Scientific Paper

Forage production and nutritional composition of four varieties of *Avena sativa* L. in Ubaté, Cundinamarca, Colombia

René Adolfo González-Uribe[1] https://orcid.org/0000-0003-4958-7810, Aurora Cuesta-Peralta[2] https://orcid.org/0000-0001-6088-7000, Teresa Carvajal-Salcedo[2] https://orcid.org/0000-0002-8740-7764 and Tomás Fernando Gracia-Díaz[1] https://orcid.org/0000-0003-4574-0064

[1]*Facultad de Ciencias Agropecuarias, Universidad de Cundinamarca, Sede Ubaté UDEC.* [2]*Facultad de Ciencias Agropecuarias, Universidad de Ciencias Aplicadas y Ambientales, Bogotá UDCA. E-mail:* radolfogonzalez@ucundinamarca.edu.co, acuesta@udca.edu.co, tcarvaja@udca.edu.co, tgracia@ucundinamarca.edu.co

Abstract

Objective: To evaluate the forage performance and chemical composition of four varieties of *Avena sativa* L. in Ubaté, Cundinamarca, Colombia.

Materials and Methods: The essay was conducted in the Agro-Environmental Unit El Tíbar, of the University of Cundinamarca, located on the Palo Gordo district, Colombia. The experiment was conducted through a randomized block design. Each block corresponded to two periods of planting moments (October-November and April-May). The treatments corresponded to four *A. sativa* varieties: cayuse, konan, everleaf and suprema. The experimental units had plots of 4 m^2. Plant height was measured and cutting was done with a frame of 1 x 1 m to determine forage production. Samples were taken to measure quality by a chemical-nutritional analysis.

Results: The average value of plant height at the moment of cutting was 167 cm, with significant differences ($p < 0,05$) among varieties. The variety cayuse stood out, with 175 cm, which was the tallest. No significant differences were shown regarding the biomass production, whose average was 31,5 ± 7,26 t/ha. With regards to the chemical composition, dry matter showed significant differences ($p < 0,05$), with the highest values for the variety everleaf in both planting seasons, with an average of 24,6 %. Crude energy reached an average of 4 208 kcal/kg, with the highest values ($p < 0,05$) in the variety suprema. The dry matter digestibility at 48 h averaged 54,87 %, without significant differences among the four *A. sativa* varieties. The same occurred for the degraded protein in the rumen (average of 94,5 %) and degradability of the neutral detergent fiber (53,8 %).

Conclusions: The planting season did not influence biomass production or the nutritional composition of the different evaluated oat varieties, which obtained similar results.

Keywords: biomass, nutritional value, milk production

Introduction

In the Ubaté province, dairy capital of Colombia, milk producers are economically affected in the summer season, due to the low feed availability for cattle and the subsequent decrease of milk production. Under those edaphoclimatic conditions (high tropic), forages have higher nutrient quantity than those that can be found in forages of the low tropic. Nevertheless, they show decreased energy content, for which it is necessary to supplement cows under production. For such purpose, nutritionists promote and socialize feeding alternatives, such as the use of silages, haylages, nutritional blocks, compensatory forage areas, among others. *Avena sativa* L. is one of the plant materials most widely used as forage. Farmers consider it one of the main options for feeding in the animal husbandry sector (Rodríguez-Herrera *et al*., 2020). It is characterized by its high forage and grain production, high dry matter digestibility (66,5 %) and high energy quality (NLE 1,33 Mcal/kg). The grain has very good protein quality; while carbohydrates are of high digestibility, due to the presence of ß-glucans (FEDNA, 2016). Additionally, it has good levels of unsaturated fatty acids, minerals, vitamins and arabinoxylan (Can *et al*., 2018; Rodríguez-Herrera *et al*., 2020).

