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YIELDS AND QUALITY PERFORMANCES OF CORIANDER (*Coriandrum sativum* L.) GENOTYPES UNDER DIFFERENT ECOLOGICAL CONDITIONS

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ABSTRACT

The experiments were conducted in two successive vegetation seasons of 2013 and 2014 at the Isparta and Eskişehir ecological conditions. The aim of this study was to determine the performance and stability of coriander genotypes for yield and yield components and essential oil content. In the study, Gamze, Kudret, Erbaa, Arslan and Pel-mus coriander cultivars and Burdur, Antalya and Tokat genotypes were evaluated growing seasons of 2013 and 2014 under the Isparta and Eskisehir ecological conditions in Turkey. Years and locations with different climatic and geographic characters had significant effects in coriander genotypes for yield, yield components and essential oil content. Increase in seed yield and decrease in essential oil content occurred with increasing rainfall. Results revealed that Arslan cultivar in Eskişehir location and Kudret in Isparta location had the highest seed yield. Besides Kudret cultivar and Gamze cultivar gave the highest seed yield as a means of locations; Eskisehir location had also higher seed yield.

Keywords: Coriander (*Coriandrum sativum* L.), essential oil content, genotypes, seed yield, stability, yield components.

INTRODUCTION

As an annual herbaceous crop, and belonging to the *Apiaceae* (*Umbellifera*) family, coriander (*Coriandrum sativum* L.) is known to be native plant of Mediterranean region, Western Europe and Asia (Jarcau, 2013; Dyulgerov and Dyulgerov, 2013; Ghamarnia and Daichin, 2013; Moniruzzaman et al., 2014 and Meena et al., 2014). The leaves as culinary herb and fruits as spice have been used in the various regions of the world for a long time (Yousuf et al., 2014; Ghamarnia and Daichin, 2013; Meena et al., 2014; Jarcau, 2013; Moniruzzaman et al., 2014 and Dyulgerov and Dyulgerov, 2013). Coriander seed rich in volatile oil is used as a spice and folk remedy, and essential oil derived from seeds is also used in perfumery, food, tobacco, soft and alcoholic beverage, and pharmaceutical industries and this could be answer why coriander seeds are an important ingredient of curry powder widely used in world cuisines (Şarer, 2004; Dyulgerov and Dyulgerov, 2013; Moniruzzaman et al., 2014 and Yousuf et al., 2014). Moreover, studies reported that seed and essential oil of coriander have anti-diabetic, laxative, carminative, diuretic, tonic, hypolipidemic, anti-cancer etc. effects (Ghamarnia and Daichin, 2013, Inan et al., 2014 and Hani et al., 2015).

Yield and quality characters of genotype are commonly under effect of genetic makeup, environmental condition and agronomical practices (Sifola and Barbieri, 2006, Gharıb et al., 2008 and Hadian et al., 2010). Seed yield of coriander changed almost from 0,90 t ha^{-1} to 2,1 t ha^{-1} (Kizil, 2002; Kaya et al., 2000 and Inan et al., 2014). Differences of these values may be attributed to genotype × environment interactions (Kaya et al., 2000 and Inan et al., 2014). Meanwhile, seed yield is mostly under effect of some yield components (plant height, number of branches, number of umbrella per plant and 1000 seed weight and essential oil content), appearing essential determiners for breeding programs (Gharib et al., 2008; Hadian et al., 2010 and Inan et al., 2014). The aim of this study was to determine the performance and stability of coriander genotypes for yield and yield components and essential oil content.

MATERIALS AND METHODS

The trails were carried out during two successive growing seasons of 2013 and 2014 under the Isparta and Eskişehir ecological conditions in Turkey. The province of Isparta located in the transition region in the inner part of the western Mediterranean region in between the Mediterranean Sea and the Central Anatolia Region bear the climate features (average annual rainfall is 524.0 mm) of both of the regions with 1050 meters altitude.

The province of Eskisehir located in Aegean, Marmara and Central Anatolia Region with 788 meters altitude has semi-arid (average annual rainfall is 349.8 mm) and cool continental climate. Winter months are frosty and summer months are hot and the nights are cool. There are big differences between day and night temperatures. Five different coriander cultivars (Arslan, Erbaa, Gamze, Kudret-K and Pel-Mus) and three different genotypes (Burdur, Antalya and Tokat) were used in the study. Climatic data for the two successive growing seasons and long years of locations are given in Table 1. During the growing seasons (from March to end of August) in 2013, 2014 and in long years; total precipitation of 289.5, 284.2 and 207.8 mm, average temperature of 20.6, 19.7 and 19.7 ºC and an average humidity of 61.0, 66.1 and 63.8% were recorded in Isparta. Besides, total precipitations were 142.9, 133.6 and 156.7 mm, average temperatures were 16.7, 16.6 and 15.4 ºC, average humidity values were 55.6, 61.8 and 57.9% in 2013, 2014 and long years (from March to end of August) of Eskisehir. Soil at a depth of 60 cm was sampled before the experiment and subjected to a physicochemical analysis. Data for the years and locations are indicated in Table 2.

