Selcuk Journal of Agriculture and Food Sciences
https://dergipark.org.tr/tr/pub/selcukjafsci
Research Article

(2025) 39(1), 135-148 DOI:10.15316/SJAFS.2025.012 e-ISSN: 2458-8377 Selcuk J Agr Food Sci

Determination of The Effects of Different Applications on Some Forage Quality Characteristics in Alfalfa Harvesting with Disc Mowers

Yusuf Çiftci[1,*], Mehmet Hakan Sonmete[1]

[1]Selcuk University, Faculty of Agriculture, Department of Agricultural Machinery and Technology Engineering, Konya, Türkiye

HIGHLIGHTS

- Harvesting alfalfa with three different harvesting systems
- Determination of drying rates and dry matter losses of alfalfa with different harvesting systems
- Some factors affecting forage quality

Abstract

In this study, the effects of different harvesting systems on the drying process, dry matter loss and some forage quality characteristics of alfalfa were investigated. In the research, alfalfa, a forage plant, was harvested with three different harvesting systems: disc mower (UI), disc mower + rubber roller conditioning unit (UII), and disc mower + finger type conditioning unit (UIII) and baling has been done. The trials were conducted according to the randomized block trials design. In the research, moisture content, drying rate, dry matter loss, forage quality values and relative forage values were determined depending on the drying time of the harvesting systems. At the end of the third day of harvesting applications, moisture losses were determined as 34.94%, 39.13% and 31.51%, drying ratios as 3.05, 2.95 and 3.37, and total dry matter losses as 3.72%, 2.26% and 7.80% in UI, UII and UIII applications, respectively. CP values, which express forage quality after baling, are on average 17.63%, 21.33% and 16.87% in UI, UII and UIII applications has been determined respectively, ADF values are 26.93%, 28.27% and 30.76%, NDF values if 31.97%, 30.93% and 34.77%. The relative forage value was determined as 205.18%, 201.21% and 173.75%, respectively. As a result of the research, it was seen that the UII application was the best application.

Keywords: Alfalfa; disc mower; dry matter losses; drying rate; forage quality

1. Introduction

Living things need nutrition to survive. Agriculture and animal husbandry activities form the basis of human nutrition. For people to have a healthy and balanced diet, the proteins contained in meat and milk of animal origin and the products obtained from them are very important.

Citation: Çiftci Y, Sonmete MH (2025). Determination of the effects of different applications on some forage quality characteristics in alfalfa harvesting with disc mowers. *Selcuk Journal of Agriculture and Food Sciences*, 39(1), 135-148. https://doi.org/10.15316/SJAFS.2025.012

***Correspondence:** yusuf.ciftci@selcuk.edu.tr

Received date: 05/12/2024
Accepted date: 25/02/2025

According to TurkStat 2021 data, it is understood that there are 17.7 million head of livestock, 1.2 million tons of red meat and 23 million tons of milk production in our country as of 2019. According to the values of the last 10 years, there has been an increase of 55.6% in the number of cattle, 53.9% in red meat production and 69.5% in milk production. 91% of milk production and 89.5% of red meat production are obtained from cattle (TurkStat 2021).

Feeds used in animal nutrition are divided into two main groups: concentrated feed and roughage. The high cost of concentrated feed also increases the feeding cost of animals. The biggest cost in animal production is feed input (Mavruk 2017). Feed input is of even greater importance for small and medium-sized agricultural enterprises in our country. For this reason, the ability of agricultural enterprises to carry out animal husbandry activities with the highest profitability depends on their ability to obtain quality roughage at the lowest cost (Toruk 1997).

In our country, roughages used in animal nutrition are generally supplied from meadow-pasture areas, forage crops grown in agricultural lands and dry grass and silage obtained from crop production residues.

According to TurkStat's 2001 agricultural census, meadow-pasture areas in our country are 14.6 million hectares (12.95 million hectares of land have been determined as of 2020), corresponding to approximately 5% of Turkey's surface area and 38.8% of the total agricultural areas (Anonymous 2020). Since the early 2000s, meadow-pasture areas have become unable to meet the required roughage due to reasons such as heavy and overgrazing. Since the meadow-pasture areas are insufficient for grazing, the roughage needs of the animals are tried to be met with forage plants such as alfalfa, silage corn and vetch.

With the government support given to livestock farming in recent years, forage crop cultivation areas have increased by approximately 50%, reaching 2.3 million hectares from 1.5 million hectares (TurkStat 2021). As a result of this increase, the roughage need in livestock enterprises has begun to be met to a large extent by forage plants such as corn silage, dry alfalfa and legume straw.

