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Research Article

Yield and Nutritional Value of Oats Associated With Vicia in High Andean Conditions of Puno, Peru

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Abstract: The objective of the study was to determine the yield (Kg/ha) and nutritional value of the associated cultivation of oats (Avena sativa) and vicia (Vicia sativa) using different varieties and sowing proportions in high Andean conditions in the Puno region. Three oat varieties were selected: Tayko, Africana and Vilcanota I, and were sown in association with vicia in two proportions: 80-20 and 70-30 kg/ha, respectively. For the experimental design, a Completely Randomized Block Design (CRBD) with a 3x2 factorial arrangement was used, which allowed the evaluation of the combinations of varieties and sowing proportions. The main findings of the study showed that dry matter yield was very similar among the three oat varieties, with values of 15.57, 15.81 and 15.88 tn/ha for Tayko, Africana and Vilcanota I, respectively. In terms of crude protein, the three varieties also showed similar results with values of 10.4%, 10.3% and 10.1%, respectively. However, metabolizable energy varied significantly among varieties: Tayko presented 10.1 MJ/kg, Africana 9.6 MJ/kg and Vilcanota I 9.4 MJ/kg. In addition, statistically significant differences were observed in neutral detergent fiber and in vitro digestibility of organic matter, although exact values are not specified in the available summary. These differences suggest that, although the varieties evaluated have similar yield and protein content, the quality of available energy and digestibility may vary considerably. In conclusion, the study highlights that the three oat varieties evaluated in combination with vicia have similar yield and nutritional value in terms of dry matter and crude protein. However, differences in metabolizable energy and other nutritional parameters, such as fiber and digestibility, underline the importance of selecting the appropriate variety according to the specific production and nutritional needs in the high Andean region of Puno.

Keywords: Yield, Nutritional Value, Oats Sativa, Vicia Sativa

Introduction

Climate change is an inescapable reality that is exerting significant pressure on agricultural systems, particularly in communities that depend on pasture production for livestock feed (Herzog *et al.*, 2012; Suarez Rivadeneira *et al.*, 2025). Studies indicate that forage availability will decrease due to the increase in extreme weather events, which threatens the sustainability of these communities. In this context, (Flores Nájera *et al.*, 2016), suggest that the capacity of ecosystems to produce forage is decreasing, and propose intercropping as a viable alternative to face this challenge.

Intercropping, specifically oats (Avena sativa) with vicia (Vicia sativa), is a promising strategy to improve forage production. This technique not only increases forage quantity and quality, but also improves nutrient supply, palatability and digestibility. Oats provide energy, while vicia provides protein, which creates an ideal nutritional combination for cattle (Enciso Altamirano *et al.*, 2019). Studies conducted in high Andean regions, where these crops can be established between 3000 and 4000 masl, have shown considerable yields in terms of dry matter and nutritional value (Desalegn & Hassen, 2015). Dry matter yields of the associated oat and vetch crop under high Andean conditions vary according to the phenotype and the specific oat variety used. For example, varieties such as Mantaro 15 and Centenario have shown yields of 12.77 and 15.83 tons per hectare, respectively (Enciso Altamirano *et al.*, 2019). Other studies report yields ranging from 15.17 to 16.5 tons per hectare (Espinoza-Montes *et al.*, 2018; Flores Nájera *et al.*, 2016). In terms of nutritional value, forage protein can range from 7.9% to 11.9%, while neutral detergent fiber and in vitro digestibility of organic matter present ranges from 40.2% to 46.3% and 61.5% to 63.0%, respectively (Dear *et al.*, 2005; Lithourgidis *et al.*, 2006). The metabolizable energy of forage also shows significant variations, ranging from 8.9 MJ/kg to 9.7 MJ/kg (Salcedo Díaz, 1998). Oat forage associated with vicia is used as a feed supplement during the dry season in the high Andean regions, being exploited both as green forage and as hay and silage (Espinoza-Montes *et al.*, 2018). The main objective of this study is to determine the yield (Kg/ha) and the nutritional value of the crop in association of oats and vicia, using different varieties and sowing proportions in high Andean conditions in the department of Puno. It is hypothesized that the association of oats and vicia will not only improve forage yield, but also optimize its nutritional value, offering a sustainable solution for livestock communities affected by climate change.