Table 1. Meteorological data of the experiment locations*

Isparta								
Climatic factors	**Years**	**Months**						**Total or Average**
		March	**April**	**May**	**June**	**July**	**August**	
Precipitation (mm)	2013	25.1	59.9	66.5	34.4	68.2	15.4	289.5
	2014	78.6	44.8	107.0	42.8	20.8	10.2	284.2
	Long Years	52.8	56.6	50.8	28.4	18.4	0.8	207.8
Average Temperature (˚C)	2013	7.2	11.9	17.1	20.5	23.0	23.7	20.6
	2014	7.2	11.0	14.5	19.1	23.7	23.2	19.7
	Long Years	5.9	10.8	15.6	20.1	22.3	23.9	19.7
Relative humidity (%)	2013	60.0	58.0	52.0	50.0	44.0	41.0	61.0
	2014	63.7	60.4	62.4	52.7	45.3	45.9	66.1
	Long Years	61.3	64.2	50.3	53.0	45.8	44.5	63.8
Eskişehir								
Climatic factors	**Years**	**Months**						**Total or Average**
		March	**April**	**May**	**June**	**July**	**August**	
Precipitation (mm)	2013	45.1	35.9	23.5	36.3	2.1	0.0	142.9
	2014	23.1	15.2	27.2	60.6	7.5	0.0	133.6
	Long Years	27.6	43.1	40.0	23.7	13.1	9.2	156.7
Average Temperature (˚C)	2013	7.1	10.8	18.2	20.0	21.6	22.4	16.7
	2014	6.5	11.3	16.4	19.9	23.7	21.9	16.6
	Long Years	4.9	9.6	14.9	19.1	22.1	21.8	15.4
Relative humidity (%)	2013	59.8	63.2	51.5	53.9	51.9	53.1	55.6
	2014	69.0	63.7	63.3	64.1	57.8	52.8	61.8
	Long Years	64.2	62.7	59.5	55.2	51.9	53.6	57.9

*Data were taken from Isparta and Eskisehir Regional Meteorological Service

Table 2. Physical and chemical characteristics of soil in experiment locations

Years	**Structure**	**Lime (%)**	**Available Phosphorus (P_2O_5) (kg ha^{-1})**	**Available Potassium (K_2O) (kg ha^{-1})**	**pH**	**Organic Matter (%)**
Isparta						
2013	**Clay-Loam**	10.79	9.61	705	8.1	1.69
2014	**Clay-Loam**	9.62	9.00	650	7.9	1.38
Eskişehir						
2013	**Clay-Loam**	8.,57	8.95	1290	7.71	1.58
2014	**Clay-Loam**	7.13	6.69	1050	8.0	1.43

The experimental plots were plowed, cultivated and then prepared for planting with a single pass of a disk-harrow. The experiments were arranged according to a randomized complete-block design with three replicates. Seeds were sown by hand in the first week of March in the sowing rate of 40 seeds m^{-2} in both the experimental years in Isparta location and were sown in the second week of March in both the experimental years in Eskisehir location. The distance between rows was 25 cm and within the rows were 10 cm. Each plot area was 7.5 m^2 (5 m x 1.5 m) and consisted of 6 rows. Seeds were sown at 2-3 cm depths by hand. Nitrogen and phosphorus fertilizers were applied at the rate of 60 kg ha^{-1} and 30 kg ha^{-1} in the form of ammonium sulphate and P_2O_5, respectively (Kizil, 2002). One-half of nitrogenous fertilizer was applied as base fertilizer at the time of sowing and the rest one-half at plant height when 10-15 cm. Phosphorus fertilizer was applied as basal fertilizer at the time of sowing. In both years and locations, the experiments were non-irrigated at any growing stage.

All the necessary cultural practices were similarly applied to the plots during the two growing seasons in both locations. When the seeds ripen, plants from 4 rows in the center of each plot were harvested manually. Seed yield (t ha^{-1}) and its components including plant height (cm), number of branches per plant (branches $plant^{-1}$), number of umbrella per plant (umbrella $plant^{-1}$) and 1000 seed weight (g) were determined. To determine the seed essential oil content, 100 g powdered coriander seed samples in 0.5 L water from each population and cultivar were extracted by hydro-distillation for 3 hours using Clevenger apparatus according to the standard procedure described in European Pharmacopoeia (Stainier, 1975) for determining the oil content (v/w, %). All the data were subjected to variance analysis (ANOVA) by using SAS Statistical Package Program, the significant differences between the group means were separated using the LSD (Least Significant Difference) test (Duzgunes et al., 1987). Stability analyses (genotypes × environment interaction) for seed yield and yield components and essential oil content based on two locations (Isparta and Eskisehir) over two years were performed as suggested by Finlay and Winkinson (1963), Eberhart and Russel (1966).

RESULTS AND DISCUSSION

Having different flavors, almost all parts of coriander plant is used for its leaves, stems and seeds. Particularly seeds are consumed; rapid tasteless flavors give when it is green and fresh. It turns spicy flavored style when dried and get a pale brown seed. Coriander has a lot of health benefits comprising treatment of skin inflammation, high cholesterol levels, diarrhea, mouth ulcers, anemia, indigestion, menstrual disorders etc. (Carubba et al., 2002; Islam et al., 2004 and Singh et al., 2006). The main objective of coriander breeding programs is to introduce promising genotypes having greater yielding ability and stability, greater essential oil content and resistance to environmental conditions and tremendous efforts have been made to create novel genotypes. Results from the coriander breeding program indicate that seed yield, plant height, 1000 seed weight, number of umbrella, number of branches and essential oil content.

Seed yields (t ha^{-1}), plant height (cm), number of branches (branches $plant^{-1}$), number of umbrella per plant (umbrella $plant^{-1}$) and 1000 seed weight (g) of coriander cultivars and populations in Isparta and Eskisehir locations are shown in Table 3. In different plant characters, plant height, number of branches and umbrella, thousand seed weight, seed yield and oil content could be considered as a criteria for success of breeding and development of new genotypes (Kaya et al., 2000; Inan et al., 2014; Moniruzzaman et al., 2014 and Yousuf et al., 2014). Plant height may be considered as a momentous yield component that is associated with seed yield along with other yield determinants (Singh et al., 2006). Differences years and locations, interactions between factors were found to be significant; and statistically insignificant differences were found between genotypes and year × location × genotype interactions. Higher plant heights in year of 2014 and Isparta location were recorded that of 2014 and Eskişehir location. These can be explained with differences of climatic conditions in among the years and locations during growing period of both the years (Table 1).

