Safflower (*Carthamus tintorius*): A Promising Forage Crop for Semi-Arid Regions

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SAFFLOWER (*Carthamus tintorius*): A PROMISING FORAGE CROP FOR SEMI-ARID REGIONS

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Abstract

The yield, quality, preservation and intake of safflower hay were determined in two successive years - 1998 and 1999. Field experiments carried out at the Bet Dagan experimental station on the coastal plain of Israel under rain-fed conditions. A spineless variety was tested under three sowing dates. Yield decreased and quality improved as the sowing date receded from November 12 to February 3. Respective yields, IVDMD and CP content were: 22 and 8 ton DM/ha, 48.9% and 65.5% , 10.0% and 14.6%. Safflower at 290, 410 and 770 g/kg DM was ensiled in 1.5-l anaerobic glass jars with or without *Lactobacillus plantarum* applied at 10^6 cfu/g. Good-quality silages were obtained at 290 and 410 g/kg DM. The pH of the inoculated silages was 3.9-4.0 as compared to 4.7 in the control silages; the former contained more lactic acid than the controls. All silages were stable upon aerobic exposure. Inoculation with L*actobacillus plantarum* improved the ensiling fermentation, and these silages, too, were stable upon aerobic exposure. Feeding experiments with heifers were conducted with safflower hay. The intake and performance of heifers fed with 25 or 50% safflower hay (DM basis) did not differ from those animals fed a control diet (no safflower in diet).

Keywords: Cattle, safflower, forage, preservation

Introduction

Wheat is the main field crop in Israel. In the southern part of the country the crop very often fails to form grains because of sporadic droughts. Although drought- resistant cultivars have been developed - wheat cropping in 250-300 mm annual rainfall belt is

seldom economic. Safflower with its deep root system and resistance to water stress is a crop which can “harvest” the rain efficiently and provide economic fodder. The aim of the present experiment was to study the value of safflower as forage under rainfed condition (yields, quality, preservation, value to livestock).

Material and Methods

The effects of three sowing dates – November 12, December 9 and February 3 on DM yield and quality were tested in randomized blocks replicated four times. The harvested area was 6 m^2. The annual rainfall was 450 mm. and only 30 mm of water was applied by sprinklers after sowing. After plots had been hand-harvested, fresh samples of 5 kg were randomly taken from each plot to determine: leaf: stem ratio, DM content of the leaves, stems and whole plant, and the IVDMD and N- content of each of the plant components.

In order to check their suitability for silage making, whole plants were harvested at the bloom initiation stage of maturity and wilted to 290, 410 or 770 g/ kg DM, chopped to *ca*. 2 cm and ensiled in 1.5 -l anaerobic jars, each filled with about 700 g (wet weight) plant material and stored at ambient temperature (25-27^{0}C). Three jars per treatment were sampled on days 3, 16 and 60 for chemical and microbiological analyses. At the end of the experiments, the silages were subjected to an aerobic stability test lasting 5 days (Ashbell *et al*., 1991). The treatments comprised control (no additives) and application of *Lactobacillus plantarum* at 10^6 colony-forming units (cfu)/g (ATCC 8014, American Type Culture Collection, kindly supplied by G. Szakacs, Technical University of Budapest, Hungary). DM was determined by oven drying for 48 h at 60C^0. Lactic acid was determined by spectrophotometry. Volatile fermentation end products were determined in aqueous extracts by gas chromatography (Hewlett-Packard, Germany), over a temperature range of 45-230^{0}C. Gas losses were calculated from weight loss. Microbiological evaluation included enumeration of lactobacilli (on pour plate Rogosa agar), yeasts and molds (on spread plate malt extract agar acidified to pH 4.0 with lactic acid) in plates incubated for 3 d at 30^{0}C.