According to TurkStat 2021 data in our country, when the last 10-year production values of alfalfa, silage corn, vetch and sainfoin plants are examined, it is understood that there is an increase of 59.7% in alfalfa, 2.3% in vetch, 104.5% in silage corn and 23.1% in sainfoin (TurkStat 2021).

In the same period, it was observed that there was an increase of 90.2% in alfalfa production, 88.9% in vetch and 320% in silage corn in Konya province, and a 36.6% decrease in sainfoin.

In our country, alfalfa which is produced in the largest area among all forage crops, is consumed with pleasure by animals. Demiroğlu et al. (2008) stated that alfalfa is the queen of forage crops due it has a high quality forage value.

Feed quality can be defined as whether the feed is liked by the animal and can be converted into animal products at most. Feed quality is closely related to the nutritional and energy value, the proportion of crude protein and vitamins, the amount of mineral substances, in addition to fiber and digestibility rates, it is also closely related to the productivity of animals.

Budak and Budak (2014) stated that the quality of forage plants is determined by milk yield and live weight gain; They also stated that the palatability of the forage, the amount eaten by the animals, its digestibility, nutritional element content, toxic content and the performance of the animals are indicators. They emphasized that if the crude protein content of the forage plant is 12% or less, it is low quality forage, if it is 15% or so, it is medium, and if it is 18% or more, it is high quality forage.

In determining forage quality, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF) analyses, forage consumption and forage digestibility level are also used as important quality criteria (Vurarak 2016).

If the forage plants are harvested in accordance with the technique, the high quality forages needed by the animals can be obtained. Harvesting consists of sequential processes that influence each other. These operations to contain mowing or mowing + conditioning, raking, baling and transporting. During harvest collecting and storing the green and very moist product from the field in a short time without losing its nutritional value is only possible with mechanization practices. Forages plants harvested green are stored either by making silage or by drying.

The main purpose of drying is to reduce the moisture content from 70-80% at the time of harvest to 20-25% moisture content where it can be safely stored (Dursun and Güner 1999; Sessiz at al., 2020). There are three ways of drying to a safe moisture level in practice. These are drying completely in the field with meteorological factors, drying in the field up to a certain level and then artificial drying in closed places and artificially removing all the water rapidly (Evcim 1979).

Today, as in the past, natural drying continues to play an important role in forage production. Freshly harvested forages may require several days to reduce to the ideal moisture desired for baling. Although this period is affected to some extent by the type of forage plant, the harvesting method and the equipment used, it is mainly determined by the weather conditions prevailing during the drying period. During this time, the forage crop can be exposed to various factors leading to quality loss.

Losses that start immediately after harvesting are due to two main causes, biological and mechanical (Rotz 1995). In some cases, artificial drying methods are applied to reduce this possible quality loss, the energy cost required makes forage production more expensive. Under these circumstances, the traditional drying method continues to be a widely accepted practice. It is important to introduce practices that will minimize the drying time without damaging the forage quality.

Harvesting of forage crops is usually done with rotary or double blade mowers and raking is done with grass rakes. Baling is done with balers that make cylindrical and prismatic bales. Mavruk (2017) emphasized that the production of roughage at the lowest cost and the best quality depends on the most effective use of these machines.

In this study, it was aimed to determine the effects of different harvesting practices on field drying rate, dry matter losses and forage quality in the harvest of alfalfa a roughage crop.

2. Materials and Methods

2.1. Material

2.1.1. Trial area

The trials were carried out in the alfalfa cultivated field numbered 29 987, parcel 102 in Yukarıpınarbaşı neighborhood of Selçuklu district of Konya province. Geographic location of the trial plot: (Latitude: 38˚06'22"N, Longitude: 32˚63'33 "E).

The trial study has been made out with the 3rd mowing (harvest) on 20.08.2021 in an area of 2.5 da (20 m x 125 m) on the south-western edge of the field.

2.1.2. Trial material

Bilensoy-80 alfalfa plant, the first synthetic variety registered in our country in 1984 by the Central Research Institute of Field Crops Directorate, was used as trial material.

2.1.3. Tools and machines used in the trial

New Holland brand TD 110D model tractor was used in the trials. The technical specifications of the disc mowers used in the trials are given in Table 1.

2.2. Method

2.2.1. Mowing and baling time

The trials has been made on 20-21-22 August 2021. The mowing process has been made on 20.08.2021out as the 3rd mowing when there was approximately 10-15% flowering in clover (average plant height 61 cm) (Figure 1).

Table 1. Technical specifications of the harvesting machines used in the trials

Harvesting method	Working width (cm)	Number of discs (pieces)	Conditioning system	Swath width (cm)
Disc mower (UI)	245	6	None	160
Disc mower + rubber roller conditioning (UII)	315	8	Zigzag patterned rubber roller (2 pieces)	80
Disc mower + finger type conditioning (UIII)	245	6	Plastic fingers (52 pieces)	140

(**a**)

(**b**)

Figure 1. (**a**) Disc mower + rubber roller conditioning (UII); (**b**) Disc mower + finger conditioning (UIII).

