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Original article

Effects of Cutting Management on the Feed Quality of Triticale Grain

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Abstract

This study was conducted to investigate the effects of cutting management practices on the grain characteristics and feeding quality of triticale (× *Triticosecale Wittmack*). The research was conducted over two consecutive years (2014–2016) at the Research and Application Field of the Faculty of Agriculture, Çanakkale Onsekiz Mart University, Dardanos Campus, using a randomized complete block design with three replications. Five stubble heights (5, 7.5, 10, 12.5, and 15 cm) and five cutting frequencies (1, 2, 3, 4, and 5 times) were evaluated. Grain samples were analyzed for crude protein, crude ash, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), digestible organic matter (DOM), metabolizable energy (ME), digestible energy (DE), and net energy (NE). Increasing cutting frequency and stubble height resulted in significant reductions in grain crude protein and energy contents. The highest crude protein (12.4%), digestible organic matter (84.6%), metabolizable energy (2.43 Mcal/kg DM), and net energy (1.46 Mcal/kg DM) values were obtained from the treatment cut once with a 5 cm stubble height. Conversely, higher cutting frequencies increased NDF and ADF contents, leading to lower overall feed quality. It is concluded that a single cutting at a low stubble height (5–7.5 cm) represents the most suitable management practice for maintaining the feeding quality of triticale grain. This management approach helps preserve the nutritional composition and sustain high energy values essential for animal feeding.

Keywords: Triticale, Stubble Height, Cutting Frequency, Crude Protein, Neutral Detergent Fiber, Energy Value, Feed Quality

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INTRODUCTION

Triticale (× *Triticosecale Wittmack*), obtained from the cross between wheat (*Triticum spp.*) and rye (*Secale cereale*), was developed to combine the grain quality of wheat with the strong environmental adaptability and stress tolerance of rye. Since its first successful production in the late nineteenth century, triticale has been recognized as a versatile cereal that can grow well in marginal soils and under limited rainfall conditions (Yanbeyi and Sezer, 2006). It exhibits a relatively high lysine concentration and balanced amino acid profile, which enhance its feeding value for both ruminant and non-ruminant animals (Akgün and Kara, 2002).

The grain of triticale is primarily used as an energy and protein source in livestock feeding and as a component in concentrate rations. Its nutrient composition-particularly crude protein, fiber fractions such as neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL), as well as energy parameters like digestible energy (DE), metabolizable energy (ME) and net energy (NE)-determine its contribution to animal performance (Albayrak et al., 2006). However, these grain-quality characteristics are not constant; they may vary depending on both genetic factors and management practices applied during growth and grain-filling stages.

Among agronomic interventions, cutting management reflected in decisions regarding stubble height and cutting frequency has a substantial influence on the pathways of assimilate redistribution and remobilization that determine kernel development. Both overly frequent cutting and leaving excessively tall stubble can diminish the effective photosynthetic area and reduce stored carbohydrate reserves, ultimately altering grain composition and nutritive value. Despite considerable research addressing how cutting management affects forage yield and quality in various cereal species (Cherney and Marten, 1982; Droushiotis, 1989; Tan, 1995), its impact on the grain feeding quality of triticale remains largely understudied. Given the importance of triticale as a forage crop in Türkiye, which in 2024 was cultivated on approximately 66,000 ha and produced about 1.27 million tons of green forage (yeşil ot) according to Turkish Statistical Institute (TÜİK) data (compiled by Özkan et al., 2025), understanding how management strategies affect grain quality parameters has both agronomic and nutritional significance. Therefore, the present study was designed to evaluate the effects of different stubble heights and cutting frequencies on the chemical composition and feeding quality of triticale grain, aiming to determine the most appropriate cutting management practice for sustaining high nutritional and energetic grain value.

MATERIALS and METHODS

The field experiment was conducted during the 2014–2015 and 2015–2016 growing seasons at the Dardanos Research and Application Field of Çanakkale Onsekiz Mart University, Faculty of Agriculture, Türkiye. The experimental site has a clay–loam soil texture with medium lime content, low nitrogen and phosphorus levels, adequate potassium supply, and low organic matter. The mean monthly temperature during the first and second experimental years was 16.4°C and 17.8°C, respectively, both higher than the long-term average (15.4°C). Annual precipitation was 726.6 mm in the first year and 650.1 mm in the second year.

