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The Effects of Differences such as Variety, Region and Plant Density on the Relationship between Grain Quality Criteria in Faba Bean

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Quality criteria,
Starch

Abstract: In this study, two varieties of faba beans were grown in two different locations at three different plant densities and their grain quality criteria were examined. As a result, the ash, oil, moisture, protein, starch and hundred grain weight (HGW) values of the faba beans varied between 3.44-3.76%, 1.16-1.70%, 10.63-11.58%, 25.71-31.15%, 37.86-44.75% and 97.53-157.50 g respectively. In correlation analysis, the highest interaction between moisture and oil; between protein and ash, oil and moisture; and between HGW and oil, moisture. In addition, it was determined that the significance level of the interaction among properties varies in terms of factors. PCA results, it was noted that each location formed separate groups. In general, all the features in Sanli-Urfa location were high and positive. In terms of varieties, the data of all properties except HGW were statistically the same, while the HGW value was high in Salkim variety. The distance row spacings significantly affected the starch and HGW properties, the highest values in terms of starch and HGW were obtained between the 60 cm and 50 cm row spacings respectively. According to these results, it was understood that the varieties and plant densities used significantly affected the quality criteria according to the locations.

Baklada Çeşit, Bölge ve Bitki Yoğunluğu gibi Farklılıkların Tane Kalite Kriterleri Arasındaki İlişkiye Etkileri

Anahtar Kelimeler
Korelasyon analizi,
Temel bileşenler analizi,
Protein,
Kalite kriterleri,
Nişasta

Öz: Bu çalışmada, iki çeşit bakla iki farklı lokasyonda üç farklı bitki yoğunluğunda yetiştirilmiş ve tane kalite kriterleri incelenmiştir. Sonuç olarak baklagillerin kül, yağ, nem, protein, nişasta ve yüz tane ağırlığı (HGW) değerleri sırasıyla %3.44-3.76, %1.16-1.70, %10.63-11.58, %25.71-31.15, %37.86-44.75 ve 97.53-157.50 g arasında değişmiştir. Korelasyon analizinde, nem ile yağ; protein ile kül, yağ ve nem; yüz tane ağırlığı ile yağ ve nem arasında önemli etkileşim gözlenmiştir. Ayrıca, özellikler arası etkileşimin anlamlılık düzeyinin faktörlere göre farklılık gösterdiği belirlenmiştir. PCA sonuçlarında, her lokasyonun ayrı gruplar oluşturduğu kaydedilmiştir. Genel olarak Şanlı-Urfa lokasyonunda tüm özellikler yüksek ve olumlu bulunmuştur. Çeşitler açısından yüz tane ağırlığı dışındaki tüm özelliklerin verileri istatistiksel olarak aynı iken, yüz tane ağırlığı değeri Salkım çeşidinde yüksektir. Sıra arası mesafeler nişasta ve HGW özelliklerini önemli ölçüde etkilemiş, nişasta ve HGW açısından en yüksek değerler sırasıyla 60 cm ve 50 cm sıra aralıkları arasında elde edilmiştir. Bu sonuçlara göre, kullanılan çeşitlerin ve bitki yoğunluklarının lokasyonlara göre kalite kriterlerini önemli ölçüde etkilediği anlaşılmıştır.

1. Introduction

Faba bean is used as a source of protein in human nutrition, as a forage and fodder crop for animals [1]. It plays an important role in the renewal of soil fertility as a suitable rotation product by fixing the free nitrogen in the atmosphere; thus, it saves money by causing less fertilizer use for small scale farmers [2].

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Therefore, it is a very valuable legume crop due to its benefits such as improving soil health, reducing diseases, reducing insect pests and weed formation, contributing to the sustainability and diversification of crop systems [3]. It is also included in crop rotation for green manure production or with cereal crops [4].

It is generally accepted that faba bean seed has a long history of use in human food or animal feed due to its high quality nutritional value [3]. Faba beans have been confirmed to be rich in protein and other nutrient contents [5]. However, the starch, protein and fiber contents of faba bean seeds have been exhibited a large genetic variability depending on genotypes. [6]. Plant based proteins have created an alternative to animal derived proteins as a sustainable protein source [7]. In recent years, the trend of consumer has turned to increasing consumption of plant based proteins [8]. Faba beans contain many nutritional compounds such as carbohydrates (starch, sugars, dietary fibers), proteins and amino acids, polyphenols (flavonoids, tannins), alkaloids, terpenoids, jasmonates, organic acids, nucleosides / nucleotides [9]. On the other hand, faba beans are low in terms of sodium and fat, free of cholesterol [10].

