Investigation note

Growth curve of the perennial ryegrass and common vetch association

Benito Bello Olivera[1]
Sergio Iban Mendoza Pedroza[1§]
Eliseo Sosa Montes[2]
José Ricardo Bárcena Gama[1]
Arturo Pro Martínez[1]
María Guadalupe Zambrano Velasco[1]

[1]*Campus* Montecillo-College of Postgraduates. Mexico-Texcoco highway km 36.5, Montecillo, Texcoco, State of Mexico. CP. 56230. Tel. 595 9520200. (olivera14@hotmail.com; rbarcena@colpos.mx; aproma@colpos.mx; guadalupezamvel@gmail.com). [2]Department of Zootechnics-Chapingo Autonomous University. Mexico-Texcoco highway km 38.5, Chapingo, State of Mexico. CP. 56230. Tel. 595 9521500. (eliseososa@yahoo.com.mx).

[§]Corresponding author: sergiomp@colpos.mx.

Abstract

Annual species generate establishment costs several times per year, perennial grasslands allow the initial investment to be amortized for two or more years; however, perennial species have a slow establishment and compete with undesirable weeds, so the present research work aims to determine the yield of a perennial ryegrass (*Lolium multiflorum* L.) and common vetch (*Vicia sativa* L.) association. The study was conducted in the experimental field 'Predio Nuevo' of the College of Postgraduates, Texcoco, State of Mexico. The following variables were evaluated: dry matter (DM) content, DM yield, leaf:stem ratio, dead material, weeds and intercepted radiation. The first sampling was at 38 days, after that they were made every 14 days until 150 days when a mechanical cut was made, two subsequent cuts were made every 28 days. A progressive increase was observed as age progressed until 150 days (10 052 kg DM ha^{-1}), as well as 6 331 kg DM ha^{-1} and 6 397 kg DM ha^{-1} for the second and third cuts. The DM increased from 12.4 to 28.04% from day 38 to 150 for the first cut and to 26.67 and 27.2% for the second and third cuts. The dead material was observed on day 80 with 0.84%, the value reached 17.3% for day 150. The association of perennial ryegrass and common vetch increases DM yield at the first cut without affecting the subsequent yields of the perennial crop.

Keywords: forage, grassland, yield.

Reception date: June 2022
Acceptance date: July 2022

Ruminants generate great benefits for humanity, among them are foods of high nutritional quality, forages constitute an important part in the diet of these animals and are the cheapest source of food for animal production (Pérez *et al*., 2002). To meet the demand for forage, there are various strategies for the production and management of grasslands, in which species that best adapt to the climate and that have a high nutritional value are used. For example, the central zone of Mexico has a temperate climate, with a very marked cold season (autumn-winter) and there are animal production systems that have the use of pure and associated grasslands as an important component (Moreno *et al*., 2015; Rojas *et al*., 2016).

Annual summer and winter species are used in the production systems, which involves the costs of preparing the land, seed and inputs two or more times a year. The establishment of grasslands with perennial forages allows the initial investment to be amortized for two to five years of the establishment, with cuts every four, six or eight weeks, which depends on the temperature and the crop. However, perennial species may have a slow species establishment, compared to an annual one, and compete with undesirable weeds that prevent higher yields (Velasco *et al*., 2005).

In some cases, it is necessary to generate associations of perennial species with an annual species that serves as a protector to increase competition against other undesirable species and thus generate greater quantity and quality of forage at the first cut (Villalobos *et al*., 2013). Therefore, the present research work aimed to determine the forage yield in a perennial ryegrass (*Lolium multiflorum* L.) and common vetch (*Vicia sativa* L) association, as well as to determine the effect on the perennial crop at the end of the association.

