Available online www.jsaer.com

Journal of Scientific and Engineering Research, 2020, 7(12):43-50

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Determining the Feed Value of the Herbage Obtained from the Quinoa Planted at Different Times and Row Spaces

Ömer Süha Uslu[1]*, Gülay Zülkadir[2], Leyla İdikut[1]

[1]Department of Field Crops, Faculty of Agriculture, Kahramanmaras Sutcu Imam University, Kahramanmaras, Turkey
[2]Department of Organic Agriculture Management, Applied Technology and Management School of Silifke, Mersin University, Mersin, Turkey
*Corresponding author: suhauslu@ksu.edu.tr

Abstract The present study was conducted to determine the adaptation of quinoa plant in Kahramanmaras region, which is dominated by the typical Mediterranean climate and the effect of different sowing times (ST) (26 March, 13 April, 26 April and 11 May) and the effect of the distance between different rows (DR) (20, 40 and 60 cm) on the feed values of plant samples harvested during flowering periods in Kahramanmaras Sütçü Imam University, Faculty of Agriculture, Department of Field Crop experimental area in 2018. The experimental design was the split plot in randomized complete block design with three replications. As the plant material, a type of quinoa called "Q52" (*Chenopodium quinoa*) was used. According to the results of the present study, the effects of the changes in sowing times and sowing row spaces on all properties examined in the quinoa (excluding crude ash ratio) were found to be statistically significant. In terms of the effects of DR × ST interaction on neutral detergent fiber (NDF), acid detergent fiber (ADF), digestible dry matter DDM, dry matter intake (DMI), relative feed value (RFV), digestible energy (DE) and metabolic energy (ME) were found to be significant; and insignificant on dry matter ratio (DMR), crude protein ratio (CPR) and crude ash ratio (CAR). It was also found that that if the quinoa is planted on April 13 and in 20 cm row space, a feed with a high ME value will be obtained, providing very significant benefits to animal nutrition because of the high RFV and low NDF.

Keywords Feed quality, protein content, quinoa, row space, sowing time

Introduction

Quinoa (*Chenopodium quinoa* Willd.) is an annual and dicotyledonous plant of the Amaranthaceae (Chenopodiaceae) family [1]. It is known that it has approximately 250 species worldwide [2]. It shows high diversity and variability with the use of the quinoa plant with cultural forms and wild relatives (*Chenopodium carnosolum*, *C. petiolare*, *C. pallidicaule*, *C. hircinum*, *C. Quinoa subsp. melanospermum* and *C. ambrosoidesincisum*) [3,4]. It was reported that quinoa, whose origin is South America, has been consumed by collecting from the nature in Ecuador, Peru, Bolivia, Chile, Argentina and on the Andes Mountains of Colombia for 7.000 years, and has been cultured for 5000 years [5]. In early 1980s, it was reported that it was brought to the European Continent [6]. Quinoa (*Chenopodium quinoa* Willd.) can be cultivated at 4.000 m elevation above the sea level [7], and at -8 °C [8] and 38 °C [1], and is a plant that is quite resistant to drought, salinity, poor lands, and to negative environmental and climatic factors like frost and hail [7,9]

Quinoa, which is not originally a grain plant, is made use of in the grain group with its grain-like properties. Quinoa and quinoa products are rich in terms of macro elements like protein, polysaccharides and fats, as well as micro-elements like polyphenols, vitamins and minerals [10,11]. The Quinoa plant, which is mostly mentioned with its grains, is also grown as forage. Depending on the variety, climate, sowing and care methods, the yield of its dry form varies between 456-1566 kg/da [12]. According to Van Schooten and Pinxterhuis [13] (2003), the rate of dry matter of its weed varies between 26% and 28%, crude protein ratio between 13% and 22%, and dry matter digestion 63% and 69%.

When studies conducted on the feed value of the Quinoa plant are examined, it is seen that previous studies were on different format dates; however, studies on the effects of sowing time and row space on feed value are inadequate. Considering this deficiency in the literature, the feed values of the grass of quinoa obtained with different sowing times and different row space were examined in the present study in Kahramanmaras conditions, which are dominated by the typical Mediterranean climate.