Differences in protein concentration may be a result of variety, climate, and cultural processes [7]. Increasing global temperatures and more irregular climate conditions seriously affect legumes [11]. Vicia faba is resistant to lower temperatures than other grain legumes [12]. Therefore, grain legumes are grown especially in conditions of seasonal weather fluctuations such as rainfall and temperature [13]. It is also a source of cash to farmers and foreign currency to the country and serves as a "break" to pests and restores soil fertility when grown in rotation with cereals and other crops [14]. As a long day plant, faba bean grows better in cool climates [3], flowering and seed filling periods, in watery conditions [15]. However, when the faba bean is exposed to biotic and abiotic stresses (soil acidity and others), the average yield decreases [16]. For this reason, in faba bean cultivation, the area grown, the variety used, the climatic conditions, the plant density and cultural processes are very important to obtain high quality and high yield.

In this study, faba bean, which is an important plant in many aspects, was investigated in terms of varieties, locations and plant densities. Thus, the effects of these factors on grain quality were tried to be determined.

2. Material and Method

The study was conducted both Kahramanmaras (K) and Sanliurfa (U) locations in 2017. In the study, 2 cultivars [Salkim (S) and Fontes (F)] supplied from a commercial company. The experiment was analyzed according to the divided plots pattern in random blocks repeated in different places and in factorial order with 4 replications. Sowing in Kahramanmaraş conditions on January 24, 2017, harvest on June 6, 2017; In Şanlıurfa, the sowing was done on 25 January 2017 and the harvest was on 26 May 2017. Row spacing were determined as 40 cm (1), 50 cm (2) and 60 cm (3) and also intra-row distance was determined 10 cm. And the plots were constituted as 4 rows.

Soil samples belonging to the trial sites were taken from 0-30 cm depth to represent the whole area and analyzed according to Kara et al. [17] (Table 1). According to Table 1, the soil of the trial area in Kahramanmaras was composed that it is very low in organic matter, high in potassium and phosphorus content. The texture of soil was sandy-clay loam, pH was light alkaline near neutral. Other hands, the soil of the trial area in Sanliurfa was composed with medium in organic matter, very high in potassium and low in phosphorus content. The texture of soil was Clayey-loam, pH was light alkaline near neutral.

Some climate data in experiment areas were given in Table 2. The Kahramanmaras region has characteristic temperature and humidity of the mediterrenean climate. But the Sanlıurfa region has characteristic of the terrestrial climate. Temperature and humidity values of vegetation period were lower to the Sanliurfa region, and temperature values were higher to Kahramanmaras. However, the rainfall was erratic and inadequate compared with the long years average.

All traits investigated on grains collected from per plot. Ash, oil, moisture protein and starch in grain and hundred grain weight were measured, means and standard deviations values were calculated. The values obtained were subjected to variance analysis according to the randomized complete block design using the SAS package program, and differences between means were tested at 1% significance level according to Duncan multiple comparison method. Also, these values were first subjected to correlation analysis Using a Pearson correlation model imlemented in the SPSS package program. A Principal

Table 1. Properties of soil in the study area

Location	Structure		pH		Organic matter %		Phosphorus (P_2O_5) kg/da		Potassium (K_2O) kg/da	
	Values	Comment	Values	Comment	Values	Comment	Values	Comment	Values	Comment
Kahramanmaras	32.1	Sandy-clay loam	7.60	Light Alkali	0.73	Very low	11.4	High	50.40	High
Sanlıurfa	56.1	Clayey-loam	7.78	Light Alkali	2.50	Medium	3.73	Low	119.72	Very high

Table 2. Some climate values of belonging to the Kahramanmaras and Şanlıurfa provinces covering the research season

