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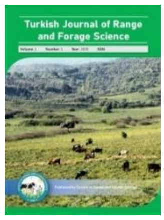

Effect of Quinoa-Corn Intercropping Production System on Yield and Quality of Mixture Silage

Hörünaz ERDOĞAN[1] **Yakup Onur KOCA**[1*]

[1]Department of Field Crops, Faculty of Agriculture, Aydın Adnan Menderes University, Aydın,Turkey

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A B S T R A C T

The experiment was conducted on Adnan Menderes University, Agriculture Faculty of the farm under the Aegean Ecological Conditions in the Western Part of Turkey (Koçarlı/Aydın) in 2019 and 2020. In addition to corn and quinoa parcels, 3 different mixtures (25% quinoa - 75% corn, 50% quinoa - 50% corn and 75% quinoa - 25% corn) were determined. The field experiment was carried out in a randomized block design with three blocks as replication. Periodic (approximately 20 daily) measurements (plant height, stem diameter, and chlorophyll amount) were made during the plant growth period. Green and dry grass yield values and some silage quality measurements (ADF, NDF, protein, fiber, and ash rate) were made at harvest date when the corn plant reached the dough maturity stage period (1/4 milk line). As a result of the study, it was determined that corn has serious adverse effects on quinoa during the plant growing and quinoa had also some negative effects on corn. None of the mixture treatments (25%, 50%, or 75% quinoa) containing quinoa plant showed as high green and dry grass yield values as 100% corn. However, all mixtures containing quinoa have shown that higher-quality grass (especially high protein rate) can be produced. Moreover, ADF and NDF values obtained from the mixtures also showed some positive changes. So, the results showed that quinoa can increase the quality of feed in some amount in the mixtures. It can necessary to do more studies on the subject in the future.

1. Introduction

According to statistics data of Turkey, the number of cattle has reached approximately 18 million heads and the number of sheep and goats has reached approximately 50 million heads (Anonymous, 2020). Although these figures seem to be sufficient for our country, the yield from animals (meat, milk, etc.) is insufficient.

To increase productivity, fattening should be done with high-quality feed with high nutritional content. However, feed expenses constitute the biggest expense of livestock businesses. Feed expenses reach up to approximately 70% of total operating expenses in some branches of the livestock business (Arslan and Erdurmus, 2012). The high production costs of animal products (especially feed costs) are directly reflected in the sales prices of all animal products (milk, cheese, butter, etc.), especially meat.

*Correspondence author: yokoca@adu.edu.tr

Quality feed production, which is one of the most important costs of livestock enterprises in our country; every year about 11 million tons of agricultural land, grassland areas of about 10 million tons are produced as 21 million tons in total. Considering our animal assets and the amount of grass produced, it is understood that the amount of roughage deficit is approximately 51 million tons. Nowadays this open stalk, straw, and husk, etc. Although it is tried to be supplied from roughages with low feed value or intensive/mixed feed sources, it is not sufficient (Topcu and Ozkan, 2017). One of the most important problems to be solved in the development of our country's livestock is to meet the need for high quality, cheap and abundant roughage regularly. Roughages are indispensable feed sources in animal husbandry and it is a fact that there is a serious shortage of quality roughage in livestock farming in our country.

Quinoa plant, which is mostly used in human nutrition, is a dioctyl and one-year plant from the family of goose fats or spinach, and its main homeland is South America (Kaya & Karaer, 2017). Quinoa seeds are an extremely valuable foodstuff with high carbohydrate, quality protein, fat, fiber, vitamin, and mineral content (Keskin and Kaplan Evlice, 2015). It is thought that a plant with such a rich nutrient content can be an alternative feed plant that can increase the quality of roughage production. If this plant can be grown with corn, even if the green grass yield decreases slightly, the loss in yield can be compensated by the product quality. This project aims to determine the amount of grass to be obtained (green and dry weight) by planting quinoa plants at different rates together with the corn plant and to observe the nutritional value (protein rate, fiber rate, ash rate, ADF, and NDF) changes of the obtained grass. Also, with this project, the responses of different field crops under living conditions were measured (Plant height, stem thickness, chlorophyll). Thus, the quinoa (*Chenopodium quinoa* Willd.) plant, which has gained popularity in our country in recent years, can be considered as an alternative plant in animal nutrition due to its rapid growth and easy cultivation.