In spite of being a forage material highly utilized in the zone, data about its biomass production or about the nutritional quality of the different *A. sativa* varieties that are commercialized in the region, are scarce. Only the information that appears in the labels of the seeds bags, indicating the trademark, type of treatment and unit weight, is available. This information is often far from the reports in literature in other regions or in other countries. Considering that in the region of Villa de San Diego de Ubaté the forage production and the nutritional characteristics of some varieties of forage *A. sativa*,

Received: June 23, 2021
Accepted: September 30, 2021

How to cite a paper: González-Uribe René Adolfo; Cuesta-Peralta, Aurora; Carvajal-Salcedo, Teresa & Gracia-Díaz, Tomás Fernando. Forage production and nutritional composition of four varieties of *Avena sativa* L. in Ubaté, Cundinamarca, Colombia. *Pastos y Forrajes*. 44:eI28, 2021.

used to feed the cattle aimed at milk production, are unknown, the objective of this study was to evaluate the quantity of biomass produced by each of the *A. sativa* varieties and determine their nutritional quality in two periods corresponding to planting moments.

Materials and Methods

Location of the study. The essay was conducted in the Agro-Environmental Unit El Tíbar, of the University of Cundinamarca, located in the Palo Gordo district, Novilleros Farm, of the Villa de San Diego de Ubaté Cundinamarca municipality. This facility is at an altitude of 2 566 m.a.s.l., with average temperature of 14 ºC and annual rainfall of 1 100 mm, distributed in two rainy seasons: mid-April (220 mm) and mid-October (180 mm).

Treatments. Four *A. sativa* varieties, available and utilized in the region, were used: *konan, cayuse, everleaf* and *suprema*. The evaluation was established in the two different rainy seasons. The first planting was carried out in the season of lower rainfall (October, 2018) and the second one, in the season of most abundant rains (April, 2019), in order to establish the contrast between both rainy seasons. The experiment was established through a complete randomized block design. The blocks represented each one of the planting moments and the treatments corresponded to each of the *A. sativa* varieties. The experimental units had 4-m^2 plots and each treatment had four repetitions. Inside the land, the plots were separated by a one-meter strip. For the two planting processes minimum tillage was carried out. In each plot 28,0 g of seed were deposited, the equivalent to 70 kg/ha, according to the recommendation of the trading house.

The cutting of the material to determine forage production was done when the grain of each one of the varieties reached the milky state (133 days for konan and cayuse and 156 for everleaf and suprema). It was done with the aid of a scythe, at 10 cm from the soil, within a metallic square of 1,0 x 1,0 m, located in the central part of each plot, in order to prevent the edge effect. After cutting the forage, each sample was weighed to determine the forage production. From each plot a 1-kg sample was taken, which was labeled and sent to the laboratory for its nutritional evaluation.

Chemical nutritional analysis. The nutritional characterization was performed in the Animal Nutrition Laboratory, ascribed to the School of Agricultural Sciences of the University of Applied and Environmental Sciences (UDCA, for its initials in Spanish). The variables dry matter (DM), total protein (TP), ethereal extract (EE), ash (A), neutral detergent fiber (NDF), acid detergent fiber (ADF), organic matter (OM), were evaluated, all according to AOAC (2016) methodology. The crude energy (CE) was determined through a calorimeter. The *in vitro* DM digestibility (IVDMD), total protein digestibility (Dig TP) and NDF digestibility (Dig NDF) were determined according to the method proposed by Tilley and Terry (1963) and Mehrez and Orskov (1977).

Statistical analysis. The data, in field as well as in the laboratory, were analyzed through the GLM procedure of SAS, in a complete randomized block design. The blocks represented the two planting moments (April and October) and the treatments, the four *A. sativa* varieties. Each variety had four repetitions. The averages were analyzed with Tukey's multiple comparison test, for a significance level of 5 %. The program *Statistical Analysis System* (SAS) was used.