On the first day, mowing was started at 9 am and finished at 10 am. Samples were taken between 11-12 and 17-18 hours on the same day. Samples were taken at the same times on the second and third days. At the end of the second day, swath joining was done with a weed harrow and at the end of the third day, baling was done with a baling machine. The created bale dimensions are 36 x 46 x 90 cm, and the average bale weight is 25 kg.

2.2.2. Meteorological data

The averages of temperature, relative humidity and wind speed values measured during the trials are given in Table 2.

Table 2. Values measured in the trial area.

	1.day		2.day		3.day	
	1st Sample	2nd Sample	1st Sample	2nd Sample	1st Sample	2nd Sample
Temperature (°C)	28.5	33.3	33.2	29.4	34.9	31.2
Relative humidity (%)	50.18	27.35	33.80	28.90	30.05	27.43
Wind speed (m/s)	2.85	1.97	0.50	2.16	1.33	2.01

2.2.3. Finding field fresh alfalfa yield

In order to find the field fresh herbage yield, 5 samples of 0.25 m² (50x50 cm) randomly selected from the trial plots were mowed at the normal mowing height of the mower (8-10 cm) and weighed with a precision balance immediately after mowing. The field fresh alfalfa yield obtained from the weighed samples was determined by the following formula (Dursun and Güner 1999; Gökkaya 2019).

$$Tw = \frac{Ww}{0.25} x1000 \quad (1)$$

Tw : Field wet alfalfa yield (kg da^{-1})

Ww : Average amount of alfalfa sampled (kg)

After determining the field fresh grass yield, the samples taken were dried in an oven at 70 ^{o}C for 48 hours, then the samples that reached a constant weight were weighed and the field dry grass yield was found in kg da^{-1}.

2.2.4. Taking samples and determining moisture content

To determine the moisture content and drying rate of the material after mowing, 5 samples were taken from each parcel in each block, twice a day for three days. They were weighed on a scale with a precision of 0.5 g, disconnected from air, brought to the laboratory, and weighed again after being dried in an oven at 70 ^{o}C for 48 hours (Ayaz 2010; Mutlu 2019). The moisture content was calculated on a wet weight basis with the following formula (Toruk 1997). Additionally, the dry matter ratio was determined.

$$Mw = \frac{Ww - Wd}{Ww} x100 \quad (2)$$

Mw : Moisture content of the product (w.b.) (%)

Ww : Initial weight of the samples (g)

Wd : Weight of the samples after drying (g)

2.2.5. Determination of drying rate

The drying rate was calculated with the following formula, based on the % moisture lost per drying hour depending on the drying time (Evcim 1979; Toruk 1997; Dursun and Güner 1999).

$$DR = \frac{Mwa - Mwi}{\sum_a^i Dt} x100 \quad (3)$$

DR : Drying rate (%h^{-1})

Σ Dt : Time from start to time i (h)

Mwa: Initial moisture content (w.b.) %

Mwi: Moisture content at time i (w.b.) %

2.2.6. Calculation of dry matter losses

To determine the dry matter loss of different harvesting systems, the material falling on the soil surface was collected along the harvest width in five replicates from the trial plots after harrowing and after bale making.

In order to determine the dry matter loss of different harvesting systems, the materials remaining on the soil surface (spilled) were collected along the harvest width in five replicates from the trial plots after raking and after baling. Dry matter losses of harvesting systems were calculated as a percentage (Rotz and Sprott 1984; Rotz et al. 1987).

$$DML = \frac{\sum m\,xDMY}{BxBs}x100 \quad (4)$$

DML: Dry matter loss (%)

m: Mass (g)

DMY: Dry matter yield (w.b.)

B : Working width (m)

Bs : Sampling width (m)

2.2.7. Determination of nutritional value

From samples taken in triplicate after baling, CP (crude protein) ratio (%), ADF (acid detergent fiber) ratio (%), NDF (neutral detergent fiber) ratio (%), CA (crude ash) ratio (%) and CO (crude oil) ratio (%) was determined in the NIR device (Bulgurlu and Ergül 1978; Gökkaya 2019).