Materials and Methods

Material

The experiment was conducted in the spring season of 2018 in Kahramanmaras Sütçü Imam University, Faculty of Agriculture, Department of Field Crops experimental fields. The "Q-52" type of quinoa (*Chenopodium quinoa* Willd.), which was well adapted to Mediterranean climatic conditions, was used as the plant material in the study. According to the analysis of the soil samples taken from the experiment area from a depth of 0-30 cm, the pH was 7.28 %, salt ratio was determined to be 0.30 %, lime was 1 %, organic matter was 2.08 %, potassium was 266.8 mg/kg, and phosphorus was 10.46 mg/kg [14]. The experiment area has an altitude of 487 m in the east of the Mediterranean region between 37°35'40.86" northern latitude and 36°48'47.51" eastern longitudes. The Mediterranean Climate is dominant in the area, the temperature difference between night and days is low, winters are rainy and warm, and summers are dry and warm. The total rainfall for many years was 220.4 mm in the season when quinoa was cultivated. This value was 188.4 mm during the experiment period, which means there was 32 mm less rainfall in 2018 compared to the long-term average. Again, according to long-term seasonal averages, the average temperature in Kahramanmaras was 21.2 °C. The average temperature was 22.9 °C in the 2018 cultivation period, when the study was conducted, which means higher than the long term average. According to the long-term seasonal averages, the average relative humidity was 54.5 % in Kahramanmaras. This value was 54.5 % in 2018, which was a lower rate [15].

Method

The experimental area was deep ploughed in early winter, and it was ploughed with second-class soil processing tools, and was made ready for cultivation in March. The experimental design was the split plot in randomized complete block design with 3 replications. The experiment included 4 different sowing times (26 March, 13 April, April 26, and May 11). In October, the distance between the rows was 20, 40 and 60 cm (4 rows in each parcel) drawn with a hand marker, and the sowing was made manually in 1 cm deep soil. The amount of the seeds to be sown was calculated as 2 kg da-1 in the experiment parcels [16]. To prevent mechanical mixing, 1 m of aisles were left between the parcels and 2 m between the blocks.

Considering the amount of nutrients in the soil, 50 kg ha-1 N, 60 kg ha-1 P_2O_5 and 60 kg ha^{-1} K_2O were given as basic fertilizers before sowing. Then, 30 kg ha^{-1} N was applied as top fertilizer approximately 35 days after the sowing. Irrigation was done depending on the climate conditions and according to the water needs of the Quinoa plant. The plant samples were collected by hand at the beginning of the flowering period, and weighed in wet form, then were dried for 48 hours at 70 ºC, and were grounded, and filtered with a 1 mm pore filter. Then the dry matter ratio (DMR), crude protein ratio (CPR), crude ash ratio (CAR), neutral detergent fiber (NDF), acid detergent fiber (ADF), digestible dry matter value (DDMV), dry matter intake value (DMIV), relative feed value (RFV), digestible energy (DE), and metabolic energy (ME) characteristics were examined. The total nitrogen determination was made in the ground samples according to Micro Kjeldahl Method. Crude ash sample content was burned in an ash oven for 8 hours at 550 ℃, and the Nitrogen (N) content was determined by using the Kjeldahl Method [17]. Then the nitrogen ratios were multiplied by the coefficient 6.25, and crude protein ratios of the plant were found according to the principles of Kacar (1972) [18]. The neutral detergent fiber (NDF) [19] and acid detergent fiber (ADF), which make up the cell wall components, were identified using the Ankom 200 Fiber Analyzer (ANKOM Technology Corp. Fairport, NY, USA) device [20]. The digestible dry matter intake, digestible energy, metabolic energy, dry matter intake, and relative feed values of the plant samples were calculated by using the following equations and the NDF and ADF ratios.

DDMV = 88.9-(0.779 x ADF %) [21]

DE = 0.27 + 0.0428 x (DDMV %) [22]

ME = 0.821 x DE (Mcal/kg) [23]

DMIV = 120 / (NDF %) [24]

RFV = (DDMV x DMIV) /1.29 [24]

The data obtained at the end of the study were analyzed with the ANOVA method according to the split plot in randomized complete block design using the SAS V9.4 [25] statistical program. The averages of the statistically significant features were grouped in the LSD Multi-Comparison Test.

Results and Discussion

The averages of the feed quality values of the herbage obtained from quinoa planted in different times and row space and the groups are given in Tables 1 and 2.

