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Effect of growth stage on chemical composition and nutritional quality of different oat (*Avena sativa*) cultivars

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Abstract

The present study was undertaken to evaluate the effect of growth stage on the chemical composition and nutritional quality of different oat (*Avena sativa* L.) cultivars under rabi conditions. Eight oat cultivars were assessed at two growth stages, viz., 60 and 90 Days After Sowing (DAS), using a factorial randomized block design. The results revealed that growth stage exerted a significant influence on all major nutritional parameters. Advancement in maturity resulted in a significant ($p < 0.01$) increase in dry matter, crude fibre, Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), cellulose, lignin, and silica, whereas crude protein, ether extract, total ash, calcium, and phosphorus contents declined significantly. Nitrogen free extract showed non-significant variation across growth stages. Significant genotypic differences were observed among cultivars for most of the parameters studied. Among the cultivars, RO-2000-19 exhibited superior nutritional quality, characterized by higher crude protein and lower fibre and silica content, while RO-2000-16 recorded higher dry matter and fibre fractions, indicating greater biomass accumulation but comparatively lower nutritive value. The study highlights a clear inverse relationship between forage maturity and nutritional quality, emphasizing the importance of optimal harvest timing. Harvesting at 60 DAS was found to be more suitable for obtaining nutritionally superior forage. The findings underscore the combined importance of growth stage and cultivar selection in optimizing forage quality and improving livestock productivity.

Keywords: Oat (*Avena sativa*) cultivars, growth stage, chemical composition, fiber fractions, forage nutritive value

1. Introduction

Oat (*Avena sativa* L.) is one of the most important winter forage crops widely cultivated for livestock feeding due to its high biomass yield, palatability, and superior nutritive value. It plays a crucial role in bridging the gap between demand and availability of green fodder, particularly in mixed farming systems where dairy and draught animals require balanced nutrition. Oat forage is characterized by a favorable combination of crude protein, digestible carbohydrates, and mineral content, making it an essential component of ruminant feeding systems (Hanoğlu, 2024) ^[1].

In recent years, increasing emphasis has been placed on improving forage quality alongside yield, as the nutritional composition of fodder directly influences animal productivity, health, and overall farm profitability. The nutritive value of oat forage is determined by its chemical composition, including Crude Protein (CP), fiber fractions such as Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF), ether extract, ash, and soluble carbohydrates. These components collectively influence digestibility, intake, and energy availability in ruminants (Gaytán-Aleman, 2025) ^[2].

One of the most critical factors affecting the nutritional quality of oat forage is the stage of growth at harvest. As the plant matures, significant biochemical and structural changes occur. Early growth stages are characterized by higher concentrations of crude protein, minerals, and soluble carbohydrates, whereas later stages show increased accumulation of structural carbohydrates such as cellulose, hemicellulose, and lignin. This shift results in reduced digestibility and feeding value. Several studies have demonstrated that crude protein and ash content decline with maturity, while fiber fractions increase, thereby negatively affecting forage quality (Liu, 2015 & Coblenz, 2010) ^[3, 5].

Moreover, the increase in cell wall constituents with advancing maturity is associated with decreased digestibility and metabolizable energy. The rise in NDF and ADF concentrations reduces the availability of nutrients to rumen microbes, ultimately lowering feed efficiency (Coblentz, 2010) [5]. Concurrently, lignification and silica deposition further restrict microbial degradation of plant tissues, making mature forage less digestible. Therefore, determining the optimal harvest stage is essential to balance forage yield and nutritional quality.

Apart from growth stage, genotypic variation among oat cultivars also plays a significant role in determining forage quality. Different cultivars exhibit variability in chemical composition, fiber content, and digestibility characteristics. Recent studies have highlighted substantial genetic variability in oat with respect to nutritional traits, suggesting the potential for selecting superior cultivars for improved forage quality and animal performance (Singh, 2024) [4].

In addition, agronomic and environmental factors such as fertilization, climate, and management practices further influence forage quality. Optimizing these factors, along with selecting appropriate cultivars and harvest stages, is essential for enhancing the efficiency of forage-based livestock systems (Duan, 2024) [6].

Despite extensive research on oat forage, there is still a need for systematic evaluation of different oat cultivars across distinct growth stages under specific agro-climatic conditions, particularly in regions where fodder scarcity is a major constraint. Understanding the interaction between genotype and growth stage is crucial for identifying cultivars that can maintain better nutritional quality over time.