Materials and Methods

Yield and Nutritional Value of Oats Associated With Vetch

The present experiment was conducted the period December 2016 to May 2017 at the Illpa Experimental unit of the National Institute for Agrarian Innovation (INIA), Puno Province, Puno Department (Altamirano *et al.*, 2024) (Figure 1).

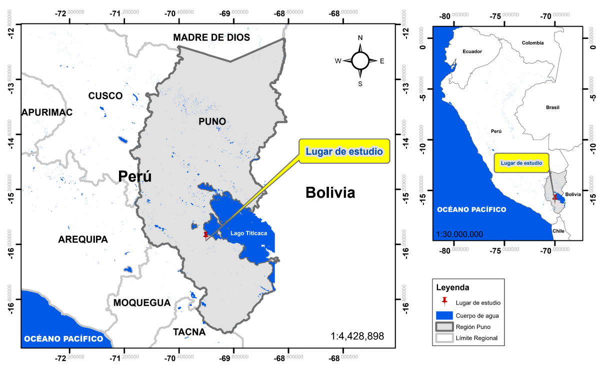

Fig. 1: Geographical location of the study site

The experimental unit consists of 2.0 ha and is located at 3813 masl, with an average temperature of 88 °C and total annual precipitation of 4519 mm/year The treatments were established as follows (Table 1).

Table 1: Description of treatments (Seeds, Kg/ha)

Tto: Association	Cultivation C1	Cultivation C2	Ratio: C1/C2 (kg/ha)
1	*Avena sativa* var. Tayko	*Vicia sativa*	80/20
2	*Avena sativa* var. Africana	*Vicia sativa*	80/20
3	*Avena sativa* var. Vilcanota I	*Vicia sativa*	80/20
4	*Avena sativa* var. Tayko	*Vicia sativa*	70/30
5	*Avena sativa* var. Africana	*Vicia sativa*	70/30
6	*Avena sativa* var. Vilcanota I	*Vicia sativa*	70/30

Installation and Crop Management

Soil

The relief of the soil was flat, 30 experimental plots were installed, in which 3 pits were made (30 cm deep) for sampling, then a representative sample was collected, labeled and sent to the Soil Analysis Laboratory of the National Agrarian University of La Molina. Soil characterization included electrical conductivity, carbonate, pH, Cation Exchange Capacity (CEC), % Organic Matter (OM), Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg) and Aluminum (Al).

Land preparation consisted of using a harrow (16 discs) pulled by tractor, the plots (30) were designed in such a way that each one had 600 m2. Planting was done using the broadcasting technique, then two manual weeding were applied, the fertilization formula was 60-60-0 for N, P and K respectively, based on soil analysis.

Agronomic Characteristics

Agronomic characteristics were evaluated by seed germination percentage, leaf area, number of leaves per plant and plant height. Harvesting was carried out in phenological event at 50% flowering and 50% milk grain.

Seed Germination

The evaluation of seed germination (%) was carried out in vitro 21 days after the start of the test at the Grassland Laboratory of the Illpa-Puno experimental station. The method consisted of placing 100 grains of oats and/or vetch on sheets of filter paper, previously moistened, which were placed on a sheet of glass and then placed inside the germination chamber, controlling the temperature and humidity. After 72 hours the germinated grains were counted, eliminating the non-germinated ones, this process lasted 14 and 21 days in oats and vicia respectively, calculating the germination percentage by the formula PG = [(N° germinated seeds) / (N° sown seeds)] x 100. Carota *et al.* (2016).

Leaf Area

It is given by the sum of each of the leaves of the plant and was estimated by the following formula (Miralles & Slafer, 1991).