	Rainfall (mm)				Average Temperature (°C)				Relative Humidity (%)			
	Kahramanmaraş		Şanlıurfa		Kahramanmaraş		Şanlıurfa		Kahramanmaraş		Şanlıurfa	
	2017	Long years average	2017	Long years average	2017	Long years average	2017	Long years average	2017	Long years average	2017	Long years average
January	126.7	129.3	9.0	85.7	3.8	4.9	5.4	5.7	65.9	70.2	61.9	70.3
February	3.7	112.8	1.8	71.4	7.4	6.6	7.7	7.0	44.0	66.4	60.1	66.9
March	74.5	97.5	55.2	64.1	12.2	10.8	12.7	11.0	55.4	60.4	57.1	60.4
April	67.8	73.4	79.2	46.8	15.8	15.5	16.6	16.2	49.0	58.0	50.2	56.2
May	105	40.6	7.2	28.1	19.6	20.3	22.9	22.3	55.0	54.5	39.0	44.9
June	3.1	6.8	0.0	3.6	26.4	25.2	29.7	28.2	42.9	49.1	27.0	32.8
Total	380.8	460.4	152.4	299.7	85.2	83.3	95.0	90.4	312.2	358.6	295.3	331.5
Mean	55.2	76.7	25.4	49.95	14.2	13.9	15.8	15.1	52.0	59.8	49.2	55.25

Referances: [18; 19]

Component Analysis (PCA) on the investigated traits was carried out conssidering the overall mean values of both region using the PCORD 6 program.

3. Results

The two faba bean varieties were grown as three different row spacing in two different locations. As a results of the study, the grain quality characteristics of beans were measured. According to this, the means and standard deviation values of examined features were shown Table 3, and differences between means of examined features according to Duncan test and distribution to groups were shown Table 4.

The ash values were changes between 3.44 to 3.76%. The highest ash was determined in UF1 and the lowest one was observed KF3. However, the difference between locations was statically significant, other hand, difference between varieties and row spaces were not significant ($p>0.05$). The oil values were change between 1.16 (KF3) to 1.70 % (UF3). Oil had a significant variation among locations. But, differences the terms of varieties and row space were not significant.

The values obtained in terms of moisture content varied between 10.63 to 11.58%. The lowest of these values was obtained from KF2 with 10.63, while the highest value was obtained from UF2 with 11.58. The moisture contents were found to significantly differ between locations ($p<0.01$). On the other hand, the values obtained in terms of protein content varied between 25.71 to 31.15% and were found to significantly differ between locations ($p<0.01$). The lowest of these values was obtained from KS2 with 25.71, while the highest value was obtained from UF1 with 31.15.

Table 3. The means and standard deviation values of examined features

Location	Variety	RS	Ash		Oil		Moisture		Protein		Starch		HGW	
K	S	1	3.67	±0.20	1.18	±0.09	10.94	±0.39	28.15	±2.61	**37.86**	±3.62	118.27	±12.34
K	S	2	3.57	±0.23	1.22	±0.08	10.86	±0.18	**25.71**	±1.78	40.31	±4.56	134.42	±15.41
K	S	3	3.52	±0.04	1.29	±0.05	10.81	±0.21	26.52	±0.47	43.37	±0.47	122.52	±18.14
K	F	1	3.48	±0.09	1.18	±0.08	10.78	±0.20	28.18	±0.86	42.08	±1.01	102.96	±4.74
K	F	2	3.55	±0.11	1.23	±0.13	**10.63**	±0.33	27.99	±1.09	42.36	±0.73	109.78	±4.06
K	F	3	**3.44**	±0.03	**1.16**	±0.03	10.96	±0.09	27.81	±0.62	43.90	±0.60	**97.53**	±13.46
U	S	1	3.68	±0.09	1.63	±0.07	11.40	±0.18	30.12	±1.40	43.74	±1.57	142.50	±11.90
U	S	2	3.73	±0.12	1.62	±0.21	11.47	±0.18	29.94	±0.73	44.22	±1.61	**157.50**	±18.20
U	S	3	3.70	±0.12	1.59	±0.16	11.49	±0.10	30.53	±0.81	44.45	±1.39	142.50	±15.00
U	F	1	**3.76**	±0.22	1.59	±0.12	11.56	±0.29	**31.15**	±0.37	43.08	±2.85	121.25	±14.93
U	F	2	3.74	±0.13	1.59	±0.25	**11.58**	±0.23	30.52	±1.36	43.51	±2.22	128.75	±8.54
U	F	3	3.69	±0.08	**1.70**	±0.11	11.50	±0.24	29.98	±0.97	**44.75**	±1.37	126.25	±11.09

