

Behavior of the forage mixture *Avena sativa* and *Vicia sativa* in its different proportions

Abstract

A field study was carried out in order with the aim of evaluating the productive and nutritional potential of the mixture *Avena sativa* (A) and *Vicia sativa* (V), in their different association proportions (100A:0V, 75A:25V, 50A:50V, 25A:75V and 0A:100V) at 3670 masl. The planting of the mixtures was carried out on the valley, requiring 100 kg/ha and 70 kg/ha of oats and forage vetch respectively. The experimental design used was the completely random, with 4 repetitions, thus using 20 plots of 25 m². The results showed that the ratios of 25A:75V and 50A:50V were better in green forage (YGF) yields, average plant height (APH) and high raw protein content (%CP); while the 100A:0V ratio showed a much lower yield, this is due to the fact that probably the sowing date, climatic conditions and soil type had a negative influence on this species, but not on the higher proportion of forage vetch (0A:100V).

Keywords: oats, vetch, forage, crude protein, associated

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Introduction

Cultivated grasses such as oats (*Avena sativa*) and vetch (*Vicia sativa*) are widespread crops in Peru, both permanent and temporary, forming cheaper and more practical foods that can be produced in the country's high Andean livestock areas. One of the causes that limits livestock production in the central highlands of Peru, is the slow growth of plants during the dry season, when the availability of the meadow is very reduced, where natural grasses and residues of agricultural crops are main food for this time of year, so fodder cereals are an alternative of great importance in feeding livestock for its high production of dry matter and low cost, however, are poor in protein content. Fodder legumes are used in livestock nutrition for their high protein content at low cost, but have a low dry matter yield.¹ The association of both forages can increase their nutritional value and biomass production.²

The natural pastures do not cover the nutritional needs of the cattle both in quantity and quality, especially during the dry season; for this reason, it was suggested that the association oats - vetch can constitute an alternative for their feeding.³ The associated cultivation of cereals and legumes is important for the development of sustainable food production systems, particularly in crop systems with limited external inputs.⁴ Species within affiliated cropping systems develop and compete with each other for resources in the environment, resulting in interspecific competition between species. Plants also compete for the abiotic components of the agroecosystem to survive, the most frequent being water, nutrients, light, O₂ and CO₂.⁵

In this sense, bearing in mind the above considerations, the objective of the research was to evaluate the behavior of the forage

mixture *Avena sativa* and *Vicia sativa* in their different proportions with respect to the productive potential; such as the yield of green forage kg/ha (YGF), yield of dry matter kg/ha (DMY), average height of plants cm (APH), number of macollos stems/plant (NM); and nutritional potential; such as the percentage of dry matter (%DM), percentage of crude protein (%CP) in proportions (100A):0V, 75A:25V, 50A:50V, 25A:75V and 0A:100V) from the association *Avena sativa* (A) and *Vicia sativa* (V).

Methods

Location of the experimental área

The experiment was conducted in the Poblado de Muquecc Alto (12°38'08"9 "S 74°54'00.4 "W), district of Acoria, province and department of Huancavelica, at an altitude of 3 670 m.a.s.l. with a mild climate, and generally warm and temperate, an average annual air temperature of 12.0°C, an annual sum of precipitation of 607 mm, with an unequal distribution and precipitation delays, where sprinkler irrigation had to be used to maintain a soil in its field capacity at the beginning of sowing. The analyses were conducted at the Animal Nutrition and Food Evaluation Laboratory (LUNEA) of the National University of Huancavelica (UNH), Peru.

Mantaro 15 and vetch common, were the varieties used of oats and vetch, respectively. The sowing of the mixtures was done broadcast, requiring 100 kg/ha and 70 kg/ha of oats and forage vetch respectively. Likewise, the analysis was carried out after 120 days of sowing, when *Avena sativa* was in milky grain and *Vicia sativa* in immature legume state (period between flowering and pod formation). The area of the plot was 500m² divided into sub-plots of 5m x 5m, where it was

limited with stakes, enclosing them with raffia, with a separation of 50 cm, between sub-plots, except for the proportion (0A:100V) with vetch domain, for which the raffia was extended to a distance of 30 cm in all the area to give support due to having a habit of climbing growth with erect stem. The experiment was established in a sandy clay loam soil with pH 6.0 and organic matter content 2.0% (0 to 30 cm deep). The previous crop was weed, with crop residues chopped and incorporated into the soil.