Dual significant interactions showed that significant differences between environmental conditions or interactions could result in huge variations in plant height. Plant height is mainly controlled by genotype × environment interactions and this may also be influenced by ecological conditions and agronomic practices (Inan et al., 2014). Moreover, literatures reported that distribution of precipitation/rainfall in seasons is to influence the plant height (Mencuccini and Magnani, 2000 and Midgley, 2003). Similarly we found that higher rainfall in the first year increased plant height. In our study, plant height ranged between 35.17-93.80 cm. It was reported that plant height ranged from 11.8-98.77 cm (Bhandari and Gupta, 1993; Datta and Choudhuri, 2006). Positive and significant correlations between plant height and number of umbrella, plant height and number of branches; negative and significant correlations between plant height and 1000 seed weight, plant height and seed yield were found in the study (Table 4).

Moreover, stability analysis revealed that Antalya, Arslan and Erbaa were more stable genotypes for plant height (Table 5 and Figure 1). The number of branches are seen in Table 3 indicated that differences between years, locations and genotypes, interactions between them were significant; alias, values were influenced by the years, locations, genotypes and their interactions.

When compared to the locations, higher number of branches was obtained in Isparta location, and in years, the number of branches was higher in 2014. On average, in terms of locations, the highest number of branches in 2013 and 2014 were found in Arslan genotype while the lowest one was Pel-mus genotype (Table 3). According to stability analysis, Antalya and Pel-mus were found to be more stable genotypes for number of branches (Table 5 and Figure 1). In the study, significant correlations ($p<0,01$) of number of branches with plant height, number of branches and seed yield; significant negative correlation ($p<0,05$) occurred between number of branches and essential oil content. The number of branches increased with the elongation of plant height due to rainfall that positively affected this component. Reported that coriander is a medicinal plant sensitive to water stress. The same authors stated that seed yield and its components were decreased rapidly according to increasing water stress during growing periods under semi-arid climatic conditions (Ghamarnia and Daichin, 2013 and Nowak and Zempliski, 2014). It was stated that yield components such as the number of branches and umbrella affect directly seed yield and positive correlation between seed yield and aboveground biomass were reported (Tuncturk and Yildirim, 2006; Ozguven and Sekeroglu, 2007 and Sadeghi, 2009). Besides, Singh et al. (2006) stated that the number of branches per plant, directly effecting seed yield, is particularly important in coriander breeding.

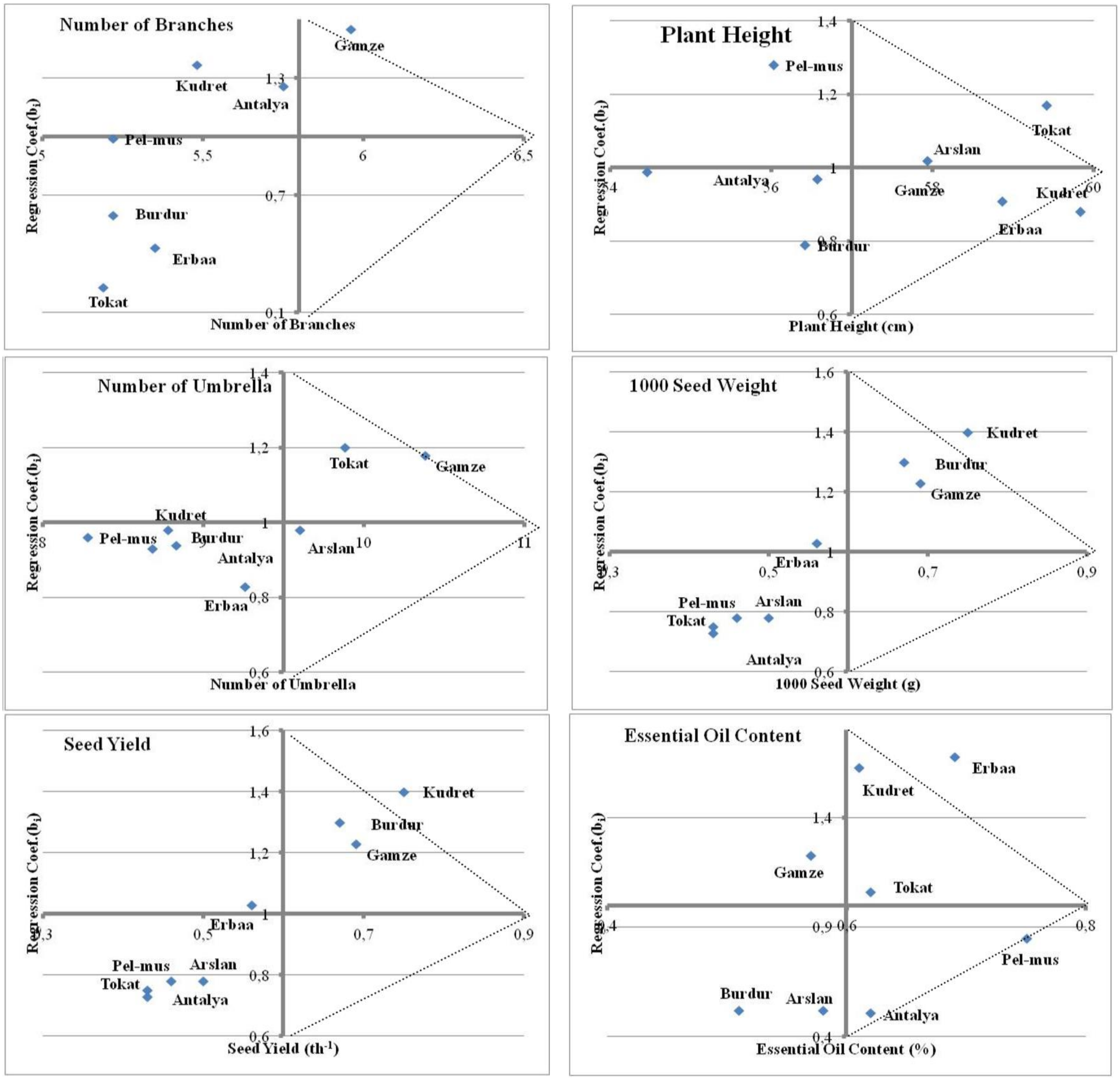

Figure 1. Stability performances of coriander genotypes for yield, yield components and essential oil content.

