Pak. J. Agri. Sci., Vol. 57(2), 311-317; 2020
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
DOI: 10.21162/PAKJAS/20.7229
http://www.pakjas.com.pk

DETERMINING THE FORAGE YIELD, QUALITY AND NUTRITIONAL ELEMENT CONTENTS OF QUINOA CULTIVARS AND CORRELATION ANALYSIS ON THESE PARAMETERS

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Quinoa (*Chenopodium quinoa* Willd.), preferred especially by cattle, is generally grown for its seeds, while it may also be grown for its green leaves. This study aimed to determine the seed and leaf yields, quality and nutritional element contents of different quinoa cultivars that are grown in the Bilecik region in Turkey. The relationships among the leaf and seed yields, quality, nutritional values and nutritional contents were investigated via simple correlations, and it was aimed to determine the characteristics that may be selection criteria for yield. This study was conducted in 2017 in the field of Biotechnology Research and Application at Bilecik Şeyh Edebali University. As a result of the study, the highest green leaf yield, dry matter yield and crude protein yield were found respectively as 1387.46 kg da^{-1}, 454.42 kg da^{-1} and 61.90 kg da^{-1}and the highest Ca, K nutritional element values were found respectively as 12.73 and 33.43 g kg^{-1} DM in the A Heloud cultivar. In the region's conditions, it was found that the most suitable cultivars for forage yield and dry matter yield were A Heloud, Innia and Pasankalla. Correlation relationships among 18 morphologic characteristics of the quinoa cultivars were tested on the studied samples. Statistically significant and very significant differences were found between individual traits, expressed by phenotypic correlation coefficients.
Keywords: Cultivar, correlation analysis, quality, quinoa, yield.

INTRODUCTION

Destruction of natural resources and increased global warming as a result of the rapidly rising population of the world have started to create significant pressure on sufficient and balanced nutrition of living beings and pushed humankind into a search for new resources. Especially plants that grow in extreme climate and soil conditions and provide sufficient quantities and quality for feeding humans and animals have been prioritized. In this sense, the quinoa (*Chenopodium quinoa* Willd.) plant, which is not selective in terms of climate and soil conditions and can grow in a very diverse set of ecological conditions, was seen as one of the plants that may first come to mind. Quinoa is a plant which may be easily grown in different altitude, soil and climate conditions and used for human and animal diets with its high nutritional value (Kır, 2016). Quinoa, which is a plant of the Andes, is considered to the plant of the future for feeding the people and animals in the world. Studies have shown that this plant has been grown since the year 3000 BCE. It is resistant to cold and drought, and it may be cultivated even in mountainous areas with high altitude. Additionally, its seeds are rich in minerals, vitamins, fats and antioxidants. Quinoa, which attracts the whole world due to the contributions it may make in reaching biodiversity and food safety and elimination poverty with its high nutritional superiorities, has also been taken under watch by the United Nations (UN), and the year 2013 was declared the "International Year of Quinoa" in terms of its potential to provide significant contributions in reaching the development goals of the future thousand years (Demir and Kılınç, 2016).

This plant which can grow at 4000 m above sea level has a great capacity of adaptation due to its genetic diversity. While it is not grown in broad areas in Turkey, its farming has started in the Thrace Region, and provinces of Adana, Kırşehir and Konya.

Quinoa grain is an amylaceous raw material that has a high carbohydrate content, mainly consisting of starch and a small percentage of sugars. The nutritional value of a food is determined mainly by the quality of its protein, which depends on the composition, proportion and biological utilization of the amino acids presents. The nutritional quality of the proteins is, therefore, determined by the proportion of essential amino acids. Nine amino acids are strictly essential for humans: phenylalanine, isoleucine, leucine, lysine, methionine, threonine, tryptophan, valine and histidine (essential in childhood), which are present in quinoa, providing a protein value similar to casein from milk. This is why it is accepted that quinoa is a good source of protein. Quinoa is a highly nutritious human food. It is a relatively superior source of protein, minerals like calcium and iron, and vitamins E and B (Repo-Carrasco-Valancia and Serno, 2011).

