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EFFECT OF PHOSPHORUS FERTILIZER ON SOME YIELD COMPONENTS AND QUALITY OF DIFFERENT ANISE (*Pimpinella anisum* L.) POPULATIONS

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ABSTRACT

The objective of the study was to investigate the effect of phosphorus treatments on yield and quality traits of three anise populations with different origin under Bornova-Izmir conditions in 2016 and 2017. Phosphorus fertilizer was applied at the rate of 0, 30, 60 and 90 kg ha^{-1} to three different anise populations (Turkish, Spanish and Syrian). Field trials were arranged as split-plot in the Randomized Complete Block design with three replications. The plant characteristics such as plant height (cm), biomass (kg ha^{-1}), number of branches, number of umbels per plant, number of seeds per umbel, seed yield(kg ha^{-1}), 1000-seed weight (g), essential oil content (%) and essential oil yield (L ha^{-1}) were measured. It was found that the highest number of seeds per umbel, 1000-seed weight and essential oil content were obtained from the 60 kg ha^{-1} phosphorus application.

Keywords: ***Pimpinella anisum*** **L., anise, phosphorus fertilizer, essential oil**

INTRODUCTION

Anise (*Pimpinella anisum* L.) is one of the most important medicinal plants from Umbelliferae family in the World. The origin of anise is not exactly known but it has been a commonly found in Egypt, Syria, Cyprus, Greece, Crete Islands and Turkey. The seeds are used in medicine, pharmaceutics, perfumery and cosmetic industries (El-Gamal and Ahmed, 2017; Meena et al., 2015; Faravani et al., 2013; Nabizadeh et al., 2012 and Ceylan, 1997). The anise fruit contains essential oil from 1.5 to 4.0% (Radosav et al., 2012) and main component of essential oil is trans-anethole (Ceylan, 1997). They are used to carminative, treat dyspeptic complaints and catarrh of the respiratory tract, and as mild expectorants (Khalid, 2014; Ceylan, 1997).

To increase yield is major aims in agriculture. Therefore plant nutrition’s such as macro and micro nutrition’s are important factors in crops production (Dogramacı and Arabaci, 2015). Less or more fertilization has an adverse effect on growth and yield in plant production. Also, fertilizer has a distinct importance in medicinal and aromatic plants. Secondary metabolites and yield parameters are affected by fertilizations types and dosages. The amounts of secondary metabolites indicate the quality of medicinal and aromatic plants.

Generally, it is known that nitrogen fertilizations promote vegetative growth in plants. Phosphorus (P) is one of the major essential macronutrients for the development of plant growth in cultivated crops (Zand et al., 2013). Phosphorus plays a significant role in metabolism of plants such as cell division, flower initiation, maturing of fruit or seed and etc. (Khalid, 2012b). Although several studies have focused nitrogen, phosphorus and potassium fertilizer in anise, the number of studies that considered phosphorus fertilizer in anise is limited (Khalid 2014; Zand et al., 2013; Bhuvaneshwari et al., 2002). Anise seeds are used for different purposes and are of importance as a raw material. Hence the effects of P fertilizers on anise, yields and quality parameters should be studied. The objective of this study was to determine the optimum phosphorus requirement for seed productivity in three anise populations with different origins.

MATERIALS AND METHODS

Field trial was conducted the experimental field of the Field Crops Department, Faculty of Agriculture, Ege University at Bornova/Izmir in 2016 and 2017. Izmir province has a typical Mediterranean climatical conditions located in the western Turkey. The highest temperature in the area was recorded as 26.9 C° in July in the first year, and 29.8 C° in July in the second year (Table 1).