AF = (LxA) x 0.835 (cm2)

Where: L = Leaf length (cm), A = Width of the blade (cm), 0.835 = Correction factor for oats and AF = Leaf area (cm2). Leaf length and width were measured using a digital vernier (0.5 mm error), considering 5 plants per square meter, with 5 replications per experimental unit; finally, the average leaf area per plant was calculated in cm2.

Number of Leaves per Plant

Five plants were taken at random in 1 m2 considering 5 replications per experimental unit, then the number of leaves per plant was counted, finally calculating the average number of leaves per plant. In the case of oats, the leaf structure (laminae and sheath) was considered.

Plant Height

Plant height was measured longitudinally with a tape measure (0.1 mm error) from the base of the stem to the last node, where the last leaf of the plant emerges in oats or where it holds the last branch in vetch, considering 5 plants per 1 m2 randomly and 5 replications per experimental unit.

Evaluation of Green Matter and Dry Matter Yield in (Kg/ha)

All plants whose crown was within a 1 m2 pvc quadrant were cut at ground level with 5 replications per experimental unit and the initial fresh weight (kg) was recorded, using a digital scale (OHAUS®, Ranger 5000) with a capacity of 5000 g and an accuracy of 0.1 g. The samples were taken to the Food Nutritional Evaluation Laboratory (LENA) of the Universidad Nacional Agria la Molina.

The samples were dried at 60 °C for 48 hours in a circulating air oven, weighed to obtain the final weight and thus determine the initial moisture percentage. Finally, they were ground in a Willey mill with a 1 mm diameter sieve for chemical analysis. Finally, the ground samples were subjected to 105 °C for 12 hours by the Official International Method of Analysis (AOAC, 2005) where total moisture (%) and dry matter (kg/ha) were calculated.

Chemical Composition

It consisted of determining crude protein (CP), neutral detergent fiber (NDF) (AOAC. 2005) and in vitro apparent digestibility of organic matter at 48 hours (IVODM) according to the method of (Steel & Torrie, 1980).

Metabolizable Energy (ME)

Metabolizable energy (MJ/kg) of forage was calculated using the formula proposed by (Geent & Dyson, 1987) as follows:

ME = 0.16 x In vitro digestibility of organic matter (IVODM).

Statistical Analysis

The variables were evaluated by means of an analysis of variance, using a completely randomized block design with a 3×2 factorial arrangement (three varieties, two sowing proportions and 5 blocks), (Kuehl, 2000). The comparison of means was carried out by Tukey's test with a significance level of 5%, using SAS 9.4 statistical software (Vargas Castro *et al.*, 2013)

Results and Discussion

Agronomic Characteristics

Seed germination was 80±0.9% for Tayko oats, 90±0.8% for African oats and 83±0.9% for Vilcanota I oats. These values are similar to those reported by (Argote & Halanoca, 2007), who indicate percentages of 80, 92 and 82%, respectively. However, Vicia sativa showedsuperior germination, reaching 92±0.5%.

The Vilcanota I variety had a higher number of leaves per plant compared to the Africana variety, and a similar number to the Tayko variety, with 4.7, 4.6 and 4.4 leaves per plant, respectively (Table 2). The number of leaves per plant of the Tayko, Africana and Vilcanota I varieties was higher than the values reported by (Enciso Altamirano *et al.*, 2019), who reported 4.3 leaves per plant for the Mantaro 15 variety and 4.9 for the Centenario variety. This variation is probably due to differences in varieties and study sites.