The YGF was determined by the square method, taking sAPHles with a quadrant of 1 m² per plot, where it was cut to a height of 3 cm from the floor, and then estimated production in Kg/ha. The APH (cm) was measured with a flexometer from the soil to the terminal part of the inflorescence in all experimental units (15 plants/plot, taken at random); for the number of macollos stems/plant (NM) 10 plants were taken at random within a square meter that were then counted each. DM and CP analyses were done in the laboratory, following the⁶ method.

The experimental design used was completely random, with 4 repetitions, conducted according to the following linear additive model: $Y_{ij} = \mu + T_i + E_{ij}$; where Y_{ij} refers to the response variable

Table 1 General summary of the analysis of variance (ANOVA), mean and coefficient of variation (CV), of the productive and nutritional characteristics of the different proportions of oats and vetch

Sources of Variation	g.l	Middle squares					
		YGF (kg/ha)	DMY (kg/ha)	NM (stems/plant)	APH (cm)	DM (%)	CP (%)
Treatments	4	440315269*	5143959,9ns	1,05 ns	293,15*	55,2**	131,87***
Error	15	119580705	2354037	0,36	63,92	7,68	0,88
mean		28905,33	4879,44	2,77	87,22	18,40	16,04
CV (%)		37,83	31,44	21,62	9,17	15,06	5,83

F tests: ***, P<0.001, **, P<0.01, *, P<0.05, ns; Not significant

Table 2 Means and standard deviations of the different proportions (oats and vetch) in green forage yield (YGF), dry matter yield (DMY), number of macollos (NM), mean plant height (APH) and percentage of dry matter (%DM)

Treatments	YGF (kg/ha)	DMY (kg/ha)	NM (stems/plant)	APH (cm)	DM (%)	CP (%)
100A: 0V	13 657 ±4093,51 b	3 356±1240,93 a	2,23±0,51 a	72,45±10,08 b	24,47±3,10 a	6,53±0,23 c
75A: 25V	22 883±12181,71 ab	4 039±1394,32 a	2,29±0,28 a	87,98±3,51 ab	19,25±4,10 ab	5,62±0,15 b
50A: 50V	33 033±12043,93 ab	5 315±1083,36 a	2,95±0,64 a	91,38±10,12 a	16,90±3,02 b	16,98±0,62 b
25A: 75V	35 533 ±13253,74ab	5 660±1829,18 a	2,94±0,43 a	94,22±10,03 a	16,22±1,51 b	20,63±1,84 a
0A: 100V	39 420±10584,65 a	6 028 ±1940,77a	3,45 ±0,93a	90,08±1,57 a	15,15 ±0,77b	20,44 ±0,73a

A: Oat, V; Vetch, a, b, c means within columns with different letters differ from each other according to Tukey's test (p<0.05)

Yield of green fodder (kg/ha)

The proportion that had better behavior was 25A:75V, with a green forage production of 35 533kg/ha, followed by 50A:50V (33,033 kg/ha) and 75A:25V (22 883 kg/ha), demonstrating that the incorporation of the vetch significantly improves the yield of green forage, the higher the percentage of vetch, higher yield. In addition, the monoculture with the best green forage yield was vetch (0A:100V), while oat

(YGF Kg/ha, APH/cm, NM stems/plant, DMY kg/ha, %DM, and %CP), to the general mean, T_i to the association proportions (oats and vetch), where (i=1, 2, 3, 4, 5) and E_{ij} was experimental error. The comparison of means was made using Tukey's test with 5% error with GLM procedure of SAS v. 9.2.⁷

Results

Table 1 shows that there are significant statistical differences between treatments (proportions) within YGF and APH (P<0.05), %DM (P<0.01) and %CP (P<0.001), but not within DMY and NM. It is also shown that the overall mean of the proportions was 28905.33 (kg/ha), 4879.44 (kg/ha), 2.7 (stems/plant), 87.22 (cm), 18.40 (%) and 16.04 (%), for YGF, DMY, NM, APH, DM and CP respectively.

Table 2 shows the means, their respective deviations and the statistical differences of the proportions of oats and vetch, where 25A:75V was the proportion with the best behaviours for YGF (35533kg/ha), DMY (5660 kg/ha), APH (94.22 cm) and CP (20.63%), resulting in a statistically different crude protein (P<0.05). Meanwhile, the 75A:25V ratio was outstanding in %DM, with 19.25%.

monoculture (100A:0V) showed a lower yield. It follows that the time of establishment, climatic factors and soil type had a strong influence on the yield of oats alone but were very favourable for vetch alone and as for the other proportions.