Dry Matter, Crude Protein and Crude Ash Ratios

When the study results were evaluated, it was found that the sowing time ($p<0.01$) and sowing space applications ($p<0.05$) were statistically significant in terms of dry matter ratio, and the sowing time x row space interaction was found to be insignificant. Among the different sowing times, the highest value was obtained in fourth sowing time (28.4 %), and in sowing space of 20 cm (25.1 %) (Table 1). It was observed that although the increase in space between the rows reduced the dry matter ratio, there was an increase in the sowing made in further times. With the increasing distance between rows, the distance between plants also increased, which reduced plant density and increased water loss; and therefore, caused a decrease in the dry matter ratio. Our findings regarding the dry matter ratio are partially similar to the findings of Temel and Şurgun (2019) [26] (21.07-27.43 %), and completely similar to the findings of Temel and Keskin (2019) [27] (14.9-31.6 %). However, Tan and Temel (2017) [12] reported different findings in their study in Erzurum and Igdir (24.2%-38.4). Van Schooten et al. (2003) [13] found the dry matter ratio as 26 % in their study. When evaluated in terms of crude protein ratios, it was found that the effect of the sowing space ($p<0.05$) and the sowing time ($p<0.01$) were significant, and the effect of the sowing space x sowing time interaction was statistically insignificant ($p<0.05$). The highest protein value (22.1 %) was determined in March 26 (17.1 %) in 60 cm sowing space (Table 1). With increasing sowing space, branching increased in the unit area, and as a result, the rate of leaves and the resulting increase in the crude protein ratio was detected. It was considered that increasing the distance between rows decreased the competition among plants, strengthened the plant development, and caused that the crude protein ratio increased. In Greece, Papastylianou et al. (2014) [28] conducted a study and found that the crude protein ratio varied between 11.1 % and 14.7 %. In their study conducted in Igdir, Temel and Keskin (2019) [27] found the crude protein ratio to be between 13.5 % and 17.7 %. In this context, the highest crude protein ratio was achieved in 70 cm sowing space, and the lowest crude protein ratios were achieved in 35 cm sowing space. These researchers stated that different sowing spaces did not have any significant effects on the nutritional contents of quinoa. In the study conducted by Temel and Şurgun (2019) [26], the crude protein ratio was found to be between 11.97 % and 15.85 %. In their study conducted in Erzurum and Igdir, Tan and Temel (2017) [12] found the crude protein ratio to be between 15.8 % and 18.6 %. The difference between the locations was not significant. Kaya and Aydemir (2020) [29] found the crude protein ratio to be between 11.3 % and 13.6 %. The researchers reported that the crude protein ratio was affected by many factors like the vector, temperature, length of day, and irrigation count [30,31,32]. The difference between the crude ash ratio averages of the quinoa obtained in different sowing times was found to be statistically significant ($p<0.01$), and the distance between the sowing spaces, sowing time x the distance between sowing spaces interaction were found to be insignificant ($p<0.05$). The highest crude ash ratio was achieved on March 26 (19.8 %) (Table 1). In late sowing, it was observed that the crude ash ratio decreased. Papastylianou et al. (2014) [28] conducted a study in Greece, and reported that they found the crude ash ratio to be between 18.0 % and 18.8 %; however, Kakabouki et al. (2014) [33] found the crude ash ratio to be between 13.08 % and 14.65

% in their study conducted in Greece. It can be argued that the differences in the ash ratios differed depending on the variety used and on the environmental factor.

Table 1: The means of DMR, CPR, CAR, NDF and ADF ratios obtained from quinoa herbage planted in different time and sowing spaces.