K: Kahramanmaras; U: Sanliurfa; S: Salkim; F: Fontes; RS: Row space; HGW: Hundred grain weight

Table 4. Differences between means of examined features according to Duncan test and distribution to groups

	Ash	Oil	Moisture	Protein	Starch	HGW
Location	14.67**	248.88**	99.23**	87.41**	7.81*	66.17**
Kahramanmaras	3.54 b	1.21 b	10.83 b	27.39 b	41.65 b	114.25 b
Sanlıurfa	3.72 a	1.62 a	11.50 a	30.37 a	43.96 a	136.46 a
Variety	0.55	0.34	0.02	5.91	1.35	64.13**
Salkim	3.65	1.42	11.16	28.49	42.32	136.29 a
Fontes	3.61	1.41	11.17	29.27	43.28	114.42 b
Row Spacing	1.24	0.31	0.24	2.98	8.41**	3.86*
40 cm	3.65	1.39	11.17	29.40	41.69 b	121.25 b
50 cm	3.65	1.41	11.13	28.54	42.60 b	132.61 a
60 cm	3.59	1.43	11.19	28.71	44.12 a	122.20 b

The starch values of grain were changes between 37.86-44.75 %. The highest starch was determined in UF3 and the lowest one was observed KS1. However, the difference between locations were statically significant ($p<0.05$) and the difference between row spaces were statically significant ($p<0.01$). The other hand, difference between varieties were not significant ($p>0.05$). The HGW values were change between 97.53 (KF3) to 157.50 g (US2). HGW had a significant variation among locations and varieties ($p<0.01$). But, differences the terms of row space were significant ($p<0.05$).

3.1. Correlation analysis

The correlation coefficients between the quality traits for all factors and general means are reported in Table 5. Protein values showed a high correlation (r= 0.79**) with moisture values in terms of 60 cm row spacing. Also, oil values had a positive significant correlation with ash values of Fontes variety (r=0.55**), 60 cm row space (r= 0.61*) and means of all factors (r= 0.35*) but oil values had negative significant correlation with ash values of Sanliurfa lacation (r= -0.62**). Moisture values had a positive significant correlation with ash values of Fontes variety (r=0.53**), 60 cm row space (r= 0.78**) and means of all factors (r= 0.37**) but oil values had negative significant correlation with ash values in Kahramanmaras location (r= -0.57**). Moisture value had a positive significant correlation with oil values in terms of Salkim variety (r=0.58**), Fontes (r= 0.55**), 20 cm row space (r= 0.59*), 60 cm row space (r= 0.67**) and means of all factors (r= 0.56**) but moisture values had negative significant correlation with oil values in terms of Kahramanmaras (r= -0.59**) and Sanliurfa location (r= -0.60**).

Table 5. Correlation coefficients among the quality traits of faba bean on mean data each factor and means of all factors.

Characters	Factors	Ash	Oil	Moisture	Protein	Starch
Oil	Kahramanmaras	0.14				
	Sanliurfa	-0.62**				
	Salkim	0.10				
	Fontes	0.55**				
	20 cm	0.37				
	40 cm	0.20				
	60 cm	0.61*				
	Means of all factors	0.35*				
Moisture	Kahramanmaras	-0.57**	-0.59**			
	Sanliurfa	0.34	-0.60**			
	Salkim	0.17	0.58**			
	Fontes	0.53**	0.55**			
	20 cm	0.13	0.59*			
	40 cm	0.40	0.47			
	60 cm	0.78**	0.67**			
	Means of all factors	0.37**	0.56**			
Protein	Kahramanmaras	0.45*	-0.16	-0.38		
	Sanliurfa	0.14	0.15	0.08		
	Salkim	0.68**	0.64**	0.49*		
	Fontes	0.63**	0.76**	0.69**		
	20 cm	0.51*	0.69**	0.39		
	40 cm	0.68**	0.62*	0.54*		
	60 cm	0.69**	0.73**	0.79**		
	Means of all factors	0.61**	0.65**	0.55**		
Starch	Kahramanmaras	-0.85**	0.08	0.03	-0.46*	
	Sanliurfa	-0.85**	0.38	-0.19	-0.23	
	Salkim	-0.44*	0.62**	0.62**	0.05	
	Fontes	-0.32	0.34	0.28	0.07	
	20 cm	-0.43	0.49	0.59*	0.13	
	40 cm	-0.40	0.49	0.43	0.09	
	60 cm	-0.02	0.61*	0.30	0.44	
	Means of all factors	-0.38**	0.46**	0.44**	0.09	
HGW	Kahramanmaras	0.22	0.06	0.17	-0.43*	-0.28
	Sanliurfa	-0.07	0.19	-0.23	-0.15	0.03
	Salkim	0.18	0.51*	0.51*	0.32	0.32
	Fontes	0.60**	0.74**	0.61**	0.61**	0.12
	20 cm	0.18	0.63**	0.55*	0.08	0.30
	40 cm	0.38	0.45	0.38	0.37	-0.01
	60 cm	0.56*	0.59*	0.58*	0.38	0.21
	Means of all factors	0.36*	0.53**	0.45**	0.24	0.12