While quinoa is a plant which is usually grown for its seeds, it may also be grown for its green leaves. It is a food preferred especially by cattle. Based on the cultivars, its dry matter yield may reach over 800 kg da^{-1}. The dry matter ratio of the leaf is 26-28%, while its crude protein ratio is around 13-22%. Its dry matter digestion is 63-68% at the harvesting stage (Van Schooten and Pinxterhuis, 2003). Quinoa grows fast and it is easily ensiled. However, its silage quality is not as high as that of maize. On the other hand, it is grown as a feed source in organic agriculture as it is easy to grow. Dry matter ratios need to be high for appropriate fermentation. Three-three and a half months after sowing, quinoa produces silage material with a sufficient dry matter ratio and high crude protein ratio (Van Schooten and Pinxterhuis, 2003). Quinoa seed is also excellent feed for birds and poultry and the plant itself is good forage for cattle.

As it is known, although Turkey has a high potential for animal assets, the levels of yield are generally low nationwide. In order to achieve yield from dairy cattle to an extent that is allowed by their genetic characteristics, it is highly important to provide them with micro elements in addition to macro elements. This is because, although micro elements are in low quantities, they take on very important tasks in the organism. In order to achieve the optimal yield in dairy cattle businesses, all four of energy, proteins, minerals and vitamins should be provided to the animals by rationing in a balanced way. When the balance among these four factors is disrupted, levels of utilization of each nutritional substance are altered, and because of this, the yield is reduced (Kreplin and Yaremcio, 2009).In order to achieve the goals of high levels of yield, in addition to meeting the energy and protein needs of dairy cattle, it is also necessary to provide them with mineral substances that have important roles in protecting health and increasing reproductive yield. Mineral substances that are important in the nutrition of dairy cattle include calcium (Ca), phosphorus (P), magnesium (Mg), sodium (Na) and potassium (K), as well as chlorine (Cl) and sulfur (S) macro elements. The most important micro (trace) elements are listed as iron (Fe), iodine (I), cobalt (Co), copper (Cu), manganese (Mn), selenium (Se) and zinc (Zn). In general, in normal feeding conditions, needs of potassium (K), chlorine (Cl), sulfur (S) and iron (Fe) can be met to a sufficient extent with coarse and dense feeds. However, it should be kept in mind that coarse feeds are inadequate in terms of phosphorus (P) and sodium (Na). In balancing the dairy cattle rations in terms of mineral substances, there is great importance in knowing the mineral contents of the existing coarse and dense feeds (NRC, 1989).

The criterion of a linear relationship between variables is the correlation coefficient. The correlation coefficient between two variables is the degree to which these change together. That is, if the correlation coefficient calculated for two variables is high, we may say that these variables are dependent on each other and they change together (Düzgüneş and Akman, 1985; Düzgüneş *et al.,* 1987).

This study was conducted with the aim of determining the green leaf and seed yields, yield components, quality and nutrition values and nutritional element contents of cultivars of quinoa, which is not yet farmed by producers in Turkey to a great extent but expected to spread more in the future, that are found in the Bilecik region.

MATERIALS AND METHODS

This study was carried out at the experiment space for the field of Biotechnology Research and Application at Bilecik Şeyh Edebali University. The field selected as the study area was a lower point with an altitude of 299 m.

In parallel to the location of Bilecik in a gateway region, its water resources and variable topography, 3 different types of climates are seen in this province. In general, the climate of the Marmara Region is dominant in the central district and districts of Gölpazarı, Osmaneli and Söğüt, and the climate of the Central Anatolia Region is dominant in the districts of Boyüzük, Pazaryeri and Yenipazar. Additionally, there are microclimate areas around the coastlines of the River Sakarya in the districts of Gölpazarı, Osmaneli and Söğüt. The climate of the Marmara Region is dominant in the space where the trials were carried out. Based on long-term averages, it is seen that the total annual precipitation in the province of Bilecik is approximately 452.6 mm, and precipitation is the highest in January and December. The highest temperature found in the province was recorded in July 2000 as 41 ºC, while the lowest was recorded in January 1950 as -16 ºC. Western and northwestern winds are dominant in Bilecik. The average wind speed is 3.4 m/s. During the year, high winds are effective for 135 days and there are storms for 17 days. The average temperature values for May, June, July, August and September in 2017 were 19.5, 22.4, 24.8, 22.6 and 20.5^{0}C, respectively. The total monthly precipitation was found as 69.9 mm in June, which was higher than the long-term average. The total monthly precipitation values for July, August and September were found respectively as 7.0, 16.0 and 3.0 mm (General Directorate of Meteorology, 2017).