		DMR (%)	CPR (%)	CAR (%)	NDF (%)	ADF (%)
Sowing Time		**	**	**	**	**
26 March (I)		16.4 ^{d}	22.1 ^{a}	19.8 ^{a}	41.71 ^{b}	16.24 ^{d}
13 April (II)		26.4 ^{b}	14.1 ^{b}	15.4 ^{c}	35.48 ^{d}	19.83 ^{c}
26 April (III)		24.4 ^{c}	14.2 ^{b}	18.3 ^{b}	40.19 ^{c}	21.61 ^{b}
11 May (IV)		28.4 ^{a}	14.3 ^{b}	17.4 ^{b}	43.75 ^{a}	25.98 ^{a}
LSD		1.9452	1.5637	1.1643	0.8328	0.7633
Row space (cm)		*	*	is	**	**
20 cm		25.1 ^{a}	15.2 ^{b}	17.3	37.89 ^{c}	19.66 ^{b}
40 cm		23.9 ^{ab}	16.2 ^{ab}	17.5	40.89 ^{b}	20.09 ^{b}
60 cm		22.8 ^{b}	17.1 ^{a}	18.2	42.07 ^{a}	23.01 ^{a}
LSD		1.68	1.35	1.008	0.721	0.661
Interaction		ns	ns	ns	**	**
I	**20 cm**	17.4	19.9	20.2	42.00 ^{c}	20.00 ^{e}
	40 cm	16.1	22.9	19.1	45.51 ^{a}	13.88 ^{f}
	60 cm	15.8	23.2	20.0	37.61 ^{e}	14.84 ^{f}
II	**20 cm**	27.6	14.0	15.3	26.96 ^{g}	14.78 ^{f}
	40 cm	26.4	13.5	15.1	34.95 ^{f}	18.99 ^{e}
	60 cm	25.2	14.8	15.6	44.53 ^{ab}	25.73 ^{b}
III	**20 cm**	25.0	13.1	16.9	39.59 ^{d}	18.84 ^{e}
	40 cm	24.4	14.2	19.1	38.00 ^{de}	22.00 ^{d}
	60 cm	23.8	15.2	18.8	43.00^{bc}	24.00 ^{c}
IV	**20 cm**	30.1	13.5	16.9	43.00^{bc}	25.00^{bc}
	40 cm	28.7	14.2	16.8	45.10 ^{a}	25.49^{bc}
	60 cm	26.4	15.2	18.4	43.14^{bc}	27.45 ^{a}
Mean		23.9	16.2	17.7	40.28	20.92
CV%		8.14	9.67	6.58	2.07	3.65

DMR: dry matter ratio, CPR: crude protein ratio. CAR: crude ash ratio, NDF: neutral detergent fibre, ADF: acid detergent fibre, **: significant according to $p<0.01$, *: significant according to $p<0.05$, ns: non-significant

NDF and ADF Ratios

The effects of the distance between rows, sowing time, and the distance between rows x sowing time interaction on the NDF and ADF ratios of quinoa were statistically significant ($p<0.01$). The increased NDF and ADF levels, which slow the digestion in feed, cause the animal to feel physically saturated, limiting the feed consumption of the animal [34,35]. Since the digestion of NDF and ADF is very slow and at low levels, the feed is desired to be low on NDF and ADF [36]. The lowest NDF and ADF ratio values were achieved as 26.96 % and 14.78 %, respectively on April 13 and in 20-cm sowing space (Table 1). In their study conducted in Greece, Papastylianou et al. (2014) [28] found the ADF ratio to be between 27.1 % and 32.1 %, and again in Greece, Kakabouki et al. (2014) [33] found that the ADF ratio was 24.78 %-39.45 %. In their study in Igdir, Temel and Keskin (2019) [27] reported that the NDF ratio was measured between 38.0 %-43.5 %, ADF ratio was measured between 22.8 %-26.9 %, and the lowest NDF ratio was achieved in 17.5 cm and 70 cm sowing space application. In their study, Temel and Şurgun (2019) [26] found the NDF ratio to be between 47.22 % and 54.52 %. Kaya and Aydemir (2020) [29] found that the NDF ratio was between 42.33 % and 45.22 %, and ADF ratio was between 29.57 % and 30.32 %.