2.2.8. Determination of relative forage value

ADF and NDF values in the alfalfa content are used to determine the relative forage value. Relative forage value was calculated with the following formula (Schroeder, 1994; Van Dyke and Anderson, 1994; Budak and Budak 2014).

$$RFV = DRMxDMIx0.775 \quad (5)$$

$$DRM = 88.9 - (0.779xADF) \quad (6)$$

$$DMI = \frac{120}{NDF} \quad (7)$$

RFV: Relative forage value (%)

DRM: Digestible dry matter ratio (%)

DMI: Dry matter intake percentage (%)

ADF: Acid detergent fiber ratio (%)

NDF: Neutral detergent fiber ratio (%)

2.2.9. Organizing and conducting trials

The trials were carried out with three replications according to the randomized block trial design, and the parcel dimensions were formed by the working width of the machines and a length of 125 m. The machines used are symbolized in the text as follows;

UI : Disc mower

UII : Disc mower + rubber roller conditioning unit

UIII : Disc mower + finger type conditioning unit

For humidity measurement values, six measurements were made over three days and these measurements were; T1 (between 11.00-12.00 hours on the 1st day), T2 (between 17.00-18.00 hours on the 1st day), T3 (between 11.00-12.00 hours on the 2nd day), T4 (between 17.00-18.00 hours on the 2nd day), T5 (between 11.00-12.00 hours on the 3rd day) and T6 (between 17.00-18.00 hours on the 3rd day) it is shown as. Windrow joining has been done between T4 and T5 with a hay rake. The time intervals of these six measurements were used for the drying rate and A1 (T1-T2 interval), A2 (T2-T3 interval), A3 (T3-T4 interval), A4 (T4-T5 interval) and A5 (T5-T6 interval) it is shown as.

The working widths of the machines used in the trials are: 245 cm in UI, 315 cm in UII and 245 cm in UIII. The swath widths resulting from the harvest were measured as 160 cm (65% of the mowed area), 80 cm (25.4% of the mowed area) and 140 cm (57% of the mowed area), respectively. At the end of the second day, the windrows were combined with a hay rake to create new windrows with a width of 90 cm. At the end of the third day, rectangular (36 cm x 46 cm x 90 cm) bales were made using a baler.

2.2.10. Statistical analysis

On the data obtained from the trials, variance analysis was performed with the Minitab 16 package program and MSTAT-C, and the LSD test was applied to the significant results.

3. Results and Discussion

3.1. Wet and Dry Grass Yield

The average field wet grass yield was found to be 1 831 kg da^{-1}, and the dry grass yield was 421 kg da^{-1}, by calculation from the samples taken before harvest.

3.2. Result on Moisture Content

The moisture content values obtained as a result of the harvest of alfalfa using different harvesting systems, depending on the drying times, are given in Table 3.

By examining Table 3, we can state that moisture loss is close to each other in all three harvest systems on the first day of harvest. It is seen that the alfalfa loses moisture faster in UIII starting from the second day of harvest and the moisture content of the material is 15.9% at the end of the day of windrow assembly.

Table 3. Moisture content changes (% w.b.) in alfalfa harvested with different harvesting systems

Applications	1.day		2.day		3.day		Average of applications
	(T1)	(T2)	(T3)	(T4)	(T5)	(T6)	
UI	75.06±2.25a	48.57±0.76b	35.56±2.75d	19.63±1.29f	18.57±0.57fg	12.23±1.21h	34.94b
UII	77.57±3.21a	49.80±1.35b	42.70±1.42c	26.23±1.06e	18.63±2.16fg	19.87±1.46f	39.13a
UIII	76.47±0.67a	50.77±1.11b	25.87±1.12e	15.93±0.85f	11.50±0.80hı	8.50±0.66ı	31.51c
	LSD=3.440						LSD=1.986

From the evaluation of Table 3, it was determined that the lowest moisture value before baling occurred in UIII, followed by UI and UII applications. We can explain the high humidity value in UII as the high density of the windrow (working width of 315 cm and the created windrow width of 80 cm) delaying moisture loss.

As a result of the variance analysis applied to the moisture loss values, the harvesting systems, time and harvesting systems x time interaction were found to be statistically significant ($p<0.01$). Moisture loss values decreased depending on the time periods in which the samples were taken and the moisture loss between the time intervals was found to be statistically significant (Table 4).

Table 4. Results of variance analysis applied to the drying time index values of alfalfa for different harvesting practices

Source of variation	DF	SS	MS	F	
Application	2	525.4	262.7	108.83**	Time
Time	5	26530.6	5306.1	2198.33**	76.367a
ApplicationxTime	10	385.2	38.5	15.96**	49.711b
Error	36	869	2.4		34.711c
Total	53	27528.1			20.600d
					16.233e
					13.533f
					LSD=1.986

(**) sign indicates that the difference is significant according to the 1% probability limit.

When the binary interaction was evaluated, it was determined that the lowest moisture value was reached in the UIIIT6 interaction and there was no statistical difference between it and the UIIIT5 interaction.

3.3. Results Regarding Drying Rate

Depending on the drying time, the drying rate data calculated based on the % moisture lost per drying hour is given in Table 5.

