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EFFECTS OF DIFFERENT ROUGHAGE HARVESTING SYSTEMS ON YIELD AND DRY MATTER LOSSES

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Abstract

The objective of this study was to investigate the effects of different roughage harvesting systems in terms of yield and dry matter (DM) losses. Also, some quality parameters such as pH, acid detergent fiber (ADF), neutral detergent fiber (NDF) and relative feed value (RFV) were evaluated. To this aim, four harvesting systems (S1: mower + round baler, S2: disc mower with conditioner + round baler, S3: mower + round baler + wrapping machine, S4: disc mower with conditioner + round baler + wrapping machine) were tested according to randomized block design with three replications. As plant material, vetch + triticale (Vicia sativa L. + Triticasecale wittmack) mixture was used.It was found that the bale silages have lower pH content comparing with dried forage. Also the best harvesting systems was S4 in terms of RFV. While the highest DM losses occurred in S1 system, S4 system gave the highest yield. These results indicate that the choice of method and machine is very important in the roughage harvest.

Keywords: *roughage, bale silage, harvesting machines, yield, dry matter losses.*

INTRODUCTION

In the livestock sector, feed costs take first place in all inputs. Yılmaz et al. (2005) reported that feed production costs accounted for about 88% of total production costs. From this point of view, decreasing feed production costs can be considered as a prerequisite for reducing animal product prices. This condition can be achieved by obtaining a high quality and high yield roughage. The priority of this requirement is to reduce dry matter losses that occur during harvest and storage. Harvesting and storage are the main steps that determine the method of roughage production and vary according to climatic conditions, size of farm, plant variety and mechanization infrastructure.

Roughages with high moisture content are dried by natural drying on the field after the harvesting. However, with this method, dropping the humidity from 85% to 20% depends on the number of sunny days and may not always be possible. DM losses during harvest and storage vary depending on the moisture content of the crop. During drying, the loss rate of DM increases and low quality feed is obtained (Schroder, 2004). The roughage preparation is very difficult in rainy and moist regions.High rainfall rate and moisture reduce drying speed and roughage quality.Because, the plants start to deteriorate in a short period of time (Kılıç, 2010).Nutrient losses such as carotene increase in roughage that are exposed to excessive rain and sunlight. Baytekin and Gül (2009) reported that the digestibility ratio decreased by 12% for alfalfa remains in the rain and by 6% in the wheatgrass.

These negativities have forced producers into alternative methods of producing roughage. Bale silage which is also known haylage is one of these methods. The bale silage, which can be prepared in large and small sizes, allows the farmers to manage the roughage in good quality. In this way, especially small farms that want to expand their herd can be get quality feeds with low cost.

However, DM losses are a matter that needs to be investigated in bale silage as well as in traditional methods.The objective of this study was to investigate the effects of different roughage harvesting systems in terms of yield and dry matter (DM) losses. Also, some quality parameters such as pH, acid detergent fiber

(ADF), neutral detergent fiber (NDF) and relative feed value (RFV) were evaluated. Thus, it is targeted to determine the most suitable method for preparing high quality and low DM loss roughage in Mediterranean climate conditions.

MATERIALS AND METHODS

The study was conducted in Adana province, Turkey which is located in the Mediterranean Region. Researches were done between November-2014 and June-2015. The average climaticvalues during this period were presented in Table 1. The soil characteristics of the experimental area were sandy-loam and alkaline (pH: 7.86-7.75). Organic matter, lime content, potassium and phosphorus in the experimental area were 2.28-2.41%, 15.9-16.3%, 109.2-123.3 kg da^{-1}, 4.32-5.16 kg da^{-1}, respectively.

Table 1. Average Climate Data of Research Area (Anonymous, 2016)

Months	Temp. (^{o}C)	R. Humidity (%)	Rainfall (mm)
November 2014	15.1	57.4	36.06
December 2014	13.4	71.6	50.05
January 2015	9.7	66.9	72.39
February 2015	11.3	70.1	90.68
March 2015	14.0	64.9	148.80
April 2015	16.9	62.5	7.80
May 2015	22.5	64.4	81.02
June 2015	24.2	69.1	0.00
Total rainfall and average of temperature values-R.Humidity	15.8	65.5	486.8

Mixture of vetch + triticale (*Vicia sativa* L.+*Triticasecale wittmack*) was used as plant material. Mixture rate was 70% and 30% for vetch and triticale, respectively. The average yield of the material was calculated as 5000.6 kg da^{-1}. The properties of the mixture are given in Table 2.