2. Material and Method

The experiment was conducted on Adnan Menders University Agriculture Faculty Farm under the Aegean Ecological Conditions in the Western Part of Turkey (Koçarlı/Aydın) during the summer plant production season of 2019 and 2020.

The field experiment was conducted in a Randomized Complete Block Design double factor (treatment and year) with three blocks as replication. Five different treatments were determined within the scope of the experiment. In addition to the whole corn (100% corn) and quinoa (100% quinoa) parcels named as standard, the proportional mixtures (25%, 50%, and 75%) of these two plants have provided other three different treatments. "25% quinoa - 75% corn" treatment was made by growing one-row quinoa and three rows of corn in four rows of parcels. Similarly, mixtures of "50% quinoa-50% corn" and "75% quinoa-25% corn" were made by growing two rows quinoa - two rows corn and three rows quinoa - one-row corn, respectively. For each parcel (100% corn, 100% quinoa, 25% corn - 75% quinoa, 50% corn - 50% quinoa and 75% corn - 25% quinoa) were planned as 280 m^2 with 10 m row length and 3 repetitions.

The results of the analysis of soil taken from the experiment area (Table 1) were examined. It was determined that the land on which the experiment was established had a sandy loam structure, the amount of organic matter is low and the reaction is alkaline. Besides, the results were obtained that amount of potassium was low but, the amount of phosphorus was high.

The average temperature, precipitation, and average values for long year's dates in Aydın/Koçarlı during the 2019-2020 crop growing period were shown in Table 2. It was seen that the average temperatures of all months of 2019 (except June) were found to be lower than those measured in 2020. Furthermore, it was said that the summer period of 2019 (from April to September) was rainier than in 2020. So, it was generally interpreted in terms of average temperature and precipitation amounts that the summer season of 2019 (from April to September) was colder and humid.

Table 2. Weather conditions of two years of the experiment

Months	Temperature (°C)			Precipitation (mm)		
	2019	2020	Many years	2019	2020	Many years
April	15.8	16.5	15.7	59.2	43.8	45.5
May	22.4	23.6	20.9	8.3	40.3	33.5
June	25.6	24.1	25.9	97.7	8.7	14.0
July	26.6	27.7	28.4	0.2	1.4	3.5
August	27.2	28.9	27.2	0.0	0.7	2.2
September	22.1	25.7	23.2	11.8	0.0	14.4

Considering the plant growth and development periods, agricultural processes such as top fertilization, intermediate hoe, and irrigation were applied. Fertilization took place in two stages. First fertilization (safe 80 kg/ha N, P, and K applied as 15-15-15 compound fertilizer) was carried out in the determined field area before sowing. Then, sowings were carried out (03.05.2019 - 25.05.2020) when soil and weather conditions were suitable. Emergency dates of the corn plant were recorded as 10.05.2019-30.05.2020 and the quinoa plant as 14.05.2019-04.06.2020. The top fertilization process with urea performed during the study (safe 150 kg/ha N) was carried out on 03.06.2019-15.06.2020. At regular weekly intervals, the roads around the parcels were sent manually. The drip irrigation method was envisaged for irrigation. Thus, it was contributed to the reduction of weed damage.

Table 1. Soil analysis results

Soil texture (%)			pH	Organic Matter (%)	P (ppm)	K (ppm)
Sand	Mile	Clay				
72	16.7	11.3	8.0	1.91	21	176
Sandy loam			High	Low	High	Low

Measurements

Periodic measurements and harvest (for silage)

During the study, periodic (approximately 20 daily) measurements (plant height, stem diameter, and chlorophyll amount) were made. The first sampling dates were done on 07.06.2019 - 19.06.2020. This was followed by sampling in 20-day periods in two years and the last sampling dates were done on 05.08.2019 - 23.08.2020. Plant height, stem thickness, and chlorophyll rate measurements were measured with a wooden meter (ruler of 300 cm), an electronic caliper (Mitutoyo digital 500-181-30, 0.01 mm precision), and a chlorophyll meter (SPAD 502 Plus) (Uddling et. al., 2007).

