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Research article

Orchard grass (*Dactylis glomerata* L.) yield and nutritive characteristics in response to different cutting regimes in a temperate region

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Abstract

The present study was carried out at the Research Farm of Regional Research Station, ICAR-IGFRI, Rangreth, Srinagar, to evaluate three harvesting stages and three cutting intervals for achieving higher fodder yield and quality in orchard grass (*Dactylis glomerata* L). Among the harvesting stages, H3 (harvesting at the flowering stage) recorded the highest green (27.04 t/ha) and dry (8.05 t/ha) fodder yield. Among the cutting intervals, CI 3 (cutting at 60-day intervals) recorded higher fresh and dry biomass yield. Fodder yield increased with harvesting at later stages and increased cutting intervals. The highest crude protein content (11.87%), lowest NDF (55.87%) and ADF (31.65%) contents were recorded when grass was harvested at the vegetative stage. Digestible dry matter (DDM) varied significantly with both harvesting stage and cutting interval and was found to be highest with H1 (64.23%) and CI 1 (63.54%). The highest relative feed value (RFV) of 106.92% and highest total digestible nutrients (TDN) of 65.68% were found in the orchard grass cut at the vegetative stage (H1), which was at par with orchard grass harvested first at the booting stage (H2). Harvesting at both vegetative and booting stages resulted in good quality (RFV >103%) and energy-rich (TDN> 65%) forage. Harvesting at the flowering stage resulted in fair quality (RFV 96.67% and TDN 63.65%) fodder.

Keywords: Cutting interval, *Dactylis glomerata*, Fodder yield, Harvesting stage, Quality

Introduction

Orchard/cocksfoot grass (*Dactylis glomerata* L.) is an important perennial grass cultivated widely in temperate regions of the world (Boller *et al*., 2010; Mir *et al*., 2018). Due to its high forage quality, *i.e.*, sugar and protein contents, shade tolerance and persistence, it is more suitable for cultivation than many other cool-season perennial grasses and is used for hay or silage production and grazing worldwide (Last *et al*., 2013). Orchard grass produces a continuous growth of young leaves and the persistence of orchard is outstanding among the temperate perennial grasses (Shuo *et al*., 2016). It is well adapted to intercropping with legumes as it is more competitive with legumes than many other cool-season grasses (Moser *et al*., 1996; FAO, 2010). It is suitable for mixed sowing with alfalfa (*Medicago sativa* L.) or red clover (*Trifolium pratense* L.) for hay or white clover (*T. repens* L.) for grazing (Sanada *et al*., 2010). The average dry matter yield of native and exotic grasses varies considerably from 2.5 t/ha in *Agrostis* spp. to 10.0 t/ha in *D. glomerata* L., hence this grass has a great potential for seeding the temperate pasturelands in combination with perennial legumes especially red and white clover and as such offers a great prospective for rehabilitation of alpine and sub-alpine grasslands (Ahmad *et al*., 2018; Singh *et al*., 2018).

Careful selection of the stage of cutting is an important factor affecting yield and quality of forage crops (Kadam *et al*., 2022; Ghosh *et al*., 2022). Decisions on when to cut perennial forage crops are based on consideration of both quantity and quality of forage (Foster *et al*., 2021), as the stage and frequency of cuttings greatly affect forage yield and quality. Generally, postponing harvesting time increases the fiber content of fodder crops while the crude protein content decreases, resulting in reduced forage digestibility and relative feed value. However, harvesting forage with the highest quality might significantly reduce its yield (Zhang *et al*., 2023). Production and cutting frequency of orchard grass are greatly affected by soil moisture, soil temperature, soil fertility, and disease incidence (Hall, 2008). Early harvesting leads to lower yields and late harvesting each year will reduce quality and cause thin and bunchy plant stands. Cocksfoot/ orchard grass has a high nutritional value with a crude

protein content ranging from 28.3% at pre-joint to 12.5% at the late bloom stages (Hall, 2008; Salehi Shanjani *et al*., 2012). At the vegetative growth stage, orchard grass approaches the feeding value of alfalfa but results in a lower yield. At full bloom, it has about half the value of alfalfa but produces high fodder quantities. Delaying harvesting beyond the boot stage causes older stems to become coarse and unpalatable and yields low-quality hay. Balanced cocksfoot dairy rations can be well utilized by lactating dairy cattle, resulting in higher yields than alfalfa, provided that grass is harvested at an appropriate stage, resulting in higher yield and quality (Jonker *et al*., 2002; Kumar *et al*., 2023). Cocksfoot has to be cut at the flowering stage to ensure it is nutritious (high protein content), and also to promote the growth of palatable tillers. Feeding values of pastures are assessed based on the amount of feed voluntarily consumed by animals and the digestibility of nutrients consumed (Peri *et al*., 2007). Crude protein (CP), acid detergent fiber (ADF), and digestible dry matter (DDM) are important traits to determine the forage quality (Arzani *et al*., 2006). Quantity and quality of fodder follow opposite trends with the advances in crop development. Identifying the most suitable cutting stage is important to harvest adequate quantities of fodder without compromising its nutritional quality. Hence harvesting schedule of orchard grass was standardized for achieving higher fodder yield and quality in the temperate Himalayan region.