Average plant height (cm)

The analysis of variance of main effects reveals that there are statistical differences (P<0,05) between the treatments with respect

to the average height of the plant, where the general average that was reached was 87.22 cm, with a coefficient of variation of 9.17 %. The results show that the ratio 25A:75V is statistically different from the monoculture of oats (100A:0V), but not the other proportions, the maximum height that reached the ratio was 94.22cm, followed by the ratio 50A:50V, which reached 91.4 cm (Table 2). On the other hand, it is observed that the average height of the plant is related to the yield of green forage and its nutritional quality, clearly noting that the proportion can improve the height in both species, which planted as 100A:0V, therefore, the oats support the vetch and this develops better its height.

Number of macollos (stems/plant)

Table 1 shows that there is no statistically significant difference ($P>0.05$) between the treatments for the number of macollos, where the average reached was 2.77 stems/plant with a coefficient of variation of 21.62%. Oat monoculture reached 2.23 macollos and vetch 3.45. Meanwhile, the associated crops 50A:50V and 25A:75V reached 2.95 and 2.94 macollos per plant, respectively.

Percentage of dry matter (%DM)

The analysis of variance of the main effect reveals that there are statistical differences ($P<0.01$) for the treatments with respect to the percentage of dry matter, with an overall average of 18.40% of DM with 15.06% CV (Table 1).

The results show (Table 2) that the oat monoculture (100A:0V) is statistically different from the different proportions and the vetch monoculture (0A:100V). The 100A:0V ratio turned out to be better with 24.47% planting as a monoculture. On the other hand, the 75A:25V ratio performed better with 19.25 % DM with respect to the other proportions.

Dry matter yield kg/ha

The ANOVA reveals that there is no statistically significant difference ($P>0.05$) between treatments for dry matter yield (kg/ha). The average reached by this variable was 4 879.44 kg/ha with a variation coefficient of 31.44 % (Table 1). The value of the coefficient of variation is very high because the dry matter yield is a function of green forage and percentage of dry matter, it is known that in green forage yield there was much variation in the data due to the influence of foreign factors such as climatic conditions, planting season and soil type.

Percentage of crude protein (%CP)

The analysis of variance for the main effects reveals the existence of statistically significant differences ($P<0.001$) between the treatments with respect to the percentage of crude protein, where the general average reached was 16.04%, with a CV of 5.85% (Table 1).

Discussion

These beneficial effects of the association are similar to the results obtained in the work carried out by,³ who obtained the highest yield of the association of 39 683 and 17 400 kg/ha, at 2525 and 2950 m.a.s.l. respectively, where he mentions that the difference in his results was due to factors of altitude and humidity. On the other hand,⁸ in monocultures of oats tolerant to climatic conditions, reported the yield of *Avena sativa* (Mantaro Variety 15) of 80000 kg/ha, this due to the application of fertilizer in the sowing and in the state of tumbling. Likewise,⁹ performed a study in the same proportion of association of oats and vetch, who reported results lower than the

work done, which were 12640, 11520 and 12650 kg/ha for treatments 25A:75V, 50A:50V and 75A:25V respectively. In addition, the vetch monoculture (0A:100V) reached a yield of 6490 kg/ha and 11170 kg/ha of oats, lower results that were due to the use of other varieties of oats and vetch, where the legume presented problems such as lack of nodulation and beginning of drying before harvest from the base to the apex, possibly because of the effect of climatic conditions and soil type.

The vetch provides nutrients to the soil through a symbiosis¹⁰ that should influence the plant height of the associations. These beneficial effects of the association differ from the results sustained by,¹¹ who obtained heights of 135 and 110 cm for the months of June and August for the monoculture of oats, and for the associated of 152 and 120 cm respectively; where the difference in production at both times was given by the increase in temperature that affects the growth of plants planted late. They also differ from the reports of,¹² who in the sowing of *Vicia sativa* monoculture (0A:100V) with fertilization before sowing obtained a height of 50 to 55 cm. Also, the study of¹³ indicates inferiority values in associated oat and vetch crops, shows average height of 65.3 cm, noting that their habit of growing the vetch is prostrate and the association with oats increases the height of the plant. On the other hand,¹⁴ in oat and vetch associated plantings reported a height of 25.9 cm, a study carried out at more than 4000 masl, a result that differs from the values obtained in the present study (in the same phenological states of both oat and vetch).