Table 5. Effect of different harvesting systems on the drying rate of alfalfa (%)

Applications	A1	A2	A3	A4	A5	Average of applications
UI	4.41±0.50a	3.31±0.18bc	3.07±0.17bcd	2.36±0.08ghı	2.09±0.12hı	3.05b
UII	4.63±0.50a	2.91b±0.19cde	2.85±0.14cdef	2.44±0.11efgh	1.93±0.13ı	2.95b
UIII	4.29±0.17a	4.22±0.15a	3.37±0.05b	2.71±0.01defg	2.25±0.04ghı	3.37a
			LSD=0.4930			LSD=0.286

Examining Table 5, it is seen that on the first day of harvest (A1), the drying rate of the alfalfa harvested in UIII is low (dries slowly), while the drying rate is high in UII. At the end of the second day, in the samples taken from the windrows created as a result of the raking process in all parcels, the drying rates of the harvest systems were determined as 2.36 %, 2.44 and 2.71 and 2.09, 1.93 and 2.25, respectively, in the A4 and A5 time periods.

As a result of the variance analysis applied to the drying rate values, the harvesting systems, measurement interval (time period) and the harvesting systems x measurement interval interaction were found to be statistically significant ($p<0.01$) (Table 6).

When the binary interaction was examined, it was found that the highest drying rate value was reached in the UIA1, UIIA1, UIIIA1 and UIIIA2 interactions and there was no statistical difference between them (Table 5).

The average drying rate among the harvesting systems was 3.37 % in UIII, 3.05 % in UI and 2.95 % in UII. This difference resulted from the differences in swath widths during harvest (80 cm in UII, 140 cm in UI, 160 cm in UIII) and the function of the conditioning units. The values found, Shinners et al. (1991) reported that drying in a wide swath increased the drying rate by 34% compared to drying in a narrow swath, Rotz and Sprott (1984) reported that alfalfa dried 20-30% slower in a narrow swath than in a wide swath, and Greenlees et al. (2000) is consistent with the findings that the forage obtained from mowers with finger conditioning dries faster than from mowers with roller conditioning.

Table 6. Results of variance analysis applied to the drying rate index values of alfalfa in different harvesting practices

Source of variation	DF	SS	MS	F	
Application	2	1.4283	0.7141	14.8**	Time
Time	4	29.8794	7.4699	154.84**	4.4433a
ApplicationxTime	8	2.2298	0.2787	5.78**	3.4789b
Error	30	1.4473	0.0482		3.0956c
Total	44	34.9848			2.5011d
					2.0922e
					LSD=0.286

(**) sign indicates that the difference is significant according to the 1% probability limit.

It is noteworthy that the drying rate value is high in the second time interval of UIII. It can be said that the finger conditioner is effective in breaking down the material.

3.4. Results Regarding Dry Matter Losses

The average dry matter losses of the samples taken before and after baling during the trials are given in Table 7.

Table 7. Dry matter loss (%)

Applications	Before baling (mowing + raking)	After baling	Total dry matter loss
UI	1.49±0.031e	2.23±0.036c	3.72b
UII	1.86±0.031d	0.40±0.025f	2.26c
UIII	3.01±0.121b	4.79±0.193a	7.80a
	LSD=0.2444		LSD=0.558

Examining Table 7, it can be seen that after the mowing and raking process, the lowest dry matter loss was in UI (1.49%), followed by UII (1.86%) and UIII (3.01), respectively. After baling, it was determined that the highest dry matter loss was in UIII with a value of 4.79%, followed by UI with 2.23% and UII with 0.40%. When the total dry matter loss of the systems was evaluated, it was determined that the lowest dry matter loss was obtained in the UII application with a rate of 2.26%, and the highest was obtained in the UIII application with 7.80%. It was determined that dry matter loss occurred 1.65 times more in UI and 3.45 times more in UIII compared to UII. When Table 8 is examined, this situation was found to be statistically significant ($p<0.01$).

Table 8. Results of variance analysis applied to total dry matter loss index values of alfalfa for different harvesting practices

Source of variation	DF	SS	MS	F
Application	2	49.487	27.744	719.75**
Error	6	0.206	0.034	
Total	8	49.693		

(**) sign indicates that the difference is significant according to the 1% probability limit.

It is thought that the moisture content of the windrows before baling is effective in dry matter losses. Before bale making, the moisture content of the windrows was found to be 12% in UI, 20% in UII and 9% in UIII. In addition, it is considered that the finger conditioner has an effect on the high dry matter loss in UIII. Shinners et al. (1991) that increasing the violence of the conditioner in the mower increased leaf loss, and Greenlees et al. (2000) reported that finger conditioner caused more leaf loss. Rotz and Muck (1994) reported in their study that increasing swath density caused the loss rate to decrease, while Savoie (1988) reported that leaf loss was greatly affected by moisture content and that leaf breakage increased exponentially when the humidity dropped below 30%.