Digestible Dry Matter, Dry Matter Intake and Relative Feed Value

The nutritional behaviours, digestibility and sustainability of the hay, and the transformation of the hay into animal products vary depending on the quality of the feed [34]. The quality of the feed is usually determined by measuring the chemical, physical and biological values of the feed. The relative feed value, which was developed in the USA for the alfalfa plant by using digestible dry matter and dry matter intake value, which is also used for other feeds, is used to measure the nutritional value of any feed [37]. The relative feed value is calculated by using neutral detergent fiber (NDF) and acid detergent fiber (ADF) values [38]. In terms of the digestible dry matter (DDMV), dry matter intake (DMIV) and relative feed value (RFV), the differences between the averages of the distance between the sowing spaces were found to be statistically significant ($p<0.01$). When the averages of sowing times were evaluated, it was found that the highest DDMV, DMIV and RFV were calculated as 76.25% on March 26, and 3.53% and 202.75% in April 13. When the averages of the distances among sowing spaces were examined, it was found that the highest DDMV, DMIV and RFV were calculated as 73.59%, 3.29%, and 188.51%, respectively in 20-cm distance. The highest SKM, KMA and RFV were calculated to be 77.38 %, 4.45 %, and 267.03%, respectively in April 13 and in 20 cm sowing according to sowing time x sowing space interaction, which was statistically significant. In their study conducted in Igdir, Temel and Keskin (2019) [27] found that KMS was between 67.96-71.14%, KMT between 2.76-3.19%, and RFV 146.3-173.2 (Table 2).

Table 2: The means of DDM, DMI, RFV, DE and ME values obtained from quinoa herbage sown in different times and sowing spaces

		DDM (%)	DMI (%)	RFV (%)	DE (MCal/ kg KM)	ME (MCal/kg KM)
Sowing Time		**	**	**	**	**
26 March (I)		76.25 [a]	2.89 [c]	171.15 [b]	3.53 [a]	2.90 [a]
13 April (II)		73.45 [b]	3.53 [a]	202.75 [a]	3.41 [a]	2.80 [b]
26 April (III)		72.06 [c]	2.99 [b]	167.36 [b]	3.35 [c]	2.75 [c]
11 May (IV)		68.66 [d]	2.75 [d]	146.08 [c]	3.21 [d]	2.63 [d]
LSD		0.5953	0.0597	4.2362	0.0261	0.022
Row space (cm)		**	**	**	**	**
20 cm		73.59 [a]	3.29 [a]	188.51 [a]	3.42 [a]	2.81 [a]
40 cm		73.25 [a]	2.97 [b]	168.79 [b]	3.41 [a]	2.79 [a]
60 cm		70.98 [b]	2.87 [c]	158.20 [c]	3.31 [b]	2.72 [b]
LSD		0.515	0.0517	3.668	0.022	0.019
Interactions		**	**	**	**	**
I	**20 cm**	73.32 [b]	2.86 [e]	162.43 [d]	3.41 [b]	2.80 [b]
	40 cm	78.08 [a]	2.64 [g]	159.65 [de]	3.61 [a]	2.97 [a]
	60 cm	77.34 [a]	3.19 [c]	191.37 [b]	3.58 [a]	2.94 [a]
II	**20 cm**	77.38 [a]	4.45 [a]	267.03 [a]	3.58 [a]	2.94 [a]
	40 cm	74.11 [b]	3.43 [b]	197.34 [b]	3.44 [b]	2.83 [b]
	60 cm	68.86 [e]	2.69[fg]	143.88[fg]	3.22 [d]	2.64 [e]
III	**20 cm**	74.22 [b]	3.03 [d]	174.42 [c]	3.45 [b]	2.83 [b]
	40 cm	71.76 [c]	3.16 [c]	175.74 [c]	3.34 [c]	2.74 c
	60 cm	70.20 [d]	2.79[ef]	151.92[ef]	3.27 [d]	2.69 [d]
IV	**20 cm**	69.42 [de]	2.79[ef]	150.18[fg]	3.24 [d]	2.66 [de]
	40 cm	69.04 [de]	2.66 [g]	142.44 [g]	3.23 [d]	2.65 [de]
	60 cm	67.52 [f]	2.78[ef]	145.63[fg]	3.16 [e]	2.59 [f]
Average		72.61	3.04	171.84	3.38	2.77
CV%		0.82	1.97	2.47	0.77	0.79

DDM: Digestible Dry Matter, DMI: Dry Matter Intake, RFV: Relative Feed Value, DE: Digestible Energy, ME: Metabolic Energy, **: significant according to $p<0.01$, *: significant according to $p<0.05$.