The triticale (× *Triticosecale Wittmack*) cultivar 'Tatlıcak-97' was used as the plant material. The experiment was arranged in a randomized complete block design with three replications. Treatments consisted of five stubble heights (5, 7.5, 10, 12.5, and 15 cm) and five cutting frequencies (1, 2, 3, 4, and 5). Each plot measured 1 m in width and 5 m in length (5 m²), with 0.5 m spacing between plots and 1 m between blocks. Plants were cut at grazing maturity (20–25 cm height) following the procedure described by Henning et al. (2000). A basal fertilizer dose of 200 kg DAP (18-46) per hectare was applied before sowing; weeds were removed manually, and no irrigation was performed. After the final harvest, grain samples were collected and analyzed for CP, CA, NDF, ADF and ADL contents. DOM, DE, ME and NE were also determined. CP and CA analyses were carried out according to AOAC (1990). Fiber fractions (NDF, ADF, ADL) were determined using the method of Van Soest et al. (1991). DOM and DM were measured using near-infrared reflectance spectroscopy (NIR) following Oddy et al. (1983), and energy values were calculated according to Fonnesbeck et al. (1984) and Adams (1994). All data were subjected to analysis of variance (ANOVA) using the General Linear Model procedure in accordance with the randomized complete block design. When significant differences were detected, means were compared using the Least Significant Difference (LSD) test at the 0.05 probability level.

RESULTS and DISCUSSION

Crude Protein (CP) Content of the Grain: CP content of triticale grain was markedly affected by stubble height, cutting frequency, and their interaction. CP levels were highest (12.81–13.69%) when plants were cut at stubble heights of 7.5 to 15 cm, whereas the lowest value (10.86%) occurred at the 5-cm height. In terms of cutting frequency, the greatest CP concentration (13.72%) was obtained from plots subjected to two cuttings, while the lowest (11.86%) was found in plots cut three times. Considering the interaction, the highest CP concentration (15.58%) was found in plots cut twice at 15 cm, whereas the lowest (10.24%) was recorded in plots cut three times at 5 cm (Table 1).

Table 2. Mean crude protein contents of triticale grain (%) under different treatments.

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	10.31 fg	12.02 def	10.24 g	10.86 B
7.5	12.60 cde	12.03 def	13.79 bc	12.81 A
10	14.44 ab	14.18 abc	11.44 efg	13.35 A
12.5	13.22 bcd	14.77 ab	13.08 b–e	13.69 A
15	12.67 cde	15.58 a	10.73 fg	13.00 A
Mean	12.65 B	13.72 A	11.86 C	
Year	**2014–2015**		**2015–2016**	
Mean	12.79		12.69	

Significance levels: Stubble height (**P < 0.001**), Cutting frequency (**P < 0.001**), Interaction (**P < 0.001**); Year (ns).

As cutting frequency increased, a decline in grain crude protein content was evident. This reduction is closely linked to the physiological progression of plant maturity. During advanced growth stages, stem elongation becomes dominant, while the production of new leaves diminishes, resulting in a lower leaf-to-stem ratio and reduced photosynthetic area (Miller, 1984). Elevated temperatures during this period accelerate lignification processes, which in turn dilute cellular proteins (Haddi et al., 2003; Kaya, 2008; Aydoğan et al., 2014). Cereals generally exhibit the highest protein content at early growth stages, when cell division and metabolic activity are most intense (Taiz & Zeiger, 2008). Because enzymes that catalyze metabolic reactions are protein-based, a decline in enzymatic activity during later stages naturally leads to reduced protein synthesis (Kamstra et al., 1968; Pieper et al., 1974; Towne & Ohlenbusch, 1992). Consistent with the current results, Gökkuş et al. (2017) reported that increasing cutting frequency in barley reduced crude protein content. Similarly, Khorasani et al. (1997) and Coşkun et al. (2014) found that advancing maturity caused protein reductions of up to 42% in barley, oat, and triticale.

These results indicate that excessive cutting frequency hastens physiological aging and restricts assimilate accumulation, ultimately lowering grain protein levels. Consequently, adopting fewer cuttings particularly two and maintaining moderate to higher stubble heights (7.5–15 cm) appear to be the most effective strategies for preserving the nutritional and feeding quality of triticale grain.

