Turk J
Field Crops
2023, 28(1), 70-78
DOI: 10.17557/tjfc.1235699

DETERMINATION OF YIELD AND QUALITY CHARACTERISTICS OF COMMON REED (*Phragmites australis* (Cav.) Trin. Ex Steud) HARVESTED AT DIFFERENT GROWTH STAGES

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Received: 16.01.2023

ABSTRACT

Common Reed *(Phragmites australis* (Cav.) Trin. Ex Steud, which is remained inactive and grown in saline drainage channels, has been seen as an important potential to reduce the roughage deficit needed in animal nutrition. For this purpose, some yield, fermantation, chemical and nutritional characteristics of *P.australis* herbage and silage obtained from the end of the vegetative stage (EVS), the beginning of panicle (BP) and the full panicle stage (FPS) were determined. The study was carried out in 2021-2022 in Igdir, which is located in the North-East of Turkey. The results showed that the forage yield characteristics increased as the development period progressed and also that high lactic acid, low pH, acetic, propionic and butyric acid contents desired in silo feeds were obtained from the cuttings at FPS. In addition, ammonia production was low in silages at BP and FPS, but high the fleig score. It was observed that the dry matter digestibility, metabolic energy and relative feed value were higher while dry matter and crude protein ratio, acid detergent fibre and crude ash content of herbage according to silage were lower. On the other hand, the desired chemical and nutritional values in both herbage and silage were determined during the most suitable BP. As a result, it was determined that the common reed was appropriate to harvest in FPS for a silo feed with high yield and fermentation properties. In addition, it was concluded that the herbage and silage harvested at BP produced a higher quality feed material in terms of nutritional and chemical composition, respectively.

Keywords: Chemical and nutritional composition, common reed, development stages, fermentation characteristics

INTRODUCTION

Since the herbaceous species in the vegetation are dry in late summer, autumn and especially in winter, roughage in sufficient amount and quality cannot be obtained. This quality roughage shortage is an important problem in terms of ruminants' nutrition in Turkey (including the Igdir region) as in many countries in the world. Although this roughage deficit is tried to be provided by meadow-pasture and forage crops, it is not sufficient for the balanced nutrition of the existing ruminants. For this reason, it was thought that it would be easier and more economical to meet the quality roughage deficit with alternative species grown naturally in vegetatiton (Oktay and Temel, 2015; Temel, 2015; Temel and Kir, 2015; Temel et al., 2015; Temel, 2018; Temel, 2019). One of these species is common reed (*Phragmites australis* (Cav.) Trın Ex. Steud), which develops rapidly in wetlands with its strong rhizomes (horizontal and vertical growing) and produces in a high amount of aboveground biomass per unit area (Hocking et al., 1998; Deakin et al., 2016). Common reed, which is a perennial grass, is a cosmopolitan species and is extremely abundant in low-lying wet areas such as drainage ditches, fresh and salt water marshes, through rivers, sandy banks, roadsides, woodlands, shallow lake edges and waterways particularly in the warm and temperate regions of the world (Saltonstall, 2001; Lewandowski et al., 2003; Scragg, 2009). It can also tolerate high salinity (1.8-3.0%), acidic (pH 2.9) and basic (pH above 8.5) environments (Matoh et al., 1988; Lissner et al., 1999; Small and Catling, 2001) and grow in soils with organic contents ranging from 1 to 97% (Van der Werff et al., 1987).

A similar situation is valid for the geography of Igdir, which is located in the North-East of Turkey. 1/3 of the plain has been affected by salinity due to low rainfall (265 mm), high evaporation (1094 mm), unconscious irrigation, high groundwater level and closed basin. In order to bring these areas to production and to prevent more agricultural areas from being affected by salinity, many drainage channels were opened in the plain and the area covered by these channels is 6000 hectares (Temel and Simsek, 2011). In addition, the passage of the Aras river through the plain, excessive irrigation and the clogged drainage channels have increased the groundwater level in the plain and caused the formation of water marshes in places. This has increased the distribution area of the common reed, which has a high response to salinity and its density per unit area. For these existing reasons, Common reed species grown in salt-water marshes, drainage ditches and abandoned agricultural areas in the region have been seen as an important advantage in terms of roughage supply in ruminant nutrition.