Table 1. Trial years and long term mean temperature (°C) and total precipitation (mm) values of Bornova ecological conditions

Climate Factors	Years	Months												Average
		Jan.	Feb.	March	April	May	June	July	August	Sept.	Oct.	Nov.	Dec.	
Average Temperature(°C)	2016	5.8	11.0	10.6	16.2	17.9	25.0	26.9	26.8	22.1	16.5	11.2	10.2	16.7
	2017	6.3	10.4	13.3	16.6	21.7	26.5	29.8	29.4	24.6	18.8	13.3	11.8	18.5
	Long Years	8.8	11.2	13.3	16.9	21.9	26.0	29.1	29.0	24.7	18.8	14.3	9.6	18.6
														Total
Precipitation (mm)	2016	232.9	84.9	122.0	28.4	37.1	2.6	0.0	0.4	8.6	0.5	123.8	20.2	661.4
	2017	235.7	55.6	72.5	15.7	27.0	1.8	0.0	0.0	0.9	24.0	62.1	81.4	577.7
	Long Years	165.1	74.9	69.8	35.7	40.1	19.8	0.6	6.7	6.6	43.7	71.1	52.2	586.3

(Anonymous, 2017).

The total annual precipitation was 661.4 and 577.7 mm in 2016 and 2017, respectively. Experimental area is 31 m above sea level with mild Mediterranean climate condition. Average temperature and total precipitation are shown in Table 2. Soil texture of the experimental area was generally composed of clay. The first 20 cm soil was silty-clay with pH of 8.2 whereas soil of 20-40 cm deep was clay-loamy with pH of 7.8 in the experimental field (Sonmez, 2015).

Table 2. Some physical and chemical characteristics of the soils of the experimental sites (Sonmez, 2015)

Soil depth	Sand	Silt	Clay	N (%)	P (ppm)	K (ppm)	Ca (ppm)	Na (ppm)	Fe (ppm)	OM[a] (%)	pH
0-20 cm	24.72	32.56	42.72	0.101	0.4	400	5400	20	13.6	1.130	8.2
20-40 cm	32.72	30.56	36.72	0.123	0.4	300	5100	20	16.2	1.150	7.8

[a]: Organic Matter

In this study, three anise populations (Turkey, Spain and Syria) were used as genetic material. The field trial was arranged as in the RCBD with three replications with split plot arrangement as following. Four phosphorus fertilizers doses were (0-30-60-90 kg ha^{-1}) in main plots and three different anise populations (Turkey, Spain and Syria) in sub plots. Seeds were sown by hand in first week of January at both years. Phosphorus as 46% granular triple superphosphate was applied before sowing. Each plot consisted of four rows, each 3 m long at row spacing of 40 cm. Plant densities of each different origins of anise population were determined based on a seed rate of 25 kg ha^{-1}. During the growing period, some agronomic practices were applied at appropriate time intervals. The dates of the harvest were 14 July 2016 and 12 July 2017. Each plot was harvested 5 cm above the soil surface at the seeds matured and weighed in order to obtain plot yields. Then the plot yield (biomass) was converted to hectare by a conversion factor. Seeds were separated by manually and weighed for each plot. Seed weights were converted to hectare all applications to obtain seed yield. Plant height, number of branches, number of umbels per plant and number of seeds per plant measured from 10 plants randomly selected from each plot at the harvesting time and thousand-seed weight was determined. The extraction of essential oil was also carried out by weighting 10 g of drug anise seed materials were subjected to 3 hours water-distillation using Neo-Clevenger apparatus. The essential oil ratios of the plants were determined by the volumetric method (ml/100 g) (Wichtl, 1971).

All data were statistically analyzed using the TOTEMSTAT statistical program (Acikgoz et al., 2004). The treatment means were compared by using the LSD test as described by Steel and Torrie (1980).

RESULTS AND DISCUSSION

Mean squares (variances) of the yield and quality characteristics obtained from the combined analysis over two years are shown in Table 3. It could be seen in the Table 3 that main effects such as phosphorus and population had significant variation for plant height, number of umbels per plant, number of seeds per umbel, 1000 seed weight, essential oil content and essential oil yield. Population had significant variation for number of branches and seed yield. Two main effects had non-significant F values indicating no differences among means of biomass and seed yield for phosphorus.