Harvest was carried out (08.08.2019 - 27.08.2020) when the corn plant reached the dough maturity stage period (1/4 milk line). The harvesting process was carried out by manually cutting the middle part from the soil surface after leaving the edge effects of the two rows in the middle of each parcel ($6 * 1.4 = 8.4$ m^2). Yields (green weight) were calculated by converting the figures obtained (green and dry weight). The obtained material from parcels was sampled and dried in an oven (48 hours at 70 ^{o}C, Perry and Compton, 1977). Using the obtained results for calculation, dry yield (dry weight) was tried to be determined.

Quality measurements (ADF, NDF, protein, fiber, and ash rate)

Samples were ground after the material obtained from the parcels was weighed. NIRS-FT (Bruker MPA) instrument was used for silage quality analyzes (protein, ADF, NDF, ash, and fiber), in the TARBIYOMER laboratory of Adnan Menderes University. For measurements, a sample with a depth of 2.8 cm was placed in the chamber of the instrument, approximately 9 cm in diameter, and analyzes were performed (Gislum et. al., 2004).

Measurements obtained from experiment repetitions were analyzed (variance analysis) using the TARIST package program according to the random blocks trial design (Acikgoz et. al., 2004). A comparison of the averages was made using LSD (0.05).

4. Results and Discussions

Two main results were emphasized within the scope of the study. The first of these was to determine the effects of intercrop production rates on plants during the vegetation period. For this purpose, when the plants reach a certain growth level, plant height, chlorophyll, and stem thickness values were measured in certain periods (about 20 days). The results and LSD values (mixture*variety) calculated with variance analysis were given in Table 3. The second was to determine the changes in the final product (green and dry grass) obtained as a result of intercrop production. In addition to green and dry weight values, some quality characteristics (protein rate, fiber rate, ash rate, ADF, and NDF) of the grass were determined. The results and LSD values (mixture*year) calculated with variance analysis were given in Table 4.

Table 3 shows that the first measurements during the growing period of corn were made on 07.06.2019 and 25.06.2020. The maximum corn plant height values were given as 136.2 cm (75% quinoa - 25% corn) in the first year and 162.3 cm (50% quinoa - 50% corn) in the second year. Similarly, the maximum quinoa plant height values were appeared to 82.3 cm by 2019 (100% quinoa) and 93.6 cm (75% quinoa - 25% corn) by 2020. The maximum Chlorophyll values of corn and quinoa were determined 75% quinoa - 25% corn parcel as 55.8 and 52.2 in 2019 respectively. The values were determined as 56.5 (25% quinoa - 75% corn) in the corn plant and 56.6 (75% quinoa - 25% corn) in the quinoa in 2020. “75% quinoa - 25% corn” parcel gave the highest values of stem thickness in both plants in both years (except quinoa (16,3 mm) in 2020). The maximum stem thickness measured corn as 29.2 mm (2019) and 25.0 mm (2020) and quinoa as 13.9 mm (2019).

The next measurements of the experiment were made on 28.06.2019 and 15.07.2020. The maximum corn plant height values were given as 266.0 cm (75% quinoa - 25% corn) in the first year and 231.0 cm (100% corn) in the second year. Similarly, the maximum quinoa plant height values were appeared to 134.7 cm by 2019 (75% quinoa - 25% corn) and 178.8 cm (50% quinoa - 50% corn) by 2020. The maximum Chlorophyll values of both plants were reported as 63.2 for corn and 63.6 for quinoa in 2019 at 75% quinoa - 25% corn parcel. The values were determined as 57.9 (50% quinoa - 50% corn) in the corn plant and 60.7 (100% quinoa) in the quinoa in 2020. Stem diameter values in the table were examined that the maximum values of corn were given as 28.8 mm (100% corn) for 2019 and 27.2 mm (75% quinoa - 25% corn) for 2020. The maximum stem thickness value in the quinoa plant was given 13.8 mm (50% quinoa - 50% corn) in 2019 and 19.6 (100% quinoa) in 2020.

