Abanico Boletín Técnico. ISSN: 3061-8452.
https://abanicoacademico.com/abanicoboletintecnico/index
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Abanico Boletín Técnico. January-December, 2026; 5:1-6. Code: e2026-1.
Original Article. Received:10/01/2026. Accepted:16/02/2026. Published:26/02/2026.
https://doi.org/10.21929/abanicoboletin/2026.5

Nutritional value of oat (*Avena sativa*) forage with different fertilization treatments

Valor nutricional de forraje de avena (*Avena sativa*) con diferentes tratamientos de fertilización

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ABSTRACT

Oats (Avena sativa) is a grass cultivated as fodder for cattle feed. The objective of this work was to evaluate the nutritional value of turquoise oat forage variety with different fertilization treatments. Planting was carried out in the experimental field of the Tecnológico Nacional de México campus Valle del Guadiana in Ejido Villa Montemorelos, Durango in January 2021. Four fertilization treatments were evaluated: Control (without fertilization), Chemical, Tea of manure and NB Soil (commercial organic fertilizer). The ash content (CEN), crude protein (PC), ethereal extract (EE), crude fiber (FC), nitrogen-free extract (ELN), neutral detergent fiber (FDN), acid detergent fiber (FDA) and lignin (L). A completely randomized design with three repetitions and a comparison of means with Tukey's test (α=0.05) was used. Significant differences were found only for EE, PC and L between treatments. Both in the EE and in the PC the chemical treatment presented the highest values (3.86 % and 5.84 %, respectively) while for L the NB Soil treatment registered the highest value (12.48 %). The nutritional value of oat forage is not negatively affected by the application of unconventional fertilizers, and may be an option for its use in this type of crop.

Keywords: forage, nutritional value, organic fertilization, Turquoise.

RESUMEN

La avena (*Avena sativa*) es una gramínea cultivada como forraje para alimentación de ganado. El objetivo de este trabajo fue evaluar el valor nutricional del forraje de avena variedad Turquesa con diferentes tratamientos de fertilización. La siembra se llevó a cabo en el Tecnológico Nacional de México campus Valle del Guadiana en el Ejido Villa Montemorelos. Se evaluaron cuatros tratamientos de fertilización: Testigo

(sin fertilización), Químico, Té de estiércol y NB Soil. Se evaluó el contenido de cenizas (CEN), proteína cruda (PC), extracto etéreo (EE), fibra cruda (FC), extracto libre de nitrógeno (ELN), fibra detergente neutra (FDN), fibra detergente ácida (FDA) y lignina (L). Se utilizó un diseño completamente al azar con tres repeticiones y una comparación de medias con la prueba de Tukey (α=0.05). Se encontraron diferencias significativas para EE, PC y L entre tratamientos. Tanto en el EE (3.86 %) como en la PC (5.84 %) el químico presento los valores más altos, mientras que, para L, NB Soil registró el porcentaje más alto (12.48 %). El valor nutricional del forraje de avena no se ve afectado negativamente por la aplicación de fertilizantes no convencionales pudiendo ser una opción para su utilización en este tipo de cultivo.
Palabras clave: forraje, valor nutricional, fertilización orgánica, Turquesa.

INTRODUCTION

Oat (*Avena sativa*) is a grass species that can be cultivated during winter under irrigated conditions because it tolerates low temperatures during the vegetative growth stage (Zamora *et al*., 2002). It is widely used in the livestock industry, as a large proportion of its production is destined for forage consumption due to its high digestibility and the good quality of its fiber content (INFOAGRO, 2010). This crop is commonly produced under rainfed conditions on lands with low productive potential and is considered a strategic forage crop for the productive conversion of agricultural lands into livestock production systems.

The Turquesa oat variety was released by INIFAP in 2006 for both grain and forage production (Villaseñor-Mir *et al*., 2021) and has shown good performance in hay forage production (Villaseñor *et al*., 2009).

In 2022, a total production of 10,502,262.81 tons of forage oat was reported in Mexico, of which the state of Durango contributed 20.8%, ranking as the second largest producer of this crop (INFOSIAP, 2022). In oats, as in other crops, maximum forage yield and nutritional quality depend on the stage of plant maturity. During the vegetative stage, leaf accumulation is high; however, as the plant grows, the proportion of leaves decreases while the proportion of stems increases (Feyissa *et al*., 2007).

The use of alternatives such as organic fertilizers is necessary to meet crop nutritional requirements, achieve forage yields comparable to those obtained with conventional fertilizers, and produce high-quality crops (Tamayo *et al*., 2007). Therefore, the objective of this study was to evaluate the nutritional value of forage from the Turquesa oat variety under different chemical and organic fertilization treatments.

MATERIALS AND METHODS

The experiment was established in January 2021 at the experimental field of the Tecnologico Nacional de Mexico, Valle del Guadiana Campus, located in Ejido Villa

Montemorelos, Durango, Mexico (24°00′37.3″ N, 104°26′39.7″ W). The Turquesa oat (*Avena sativa* L.) variety was used as the plant material. The fertilization treatments evaluated in this study are described in Table 1.