The research work was conducted from October 28, 2020, to May 16, 2021, in the experimental field called ‘Predio Nuevo’ of the College of postgraduates, Montecillo, Texcoco, State of Mexico, located at 19º 29’ north latitude, 98º 53’ west longitude and 2 240 masl, with an approximate area of 2 500 m^2. The climate of the place is temperate subhumid, the driest of the subhumids, with an average annual rainfall of 636.5 mm, with a rainfall regime in summer (June to October) and an average annual temperature of 15.2 ºC (García, 2004). The soil of the area is sandy loam and slightly alkaline, pH 7.8, with 2.4% of organic matter (Wilson *et al*., 2018).

The grassland was established on October 28, 2020, broadcast sowing was used with a density of 40 and 35 kg of seed ha^{-1} of *Lolium multiflorum* L. and *Vicia sativa* L., respectively, subsequently the seed was covered with a step of harrow, it was not fertilized, and gravity irrigations were provided at field capacity every 14 days. The measurements were made from day 38 after sowing (DAS), then samples were taken every 14 days until 150 DAS, where a first mechanical cut was made to the entire plot, at 178 and 206 DAS the process was repeated, allowing 28 days of recovery to the plot.

Dry matter yield

The dry matter (DM) yield of the aerial part of the plot was obtained by carrying out five random samplings on the plot with squares of 0.25 m^2 and the forage was harvested at ground level. The biomass of each square was deposited in previously labeled Ziploc-type plastic bags, to later determine the partial moisture in the forage laboratory of the College of Postgraduates, Montecillo campus, and the residual moisture in the animal nutrition laboratory of the Department of Zootechnics of the Chapingo Autonomous University (UACH).

To quantify the partial dry matter (pDM), approximately 100 g of fresh matter was placed in a #8 paper bag and deposited in a forced air oven for 72 h at 55 °C, once the time was completed, the bags were removed from the oven and then weighed on a dibatec balance with 600 g capacity, once the weights were obtained, the pDM was calculated with the following formula: % pDM= (weight of dry matter/weight of fresh matter)∗100. Once the samples were partially dry, the total dry matter (tDM) was determined in an oven at 105 °C for 12 h, AOAC (1980) method 7.003, the DMs obtained were used to determine the tDM with the following equation: % of tDM= (% DM at 55°C)∗(% of DM at 105°C)/100.

Intercepted radiation

To calculate the intercepted radiation (IR), a linear ceptometer, model LP-80 (Decagon Devices INC.) manufactured in the United States of America, was used, which was placed horizontally above the plant canopy, with an east-west orientation and the incident light above the canopy was recorded, in μmol of photons m^{-2} S^{-1}, which was assigned a value of 100%. Immediately afterwards, the sensor was placed under the canopy with the same orientation and the incidence of light was recorded. The IR was expressed in (%) using the following equation: % IR= 100- ((reading below the canopy∗reading above the canopy^{-1})∗100).

Botanical composition and leaf:stem ratio

To determine the botanical composition, a subsample of approximately 20% of the forage sample was taken, each subsample was separated into the species of interest (common vetch) and (ryegrass), undesirable species (weeds) and dead material, the weights of each composition were obtained with the help of a digital scale, subsequently the (%) of each fraction was calculated by dividing the weight of each botanical composition by the total weight and multiplied by 100. For the leaf:stem ratio, they were separated into leaves (L) and stems (S), finally the weight was determined, and the leaf component was divided by the stem.

Statistical analysis

An analysis of variance was performed and the PROC GLM procedure of the statistical program SAS 9.0 Statistical Analysis System (2002) was used, with a completely randomized design with five repetitions, in order to evaluate the relationship between the variables studied in the experiment. The comparison of means was performed using the adjusted Tukey test (p= 0.05).

Dry matter yield and intercepted radiation

A progressive increase in dry matter yield was observed as age progressed, from 155 kg DM ha^{-1} to 10 052 kg DM ha^{-1} from day 38 to day 150 after sowing (Table 1). The percentage of dry matter increased over time from 12.4 to 28.04% from 38 to 150 DAS, 26.67 and 27.2% of DM were obtained in the second and third cuts, respectively. Intercepted radiation (IR) increased as the days of the crop progressed, a significant increase (p< 0.05) in IR was observed until day 80, reaching 90.57%. However, in subsequent DAS, the increases were not statistically significant (p> 0.05).