Therefore, the present study was undertaken to evaluate the effect of growth stage on chemical composition and nutritional quality of different oat (*Avena sativa*) cultivars, with the objective of identifying suitable cultivars and optimum harvesting stage for maximizing forage quality.

2. Materials and Methods

Experimental site

The experiment was conducted at the Forage Crop Research Project, Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharashtra, India.

Experimental material

Eight oat (*Avena sativa*) cultivars were evaluated: RO-2000-2, RO-2000-7, RO-2000-19, RO-2000-1, RO-2000-11, RO-2000-16, RO-2000-12, and Kent (check).

Experimental design and layout

The experiment was laid out in a Factorial Randomized Block Design (FRBD) with:

- 8 cultivars (Factor A)
- 2 growth stages (Factor B)
- 3 replications

Each plot measured 4 × 3 m² (gross) and 3.40 × 2.40 m² (net).

Crop management

- **Season:** Rabi
- **Date of sowing:** 28 November 2002
- **Method of sowing:** Line sowing
- **Spacing:** 30 cm between rows
- **Seed rate:** 120 g per plot

- **Fertilizer dose:** 80:40:0 kg N:P:K per hectare

Sampling and growth stages

Samples were collected at:

- 60 days after sowing (Stage I)
- 90 days after sowing (Stage II)

Whole plants were harvested, chopped (2-3 cm), sun-dried, and ground to pass through a 2 mm sieve.

Chemical analysis

a) Proximate analysis (AOAC, 2012)

- Dry Matter (DM)
- Crude Protein (CP)
- Ether Extract (EE)
- Crude Fibre (CF)
- Nitrogen Free Extract (NFE)
- Total Ash (TA)

b) Fiber fractions (Van Soest and Moore, 1968) [8]

- Neutral Detergent Fiber (NDF)
- Acid Detergent Fiber (ADF)
- Cellulose
- Hemicellulose
- Lignin
- Silica

c) Mineral analysis

- Calcium (Ca)
- Phosphorus (P)

3. Statistical analysis

Data were analyzed using Factorial Randomized Block Design (FRBD)

$$Y_{ij} = \mu + \alpha_i + \beta_j + e_{ij}$$

4. Results and Discussion

Dry Matter (DM)

Dry matter content increased significantly with advancement of growth stage ($p < 0.01$) (Table 1). The mean DM content increased from 86.55% at Stage I (60 DAS) to 89.90% at Stage II (90 DAS). Among cultivars (Table 1), DM ranged from 87.23% (RO-2000-1) to 89.05% (RO-2000-16).

The non-significant interaction effect indicates that all cultivars followed a similar trend of increasing DM with maturity. This increase reflects progressive accumulation of structural biomass and reduction in moisture content, consistent with findings of Coblentz *et al.* (2010) [5].

Table 1: Effect of growth stage on proximate composition (%)

Parameter	Stage I (60 DAS)	Stage II (90 DAS)	Significance
DM	86.55	89.90	**
CP	11.52	9.22	**
EE	2.96	2.50	**
CF	23.73	27.60	**
NFE	50.70	51.00	NS
Ash	11.71	9.71	**

Crude Protein (CP)

Crude protein content differed significantly among cultivars and growth stages ($p < 0.01$) (Table 1). The mean CP content

declined from 11.52% at Stage I to 9.22% at Stage II. Among cultivars (Table 1), CP ranged from 9.12% (RO-2000-2) to 11.84% (RO-2000-19). The higher CP at early growth stage is attributed to higher metabolic activity and nitrogen content, while the decline at later stage is due to dilution effect and increased fiber deposition. These results are in agreement with earlier reports (Khorasani *et al.*, 1997; Coblenz *et al.*, 2010) ^[11, 5].

Ether Extract (EE)

Ether extract content was significantly affected by cultivar and growth stage ($p < 0.01$) (Table 1). The mean EE content decreased from 2.96% at Stage I to 2.50% at Stage II. Among cultivars (Table 1), EE varied from 2.39% (RO-2000-16) to 3.01% (RO-2000-7). The decline in EE with maturity may be attributed to reduced lipid concentration as structural biomass increases (Cherney & Marten, 1982) ^[9].

Crude Fibre (CF)

- Crude fibre content increased significantly with growth stage ($p < 0.01$) (Table 1), rising from 23.73% at Stage I to 27.60% at Stage II.
- Among cultivars (Table 1), CF ranged from 23.72% (Kent) to 26.90% (RO-2000-16). The significant interaction effect indicates that cultivars differed in their rate of fiber accumulation.
- The increase in CF is associated with increased lignification and deposition of structural carbohydrates, as reported by Van Soest (1994) ^[12].