Table 1. Fertilization treatments applied to the Turquesa variety of oat (*Avena sativa* L.).

Tratament	Dose
Control	Unfertilizer
Chemical fertilizer	3 L/ha
Manure tea	50 %
NB Soil	20%

Harvesting was performed at 147 DAS (days after sowing), and the treatments were applied at 47, 71, 103, and 134 DAS. At harvest, the samples were placed in paper bags and dried in a forced-air oven at 50 °C. Subsequently, the dried samples were ground using a Wiley® mill to a particle size of 1 mm. Samples from each treatment were stored in airtight bags until further analysis.

The analyses used to determine the nutritional value of oat forage included the evaluation of ash (ASH), crude protein (CP), ether extract (EE), crude fiber (CF), and nitrogen-free extract (NFE) contents, following the methods proposed by AOAC (1990). Additionally, fiber fraction analyses were conducted, including the determination of neutral detergent fiber (NDF), acid detergent fiber (ADF), and lignin, according to the protocol described by ANKOM (2005).

The data obtained were analyzed using a completely randomized design, and mean comparisons were performed using Tukey's test ($\alpha = 0.05$) with the Infostat statistical software package.

RESULTS AND DISCUSION

Statistical differences among treatments were observed for crude protein (CP), ether extract (EE), and lignin (L) contents (Table 2, $P < 0.05$), whereas no significant differences were detected for the remaining variables. Ash content ranged from 9.61 to 10.91%.

Crude protein content was highest in the chemical fertilizer treatment (5.84%), followed by the manure tea treatment (4.36%). Similarly, ether extract content was greatest in the chemical fertilizer treatment (3.86%) and lowest in the manure tea treatment.

Crude fiber content ranged from 26.79 to 28.56%, while nitrogen-free extract (NFE) varied from 50.83 to 57.41%. Neutral detergent fiber (NDF) ranged from 53.66 to 71.45%, and acid detergent fiber (ADF) ranged from 32.16 to 43.80%.

Regarding lignin content, the highest percentage was observed in the NB Soil treatment (12.48%), whereas the control treatment showed a lignin content of 6.38% (Table 3, $P < 0.05$).

Table 2. Mean squares obtained from the analysis of variance of forage from the Turquesa oat (*Avena sativa* L.) variety subjected to different organic fertilization treatments

	Variation source			
	Treatament	Error	C.V.	P
Degrees of freedom	3	8		
Ash	1.03	1.24	10.71	0.5145
Crude protein	7.79	0.36	13.46	0.0093
Ether extract	2.41	0.12	13.17	0.0005
Crude fiber	2.03	4.07	7.36	0.6940
Nitrogen-free extract	25.37	6.61	4.67	0.0569
Neutro fiber detergent	219.95	183.54	20.42	0.3705
Acid fiber detergent	91.36	74.21	21.45	0.3602
Lignin	32.11	0.71	11.10	<0.0001

C.V.=coefficient of variation

Table 3. Chemical composition of Turquesa oat (*Avena sativa* L.) forage under different organic fertilization treatments

Nutrient	Treatement			
	Control	Chemical	Manure tea	NB Soil
Ash	10.31	10.91	9.61	10.76
Crude protein	3.78^{b}	5.84^{a}	4.36^{ab}	3.82^{b}
Ether extract	2.26^{bc}	3.86^{a}	1.78^{c}	2.82^{b}
Crude fiber	27.43	28.56	26.84	26.79
Nitrogen-free extract	56.23	50.83	57.41	55.80
NDF	53.66	68.59	71.44	71.45
ADF	32.16	41.04	43.80	43.68
Lignin	6.38^{a}	5.80^{b}	5.71^{b}	12.48^{a}

NDF=neutro detergent fiber; FDA=acid detergent acid. $^{a\text{-}c}$Means within the same row with different lowercase letters differ significantly ($P < 0.05$).

The Turquesa variety reaches physiological maturity at 105 DAS (days after sowing) during the autumn–winter growing cycle (Villaseñor *et al.*, 2009). In the present study, however, the same variety reached physiological maturity at 147 DAS. This difference may be attributed to the growing season under which the crop was maintained, as well as climatic, edaphic, and agronomic management factors. Ramírez-Ordoñes *et al.*, (2013) reported values of 67.5% for neutral detergent fiber (NDF), 40.3% for acid detergent fiber (ADF), and 4.2% for lignin (L) at physiological maturity (92 DAS) in early-maturing oat varieties. These values were higher than those observed in the present study.

High-quality forage should contain no more than 52% neutral detergent fiber (NDF) and 32% acid detergent fiber (ADF) (Van-Soest, 1965). These values tend to increase as plant maturity advances (Aganga, 2004) therefore, the high percentages observed in the present study can be attributed to the advanced maturity stage of the forage at harvest.

CONCLUSIONS

The application of non-conventional fertilizers did not adversely affect the nutritional value of oat forage, suggesting their potential as an alternative fertilization strategy for this crop. Nevertheless, the advanced maturity stage at harvest resulted in reduced forage quality, characterized by low crude protein content and elevated NDF and ADF concentrations, indicating limited nutritional value for animal feeding.

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