Table 2: Agronomic evaluations of oats

Variable	Variety of Oats			Proportion of Oats-vicia	
	Tayko + vicia	Africana + vicia	Vilcanota I + vicia	80-20 Kg/ha	70-30 Kg/ha
N° of leaf/plant	4.4^{b} ± 0.09	4.6^{ab} ± 0.09	4.7^{a} ± 0.09	4.5^{a}	4.7^{a}
Plant height, m	1.0^{b} ± 0.03	1.1^{ab} ± 0.03	1.12^{a} ± 0.03	1.1^{a}	1.1^{a}
Leaf area, cm^2	183.9^{a} ± 7.7	193.2^{a} ± 10.4	180.4^{a} ± 7.0	184.5^{a}	180.5^{a}

[a]*Superíndices con letras iguales entre filas indican que no existen diferencias significativas (p>0.05).*

In the plant height variable, the Vilcanota I variety (1.12 m) was superior ($p<0.05$) to the Tayko variety (1.0 m); however, it was similar to the Africana variety (1.1 m) (Table 2). According to Argote and Halanoca (2007), values of 1.3 m are reported for the Tayko variety. For his part, (Montoya Quispe, 2017) reported 1.15 m for the Mantaro 15 variety in a phenological event at 100%

flowering. The values obtained in the present experiment were lower than those reported by (Argote & Halanoca, 2007; Montoya Quispe, 2017). This variation in results is due, in part, to the different methods used in measuring plant height.

The leaf area of the varieties Tayko (183.9 cm²), Africana (193.2 cm²) and Vilcanota I (180.4 cm²) did not show statistically significant differences (p>0.05) (Table 2). However, this study found higher values than those reported by (Montoya Quispe, 2017), who indicated a leaf area of 90 cm². The larger leaf area size in the varieties studied can be attributed in part to the higher soil moisture during the experimental period, with an average rainfall of 564.4 mm/year, which allowed for greater plant development.

The sowing of the oat varieties Tayko, Africana and Vilcanota I, together with vicia in different proportions (80-20 and 70-30 Kg/ha), did not show a statistically significant influence (p>0.05) on the number of leaves per plant, plant height or leaf area (Table 2). It is important to mention that greater leaf area is related to greater photosynthetic activity and decreases as the vegetative stage advances (Galindo & Clavijo, 2007).

Yield in Green Matter and Dry Matter (Kg/ha)

Forage yields in green matter (kg/ha) were statistically similar (p>0.5) among the varieties studied (Table 3). The green matter yield values of the varieties Tayko, Africana and Vilcanota I exceeded those reported by (Espinoza-Montes *et al.*, 2018), who recorded values of 15.17 t/ha in associated crops. In the case of oat-vetch associated crops, (Ansarul Haq *et al.*, 2018) indicated values of 18.16 t/ha, (Tuna & Orak, 2007) reported up to 20.30 t/ha and (Alberto Arias *et al.*, 2021) found values of 20.40 t/ha, being all these values much lower than those found in this experiment. This superiority could be due to climatic factors, such as precipitation, which favor soil moisture, as well as crop management and fertilization after soil analysis.

Table 3: Green matter and dry matter yield (Kg/ha) of oat-vetch

	Variety of oats			Ratio of oats-vicia	
	Tayko + vicia	Africana + vicia	Vilcanota I + vicia	80-20 Kg/ha	70-30 Kg/ha
Green matter	81248[a] ± 3935	76784[a] ± 2285	78554[a] ± 2910	81787[a]	75937[a]
Dry matter	15569[a] ± 110	15809[a] ± 274.3	15875[a] ± 357.4	16223[a]	15274[a]

[a]Superscripts with equal letters in the same row indicate no significant differences (p>0.05).

Oat-vetch yields in dry matter (kg DM/ha) were statistically similar (p>0.05) among the varieties studied. The values obtained in the present experiment exceeded those reported by (Alberto Arias *et al.*, 2021; Ansar *et al.*, 2010; Ansarul Haq *et al.*, 2018; Enciso Altamirano *et al.*, 2019; Rahetlah *et al.*, 2010) who reported yields of 3,980.0, 7,640.0, 7,500, 9,280.0, and 12,765.0 kg/ha, respectively. However, the yields were slightly lower than those reported by (Flores Nájera *et al.*, 2016), which reached 16,500.0 kg/ha. This variation in dry matter yield results (kg/ha) is probably due to differences in harvest phenological events, varieties used, and seeding ratios, as noted by (Espinoza-Montes *et al.*, 2018).