The third measurement of the experiment was made on 17.07.2019 and 03.08.2020. The maximum corn plant height values were determined as 284.0 cm in the first year and as 260.8 cm in the second year at 100% corn parcel. The maximum quinoa plant height values were appeared to 145.0 cm by 2019 (100% quinoa) and 182.8 cm (50% quinoa - 50% corn) by 2020. The maximum Chlorophyll values were reported as 60.6 (75% quinoa - 25% corn) for corn and 55.1 (100% quinoa) for quinoa in 2019. The values were determined as 64.8 (100% corn) in the corn plant and 60.3 (50% quinoa - 50% corn) in the quinoa in 2020. Stem diameter values in the table were examined that the maximum values of corn were given as 30.7 mm (100% corn) for 2019 and 21.4 mm (75% quinoa - 25% corn) for 2020. The maximum stem thickness value in the quinoa plant was given 16.5 mm (100% quinoa) in 2019 and 17.2 (25% quinoa - 75% corn) in 2020.

The last measurements of the experiment were made on 05.08.2019 and 19.08.2020. The maximum corn plant height values were given as 296.5 cm (100% corn) in the first year and 261.0 cm (100% corn) in the second year. The maximum quinoa plant height values were appeared to 159.0 cm by 2019 (100% quinoa) and 200.2 cm (75% quinoa - 25% corn) by 2020. The maximum Chlorophyll values were reported as 60.1 (75% quinoa - 25% corn and 100% corn parcels) for corn and 55.9 (100% quinoa) for quinoa in 2019. The values were determined as 60.5 (100% corn) in the corn plant and 58.2 (50% quinoa - 50% corn) in the quinoa in 2020. Stem diameter values in the table were examined that the maximum values of corn were given as 29.6 mm (100% corn) for 2019 and 22.0 mm (50% quinoa - 50% corn) for 2020. The maximum stem thickness value in the quinoa plant was given 15.9 mm (100% quinoa) in 2019 and 18.0 (25% quinoa - 75% corn) in 2020.

Table 3. Plant height, stem diameter, and chlorophyll amount values obtained from plants at the sampling dates throughout the study

Years			2019			2020		
Dates	Mixture	Variety	Plant height (cm)	Chlorophyll	Stem diameter (mm)	Plant height (cm)	Chlorophyll	Stem diameter (mm)
07.06.2019 – 25.06.2020	100% Quinoa		82.3	51.0	13.7	91.7	56.4	16.3
	100% Corn		134.4	53.1	29.1	162.2	51.1	21.9
	75% Quinoa - 25% Corn	Quinoa	81.5	52.2	13.9	93.6	56.6	15.3
		Corn	136.2	55.8	29.2	156.7	55.9	25.0
	50% Quinoa - 50% Corn	Quinoa	80.8	48.6	13.5	85.2	52.5	13.9
		Corn	126.3	55.4	27.3	162.3	56.0	22.6
	25% Quinoa - 75% Corn	Quinoa	58.8	45.1	10.2	90.1	53.1	14.7
		Corn	133.4	48.7	25.8	161.0	56.5	20.3
28.06.2019 – 15.07.2020	100% Quinoa		132.8	59.1	13.3	153.6	60.7	19.6
	100% Corn		258.0	61.5	28.8	231.3	57.3	24.6
	75% Quinoa - 25% Corn	Quinoa	134.7	63.6	12.4	145.2	57.4	18.0
		Corn	266.0	63.2	25.8	202.8	56.8	27.2
	50% Quinoa - 50% Corn	Quinoa	130.3	55.3	13.8	178.8	58.1	16.7
		Corn	237.3	56.9	26.2	202.3	57.9	26.4
	25% Quinoa - 75% Corn	Quinoa	122.5	52.6	11.6	132.0	58.9	16.2
		Corn	260.5	58.4	26.3	211.7	57.6	27.1
17.07.2019 – 03.08.2020	100% Quinoa		145.0	55.1	16.5	182.4	50.4	16.6
	100 % Corn		284.0	60.1	30.7	260.8	64.8	18.3
	75% Quinoa - 25% Corn	Quinoa	140.5	51.7	15.3	174.6	56.6	17.0
		Corn	265.3	60.6	24.1	226.9	57.7	21.4
	50% Quinoa - 50% Corn	Quinoa	132.5	55.0	14.8	182.8	60.3	16.0
		Corn	255.5	54.8	27.0	226.7	47.2	20.5
	25% Quinoa - 75% Corn	Quinoa	133.8	53.6	12.5	143.1	53.2	17.2
		Corn	276.0	54.7	25.7	222.7	59.6	19.1
05.08.2019 – 19.08.2020	100% Quinoa		159.0	55.9	15.9	188.3	57.4	17.1
	100% Corn		296.5	60.1	29.6	261.0	60.5	18.6
	75% Quinoa - 25% Corn	Quinoa	145.0	51.5	14.1	200.2	53.4	17.4
		Corn	270.3	60.1	25.2	225.0	57.6	18.3
	50% Quinoa - 50% Corn	Quinoa	141.8	53.6	15.5	193.6	58.2	16.4
		Corn	261.3	53.6	26.6	242.7	50.8	22.0
	25% Quinoa - 75% Corn	Quinoa	144.0	52.9	11.9	163.4	55.0	18.0
		Corn	289.0	56.4	26.0	258.2	58.7	20.4
LSD mixture*variety (0.05)			47.0	1.48	0.61			