The soil in the area where the trials were made had a clayed, loamy structure rich in organic substances and a medium-level calcareous body, and there was no limiting factor for quinoa farming. The material of the study consisted of the registered quinoa cultivars of Salcedo Inia, Black Negro Collana, Innia, Pasankalla, A Heloud and Valiente. The seeds of the quinoa cultivars were placed by hand on 10 April 2017 for fours and trays in each cultivar (180 plants/cultivar).

On 4 May 2017, the seeds that root in the sand trays were transplanted into holes with 70 cm inter row and 50 cm inter row distances with 3 replications based on a randomized blocks experiment design. The first water was provided on 5 May. The blocks had 4 rows with block width of 5 m, and they had dimensions of 2.80x5= 14 m^2. While the seedlings were transplanted to the field, bottom fertilizer was provided to include pure 7.5 kg N, 6 kg P_2O_5, 6 kg K_2O per decare. Irrigation was carried out in order to provide better attachment of seedlings to soil. When the plants reached 30-40 cm, the second process of fertilization was carried out to include 7.5 kg da^{-1} pure N. Weed struggle was carried out manually when needed.

The study determined the emergence days and number of inflorescence, and the plant heights, number of panicula and panicula lengths were recorded for ten plants selected randomly from each block when the seeds reached their starch accumulation stage. After the edges of each block were discarded, half of the block was harvested to calculate green leaf yields per decare. During the harvest, approximately 500 g specimens were collected from each block and dried (for 48 h at 72 ^{0}C), the dry leaf yield per decare was calculated. These specimens were then ground, and their quality analyses and nutritional element contents (crude protein, ADF and NDF ratios, Ca, Mg, P, K, Zn g kg^{-1} DM) were determined.

Crude protein yields were calculated by determining the ratios of crude protein by the Kjeldahl method and multiplying the ratios by dry matter yield values (Kaçar, 1984). Cell wall components in the plants: the ADF (acid detergent fiber) and NDF (neutral detergent fiber) analyses of the dry leaf samples were carried out with an ANKOM Fiber Analyzer device (Fiber Analyzer, ANKOM brand, A220 model) (Van Soestet *et al.*, 1991). The metabolic energy (ME) and organic substance digestion rates of the plants were calculated using these values.

The findings were subjected to analysis of variance. The significance of the differences among the means was determined by Duncan test. The correlation analysis was carried out by using the SAS (SAS Inst., 1999) software.

RESULTS

The values of inflorescence number, plant height, number of panicula and panicula length that were obtained in the quinoa cultivars are given in Table 1.

According to Table 1, there was a significant difference among the cultivars in terms of the mean blooming time and plant height on a level of 0.05%.

According to the analysis results, the Valiente cultivar

Table 1. The values of blooming time, plant height, number of panicula and panicula lengths that were obtained in the quinoa cultivars.

Quinoa Cultivars	Blooming time (days)	Plant Height (cm)	Number of Panicula	Panicula Length(cm)
Salcedo Inia	68 B	137.53 BC	17.00	41.83
Black Negro	76 A	118.13 E	16.37	35.80
Innia	68 B	135.07 CD	18.17	40.87
Pasankalla	68 B	151.33 AB	20.30	34.73
A Heloud	76 A	160.07 A	16.37	45.70
Valiente	58 C	120.83 DE	16.27	38.07
Mean	69	137.16	17.41	39.50
LSD	1.993*	14.29*	N/A	N/A
CV (%)	1.59	5.73	13.51	10.78

*:p<0.05 **: P<0.01

Table 2. The values of forage yield, dry matter yield, crude protein ratio and crude protein yield obtained from the quinoa cultivars.

QuinoaCultivars	Forage Yield (kg da^{-1})	Dry Matter Yield (kg da^{-1})	Crude Protein Ratio (%)	Crude Protein Yield (kg da^{-1})
Salcedo Inia	941.60	326.21	12.43 C	40.12 B
Black Negro	1099.72	337.61	11.33 D	38.18 B
Innia	1028.49	276.35	13.37 AB	36.76 B
Pasankalla	1103.99	266.38	12.60 BC	33.65 B
A Heloud	1387.46	454.42	13.60 A	61.90 A
Valiente	1126.78	408.83	12.16 CD	49.29 AB
Mean	1114.67	344.97	13.49	43.32
LSD	N/A	N/A	0.9312*	16.77*
CV (%)	22.30	24.61	4.07	21.28

*:p<0.05 **: P<0.01

inflorescences in 58 days, which was the shortest time in comparison to the others. Additionally, the cultivars Salcedo Inia, Inniaand Pasankalla inflorescences in the same time. The Black Negro and A Heloud cultivars in florescence the latest.