The interaction variations among the treatments were significant for all the characteristics studied. The non-significant interaction of years for the phosphorus and population indicated that the means over two years could be used in the discussion of the main effects for all the traits investigated. Non-significant variation found for the trait such as biomass could be interpreted that the selection possibility was very low for them in terms of phosphorus doses and population so any doses of phosphorus could be used for them without considering the population choice. The non-significant interaction effects for the trait studied indicated that phosphorus dose and population could be selected independently.

Table 3. Variances (mean squares) of characteristics studied obtained from the combined analysis over two years

Source	Degrees of freedom	Plant height	Number of Branches	Number of umbels per plant	Number of seeds per umbel	Biomass	Seed yield	1000 seed weight	Essential oil content	Essential oil yield
Year	1	0.798	0.082	0.017	0.102	43.805	0.109	0.009	0.051	0.029
Phosphorus	3	25.296**	0.081ns	0.688*	408.484**	62.333	24.408	1.142**	2.626**	1.897**
Population	2	102.086**	3.519**	2.167**	98.435**	27.886	2496.234**	0.447**	0.325**	2.116**
Phos. X Population	6	8.405ns	0.168	0.164	7.471	10.973	9.226	0.054**	0.028	0.056
Year X Phosphorus	3	0.427ns	0.092	0.076	5.402	6.822	1.24	0.01	0.003	0.002
Years X Population	2	1.403ns	0.171	0.013	2.083	1.184	7.087	0.004	0.012	0.002
Years X Phosphorus X Population	6	1.943ns	0.184	0.057	3.356	2.161	4.575	0.001	0.007	0.008
Error	48	4.25	0.23	0.22	10.547	32.83	12.173	0.044	0.025	0.025

*: significant at the $p \leq 0.05$ probability level
**: significant at the $p \leq 0.01$ probability level
ns: not significant

The mean of plant height are shown in Table 4. The plant height was significantly affected by phosphorus applications and there was found significant variation among different anise populations in the first year of study while, the plant height was not observed to be significantly different at different phosphorus doses in the second year. In addition, there were significant differences in plant height between anise populations. According to mean values, the highest plant height was obtained at a from phosphorus dosage of 60 kg ha^{-1} as 47.38 cm while the Turkish population had 48.69 cm in 2016. In second year, the highest plant height was recorded as 48.41 cm in Turkish anise population.

Several studies showed that fertilizer applications had affected plant height in anise. Acimovic et al. (2014), investigated six different types of fertilizers on three anise local cultivars. According to the results obtained from the study, the plant heights varied between 40.92 and 53.18 cm among anise cultivars in zero (control) fertilizer conditions. Furthermore, in 60 kg ha^{-1} phosphorus level equivalent value, the means of cultivars for plant heights were varied between 45.71 and 49.03 cm. Khalid (2012a) reported that for the effect of nitrogen and phosphorus treatment on anise, the plant heights were 29.5-33.1 cm under Egypt conditions. In another study (Arslan et al., 1999) reported that the plant heights ranged from 44.2 to 58.9 cm under Ankara ecological conditions. Bhuvaneshwari et al. (2002) determined that anise plant heights were 51.33, 53.96 and 53.58 cm for control, 30 kg ha^{-1} and 60 kg ha^{-1}phosporus levels respectively. Kara (2015) demonstrated that the plant heights ranged between 13.6-48.5 and 17.3-54.3 in first and second year in study for plant density and sowing time research. Bayram (1992) focused on the effect of nitrogen and phosphorus applications on four anise populations in Izmir conditions without irrigation. Statistically significant differences in plant height with different phosphorus doses were obtained. The plant height varied between 33.3 and 45.4 cm among populations without fertilizer and these values were altered 34.4-46.00 cm under 60 kg ha^{-1} phosphorus fertilizer treatments.

