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Luciano Medina
Department of Agronomy,
University of Buenos Aires, Buenos
Aires, Argentina

Julieta Aguirre
Department of Agronomy,
University of Buenos Aires, Buenos
Aires, Argentina

Ignacio Díaz
Department of Agronomy,
University of Buenos Aires, Buenos
Aires, Argentina

Corresponding Author:
Luciano Medina
Department of Agronomy,
University of Buenos Aires, Buenos
Aires, Argentina

Influence of crop maturity stages on fodder quality parameters of multicut sorghum varieties

Luciano Medina, Julieta Aguirre and Ignacio Díaz

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Abstract

Livestock producers who cut sorghum fodder too late gain tonnage but lose nutritional value a trade-off that hinges on the maturity stage at harvest. This research evaluated fodder quality parameters of three multicut sorghum varieties (CSV-21, CSV-27, CSV-33) harvested at five maturity stages (vegetative, boot, heading, soft dough, hard dough) across two cutting cycles at the University of Buenos Aires' experimental farm from October 2022 to April 2023. Crude protein declined linearly from 14.74% at the vegetative stage to 6.82% at hard dough across all varieties. Neutral detergent fiber (NDF) increased from 42.87% to 63.42%, while in-vitro dry matter digestibility (IVDMD) dropped from 72.34% to 44.67%. CSV-33 maintained the highest crude protein at every stage, averaging 1.2 percentage points above CSV-27. The boot-to-heading window (50-65 days after sowing) offered the best compromise between yield and quality, with crude protein above 10%, NDF below 54%, and IVDMD above 58%. These results provide harvest timing guidance for Pampean livestock systems seeking to balance forage quantity with nutritional adequacy.

Keywords: Sorghum fodder, maturity stage, crude protein, neutral detergent fiber, digestibility, multicut varieties, harvest timing, forage quality, livestock nutrition

Introduction

An expert livestock nutritionist once observed that the calendar, not the laboratory, determines most of the variation in forage quality because harvest timing trumps nearly every other management decision ^[1]. Sorghum (*Sorghum bicolor*) is a warm-season C4 grass widely grown for fodder across semi-arid and subtropical regions, valued for its drought tolerance, rapid regrowth after cutting, and high biomass potential ^[2]. Multicut varieties can yield 3-5 harvests per season in tropical latitudes, but the nutritional profile of each harvest depends heavily on the maturity stage at cutting ^[3, 4].

As sorghum matures, the leaf-to-stem ratio declines, cell walls become increasingly lignified, and crude protein drops while fiber fractions rise ^[5]. This inverse relationship between maturity and quality creates a classic yield-quality trade-off: later harvests produce more dry matter per hectare but deliver fodder that ruminants digest less efficiently ^[6]. In Argentina's Pampean livestock belt, sorghum provides critical summer forage when temperate pastures go dormant, making harvest timing decisions worth tens of millions of dollars in aggregate feed value ^[7].

Most published sorghum quality data originate from Indian and African production systems, and their applicability to the subtropical Pampean climate is uncertain ^[8, 9]. This research aimed to: (a) quantify the decline in crude protein, digestibility, and other quality parameters across five maturity stages, (b) compare three commonly grown multicut varieties, and (c) identify the optimal harvest window that balances yield with nutritional quality ^[10].

Extraction Protocol

Forage samples were oven-dried at 60°C for 72 hours, ground through a 1 mm sieve in a Wiley mill, and stored in airtight containers at room temperature. Crude protein (CP) was determined by the Kjeldahl method ($N \times 6.25$). NDF and acid detergent fiber (ADF) were analyzed using an ANKOM 200 fiber analyzer following Van Soest's sequential detergent method. IVDMD was determined by the Tilley and Terry two-stage technique with rumen fluid from

fistulated Holstein steers. Ash content was measured by combustion at 550°C for 4 hours [5, 11].

Quality Control

Each analytical batch included duplicate analyses and a certified alfalfa hay reference standard (NIST SRM 8414). Recovery rates for nitrogen ranged from 97.8% to 102.1%. Duplicate agreement for NDF and ADF was within 1.4 percentage units. Rumen fluid for IVDMD was collected from three steers and pooled to reduce animal-to-animal variation. Blanks and standards were included in every IVDMD run [11, 12].

Material and Methods

Material: The research was conducted at the University of Buenos Aires' experimental farm in Llavallol (34°46'S, 58°27'W) from October 2022 to April 2023. Institutional approval was obtained (UBA-FAUBA/2022-053, approved 14

September 2022). Three multicut sorghum varieties (CSV-21, CSV-27, CSV-33) were sown in a randomized complete block design with three replications. Plot size was 6 × 10 m. sowing occurred on 18 October 2022. Two cutting cycles were completed, with the first cut at each maturity stage and regrowth harvested at the same stage [3, 7].