Results and Discussion

Agronomic variables. The variable plant height at the moment of harvest (table 1) showed statistical differences among treatments ($p < 0,05$). The average value of all the varieties was 167 ± 8,2 cm, lower than that obtained by the variety cayuse, which reached an average height of 175,2 cm. Meanwhile, the lowest height was reached by the variety suprema (156 cm). These results of height are higher than those obtained by Can *et al.* (2018) and Campuzano (2018).

Biomass production (table 1) in the two evaluation periods did not show significant differences among treatments ($p > 0,05$), although the highest numeric value was obtained by the variety cayuse with 36,2 t/ha, and the lowest one by suprema with 28,8 t/ha. The general average was 31,5 ± 7,263 t/ha. These values are higher than those reported by Mamani-Paredes and Cotacallapa-Gutiérrez (2018), in whose studies the results did not exceed 23,0 ± 3,861 t/ha.

Nutritional quality. The results of the chemical nutritional analysis of the different oat varieties at the two planting moments are shown in table 2.

The DM showed statistical differences ($p < 0,05$) among the different varieties, with the lowest values for cayuse in October and for konan, in April. The variety everleaf showed the highest DM percentages in both seasons, for which it differed from the others.

When relating the average green forage yield of all the varieties with the obtained DM, it is inferred

Table 1. Height and biomass production of four forage *A. sativa* varieties

Planting moment	Variety	Height, cm	Biomass, t/ha
October	Konan	171,3^{ab}	30,0
	Cayuse	180,3^{a}	42,5
	Everleaf	160,1^{ab}	35,0
	Suprema	150,8^{b}	27,5
April	Konan	160,6^{ab}	28,2
	Cayuse	170,0^{a}	29,9
	Everleaf	167,6^{ab}	28,8
	Suprema	174,5^{b}	30,1
P - value		<0,0357	0,1766
SE ±		8,701	0,726

Numeric values with different letter in a column are statistically significant according to Tukey ($p < 0,05$).
SE: Standard error

Table 2. Chemical nutritional composition of four *A. sativa* varieties (dry basis).

Planting moment	Variety	DM, %	TP, %	EE; %	A, %	OM, %
October	Konan	21,7^{a}	7,6	2,8^{a}	9,0^{ab}	90,9
	Cayuse	19,5^{a}	7,1	2,7^{a}	9,6^{ab}	90,3
	Everleaf	26,2^{b}	7,6	2,7^{a}	10,8^{a}	89,1
	Suprema	22,4^{a}	7,1	1,4^{b}	9,3^{b}	90,6
April	Konan	19,2^{a}	11,1	2,5^{a}	9,2^{ab}	90,7
	Cayuse	21,8^{a}	11,3	2,4^{a}	8,2^{ab}	91,7
	Everleaf	40,8^{b}	8,5	2,8^{a}	8,4^{a}	91,5
	Suprema	23,3^{a}	10,8	1,7^{b}	6,8^{b}	93,1
P - value		<0,0001	0,2529	<0,0024	0,0635	0,063
SE ±		4,436	0,930	0,316	0,682	0,682

DM: dry matter, TP: total protein, EE: ethereal extract, A: ash, OM: organic matter
Numeric values with different letter in a column are statistically significant according to Tukey ($p < 0,05$).
SE: Standard error

that it is possible to obtain an average DM yield of 7,7 t/ha, higher in 19,9 % than the one reported as average yield for forage oat in the region (Mamani-Paredes and Cotacallapa-Gutiérrez, 2018). It is also a higher yield than the one recorded by Ramírez-Ordóñes *et al.* (2013) and Salmerón *et al.* (2003), which was 4 475 and 5 000 kg DM/ha, respectively. The average DM value of 24,6 % of all the studied oat varieties was over the 22,5 % reported by FEDNA (2016). Even the variety everleaf showed as average 34,3 % of DM.