The similar results found in this study were reported by Kara (2015); Acimovic et al. (2014); Khalid (2012a); Arslan et al. (1999) and Bayram (1992). Also, the result of phosphorus fertilizer effect on plant heights was in accordance with those of some previous studies (Acimovic et al., 2014; Bhuvaneshwari et al., 2002 and Bayram, 1992). Increasing phosphorus doses resulted in an increased in plant heights up to 60 kg ha^{-1} phosphorus level as found in previous studies. On the other hand, the effect of phosphorous at a dose of 90 kg ha^{-1} was not the same as compared to 60 kg ha^{-1} phosphorus level. The results of the previous studies were not in agreement with 90 kg ha^{-1} phosphorus results of this study in anise researches. However, Bhuvaneshwari et al. (2002) detected a similar trend at different phosphorus levels (0, 30 and 60 kg ha^{-1}).

In this study, the biomass value was not affected by different phosphorus doses, Also there were no significant variations among examined anise population in both years. In the present study, biomass values were not significantly influenced by phosphorus treatment. There were no significant differences among means of anise populations for biomass.

Table 4. Means of studied characters of anise populations at different phosphorus fertilizer treatments

Phosphate treatment (kg ha-1)	Plant Height (cm)				Biomass kg h^{-1}				Number of Branches				Number of umbels per Plant				Number of seeds per umbel			
	Origins																			
	Turkey	**Spain**	**Syria**	**Mean**	**Turkey**	**Spain**	**Syria**	**Mean**	**Turkey**	**Spain**	**Syria**	**Mean**	**Turkey**	**Spain**	**Syria**	**Mean**	**Turkey**	**Spain**	**Syria**	**Mean**
2016																				
0	46.79	43.85	43.77	44.80^{c}	1353.00	1393.67	1365.67	**1370.78**	6.06	7.27	7.03	**6.79**	7.70	8.07	7.67	**7.81**	49.20	51.55	48.99	**49.91^{b}**
30	47.50	44.50	43.53	45.18^{bc}	1394.33	1410.33	1397.36	**1400.67**	6.33	7.13	6.37	**6.61**	7.60	7.80	7.27	**7.56**	53.35	54.76	51.01	**53.04^{b}**
60	49.07	46.43	46.63	47.38^{a}	1370.20	1397.33	1364.36	**1377.29**	6.63	7.00	6.60	**6.74**	7.77	7.87	7.13	**7.59**	62.21	63.01	57.14	**60.79^{a}**
90	51.40	44.17	45.13	46.90^{ab}	1356.00	1333.67	1344.36	**1344.67**	6.13	7.13	6.20	**6.49**	7.53	7.97	7.07	**7.52**	51.98	54.97	48.76	**51.90^{b}**
Mean	**48.69^{a}**	**44.74^{b}**	**44.77^{b}**		**1368.38**	**1383.75**	**1367.92**		**6.29^{b}**	**7.13^{a}**	**6.55^{b}**		**7.65^{ab}**	**7.93^{a}**	**7.28^{b}**		**54.19^{ab}**	**56.07^{a}**	**51.48^{b}**	
LSD%	P=1.89* O=2.31**				P=ns O=ns				P=ns O=0.54**				P=ns O=0.52**				P=4.20** O=3.64**			
2017																				
0	46.10	43.63	45.63	45.12	1337.33	1365.67	1333.00	**1345.33**	6.53	7.17	6.37	**6.69**	7.80	8.57	7.73	**8.03**	49.84	54.74	49.42	**51.33^{b}**
30	48.60	45.03	43.33	**45.66**	1355.00	1402.00	1378.67	**1378.56**	6.27	7.10	6.77	**6.71**	7.57	7.67	7.37	**7.53**	53.04	53.74	51.64	**52.81^{b}**
60	48.80	48.13	46.03	**47.66**	1359.67	1375.67	1345.67	**1360.33**	6.70	7.07	6.53	**6.77**	7.87	7.63	7.23	**7.58**	62.93	61.07	59.31	**61.10^{a}**
90	50.13	44.90	44.97	**46.67**	1363.67	1344.33	1332.33	**1346.78**	6.70	7.17	6.33	**6.73**	7.40	7.83	7.13	**7.46**	50.32	53.27	48.51	**50.70^{b}**
Mean	**48.41^{a}**	**45.43^{b}**	**44.99^{b}**		**1353.92**	**1371.92**	**1347.42**		**6.55^{b}**	**7.13^{a}**	**6.50^{b}**		**7.66^{ab}**	**7.93^{a}**	**7.37^{b}**		**54.03**	**55.7**	**52.22**	
LSD%	P=ns O=2.63**				P=ns O=ns				P=ns O=0.43*				P=ns O=0.40*				P=4.39** O=ns			

