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Technical note

Yield and nutritional value of common vetch (*Vicia sativa* l.) during fall-winter in Zacatecas, Mexico

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Abstract:

Common vetch (*Vicia sativa* L.) can be used to improve overall livestock feed quality and improve soils, but more information is needed on optimum harvest time and plant nutritional profile to broaden it use in livestock production systems. An evaluation was done of forage yield, crude protein content and plant element yields in common vetch at six harvest times during a fall-winter season under irrigation in the state of Zacatecas, Mexico. Vetch seed was sown in early December 2016 following a completely randomized experimental design with four replicates. Plants were harvested 47, 61, 75, 89, 103 and 117 d after sowing. The variables measured included fresh and dry forage yield, green and senescent leaf, stem, flower and pod yields and crude protein content. Data were analyzed using a repeated measure analysis in the SAS statistical package. Fresh forage yield increased (P<0.05) from 493 kg ha^{-1} at 47 d to 20,562 kg ha^{-1} at 103 d. Dry forage yield increased constantly (P<0.05) from 14 kg DM ha^{-1} at 47 days to a maximum of 3,796 kg DM ha^{-1} at 103 d. Crude protein content decreased (P<0.05) after 60 d, remained between 27 and 29 % DM from 75 to 103 d, and then dropped to 20.7 % at 117 d (P<0.05). Under the experimental conditions optimal harvest time for common vetch intended as cattle feed is approximately 100 d, just as flowering begins.

Key words: Common vetch, Yield, Crude protein.

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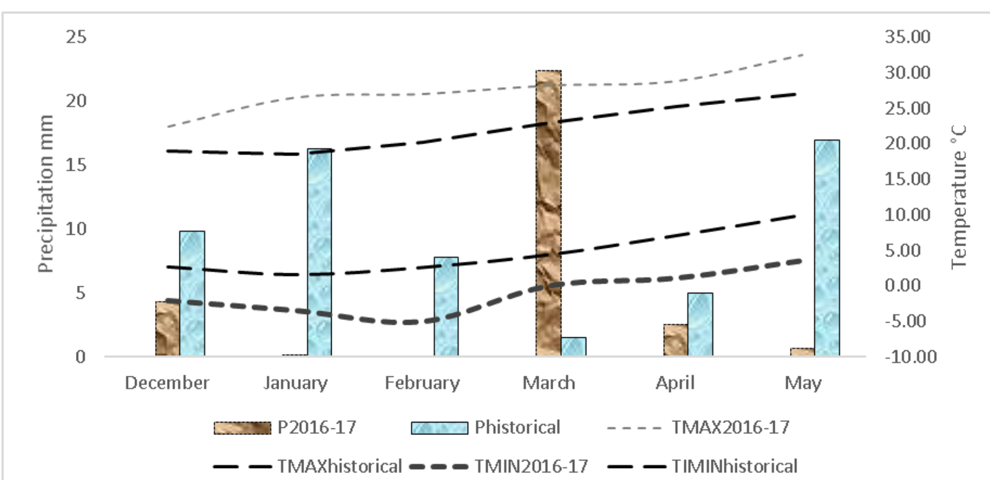
Forages classified as having good protein quality, be it for grazing or harvesting, are those with the highest demand for animal feed. There are approximately 33.5 million cattle and 17.4 million sheep and goats in Mexico, all of which require quality feed to meet maintenance and production needs(1). Alfalfa (*Medicago sativa* L.) is the most widely used feed crop in beef and milk production systems, but has the limitation of decreased production during the winter months(2). In north-central Mexico small grain cereals such as oats, barley, wheat and triticale are used as alternative crops to alfalfa during the fall-winter cycle(3). These are characterized for having regular to low protein quality when at their highest dry matter (DM) production levels(4,5). A more promising alternative to alfalfa is annual fodder legumes. These have high crude protein content and improve soil properties, making them ideal for increasing resource use efficiency in livestock production systems(6).