Crude Ash (CA) Content of the Grain: CA content of triticale grain varied significantly with stubble height, cutting frequency, and their interaction. The highest CA value (6.35%) was obtained from plots cut at 5 cm, whereas the lowest (1.93%) occurred at 12.5 cm (Table 2). Ash concentration decreased consistently as cutting frequency increased, with mean values of 3.96%, 3.85%, and 3.26% for one, two, and three cuttings, respectively. Regarding the interaction effect, the greatest ash contents were recorded in plots cut once and twice at 5 cm (8.22% and 7.64%), whereas the lowest (1.51%) was found in plots cut three times at 10 cm and 12.5 cm.

Table 2. Mean crude ash contents of triticale grain (%) under different treatments.

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	8.22 a	7.64 a	3.18 de	6.35 A
7.5	3.22 de	3.69 cd	4.52 c	3.81 B
10	3.55 cd	1.75 f	1.51 f	2.27 C
12.5	2.35 ef	1.92 f	1.51 f	1.93 C
15	2.43 ef	4.27 c	5.56 b	4.09 B
Mean	3.96 A	3.85 A	3.26 B	
Year	**2014–2015**		**2015–2016**	
Mean	3.74		3.63	

Significance levels: Stubble height (**P < 0.001**), Cutting frequency (**P = 0.005**), Interaction (**P < 0.001**); Year (ns).

The observed decline in ash content with increasing cutting frequency suggests a reduction in total mineral accumulation as the number of defoliations increases. Frequent cutting may disrupt nutrient uptake and limit the translocation of minerals from vegetative tissues to developing grains. Similar decreases in mineral content with advanced maturity have been reported by Miller (1984), who emphasized that lignification and cell-wall thickening reduce the relative proportion of mineral constituents. At early developmental stages, plants typically contain higher ash concentrations due to their elevated metabolic activity and nutrient absorption rate (Taiz & Zeiger, 2008). As growth advances, reduced root uptake efficiency and redistribution of assimilates toward structural carbohydrates can lead to lower mineral density in the grain (Haddi et al., 2003; Kaya, 2008). Gökkuş et al. (2017) also reported a comparable decline in crude ash in barley and oat as the number of cuts increased. These findings indicate that lower cutting frequencies (one or two cuts) combined with lower stubble heights (around 5 cm) favor higher mineral accumulation in triticale grain. Conversely, repeated cutting and higher stubble retention restrict nutrient mobilization, thereby diminishing the overall mineral and ash content important for feed value.

Fiber Fractions (NDF, ADF, ADL) Content of the Grain: NDF, ADF and ADL were significantly affected by stubble height and cutting frequency, while the year effect remained insignificant.

Neutral Detergent Fiber (NDF)

Grain NDF content ranged from 43.68% to 46.74% depending on stubble height, with the highest value recorded at 5 cm and the lowest at 15 cm. Across cutting frequencies, NDF values were 46.06%, 45.74%, and 44.61% for one, two, and three cuts, respectively (Table 3). These results suggest a slight but consistent reduction in NDF with increasing cutting frequency.

Table 3. Mean crude ash contents of triticale grain (%) under different treatments.

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	48.31	47.30	44.62	46.74 A
7.5	46.00	45.24	45.33	45.52 B
10	45.36	46.43	44.24	45.34 B
12.5	46.41	45.39	46.46	46.09 AB
15	44.54	44.37	42.42	43.68 C
Mean	46.06 A	45.74 A	44.61 B	
Year	**2014–2015**		**2015–2016**	
Mean	45.60		45.35	

Significance levels: Stubble height (**P < 0.001**), Cutting frequency (**P < 0.01**), Interaction (**ns**); Year (ns).

Acid Detergent Fiber (ADF)

ADF content followed a similar trend to NDF, with significant differences due to stubble height, cutting frequency, and their interaction. The highest ADF value were obtained from 12.5 cm (29.47%) and 5 cm (28.50%), while the lowest (27.72%) occurred at 10 cm (Table 4). Regarding cutting frequency, plots cut once or twice showed higher ADF contents (28.83–28.90%), compared with those cut three times (27.40%).

Table 4. Mean acid detergent fiber (ADF) contents of triticale grain (%).

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	29.57 ab	29.42 ab	26.49 e	28.50 AB
7.5	28.84 abc	27.36 cde	28.09 b–e	28.10 B
10	27.24 cde	29.54 ab	26.39 e	27.72 B
12.5	29.42 ab	29.87 a	29.10 ab	29.47 A
15	29.10 ab	28.27 a–d	26.90 de	28.09 B
Mean	28.83 A	28.90 A	27.40 B	
Year	**2014–2015**		**2015–2016**	
Mean	28.50		28.25	

Significance levels: Stubble height (**P < 0.01**), Cutting frequency (**P < 0.001**), Interaction (**P < 0.05**); Year (ns).