*and ** means significant difference at P<0.05 and P<0.01 respectively.
ns: none significant
O: Origin and P: Phosphate

Table 4. (Continue) Means of studied characters of anise populations at different phosphorus fertilizer treatments

Phosphate treatment (kg ha-1)	Seed yield(kg ha^{-1})				1000 seed weight (g)				Essential oil content (%)				Essential oil yield (L ha^{-1})			
	Origins															
	Turkey	**Spain**	**Syria**	**Mean**	**Turkey**	**Spain**	**Syria**	**Mean**	**Turkey**	**Spain**	**Syria**	**Mean**	**Turkey**	**Spain**	**Syria**	**Mean**
2016																
0	627.33	779.00	825.67	**744.00**	2.70	2.87	2.76	**2.78^{c}**	2.67	2.73	2.57	**2.66b**	16.74	21.32	21.18	**19.75c**
30	621.67	779.33	857.00	**752.67**	3.07	3.21	2.99	**3.09^{ab}**	2.97	3.03	2.90	**2.97b**	18.46	23.60	24.85	**22.30b**
60	654.33	787.00	862.00	**767.78**	3.20	3.50	3.22	**3.31^{a}**	3.48	3.60	3.40	**3.49a**	22.74	28.32	29.36	**26.81a**
90	628.67	759.00	829.50	**739.06**	2.67	3.06	2.98	**2.90^{bc}**	2.70	2.87	2.50	**2.69b**	16.94	21.73	20.69	**19.79c**
Mean	**633.0^{c}**	**776.08^{b}**	**843.54^{a}**		**2.91^{b}**	**3.16^{a}**	**2.99^{ab}**		**2.95ab**	**3.06a**	**2.84b**		**18.72b**	**23.74a**	**24.02a**	
LSD%	P=ns O=3.20**				P=0.25** O=0.22**				**P= 0.39** O= 0.18****				**P= 2.44** O=1.87****			
2017																
0	630.33	759.00	825.33	738.22	2.60	2.81	2.67	**2.69c**	2.67	2.70	2.53	**2.63bc**	16.81	20.49	20.93	**19.41**
30	635.00	784.67	842.67	**754.11**	3.12	3.23	2.94	**3.10ab**	2.77	3.10	2.90	**2.92b**	17.54	24.29	24.47	**22.1**
60	643.00	793.00	854.33	**763.44**	3.20	3.54	3.24	**3.32a**	3.37	3.53	3.37	**3.42a**	21.63	28.00	28.75	**26.13**
90	669.67	749.00	814.00	**744.22**	2.64	3.06	2.91	**2.87bc**	2.60	2.83	2.40	**2.61c**	17.41	21.25	19.58	**19.41**
Mean	**644.50c**	**771.42b**	**834.08a**		**2.89b**	**3.16a**	**2.94b**		**2.85b**	**3.04a**	**2.80b**		**18.35b**	**23.51a**	**23.43ab**	
LSD%	P=ns O=4.28**				P=0.31** O=0.20*				P= 0.31** O= 0.19**				P=ns O=7.45*			

*and ** means significant difference at P<0.05 and P<0.01 respectively.
ns: none significant
O: Origin and P: Phosphate