Table 4. Green and dry grass and quality parameters

Years	2019							2020						
Mixtures	Green grass (kg ha^{-1})	Dry grass (kg ha^{-1})	ADF	NDF	Protein (%)	Fiber (%)	Ash (%)	Green grass (kg ha^{-1})	Dry grass (kg ha^{-1})	ADF	NDF	Protein (%)	Fiber (%)	Ash (%)
100% Quinoa	38868	16490	34.4	43.3	18.2	4.1	1.6	65271	19880	31.9	37.8	16.0	3.2	2.9
100% Corn	91253	41287	37.1	55.0	8.3	4.3	1.2	84953	28388	26.6	32.8	9.0	1.6	1.6
75% Quinoa - 25% Corn	68735	30404	33.5	48.8	13.9	3.8	1.6	59946	22724	31.7	40.1	13.6	5.4	2.6
50% Quinoa - 50% Corn	67843	31877	36.6	49.3	12.5	4.3	1.2	35895	20922	32.1	37.1	14.0	1.3	2.2
25% Quinoa - 75% Corn	89638	43069	35.6	49.2	11.3	4.0	1.3	44598	24567	34.9	40.2	12.8	1.8	1.8
LSD mixture*year (0.05)	6232	2983	3.2	4.4	2.7	0.3	0.2							

It can be concluded that the plants do not suppress each other intensely at the beginning of the vegetation period (first measurement time) from the overall Table 3. But corn had a negative effect on quinoa plant height and stem thickness in later periods (second, third, and fourth samples). Moreover, according to the chlorophyll averages measured periodically throughout the study, quinoa chlorophyll values measured in almost all treatments (except for some 25% corn and 50% corn treatments) where corn entered the mixtures were lower than 100% quinoa (especially in all 75% corn treatments). The low concentration of chlorophyll directly limits the photosynthetic potential and primary production (Curran et al., 1990). Additionally, calculating the chlorophyll content can be an alternative way of measuring the nutritional status of the plant (Filella et al., 1995). As pigmentation is directly related to plant stress physiology, while the concentration of carotenoids increases under stress, the concentration of chlorophyll decreases (Peñuelas and Filella 1998). Corn plants put stress on quinoa plants and the result was predictable prior to the study, but it was an interesting another result of the study that quinoa has also a negative effect on corn plant height and stem thickness. Although it was thought that corn can crush quinoa with a plant height approaching 3 meters, it has been observed that the corn was partially affected (shortening, stalk thinning, and fluctuations in chlorophyll values) in almost all mixing treatments (starting from 25%) added quinoa.