Common vetch (*Vicia sativa* l.) is used in making hay and for grazing livestock, and is known for tolerating temperatures as low as -10 °C(7). It can fix more nitrogen than many small grain cereals, especially under nitrogen-restricted conditions(8,9). This species' growth habit can become climbing when in competition with another crop, which has led to its mixing with different cereals(10). When vetch is associated with oats, triticale or barley, forage production is reported to increase from 3 to 33 %(11). When vetch was included in a forage mixture, neutral detergent fiber (NDF) and acid detergent fiber (ADF) did not improve compared to cereals, although crude protein (CP) content decreased because as a monocrop vetch contains from 14 to 45 % CP(12). Vetch can provide benefits in small ruminants. In a study using vetch as a supplement to forage hay at 0 to 1.5 % of live weight in lactating goats milk production increased from 40 to 50 % at the end of the lactation period(13). When lambs were grazed on vetch or barley monoculture pastures plus a feed concentrate feeding costs were reduced up to 20 % in the vetch treatment(14). In the state of Zacatecas, Mexico, 21,478 ha of oats are cultivated during the fall-winter cycle(1). Vetch is a possible alternative to oats but its adoption is limited by a lack of information on forage yield and quality as well as optimal harvest stage or date. The present study objective was to quantify the fresh and dry forage yield, crude protein content and yields for individual plant elements of common vetch (*Vicia sativa* L.) at six harvest dates with the aim of identifying optimum harvest time during the fall-winter cycle under irrigated cultivation in Zacatecas.

The experiment was carried out at the Zacatecas Experimental Station (102°39' W; 23°36' N) of the National Institute of Forestry, Agricultural and Livestock Research (Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias – INIFAP). Located at 2,192 m asl, regional climate is semi-arid, with 340 mm average annual rainfall, mostly in July and August, and an average temperature range of 12.4 to 21.8 °C during the months of December to May(15). During the crop cycle, only 29.7 mm rainfall were recorded, representing 42 % of average rainfall during this period (Figure 1). Soil in the experimental field is sandy loam with a pH of 7. For the experiment *V. sativa* crop seeds were sown directly in the soil on 9 December 2016 using a completely random experimental design with four replicates. The seed (80 kg ha^{-1}; 90 % viability) was sown in rows 0.76 m apart with double seed lines in each row. The experimental unit was eight rows 0.76 m wide and 5.00 m long. The effective plot consisted of the two middle rows along the 5 m length per harvest, omitting the two exterior rows of each experimental unit. A surface strip irrigation system was installed and an approximately 60 cm layer of water applied. An initial fertilization was done using 60-60 nitrogen (N)-phosphorus (P). Plants were harvested every 14 d, starting 47 d after sowing (DAS).

Figure 1: Cumulative monthly rainfall (mm) and mean temperature (°C) at INIFAP-Zacatecas Experimental Station during Winter and Spring 2016-17