Common reed is a preferred plant in different ecological regions of the world for different purposes (such as energy, health, food, paper, synthetic textiles and construction industry) (Small and Catling, 2001; Kering et al., 2012; Kobbing et al., 2013; Vaičekonytė et al., 2014). In addition, the plant has started to receive more attention as an alternative roughage source (hay, straw and silage) in the nutrition of ruminants in recent years due to its high nutrient content (in terms of nitrogen, NDF, potassium, manganese and magnesium) and its ability to produce dry matter (Baran et al., 2002; El-Talty et al., 2015; Tanaka et al., 2016; Asano et al., 2017; Buyukkilic Beyzi and Sirakaya, 2019; Aydogan and Demiroglu Topcu, 2022). As a matter of fact, it was revealed that the aboveground biomass dry weight of the plant varied between 1.3 and 116.0 tons ha^{-1} in the studies conducted in different geographies (countries) (Hocking et al., 1998; Warren et al., 2001; Lewandowski et al., 2003). It has also been reported that young shoot leaves and the whole plant part harvested in August contain 18% and 5.75% crude protein, respectively and shoots and leaves in early development stages are grazed by livestock (Windham and Ehrenfeld, 2003; Sun et al., 2008). Again, studies have been carried out to allow the use of aboveground biomass for a long time by drying or ensiling (Iranmanesh, 2014; Kadi et al., 2018; Monllor et al., 2020).

On the other hand, in previous studies, it was observed that the yield and nutrient content of the common reed plant were determined on samples taken from freshwater marshes, shallow lake edges and water surfaces and harvested before the beginning of flowering (early development periods). The results obtained from these studies have shown that common reed herbage and silage can be used as a resource of roughage in the nutrition of ruminants in terms of their fermentative, nutritional and anti-nutrient compositions (Buyukkilic Beyzi et al., 2022). Again, in the study carried out in different geographies, it was revealed that the yield, chemical (except HP), nutrient and energy contents of common reed herbage mowed at 10-day intervals in June differed according to the cutting times (Buyukkilic Beyzi and Sirakaya, 2019; Aydogan and Demiroglu Topcu, 2022). These results showed that the yield and quality values of the plant changed depending on the regions where it was grown and the sampling times. For this reason, in order to ensure maximum biomass yield and quality in common reed, the suitable cutting periods and forage storage methods (wet, hay, straw or silage) should be determined according to the regions where it grows. In addition, there is no study that reveals the yield, fermentative, chemical and nutritional content of common reed herbage and silage grown in saline drainage channels according to different development periods.

With the present study, it has been tried to reveal whether common reed, which is remained inactive and grown intensively in saline drainage channels in the region, can be evaluated as an alternative feed resource in the nutrition of ruminants in terms of yield and quality.

MATERIALS AND METHODS

The research was carried out in Igdir Province (39° 59′14″ N, 44° 03′ 13″ E), which is located at an altitude of 862 m in the North-East of Turkey for two years (2021-2022). According to the long-term average of the region, the annual rainfall amount was 265.4 mm, the average temperature was 12.4 ºC and the relative humidity value was 54.6%. In the years 2021 and 2022, when the samples were taken, the annual rainfall was determined as 209.3 and 171.6 mm, the average temperature was as 14.2 ºC and 15.2 ºC and the relative humidity was as 54.9% and 51.5%, respectively (GDM, 2021). These climatic values show that the region has an arid climate. In addition, since the ground water level is high in the plain of 92.200 ha (due to the closed basin of the region), 1/3 of the agricultural areas was affected by salinity. In order to remove the existing salinity, drainage channels were opened in an area of 6.000 hectares in the plain, and common reed (*Phragmites australis* (Cav.) Trin Ex. Steud) grown in these channels formed the plant material of the study. The development periods (end of vegetative stage (EVS), beginning of panicle (BP) and full panicle stage (FPS)) were chosen as trial material.