Table 2. The properties of the mixture and plant length

Content of mixture	The properties of the mixture		Plant length (cm)
	Kg m^{-2}	Botanical composition (%)	
Vetch	1498	29	155.0
Triticale	3508	71	154.2
Total	5006	100	-

Roughages were harvested at the end of flowering stage. The harvesting and storage systems investigated in the research were given in Table 3.

Table 3. Harvesting and storage systems

System code	Machines used in harvesting	Storage technique
S1	Mower+round baler	Dry hay
S2	Disc mower with conditioner+round baler	Dry hay
S3	Mower+round baler+wrapping machine	Haylage
S4	Disc mower with conditioner +round baler+wrapping machine	Haylage

The technical characteristics of machines were also tabulated in Table 4. For haylage bales were wrapped by using PE material with 25 µ thickness in white color as four layers. The bales weight varied in between 15-20 kg for hay and 30-40 kg for haylage.

The quality of the material was evaluated in terms of DM, pH, ADF and NDF. The DM content of roughage was determined by drying to constant weight at 105^{o}C according to the ASAE standards (AOAC, 1990). The pH values of samples were obtained as reported by Chen et al. (1997). ADF and NDF were determined as suggested Van Soesst et al. (1991) by using ANKOM fiber analyzer. The RFV was calculated according to Mayouf and Arbouche (2014). The systems were compared according to standards assigned by Hay Market Task Force of American Forage and Grassland Council (Mayouf and Arbouche, 2014).

Table 4. Some technical characteristics of machines

Harvesting machines	Disc mower with conditioner	Number of disc	5
		Working width (cm)	240
		Tractor power (Hp)	50-80
		PTO (min)	540
		Weight (kg)	500
	Mower	Number of drums	2
		Working width (cm)	165
		Number of cutting blade	6
		PTO (min)	540
		Weight (kg)	360
Other machines	Wrapper machine	Electrical requirements (V)	12
		Film width (mm)	200/250
		Film stretching ratio (%)	70
		Dimensions LxWxH (cm)	123x158x164
		Weight (kg)	350
	Small round baler machine	Feed Circle (mm)	500x700
		Weight (kg)	540
		Width (mm)	1520
		Length (mm)	2408
		Height (mm)	1550
		Bale weight of dried forage (kg)	25-30
		Bale weight of green forage (kg)	35-40
		Hay baleWeight of hay (kg)	15-20
		Bale production (bale h^{-1})	50-70

The yield was calculated by multiplying the average weight of bales by the number of bales. The DM yield was found by multiplying the parcel yield with DM%. A frame was used to determine the DM losses. The size of frame was equal to the working width of the harvesting machine (m) x 1 (m). The rest of plant material in this frame (in square meters) was weighed in five replication and the obtained data were transformed as decares (da). DM losses were found according to systems.

The experiments were carried out according to randomized blocks design with three replications. The effect of systems on DM, pH, ADF, NDF, RFV, DM losses were analyzed by using a statically program. Duncan's multiple range tests were used to compare the means (Yurtsever 1984; Kalaycı 2005).

RESULTS AND DISCUSSIONS

The systems were found to be statically significant on bale weight and bale density at 1% probability level while there is no significant effect on bale twine weight. When the dry hay and haylage preparation systems are assessed in themselves, the bales weight and density in both are higher in the systems used conditioner. Because the conditioner leaves the material more smooth and fluffy on the field surface and allows the bale machine to pick the material up from the surface and compress it more effectively. This difference was found to be 6.4% and 10.1% higher for bale weight and density in the S2 system than S1 system, respectively. Also, the values in the S4 system was 18.8% and 22.7% higher than the S3 system for bale weight and density, respectively (Table 5).

A review of Table 6 shows that all systems have significant effect on pH, ADF and NDF values at 1% probability level. Bale silages have lower pH content comparing dried roughage. Relative feed value (RFV) is one of the most important criteria in terms of quality. This value is calculated by using ADF and NDF values. Although systems have no effect statistically on RFV, S4 was the best system according to Quality Standards for Wheat and Legume Forage Crops (Mayouf and Arbouche, 2014).

Table 5. Changing of bale weight, density and twine weight according to the systems

Parameters	Bale weight (Kg bale^{-1})	Bale density (Kg m^{-3})	Twine of bales (g bale^{-1})
S1	16.26^{c}	117.97^{b}	26.26
S2	17.30^{c}	129.89^{b}	26.93
S3	30.31^{b}	239.88^{a}	27.20
S4	35.88^{a}	294.44^{a}	29.25
p (%)	<.0001**	0.0008**	00.51^{ns}
$LSD_{(0.05)}$	31.04	58.63	-
CV (%)	8.7	15.0	8.8

^{*,**,ns}: Significant at the levels of 5%, 1%, and not significant respectively.
Different letters fallowing means in the same column indicate statistical significance from each other (p <0.05)

This result indicates that more nutrients were preserved in bale silage. Schroeder (2004) reported that making haylage has several advantages than hay. However, greater ability to harvest the crop at ideal maturity, as less rain-free weather is needed for harvesting haylage.