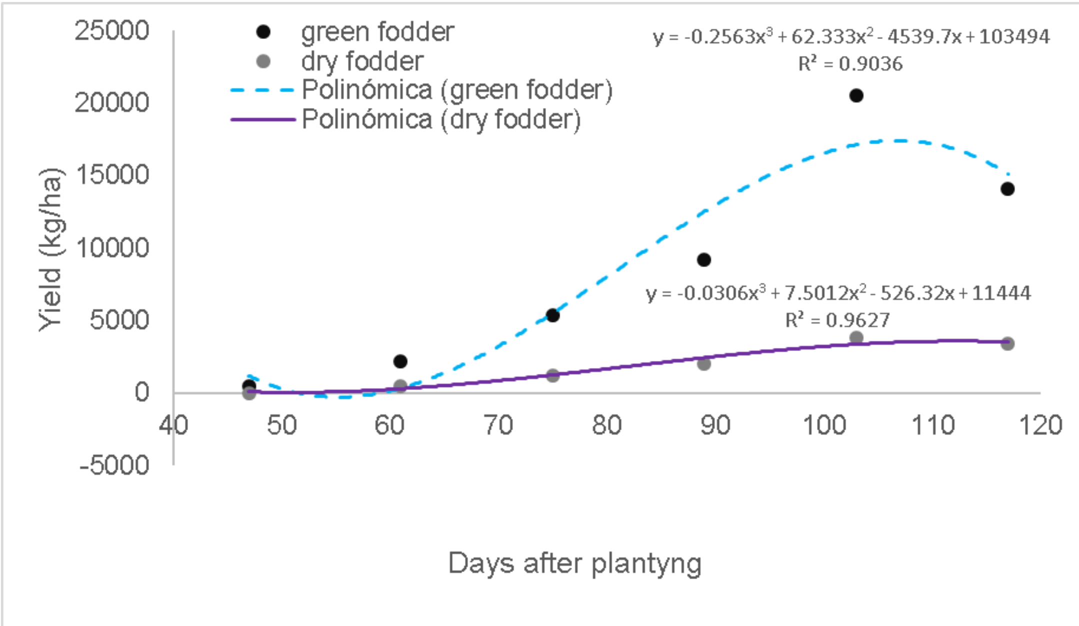


The variables were measured using the whole plant on the harvest date. They included crude protein content (CP); fresh forage yield (FFY); dry forage yield (DFY), and dry matter yield of the plant elements fresh leaf (FLY); senescent leaf (SLY); stems (SY); flowers (FY) and pods (PY). The estimate of FFY was made from the biomass harvested from the effective plot at 5 cm above ground surface and weighed. Two random samples (0.5 kg) were taken of the fresh forage. In one, stems, green and senescent leaves, flowers and pods were separated out and weighed while the other was used for quantifying CP. The plant element subsamples and all the remaining fresh forage sample were dried in an oven at 55 °C for 48 h. These were weighed separately to measure dry matter percentages. Estimation of DFY per hectare was calculated based on FFY and the dry matter percentages. The dried samples containing all plant elements were processed in a Wiley mill with a millimeter sieve. Crude protein content (CP) was calculated using total N which was quantified using the Dumas combustion analysis(16).

The results were statistically analyzed following a completely random design with repeated measurements run with the "PROC MIXED" procedure of the SAS statistical package(17). Comparison of means was done using the "Lsmeans" function with a probability of less than 5 %(17). Trends in FFY, DFY and CP were identified with a regression analysis.

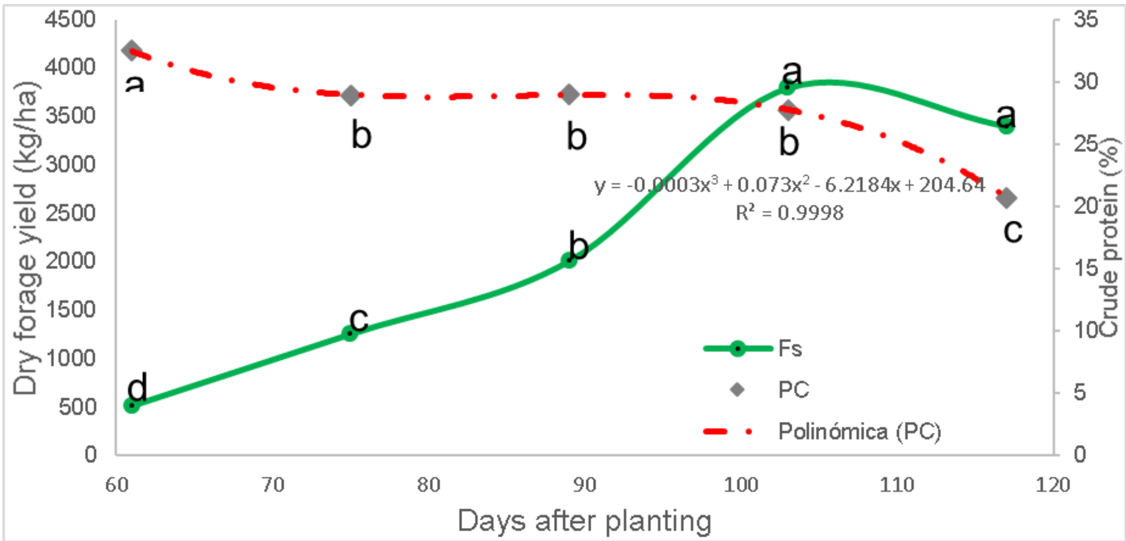
Under the experimental conditions FFY increased (P<0.05) from 493 kg ha^{-1} on d 47 to 20,562 kg ha^{-1} on d 103, and declined thereafter (Figure 2). The model with the best fit was a third-degree polynomial, which exhibited a high coefficient of determination (R^2=0.904). Dry forage yield (DFY) increased (P<0.05) constantly from 14 kg DM ha^{-1} on d 47 to 3,796 kg DM ha^{-1} on d 103, and then remained relatively constant (P>0.05). For this variable the third-degree polynomial model explained 96.3 % of variability (R^2=0.963). The present FFY results coincide with the 20.49 t DM ha^{-1} reported at peak production, with quadratic behavior(18). Yields for dry forage (DFY) were similar to the 2.6 to 4.2 t DM ha^{-1} reported 85, 92, 106 and 118 d post-harvest in Zacatecas, although no differences between harvest dates were reported(19). The common vetch growth dynamic in the fall-winter observed in the present results can be useful in making decisions about different uses of this crop. Vetch is recommended as an alternative forage crop because it increases forage organic matter content, while benefiting soil conservation by preventing erosion(20,21). Optimal harvest date for vetch to be used as green manure is from 100 to 110 d after sowing, as this is when the foliage contains sufficient biomass and the highest amount of water, both favorable conditions for soil microorganisms to break down and mineralize organic matter(22).