Green and dry grass yield values calculated by harvesting and drying of green grass of parcels at the end of the study were given in Table 4. Also, some quality parameters such as ADF, NDF, Protein (%), fiber (%), and ash (%) were given. It was observed that the mixture treatments affected green and dry grass yields and quality parameters when the values obtained from the study were examined in general (Table 4). The difference between mixtures was found to be significant in all measured parameters. The highest green grass yield was determined as 91253 kg/ha (100% corn) in 2019. It was followed up with 25% quinoa - 75% corn treatment, which yielded 89638 kg/ha. Treatments (100% corn and 25% quinoa - 75% corn) were also given the highest dry grass values (41287 kg ha^{-1} and 43069 kg ha^{-1} respectively). The highest average green grass yield was given as 84953 kg ha^{-1}in 2020.

The highest value of dry grass value was recorded as 28388 kg ha^{-1} in 2020. Similar to the first year (2019), 100% corn treatment showed the highest green and dry grass yield. But, 25% quinoa - 75% corn treatment was not performing like the first year of the experiment. The maximum ADF average in the first year of the study was measured 100% corn treatment. Similarly, the maximum NDF values were obtained from 100% corn parcels in the same year (2019). But, in the second year of the study, different results were obtained from the first year. The maximum ADF and NDF averages were obtained from 25% quinoa - 75% corn treatment in 2020. The highest protein content values (18.2% for 2019 and 16.0% for 2020) were obtained from quinoa (100% quinoa) in both years of the study. Similarly, the treatment gave the highest ash content values (1.6% for 2019 and 2.9% for 2020) in both years. However, fiber rate values show some differences. The maximum fiber rate value (4.3%) was measured from 2 different treatments (100% corn and 50% quinoa - 50% corn) in the first year of the experiment, while the maximum fiber rate value (5.4%) in the second year was measured from 75% quinoa - 25% corn treatment.

In parallel with many previous studies, 100% corn showed the highest values of green and dry grass (Koca et al., 2010; Koca and Erekul, 2016). Baghdadi et al. (2016a) reported that the crop combination rate significantly affected the total dry matter yield of corn-soybean feed in their study. Among the corn and soybean monocropping and corn-soybean intercropping, reported that the total dry matter yield of corn (1477 kg ha^{-1}) was the highest value. Similarly, Stoltz et al. (2013) in their studies, sole corn had a higher dry matter yield (by 44-57%) than intercropped corn. Other studies have shown similar results corn included in the intercropping systems significantly increased dry matter yield (Kizilsimsek et al., 2020; Javanmard et al., 2009; Geren et al., 2008; Azim et al., 2000). This study yielded similar results to those of the other studies. However, the lowest protein content value was also measured from the same treatment. In almost all treatments where quinoa was added to the mixture, decreases in green and dry grass yield were observed. Similar results have been observed in the literature in the mixture treatments with corn. Tansi (1987) determined that the crude protein rate of corn in co-cultivation is higher than in lean cultivation, which is consistent with our results. Ibrahim et al. (2006) have conducted in their study, corn and cowpea seeds mixed in various combinations affected protein production, where the increasing rate of cowpea in the seed mixture increased the crude protein concentration. While sole cowpea produced more protein (18.10%), corn monocropping produced lower (8.5%). The 75:25 crop combination of corn and cowpea produced more protein (10.45%) than a sole corn crop. Result of another study, protein content was significantly affected by crop combination rate and declined with a decrease in the proportion of soybean from 16.24% to 9.91% Baghdadi et al. (2016b). Accordingly, our study similar results included. The most dramatic result from the study that the protein rates were noticeably increased in almost all quinoa mixture treatments every two years. In addition, quinoa improved the ADF and NDF values (especially in the first year of the study) measured in almost all of the different mixtures. There have been many studies advocating the necessity of high protein rate and balanced of ADF and NDF values in roughage production. ADF is mostly a feed value used to determine the digestibility status of roughage by the animal, while NDF is a feed value used to determine the availability of roughage by animals (Sayar et al., 2018). Some researchers emphasized that ADF and NDF values should be as low as possible for good forage quality (Lacefield, 1988; Schroeder, 1994; Sayar et al., 2018). According to the studies conducted with NDF and ADF concentration, the lowest values were found in monocropping corn silage, followed by the silages of the intercropping systems (Souza et al., 2019). There was revealed that all quinoa varieties examined had a quality fiber content in terms of NDF (36.48-39.86%) and ADF (19.46-23.45%) rate (Temel and Tan, 2020). Quinoa may be recommended to improve the quality of feed. It may even be argued that it can be tolerated yield losses with good farming practice conditions.