The total protein values fluctuated between 7,1 and 11,3 %, with an average of 8,9 ± 0,93 %, without existing significant differences among the different oat varieties. Nevertheless, the values obtained in the April period were slightly higher than those recorded in the plants that were sown in August. The average value was over 8,67 % reported by Mamani-Paredes and Cotacallapa-Gutiérrez (2018), but it was much lower than the 13,0 % obtained by Aseeva *et al.* (2019), as well as the 16,0 % referred by Can *et al.* (2018), and than the protein value of 14,4 % found by Pereira *et al.* (2020).

The ethereal extract showed significant differences ($p < 0,05$), with the lowest value in the variety suprema (1,76 % in the April period and 1,48 in October). The other varieties did not differ among them, and the average value was 2,36 ± 0,31 %. These EE values are lower than the 4,1 % reported by FEDNA (2019). Regarding ash, which indicates

the content of total minerals of the forage, significant differences were recorded ($p < 0,05$) in the planting periods as well as among the varieties. An average of 8,9 % was obtained, higher than the 8,31 % reported by Pereira *et al*. (2020), but lower than the 9,58 % reported by FEDNA (2016). Between the periods it was observed that, in the one with higher water quantity, there was lower ash quantity. The organic matter, important element to generate nutrients, showed significant differences ($p < 0,05$) among varieties and planting season, with an average of 91,1 %.

Table 3 shows that the NDF, like ADF and in general, the cell contents of the different oat varieties did not show significant differences. The NDF, important indicator to predict forage quality, oscillated between 63,3 and 68,8 %, slightly higher values than 60,0 %, recommended limit for this structural fraction not to interfere in the digestibility and intake of the forage material. Both values are higher than the 63,0 % reported by Pereira *et al*. (2020) and the 60,6 % by FEDNA (2016). Regarding ADF, the average value of 38,3 % is higher than the 34,3 % recorded by Pereira *et al*. (2020) and the 24,5 % by Castro-Rincón *et al.* (2020), but lower than the 41,3 % informed by FEDNA (2016).

The percentage of non-structural carbohydrates (NSC=CC-A-TP-EE), which are of fast utilization and are formed in the leaves, are lodged at the beginning in the stems and, finally, are housed in the leaves, where they are accumulated as starch (Fernández-Mayer, 2007), did not show significant differences among the different varieties or between planting seasons. This variable had an average of 14,1 %, much lower than the 30,8 % reported by Mamani-Paredes and Cotacallapa-Gutiérrez (2018).

The crude energy (CE) content, evaluated to establish which variety could offer more consumed energy to the animal, and which would be related to higher production efficiency, showed significant differences ($p < 0,05$). The varieties cayuse and suprema showed the best caloric contents in both planting seasons. The general average was 4 208 kcal/kg, suprema oat being the one that showed the highest average CE, with 4,306 kcal/kg, which indicates that it would supply 2,3 % more energy, when the animal consumed that variety. This value surpasses the report by ICBF (2018). For FEDNA (2016), oat is the cereal that shows the lowest energy value of all cereals.

Regarding the regularity of digestibility (ruminal disappearance) of DM in time, significant differences ($p < 0,05$) were found among varieties and in the studied rainy seasons until 24 h. it was slightly higher in the period of higher rainfall (table 4).

The solubility rate (T0) or soluble fraction of DM showed the highest values in the variety everleaf, without differing from cayuse, which in turn did not differ from the others. The average values of the two seasons for these two varieties were 33,9 and 32,8 %, respectively. The lowest values were obtained by the variety konan, with 28,1 % as average. At 24 h, significant differences also appeared ($p < 0,05$). Again the everleaf oat showed the highest degradability with 57,8 %. In general, 54,9 % of digestibility was achieved, which can be considered good. At 48 h no significant differences were shown ($p > 0,05$) among the four oat varieties, which indicates that in this time the stabilization of DM digestibility in the different varieties is achieved.

Table 3. Cell wall and crude energy of four forage *A. sativa* varieties (dry basis).