Figure 2: Fresh and dry forage growth dynamic in common vetch (*Vicia sativa*) during the 2016-17 fall-winter cycle in Zacatecas



Crude protein content (CP) decreased after 60 days, remained between 27 and 29 % from 75 to 103 d and reached a low (P<0.05) of 20.7 % at 117 d (Figure 3). The third-degree polynomial model exhibited the best fit with a 0.99 coefficient of determination (R^2). This agrees with reports that CP in common vetch decreases towards the end of the growth cycle, with levels decreasing from 32 % at flowering to 14.4 % near physiological maturity(23). Minor decreases (P>0.05) in CP of 29 % at 85 d to 24 % at 118 d have also been reported in Zacatecas(19). One of the main factors affecting animal production is feed quality. In forages quality is linked to plant developmental stage, as well as to species and environmental adaptation. Under the present experimental conditions during the fall-winter cycle in Zacatecas, optimal harvest time is approximately 100 d after sowing, once DFY levels out and when CP begins to decrease.

Figure 3: Crude protein content (CP) and dry forage yield (DFY) in common vetch during the 2016-17 fall-winter cycle in Zacatecas



Stem DM yield (SY) increased significantly at each harvest up to 89 d, after which it remained relatively constant (P>0.05) (Table 1). Green leaf DM yield increased (P<0.05) from 30 kg DM ha^{-1} after 47 d to 1,487 kg DM ha^{-1} after 103 d, with no differences thereafter. Both senescent leaves and flowers were first recorded after 103 d, and neither yield differed over time (P>0.05). Pods were only recorded in the final harvest at 117 d. Green leaf DM yield (GLY) was consistently higher than SY, a good indicator of forage quality and a predictor of forage intake since crude protein accumulates largely in the leaves and is the most digestible component of the plant(24). Dry or yellowed leaves began to appear in the harvest at 103 d. These indicate incipient senescence, during which the plant redistributes nutrients from the leaves to flower and seed development(25).

Table 1: Yields (kg ha^{-1}) of common vetch (*Vicia sativa*) plant elements (±SD) in six harvests during the 2016-17 fall-winter cycle in Zacatecas

DAS	SY	GLY	SLY	FY	PY
47	27±4 a	30±2 d			
61	229±102 b	285±122 c			
75	557±55 c	699±99 bc			
89	913±194 d	1098±474 ab			
103	1085±186 d	1488±348 a	662±469 a	871±194 a	
117	1091±228 d	1183±570 a	1256±425 a	172±64 a	164±40

DAS= days after sowing; SY= stem yield; GLY= green leaf yield; SLY= senescent leaf yield; FY= flower yield; PY= pod yield; SD= standard deviation.

Based on the present results optimal harvest time for common vetch under the experimental conditions for use as green manure or as an ingredient in livestock feed was approximately 100 d. This generally coincides with the appearance of flowers and the highest crude protein content. Harvest when common vetch exhibits about 20 % flowering has been recommended in previous studies(10,11,26). Common vetch (*Vicia sativa*) is a promising element for use in sustainable livestock production and merits further research aimed at genetic selection and improvement. Six vetch lines exist in Zacatecas with yields higher than vetch lines sold in Mexico(27), highlighting the need to identify lines with potential as a monocrop forage, with erect or semi-erect growth habits and which can be mixed with small grain cereals.

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