3.5. Forage Quality Values

As a result of the research, the results obtained by analyzing the samples on the NIR device are shown in Table 9.

Table 9. Forage values of alfalfa (%)

Applications	CP	ADF	NDF
UI	17.63b	26.93b	31.97b
UII	21.33a	28.27b	30.93b
UIII	16.87b	30.76a	34.77a
	LSD=2.210	LSD=1.508	LSD=3.319

Crude protein (CP) values of dry alfalfa turned into bales after harvest with different systems were obtained as 17.63% in UI, 21.33% in UII and 16.87% in UIII. Budak and Budak (2014) stated that if the CP ratio is 12% and below, the forage is low quality, if it is 15%, it is medium quality, and if it is 18% and above, it is high quality forage. As a result of the variance analysis applied to the crude protein values, the crude protein value obtained in the UII application was found to be statistically significant ($p<0.01$) compared to the other two applications (Table 10). According to this classification, we can state that the roughage obtained as a result of applications numbered UI and UIII is of medium quality, and the roughage obtained as a result of application numbered UII is of high quality.

Table 10. Results of variance analysis applied to crude protein values

Source of variation	DF	SS	MS	F
Application	2	34.229	17.114	32.09**
Error	6	3.20	0.533	
Total	8	37.429		

(**) sign indicates that the difference is significant according to the 1% probability limit.

ADF value is a forage criterion used to determine the digestibility of roughage by the animal. For a good hay quality, ADF values are required to be as low as possible. In applications, the ADF values of the forage were determined as 26.93%, 28.27% and 30.76%, respectively. The highest ADF value was obtained in the UIII application. While there was a statistically significant difference ($p<0.05$) between the other two applications, no statistically significant difference was found between the UI and UII applications (Table 11).

Table 11. Results of variance analysis applied to ADF values

Source of variation	DF	SS	MS	F
Application	2	22.722	11.361	9.82*
Error	6	6.940	1.157	
Total	8	29.662		

(*) sign indicates that the difference is significant according to the 5% probability limit.

NDF value is a forage criterion used to determine the ability of roughage to be taken by animals. Since the high NDF value in the forage slows down digestion, it causes the animal to feel physically full and the amount of forage the animal consumes decreases. In the trial, the lowest NDF value was obtained in UII (30.93%), which has a high protein content. However, no statistically significant ($p<0.05$) relationship was found between the NDF value obtained in UI (31.97%) (Table 12).

Russell and Johnson (1993) reported that the higher the NDF value of the forage, the lower its consumption by animals and that forages containing less than 31% ADF and less than 40% NDF are good quality forage. In the studies conducted, Ayaz (2010) reports that ADF and NDF values vary between respectively 23.22% - 26.67% and 33.67% - 38.74%, respectively, and Gökkaya (2019) varies between 25.23% - 31.87% and 40.26% - 46.84%.

Table 12. Results of variance analysis applied to NDF values

Source of variation	DF	SS	MS	F
Application	2	29.136	14.568	5.27*
Error	6	16.600	2.767	
Total	8	45.736		

(*) sign indicates that the difference is significant according to the 5% probability limit.

3.6. Relative Forage Values

RFV values, which are the index of forage intake and digestibility by animals, were calculated as 205.18 for UI, 201.21 for UII, and 173.75 for UIII, and the results are shown in Figure 2.

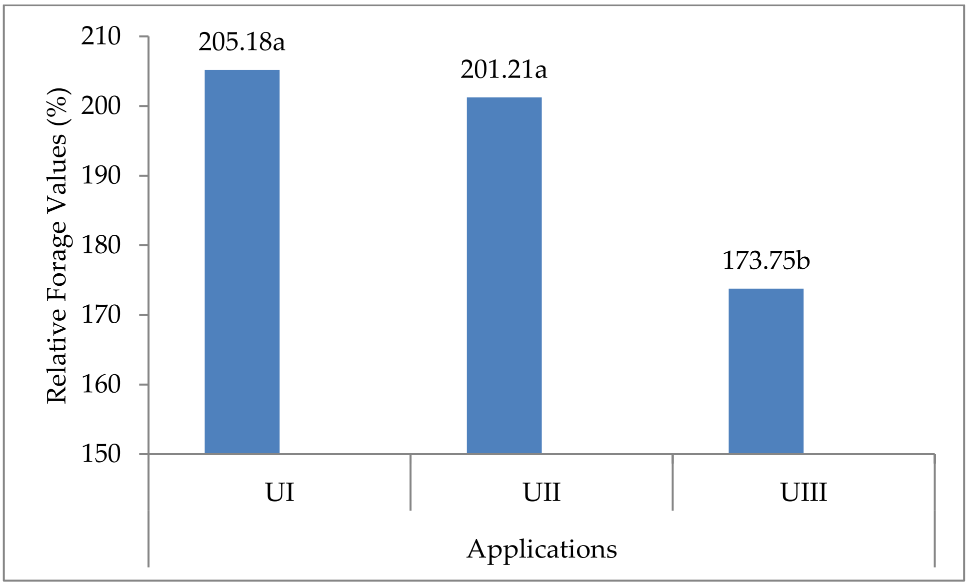

Figure 2. Relative forage values of alfalfa obtained as a result of different applications (%)