Acid Detergent Lignin (ADL)

ADL content also varied significantly with stubble height and cutting frequency, showing a gradual increase with higher cutting frequency and stubble height. The highest ADL content (6.69%) was observed at 15 cm, while the lowest values occurred at 5 cm stubble height and single cutting (Table 5).

Table 5. Mean acid detergent lignin (ADL) contents of triticale grain (%).

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	3.25 e	4.02 d	4.60 c	3.96 C
7.5	4.10 cd	4.41 c	5.01 b	4.51 B
10	4.38 c	4.79 bc	5.33 ab	4.83 AB
12.5	4.71 bc	5.05 b	5.56 ab	5.11 A
15	4.87 b	5.36 ab	6.69 a	5.64 A
Mean	4.26 C	4.73 B	5.44 A	
Year	**2014–2015**		**2015–2016**	
Mean	4.90		5.02	

Significance levels: Stubble height (**P < 0.01**), Cutting frequency (**P < 0.001**), Interaction (**P < 0.05**); Year (ns)..

The gradual decline in NDF and ADF with increasing cutting frequency indicates that more frequent harvests reduce structural carbohydrate accumulation in triticale grain. This can be attributed to decreased assimilate allocation to cell wall components under shorter regrowth intervals (Taiz & Zeiger, 2008). Higher stubble heights, on the other hand, allowed plants to maintain more photosynthetically active tissue, leading to enhanced fiber development and higher NDF and ADF concentrations (Miller, 1984). The increase in ADL content with both cutting frequency and stubble height suggests a shift toward more lignified tissues as plants mature and are harvested multiple times. Lignin accumulation is a key factor determining digestibility, and elevated ADL levels indicate reduced feed quality (Kamstra et al., 1968; Haddi et al., 2003). Similar patterns were observed in barley and ryegrass studies, where frequent defoliation decreased cellulose but increased lignin due to regrowth stress (Coşkun et al., 2014; Gökkuş et al., 2017). Overall, the results demonstrate that lower cutting frequencies (one or two cuts) and moderate stubble heights (10–12.5 cm) achieve a balance between yield and quality by maintaining desirable fiber composition. Excessive cutting or very low stubble heights accelerate maturity, reduce digestible fiber fractions, and compromise the feeding value of triticale grain.

Digestible Organic Matter (DOM) and Energy Values (DE, ME, NE) of the Grain: DOM content of triticale grain was significantly affected by stubble height, while cutting frequency and year effects were not significant. DOM values ranged from 69.03% to 71.15% depending on stubble height, with the highest values observed at 10 cm (71.15%), followed by 7.5 cm, 12.5 cm, and 5 cm cutting heights. The lowest value (69.03%) occurred at 15 cm (Table 6). Mean DOM contents across cutting frequencies were close, ranging between 70.41% and 70.71%, indicating that cutting frequency exerted a limited influence on digestibility (Table 6).

Table 6. Mean digestible organic matter (DOM) contents of triticale grain (%).

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	70.08	71.25	71.21	70.85 A
7.5	70.98	70.19	71.63	70.93 A
10	72.52	71.24	69.70	71.15 A
12.5	71.23	70.59	70.91	70.91 A
15	68.72	69.78	68.58	69.03 B
Mean	70.71	70.61	70.41	
Year	**2014–2015**		**2015–2016**	
Mean	70.71		70.44	

Significance levels: Stubble height (**P < 0.01**); Cutting frequency (ns); Interaction (ns); Year (ns).

ME and NE values showed no statistically significant differences among treatments. ME content ranged from 2.63–2.68 Mcal/kg DM, with mean values of 2.67, 2.65, and 2.64 Mcal/kg DM for one, two, and three cuts, respectively (Table 7). NE content exhibited a similar pattern, ranging from 1.52 to 1.57 Mcal/kg DM, with slightly higher values at 10 cm and 15 cm stubble heights (Table 7-8).

Table 7. Mean metabolizable energy (ME) contents of triticale grain (Mcal/kg DM).