The study was established according to the randomized blocks design with 5 replications in the drainage channel where the common reed grown intensively. While sampling in the drainage channel, it was taken from the plants growing on the soil surface near the drainage channel, not from the plants growing in the water. Then, an area of 2 m^2 from a height of 10 cm above the soil level for each replication in each development period was cut (end of vegetative stage: first week of June, beginning of panicle: last week of July and full panicle stage: mid-August), and first fresh weights and then the fresh herbage yields were determined with a simple proportion. Then, 10 plants were randomly selected from the harvesting area and their fresh herbage weight, plant height, stem thickness and leaf ratios (the leaves separated from their stems were weighed and proportioned to the total weight) were determined. 10 plants, whose fresh herbage weights were determined, were dried in an oven set at 105 °C until their weights were constant, and then they were weighed and their dry matter ratios were calculated. Dry matter yields were determined by multiplying the dry matter ratio with the fresh herbage yield (dry matter yields per hectare with a simple proportion), and crude protein yields were determined by multiplying the dry matter yields with the crude protein ratio.

The harvested plants were chopped with a diameter of 1.5-3.0 cm (in a chopper machine) and placed in vacuum bags of 2.0 kg with 5 replications. Afterwards, the samples were packaged in a laboratory vacuum machine and stored for 60 days at 25±2 ºC. 20 grams of silage samples opened after 60 days were taken and dried at 105 °C until they reached a constant weight, and the dry matter ratios were calculated by proportioning the value to the fresh sample. 20 grams of silage sample from the opened silage packages and 180 ml of distilled water were added to it and mixed in the blender until the mixture was homogeneous and then filtered. Then, the pH of the samples from the existing filtrate was determined with a pH meter and the ammonia amounts were determined by the Kjeldahl method (AOAC, 1990). The Fleig score (FS) was determined by the following equation, and the resulting values were collected and the quality class of the silage samples was revealed according to the scoring scale (Quality classes: >20 very poor, 21-40: low quality, 41-60: medium quality, 61-80: good quality, 81<: very good quality).

$$\text{Fleig score} = 220 + (2 \times \text{DMI} - 15\%) - 40 \times \text{pH} \quad (1)$$

"Required pH" values of silage samples were determined by the following equation (Meeske, 2005).

$$\text{Required pH} = 0.00359 \times \text{DM (g kg}^{-1}) + 3.44 \quad (2)$$

The filtrate taken from the silage samples was purified by the method developed by De Baere et al. (2013), and the organic acids (acetic acid, butyric acid, propionic acid and lactic acid) obtained from the extracts were determined in mg in the HPLC-DAD device. These values were then converted to %. In the dried and ground (1 mm particle size) herbage and silage samples; crude protein ratio (AOAC, 1997), crude ash ratio (AOAC, 1990), neutral detergent fibre (NDF) and acid detergent fiber (ADF) (Van Soest et al., 1991) were determined. Dry matter digestibility (DMD), dry matter intake (DMI), metabolic energy (ME) and relative feed value (RFV) were calculated by the following formulas by using the chemical analysis values performed in the samples (Sheaffer et al., 1995).