Planting moment	Variety	%				CE kcal/kg
		NDF	ADF	CC	NSC	
October	Konan	65,5	38,2	34,4	15,1	4109[b]
	Cayuse	68,7	41,6	31,2	11,7	4143[ab]
	Everleaf	67,5	41,2	32,4	11,2	4107[b]
	Suprema	67,3	40,1	32,6	14,7	4214[a]
April	Konan	65,4	38,3	34,5	16,6	4191[b]
	Cayuse	65,3	36,5	34,6	12,6	4260[ab]
	Everleaf	63,1	35,6	36,8	17,1	4241[b]
	Suprema	65,3	34,9	34,6	15,1	4398[a]
P - value		0,2744	0,5704	0,3214	0,4268	0,0065
SE ±		1,297	1,545	0,77	0,98	50,119

NDF: neutral detergent fiber, ADF: acid detergent fiber, CC: cell content (CC: 100 –NDF). NSC: CC- A-TP-EE, CE: crude energy
Numeric values with different letter in a column are statistically significant, according to Tukey ($p < 0,05$).
SE: Standard error

Table 4. Digestibility of dry matter, total protein and neutral detergent fiber of four forage *A. sativa* varieties, dry basis.

Planting moment	Variety	% DMDIG			% DIGT-TP	% DIGT-NDF
		SOL-R	24 h	48 h		
October	Konan	25,7^{c}	50,8^{b}	65,0	93,6	48,8
	Cayuse	31,8^{ab}	53,1^{ab}	66,1	94,5	51,6
	Everleaf	31,7^{a}	54^{a}	63,2	93,1	50,2
	Suprema	30,2^{bc}	49,1^{b}	64,0	94,3	50,3
April	Konan	30,2^{c}	55,0^{b}	69,1	95,6	55,7
	Cayuse	33,7^{ab}	57,0^{ab}	68,2	95,1	56,0
	Everleaf	35,99^{a}	61,6^{a}	71,2	93,9	59,4
	Suprema	30,4^{bc}	58,2^{b}	70,0	95,8	57,6
P - value		<0,0005	<0,0064	0,9975	0,1249	0,1039
SE ±		1,358	1,560	1,527	0,901	1,284

SOL-R: solubility rate, DMDIG: dry matter digestibility, Digt-TP: total protein digestibility, Digt-NDF: neutral detergent fiber digestibility
Numeric values with different letter in a column are statistically significant, according to Tukey ($p < 0,05$).
SE: Standard error

The digestible protein in rumen did not show significant differences between seasons or among varieties, because at 48 h there was general stabilization of this indicator, which coincides with the report by Contreras *et al.* (2019). An average of 94,53 % was observed, which is considered high, because only 5,47 % would be the quantity considered as bypass protein towards the lower parts of the digestive tract, which is directly utilized by the host animal. The bypass protein, although not looking for microbial growth, offers a direct supply of amino acids to the mammary gland, as source for the lactic proteins (Marin and Gallo, 2021). In addition, in the rumen non-protein nitrogen and diet protein can be found, which are fast degraded to form NH_3, which is used by rumen microorganisms for the synthesis of cell protein (Chalupa, 1982).Oat is distinguished from other cereals for its lower proportion of prolamins (10-16 %) and glutelins (5 5) and high concentrations of globulins, for which their solubility and digestibility at rumen level is very high (FEDNA, 2016).

The NDF degradability did not show significant differences among varieties either or between planting periods. The average value was 53,76 %, which is considered normal for a species that is harvested after 90 days (Oba and Allen, 1999). This acceptable digestibility of NDF propitiates higher DM intakes in dairy cows and, thus, higher milk production.

Conclusions

The results prove that in the Ubaté region it is possible to plant the different oat varieties in any rainy season of the year, because practically no differences were recorded in forage production or in the nutritional composition of these varieties. Nevertheless, the results of the variety cayuse, when it is planted in the season of lower rainfall, could favor it, regarding its acceptance by farmers.

Concerning protein digestibility, all the varieties showed very high values. The same occurred with the energy value of all the varieties, which turns them into an alternative for supplementation in high-producing cows.