Table 6. Changing quality parameters according to the systems

Parameters	pH	ADF(%)	NDF(%)	RFV
S1	6.06^{a}	45.63^{ab}	63.29^{a}	78.40$^{(4)}$
S2	5.56^{b}	42.02^{c}	60.66^{ab}	86.12$^{(4)}$
S3	5.43b^{c}	47.17^{a}	57.56^{b}	84.70$^{(4)}$
S4	5.03^{c}	44.16^{bc}	57.29^{b}	88.56$^{(3)}$
p (%)	0.0086**	0.0070**	12.09**	0.1940^{ns}
$LSD_{(0.05)}$	0.49	2.25	5.22	-
CV (%)	4.5	2.5	4.4	6.0

^{*,**,ns}: Significant at the levels of 5%, 1%, and not significant respectively;
Different letters fallowing means in the same column indicate statistical significance from each other (p <0.05).
1, 2, 3, 4, 5: Quality Standards for Wheat and Legume Forage Crops.
RFV= ((88.9 - (0.779x%ADF))x(120/%NDF)/1.29)

The systems were found to be statistically significant on DM content, yield of mixture and DM loss at 1% probability level, while theyhave effect statistically on DM yield at 5% probability level. Average DM content was approximately 90% and 48% for dried roughage and haylage respectively. According to the variance analysis, it was determined that S4 has highest DM yield value. In addition, DM losses were found highest for S1system which mower and round baler were used (Table 7). This was thought to be related to the DM content and the effect of the harvester type on the plant. While the mower cuts the plant near the surface and leaves it in the form of a low swaths, the disc mower with conditioner cuts the plant from a few places and leaves it in the form of a high swaths. The bale machine used after mower cannot pick up the material which is in the form of low swaths easily. This situation causes to increase DM losses. Moreover, the quality of the bale silage was found higher than dried roughage.

Table 7. DM, DM losses of yield and analysis of variance and grouping

Parameters	DM (%)	Yield of mixture (kg da^{-1})	DM yield (kg da^{-1})	DM losses (kg da^{-1})
S1	90.00^{a}	788.68^{b}	710.19^{B}	251.31
S2	92.10^{a}	865.00^{b}	796.68^{b}	105.78^{c}
S3	48.18^{b}	1837.37^{a}	888.95^{ab}	160.00^{b}
S4	49.06^{b}	2093.19^{a}	1027.40^{a}	70.66^{c}
p (%)	<.0001**	<.0001**	0.02*	<.0001**
$LSD_{(0.05)}$	6.10	256.20	189.22	38.96
CV (%)	4.3	9.2	11.1	13.3

^{*,**,ns}: Significant at the levels of 5%, 1%, and not significant respectively;
Different letters fallowing means in the same column indicate statistical significance from each other (p <0.05).

Yaman and Sönmezler (2011), also compared different roughages and found the nourishment of bale silage was better. The DM losses for S1 and S2 were determined as 251.31 kg da^{-1} and 105.78 kg da^{-1}, respectively.

These values were found to be 160.0 kg da^{-1} and 70.66 kg da^{-1} for S3 and S4 respectively. In other words, DM losses are about twice as high in systems where mowers are used.

Russell and Johnson (2014) reported that the amount of digestible protein and carbohydrate in the leaves are higher than in other parts of the plant.

For this reason, leaf losses must be reduced in order to save nutrition value of plant.

In this case, the use of harvesting machines with conditioners to reduce leaf losses would be a more correct approach.

CONCLUSIONS

Bale silage is an alternative option for the storage and processing of roughage obtained from legumes and grasses.

However, the harvester type is an important factor for the quality of bale silage.

Whether bale silage or hay bale, they must be harvested and storaged with protection of nutrient elements.

Since, the losses are quite high in dried roughage, recently, the bale silage is recommended by expert for ruminant feeding.

As a result of this study, it was determined that the mechanization chain used for making roughage affect the quality, yield and DM losses.

In terms of getting good quality roughage and lower DM losses, for small-size farms, "disc mower with conditioner + round baler + wrapping machine" can be recommended in rainy and humid regions like Cukurova region.

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