Table 1. DM yield (%) and IR at different sampling ages, in a perennial ryegrass-common vetch association.

DAS	DM (%)	DMY (kg DM ha^{-1})	% of intercepted radiation
38	12.4 H	155.1 G	14.88 D
52	15.69 G	833.1 G	38 C
66	16.78 FG	2 147.9 F	69.58 B
80	17.02 F	2 609 F	90.57 A
94	19.19 E	4 259 E	94.8 A
108	23.47 D	7 174.2 C	96 A
122	25 C	8 252.4 B	97.4 A
136	26.98 AB	9 470.8 A	98 A
150 first cut	28.04 A	10 052 A	98.4 A
178 second cut	26.67 B	6 331.2 D	93.4 A
206 third cut	27.2 AB	6 396.6 D	92.8 A
SEM	0.315	5.247	5.15

DAS= days after sowing; DM= dry matter; DMY= dry matter yield; SEM= standard error of the mean. Different literals in columns represent a significant difference with a $p < 0.05$.

Figure 1 shows the correlation that existed between DM yield and the (%) of intercepted radiation, as well as a proposal for a prediction equation, in which the (%) of IR is used to determine the yield with an R^2 of 0.7778. In yield (kg DM ha^{-1}), there were significant differences ($p > 0.05$) at 52, 80, 94, 108 and 136 DAS; however, no significant difference ($p > 0.05$) was found between days 136 and 150 DAS.

With the above it is inferred that the first cut can be made on day 136 without affecting yield. For the second and third cuts, a significant decrease ($p < 0.05$) was observed in the amount of DM ha^{-1} compared to the first cut at 136 or 150 DAS, which could be due to the absence of common vetch in the subsequent cuts (Figure 1).

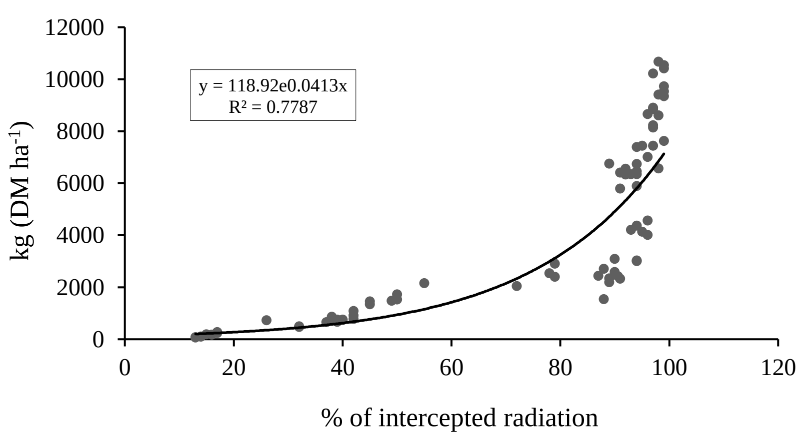

Figure 1. Behavior of the yield of DM ha^{-1} and intercepted radiation on different sampling days.

The high yield of the first cut with respect to the following cuts is mainly attributed to the association of common vetch-perennial ryegrass since, according to Sánchez *et al*. (2020), common vetch can produce an autumn-winter yield of approximately 4 000 kg DM ha^{-1} by applying 60 cm irrigation layers with a surface drip irrigation system; likewise, Espinoza *et al*. (2018) reported common vetch yields of 2 360 kg DM ha^{-1} under rainfed conditions. Mendoza *et al*. (2018) reported perennial ryegrass yields of 8 742 and 3 793 kg DM ha^{-1} in autumn and winter, respectively and Cueto *et al*. (2003) observed a yield of 4 230 kg DM ha^{-1} for perennial ryegrass at the first cut.