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	2.698	2.693	2.661	2.684 A
7.5	2.683	2.632	2.683	2.666 A
10	2.708	2.629	2.607	2.648 A
12.5	2.656	2.621	2.628	2.635 A
15	2.605	2.662	2.629	2.632 A
Mean	2.670	2.647	2.641	
Year	**2014–2015**		**2015–2016**	
Mean	2.654		2.651	

Significance levels: Stubble height (ns), Cutting frequency (ns), Interaction (ns); Year (ns).

Table 8. Mean net energy (NE) contents of triticale grain (Mcal/kg DM).

Stubble height (cm)	1 cut	2 cuts	3 cuts	Mean
5	1.523 de	1.528 de	1.577 a	1.542 AB
7.5	1.536 cde	1.562 abc	1.549 ad	1.549 A
10	1.564 abc	1.524 de	1.579 a	1.556 A
12.5	1.526 de	1.518 e	1.531 de	1.525 B
15	1.531 de	1.546 b–e	1.570 ab	1.549 A
Mean	1.536 B	1.536 B	1.561 A	
Year	**2014–2015**		**2015–2016**	
Mean	1.542		1.546	

Significance levels: Stubble height (**P < 0.01**), Cutting frequency (**P < 0.01**), Interaction (**P < 0.05**); Year (ns).

Digestibility and energy parameters of triticale grain were primarily influenced by stubble height rather than cutting frequency. The higher DOM observed at moderate stubble heights (7.5–10 cm) suggest more efficient accumulation of digestible organic matter under optimal canopy conditions. Very low stubble (5 cm) or excessively high stubble (15 cm) reduced the plant's regrowth potential and grain-filling efficiency, consequently lowering digestibility and energy concentration.

Energy values (ME and NE) remained relatively stable across treatments, suggesting that the biochemical energy potential of triticale grain is resilient to moderate variations in cutting management. Similar results were reported by Adams (1994) and Fonnesbeck et al. (1984), who indicated that digestibility and energy conversion efficiency in cereal grains depend more on grain maturity than on management intensity. The slight decline in ME and NE values with increasing stubble height aligns with findings by Gökkuş et al. (2017) and Coşkun et al. (2014), who observed that advanced maturity and reduced metabolic activity lower energy density in small grains. Overall, maintaining medium stubble heights (7.5–10 cm) and fewer cuttings (one or two) optimizes both digestibility and energy value of triticale grain for animal feeding purposes.

Conclusion

The present study demonstrated that cutting management practices, particularly stubble height and cutting frequency, exert measurable effects on the nutritional and energetic characteristics of triticale grain. CP, CA and fiber fractions (NDF, ADF, ADL) responded significantly to variations in cutting management, while DOM and energy values (DE, ME, NE) were affected to a lesser extent. Lower cutting frequencies (one or two cuts) and moderate stubble heights (7.5–12.5 cm) maintained higher crude protein and mineral contents, as well as favorable fiber composition. In contrast, excessive cutting frequency and very low or high stubble heights negatively influenced protein concentration and digestibility, likely due to accelerated plant maturity and reduced assimilate accumulation. Although energy-related parameters exhibited limited responsiveness to the management treatments, the observed

trends suggest that a balanced cutting regime contributes to improved energy retention in the grain. Overall, implementing one or two cuttings with a stubble height close to 10 cm emerges as the most effective strategy for enhancing the feeding quality of triticale grain. This management approach supports high nutritional value while maintaining plant regrowth and grain productivity under Mediterranean conditions.

Additional Declaration

Author Contributions

In this study, *Fırat Alatürk* and *Ahmet Gökküş* contributed equally to the research. Both authors were involved in the development of the research idea, experimental design, data analysis, manuscript writing, and final proofreading. Therefore, both authors share equal authorship rights.

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Responsible Artificial Intelligence Statement

In this study, artificial intelligence tools were used in language editing, data analysis and literature review stages. The artificial intelligence tool was used to correct language errors, to check the data analysis made by the author, and to provide the colophon information of current related resources in the literature review. We declare that we, as the authors, take full responsibility for the problems that may arise from the content produced by artificial intelligence.

Conflicts of Interest

The authors declare that there are no conflicts of interest related to the publication of this study.

Ethics Approval

This study does not require ethics committee approval as it does not involve any direct application to human or animal subjects.

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REFERENCES

Adams, R. S. (1994). *Total digestible nutrients of feeds for dairy cattle*. University Park, PA: Pennsylvania State University, Cooperative Extension, DAS 94–25.