* Significant at $p<0.05$; ** Significant at $p<0.01$.

The grain protein values had a positive significant correlation with ash values in terms of Kahramanmaras location (r= 0.45*), Salkim (r= 0.68**), Fontes verieties (r= 0.63**), 20 cm row space (r= 0.51*) 40 cm row space (r= 0.68**), 60 cm row space (r= 0.69**) and means of all factors (r= 0.61**). Protein values had a positive significant correlation with oil values in terms of Salkim (r= 0.64**), Fontes varieties (r= 0.76**), 20 cm row space (r= 0.69**), 40 cm row space (r= 0.62*), 60 cm row space (r= 0.73**) and means of all factors (r= 0.65**). Protein values had a positive significant correlation with moisture values in terms of Salkim (r= 0.49*), Fontes varieties (r= 0.69**), 40 cm row space (r= 0.54*), 60 cm row space (r= 0.79**) and means of all factors (r= 0.55**).

The grain starch values showed a lowest correlation (r= -0.85**) with ash values in terms of Kahramanmaras and Sanliurfa locations. Also, starch values had a positive significant correlation with oil values in terms of Salkim (r=0.62**) and means of all factors (r= 0.46**); with moisture values in terms of Salkim variety (r= 0.62**) and means of all factors (r= 0.44**). But starch values had negative significant correlation with ash values in terms of Salkim variety (r= -0.44*) and means of all factors (r= -0.38**); with protein values in terms of Kahramanmaras location (r= -0.46*).

The HGW had a positive significant correlation with ash values in terms of Fontes (r= 0.45*), Salkim varieties (r= 0.68**), Fontes variety (r= 0.63**), 20 cm row space (r= 0.51*) 40 cm row space (r= 0.60**), 60 cm row space (r= 0.56*) and means of all factors (r= 0.36*); with oil values of Salkim (r= 0.51*), Fontes varieties (r= 0.74**), 20 cm row space (r= 0.63**), 60 cm row space (r= 0.59*) and means of all factors (r= 0.53**). HGW had a positive significant correlation with moisture values of Salkim (r= 0.51*), Fontes varieties (r= 0.61**), 20 cm row space (r= 0.55*), 60 cm row space (r= 0.58*) and means of all factors (r= 0.45**); with protein values of Fontes variety (r= 0.61**). But HGW had negative significant correlation with protein values in terms of Kahramanmaras location (r= -0.43*).

3.2. Principal component analysis

The first three principal components (PCs) computed for the quality traits explained about 97% of the total variation among the traits evaluated (Figure 1 and Table 6). Oil and moisture were the important variables, and contributed largely to the first principal component (PC1; -0.979 and -0.963, respectively), explaining 71 % of the total variation.

The values of the investigated characteristics showed significant differences in both Sanliurfa and Kahramanmaras locations. However, it has been determined that the values of Sanliurfa location are higher than those of Kahramanmaras location. When the applications of the study were evaluated in terms of quality characteristics, moisture, oil and protein properties came to the fore in UF1, UF2 and US1 applications in order of importance. The application is protein, oil and moisture, whose importance is US3; Among other applications, it has been noted that starch and protein, respectively, of UF3, and ash, moisture and HGW properties of US2 are dominant.