After analyzing these values and obtaining an average of the two species in function, it can be concluded that the yield at the first cut improved when a common vetch-perennial ryegrass association was used. Forage yield (Table 1) decreased for consecutive cuts (178 and 206 DAS) with a significant difference ($p< 0.05$), even compared to yield at 108 DAS, but Mendoza *et al*. (2018) reported that for the growth of the perennial ryegrass monoculture in spring, the season in which the subsequent cuts of ryegrass are made, it was 5 271 kg DM ha^{-1} and the data obtained in the present research for the second and third cuts were higher than those reported by these authors, with yields of 6 331 and 6 396 kg DM ha^{-1}, respectively, which indicates that the common vetch-ryegrass association does not affect the subsequent yield of the perennial crop.

Da Silva and Hernández (2010) reported that, in tropical and temperate grasses, the optimal harvest point is reached with an IR of 95 moles of intercepted photons (100 moles of incident photons)$^{-1}$. In the present research work this proportion is reached for the first cut at 108 DAS; however, despite having reached 95% of IR, there is a statistically significant increase ($p< 0.05$) in yield (Table 1), even for 28 days; nevertheless, to generate suggestions, factors that determine the optimal point at the first cut must be considered, as mentioned by Castro *et al*. (2017), who indicate that the increase in the age of ryegrass affects the digestibility of the forage, therefore it is necessary to look for an optimal point between yield and nutritional quality. There is a correlation of 77.87% between yield and the (%) of IR (Figure 2), which coincides with what was reported by Da Silva and Hernández (2010), who observed high correlations between IR and dry matter yield, which can be useful to determine the cut time.

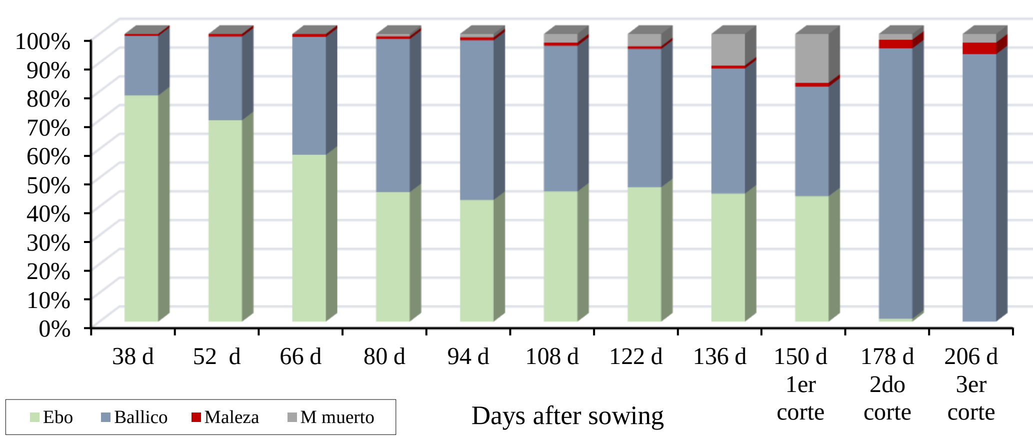

Figure 2. Botanical composition of the perennial ryegrass-common vetch association.

Botanical composition and leaf:stem ratio (LSR)

Figure 2 shows the behavior in the proportions of common vetch, ryegrass, weeds and dead material. The proportions at 38 DAS were 78 and 20.7% of common vetch and ryegrass, respectively, with greater presence of the annual crop compared to the perennial, but the values were reversed from 80 DAS, with 45 and 53% for common vetch and ryegrass, respectively, a proportion that continued to increase until 150 DAS, when the first cut was made. After the first cut, common vetch disappeared and values less than 1% were observed for the second cut and null values for the third cut, so there was an increase in the proportion of ryegrass of 94 and 93%.