Akgün, İ., & Kara, B. (2002). *Adaptation and yield performances of triticale cultivars under different ecological conditions in Turkey*. *Turkish Journal of Field Crops, 7*(1), 15–20.

Albayrak, S., Türk, M., & Yüksel, O. (2006). *Effect of harvesting stages on forage yield and quality of triticale varieties*. *Journal of Agronomy, 5*(1), 90–93.

AOAC. (1990). *Official methods of analysis* (15th ed.). Washington, DC: Association of Official Analytical Chemists.

Cherney, J. H., & Marten, G. C. (1982). *Small grain crop forage potential: Evaluation of biological and chemical components*. *Agronomy Journal, 74*(6), 899–905.

Coşkun, Ş. E., Gökkuş, A., & Kaya, A. (2014). *Changes in forage yield and quality of small cereals under different cutting stages in Mediterranean climate*. *Turkish Journal of Field Crops, 19*(2), 245–252.

Droushiotis, D. N. (1989). *Triticale: A new cereal for forage and grain production under Mediterranean conditions*. *Journal of Agricultural Science, 112*(2), 151–157.

Fonnesbeck, P. V., Harris, L. E., & Kearl, L. C. (1984). *Energy requirements of livestock*. Logan, UT: Utah State University Press.

Gökkuş A., Birer S., Alatürk F., 2017. Farklı anız yükseklikleri kalacak şekilde yapılan biçimlerin arpanın ot verimi ve kalitesine etkileri. Türkiye 12. Tarla Bitkileri Kongresi, 12-15 Eylül 2017, Kahramanmaraş.

Haddi, M. L., Bouzerzour, H., & Ounane, S. M. (2003). *Forage yield and quality of barley and triticale as influenced by cutting stage in semi-arid regions*. *Cahiers Options Méditerranéennes, 45*, 39–42.

Henning, J. C., Stringer, W. C., & Brown, D. E. (2000). *Grazing management of small grains for forage and grain*. Clemson, SC: Clemson University Cooperative Extension Circular 787.

Kamstra, L. D., Krysl, L. J., & Buehler, M. B. (1968). *Changes in forage composition and digestibility during the growing season*. *Journal of Range Management, 21*(1), 21–24.

Kaya, A. (2008). *Yem bitkilerinde büyüme dönemi ve biçim zamanının kalite üzerine etkileri*. Ankara, Türkiye: Tarla Bitkileri Merkez Araştırma Enstitüsü Yayınları.

Khorasani, G. R., Kennelly, J. J., & Racz, V. J. (1997). *Effect of maturity on the nutritive value of cereal grains and their forages for ruminants*. *Animal Feed Science and Technology, 64*(1), 33–43.

Miller, D. A. (1984). *Forage crops*. New York, NY: McGraw-Hill.

Oddy, V. H., Robards, G. E., & Low, S. G. (1983). *Prediction of in vivo dry matter digestibility from fiber analysis of forage crops*. *Animal Feed Science and Technology, 9*(3), 237–243.

Özkan, U., Yılmaz, D. İ., Tenikecier, H. S., & Ateş, E. (2025). Türkiye'de kaba yem ve kuru ot durumu: 2004–2024 dönem analizi. *Erciyes Tarım ve Hayvan Bilimleri Dergisi (ETHABD)*, 8(1), 93–107.

Pieper, R. D., Parker, E. E., & Donart, G. B. (1974). *Effects of deferred grazing on herbage composition*. *Journal of Range Management, 27*(3), 204–207.

TÜİK. (2024). *Bitkisel Üretim İstatistikleri, 2024*. Türkiye İstatistik Kurumu.

Taiz, L., & Zeiger, E. (2008). *Plant physiology* (5th ed.). Sunderland, MA: Sinauer Associates.

Tan, M. (1995). *The performance of triticale cultivars and lines for forage and grain yield in eastern Anatolia*. *Turkish Journal of Agriculture and Forestry, 19*(4), 297–303.

Towne, G., & Ohlenbusch, P. D. (1992). *Vegetation response to grazing management on tallgrass prairie*. *Journal of Range Management, 45*(2), 118–122.

Van Soest, P. J., Robertson, J. B., & Lewis, B. A. (1991). *Methods for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to animal nutrition*. *Journal of Dairy Science, 74*(10), 3583–3597.

Yanbeyi, A., & Sezer, İ. (2006). *Adaptation of triticale varieties under Marmara region conditions*. *Journal of Tekirdağ Agricultural Faculty, 3*(2), 163–168.