$$\text{DMD (\%)} = 88.9 - (0.779 \times \text{ADF\%}) \quad (3)$$

$$\text{DE (Mcal kg}^{-1}) = 0.27 + 0.0428 \times \text{DMD\%} \quad (4)$$

$$\text{ME (Mcal kg}^{-1}) = 0.821 \times \text{DE (Mcal kg}^{-1}) \quad (5)$$

$$\text{DMI (dry matter intake)} = 120 / \text{NDF\%} \quad (6)$$

$$\text{RFV} = (\text{DMD} \times \text{DMI}) / 1.29) \quad (7)$$

Since there was no significant difference between the years in terms of the characteristics examined, the two-year data obtained from the study were combined and statistical analyzes were made on the average values. In the JMP (5.0.1) statistical package program (SAS Institute, 2003, Cary, NC, USA), the values of the herbage yield and silage fermentation were analyzed according to the randomized complete block design, but the data of the chemical and nutrient composition of the herbage and silage according to the factorial experiment design in randomized complete blocks. The means were compared by using the LSD test at ($p \leq 0.05$) level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The forage yield characteristics obtained from different development periods of Common reed grown in saline drainage conditions and significance levels with the LSD values belonging to these characteristics are presented in Table 1. The results of the analysis showed that plant height, fresh and dry matter yields increased with the progress of the development periods and the highest values were obtained from the full panicle stage. This may be due to the fact that the plants utilized from the environmental conditions for a longer period of time (in the harvest made in July and August) in the late development period compared to the early development stages and thus produced more assimilation. As a matter of fact, the longer the vegetation period in plants, the higher the amount of dry matter formed by the plants and therefore the yield (Genctan, 2012). Regarding the subject, Shay and Shay (1986) stated that the maximum plant height and yields in Common reed were reached in July-August. It was also revealed that there were yield differences according to the developmental periods by Aydogan and Demiroglu Topcu (2022), but it was seen that the yields obtained by the researchers were higher than our current research findings. It is thought that this is due to the differences in the harvest periods, the number of plants per unit area, the environment (such as salty-fresh water and shallow lake edges) and ecological conditions in which the plants grow. As a matter of fact, it has been reported that different yields (1.3-116.0 tons ha^{-1}) and plant height (2.5-6.0 m) are obtained from Common reed plant grown in different geographies of the world due to similar reasons (Shay and Shay, 1986; Hocking et al., 1998; Small and Catling, 2001; Warren et al., 2001; Lewandowski et al., 2003). It has also been reported that the increase in salinity reduces the nitrogen uptake, shoot and root growth of common reed, and consequently reduces plant height and biomass production (Hellings and Gallagher, 1992; Chambers et al., 1998; Lissner et al., 1999). When Table 1 was examined, the highest leaf ratio and crude protein yield were determined at the beginning of panicle and the full panicle stage in the same statistical group. The increase in height with the progression of the development period may have caused the leaf ratio to be higher. In a different study conducted on Common reed, it was reported that the leaf ratio varied between 25-30% (Hocking et al., 1998), and these values show parallelism with our research findings. Crude protein yield is calculated by multiplying dry herbage yield by crude protein ratio. In the present study, it was observed that the highest dry herbage yield was obtained in the full panicle period (Table 1), and the highest crude protein content was obtained at the beginning of the panicle (Table 3). Therefore, the fact that these two values were higher than the end of the vegetative stage caused the crude protein yield to be higher at the beginning of the panicle and the full panicle period.

Some fermentation characteristics of common reed harvested at different development stages are presented at Table 2. Among the silage quality criteria, pH, ammonia nitrogen (NH_3N) and the amount and composition of organic acids formed during fermentation are extremely important, and they are important characteristics used to determine the silage fermentation and quality (McDonald et al., 1991; Limin Kung et al., 2003). The pH contents of the silage obtained according to the development periods varied between 4.73-5.19, and the lowest value was determined at the FPS period and found to be lower than the required pH (Table 2). This was found to be higher than the pH found by Buyukkilic Beyzi et al. (2022). Meeske (2005) reported that the silages in different dry matter are not possible to have the same pH, and therefore, as the dry matter content increases, the pH of the silage will increase. Chamberlain and Wilkinson (1996) stated that the measured pH is appropriate to be lower than the required pH. And the silage material must contain at least 3% water-soluble carbohydrates (WSC) in order to bring the pH level to 4, which is the most suitable silage pH. For this reason, the WSC source must be added to reduce the silage pH. The addition of WSC source improves lactic acid bacterial fermentation in the silo environment, which inhibits proteolysis (conversion of proteins to ammonia) (McDonald et al., 1991; Limin Kung et al., 2003), resulting in lower pH levels of silages. As the development period progressed, the ammonia content of the formed silages decreased, while the FS increased. The FS was found to be of very good quality at all developmental stages. As the development period progressed, the lactic acid content of the silages increased. The highest lactic acid content was found in FPS with 0.763%, while the lowest acetic acid and butyric acid contents were found in FPS (0.381% vs 0.091%). The increase in lactic acid level in ensiling has the greatest effect on the decrease in pH. In high quality silages, it is desired that the amount of lactic acid is high, but the levels of acetic acid and butyric acid are low. Because the increase in acetic acid content negatively affects silage quality, energy content and dry matter amount. Asano et al. (2018) found that the lactic acid level was high and the acetic acid, butyric acid and propionic acid contents were low in Common reed silages made without using any additives. When the fermentation characteristics were evaluated, it was determined that the best quality silage had the FPS harvest period.

Table 1. Some herbage yield characteristics of *Phragmites australis* cut at different development stages.