The number of umbrella is an important character, and the performance of it is formed by differences between years and locations and genotypes (Mert and Kirici, 1998, and Kizil, 2002). Similarly in our study, differences between locations and genotypes, year × location interaction were determined as significant. The highest number of umbrella were taken from Gamze, Erbaa, Tokat and Arslan cultivars; besides Isparta location had the higher number of umbrella. In stability analysis, Gamze, Erbaa, Arslan and Kudret were more stabile genotypes for the number of umbrella (Table 5 and Figure 1). Differences between locations in 2014 was higher than that of 2013 and different variations of locations in both years (Table 3 and 4). This probably occurs as a result of significant location × year interaction. Our results agreed with results Mert and Kirici (1998) and Kizil (2002). Meanwhile, number of umbrella significantly correlated with plant height and seed yield. Similar to this, the number of umbrella per plant was another important character for seed and essential oil yield (Inan et al., 2014).

Table 3. Yield, some yield components and essential oil content of coriander.

		Plant height (cm)								
		Genotypes								
Years	**Locations**	**Kudret**	**Burdur**	**Gamze**	**Erbaa**	**Tokat**	**Pel-mus**	**Antalya**	**Arslan**	**Mean**
2013	**Eskişehir**	44,40	40,47	35,17	41,57	41,53	36,77	37,20	41,00	39,76
	Isparta	85,20	78,27	83,73	84,47	93,80	92,73	82,67	87,13	86,00
	Mean	**64,80**	**59,37**	**59,45**	**63,02**	**67,67**	**64,75**	**59,93**	**64,07**	**$62,88^{A}$**
2014	**Eskişehir**	49,93	49,00	51,43	49,57	44,93	37,07	43,43	45,17	46,32
	Isparta	59,80	57,93	55,93	59,87	57,40	57,53	54,53	58,47	57,68
	Mean	**54,87**	**53,47**	**53,68**	**54,72**	**51,17**	**47,30**	**48,98**	**51,82**	**$52,00^{B}$**
As a Means of Years	**Eskişehir**	47,17	44,73	43,30	45,57	43,23	36,92	40,32	43,08	**$43,04^{B}$**
	Isparta	72,50	68,10	69,83	72,17	75,60	75,13	68,60	72,80	**$71,84^{A}$**
Grand Mean		**59,83**	**56,42**	**56,57**	**58,87**	**59,42**	**56,03**	**54,46**	**57,94**	**57,44**

F_{values}: Year: 274,92** **Loc:** 315,03** **Year×Loc:** 115,44** **Gen:** 2,173ns **Year×Gen:** 2,98* **Loc×Gen:** 3,40** **Year×Loc×Gen:** 0,94ns
C.V.(%): 22,30 | **L.S.D.(%): Year:** 6,51 **Loc:** 7,47 **Year×Loc:** 10,57 **Year × Gen:** 5,10 **Loc×Gen:** 6,79

		Number of branches								
		Genotypes								
Years	**Locations**	**Kudret**	**Burdur**	**Gamze**	**Erbaa**	**Tokat**	**Pel-mus**	**Antalya**	**Arslan**	**Mean**
2013	**Eskişehir**	4,63	4,87	5,07	5,80	5,53	5,07	6,50	6,03	5,44
	Isparta	5,07	5,67	5,67	4,40	5,33	4,33	4,00	5,33	4,98
	Mean	**4,85**	**5,27**	**5,37**	**5,10**	**5,43**	**4,70**	**5,25**	**5,68**	**$5,21^{b}$**
2014	**Eskişehir**	3,93	4,00	4,03	5,07	4,43	4,27	4,43	5,30	4,43
	Isparta	8,27	6,33	9,07	6,13	5,47	7,20	8,07	9,87	7,55
	Mean	**6,10**	**5,17**	**6,55**	**5,60**	**4,95**	**5,73**	**6,25**	**7,58**	**$5,99^{a}$**
As a Means of Years	**Eskişehir**	4,28	4,43	4,55	5,43	4,98	4,67	5,47	5,67	**$4,94^{B}$**
	Isparta	6,67	6,00	7,37	5,27	5,40	5,77	6,03	7,60	**$6,26^{A}$**
Grand Mean		**$5,48^{BD}$**	**$5,22^{D}$**	**$5,96^{B}$**	**$5,35^{CD}$**	**$5,19^{D}$**	**$5,22^{D}$**	**$5,75^{BC}$**	**$6,63^{A}$**	**5,60**

F_{values}: Year: 32,49* **Loc:** 59,34** **Year×Loc:** 107,91** **Gen:** 14,57** **Year×Gen:** 8,71** **Loc×Gen:** 15,44** **Year×Loc×Gen:** 10,95**
C.V.(%): 27,35 | **L.S.D.(%): Year:** 0,59 **Loc:** 0,79 **Year×Loc:** 1,12 **Gen:** 0,50 **Year×Gen:** 0,70 **Loc×Gen:** 0,70 **Year×Loc×Gen:** 0,99