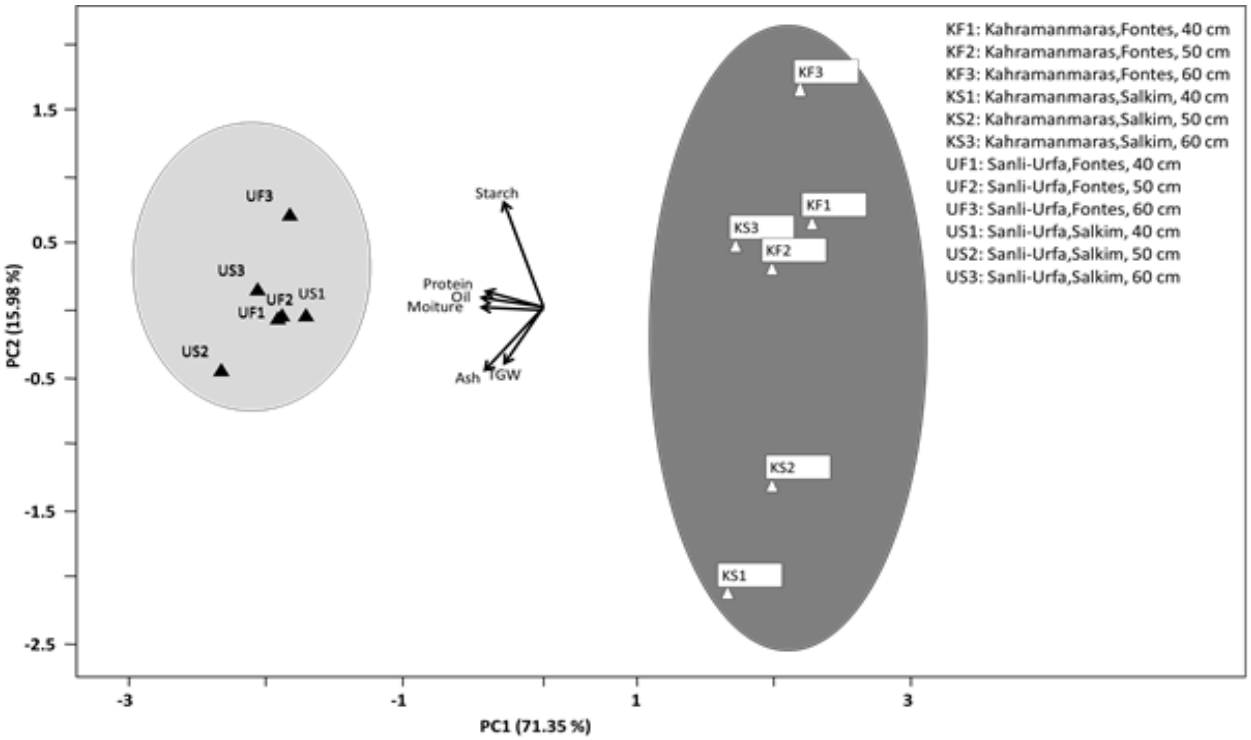

Figure 1. Principal component graph of quality traits based on the all of the factors.

Table 6. Principal component analysis factor loadings (PC1, PC2, and PC3) among the quality traits of faba bean based on the mean data of the each factor and means of all factors.

Traits	PC1	PC2	PC3
Ash	-0.875	-0.429	-0.173
Oil	-0.979	0.079	0.075
Moisture	-0.963	0.023	-0.125
Protein	-0.884	0.133	-0.402
Starch	-0.580	0.768	0.262
HGW	-0.715	-0.401	0.562
Standard deviation	4.281	0.959	0.597
Propotion of variance	71.347	15.982	9.955
Cumulative proportion	71.347	87.329	97.284

On the other hand, KF3 application attracted attention in terms of starch, KF1, KF2 and KS3 applications in order of importance in terms of protein, starch and oil properties. Among the remaining applications, KS2 was found to be higher in terms of HGW and ash properties, respectively, while KS1 application had higher ash and HGW properties.

The second component (PC2) accounted for 16% of the total variation and differentiated the accessions by starch and protein (0.768 and 0.133, respectively). The third component (PC3) explained an additional 10% of the total variation and was attributed HGW for positive loadings (0.562) and protein for negative loadings (−0.402).

4. Discussion and Conclusion

In this study, the quality performance of two faba bean varieties were investegated to grown three different row spacing in two different locations. When the results obtained were evaluated, it was seen that different locations caused significant differences in terms of all traits even for the same cultivars. It has been understood that these differences are mainly due to the differences in the soil structure as well as the climate. On the other hand, the reaction of varieties to environmental factors also causes differences.