Acknowledgements

The authors thank the management boards of the University of Cundinamarca and the University of Applied and Environmental Sciences, who allowed to make the agreement and thus execute the project «Forage production and nutritional quality of four *A. sativa* varieties in the Experimental Farm El Tíbar. Ubaté Cundinamarca». Thanks are expressed to Miss Daniela Isabela Molina Sierra for her collaboration in the data collection in field.

Conflicts of interests

The authors declare that there is no conflict of interests among them.

Authors' contribution

- René Adolfo-González U. Conception and design of the research, field work, data analysis and interpretation, paper writing and revision.
- Aurora Cuesta-Peralta. Conception and design of the research, sample analysis in the laboratory, data interpretation, paper writing and revision.
- Teresa Carvajal-Salcedo. Conception and design of the research, sample analysis in the laboratory, data analysis and interpretation, paper writing and revision.

- Tomás Fernando-Gracia. Conception and design of the research, field work, data analysis and interpretation, paper writing and revision.

Bibliographic references

AOAC International. *Official methods of analysis of the AOAC*. (G. W. Latimer, ed.). Gaithersburg, USA: Association of Official Agricultural Chemists, 2016.

Aseeva, Tatyana; Trifuntova, Irina & Tolochko, E. Features of the influence of climatic factors on the crop and quality of grain of spring oats. *Book of abstract X International Scientific Agricultural Symposium "Agrosym 2019"*. Jahorina, Bosnia and Hezergovina: University of East Sarajevo. p. 209. https://lemos.pro.br/wp-content/uploads/2019/11/AGROSYM-2019-BOSNIA-BOOK-OF-ABSTRACTS-2019.pdf. 2019.

Campuzano, L. F.; Castro-Rincón, E.; Castillo-Sierra, J.; Torres-Cuesta, D.; Cuesta-Muñoz, P. A.; Portillo-López, Paola A. *et al. Avena forrajera altoandina: nueva variedad de avena forrajera para el trópico alto colombiano. Cartilla divulgativa*. Colombia: AGROSAVIA. https://repository.agrosavia.co/bitstream/handle/20.500.12324/35561/Ver_documento_35561.pdf?sequence=4&isAllowed=y, 2018.

Can, M.; Bayram, C.; Ayan, I.; Acar, Z. & Mut, Z. Determination of the nitrogen doses effects on grain yield and yield components of some oat genotypes. *Book of Proceedings IX International Agricultural Symposium "Agrosym 2018"*. Jahorina, Bosnia and Hezergovina: University of East Sarajevo. p. 570-574. http://agrosym.ues.rs.ba/article/showpdf/BOOK_OF_PROCEEDINGS_2018_FINAL.pdf, 2018.

Castro-Rincón, E.; Cardona-Iglesias, J. L.; Hernández-Oviedo, F. & Valenzuela-Chiran, M. Effect of the silage from *Avena sativa* L. on the productivity of grazing lactating cows. *Pastos y Forrajes*. 43 (2):140-147. http://scielo.sld.cu/pdf/pyf/v43n2/en_2078-8452-pyf-43-02-150.pdf, 2020.

Chalupa, W. Protein nutrition of dairy cattle. *Proc. Dist. Feed Conf.* Cincinnatti, USA. p. 101, 1982.

Contreras, J. L.; Pariona, J.; Cordero, A.; Jurado, M. & Huamán, R. Degradabilidad ruminal de forrajes y alimentos concentrados y estimación del consumo. *Rev. investig. vet. Perú*. 30 (4):1481-1493, 2019. DOI: https://dx.doi.org/10.15381/rivep.v30i4.17189.

FEDNA. *Avena*. Madrid: Fundación Española para el Desarrollo de la Nutrición Animal. http://www.fundacionfedna.org/ingredientes_para_piensos/avena. [16/11/2016], 2016.