The mean plant heights varied between 160.07 and 118.13 cm. The tallest plant was found in the A Heloud cultivar with the mean value of 160.07 cm. The shortest plant height was found in the Black Negro cultivar with the mean value of 118.13 cm.

The mean numbers of paniculain the cultivars changed in the range of 20-16, and the mean panicula length was in the range of 45.7-34.7 cm.

Table 2 shows the values of forage yield, dry matter yield, crude protein ratio and crude protein yield obtained from the quinoa cultivars.

Table 2 shows that there was a statistically significant difference at the level of 0.05% among the cultivars of quinoa in terms of the mean value of crude protein yield and crude protein ratio. The highest forage yield was found in the A Heloud cultivar as 1387.46 kg da^{-1}, and the lowest value was found in the Salcedo Inia cultivar as 941.60 kg da^{-1}. The highest dry matter yield was found as 454.42 kg da^{-1} in the A Heloud cultivar and the lowest value was found as266.38 kg da^{-1} in the Pasankalla cultivar. The highest crude protein ratio was 13.60% in the A Heloud cultivar and the lowest crude protein ratio was found as 11.33% in the Black Negro cultivar. The mean values of the crude protein yields in the cultivars were in the range from 61.90 kg $da^{-1}$to 33.65 kg da^{-1}. The highest yield value was found as61.90 kg da^{-1}in the A Heloud cultivar and the lowest value was found as 33.65 kg da^{-1}in the Pasankalla cultivar.

Table 3 shows the results on ADF, NDF, dry matter consumption, digestible dry matter ratio, relative feed value and ME values obtained from the quinoa cultivars.

Table 3 shows that there was a statistically significant difference at the level of 0.05% among the cultivars in terms of the values of ADF, NDF, dry matter consumption and relative feed values. The ADF values of the cultivars were in the range of 30.50-27.90%. The highest ADF was in the Black Negro cultivar by 30.50%, followed by with Valiente 30.32% and Salcedo Inia with 29.57%, while the lowest value was found in Innia and Pasankalla by 27.90. The NDF ratios of the cultivars were in the range of 45.22-42.33%. The highest NDF was45.22% in Valiente, while the lowest was 42.33% in Innia. The dry matter consumption values of the cultivars were in the range of 2.83-2.65. The highest dry matter consumption was in Innia by 2.83, while this was followed by the Pasankalla cultivar in the same group. The lowest value was found as 2.65 in the Valiente cultivar. The relative feed values (RFV) of the cultivars changed in the range of 147.60-134.36. The highest RFV was found as147.60 in the Innia cultivar and the lowest was found as134.36 inValiente.

Table 4 shows the nutritional content value in the green leaf obtained from the quinoa cultivars.

Table 3. The results on ADF, NDF, dry matter consumption, digestible dry matter ratio, relative feed value and ME values obtained from the quinoa cultivars.

QuinoaCultivars	ADF (%)	NDF (%)	Dry Matter Consumption	Digestible Dry Matter Ratio (%)	Relative Feed Value	ME(MCal kg^{-1} KM)
Salcedo Inia	29.57 A	43.73 B	2.74 BC	65.87	140.12 C	2.161
Black Negro	30.50 A	43.87 B	2.74 C	65.14	138.16 C	2.135
Innia	27.90 B	42.33 D	2.83 A	67.17	147.60 A	2.209
Pasankalla	27.90 B	42.87 CD	2.80 AB	67.17	145.76 AB	2.209
A Heloud	28.13 B	43.33 BC	2.77 BC	66.98	143.80 B	2.203
Valiente	30.32 A	45.22 A	2.65 D	65.28	134.36 D	2.140
Mean	29.05	43.56	2.76	66.27	141.63	2.176
LSD	1.235*	0.7675*	0.05753*	N/A	3.583*	N/A
CV (%)	2.34	0.97	0.95	1.59	1.39	0.89

*:p<0.05 **: P<0.01

Table 4. The nutritional content value in the green leaf obtained from the quinoa cultivars.