The number of branches and number of umbels per plant were not significantly affected by different phosphorus doses in the year of 2016 and 2017. However there was significant diversity among anise populations. The highest number of branches and umbels per plant was found in Spain anise population as 7.13 and 7.93, respectively, in both years. Kara (2015) reported that the number of branches varied from 6.8 to 9.1 per plant. Also, she reported that number of umbels ranged from 9.2 to 10.6 per plant. Zand et al. (2013), used phosphate solubilizing microorganisms (PSM) on anise seeds and plant. The results of the study indicated that PSM applications caused increasing number of umbel per plant (30.24-39.58). Acimovic et al. (2014) found that for number of umbel per plant was not significantly different between control and chemical fertilizer in Serbia condition. In this study, the number of umbel per plant varied between 15.67 and 18.33. Faravani et al. (2013) studied the effects of fertilizer and plant density on yield and quality of anise and they detected that number of umbels per plant and number of branches varied from 24.22 to 23.89 and 3.00-3.07 per plant, respectively. Also, Nabizadeh et al. (2012) pointed out that the effect of nitrogen and plant density were not significant for number of branch and number of umbel per plant. In another study, significant differences were found for number of umbel per plant among control and phosphorus fertilizer levels (0, 30 and 60 kg ha^{-1} respectively) in anise populations under Indian ecological conditions. For the number of umbel of plants the high values were obtained at both of the phosphorus treatments in comparison with the control group. The highest number of umbel per plant value was obtained from 30 kg ha^{-1} (46.06 number of umbel per plant) phosphorus treatment (Bhuvaneshwari et al., 2002). Arslan et al. (1999) studied the yield and yield components of different anise populations originated from Turkey. The number of branch changed between 5.13 and 8.33 per plant.

Faravani et al. (2013) and Nabizadeh et al. (2012) reported non-significant differences due to fertilizer use on the number of branch as it was the case in this study. The number of branches found in this study was higher than the ones obtained by Faravani et al. (2013) while the number of branch was found to be less than the ones attained by Nabizadeh et al. (2012). On the other hand, these results are in agreement with the findings of Kara (2015) and Arslan et al. (1999).

The numbers of umbels were found between 9.2 and 10.6 by Kara (2015). In 2013 while Zand et al. determined that the numbers of umbels varied between 30.24 and 39.58 per plant. This characteristic was found to be changing in a wide range since Acimovic et al. (2014) reported the number of umbels changed from 15.67 to 18.33 while Faravani et al. (2013) found that between 24.22 and 23.89. The numbers of umbels were stated as minimum 40.73 and maximum 46.06 by Bhuvaneshwari et al. (2002). Furthermore, increasing of phosphorus dosages caused an increase on the number of umbel per plant. These results support the trend as found in this study about influence of phosphorus fertilizer for number of umbel per plant (Zand et al., 2013 and Bhuvaneshwari et al., 2002).

Number of seeds per umbel was also affected by the phosphorus applications significantly. The highest value of number of seeds per umbel was obtained in 60 kg ha^{-1} phosphorus treatment as 60.79 and 61.10 per plant in 2016 and 2017 respectively. Significant differences among anise population for number of seeds per umbel in the first year were obtained. The highest number of seeds per umbel was obtained from the Spanish population. Statistical analysis indicated that there was no significant variation among different origins of anise populations in the second year of study. According to some previous studies, phosphorus had positive effect on generative period and seed maturity in cultivated crops (Kacar and Katkat, 2009). In this study, the phosphorus treatments positively affected the number of seed per umbel. The highest number of seeds per umbel was obtained at 60 kg ha^{-1} phosphorus treatment. On the other hand, non-significant effects of fertilizer treatment on the number of seed per umbel were reported by Acimovic et al. (2014); Nabizadeh et al. (2012) and Bhuvaneshwari et al. (2002). Zand et al. (2013) indicated that phosphorus fertilizer affected the number of seeds and the number of seed values ranged between 144.92 and 168.24 per umbel while Faravani et al. (2013) reported that number of seeds per umbels varied from 60.79 to 78.80 per umbels.