Chemical Composition and Metabolizable Energy

The crude protein content in the different oat varieties (Tayko, Africana and Vilcanota I) was statistically similar (p>0.05) (Table 3). These results are higher than those reported by (Desalegn & Hassen, 2015; Enciso Altamirano *et al.*, 2019; Espinoza-Montes *et al.*, 2018), who found values of 6.1, 7.9 and 9.1%, respectively. However, they are close to that reported by (Lithourgidis *et al.*, 2006), whose value was 9.8%. On the other hand, the values determined in this study are lower than those reported by (Flores Nájera *et al.*, 2016) and (Ansarul Haq *et al.*, 2018), which were 11.9 and 11.3%, respectively. This variation in the results is probably due to the harvesting performed at different phenological stages and the seeding ratios employed (Atis *et al.*, 2012).

The NDF content of the Vilcanota I variety was significantly higher (P<0.05) than that of the Tayko variety, being similar to that of the Africana variety and the oat-vetch associations (Table 3). These results exceeded those reported by (Desalegn & Hassen, 2015; Espinoza-Montes *et al.*, 2018; Flores Nájera *et al.*, 2016; Lithourgidis *et al.*, 2006), who reported values of 40.2, 40.7, 44.1, and 46.3%, respectively. Variation in NDF content is related to pasture harvest age (Flores Nájera *et al.*, 2016).

The in vitro digestibility of organic matter of the Tayko variety of oats proved to be significantly superior (P<0.05) compared to the Africana and Vilcanota I varieties. On the other hand, no significant differences were observed between Africana and Vilcanota I varieties. In addition, the in vitro organic matter digestibility of the Tayko variety was statistically similar to the oat-vicia associations.

The In Vitro Digestibility of Organic Matter (IVOMD) values of the varieties (Tayko, Africana and Vilcanota I) were lower than those reported by (Dear *et al.*, 2005). 63.0%). However, the Tayko variety (62.4%) showed a slight superiority over the values reported by (Lithourgidis *et al.*, 2006), who recorded a value of 61.5%. This variation in NDF content is partly attributed to various factors such as climate, crop amendments, fertilization, irrigation frequency, variety and association ratio. These factors influence the increase in cellulose, hemicellulose, lignin and other components content in plants (Espinoza-Montes *et al.*, 2018; Ramírez-Ordóñes *et al.*, 2013).

The metabolizable energy content (MJ/kg) was significantly higher in the Tayko variety ($P<0.05$) compared to the Vilcanota I variety, although similar to the Africana variety and the two oat-vetch associations. This advantage in metabolizable energy of the Tayko variety is attributed to its low neutral detergent fiber (NDF) content and high in vitro digestibility of organic matter (IVODM). In addition, the metabolizable energy values determined for the varieties and associations are higher than those found by (Enciso Altamirano *et al.*, 2019) for the oat (Mantaro15)-vetch (80-20kg/ha) association, which was 8.9 MJ/kg. On the other hand, the metabolizable energy values of the Africana variety and the oat-vicia association (80:20) are similar to those reported by (Salcedo Díaz, 1998), with a value of 9.7 MJ/kg. This variation is explained by the adaptation of the Tayko and Africana varieties to the study conditions, coinciding with (Argote & Halanoca, 2007).

Conclusion

The green and dry matter yield (kg/ha) of the Tayko, Africana and Vilcanota I varieties was statistically similar.

In terms of nutritional value, the crude protein percentage of the Tayko, Africana and Vilcanota I varieties was similar; however, significant differences were observed in terms of metabolizable energy, neutral detergent fiber and in vitro digestibility of organic matter among them.