QuinoaCultivars	Ca (g kg^{-1} DM)	Mg (g kg^{-1} DM)	P (g kg^{-1} DM)	K (g kg^{-1} DM)	Zn (g kg^{-1} DM)
Salcedo Inia	10.17C	3.10BC	2.93BC	32.43AB	19.33A
Black Negro	8.20D	4.27A	4.00A	29.37C	17.00B
Innia	9.60C	3.43B	3.20B	30.60BC	17.80B
Pasankalla	10.93B	3.30B	3.07BC	32.47AB	18.23AB
A Heloud	12.73A	2.67C	2.70C	33.43A	19.53A
Valiente	8.27D	4.27A	4.17A	29.97C	17.33B
Mean	9.98	3.51	3.35	31.38	18.20

Table 5. The Correlation Coefficients between Characteristics.

	IN	PH	NP	PL	FY	DMY	ADF	NDF	CPR	CPY	DMC	DDMR	RFV	ME	CA	Mg	P	K
PH	0.354																	
Sig.	0.491																	
NP	-0.100	0.412																
Sig.	0.851	0.417																
PL	0.251	0.491	-0.451															
Sig.	0.632	0.322	0.369															
FY	0.389	0.510	-0.259	0.409														
Sig.	0.446	0.301	0.620	0.420														
DMY	0.072	0.103	-0.769	0.561	0.735													
Sig.	0.892	0.846	0.074	0.247	0.096													
ADF	-0.208	-.824*	-0.661	-0.309	-0.257	0.286												
Sig.	0.692	0.044	0.153	0.551	0.622	0.583												
NDF	-0.482	-0.555	-0.633	-0.145	0.049	0.583	.835*											
Sig.	0.332	0.253	0.178	0.785	0.926	0.224	0.039											
CPR	0.085	0.771	0.219	0.717	0.402	0.134	-.848*	-0.567										
Sig.	0.872	0.073	0.677	0.109	0.429	0.800	0.033	0.24										
CPY	0.136	0.347	-0.628	0.719	.817*	.956**	0.001	0.349	0.412									
Sig.	0.797	0.500	0.182	0.107	0.047	0.003	0.999	0.497	0.416									
DMC	0.507	0.550	0.635	0.119	-0.028	-0.581	-.827*	-.999**	0.546	-0.351								
Sig.	0.305	0.258	0.176	0.822	0.958	0.227	0.042	0	0.263	0.495								
DDMR	0.206	.823*	0.664	0.307	0.253	-0.290	-1.00**	-.836*	.847*	-0.005	.828*							
Sig.	0.695	0.044	0.150	0.554	0.629	0.577	0.00	0.038	0.033	0.993	0.042							
RFV	0.374	0.680	0.676	0.211	0.069	-0.491	-.939**	-.973**	0.708	-0.226	.969**	.940**						
Sig.	0.465	0.137	0.141	0.688	0.896	0.322	0.005	0.001	0.115	0.666	0.001	0.005						
ME	0.158	0.810	0.678	0.293	0.231	-0.302	-.999**	-.822*	.848*	-0.017	.813*	.999**	.931**					
Sig.	0.766	0.051	0.138	0.573	0.659	0.561	0.00	0.045	0.033	0.974	0.049	0.000	0.007					
CA	0.434	.983**	0.244	0.609	0.580	0.241	-0.747	-0.491	0.765	0.473	0.485	0.745	0.605	0.727				
Sig.	0.390	0.000	0.641	0.199	0.228	0.646	0.088	0.323	0.076	0.344	0.33	0.089	0.203	0.102				
Mg	-0.383	-.923**	-0.251	-0.693	-0.313	-0.081	0.751	0.583	-0.799	-0.327	-0.564	-0.750	-0.665	-0.735	-.941**			
Sig.	0.454	0.009	0.631	0.127	0.546	0.879	0.085	0.225	0.057	0.527	0.244	0.086	0.149	0.096	0.005			
P	-0.409	-.900*	-0.355	-0.606	-0.197	0.075	0.78	0.679	-0.759	-0.174	-0.661	-0.780	-0.739	-0.765	-.901*	.987**		
Sig.	0.420	0.014	0.490	0.202	0.708	0.888	0.067	0.138	0.080	0.742	0.153	0.067	0.094	0.076	0.014	0.000		
K	0.267	.941**	0.288	0.552	0.367	0.162	-0.646	-0.379	0.663	0.366	0.365	0.645	0.493	0.635	.946**	-.941**	-.911*	
Sig.	0.609	0.005	0.581	0.257	0.474	0.759	0.166	0.458	0.152	0.476	0.477	0.167	0.321	0.176	0.004	0.005	0.011	
Zn	0.281	0.807	0.021	0.744	0.268	0.267	-0.481	-0.283	0.636	0.446	0.259	0.480	0.362	0.467	.860*	-.933**	-.893*	.937**
Sig.	0.590	0.052	0.968	0.090	0.608	0.609	0.334	0.587	0.175	0.375	0.620	0.336	0.480	0.351	0.028	0.007	0.017	0.006