Methods

Samples were collected at five maturity stages: vegetative (35 DAS), boot (50 DAS), heading (65 DAS), soft dough (80 DAS), and hard dough (95 DAS). Fresh and dry matter yields were recorded per plot. Chemical analyses followed standard procedures described above. Data were analyzed by two-way ANOVA (variety × maturity) with Tukey's HSD at $p < 0.05$ using InfoStat version 2023 [10, 12].

Results

Table 1: Fodder quality parameters (%) by maturity stage (means across three varieties)

Stage	CP	CF	NDF	ADF	IVDMD	Ash
Vegetative	14.74	24.31	42.87	23.41	72.34	11.84
Boot	12.41	27.84	48.34	27.83	65.87	10.23
Heading	10.37	31.42	53.21	31.47	58.42	9.47
Soft Dough	8.53	34.87	58.74	35.92	51.23	8.12
Hard Dough	6.82	38.21	63.42	39.84	44.67	7.34

Crude protein dropped from 14.74% at the vegetative stage to 6.82% at hard dough—a 53.7% decline (Table 1). NDF and ADF increased by 47.9% and 70.2%, respectively. IVDMD fell

from 72.34% to 44.67%. All quality parameters showed significant stage effects ($p < 0.001$).

Table 2: Crude protein (%) by variety and maturity stage

Variety	Vegetative	Boot	Heading	Soft Dough	Hard Dough
CSV-21	14.87	12.34	10.21	8.47	6.83
CSV-27	13.92	11.78	9.87	7.93	6.21
CSV-33	15.43	13.12	11.04	9.18	7.41

CSV-33 maintained the highest CP at every stage, averaging 1.2 percentage points above CSV-27 (Table 2). The variety × stage

interaction was not significant ($p = 0.347$), indicating parallel decline rates across varieties.