5. Conclusion

The results of the corn-quinoa mixture experiment conducted under Aegean Ecological Conditions in the Western Part of Turkey (Koçarlı/Aydın) in the summer plant production season in 2019 and 2020 were given below as follows.

- In addition to the significant negative effects of a corn plant on quinoa (plant height, chlorophyll rate, and stem thickness) especially in the later growth and development periods (second, third and fourth measurements), some negative effects of quinoa on corn (plant height and stem thickness) were determined.

- None of the mixture treatments (25%, 50%, or 75% quinoa) containing quinoa plant or any of the 100% quinoa parcels showed as high yield values as green and dry grass yields from 100% corn. However, all mixtures containing quinoa (25%, 50%, or 75% quinoa) and 100% quinoa parcels have shown that higher-quality grass can be produced. In both years, a significant increase was observed in the protein rate of all mixtures parcels containing quinoa. ADF and NDF values also showed some positive changes.

Although many results have been obtained from an intercrop study in two years, measuring more grass quality parameters (dry matter content changes between periodic measurements, digestible energy, metabolizable energy, oil rate, and mineral nutrient contents) will give more accurate and available results about farming practices. Furthermore, the effects of plant mixtures on soil structure can be determined with soil samples taken from the experiment area. Also, conducting the study in different locations to see the ecological impacts can be seen as a good idea during the next years.

References

Açıkgöz N., İlker E and Gökçöl A., (2004). Computer evaluation of biological research (Tarist). Ege University Seed Technology Research and Application Center Publications, Publication Number: 2, İzmir.

Anonymous, (2020). TUIK data. Access: Animal-Production-Statistics-June -2020-33874.

Arslan M., Erdurmuş C., (2012). An Overview of Animal Husbandry and Roughage Problem in Our Country. Agriculture Engineering, Vol: 359, Pages 32-37.

Azim., A., Khan, A.G., Nadeem, M.A., and Muhammad, D. (2000). Influence of Maize and Cowpea Intercropping on Fodder Production and Characteristics of Silage. Asian Australasian Journal of Animal Sciences 13(6): 781-784.

Baghdadi, A., Halim, R. A., Ghasemzadeh, A., Ebrahimi, M., Othman, R., and Yusof, M. M. (2016a). Effect of intercropping of corn and soybean on dry matter yield and nutritive value of forage corn. Legume Research-An International Journal, 39(6), 976-981.

Baghdadi, A., Halim, R. A., Radziah, O., Martin, M. Y., and Ebrahimi, M. (2016b). Fermentation characteristics and nutritive value of corn silage intercropped with soybean under different crop combination ratios. Journal of Animal and Plant Sciences, 26(6), 1710-1717.

Curran PJ, Dungan JL, Gholz HL (1990) Exploring the relationship between reflectance red edge and chlorophyll content in slash pine. Tree Physiology 7: 33-48.

Filella I, Serrano L, Serra J, Peñuelas J (1995) Evaluating wheat nitrogen status with canopy reflectance indices and discriminant analysis. Crop Science 35: 1400-1405.

Geren, H., Avcioglu, R., Soya, H., and Kir, B. (2008). Intercropping of corn with cowpea and bean: Biomass yield and silage quality. African Journal of Biotechnology, 7(22).

Gislum R., Micklander E, and Nielsen JP., 2004. Quantification of nitrogen concentration in perennial ryegrass and red fescue using near-infrared reflectance spectroscopy (NIRS) and chemometrics. Field Crops Research, 88: 269-277.