Regarding the presence of weeds during the 150 DAS of the ryegrass-common vetch association, the highest value was 1.3%, which can be attributed to the high competition for light of the desired species, preventing the prosperity of the undesirable species. For the second and third cuts, the proportion of weeds rose to 4%. The presence of dead material was observed at 80 DAS with 0.84%, which increased to 1.2, 3, 4.3, 11.6 and 17.3 at 94, 108, 122, 136 and 150 DAS, respectively, of the dead material approximately 72% came from common vetch.

There was a higher proportion of common vetch *vs* ryegrass in the first DASs, which could be due to the fact that annual species have a higher growth rate compared to perennials (Castro *et al*., 2012). The accelerated growth of common vetch competes with weeds, preventing them from proliferating. However, the rapid growth of the annual species presents a rapid senescence, which causes the large percentage of dead material (Martínez *et al*., 2014).

Table 2 shows the leaf-stem ratio (LSR) for the common vetch and ryegrass plants of the complete plot without considering the contribution of weeds, in general there was a decrease in LSR in the case of common vetch from 2.14 to 1.14, for ryegrass from 2.44 to 0.59 and for the complete plot from 2.24 to 0.88 for 38 to 150 DAS, respectively. Sánchez *et al*. (2020) indicate that the crude protein (CP) of common vetch decreases as the cycle ends, the reported ranges of flowering to almost physiological maturity were from 32 to 14.4% of CP, which may be related to the decrease in LSR and the increase in dead material.

Table 2. Stem:leaf ratio of a plot in perennial ryegrass-common vetch association.

DAS	LSR Common vetch	LSR ryegrass	LSR plot
52	2.14 A	2.44 A	2.24 A
66	1.83 ABC	2.51 A	2.11 AB
80	2 AB	1.7 B	1.84 BC
94	1.64 BCD	1.44 B	1.52 D
108	1.5 CDE	1.64 B	1.57 CD
122	1.25 DE	0.88 C	1.06 E
150 1st cut	1.14 E	0.59 C	0.88 EF
178 2nd cut	-	0.81 C	0.81 EF
206 3rd cut	-	0.84 C	0.84 EF
SEM	0.102	0.136	0.074

LSR= leaf:stem ratio; SEM= standard error of the mean. Different literals in columns represent a significant difference with a $p < 0.05$.

There was a higher proportion of dead material from 94 DAS with a value of 3%, coming in a greater percentage (72%) from common vetch. This result coincides with what was reported by Sánchez *et al*. (2020), who found that the highest biomass production of common vetch occurred on day 103 with 20.49 t of fresh matter ha^{-1} and subsequently the amount of green forage per hectare begins to decrease. Likewise, Wilson *et al*. (2018) observed a positive relationship of dead material as the age of the plants increased.

Conclusions

In the association of perennial ryegrass (*Lolium multiflorum* L.) and common vetch (*Vicia sativa* L.), the dry matter yield at the first cut increased without affecting the subsequent yields of the perennial crop.

The first cut of the perennial ryegrass and common vetch association should be made at 136 days after sowing, which does not affect the yield compared to 150 days, a lower proportion of dead material (11.6 to 17.3%) and a higher leaf:stem ratio are obtained.

Cited literature

AOAC. 1980. Association of Official Analytical Chemists. Methods of analysis of the association of official analytical chemists. USA. Association of Official Analytical Chemists. 14th (Ed.). 125 p.

Castro, H. H.; Dominguez, V. I.; Morales, A. E. y Huerta, B. M. 2017. Composición química, contenido mineral y digestibilidad *in vitro* de raigrás (*Lolium perenne*) según intervalo de corte y época de crecimiento. México. Rev. Mex. Cienc. Pec. 8(2):201-210.

Castro, R. R; Hernández, G. A.; Vaquera, H. H.; Hernández, G. J.; Quero, C. A. R.; Enríquez, Q. J. y Martínez, P. A. 2012. Comportamiento productivo de asociaciones de gramíneas con leguminosas en pastoreo. México. Rev. Fitotec. Mex. 35(1):87-95.