Yield characteristics	**Development stages**			**SEM**	**LSD value/ significance**
	EVS	**BP**	**FPS**		
Plant height (m)	3.01 c	3.16 b	3.38 a	0.02	0.07[s]
Stem thickness (mm)	8.25	8.40	8.64	0.22	0.88[n.s.]
Leaf rate (%)	26.20 b	32.24 a	33.04 a	0.80	3.15[s]
Fresh herbage yield (tone ha^{-1})	37.60 b	39.71 b	51.40 a	0.80	3,14[s]
Dry herbage yield (tone ha^{-1})	16.32 c	20.64 b	28.35 a	0.47	1.83[s]
Crude protein yield (tone ha^{-1})	0.96 b	1.27 a	1.43 a	0.05	0.20[s]

s: significant, ns: non-significant. [a,b,c] Values represented by the different letters in the same column differ statistically. EVS: end of vegetative stage, BP: beginning of panicle, FPS: full panicle stage, SEM: standard error of the mean.

Table 2. Some fermentation characteristics of *Phragmites australis* cut at different development stages.

Fermentation characteristics	**Development stages**			**SEM**	**LSD value/ significance**
	EVS	**BP**	**FPS**		
pH	4.94 ab	5.19 a	4.73 b	0.09	0.35 [s]
Required pH	5.05 c	5.77 a	5.60 b	0.01	0.04 [s]
Ammonia production (%)	8.26 a	4.56 b	5.33 b	0.26	1.03 [s]
Fleig point	82.01 b	112.01 a	121.57 a	3.31	12.99 [s]
Lactic acid (%)	0.132 c	0.646 b	0.763 a	0.028	0.111 [s]
Acetic acid (%)	0.882 a	0.689 b	0.381 c	0.017	0.068 [s]
Propionic acid (%)	0.122 a	0.127 a	0.109 b	0.003	0.011 [s]
Butyric acid (%)	0.113 a	0.104 b	0.091 c	0.001	0.005[s]

s: significant, ns: non-significant. [a,b,c] Values represented by the different letters in the same row differ statistically. EVS: end of vegetative stage, BP: beginning of panicle, FPS: full panicle stage, SEM: standard error of the mean.

The dry matter, crude ash and crude protein ratios of common reed differed according to feed type (herbage and silage) and development periods, and mean values are given in Table 3. When Table 3 was examined, the highest dry matter ratio was determined at the beginning of the panicle and the full panicle period in the same statistical group, but the crude ash ratio in the full panicle period (Table 3). This may be due to the fact that the plants utilized from the more environmental conditions with the progression of the development period and the leaf ratio was high. Similarly, Katongole et al. (2021) found that the dry matter (18.1-20.3%) and raw crude content (15.0-16.1%) of common reed in late harvests were reported to be higher according to early harvests (DM: 12.8%-14.7% and RA: 9.3-14.2). In addition, it was reported that common reed leaves had high dry matter (93.2%) and crude ash content (12.1%) (Kadi et al., 2018). In the present study, it was observed that the plants had higher protein content at the beginning of panicle compared to the first and last development period (Table 3). This may be due to the low leaf ratio in the early development period, and the decrease in the amount of intracellular substances with maturation in the late development period. As a matter of fact, the highest nitrogen content in common reeds is found in the leaves and young tissues/organs of the plant (Baran et al., 2002; Tanaka et al., 2016), as in the plants used for forage purposes (Temel and Keskin, 2020; Temel and Keskin, 2022; Temel et al., 2022). In addition, nitrogen assimilated in shoots and leaves of common reed is transported to rhizomes at the end of the development period (Hocking et al., 1998). In previous studies on common reed, it was reported that dry matter ratios varied between 36.76%-51.79%, crude ash contents between 5.2-9.5% and crude protein ratios between 4.4-17.30% according to the harvest time or the development period of the plant (Tanaka et al., 2016; Buyukkilic Beyzi and Sirakaya, 2019). In addition, it was observed that the values obtained according to the developmental periods did not show similar increases or decreases with the results of the current study, as well as higher or lower than the current research findings. It is thought to be due to that this is different the habitats, ecological conditions, cutting heights and months of sampling.

Table 3. The dry matter, crude ash and crude protein rates of *Phragmites australis* cut at different development stages.