For the number of macollos it is possible that there was greater number of plants in the proportions, for that reason its decrease due to the mortality of stems by competition. These effects are similar to the results of the study carried out by¹³, in the associated cultivation of oats and vetch, who report the average number of macollos of 3.5 per plant, besides manifesting that, when increasing the number of plants per m² decreases the number of stems. On the other hand, the result of the present work, differ with study made by¹⁵, in monoculture sowing of *Vicia sativa*, where it was 5.1 macollos per plant, mentioning that in all the cases it observed a tendency to the decrease of the number of stems per plant with the increase of the density. ¹¹ reported results of up to 6.47 macollos/planta for the *Avena sativa* monoculture; these results being much higher than the results of our study.

The results differ with respect to the reports of ¹¹, who reported values of 25.7% in associated oat and vetch plantings and a value of 30.6% dry matter for oat monoculture; in the same way it differs with the study made by ¹⁴, who concludes that the treatment *Avena sativa* + *Vicia sativa* planting in furrows at a ratio of 60:40 had a yield of 20.61% DM. ¹⁶, in monoculture planting of *Avena sativa* reported results of 48.26% dry matter, a result that is due to the high production obtained in green fodder, in addition to being a value much higher than ours.

The beneficial effects differ from those reported by ¹¹, in associated oat and vetch plantings, who reported values of 15170 kg/ha and for single oats of 15880 kg/ha; likewise ³, reported in associated oat plantings - vetch significant results of 13020 kg/ha, and 5120 kg/ha, in two different places, who indicates that the study was affected by altitude and soil moisture. On the other hand, our result exceeded the values of the report made by ⁹, where the maximum yield reached for the 75A:25V ratio was 3590 kg/ha; where the association with oats increased crop production which could improve harvesting operations.

The results show that (Table 2), the 25A:75V ratio is statistically different from the other associations and from oat monoculture (100A:0V), but not from vetch alone. Reaching a value of 20.63%

of crude protein. On the other hand, the monoculture that had better behavior was vetch (0A:100V) with a production of 20.44% CP, lower than that reported by¹⁷ harvest at 120 days in the proportion 0A:100V with 22.25% of crude protein. The vegetative development of the associations improves crude protein inputs in production¹⁸ and these may be adequate to meet the nutritional requirements of ruminants.

The percentage of crude protein for the association 50A:50V and 25A:75V give results of 16,98 and 20,63 % of crude protein, this percentage increases according to the proportion of vetch in the treatments, the oats serves as protection and support to the vetch and thus delays the vegetative development of the leguminous, obtaining in this way the best result when 75% of vetch was incorporated, but slightly decreases the content of CP when there is no incorporation of oats. The result obtained in the present study is superior to that of¹¹ in associated oat - vetch plantings, who report values of 15% CP and for single oats in the milky grain state of 6.85%.⁹ in associated oat - vetch sowings, gives to know the best result in the proportion A50: V50 with 14,97 % of protein; almost similar to the results of¹⁹, in associated oat and vetch sowings, who reached values of 17,71% of protein. Similarly²⁰ in his study association of *Avena sativa* and *Vicia sativa* at fixed dose 35:65 as a witness, gave reports of 13.23 % of protein, similar to the result of³, in oat-vegetable associated crops, who achieved a better result of 12.29 % of protein.

Conclusion

Treatment 25A:75V was better as a forage association, because it had higher yields of green forage, average plant height and percentage of crude protein, followed by dose 50A:50V. The average plant height presented the best result in the proportion 25A:75V followed by the dose 50A:50V, where it is evidenced that the oats incorporated to the vetch serves as support and increases the average plant height and the number of macollos per plant did not show differences in treatments. The percentage of dry matter obtained a better result in monoculture of oats, followed by the ratio 75A:25V. In associated sowing they show a higher percentage of crude protein in the treatments and at the same time the oats incorporated to the mixture serves as protection and support to the vetch, this degree of protection is up to 25% and 50% of oats in the mixture and thus improves the nutritional quality in the association.

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Conflicts of interest

There is no type of conflict of interest.

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