		Number of umbrella per plant								
		Genotypes								
Years	**Locations**	**Kudret**	**Burdur**	**Gamze**	**Erbaa**	**Tokat**	**Pel-mus**	**Antalya**	**Arslan**	**Mean**
2013	**Eskişehir**	5,87	4,80	7,23	8,07	6,93	5,17	6,23	7,63	6,49
	Isparta	11,73	11,20	13,73	11,40	12,87	11,33	12,00	12,93	12,15
	Mean	**8,80**	**8,00**	**10,48**	**9,73**	**9,90**	**8,25**	**9,12**	**10,28**	**9,32**
2014	**Eskişehir**	4,40	4,90	4,43	4,30	3,67	3,77	3,83	4,03	4,17
	Isparta	13,33	14,20	16,13	13,27	16,07	12,87	12,67	13,80	14,04
	Mean	**8,87**	**9,55**	**10,28**	**8,78**	**9,87**	**8,32**	**8,25**	**8,92**	**9,10**
As a Means of Years	**Eskişehir**	5,13	4,85	5,83	6,18	5,30	4,47	5,03	5,83	**$5,33^{B}$**
	Isparta	12,53	12,70	14,93	12,33	14,47	12,10	12,33	13,37	**$13,10^{A}$**
Grand Mean		**$8,83^{BC}$**	**$8,78^{BC}$**	**$10,38^{A}$**	**$9,26^{AC}$**	**$9,88^{AB}$**	**$8,28^{C}$**	**$8,68^{BC}$**	**$9,60^{AC}$**	**9,21**

F_{values}: Year: 2,68ns **Loc:** 1588,52** **Year×Loc:** 117,06** **Gen:** 3,68** **Year×Gen:** 1,49ns **Loc×Gen:** 1,81ns **Year×Loc×Gen:** 0,94ns
C.V.(%): 46,51 | **L.S.D.(%): Loc:** 0,90 **Year×Loc:** 1,27 **Gen:** 1,38

Table 3. Continued

		1000 seed weight (g)								
		Genotypes								
Years	**Locations**	**Kudret**	**Burdur**	**Gamze**	**Erbaa**	**Tokat**	**Pel-mus**	**Antalya**	**Arslan**	**Mean**
2013	**Eskişehir**	7,30	7,47	7,57	7,60	7,80	6,63	6,93	10,37	7,71
	Isparta	7,37	7,60	7,43	7,47	9,50	8,33	9,93	11,30	8,62
	Mean	**7,33**	**7,53**	**7,50**	**7,53**	**8,65**	**7,48**	**8,43**	**10,83**	**8,16^{a}**
2014	**Eskişehir**	6,97	5,83	6,77	6,77	6,83	5,87	5,83	9,00	6,73
	Isparta	6,40	6,70	7,30	6,87	8,80	6,47	7,10	9,23	7,36
	Mean	**6,68**	**6,27**	**7,03**	**6,82**	**7,82**	**6,17**	**6,48**	**9,12**	**7,05^{b}**
As a Means of Years	**Eskişehir**	7,13	6,65	7,17	7,18	7,32	6,25	6,38	9,68	7,22^{B}
	Isparta	6,88	7,15	7,37	7,17	9,15	7,40	8,51	10,27	7,99^{A}
Grand Mean		**7,01^{C}**	**6,90^{C}**	**7,27^{C}**	**7,18^{C}**	**8,23^{B}**	**6,83^{C}**	**7,45^{C}**	**9,98^{A}**	**7,60**

F_{values}: Year: 73,82* **Loc:** 27,30** **Year×Loc:** 0,93ns **Gen:** 28,51** **Year×Gen:** 1,85ns **Loc×Gen:** 4,78** **Year×Loc×Gen:** 1,27ns
C.V.(%): 18,78 **L.S.D.(%): Year:** 0,56 **Loc:** 0,68 **Gen:** 0,75 **Loc×Gen:** 1,05

		Seed yield (t ha^{-1})								
		Genotypes								
Years	**Locations**	**Kudret**	**Burdur**	**Gamze**	**Erbaa**	**Tokat**	**Pel-mus**	**Antalya**	**Arslan**	**Mean**
2013	**Eskişehir**	1.33	0.83	1.67	0.97	1.10	1.20	1.07	1.63	1.23
	Isparta	1,47	1,14	1,33	1,06	0,83	0,96	0,86	0,95	1,08
	Mean	**1.40**	**0.99**	**1.50**	**1.02**	**0.96**	**1.08**	**0.96**	**1.29**	**1.15^{A}**
2014	**Eskişehir**	1.17	0.70	1.17	1.00	0.90	1.10	1.03	1.50	1.07
	Isparta	1,26	1,39	1,15	0,97	0,70	0,64	0,63	0,75	0,94
	Mean	**1.22**	**1.05**	**1.16**	**0.99**	**0.80**	**0.87**	**0.83**	**1.12**	**1.00^{B}**
As a Means of Years	**Eskişehir**	1.25	0.77	1.42	0.98	1.00	1.15	1.05	1.57	1.15^{A}
	Isparta	1,37	1,27	1,24	1,02	0,76	0,80	0,75	0,85	1,01^{B}
Grand Mean		**1.31^{A}**	**1.02^{C}**	**1.33^{A}**	**1.00^{C}**	**0.88^{D}**	**0.97^{CD}**	**0.90^{D}**	**1.21^{B}**	**1.08**

F_{values}: Year: 132,33** **Loc:** 44,27** **Year×Loc:** 0,15ns **Gen:** 45,36** **Year×Gen:** 5,11** **Loc×Gen:** 46,54** **Year×Loc×Gen:** 4,65**
C.V.(%): 26,19 | **L.S.D.(%): Year:** 0,126 **Loc:** 0,098 **Gen:** 0,100 **Year×Gen:** 0,142 **Loc×Gen:** 0,142 **Year×Loc×Gen:** 0,200