Development stages (DS)	**Dry matter (%)**			**Crude ash (%)**			**Crude protein (%)**		
	Herbage	**Silage**	**Mean**	**Herbage**	**Silage**	**Mean**	**Herbage**	**Silage**	**Mean**
EVS	43.53	44.84	44.19 b	7,36	9,29	8,33 b	5.92	6.11	6.02 b
BP	51.96	64.80	58.38 a	8,24	8,14	8,19 b	6.20	8.80	7.50 a
FPS	55.16	60.32	57.74 a	8,78	9,31	9,05 a	5.06	7.36	6.21 b
FT mean	50.22 b	56.65 a		8,13 b	8,91 a		5.73 b	7.42 a	
LSD value/ significance	DS: 1.78 ^{s}, FT: 1.45 ^{s}, DS x FT: 2.52 ^{s}			DS: 0.58 ^{s}, FT: 0.47 ^{s}, DS x FT: 0.82 ^{s}			DS: 0.87 ^{s}, FT: 0.71 ^{s}, DS x FT: 1.24 ^{s}		

s: significant, ns: non-significant. [a,b,c] Values represented by the different letters in the same column and row differ statistically. EVS: end of vegetative stage, BP: beginning of panicle, FPS: full panicle stage, FT: fodder type

When evaluated in terms of feed types, the dry matter (56.65%), crude ash (8.91%) and crude protein content (7.42%) of the silage material were found to be higher than the hay. These high values may be due to the higher dry matter ratio of the silage material compared to the hay. In a study, Buyukkilic Beyzi and Sirakaya (2019) determined the dry matter contents of herbage and silage harvested at the beginning of June as 30.7% and 30.59%, crude ash ratio as 9.46% and 9.12%, and crude protein content as 17.44% and 17.47%, respectively. In addition, in previous studies, it was stated that the dry matter and crude protein content of common reed silage varied between 20.0-35.0% and 15.0-20.0%, respectively (El-Talty et al., 2015; Asano et al., 2017; Asano et al., 2018). In a study conducted by Baran et al. (2002), the crude ash content of Common reed herbage was determined as 6.7%. It is thought that these differences are caused by the difference in ecological conditions, cutting height and stages. While the DM and CP ratio of dry herbage and silage were at the same level in the early development period, the DM and CP ratios of herbage showed a continuous increase with the progress of the development period. However, the DM and CP ratios of silage first increased and then decreased again (Figure 1a, 1b). When evaluated in terms of crude ash, content of dry matter continuously increased with the progress of the development period, while the crude ash content of silage first decreased and then increased (Figure 1c). This has led to the fact that the bilateral interaction is important in terms of DM, CP and RA.

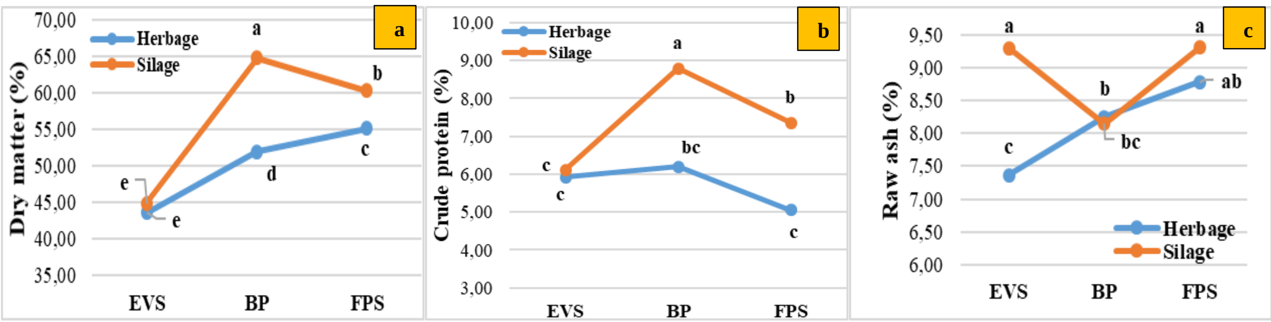

Figure 1. The effect of development stages x fodder types interaction on the dry matter (a), crude protein (b) and crude ash (c). [a,b,c] Plots followed by the different letters differ statistically. EVS: end of vegetative stage, BP: beginning of panicle, FPS: full panicle stage.