The increased phosphorus levels had positive effect on different anise populations. A significant increase was obtained for the number of seed per umbel in phosphorus treatment at 60 kg ha^{-1} and there was a similar result that declared by Faravani et al. (2013) for this characteristic in both years. Although, Zand et al. (2013) and Acimovic et al. (2014) reported higher values for the number of seeds per umbel than present study in Izmir ecological conditions.

In this study, the 1000-seeds weights were affected by different phosphorus doses. The highest 1000-seeds weights were obtained at 60 kg ha^{-1} phosphorus application in both years of this study and these values were 3.31 and 3.32 g in first and second years of research (Table 3). Also the statistical analysis indicated that anise populations had different behavior in 1000 seeds weight production. The highest 1000-seeds weight values were found in Spanish population as 3.16 g in both years. Generally, it is expected that seed weight inversely related with seed number per plant. But in this study, the phosphorus applications (between 0 and 60 kg ha^{-1}) caused to increase1000-seeds weight and number of seeds per umbel.

Acimovic et al. (2014) reported that there was not statistically difference for 1000-seeds weight. The 1000-seeds weight varied between 4.38-4.46 g and 3.87-3.92 g in first and second years of research. Also, in another study conducted under Isparta province ecological conditions and the 1000-seed weight were found between 3.04 and 3.63 g in the first year; 3.05-3.57 g the second year of study (Kara, 2015). Furthermore, the results of study about effect of fertilizer on 1000-seed weight of anise indicated that highest and lowest 1000-seed weight of anise were 3.44 and 3.88 g respectively (Faravani et al., 2013).

When the result of present study was compared for 1000-seeds weight with some previous studies, it could be seen that the mean values were found to be lower than those of Acimovic et al. (2014) and Faravani et al. (2013). The 1000-seeds weights conform to Kara (2015). In this research the results showed that there was an increase for 1000-seeds weight with enhancement of phosphorus dose until 60 kg ha^{-1} and 1000 seeds weight were decline in 90 kg ha^{-1} phosphorus level. This trend is in good agreement with Acimovic et al. (2014) results.

The means of seed yield were presented Table 4. There were significant differences among means of anise populations ($p<0.01$) in two years of the study. The maximum seed yield was obtained from Syrian population as 843.54 and 834.08 kg ha^{-1} in the first and the second years of research, respectively. However, in presented studied, phosphorus treatments not significantly affected seed yields, it could be said that increasing phosphorus doses from 0 to 60 kg ha^{-1} caused a slight increase for seed yield. A previous research of anise indicated that the seed yield was affected by phosphorus treatments (Bhuvaneshwari et al., 2002). The results of study indicated that the phosphorus fertilizer caused to increase seed yield. So, the seed yields in phosphorus levels were higher than control group. They found that the seed yields were 421, 461 and 484 kg ha^{-1} in control, 30 and 60 kg ha^{-1} phosphorus levels, respectively. Furthermore, there was a gradual increase trend in seed yield with increasing levels of phosphorus. In another research, the seed yields were found as 1371.04 (control) 1911.78 kg ha^{-1}(chemical fertilized) and 1292.99-1565.49 kg ha^{-1}in control and chemical fertilized groups in the first and second years of study, respectively (Acimovic et al., 2014). Kara (2015) reported that the anise plant seed yields changed between 60.00 and 533.30 kg per hectare in the first year, while these values were 113.20-600.00 kg ha^{-1} in the second year of study. Furthermore, Nabizadeh et al. (2012) mentioned the seed yield of anise were 179.10 in control group and 1286.40 in chemical fertilizers group. Zand et al. (2013), reported that the anise seed yields were 630.35 kg ha^{-1} in control and in PSM (phosphate solubilizing microorganisms) application 907.26 kg ha^{-1} in Iran ecological conditions. Also, Faravani et al. (2013) obtained significant differences for anise seed yield among different fertilizer levels. These values were 403.68 and 370.80 kg ha^{-1} in control and fertilized treatments, respectively.