Regarding the ash and moisture contents of the faba bean grain, Yıldız [20] determined 4.0-6.7% and 12.1-12.6% respectively, while Baloch et al. [21] reported that it varied between 3.7-3.8% and 7.5-9.5%. The fat content has been measured by Baloch et al. [21] 1.7-2.1% and Ksiezak et al. [22] determined it as 1.3-1.8% in faba bean. In this study, in which the differences between variety, location and row were examined, it was observed that the ash, oil and moisture contents obtained were compatible with previous studies. Sarah et al. [23] reported that the content of proteins, carbohydrates, ash, fat, and fibre depends on a cultivar.

Starch concentrations are the dominant and significant component of faba bean and it was determined in the previous studies that the starch concentration varied between 39-42% [24; 25]. Our findings were equal to or even slightly higher than these values. However, some researchers also obtained values such as 12.6-34.9% [20] and 12.4-40.5% [26] in their studies. These results were found to differ according to the varieties used, the regions where they were grown and different cultural practices. Furthermore, Mekkei [27] stated that regardless of a variety, large faba bean seeds contain more protein and carbohydrates.

Another important component after starch is protein. In previous studies, it was reported that during seed development, faba beans can accumulate up to 25-35% of protein in dry seeds [28; 15]. In some other studies, protein contents 19.9-26.8% [20], 27.5-33.4% [26], 21.6-22.4% [21] and 26.4-29.2% [22] was determined. It has been determined that the protein values of this study were showed different according to cultivar and enviromental.

In this study, it was seen that the HGW value, which is an important reference in determining yield and quality, ranged between 114.3-136.5 g. Other researchers reported the HGW values as 25.3-64.8 g [20], 62.3-97.0 g [29] and 59.9-187.9 g [30]. It has been observed that the values obtained from other studies except Turkeri [30] study are quite low compared to this study. It was recognized that HGW were affected by the variety characters as well as environmental.

According to Hendawey and Younes [31], the differences between faba bean cultivars resulted from both genetic and environmental factors. Musalam et al. [32] studied the chemical composition of pod seeds under soil irrigation conditions. They found that such seeds had higher protein, ash and fiber content but significantly lower fat and carbohydrate content. Pisulewska et al. [33] found a strong correlation between oil content in seeds and weather conditions during the growing season.

It has been determined that the correlation values of the examined quality characteristics of faba bean beans vary depending on the factors. It has been observed that the most and important differences are between moisture and oil, protein and ash, oil and moisture, HGW and oil and moisture. In some studies, they stated that the nutritional value of legume seeds is variable and depends on a number of factors such as

variety, environmental and agrotechnical factors (growing conditions, fertilization) [34-36].

As a result of research, it has been observed that the values of all properties are high in Sanli-Urfa location. The difference of the varieties used only caused a significant difference in the HGW feature and it was determined that the Salkim variety got a higher HGW value than the Fontes. It was noted that row spacing significantly affected starch and HGW properties, the highest starch value was obtained from 60 cm row spacing and the highest HGW value was obtained from 50 cm row spacing.

When the correlation values between features are examined, it was also determined that it varies depending on the factors. The PCA results revealed the importance of location difference by separating the samples into two different groups. The samples within the groups are positioned according to their dominance in terms of quality criteria. It has been observed that all these differences and distributions vary between locations depending on the climate and soil structure, and the effect of higher temperatures in Sanli-Urfa location has positive results in quality parameters. Differences in varieties and plant densities have caused changes in the proportions of quality components in the grain.

The study also revealed that the obtained data can be analyzed with different statistical programs and methods, correlation analysis can not only be done on different genotypes, but also the effects of environmental and cultural processes can be investigated. It was determined that PCA application can not only be performed in genotype x environment interaction, but also can be analyzed by adding factors such as plant density. In fact, it has been clearly observed that making these analyzes as used in our study can evaluate multiple factors on a single platform, and it is concluded that a better evaluation will be made.

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Declaration of Ethical Code

In this study, we undertake that all the rules required to be followed within the scope of the "Higher Education Institutions Scientific Research and Publication Ethics Directive" are complied with, and that none of the actions stated under the heading "Actions Against Scientific Research and Publication Ethics" are not carried out.

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