When Table 4 was examined, neutral detergent fiber (NDF), acid detergent fiber (ADF), dry matter digestion (DMD), dry matter intake (DMI), metabolic energy (ME) and relative feed value (RFV) showed significant differences according to development periods. Accordingly, the lowest NDF and ADF content and the highest DMD, DMI, ME and RFV were determined at the beginning of panicle (Table 4). The low NDF and ADF content at the beginning of panicle stage may be due to the higher leaf ratio compared to the end of vegetative stage and the less thickening (hardening) of the plant parts compared to the final development period. Since DMD, DMI, ME and RFV are calculated by using NDF and ADF values, low NDF and ADF values at the beginning of panicle stage cause the DMD, DMI, ME and RFV to be high. As a matter of fact, since feed materials (particularly leaves) with soft tissue and thin cell walls contain less amounts of structural carbohydrates (cellulose, hemicellulose and lignin) and higher amounts of non-structural carbohydrates (sugar, protein and fat), their digestibility and energy content are higher (Collins and Fritz, 2003; Fales and Fritz, 2007; Temel and Keskin, 2020; Temel et al., 2022). On the other hand, in a quality roughage, it is desired that the ratio of NDF and ADF are low, while other characteristics are high (Sheaffer et al., 1995; Rivera and Parish, 2010). According to this information, in the present study, it was revealed that the beginning of panicle produced a higher quality forage material than the other two development periods. Similar change rates in NDF, ADF, DMD, DMI, ME and RFV according to the development stages were also reported by Buyukkilic Beyzi and Sirakaya (2019), and these results support our research findings. In addition, it was revealed that the NDF (64.0-84.3%), ADF (29.4-61.4%), DMD (59.43-62.40%), DMI (1.57-1.69%), ME (2.10-2.15 Mcal kg^{-1}) and RFV (78.72-90.49) of Common reed differed according to the development or harvest periods in different studies (Tanaka et al., 2016; Buyukkilic Beyzi and Sirakaya, 2019; Katongole et al., 2021).

While the ADF, DMD, ME and RFV of dry herbage and silage differed statistically, NDF and DMI were found to be insignificant (Table 4). When Table 4 was examined, it was determined that the ADF content of the dry herbage was lower than the silage, but the DMD, ME and RFV higher. In the study conducted by Buyukkilic Beyzi and Sirakaya (2019), they revealed that the NDF and DMI did not differ between dry herbage and silage, but the DMD and RFV of herbage were higher than silage. In the same study, although researchers found the ADF and DMI to be statistically insignificant, they reported that herbage had a lower ADF ratio and higher DMI than silage. These results also showed parallelism with our research findings. Also, Katongole et al. (2021) revealed that the NDF ratio of Common reed varied between 67.3-71.2% and the ADF ratio between 29.4-35.3%. In another study, Tanaka et al. (2016) determined the NDF and ADF content of Common reed herbage as 79.3-84.3% and 56.7-61.4%, respectively. In terms of bilateral interaction, the contents of ADF, DMD and ME showed statistically significant differences. While the ADF contents of dry herbage and silage first decreased and then increased, their DMD and ME contents first increased and then decreased according to the developmental periods (Figure 2a, 2b, 2c). Accordingly, the lowest ADF ratio and the highest DMD and ME content were determined in the beginning of panicle stage in both dry herbage and silage.

Table 4. The chemical and nutritional composition of *Phragmites australis* cut at different development stages.

Development stages (DS)	**NDF (%)**			**ADF (%)**			**DMD (%)**		
	Herbage	**Silage**	**Mean**	**Herbage**	**Silage**	**Mean**	**Herbage**	**Silage**	**Mean**
EVS	74.71	77.07	75.89 a	46.91	54.62	50.76 a	52.36	46.35	49.36 b
BP	67.97	69.02	68.50 c	42.66	44.20	43.43 b	55.67	54.47	55.07 a
FPS	73.18	70.64	71.91 b	45.69	52.08	48.89 a	53.31	48.33	50.82 b
FT mean	71.95	72.24		45.09 b	50.30 a		53.78 a	49.72 b	
LSD value/ significance	DS: 2.18 ^{s}, FT: 1.78$^{n.s.}$, DS x FT: 3.09 $^{n.s.}$			DS: 2.26 ^{s}, FT: 1.85 ^{s}, DS x FT: 3.20 ^{s}			DS: 1.76 ^{s}, FT: 1.44 ^{s}, DS x FT: 2.49 ^{s}		
	DMI %)			**ME (Mcal kg^{-1})**			**RFV**		
EVS	1.61	1.56	1.58 c	2.06	1.85	1.96 b	65.22	55.97	60.59 c
BP	1.77	1.74	1.75 a	2.18	2.14	2.16 a	76.29	73.48	74.89 a
FPS	1.64	1.70	1.67 b	2.09	1.92	2.01 b	67.81	63.67	65.74 b
FT mean	1.67	1.67		2.11 a	1.97 b		69.77 a	64.37 b	
LSD value/ significance	DS: 0.05 ^{s}, FT: 0.04 $^{n.s.}$, DS x FT: 0.07 $^{n.s.}$			DS: 0.06 ^{s}, FT: 0.05 ^{s}, DS x FT: 0.09 ^{s}			DS: 3.85 ^{s}, FT: 3.14 ^{s}, DS x FT: 5.44 $^{n.s.}$		