Ibrahim, M., M. Rafiq., A. Sultan., M. Akram and M. A. Goheer (2006). Green fodder yield and quality evaluation of maize and cowpea sowed alone and in combination. J. Agricultural Research, 44(1), 15-22.

Javanmard, A., Nasab, A. D. M., Javanshir, A., Moghaddam, M., and Janmohammadi, H. (2009). Forage yield and quality in intercropping of maize with different legumes as double-cropped. Journal of Food, Agriculture and Environment, 7(1), 163-166.

Kaya, E., Karaer., M. (2017). Quinoa cultivation and its importance for health. Turkish Journal of Scientific Reviews, 10(2), 21-26.

Keskin, Ş., Kaplan E. A. (2015). Use of quinoa in bakery products. Journal of Field Crops Central Research Institute, 24(2), 150-156.

Kizilsimsek, M., GünAydın, T., Aslan, A., Keklik, K., and Açıkgöz, H. (2020). Improving Silage Feed Quality of Maize Intercropped with Some Legumes. Turkish Journal of Agricultural and Natural Sciences, *7*(1), 165-169.

Koca YO, Erekul O (2016). Changes of Dry Matter Biomass and Relative Growth Rate with Different Phenological Stages of Corn. Agriculture and Agricultural Science Procedia, 10, 67-75.

Koca YO, Turgut I, Erekul O (2010). Determination of Performance of Corn Grown for Grain Production in First and Second Crop. Ege University Faculty of Agriculture Journal, 47 (2): 181-190.

Lacefield, G. D., (1988). Alfalfa Hay Quality Makes the Difference. University of Kentucky Department of Agronomy AGR-137, Lexington, KY.

Peñuelas J, Filella I (1998) Visible and near-infrared reflectance techniques for diagnosing plant physiological status. Trends in Plant Science 3: 151-156.

Perry, L.J., and Compton, W.A., 1977. Serial Measures of Dry Matter Accumulation and Forage Quality of Leaves, Stalks, and Ear of Three Corn Hybrids. Agronomy Journal 69:751-755.

Sayar, M. S., Başbağ, M., Çaçan, E. (2018). Determination of feed quality values of some cereal plant species and evaluation of inter-relationships with biplot analysis method. Journal of Field Crops Central Research Institute, 27(2), 92-101.

Schroeder, J. W. (1994). Interpreting Forage Analysis. Extension Dairy Specialist (NDSU), AS-1080, North Dakota State University.

Souza, W. F. D., Costa, K. A. D. P., Guarnieri, A., Severiano, E. D. C., Silva, J. T. D., Teixeira, D. A. A.,and Dias, M. B. D. C. (2019). Production and quality of the silage of corn intercropped with Paiaguas palisadegrass in different forage systems and maturity stages. Revista Brasileira de Zootecnia, 48.

Stoltz, E., Nadaeu, E., Wallenhammar, A.C. 2013. Intercropping maize and faba bean for silage under Swedish climate conditions. Agric. Res. 2 (1):90-97.

Tansı V, 1987. Research on the Effect of Cultivation of Corn and Soybeans as Second Crops in Different Sowing Systems on Grain and Output Yield in Çukurova Region. Cukurova Univ. Institute of Science, PhD Thesis, Adana.

Temel, S., Tan, M. (2020). Evaluation of Different Types of Quinoa Grown in Dry Conditions in Terms of Coarse Feed Quality Characteristics. International Journal of Agriculture and Wildlife Sciences, 6(2), 347-354.

Topçu, G. D., Özkan, Ş. S. (2017). Forage Crops Agriculture An Overview of the Aegean Region of Turkey and Grassland Areas. ÇOMÜ Journal of the Faculty of Agriculture, 5(1), 21-28.

Uddling, J., Gelang-Alfredsson, J., Piikki, K., and Pleijel, H. (2007). Evaluating the relationship between leaf chlorophyll concentration and SPAD-502 chlorophyll meter readings. Photosynthesis Research, 91(1), 37-46.