		Essential oil content (%)								
		Genotypes								
Years	**Locations**	**Kudret**	**Burdur**	**Gamze**	**Erbaa**	**Tokat**	**Pel-mus**	**Antalya**	**Arslan**	**Mean**
2013	**Eskişehir**	0,50	0,50	0,50	0,62	0,60	0,92	0,81	0,70	0,64
	Isparta	0,93	0,60	0,80	1,00	0,80	0,80	0,60	0,60	0,77
	Mean	**0,72**	**0,55**	**0,65**	**0,81**	**0,70**	**0,86**	**0,71**	**0,65**	**0,71^{A}**
2014	**Eskişehir**	0,40	0,43	0,47	0,50	0,50	0,75	0,67	0,58	0,54
	Isparta	0,60	0,50	0,50	0,63	0,57	0,53	0,40	0,43	0,52
	Mean	**0,50**	**0,47**	**0,48**	**0,57**	**0,53**	**0,64**	**0,53**	**0,51**	**0,53^{B}**
As a Means of Years	**Eskişehir**	0,45	0,47	0,48	0,56	0,55	0,84	0,74	0,64	**0,59^{B}**
	Isparta	0,77	0,55	0,65	0,82	0,68	0,67	0,50	0,52	**0,64^{A}**
Grand Mean		**0,61^{C}**	**0,51^{D}**	**0,57^{CD}**	**0,69^{AB}**	**0,62^{BC}**	**0,75^{A}**	**0,62^{BC}**	**0,58^{CD}**	**0,62**

F_{values}: Year: 145,45** **Loc:** 22,71** **Year×Loc:** 39,19** **Gen:** 13,78** **Year×Gen:** 1,59ns **Loc×Gen:** 26,32** **Year×Loc×Gen:** 1,43ns
C.V.(%): 27,27 | **L.S.D.(%): Year:** 0,15 **Loc:** 0,05 **Year×Loc:** 0,07 **Gen:** 0,08 **Loc×Gen:** 0,11

*, **: significant at P<0.05 and P<0.01 probability levels, respectively, ns: no significant.

Table 4. Correlation matrix for characters of coriander genotypes.

	Plant Height	No of Branches	No of umbrella	1000 seed we.	Seed Yield
No of Branches	0,681**				
No of umbrella	0,839**	0,580**			
1000 seed we.	-0,316**	0,034ns	-0,170ns		
Seed Yield	-0,684**	0,423**	0,808**	0,167ns	
Es. oil content	-0,169ns	-0,195*	0,089ns	0,229*	-0,272**

1000 seed weight, one of the yield components is quantitative nature, for successful selection procedure. To achieve higher grain yield, sufficient information is necessary to evaluate the nature and magnitude of genetic variability present on the available coriander materials (Datta and Choudhuri, 2006). Table 3 indicated that differences between years, locations and genotypes, interactions between them were significant (Gul et al., 1997). The higher thousand seed weight values in 2013 and Isparta locations were taken. Moreover, the highest 1000 seed weight was taken from Arslan genotype while lowest one belonged to Pel-mus genotype. These results could have occurred because of the great differences in features of years, locations, large and significant variations in genotypic performances. Higher 1000 seed weight depends on the size of kernels (Islam et al., 2004). This assign that the genetic performance of plant for 1000 seed weight is formed under genotype × environment interaction. 1000 seed weight was significant and positively correlated with essential oil content, whereas it was negatively and significantly correlated with plant height (Table 4). In stability analysis, Burdur and Gamze genotypes were the most stabile genotypes (Table 5 and Figure 1).

Genotypes with high yielding and oil content should be the main objective of any breeding programs in coriander. To achieve this, knowledge of the existing genetic variation for yield and its components requires. Seed yield and essential oil contents in the first year and Eskisehir location were higher than that of the second year and Isparta location. In seed yield, the highest seed yields were taken from Kudret and Gamze genotypes while lowest ones were belonged to Pel-mus, Tokat and Antalya genotypes. Differences on seed yield of Gamze, Erbaa and Tokat genotypes between locations in 2013 and 2014 were lower than that of the other genotypes. Besides, variations of genotypes in Eskişehir location in 2013 and 2014 were almost similar, but greater variations occurred on genotypes in Isparta location in both years (Telci et al. 2006). In essential oil content, Pel-mus and Erbaa genotypes had the highest essential oil content; moreover Burdur genotype had the lowest essential oil content. Genotypic responses in seed yield and essential oil content created significant differences in ecological differences in locations and years, and this situation should cause significant interactions between genotypes, location and years. Moniruzzaman et al. (2014) reported that differences on seed yield in genotypes could strongly be the effect of genotypic differences and ecological variations. Similar to our findings, Dyulgerov and Dyulgerova (2013) stated that greater environmental variations occurred than if compared genotypic variations. This could mainly not only explain significant variations among years, locations and genotypes, but show significant importance of their interactions. Meena et al. (2013) stated that essential oil content was significant and positively correlated with thousand seed weight. Besides, variability, association among the traits and contributing of them to seed yield show great importance in executing successful breeding program (Sriti et al., 2009). Oil contents in plants relatively decreases or draw straight line with increasing seed yield (Bhuiyan et al., 2009). Similarly, negative and significant interaction between essential oil content and seed yield ($p<0,01$) contribute information inverse relationship of essential oil content and seed yield (Toncer et al., 1998). Meanwhile, correlation between plant height and seed yield, number of branches and essential oil content were found as negative and significant; and positive and significant relationship between 1000 seed weight and essential oil content, seed yield and number of branches were determined (Table 4). Stability analysis revealed that Erbaa and Gamze genotypes in seed yield, and Gamze, Pelmus and Erbaa genotypes were the most stabile genotypes (Table 5 and Figure 1).

CONCLUSION

Coriander crop has been used for different industrial purposes and successful seed production mainly depends on use of healthy crop, more productive, higher quality and resistant to diseases and pests (Kaya et al., 2000 and Singh *et al*., 2006). In our study, coriander genotypes were evaluated in climatic conditions of Eskişehir and Isparta provinces. Results revealed that years and locations with different climatic and geographic characters had significant effects in coriander genotypes for yield, yield components and essential oil content. Increase in seed yield and decrease in essential oil content occurred with increasing rainfall. Results revealed that Arslan cultivar in Eskişehir location and Kudret in Isparta location had the highest seed yield. Besides Arslan cultivar and Gamze cultivar gave the highest seed yield as a means of locations; Eskisehir location had also higher seed yield. Breeding programs should have intensive care in development of novel cultivars.