Materials and Methods

Study site: The experimental investigations were carried out at Research Farm of Regional Research Station, ICAR-IGFRI, Rangreth, Srinagar. The experimental site is situated in the temperate zone of Jammu and Kashmir and lies between 33º 59′ 23.9″ N latitude and 74º 48′ 0.2″ E longitude at an altitude of 1630 meters above the mean sea level. The experimental site is a *karewa* (elevated tableland) with no water logging problem. Climatically, the site is located in mid altitude temperate zone characterized by hot summers and very cold winters. The average annual precipitation is about 700 mm and more than 80 percent of the precipitation is received from western disturbances (a non-monsoonal precipitation pattern driven by the westerlies and may happen during any season). Total rainfall received during the period of crop growth (April to October) was 60.41 and 95.01 cm during 2020 and 2021, respectively. The minimum temperature ranged from 1.90 to 18.89°C during 2020 and 2.50 to 19.99°C during 2021; the maximum temperature ranged from 19.21 to 34.10°C and 17.07 to 33.29°C during 2020 and 2021, respectively. The main soil type was designated as well-drained sandy loam in texture having a neutral pH of 6.9, medium in organic carbon (0.72%), available nitrogen (295 kg/ha), available phosphorus (16.7 kg/ha), high available potassium (364.5 kg/ha) and low zinc (0.36 ppm).

Experimental design and nutritional analyses: The experiment was carried out in a factorial randomized block design with two factors: A. Harvesting stages with three levels: H1 = harvesting at vegetative stage (last week of April), H2 = harvesting at boot stage and H3 = harvesting at flowering stage, and; B. Cutting intervals with three levels: CI 1= 30 days, CI 2 = 45 days and CI 3 = 60 days. A uniform seed rate of 16 kg/ha with a row spacing of 30 cm was used in each treatment.

During each harvest, plants from 1 m^2 area were harvested to record the fresh fodder yield. Dry fodder yield was taken after sun-drying green fodder taken from 1 m^2 area and reported in t/ha. Four cuts were taken under each harvesting stage. During the second cut under each harvesting stage, oven-dried forage samples were ground to 1-mm sieve to be analyzed for quality. Total N was determined using Kjeldahl method and crude protein (CP) was calculated by multiplying N content by 6.25. Neutral and acid detergent fibers (NDF and ADF) were determined according to Van Soest's (1994) procedure. Dry matter intake (DMI), digestible dry matter (DDM), relative feed value (RFV) and total digestible nutrients (TDN) were estimated according to the following equations (Lithourgidis *et al*. 2006; Aydin *et al*., 2010); DMI = 120/ % NDF; DDM = 88.9 - (0.779 × %ADF); RFV = %DDM × %DMI/1.29; TDN = 87.84- (ADF × 0.7)

Statistical analysis; The data collected on different parameters during two-year investigations was subjected to statistical analysis and the average data of two-year results was recorded. The software package used for the analysis of data was "OPstat." Wherever the 'F' test was found significant at 5% probability, critical difference values were used to compare the treatment means (Sheoran *et al*., 1998).

Results and Discussion

Green and dry fodder biomass: Two-year average data on green and dry fodder yields as affected by harvesting stages and cutting intervals were recorded (Table 1). Among the harvesting stages, H3 (harvesting at the flowering stage) recorded the highest total green fodder yield of 27.04 t/ha. Similarly, the highest total dry fodder yield (8.05 t/ha) was recorded at the same harvesting stage. Total fodder yield increased as the harvesting was delayed from the vegetative to the flowering stage due to longer duration and more accumulation of biomass. The increased yield with the advanced stage of harvesting could be due to an increase in the structural carbohydrate and amount of cell wall materials deposited as a result of the addition of days and reduced moisture content of the grass. The increase in forage biomass with advancing maturity could be the result of the addition of tillers, leaf elongation and stem development (David *et al*., 2019). As reported earlier, the booting stage is the most suitable

Table 1. Fodder yield as influenced by different harvesting stages and cutting intervals