By examining Figure 2, RFV values were determined as 205.18%, 201.21% and 173.75%, respectively, according to the applications. As a result of variance analysis, the difference between the applications is significant ($p<0.05$), and the source of the difference is the UIII application. Buckmaster (1993) stated that RFV in animal nutrition should be between 54 and 230. The results of the variance analysis applied to the RFV values are given in Table 13.

Table 13. Results of variance analysis applied to RFV values

Source of variation	DF	SS	MS	F
Application	2	1756.9	878.4	5.14*
Error	6	1028.8	171.5	
Total	8	2785.6		

(*) sign indicates that the difference is significant according to the 5% probability limit.

4. Conclusions

The average fresh grass yield of the trial material alfalfa was 1 831 kg da^{-1} and the dry grass yield was found to be 421 kg da^{-1} on average.

Alfalfa was harvested with three different harvesting systems: disc mower (UI), disc mower + rubber roller conditioning unit (UII) and disc mower + finger type conditioning unit (UIII).

The working widths of these machines measured as 245 cm, 315 cm and 245 cm, respectively. As a result of the harvest, swath widths were 160 cm in UI (65% of the mowed area), 80 cm in UII (25.4% of the mowed area) and 140 cm in UIII (57% of the mowed area). At the end of the second day, the swaths were combined with a hay rake to create new windrows with a width of 90 cm. At the end of the third day, rectangular (36 cm x 46 cm x 90 cm) bales were made using a baler.

It was determined that moisture loss was close to each other in all three harvest systems on the first day of harvest, and that alfalfa lost moisture faster in UIII from the second day of harvest. While alfalfa harvested with UIII reached 20% moisture content after approximately 25 hours, alfalfa harvested with UI reached 20% moisture content after 31 hours and alfalfa harvested with UII after 49 hours. At the end of the day of windrow combining, the moisture content of the material was found to be at its lowest value at 15.9% at UIII.

The average drying rates among the harvesting systems were 3.37, 3.05 and 2.95 in UIII, UI and UII, respectively. This difference resulted from the differences in swath widths during harvest and the function of the conditioning units.

When total dry matter losses are evaluated; It was detected in the UII application with a rate of 2.26%, in the UI application with a rate of 3.72% and in the UIII application with a value of 7.80%. The dry matter loss was caused by differences in the moisture content of the windrows before baling.

Crude protein values (CP) of the trial material after baling were determined as 17.6% in UI, 21.3% in UII and 16.9% in UIII. ADF values of the forage obtained after different applications were determined as 26.9%, 28.3% and 30.8% in UI, UII and UIII applications, respectively, and NDF values were determined as 32.0%, 30.9% and 34.8%, respectively. Relative forage values (RFV) were determined as 205.18%, 201.21% and 173.75% according to the applications, respectively, and the highest value was obtained in the UI application.

As a result of this trial, it was determined that the disc mower (UIII) with a finger type conditioning unit would not be appropriate to use in its current form in the harvest of materials such as alfalfa, as it caused a high rate of dry matter loss. However, it is thought that it would be appropriate to conduct research as a result of improvements that can be made on the machine (change in the speed of the conditioner unit, preventing fingers from breaking the material, etc.).

The formation of narrow swath heaps as a result of harvesting with a disc mower (UII) equipped with a rubber roller conditioning unit caused a longer drying time. In order to shorten the drying time, it would be beneficial to increase the swath width at the time of harvest.

Research should be conducted on different forage crops in terms of forage quality values using disc mowers with rubber rollers and finger type conditioners.

Author Contributions: This article was prepared from Yusuf ÇİFTCİ's master's thesis. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

References

Anonymous (2020). Çayır mera ve yem bitkileri. https://www.tarimorman.gov.tr/Konular/Bitkisel-Uretim/Cayir-Mera-ve-Yem-Bitkileri: (access date: 15.11.2020).

Ayaz H (2010). Elçi yoncasında farklı biçim zamanlarında tarımsal ve fizyolojik özelliklerin gün içerisindeki değişimi. Master Thesis, Kahramanmaraş Sütçü İmam University (Unpublished), Turkey.