Table 5. Stability parameters of coriander genotypes for seed yield, yield components and essential oil content.

Genotype	Plant height				Number of branches				Number of umbrella			
	Reg.Coef. b_i	*St.Dev.from regression* S^2di	*Ecovalance* δ^2_i	*Shukla Variance* δ^2_i	*Reg.Coef.* b_i	*St.Dev.from Regression* S^2di	*Ecovalance* δ^2_i	*Shukla Variance* δ^2_i	*Reg.Coef.* b_i	*St.Dev.from Regression* S^2di	*Ecovalance* δ^2_i	*Shukla Variance* δ^2_i
Kudret	0,88	0,1	16,81	4,84	1,37	0,30	1,36	0,47	0,94	0,10	0,55	0,12
Burdur	0,79	4,0	63,37	25,53	0,60	0,50	1,89	0,70	0,98	1,80	3,56	1,46
Gamze	0,97	25,6	52,45	20,68	1,55	0,40	2,56	1,00	1,18	0,00	2,02	0,77
Erbaa	0,91	1,5	12,80	3,06	0,43	0,40	2,62	1,03	0,83	0,09	3,65	1,50
Tokat	1,17	8,1	50,35	19,75	0,23	0,20	3,81	1,56	1,20	0,30	3,26	1,32
Pel-mus	1,28	17,5	131,88	55,98	0,99	0,10	0,11	-0,08	0,96	0,20	0,51	0,10
Antalya	0,99	0,0	0,34	-2,48	1,26	0,90	2,26	0,87	0,93	0,30	0,97	0,31
Arslan	1,02	1,7	3,75	-0,97	1,57	0,20	2,32	0,90	0,98	0,70	1,39	0,49

Genotype	1000 Seed weight				Seed yield				Essential oil content			
	Reg.Coef. b_i	*St.Dev.from Regression* S^2di	*Ecovalance* δ^2_i	*Shukla Variance* δ^2_i	*Reg.Coef.* b_i	*St.Dev.from Regression* S^2di	*Ecovalance* δ^2_i	*Shukla Variance* δ^2_i	*Reg.Coef.* b_i	*St.Dev.from Regression* S^2di	*Ecovalance* δ^2_i	*Shukla Variance* δ^2_i
Kudret	0,31	0,20	1,28	0,50	1,40	118,40	128232,86	52511,37	1,63	0,10	0,07	0,03
Burdur	0,94	0,20	0,35	0,09	1,30	48068,60	168725,07	70507,91	0,52	0,09	0,01	0,00
Gamze	0,34	0,10	0,97	0,36	1,23	331,30	43755,42	14965,84	1,16	0,03	0,02	0,00
Erbaa	0,42	0,10	0,84	0,30	1,03	778,70	2155,48	-3523,02	1,14	0,04	0,05	0,02
Tokat	1,25	0,60	1,29	0,51	0,75	213,40	51434,65	18378,83	1,06	0,02	0,01	0,00
Pel-mus	1,31	0,10	0,35	0,09	0,78	11432,90	61423,66	22818,39	0,85	0,03	0,05	0,02
Antalya	2,13	0,40	3,12	1,32	0,73	3836,20	67083,59	25333,92	0,51	0,06	0,09	0,04
Arslan	1,30	0,10	0,44	0,13	0,78	2221,00	41797,14	14095,49	0,52	0,08	0,03	0,01

LITERATURE CITED

Bhandari, M. M. and A. Gupta. 1993. Divergence analysis in coriander. Indian J. Genet. 53 (1): 71-75.

Bhuiyan, N.I., J. Begum and M. Sultana. 2009. Chemical composition of leaf and seed essential oil of *Coriandrum sativum* L. from Bangladesh. Bangladesh J. Pharmacol, 4: 150-153.

Carubba, A., R. la Torre, I. Calabrese. 2002. Cultivation trials of coriander (*Coriandrum sativum* L.) in a semi-arid Mediterranean environment. *Acta Hort.* 576: 237-242.

Datta, S. and P. Choudhuri. 2006. Evaluation of coriander germplasm under tetra zone of West Bengal. Haryan J. Hortic. Sci. 35(3&4): 348-349.

Duzgunes, O., T. Kesici, O. Kavuncu and F. Gurbuz. 1987. Araştırma ve Deneme Metodları (İstatistik Metodları). Ankara Üniversitesi Ziraat Fakültesi Yayınları: 1021. ANKARA.

Dyulgerov, N. and B. Dyulgerov. 2013. Variation of yield components in coriander (*Coriandrum sativum* L.). Agrıcultural Scıence and Technology, 5(2): 160 – 163.

Eberhart, S.A. and W.A. Russell. 1966. Stability parameters for comparing varieties. Crop Sci. Vol: 6: 36-40.

Finlay, K.W. and G.N Wilkinson. 1963. The analysis of adaptation in a plant breeding programme. Austral. J. Agr. Res. Vol. 14: 742-754.

Ghamarnia, H. and S. Daichin. 2013. Effect of different water stress regimes on different Coriander (*Coriander sativum* L.) Parameters in a semi-arid climate. International Journal of Agronomy and Plant Production. 4(4): 822-832.

Gharib, F.A., A. Lobna, L.A. Moussa and O.N. Massoud. 2008. Effect of Compost and Bio-fertilizers on Growth, Yield and Essential Oil of Sweet Marjoram (*Majorana hortensis*) Plant. Int. J. Agri. Biol., Vol. 10, No. 4, Pages: 381–387.