Treatment	Green fodder yield (t/ha)					Dry fodder yield (t/ha)				
	1st cut	2nd cut	3rd cut	4th cut	Total	1st cut	2nd cut	3rd cut	4th cut	Total
Harvesting stage										
Vegetative stage (H1)	9.58	6.68	3.27	2.02	21.56	2.95	2.13	1.04	0.64	6.87
Boot stage (H2)	13.38	6.38	3.15	2.06	24.99	4.07	1.93	0.96	0.60	7.57
Flowering stage (H3)	16.64	5.84	2.86	1.66	27.04	5.05	1.70	0.83	0.48	8.05
SEM	0.25	0.29	0.14	0.18	0.67	0.29	0.16	0.09	0.079	0.38
CD ($p < 0.05$)	0.76	0.83	0.36	NS	2.02	0.88	0.38	NS	NS	1.05
Cutting interval (CI)										
CI 1 (30 days)	13.18	4.57	2.47	1.53	21.75	4.03	1.44	0.77	0.47	6.81
CI 2 (45 days)	13.17	6.69	3.20	2.09	25.18	3.93	1.99	0.95	0.62	7.47
CI 3 (60 days)	13.25	7.65	3.63	2.13	26.67	4.11	2.36	1.14	0.66	8.21
SEM	0.25	0.29	0.22	0.18	0.67	0.29	0.16	0.09	0.07	0.38
CD ($p < 0.05$)	NS	0.90	0.67	NS	2.02	NS	0.49	0.28	NS	1.10

Table 2. Interaction effect between harvesting stages and cutting interval with respect to fodder yields

	Green fodder yield (t/ha)			Dry fodder yield (t/ha)		
	Cutting interval 1 (30 days)	Cutting interval 2 (45 days)	Cutting interval 3 (60 days)	Cutting interval 1 (30 days)	Cutting interval 2 (45 days)	Cutting interval 3 (60 days)
Vegetative stage (H1)	19.167	21.783	23.750	6.117	6.900	7.617
Boot stage (H2)	21.667	25.867	27.450	6.833	7.500	8.400
Flowering stage (H3)	24.417	27.900	28.817	7.500	8.017	8.633
SEM	1.16			0.84		
CD ($p < 0.05$)	3.12			NS		

stage for higher yield and quality of orchard grass (Mir *et al*., 2018). For higher yield, orchard grass should be harvested in spring during the boot stage (Hall, 2008). The findings were also consistent with the study of Kumawat *et al.* (2021).

Fodder yield also increased as the cutting interval was increased from 30 to 60 days. Among the cutting intervals, CI 3 (cutting at 60 day intervals) recorded the highest total green (26.67 t/ha) and dry fodder (8.21 t/ha) yields. However, non-significant differences in total fodder yield were recorded between cutting intervals of 45 days and 60 days. Further, it was also observed that much of the forage biomass yield was obtained at the first cut in all three harvesting stages. In orchard grass, the fodder might be harvested at 4 to 6-week intervals, which, however, depends largely on temperature, soil moisture and soil fertility (Hall, 2008). The highest dry matter yield (5.64 t/acre) of orchard grass was also obtained at 45 day intervals by Hall (1998). Mynavathi *et al*. (2021) also reported similar results. Arif *et al*. (2023) reported a higher fodder yield of pearl millet in the first cut and lower in the second cut. Interaction effect (Table 2) indicated that combination H3 × CI 3 recorded the highest green as well as dry fodder yield.

Nutritional quality parameters: The data on fodder quality parameters (Table 3) averaged over 2 years revealed that crude protein content, fibre fractions (NDF and ADF) and estimated digestibility parameters varied significantly with the harvesting stage. The highest average crude protein content (11.87%) was recorded with harvesting at the vegetative stage (H1), which was significantly higher overharvesting at the flowering stage (H3). Crude protein content decreased as the harvesting was delayed to boot (11.45%) and flowering (10.88%) stages. H1 also recorded the lowest NDF (55.87%) and ADF (31.65%) contents which increased as harvesting was delayed till H2 and H3. NDF and ADF contents also increased as the cutting interval increased from 30 to 60 days. The decrease in crude protein and increase in fibre content and lignification as the crop age advances is well established.

Similar findings have been reported by Hall (2008). Enoh *et al*. (2005) observed that as the harvesting interval was delayed in pasture species from 8 to 12 weeks, the CP declined by 23%, while the fibre fractions (CF, NDF, ADF) increased by 20%. Tenikecier and Ates (2019) reported that the orchard grass samples showed an increase in average crude protein content from 15.02 to 15.08%. However,

Table 3. Fodder quality parameters as influenced by different harvesting stages and cutting intervals

