7
Essential oil (%)	2.9	2.0	2.4
Fixed oil (%)	5.8	5.8	5.8

LSD (5%): Plant height:4.30; Branch number: 4.50; Umbrella number: 9.98; Seed number in umbrella: 12.01; 1000-seed weight: 7.32; Yield: 26.21; Biological Yield: 5.19; Harvest Index: 17.15; Essential oil: 14.75; Fixed oil: 25.54
Means in the same column by the same letter are not significantly different to the test of Duncan (α = 0.05).

in fennels in base conditions was 2.6% and in arid conditions was 1.54% (Oğuz, 2000). Mimica-Dukic et al. (2003) reported the content of the essential oils obtained from fennel seeds by steam distillation was in the range of 1.82 to 3.38%. Maximum extract yield was ascertained with methanol 19.6% and minimum with hexane 5.6%. The essential oil yield in the current study coincided with the previous reports. (Table 4).

Dill (*Anethum graveolens L*)

There were no-statistically significant changes in dill with respect to the agricultural and chemical parameters but the highest values in parameters were determined in the second experimental year. Essential oil content (2 to 4%), plant height (118.0 cm), number of umbrella per plant (27.0), branch number per plant (5.6), and seed yield (91.9 kg/da) were reported by Randhawa et al. (1996). Plant height (120 cm), seed essential oil content (2.5 to 4%), 1000-seed weight (0.98 to 2.07 g), and seed yield (60 to 120 kg/da) were proposed by Ceylan (1997). Seed yield (149 to 174 kg/da), and 1000-seed weight (1.41 to 1.46 g) were reported in the study by Wander and Bouwmeester (1998). The presented results (Table 5) are in good agreement with the previous researches.

Table 5. Changes in agricultural and chemical properties of dill in two-experimental years.

Agricultural and chemical properties	Experimental years		
	2010	2011	Mean
Plant height (cm)	77.6	85.40	81.49
Branch number per plant	5.4	6.4	5.9
Umbrella number per plant	25.2	28.43	26.82
Seed number in umbrella per plant	180.7	260.4	220.55
1000-seed weight (g)	1.07	1.17	1.12
Yield (kg/da)	81.23	105.87	93.55
Biological yield (kg/da)	851	1037.37	944.18
Harvest index (%)	25.57	30.10	27.84
Essential oil (%)	3.67	3.3	3.49
Fixed oil (%)	0.73	0.60	0.67

LSD (5%): Plant height:14.86; Branch number: 12.16; Umbrella number: 10.82; Seed number in umbrella:32.21; 1000-seed weight: 27.60; Yield: 13.46; Biological Yield: 22.59; Harvest Index: 17.15; Essential oil: 5.11; Fixed oil: 16.20
Means in the same column by the same letter are not significantly different to the test of Duncan (α = 0.05).

CONCLUSION

We can deduce that fennel, coriander, black cumin, fenugreek and dill can be conveniently grown under ecological conditions of Rize province. The two-year study results herein comply with the previous reports in comparison with respect to the yield and quality parameters. Those medicinally and economically important plants can be cultivated in the region.

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