Buckmaster D (1993). Alfalfa raking losses as measured on artificial stubble. *Transactions of the ASAE*, 36 (3): 645-651.

Budak F, Budak F (2014). Yem bitkilerinde kalite ve yem bitkileri kalitesini etkileyen faktörler. *Türk Bilimsel Derlemeler Dergisi*, 7 (1): 01-06.

Bulgurlu Ş, Ergül M (1978). Yemlerin fiziksel, kimyasal ve biyolojik analiz metotları. *Ege Üniversitesi Ziraat Fakültesi Yayınları*, İzmir, Türkiye, pp. 58-76.

Demiroğlu G, Geren H, Avcıoğlu R (2008). Farklı yonca (*Medicago sativa* L.) genotiplerinin Ege bölgesi koşullarına adaptasyonu. *Ege Üniversitesi Ziraat Fakültesi Dergisi,* 45(1):1-10.

Dursun E, Güner M (1999). Biçme-ezme makinasının yoncanın tarlada kuruma hızına etkisi. *Tarım Bilimleri Dergisi*, 5 (2): 23-29.

Evcim Ü (1979). Tarlada kurutma amacıyla yonca hasadında değişik biçim ve biçim sonrası işlemlerin performans irdelemesi ve kuruma olgusunu kestirmede optimizasyon. *E.Ü. Ziraat Fakültesi Yayınları*, İzmir, Türkiye, p. 413.

Gökkaya G (2019). Önemli bazı yonca çeşitlerinde (*Medicago sativa* L.) biçim zamanının verim ve kalite özellikleri üzerine etkilerinin saptanması. Master Thesis, Tekirdağ Namık Kemal University (Unpublished), Turkey.

Greenlees WJ, Hanna HM, Shinners KJ, Marley S, Bailey T (2000). A comparison of four mower conditioners on drying rate and leaf loss in alfalfa and grass. *Applied Engineering in Agriculture*, 16 (1): 1.

Mavruk A (2017). Kaba yem hasadında farklı tip çayır biçme makinelerinin iş başarılarının belirlenmesi. Master Thesis, Çukurova University (Unpublished), Turkey.

Mutlu Z (2019). Bazı yonca çeşitlerinde farklı biçim zamanı uygulamalarının ot verimi ve kalitesi üzerine etkileri. PhD Thesis, Ankara University (Unpublished), Turkey.

Rotz C, Muck R (1994). Changes in feed quality during harvest and storage. In: Feed quality, evaluation, and utilization, Eds: George C, Fahey Jr. American Society of Agronomy, Madison, USA, pp. 828-868.

Rotz C, Sprott D (1984). Drying rates, losses and fuel requirements for mowing and conditioning alfalfa, *Transactions of the ASAE*, 27 (3): 715-0720.

Rotz C, Abrams S, Davis R (1987). Alfalfa drying, loss and quality as influenced by mechanical and chemical conditioning, *Transactions of the ASAE*, 30 (3): 630-0635.

Rotz C (1995). Loss models for feed harvest, *Transactions of the ASAE*, 38 (6): 1621-1631.

Russell M, Johnson K (1993). Selecting quality hay for horses, *ID-Cooperative Extension Service, Purdue University (USA).*

Savoie P (1988). Hay tedding losses. *Canadian Agricultural Engineering*, 30 (1): 39-42.

Schroeder J (1994). Interpreting feed analysis. North Dakota State Univ. Coop. Ext. Serv. Pub. AS-1080.

Sessiz A, Eliçin AK, Turgut MM, Pekitkan FG (2020). Tarım Makinaları Esasları. *Nobel Akademik Yayıncılık*. Yayın No:3056. ISBN: 978-625-406-658-0.

Shinners KJ, Koegel RG, Straub RJ (1991). Leaf loss and drying rate of alfalfa as affected by conditioning roll type, *Applied Engineering in Agriculture*, 7 (1): 46-49.

Toruk F (1997). Yonca hasadında farklı hasat sistemlerinin otun kuruma olgusu ve kalitesi üzerine etkilerinin saptanması. PhD Thesis, Trakya University (Unpublished), Turkey.

TurkStat (2021). Turkish Statistical Institute. https://data.tuik.gov.tr/Kategori/GetKategori?p=tarim-111&dil=1 (access date: 13.05.2021).

Van Dyke N, Anderson P (1994). Interpreting a feed analysis, *Circular ANR,* USA, p. 890.

Vurarak Y (2016). Bazı yem bitkileri karışımlarında farklı hasat ve muhafaza sistemlerinin makina işletmecilik değerleri ve yem kalitesi üzerine olan etkilerinin belirlenmesi. PhD Thesis, Çukurova University (Unpublished), Turkey.