Treatment	CP (%)	NDF (%)	ADF (%)	DMI (%)	DDM (%)	RFV (%)	TDN (%)
Harvesting stage (H)							
Vegetative stage (H1)	11.87	55.87	31.65	2.14	64.23	106.92	65.68
Boot stage (H2)	11.45	56.59	32.54	2.12	63.54	104.39	65.05
Flowering stage (H3)	10.88	60.08	34.12	2.00	62.31	96.67	63.95
SEM	0.23	0.60	0.62	0.02	0.48	1.45	0.42
CD ($p < 0.05$)	0.78	1.82	1.87	0.06	1.43	4.31	1.31
Cutting Interval (CI)							
CI 1 (30 days)	11.77	57.05	32.54	2.10	63.54	103.83	65.06
CI 2 (45 days)	11.38	57.27	32.74	2.10	63.39	103.02	64.92
CI 3 (60 days)	11.06	58.23	33.04	2.06	63.16	101.14	64.71
SEM	0.14	0.36	0.13	0.02	0.10	0.63	0.42
CD ($p < 0.05$)	0.44	1.08	0.39	NS	0.30	1.84	NS

average NDF content showed a reduction from 61.97 to 61.03% when comparing results of two consecutive years. De Giorgio *et al*. (2005) reported that cocksfoot showed wide variations in crude protein (9–18%) and NDF (45.8–50.1%) contents during three-year experimentations. Tuna *et al*. (2004) and Yavuz and Karadag (2016) recorded that NDF and ADF contents ranged from 64.31 to 65.31% and 37.69 to 39.90%, respectively, in orchard grass. Sahin *et al*. (2012) also obtained similar values on crude protein (11.98%), NDF (60.93%) and ADF (35.73%) contents in orchard grass lines at the beginning of the flowering stage. In fodder maize, maximum acid detergent fiber content, neutral detergent fiber content and lignin were observed at delayed harvesting (100 days), while crude protein was maximum at early harvesting (80 days; Rehman *et al*., 2017). Mynavathi *et al*. (2021) reported better fodder quality parameters in hedge lucerne harvested at shorter cutting intervals of 30 days as compared to longer intervals.

Dry matter intake (DMI%) varied with the harvesting stage and the highest DMI of 2.14% was recorded with harvesting at the vegetative stage (H1), which was, however, at par with H2 (2.12%). Cutting interval had no significant influence on DMI. Digestible dry matter (DDM) varied significantly with both the harvesting stage and cutting interval and was found to be highest with H1 (64.23%) and CI 1 (63.54%). The highest relative feed value (RFV) of 106.92% and highest total digestible nutrients (TDN) of 65.68% was found in orchard grass cut at the vegetative stage (H1), which was at par with orchard grass harvested first at the booting stage (H2). Harvesting at both vegetative and booting stages resulted in good quality (RFV >103%) and energy-rich (>65%) forage. Harvesting at flowering decreased both RFV (<100%) and TDN (<65%) and resulted in forage of fair quality.

Cutting interval had no significant influence on TDN. Increasing cutting interval from 30 to 60 days significantly reduced RFV. However, all three cutting intervals resulted in fodder of the same quality class. As fodder quality parameters (DMI, DDM, TDN and RFV) are governed by fiber fractions (ADF and NDF), hence lower fiber values are the intake, digestibility and feeding value of forage and *vice-versa*. Giovanni *et al*. (2016) reported that based on DMI, DDM. TDN and RFV annual ryegrass (*Lolium rigidum*) + burr medic (*Medicago polymorpha*) mixtures could be categorized as prime forage at flowering stages and fair-good quality in late stages. The DDM content of orchard grass was 61.3% during the flowering stage (Christie and McElroy, 1995). DDM was positively correlated with CP and negatively correlated with crude fiber and acid detergent fiber (Farshadfar, 2017). Since, the RFV is used to predict the intake and energy value of forages, the higher the RFV better the nutritional quality of the forage. RFV is positively correlated with CP content, suggesting that CP plays a role in enhancing the RFV (Tahir *et al*., 2022). CP content varied from 12.96 to 16.55%, DDM from 48.69 to 54% and ADF from 31.18 to 38.46% in orchard grass accessions harvested in spring and summer (Farshadfar, 2017). The lowest ADF, NDF and ADL, and highest forage values in terms of TDN, DMI, DDM, RFV and CP were recorded at first harvesting time in orchard grass along with legumes (Demirbag *et al*., 2020). Higher forage quality characteristics with early harvesting were also reported earlier (Bo *et al*., 2022; Arif *et al*., 2023).

Conclusion

From the study, it was concluded that both biomass yield and nutritive characteristics of orchard grass were affected by the harvesting stage and cutting intervals. The fodder yield and fiber fractions (NDF and ADF) increased as harvesting was delayed from the vegetative to the flowering stage. However, the highest crude protein content, dry matter intake, digestibility, total digestible nutrients and relative feed value were recorded at earlier harvesting (vegetative and booting) stages. Therefore, in order to harvest higher fodder yield without compromising

much in its forage quality, orchard grass should be harvested after the boot stage at an interval of 45 to 60 days.

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