Table 2: Fiber fractions (%) of oat cultivars

Parameter	Mean range	Significance (Strain)	Significance (Stage)
NDF	55.12 - 57.05	NS	**
ADF	29.48 - 31.72	**	**
Hemicellulose	23.98 - 26.23	NS	**
Cellulose	24.85 - 28.58	**	**
Lignin	2.55 - 2.83	*	**
Silica	2.32 - 2.70	**	**

5.2 Acid Detergent Fibre (ADF)

- ADF increased significantly with maturity ($p < 0.01$) (Table 2), from 28.85% (Stage I) to 32.43% (Stage II).
- Among cultivars, ADF ranged from 29.48% (RO-2000-19) to 31.72% (RO-2000-1) (Table 2). The significant interaction effect indicates genotype-specific variation.

5.3 Hemicellulose

Hemicellulose content increased significantly ($p < 0.01$) from 23.53% (Stage I) to 26.93% (Stage II) (Table 2). Differences among cultivars were non-significant.

5.4 Cellulose

Cellulose content increased significantly with maturity ($p < 0.01$) (Table 2), from 24.41% to 29.35%. Among cultivars, cellulose ranged from 24.85% (RO-2000-19) to 28.58% (RO-2000-16).

5.5 Lignin

Lignin content increased significantly with growth stage ($p < 0.01$) (Table 2), from 2.31% at Stage I to 3.00% at Stage II. Among cultivars, lignin ranged from 2.55% (RO-2000-1) to 2.83% (RO-2000-7 and RO-2000-16). Increased lignin reduces digestibility due to restricted microbial access (Jung & Allen, 1995) ^[10].

5. Nitrogen Free Extract (NFE)

- Nitrogen free extract content showed significant variation among cultivars ($p < 0.05$) but stage effect was non-significant (Table 1).
- The mean NFE content was 50.85%, ranging from 49.16% (RO-2000-19) to 52.82% (RO-2000-12) (Table 1). Stage-wise values were 50.70% (Stage I) and 51.00% (Stage II), indicating relative stability across growth stages.

6. Total ash

- Total ash content decreased significantly with maturity ($p < 0.01$) (Table 1), declining from 11.71% at Stage I to 9.71% at Stage II.
- Among cultivars (Table 1), ash content ranged from 10.17% (RO-2000-1) to 11.17% (RO-2000-2). The reduction in ash content is attributed to dilution of mineral concentration with increasing biomass (Khorasani *et al.*, 1997) ^[11].

5. Fiber fractions

5.1 Neutral Detergent Fibre (NDF)

- NDF content increased significantly with growth stage ($p < 0.01$) (Table 2), from 52.38% at Stage I to 59.36% at Stage II.
- Among cultivars, NDF ranged from 55.12% (RO-2000-19) to 57.05% (RO-2000-16) (Table 2). The increase reflects higher cell wall content and reduced digestibility (Van Soest, 1994) ^[12].

6.6 Silica

Silica content increased significantly ($p < 0.01$) (Table 2), from 2.32% (Stage I) to 2.77% (Stage II). Among cultivars, silica ranged from 2.32% (RO-2000-19) to 2.70% (RO-2000-16).

7. Mineral composition

7.1 Calcium (Ca)

Calcium content differed significantly among cultivars and growth stages ($p < 0.01$) (Table 3). The mean Ca content was 0.085%, decreasing from 0.09% (Stage I) to 0.08% (Stage II). Highest Ca content was observed in Kent, while lowest in RO-2000-1, RO-2000-7 and RO-2000-12.

7.2 Phosphorus (P)

Phosphorus content also showed significant variation ($p < 0.01$) (Table 3), with mean value of 0.13%. Stage-wise values were 0.14% (Stage I) and 0.11% (Stage II). Among cultivars, highest P was recorded in Kent (0.17%), while lowest (~0.10%) in some cultivars.

Table 3: Mineral composition (%) of oat cultivars

Parameter	Stage I	Stage II	Mean	Significance
Calcium	0.09	0.08	0.085	**
Phosphorus	0.14	0.11	0.13	**

8. Nutritional ranking of oat cultivars

Table 4 delineates cultivar-wise nutritional stratification, clearly indicating RO-2000-19 as the superior genotype, characterized by highest crude protein and lowest silica content, reflecting enhanced nutritive value and digestibility potential. In contrast, RO-2000-16 exhibited maximum dry matter, crude fibre, and silica, signifying greater structural biomass but inferior feeding quality. Kent recorded the lowest crude fibre, while RO-2000-1 showed minimum lignin content, both favorable for digestibility. These findings underscore a distinct trade-off between forage quality and structural biomass, highlighting the importance of genotype selection based on nutritional objectives.