Cueto, J. A.; Quiroga, H. M. y Becerra, C. T. 2003. Nitrógeno disponible y desarrollo del ballico anual. i. producción, calidad del forraje y acumulación de nitratos. México. Terra Latinoam. 21(2):285-295.

Da Silva, C. y Hernández, A. 2010. Manejo de pastoreo en praderas tropicales. Forrajes y su impacto en el Trópico. México. Universidad Autónoma de Chiapas. 1ra. (Ed.). 43-62 pp.

Espinoza, M. F.; Nuñez, R. W.; Ortiz, G. I. y Choque, C. 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. Perú. Rev. Inv. Vet. 29(4):1237-1248.

García, E. 2004. Modificaciones al sistema de clasificación climática de Köppen. México. 4ª (Ed.). Universidad Nacional Autónoma de México (UNAM). 217 p.

Martínez, R. A. y Leyva, G. A. 2014. La biomasa de los cultivos en el agroecosistema. Sus beneficios agroecológicos. Cuba. Cultrop. 35(1):11-15.

Mendoza, P. S. I.; Hernández, G. A.; Rojas, G. A. R.; Vaquera, H. H; Ramírez, R. O. y Castro, R. R. 2018. Comportamiento productivo de pasto ballico perenne solo y asociado con pasto ovillo y trébol blanco. México. Rev. Mex. Cienc. Agric. 9(2):343-353.

Moreno, M. A.; Hernández, G. A.; Vaquera, H. H.; Trejo, L. C.; Escalante, J. A.; Zaragoza, J. L. y Joaquín, B. M. 2015. Productividad de siete asociaciones y dos praderas puras de gramíneas y leguminosas en condiciones de pastoreo. México. Rev. Fitotec. Mex. 38(1):101-108.

Pérez, B. M. T.; Hernández, G. A.; Pérez, J.; Herrera, H. J. G. y Bárcena, G. R. 2002. Respuesta productiva y dinámica de rebrote del ballico perenne a diferentes alturas de corte. México. Téc. Pec. 40(3):251-263.

Rojas, A. R.; Hernández, G. A.; Walter, A.; Mendoza, S. I.; Joaquín, C. S.; Vaquera, H. H y Santiago, M. A. 2016. Comportamiento productivo de praderas con distintas combinaciones de ovillo (*Dactylis glomerata* L.), ballico perenne (*Lolium perenne* L.) y trébol blanco (*Trifolium repens* L.). Argentina. Rev. FCA UNCUYO. 48(2):57-68.

Sánchez, R. A.; Figueroa, J. J.; Rivera, J. S.; Reveles, H. M.; Gutiérrez, B. H. y Espinoza, C. A. 2020. Comportamiento productivo y valor nutricional de veza común (*Vicia sativa* L.) durante otoño-invierno en Zacatecas, México. México. Rev. Mex. Cienc. Pec. 11(1):294-303.

Villalobos, L.; Arce, J. y Wing, Ch. R. 2013. Producción de biomasa y costos de producción de pastos estrella africana (*Cynodon nlemfuensis*), kikuyo (*Kikuyuocloa clandestina*) y ryegrass perenne (*Lolium perenne*) en lecherías de Costa Rica. Costa Rica. Agron. Costarricen. 37(2):91-103.

Velasco, Z. M. E.; Hernández, G. A. y González, H. V. 2005. Rendimiento y valor nutritivo del ballico perenne (*Lolium perenne* L.) en respuesta a la frecuencia de corte. México. Téc. Pec. Méx. 43(2):247-258.

Wilson, C. Y.; López, N. E.; Ortega, M. E.; Ventura, J.; Villaseñor, H. E. y Hernández, A. 2018. Acumulación de forraje, composición morfológica e intercepción luminosa en dos variedades de avena. Venezuela. Interciencia. 43(9):630-636.