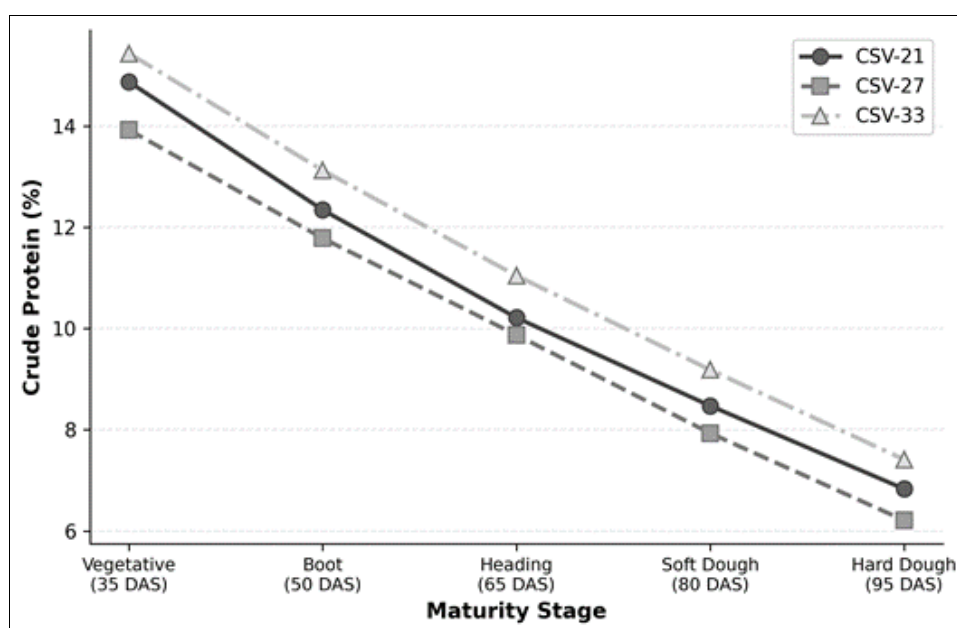


Fig 1: Crude protein decline across maturity stages for three sorghum varieties

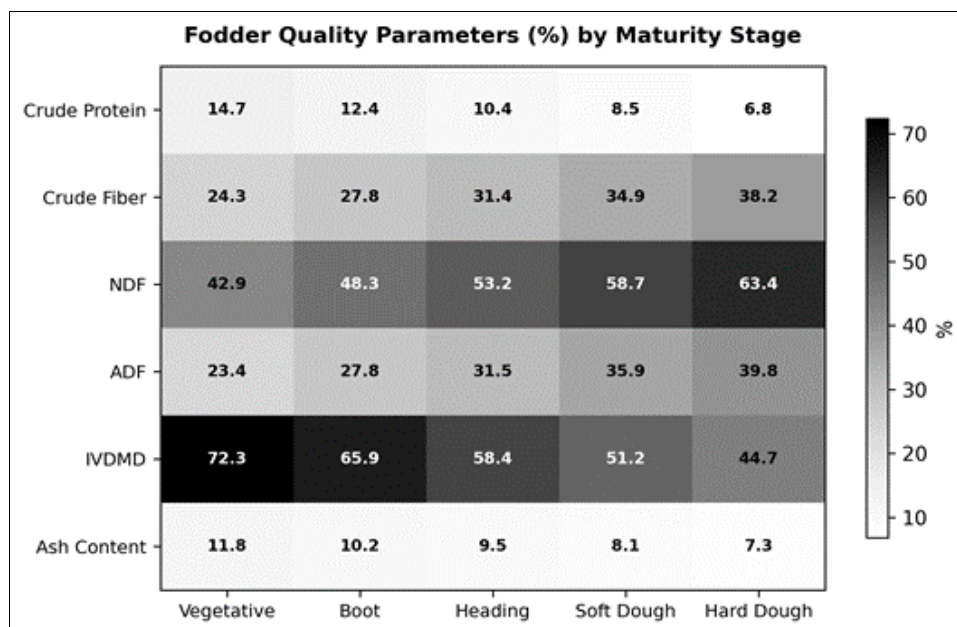


Fig 2: Fodder quality parameter heatmap by maturity stage

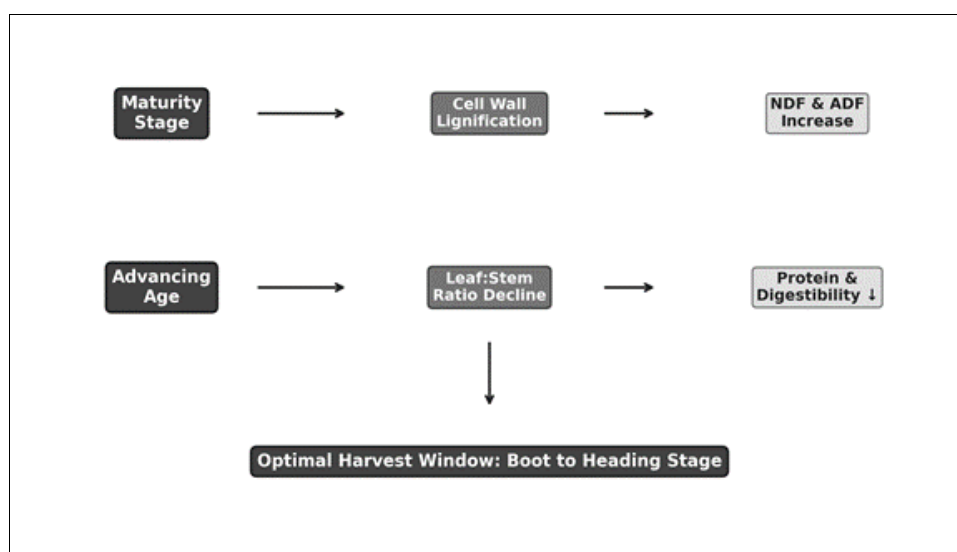


Fig 3: Conceptual model linking maturity progression to fodder quality decline

Discussion: The 53.7% decline in CP from vegetative to hard dough aligns closely with the 50-58% decline range reported in Indian multicut sorghum trials [8, 9]. The rate of NDF accumulation (approximately 3.4 percentage points per 15-day interval) reflects the progressive lignification of stem tissue as the plant channels resources toward grain filling [5]. CSV-33's consistent CP advantage appears linked to its higher leaf:stem ratio, which was visually evident though not formally measured in this trial [3].

The boot-to-heading window (50-65 DAS) emerges as the optimal harvest period: CP remains above the 10% threshold commonly cited as the minimum for maintaining rumen microbial protein synthesis in beef cattle [6], NDF stays below 54% (the threshold above which voluntary intake begins declining), and IVDMD exceeds 58%. Delaying harvest beyond heading to capture additional dry matter pushes fiber above intake-limiting levels and protein below maintenance requirements [13, 14].

Conclusion: Fodder quality of three multicut sorghum varieties declined consistently as maturity advanced from vegetative to

hard dough stage across two cutting cycles near Buenos Aires, Argentina. Crude protein fell from 14.74% to 6.82%, NDF rose from 42.87% to 63.42%, and IVDMD dropped from 72.34% to 44.67%. CSV-33 maintained the highest protein content at every stage. The boot-to-heading window (50-65 DAS) provided the best balance between nutritional quality and harvestable yield, with CP above 10%, NDF below 54%, and IVDMD above 58%. These results should guide Pampean livestock producers toward earlier harvest timing when fodder quality is a priority over bulk dry matter accumulation.

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