Digestible Energy and Metabolic Energy Value

Nutrition norms must be prepared according to the Metabolic Energy System, which is now used in the nutrition of ruminants in many countries. For this reason, metabolic energy values of the energy contents of the feeds must be determined, the needs of animals must be met, and metabolic energy units must be used in the preparation of rations [39]. An animal uses energy to walk, graze, breathe, milking and conceive. Energy is the most important requirement for milk production of cows. Energy also affects the milk yield, milk content (fat and protein), and body weight. The energy in the feed is the measurement of the contribution of these feeds to the functioning and productivity of animals. All feeds have gross energy value, some of which is lost in the feces. Energy that is taken by animals is called "digestible energy", some of which is used for urine production as well as heat and gas operations related with digestion. All the remaining energy is known as the "metabolic energy". Megacalorie (MCal) unit is used to measure the energy value. For this reason, digestible and high metabolic energy value is important for the quality of the feed. The effects of different sowing times, different sowing spaces, and sowing times x different sowing spaces interactions were found to be significant on the DE and ME value of quinoa ($p<0.01$). Early and frequent sowing increased the DE and ME values. The highest DE value was in the same group in different sowing times, and was calculated to be 3.53 and 3.41 MCal kg-1, respectively on March 26 and April 3; and the highest ME value was found to be 2.90 MCal kg-1 on March 26. The highest DE and ME values in different sowing space applications were found to be 3.42, 3.41, and 2.81, 27.79 MCal kg-1 in 20 cm and 40 cm applications in the same group. Temel and Keskin (2019) [27] calculated the DE values to be between 3.18 and 3.31 MCal kg-1 in the form of sowing space applications between different rows and over the rows in quinoa on April 5 and the ME values were found to be between 2.61 and 2.72 MCal kg-1 (Table 2). Although our findings are partly similar to the findings of these researchers, the early sowing date increased the DE and ME values.

Conclusion

In the study, the plant quality of the quinoa plant sown at different sowing times and distances was examined. According to the results of the study, it was found that the effect of different sowing times on all the features examined was significant. The effect of sowing space applications between different rows on all examined features was found to be significant except for the crude ash ratio. The sowing time significantly affected the feed value of the quinoa plant. When the sowing times were compared, the highest CPR, CAR, DDMV, DE and ME and the lowest ADF values were obtained in the sowing on March 26, and the lowest NDF and the highest DMIV and RFV values were obtained on April 13. With the delay in the sowing time, crude protein ratio and crude ash ratio decreased, and the value of the feed of the quinoa decreased. When the sowing space applications between the rows were compared, the most suitable values in terms of animal feeding were obtained in the 20 cm range distance application except for the crude protein ratio and crude ash ratio. According to the results of the study, when the quality and efficiency of feed were considered, the lowest NDF and ADF values and the highest DDMV, DMIV, RFV ratios DE and ME values were obtained when quinoa was sown on April 13 and in case quinoa was planted with a range of 20 cm in Kahramanmaras conditions.

References

[1]. Zurita-Silva, A., Fuentes, F., Zamora, P., Jacobsen, S. E., & Schwember, A. R. (2014). Breeding quinoa (*Chenopodium quinoa* Willd.): potential and perspectives. *Molecular Breeding*, *34*(1), 13-30.

[2]. Filhoa, A.M.M., Pirozia, M. R., Borgesb, J. T. S., Sant'Anac, H. M. P., Chavesa J. B. P., & Coimbra, J. S. R. (2015). Quinoa: Nutritional, functional and anti-nutritional aspects. *Critical Reviews in Food Science and Nutrition*, *57*(8), 1549-7852.

[3]. Fuentes, F., Espinoza, P. A., Von Baer, I., Jellen E. N., & Maughan, P. J. (2009[a]). Determinación de relacionesgenéticas entre Chenopodium quinoa Willd. del sur de Chile y parientessilvestres del género Chenopodium. Anales del XVII Congreso Nacional de Biología del Perú, 45. Tacna, Perú.

[4]. Fuentes, F., Martínez, E. A., Hinrichsen, P. V., JellenE. N., & Maughan, P. J. (2009b). Assessment of genetic diversity patterns in Chilean quinoa (*Chenopodium quinoa* Willd.) germplasm using multiplex fluorescent microsatellite markers. *Conservation Genetics10*, 369-377.