s: significant, ns: non-significant. ^{a,b,c} Values represented by the different letters in the same column and row differ statistically. EVS: end of vegetative stage, BP: beginning of panicle, FPS: full panicle stage, FT: fodder type, NDF: neutral detergent fibre, ADF: acid detergent fibre, DMD: dry matter digestibility, DMI: dry matter intake, ME: metabolic energy, RFV: relative feed value

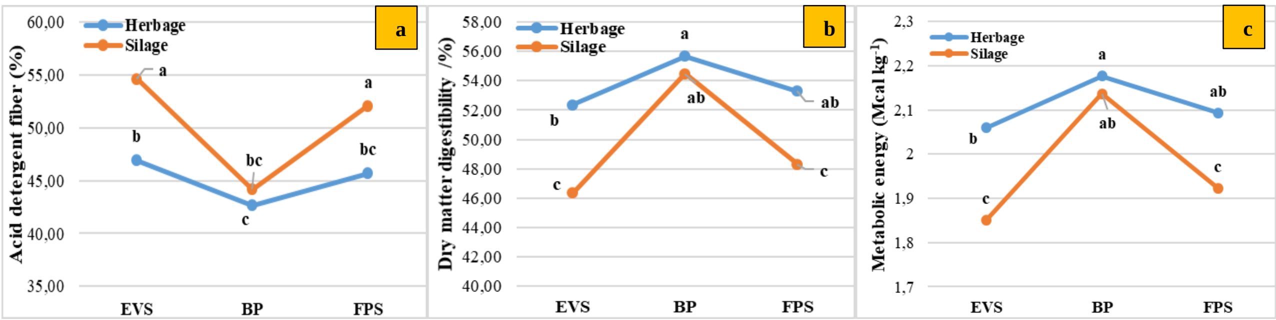

Figure 2. The effect of development stages x fodder types interaction on the acid detergent fibre (a), dry matter digestiblity (b) and metabolic energy (c).
[a,b,c] Plots followed by the different letters differ statistically. EVS: end of vegetative stage, BP: beginning of panicle, FPS: full panicle stage.

CONCLUSION

It was determined that common reed, which grows intensively in saline drainage channels where other cultivated plants did not develop, produced a substantial dry matter yield per unit area, and it was revealed that the yields differed according to the development periods. The highest dry matter yields were obtained from the cutting made at the full panicle period. However, considering the crude protein yields obtained from the unit area, it was seen that the beginning of panicle and the full panicle periods were more suitable. When evaluated in terms of the examined fermentation characteristics, the best quality silage material was determined at the full panicle stage. In addition, it was concluded that in terms of chemical and nutritional composition, the beginning of panicle produced a higher quality forage material than the other development periods, and dry herbage compared to silage. As a result, it was revealed that the material obtained from common reed according to the development periods and feed types produced a low quality feed material in terms of fermentative, chemical and nutritional content. However, it was determined that the feed quality of common reed was higher compared to the feed quality of different plant product wastes such as barley (CP: 4.5%), wheat (CP: 4.1%), rye (CP: 3.6%), rice (CP: 4.5%), corn (CP: 4.3%) and oats (CP: 4.9%) (Karabulut and Filya, 2012). Therefore the plant can be used as a source of roughage in animal feeding. In addition, since the dry matter content of common reed was very high and the lactic acid content was low, it was concluded that it would be appropriate to add the water-soluble carbohydrate sources and the additives with high water content for a better quality silage material.

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