*Correlation is significant at the 0.05 IN: Inflorescence number, PH: Plant height, NF: Number of panicula, PL: Panicula length, FY: Forage yield, DMY: Dry matter yield, ADF, NDF, CPR: Crude protein ratio, CPY: Crude protein yield, DMC: Dry matter consumption, DDMR:Digestible dry matter ratio, RFV: Relative feed value, ME: Metabolik energy, Ca: Calcium, Mg: Magnesium, P: Phosphorus, K:Potassium, Zn: Zinc.

Table 4 shows that there was a significant difference between the cultivars of quinoa in terms of their mean values of Ca, Mg, P, K and Zn (g kg^{-1} DM).

The highest value of Ca was found as 12.73 g kg^{-1}DMin the A Heloud cultivar, while the lowest was in the Black Negro cultivar as 8.20 g kg^{-1}. The highest Mg value was in Black Negro and Valiente by 4.27 g kg^{-1} DM, while the lowest values were3.10 and2.67 g kg^{-1} DM for Salcedo Inia and A. Heloud respectively. The highest P value was found as 4.17g kg^{-1}DM for Valiente, while the lowest was obtained as2.70g kg^{-1} DM inA. Heloud. The highest K value was 33.43 g kg^{-1} DM for A Heloud, this was followed by the Pasankalla and Salcedo Inia cultivars, and the lowest K value was obtained from the cultivars Black Negro and Valiente. The green leaf Zn values of the cultivars were in the range of19.53-17.00 g kg^{-1} DM, while the highest value was obtained in A Heloud , and the lowest value was in the Black Negro. According to Maletic *et al.* (2010), phenotypic correlations, which indicate tendencies of potential alterations by the selected breeding methods are highly important. Thus, relationships of correlation among 18 morphological characteristics of the quinoa cultivars studied in the study were analyzed. We found significant and very significant difference in individual characteristics indicated by coefficients of phenotypic correlation (Table 5).

As seen in Table 5, the relationships between different parameters studied were found to be significant.

DISCUSSION

As a result of the study, it was seen that there were differences between the quinoa cultuvars in terms of blooming time in Bilecik ecologic conditions. These differences are caused by the individual characteristics of the cultivars and ecologic conditions of Bilecik. Gęsiński (2008a,b) reported that the vegetation time of quinoa in the ecologic conditions of Italy, Greece, Sweden, Denmark and Poland, respectively as 116, 106, 140, 134 and 128 days, and added that these differences were caused by the variations in cultivars and ecology.

In this study, there was a change between plant heights of cultivars. It is believed that these differences may have been caused by the genetic differences among the cultivars and the differences in their reactions to the environment.

Kaya (2010), in his study in Çukurova conditions in the year 2009, reported that plant height changes in the range of 116-130 cm. These findings agree with ours.

Forage crops of quinoa are very beneficial in supplying of livestock with nutrition fodder. While making up a ration, it is necessary to take into consideration a sharp deficit of protein in zone. Quinoa, meanwhile, has a substantial amino acid composition and contains 9 essential amino acids, including lysine, izoleucine, which cannot be found in main cereals.In this study, the mean forage yield values of the cultivars were in the range of 1387.46-941.60 kg da^{-1}. The mean dry matter yield values were in the range of 454.42-266.38 kg da^{-1}. The mean crude protein ratios of the cultivars changed between 13.60% and 11.33%.Similar to ours in a study, Van Schooten and Pinxterhuis (2003) found that dry matter yield may reach beyond 800 $kgda^{-1}$ based on the cultivar of quinoa, and for the leaf, the dry matter ratio was around 26-28% and the crude protein ratio was around 13-22%, while they reported that the dry matter digestion during the harvesting stage was 63-69%.