FEDNA. *Tablas FEDNA de composición y valor nutritivo de alimentos para la fabricación de piensos compuestos*. Madrid: Fundación Española para el Desarrollo de la Nutrición Animal. http://www.fundacionfedna.org/tablas-fedna-composicion-alimentos-valor-nutritivo. [11/11/2019], 2019.

Fernández-Mayer, A. *El efecto de los azúcares solubles sobre la ganancia de peso y su relación con el manejo de los verdeos de invierno*. Buenos Aires: INTA, Estación Agropecuaria Bordenave. https://inta.gob.ar/sites/default/files/script-tmp-23__ganaderia_ganancia_peso.pdf. [23/02/2020], 2007.

ICBF. *Tabla de composición de alimentos colombianos (TCAC) 2018*. Bogotá: Instituto Colombiano de Bienestar Familiar. https://www.icbf.gov.co/system/files/tcac_web.pdf. 2018.

Mamani-Paredes, J. & Cotacallapa-Gutiérrez, F. H. Rendimiento y calidad nutricional de avena forrajera en la región de Puno. *Rev. investig. Altoandin*. 20 (4):385-400, 2018. DOI: http://dx.doi.org/10.18271/ria.2018.415.

Marin, J. & Gallo, J. Evaluación de los tenores de grasa y proteína en la leche. En: M. Olivera-Angel y K. Vargas, eds. *La lactancia vista desde múltiples enfoques. Segunda parte: métodos, interpretación de resultados y costos de producción de leche*. Medellín, Colombia: Universidad de Antioquía. p. 69-77. https://revistas.udea.edu.co/index.php/biogenesis/article/view/345367/20804890, 2021.

Mehrez, A. & Ørskov, E. A study of artificial fibre bag technique for determining the dig estibility of feeds in the rumen. *J. Agric. Sci*. 88 (3):645-650, 1977. DOI: https://doi.org/10.1017/S0021859600037321.

Oba, M. & Allen, M. S. Evaluation and the importance of the digestibility of neutral detergent fiber from forage. Effects on dry matter intake and milk yield in dairy cows. *J. Dairy Sci*. 82 (3):589-596. https://www.journalofdairyscience.org/article/S0022-0302(99)75271-9/pdf, 1999.

Pereira, Fabiellen C.; Machado, L. C. P.; Kazama, Daniele C. da S. & Guimarães, R. Black oat grown with common vetch improves the chemical composition and degradability rate of forage. *Acta Sci.-Anim. Sci*. 42:e49951, 2020. DOI: https://doi.org/10.4025/actascianimsci.v42i1.49951.

Ramírez-Ordóñes, S.; Domínguez-Díaz, D.; Salmerón-Zamora, J. J.; Villalobos-Villalobos, G. & Ortega-Gutiérrez, J. A. Producción y calidad del forraje de variedades de avena en función del sistema de siembra y de la etapa de madurez al corte. *Rev. fitotec. mex*. 36 (4):395-403. http://www.scielo.org.mx/pdf/rfm/v36n4/v36n4a5.pdf, 2013.

Rodríguez-Herrera, S. A.; Salgado-Ramírez, O.; García-Rodríguez, J. G.; Cervantes-Ortiz, F.; Figueroa-Rivera, María G. & Mendoza-Elos, M. Fertilización química y orgánica en avena: rendimiento y calidad de la semilla. *Agron. Mesoam.* 31 (3):567-579, 2020. DOI: https://doi.org/10.15517/am.v31i3.39184.

Salmerón, Z. J. J.; Meda, F. J. & Bárcena, J. R. *Variedades de avena y calidad nutricional del forraje*. Chihuahua, México: CESICH, CIRNOC, INIFAP, SAGARPA. Folleto Técnico No. 17, 2003.

Tilley, J. M. A. & Terry, R. A. A two-stage technique for the *in vitro* digestion of forage crops. *Grass Forage Sci*. 18 (2):104-111, 1963. DOI: https://doi.org/10.1111/j.1365-2494.1963.tb00335.x.