[5]. Mujica, Á., & Jacobsen, S. (2006). *La Quinua (Chenopodium quinoa Willd) y susparientessilvestres*. La Paz, Botánica Económica de los Andes Centrales, 449-457.
[6]. Geren, H., Kavut, Y. T., Demiroğlu Topçu, G., Ekre, S., & İştipliler, D. (2014). Effects of different sowing dates on the grain yield and some yield components of quinoa (*Chenopodium quinoa* Willd.) grown under Mediterranean climatic conditions. *Journal of Agriculture Faculty of Ege University*, *51*(3), 297-305.
[7]. Jacobsen, S.E. (2003). The worldwide potential for quinoa (*Chenopodium quinoa* Willd.), *Food Rev. Int.*, *19*(1–2), 167–177.
[8]. Jacobsen, S.E., Monteros, C., Corcuera, L. J., Bravo, L. A., Christiansen, J. L., & Mujica, A. (2007). Frost resistance mechanisms in quinoa (*Chenopodium quinoa* Willd.). *European Journal of Agronomy*, *8*(4), 471–475.
[9]. Aguilar, P.C., & Jacobsen, S.E.(2003). *Cultivation of Quinoa on the Peruvian Altiplano*. Food Rev. Int. 19: 31–41.
[10]. Repo-Carrasco-Valenciaa, R., Hellströmb, J. K, Pihlavac, J. M., & Mattilab, P. H. (2010). 'Flavonoids and other phenolic compounds in Andean indigenous grains: Quinoa (*Chenopodium quinoa*), kañiwa (*Chenopodium pallidicaule*) and kiwicha'. Food Chemistry, *120*, 128-133.
[11]. Vega-Gálvez, A., Miranda, M., Vergara, J., Uribe, E., Puente, L., & Martínez, E. A. (2010). Nutrition facts and functional potential of quinoa (*Chenopodium quinoa*Willd.). An ancient Andean grain: A review, *Journal of the Science of Food and Agriculture*, *90*, 2541-2547.
[12]. Tan, M., & Temel, S. (2017). Determination of Dry Matter Yield and Some Properties of Different Quinoa Genotypes Grown in Erzurum and Iğdır Conditions. *Iğdır Univ. J. Inst. Sci. & Tech.7*(4), 257-263
[13]. Van Schooten, H. A., & Pinxterhuis, J. B. (2003). Quinoa as an alternative Forage crop in organic dairy farming. In Optimal forage systems for animal production and the environment. Proceedings of the 12th Symposium of the European Grassland Federation, Pleven, Bulgaria, 445-448.
[14]. Anonymous. (2019a). Eastern Mediterranean Agricultural Research Institute laboratory.
[15]. Anonymous. (2019b). T.C. Ministry of forestry and water affairs, general directorate of meteorology, Kahramanmaraş.
[16]. Risi, J., & Galwey, N. W. (1991). Effects of sowing date and sowing rate on plant development and grain yield of quinoa (*Chenopodium quinoa*) in a temperate environment, *The Journal of Agricultural Science*, *117*(3), 325-332.
[17]. AOAC. (1990). Official Method of Analysis. 15th. Ed. Association of Official Analytical Chemist, Washington, DC., USA.
[18]. Kacar, B. (1972). *Chemical analysis of plants and soil*. Ankara University Faculty of Agriculture Publication No: 453, Ankara.
[19]. Van Soest P. J., &Wine, R. H. (1967). The use of detergents in the analysis of fibrous feeds. IV. Determination of plant cell wall constituents. *Journal of the Association of Official Analytical Chemists*, *50*, 50-55.
[20]. Van Soest, P.J. (1963). The use of detergents in the analysis of fibre feeds. II. A rapid Method for the determination of fibre and lignin. *Journal of the Association of Official Analytical Chemists*, *46*, 829-835.
[21]. Oddy, V. H., Robards, G. E., & Low, S. G. (1983). *Prediction of in vivo dry matter digestibility from the fiber nitrogen content of a feed.* In: Robards, G.E., Packham, R.G. (Eds.), Feed Information and Animal Production. Commonwealth Agricultural Bureaux, Farnham Royal, UK, pp. 395-398.
[22]. Fonnesbeck, P.V., Clark, D. H., Garret W. N., & Speth, C. F. (1984). Predicting energy utilization from alfalfa hay from the Western Region. *Proceeding of American Society of Animal Sciences*, *35*, 305-308.
[23]. Khalil, J. K., Sawaya, W. N., & Hyder, S. Z. (1986). Nutrient composition of a triplex leaves grown in Saudi Arabia. *Journal of Range Management*, *39*, 104-107.