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Author's Contributions

Marcial Enciso Altamirano, Jimny Nuñez Delgado and Alejandrina Sotelo Méndez: Designed the research plan and organized the study. In addition, they participated in all experiments, coordinated the data analysis and contributed to the writing of the manuscript.

Wilfredo Ruiz Camacho, Italo Maldonado Ramirez and Juan Eduardo Suarez Rivadeneira: Coordinated the data analysis, participated in all experiments and contributed to the writing of the manuscript.

Ethics

All references related to the enrichment of this scientific knowledge have been included in the bibliography of the journal.

References

Alberto Arias A., A., Cruz L., J., Pantoja A., C., Contreras P., J., & Lopez R., M. (2021). Rendimiento y calidad de Avena sativa asociada con Vicia sativa en la región puna del Perú. *Revista de Investigaciones Veterinarias Del Perú*, *32*(5), e21339. https://doi.org/10.15381/rivep.v32i5.21339

Ansar, M., Ahmedbr, Z., Malikbr, M., Nadeembr, M., & Rischkowsky, A. (2010). Forage yield and quality potential of winter cereal-vetch mixtures under rainfed conditions. *Emirates Journal of Food and Agriculture*, *22*(1), 25. https://doi.org/10.9755/ejfa.v22i1.4904

Ansarul Haq, S., Joseph Korieng, K., Shiekh, T. A., Bahar, F. A., Dar, K., Raja, W., A. Wani, R., & Khuroo, N. S. (2018). Yield and Quality of Winter Cereal-Legume Fodder Mixtures and their Pure Stand under Temperate Conditions of Kashmir Valley, India. *International Journal of Current Microbiology and Applied Sciences*, *7*(2), 3626-3631. https://doi.org/10.20546/ijcmas.2018.702.431

Argote, G., & Halanoca, M. (2007). *Evaluación y selección de gramíneas forrajeras tolerantes a condiciones climáticas del altiplano de Puno*.

Atis, I., Kokten, K., Hatipoglu, R., Yilmaz, S., Atak, M., & Can, E. (2012). Plant density and mixture ratio effects on the competition between common vetch and wheat. *Australian Journal of Crop Science*, *6*(3), 498-505. https://doi.org/10.3316/INFORMIT.361152491131442

Dear, B., Kaiser, A., & Piltz, J. (2005). Yield and digestibility of legume and oat forages. *Primefacts*, *52*, 1-6.

Desalegn, K., & Hassen, W. (2015). Evaluation of Biomass Yield and Nutritional Value of Different Species of Vetch (Vicia). *Academic Journal of Nutrition*, *4*(3), 99-105. https://doi.org/10.5829/idosi.ajn.2015.4.3.96130

Enciso Altamirano, M., Bravo, C. G., Rojas, M. E., Zavala, C. O., Quispe, O. C., & Camacho, W. R. (2019). Rendimiento y valor nutricional de avena asociada con vicia en condiciones altoandinas de Junín, Perú. *Producción Agropecuaria y Desarrollo Sostenible*, *8*, 53-64. https://doi.org/10.5377/payds.v8i0.8712

Enciso Altamirano, M., Delgado, J. N., Sotelo-Méndez, A., Ruiz-Camacho, W., Ramirez, Í. M., & Rivadeneira, J. E. S. (2024). Oat Pellets and Hay in Alpacas of Pastures of the Andean Zone, Perú. *American Journal of Animal and Veterinary Sciences*, *19*(4), 444-449. https://doi.org/10.3844/ajavsp.2024.444.449

Espinoza-Montes, F., Nuñez-Rojas, W., Ortiz-Guizado, I., & Choque-Quispe, D. (2018). Producción de forraje y competencia interespecífica del cultivo asociado de avena (Avena sativa) con vicia (Vicia sativa) en condiciones de secano y gran altitud. *Revista de Investigaciones Veterinarias Del Perú*, *29*(4), 1237-1248. https://doi.org/10.15381/rivep.v29i4.15202