Gul O., Tansi, S., 1997 The effect of different row spacing on seed yield and essential oil content of Coriander (*Coriandrum sativum* L.), C.U. Journal of the Faculty of Agriculture. No: 181, 12 (2): 155-162.

Hadian, J., S.N. Ebrahimi and P. Salehi. 2010. Variability of morphological and phytochemical characteristics among *Satureja hortensis* L. accessions of Iran. Industrial Crops and Products, 32(1): 62–69.

Hani, M. M., S.A.H.A. Hussein, M.H. Mursy, W. Ngezimana, and F.N. Mudau. 2015. Yield and Essential Oil Response in Coriander to Water Stress and Phosphorus Fertilizer Application. TEOP 18(1): 82-92.

Inan, M., S. Kirici, E.S. Giray, M. Turk and H. Taghikhani. 2014. Determination of suitable coriander (*Coriandrum sativum* L.) cultivars for eastern mediterranean region. Turk. J Field Crops Crops 19(1): 1-6.

Islam, M.S., M.A. Rahman, M.M. Mazumder, R.K. Hossain, M.A.J. Bhuyan. 2004. Performance of some coriander genotypes for grain yield and its attributes. Bangladesh J. Agril. Res. 29(1): 59-66.

Jarcău, M. 2013. Physical Properties of Coriander Seeds and How They Are Influenced By Packaging. University of Agricultural Sciences and Veterinary Medicine Iasi, Vol:60 pp:258-262.

Kaya, N., G. Yilmaz ve I. Telci, 2000. Agronomic and Technological Properties of Coriander (*Coriandrum sativum* L.) Populations Planted on Different Dates. Turk J Agric For 24: 355–364.

Kizil, S. 2002. The effects of different seed rates of selected coriander (*Coriandrum sativum* L.) lines on yield, yield components and essential oil rate. Turk. J Field Crops 7(2): 99-10l.

Meena, B.S., B.L. Dhaka and M.K. Poonia. 2013. Assessment of yield, quality and economics of coriander (*Coriandrum sativum* L.) genotypes in south-eastern plains of Rajasthan under irrigated condition. International Journal of Seed Spices, 3: 58-60.

Meena, Y.K., B.J. Jadhao and V.S. Kale. 2014. Genetic Analysis of Agronomic Traits in Coriander. Sabrao Journal of Breeding and Genetics, 46(2): 265-273.

Mencuccini, M. and F. Magnani. 2000. Comment on 'Hydraulic limitation of tree height: a critique' by Becker, Meinzer&Wullschleger. Funct. Ecol. 14: 135–137

Mert, A. and S. Kirici. 1998. To determine the yield and yield charecters of coriander (*Coriandrum sativum* L.) populations. Proceedings of XIIth International Symposium on Plant Originated Crude Drugs, New Trends and Methods in Natural Products Research. May, 20-22, Ankara, Abstract Book p: 112.

Midgley, J.J. 2003. Is bigger better in plants?. The hydraulic costs of increasing size in trees. Trends Ecol. Evol. 18: 5–6

Moniruzzaman, M., M.M. Rahman, M.M. Hossain, A.J.M.S. Karim and Q.A. Khaliq. 2014. Response of Coriander (*Coriandrum sativum* L.) Foliage To Different Rates and Methods Of Nitrogen Application. Bangladesh J. Agril. Res. 39(2): 359-371.

Ozguven, M. and N. Sekeroglu. 2007. Agricultural practices for high yield and quality of black cumin (*Nigella sativa* L.) cultivated in Turkey. Acta Horticulturae. 756: 329-337

Sadeghi, S., A. Rahnavard and Z.Y. Ashrafi. 2009. The effect of plant density and sowing date on yield of Basil (*Ocimum basilicum* L.) in Iran. J. Agric. Technol., 5: 413-422.

Sarer, E. 2004. The effect of summer and winter cultures from the chosen coriander lines on the quality of the product. Project No: 2000-05-03-015.

Sifola, M.I. and G. Barbieri. 2006. Growth, yield and essential oil content of three cultivars of basil grown under different levels of nitrogen in the field. Sci. Hortic., Volume: 108, ıssue:4, 408-413.

Singh, D.,U.K. Jain, S.S. Rajput, V. Khandelwal and K.N. Shiv. 2006. Genetic variation for seed yield and its components and their association in coriander (*Coriandrum sativum* L.) germplasm. Journal of Spices and Aromatic Crops, 15(1): 25-29.

Sriti, J., T. Talou, W.A. Wannes, M. Cerny and B. Marzouk. 2009. Essential oil, fatty acid and sterol composition of Tunisian coriander fruit different parts, J. Sci. Food Agric. 89: 1659-1664.

Stainier, C. 1975. Role and functions of the European Pharmacopoeia. Ann Ist Super Sanita. 11(3-4): 211-219.

Telci,I., G.O. Toncer and N. Sahbaz. 2006. Yield,essential oil content and composition of *Coriandrum sativum* varieties (var. *vulgare* Alef. and var. *microcarpum* DC.) grown in two different locations. J. Essent. Oil Res., 18, 189-193.

Toncer, O., S. Tansi and S. Kizil. 1998. The effect of different sowing time on essential oil of Coriander (*Coriandrum sativum* L.)' in GAP region. Anadolu. Journal of Eagean Agricultural Research Institute Vol. 8, No 2. 101-105.

Tuncturk, M. and B. Yildirim. 2006. Effect of seed rates on yield and yield components of anise (*Pimpinella anisum* L.). Indian J. Agr. Sci. 76: 679-681.

Yousuf, M.N., S. Brahma, M.M. Kamal, S. Akter and M. E. K. Chowdhury, 2014. Effect of Nitrogen, Phosphorus, Potassium, And Sulphur on The Growth and Seed Yield of Coriander (*Coriandrum sativum* L.). Bangladesh J. Agril. Res. 39(2): 303-309