The means of seed yields in this research were higher than those of Kara (2015); Faravani et al. (2013) and Bhuvaneshwari et al. (2002) and lower than those of Acimovic et al. (2014). Also, our results were in agreement with results from Zand et al. (2013) and Nabizadeh et al. (2012). Generally, results of previous studies showed that the phosphorus treatments increased the seed yields similar to present study (Zand et al., 2013 and Bhuvaneshwari et al., 2002).

The means from the essential oil content (EO) and essential oil yield (EOY) are given in Table 3. The various phosphorus treatments had highly significant effect ($p<0.01$) on essential oil content in both years. The maximum essential oil ratios were obtained from the 60 kg ha^{-1} phosphorus dose as 3.49% and 3.42% in both years, respectively. Also, essential oil contents were affected ($p<0.01$) by origin of the anise seed. In experiment of two years, origins of the Spanish anise seeds had the highest essential oil ratio as 3.06% and 3.04%, respectively. The essential oil yields were affected significantly ($p<0.01$) by phosphorus treatments and the highest essential oil yield was obtained from 60 kg ha^{-1} phosphorus dose as 26.81 L ha^{-1}in first year. The highest essential oil yields were obtained from Syrian anise seed (24.02 L ha^{-1}) and Spanish anise seed (23.74 L ha^{-1}) in 2016. In the second year of study it was observed that the essential oil yield was significantly influenced by different origins of anise seed. The anise populations of Spanish (23.51 L ha^{-1}) and Syrian (23.43 L ha^{-1}) had nearly similar essential oil yield values.

Several studies have shown that fertilizer applications had increased essential oil content (Radosav et al., 2012; Faravani et al., 2013 and Acimovic et al., 2015). Radosav et al. (2012). The anise EO to be 2.49% in control while with fertilizer of NPK (400 kg ha^{-1} the same rate of each nutrient) it was obtained as 3.28%. Faravani et al. (2013) reported that anise EO was 3.78% in control and NPK (60 kg ha^{-1} the same rate of each nutrient) application was increased to 4.10%. Acimovic et al. (2014) indicated the influence of NPK (15:15:15) application on anise seed in Serbia conditions. They found that EO changed from 3.64% (in control) to3.85 % (fertilizer app.). Khalid (2015) and Bhuvaneshwari et al. (2002) published that EO and EOY values increased with phosphorus applications. In the study of Bhuvaneshwari et al (2002), EO was 2.59% in control but it was found as 2.90% with P_2O_5 (60 kg ha-1 phosphorus) treatment. Althoug the EOY value was 10.94 L ha^{-1} in zero phosphorus application had as 14.07 in 60 the kg ha^{-1} phosphorus dose. Khalid (2014) reported that with different P_2O_5 treatments the essential oil ratio changed from 2.1% in control to 3.3% in 75 kg ha^{-1} phosphorus doses and same trend was observed for essential oil yields. When the result of EO and EOY values were considered in this study, increase in P_2O_5 dose increased both EO and EOY up to 60 kg ha^{-1} phosphorus dose. This trend was in agreement with Bhuvaneshwari et al. (2002) and Khalid (2014). But EOY was found in present research to be higher than that of Bhuvaneshwari et al. (2002). It could be said that this was due to from the different genetic materials and ecological conditions.

CONCLUSIONS

The followings conclusion could be drawn for the discussions.

- Agro-morphological characteristics such as number of branch, number of umbels per plant, number of seeds per umbel, 1000-seeds weight, essential oil content and essential oil yields were obtained the highest values from Spanish population in Izmir province ecological conditions.

- Spanish anise population was identified as superior population among evaluated populations. Although, the highest seed yield was obtained from Syrian population.

- The optimum doses of phosphorus was 60 kg ha^{-1} for highest number of seeds per umbel, 1000-seed weight and essential oil content in both years under Izmir ecological conditions.

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