Table 4: Best and poorest cultivars (nutritional ranking)

Trait	Best cultivar	Value	Poor cultivar	Value
CP	RO-2000-19	Highest	RO-2000-2	Lowest
DM	RO-2000-16	Highest	RO-2000-1	Lowest
CF	Kent	Lowest	RO-2000-16	Highest
Lignin	RO-2000-1	Lowest	RO-2000-7/16	Highest
Silica	RO-2000-19	Lowest	RO-2000-16	Highest

9. Conclusion

The present investigation clearly demonstrated that growth stage exerts a predominant influence on the chemical composition and nutritive value of oat (*Avena sativa*) cultivars, with maturity-associated changes significantly altering forage quality. Advancement from 60 to 90 days after sowing resulted in a marked increase in structural carbohydrates (crude fibre, NDF, ADF, cellulose, lignin, and silica) accompanied by a concomitant decline in crude protein, ether extract, ash, and mineral content (Ca and P). These compositional shifts reflect progressive lignification and cell wall development, ultimately reducing the nutritive value of the forage.

Significant genotypic variation was also observed, indicating the potential for selection of superior cultivars. Among the tested entries, RO-2000-19 consistently exhibited superior nutritional attributes, characterized by higher crude protein and lower fibre and silica content, whereas RO-2000-16 showed greater dry matter accumulation but inferior quality due to elevated structural constituents.

Overall, the findings establish a clear trade-off between forage yield and nutritional quality, emphasizing that early harvesting (around 60 DAS) is optimal for maximizing nutritive value, while later stages favor biomass accumulation. Therefore, strategic selection of cultivar in conjunction with appropriate harvest timing is critical for optimizing forage utilization and enhancing livestock productivity.

References

1. Hanoğlu Oral H. Forage yields and nutritive values of oat and triticale pastures for grazing sheep in early spring. *PeerJ*. 2024;12:e17840. DOI:10.7717/peerj.17840.

2. Gaytán-Aleman L, Mendoza-Carreola J, Calderón-Leyva G, Arellano-Rodriguez F, Angel-García O, Contreras-Villarreal V, *et al*. Nutrient composition, digestibility, and intake of diets chosen by goats that grazed alfalfa and oat field residues. *J Appl Anim Res*. 2025;53(1):2486265.

3. Liu K, Mahmood K. Nutrient composition and protein

extractability of oat forage harvested at different maturity stages as compared to grain. *J Agric Sci*. 2015;7(12):50.

4. Singh S, Koli P, Ahmed S, Kumar N, Rana M, Singhal R, *et al*. Exploring the genetic variability in yield, nutritional and digestibility traits in oat grains through ruminant nutrition. *Heliyon*. 2024;10(10).

5. Coblenz WK, Walgenbach RP. Fall growth, nutritive value, and estimation of total digestible nutrients for cereal-grain forages in the north-central United States. *J Anim Sci*. 2010;88(1):383-399.

6. Duan L, Ju Z, Ma X, Pan J, Mustafa AEZM, Jia Z. Research on enhancing the yield and quality of oat forage: Optimization of nitrogen and organic fertilizer management strategies. *Agronomy*. 2024;14(7):1406.

7. AOAC. Official methods of analysis of the AOAC International. No. 994.12. 19th ed. Gaithersburg (MD): AOAC International; c2012. Chapter 4, p. 18-19.

8. Van Soest PJ, Jones LHP. Effect of silica in forages upon digestibility. *J Dairy Sci*. 1968;51(10):1644-1648.

9. Cherney JH, Marten GC. Small grain crop forage potential: II. Interrelationships among biological, chemical, morphological, and anatomical determinants of quality. *Crop Sci*. 1982;22(2):240-245.

10. Jung HG, Allen MS. Characteristics of plant cell walls affecting intake and digestibility of forages by ruminants. *J Anim Sci*. 1995;73(9):2774-2790.

11. Khorasani GR, Jedel PE, Helm JH, Kennelly JJ. Influence of stage of maturity on yield components and chemical composition of cereal grain silages. *Can J Anim Sci*. 1997;77(2):259-267.

12. Van Soest PJ. Nutritional ecology of the ruminant. Ithaca (NY): Cornell University Press; 1994.