Feeding behavior of animals, digestibility and sustainability of the feed, and its conversion into animal products vary based on the quality of the feed (Van Soest, 1994). Quality of feed is usually determined by measuring the chemical, physical and biological values of the feed. Relative feed value, which was developed in the USA for the clover plant and also used for other feeds, is used to measure the nutritional value of feeds (Ball *et al.*, 1996). Relative feed value is calculated by the utilization of acid detergent fiber (ADF) and neutral detergent fiber (NDF) values (Moore and Undersander, 2002). Increased levels of NDF and ADF, which slow down digestion in feeds lead the animal to feel physically full and limit the animal's consumption of the feed (Van Soest 1994;Yavuz 2005).

As ADF and NDF digestion is very slow and on a low level, it is desired that ADF and NDF of the feed are low (Van Soest *et al.*, 1991). Accordingly, it may be stated that the Innia and Pasankalla cultivars have high nutritional value due to their low ADF and NDF values, and high dry matter consumption, digestible dry matter ratio, relative feed value and metabolic energy values.

Similar to our study, in a study planted at 10, 20, 30 and 40 cm row spacing of the quinoa plant, the obtained NDF rates were 41.4%, 41.0%, 42.0% and 40.8%, respectively. ADF rates ranged from 22.8% to 26.9%. BMT rates were 2.90%, 2.93%, 2.86% and 2.94%. CMS rates ranged from 67.96% to 71.14%. The relative feed values ranged from 146.3 to 173.2. ME amounts ranged from 2.61 Mcal kg^{-1} to 2.72 Mcal kg^{-1} (Temel and Keskin, 2018).

Korkut, in a study in 2013, determined the daily Ca requirements of cattle with milk yields of 10 to 40 kg a day as 4.1-6.5 g kg^{-1} DM, while this value was 5.0 g kg^{-1} DM for Mg, 2.6-4.0 g kg^{-1} DM for P and 5.0 g kg^{-1} DM for Zn. Considering the Ca, Mg, P and Zn values obtained in our study, this shows the importance of these quinoa cultivars as a source of food for animal feeding.

Correlation coefficients show relationships among various traits along with the degree of linear relation between these characters. Evaluation of seed yield, morphological variability and nutritional quality of 27 germplasm lines of *Chenopodium quinoa* was carried out in subtropical North Indian conditions over a 2-year period by Bhargava *et al.* (2007). All morphological traits except days to flowering, days to maturity and inflorescence length exhibited significant positive association with seed yield.These findings agree with ours.

***Conclusion*:** As a result of this study, the Valiente cultivar was found as the earliest-flowering cultivar by its inflorescence number of 58 days. The highest Relative Feed Value, which is important for animal nutrition, was obtained as 147.60 and 145.76 for the Inia and Pasankalla cultivars, respectively. The highest forage yield value, dry matter yield value and crude protein value was found respectively as1387.46 kg da^{-1}, 454.42 kg da^{-1} and 61.90 kg da^{-1}in the A Heloud cultivar. Additionally, the highest green leaf Ca, K and Zn contents were found respectively as 12.73, 33.43and 19.53 g kg^{-1} DM in A Heloud. Based on these results, it was concluded that the most suitable cultivars in farming for forage yield and dry matter yield to use as animal feed in these regional conditions were A Heloud, Innia and Pasankalla.

***Acknowledgments*:** This study was the article based on the master's thesis coded FBE EYK 2016/67-7 for the Department of Biotechnology, Institute of Sciences, Bilecik Şeyh Edebali University. We would like to thank the Department of Scientific Research Projects at Bilecik Şeyh Edebali University who supported us for this study (Project no: 2017-01.BŞEÜ.06-01).

Authors' Contributions: This research is Esra Kaya's master thesis work. Serap Kızıl Aydemir also served as a consultant in this research.

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[Received 20 March 2018; Accepted 23 Dec- 2019; Published 8 Feb. 2020]