Flores Nájera, M. D. J., Sánchez Gutiérrez, R. A., Echavarría Cháirez, F. G., Gutiérrez Luna, R., Rosales Nieto, C. A., & Salinas González, H. (2016). Producción y calidad de forraje en mezclas de veza común con cebada, avena y triticale en cuatro etapas fenológicas. *Revista Mexicana de Ciencias Pecuarias*, *7*(3), 275-291. https://doi.org/10.22319/rmcp.v7i3.4210

Galindo, J. R., & Clavijo, J. (2007). Modelos alométricos para estimar el área de los foliolos de arveja (Pisum sativum L.). *Ciencia & Tecnología Agropecuaria*, *8*(1), 37-43. https://doi.org/10.21930/rcta.vol8_num1_art:81

Geent, K. G., & Dyson, C. B. (1987). A Compariso N of Lamb Growth Rate and Lean Carcass Gain Within and Among Farm Flocks. *Proceedings of the New Zealand Society of Animal Production*, *47*, 99-100.

Herzog, S. K., Martinez, R., Jørgensen, P. M., & Tiessen, H. (Eds.). (2012). *Cambio Climático y Biodiversidad en los Andes Tropicales*.

Kuehl, R. O. (2003). *Diseño de experimentos: principios estadísticos de diseño y análisis de investigación*.

Lithourgidis, A. S., Vasilakoglou, I. B., Dhima, K. V., Dordas, C. A., & Yiakoulaki, M. D. (2006). Forage yield and quality of common vetch mixtures with oat and triticale in two seeding ratios. *Field Crops Research*, *99*(2-3), 106-113. https://doi.org/10.1016/j.fcr.2006.03.008

Miralles, D. J., & Slafer, G. A. (1991). A Simple Model for Non-Destructive Estimates of Leaf Area In Wheat. *Cereal Research Communications*, *19*(4), 439-444.

Montoya Quispe, K. H. (2017). *Características agronómicas y valor nutricional de siete cultivos forrajeros bajo secano en la sierra central*.

Rahetlah, V. B., Randrianaivoarivony, J. M., Razafimpamoa, L. H., & Ramalanjaona, V. L. (2010). Effects of seeding rates on forage yield and quality of oat (Avena sativa l.) vetch (Vicia sativa l.) mixtures under irrigated conditions of Madagascar. *African Journal of Food, Agriculture, Nutrition and Development*, *10*(10). https://doi.org/10.4314/ajfand.v10i10.62905

Ramírez-Ordóñes, S., Domínguez-Díaz, D., Salmerón-Zamora, J. J., Villalobos-Villalobos, G., & Ortega-Gutiérrez, J. A. (2013). Producción Y Calidad Del Forraje De Variedades De Avena En Función Del Sistema De Siembra Y De La Etapa De Madurez Al Corte. *Revista Fitotecnia Mexicana*, *36*(4), 395. https://doi.org/10.35196/rfm.2013.4.395

Salcedo Díaz, G. (1998). Valor nutritivo y degradabilidad ruminal de avena sativa y vicia sativa. *Pastos*, *1*, 71-85.

Steel, R. G., & Torrie, J. H. (1980). *Principios y procedimientos de la estadística: un enfoque biométrico*.

Suarez Rivadeneira, J. E., Manayay, F. A., Ruiz Camacho, W., & Perales Rojas, G. B. (2025). Participatory Road Infrastructure and Sustainable Development Goals: An Andean Model for Sustainable. *Ediciones Clío*, *5*(10), 1633-1654. https://doi.org/10.5281/zenodo.15550345

Tuna, C., & Orak, A. (2007). The role of intercropping on yield potential of common vetch (vicia sativa L.) oats (avena sativa L.) cultivated in pure stand and mixtures. *Journal of Agricultural and Biological Science*, *2*(2), 14-19.

Vargas Castro, J. P., Patiño Oquendo, L. F., Lugo Rozo, C. C., & Oquendo, V. (2013). *Software de Análisis Estadístico SAS*.