[24]. Sheaffer, C.C., Peterson, M. A., Mccalin, M., Volene, J. J., Cherney, J. H., Johnson, K. D., Woodward, W. T., & Viands, D. R. (1995). Acid detergent fiber, neutral detergent fiber concentration and relative feed value. North American Alfalfa Improvement Conference, Minneapolis.
[25]. SAS Institute. (2014). SAS 9.4 User's Guide. SAS Inst., Cary, NC.
[26]. Temel, S., & Şurgun, N. (2019). The Effect of Different Nitrogen and Phosphorus Doses on Hay Yield and Quality of Quinoa. *Journal of the Institute of Science and Technology*, *9*(3), 1785-1796.
[27]. Temel, I., & Keskin, B. (2019). The effects of different row spacing and ıntra-row spacing on hay yield and some yield components of quinoa (*Chenopodium quinoa* Willd.). *Journal of the Institute of Science and Technology*, *9*(1), 522-532.
[28]. Papastylianou, P., Kakabouki, I., Tsiplakou, E., Travlos, I., Bilalis, D., Dimitra, H. E. L. A., Chachalis, D., Anogiatis, G., & Zervas, G. (2014). Effect of fertilization on yield and quality of biomass of quinoa (*Chenopodium quinoa* Willd.) and green amaranth (*Amaranthus retroflexus* L.). *Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Horticulture*, *71*(2), 288-292.
[29]. Kaya, E., & Aydemir, S. K. (2020). Determining the forage yield, quality and nutritional element contents of quinoa cultivars and correlation analysis on these parameters. *Pakistan Journal of Agricultural Sciences*, *57*(2), 311-317.
[30]. Koca, Y.O., & Turgut, I. (2012). Leaf Area Index and Some Growth Parameters in Maize (*Zea mays* L.). *Adnan Menderes University Faculty of Agriculture Journal of Agricultural Sciences*, *9*(1), 1-10.
[31]. Koca, Y.O., & Canavar, Ö. (2014). The effect of sowing date on yield and yield components and seed quality of corn (*Zea mays* L.). *Scientific Papers Series A. Agronomy*, *57*, 227-231.
[32]. Erekul, O., Yiğit, A., Koca, Y. O., Ellmer, F., &Weiß, K. (2016). Quality potentials and importance in terms of nutrition physiology of some bread wheat (*Triticum aestivum* L.) Varieties. *Biotech Studies, 25*(1), 31-36.
[33]. Kakabouki, I., Bilalis, D., Karkanis, A., Zervas, G., & Hela, D. (2014). Effects of Fertilization and tillage system on Growth and crude protein content of quinoa (*Chenopodium quinoa* Willd.): An alternative Forage crop. *Emirates Journal of Food and Agriculture*, *26*(1), 18-24.
[34]. Van Soest, P.J. (1994). *Nutritional Ecology of the Ruminant*. 2nd Ed. Cornell Univ. Press. Ithaca, NY.
[35]. Yavuz, M. (2005). Determination of relative feed value and in vitro digestibility values of some ruminant feeds. Gaziosmanpasa Univ. *Agri. Fac. J.*, *22*, 97-101.
[36]. Van Soest, P. J., Robertson, J. D., & Lewis, B. A. (1991). Methods for dietary fiber, neutral detergent fiber and non-starch poly saccharine in relation to animal nutrition. *Dair. J. Sci*. *74*, 3583-3597.
[37]. Ball, D.M., Hoveland, C. S., & Lacefield, G. D. (1996). *Forage Quality*. In: S. Forages (2nd ed.). Potash & Phosphate Inst. and Foundation for Agronomic Research. Norcross, GA. pp. 124-132.
[38]. Moore, J. E., & Undersander, D. J. (2002). Relative forage quality alternative to relative feed value and quality index. Proceedings 13th Annual Florida Ruminant Nutrition Symposium; Jan. 10-11, Florida. pp. 16-32.
[39]. Ertürk, M.M., &Okuyan, M. R.(1995). Calculation methods of metabolisable energy requirements in ruminant animals. *Mediterranean Agricultural Sciences, 8*, 300-314.