The effects of including 0, 25 or 50% (DM basis) of safflower hay in a complete mixed diet (CMD) for dairy heifers, weighing 310 kg on average, were investigated, in a Latin Square design involving six heifers. Every cycle of the Latin Square lasted 9 days. Heifers were freely housed in individual yards with feed and water constantly available. Orts were weighed every morning and analyzed for dry matter. The basic CMD,

formulated according to NRC (1989), consisted of 27.6% cereal hay, 9.9% garden pea hay, 10% wheat straw, 34.9% wheat silage and 17.5% of a commercial concentrate. The chemical composition on DM basis of the basic CMD, which contained 54% DM was: 16.1% CP, 52.6% NDF, 31.2% ADF and 10% ash. Safflower hay contained 88% DM and, on a DM basis, its composition was: 13.9% CP, 47.6% NDF, 33.2% ADF and 12.6 % ash. On the last 2 days of each feeding cycle, heart rate was monitored every 10 minutes by using data loggers for ECG (Dansoft, Rehovot, Israel). Oxygen uptake was measured twice on each animal (morning and afternoon) by using a face mask open-circuit respiratory, and energy expenditure was calculated from mean heart rate and O^2 uptake, assuming 20.47 kJ/l O^2, as described by Brosh et al. (1998).

Results and Discussion

Safflower sown on November 12 and December 9 and harvested on April 27 produced 22 and 15 t DM/ha respectively. Respective figures for IVDMD and CP content were 48.9 and 52.1%; and 10.0 and 11.4% CP. Delaying sowing to the February 3,1999, reduced DM yield to 8 t/ha and increased IVDMD to 65.5% and CP content to 14.6%. Decreasing the seeding rate from 50 to 25 kg/ha and increasing the distance between rows to 30 cm increased the level of branching of the plant and therefore the leaf: stem ratio. Since both IVDMD and CP contents were higher for leaves than for stems, branching increased quality. The optimal harvest time in Israel is around the middle of April: an earlier harvest is exposed to the hazard of rain soaking. At harvest, safflower from the two first sowing dates had high proportions of coarse stems. It is suggested that yield could be increased if the growing season could be stretched to 100 days rather than the 83 days given by third sowing date: In such a case 10

t DM/ha DM would be expected, with relatively high quality. No fermentative activity was recorded during anaerobic storage of safflower ensiled at 770 g kg^{-1} DM. Safflower ensiled at 290 and 410 g kg^{-1} DM had 71 and 57, 85 and 89, 86 and 92 g kg^{-1} in DM WSC, CP and ash, respectively.

The pHs' of the inoculated silages decreased faster and to lower values, than those of the control silages. The pH values on day 60 were 4.7 and 3.9-4.0 in the control and inoculated silages, respectively at both DM contents. Gas losses were 0.4 to 1.0%, with lower values in the inoculated silages. The inoculated silages contained more lactic acid than the control silages (42-47 vs. 19-20 g kg^{-1}, respectively) which explains their lower pH values. Other fermentation products were acetic acid and ethanol, detected at less than

10 g kg^{-1} DM, with no differences between treatments. At the end of the ensiling period large numbers of lactobacilli were found (>10^5 cfu g^{-1}). The numbers of yeasts and molds were variable. Silages of all treatments were quite stable upon aerobic exposure, with no CO_2 production or change in pH; however, the numbers of yeasts and molds increased during aerobic exposure, in some cases from 0 to 10^8 cfu g^{-1}.

No differences in feed or water intake, heart rate, O_2 pulse and expenditure of energy (Table 1) were found among treatments. Our results suggest that safflower grown for forage could replace fallow in the traditional wheat/fallow production system in the Mediterranean area.

References

Ashbell, G., Weinberg Z.G., Azrieli A., Hen Y. and Horev B. (1991). A simple system to study the aerobic deterioration in silages. Can. Agric. Engin. **33**: 391-394.

Brosh, A., Aharoni Y., Degen A.A., Wright D. and Young B. (1998). Estimation of energy expenditure from heart rate measurements in cattle maintained under different conditions. J. Anim. Sci. **76**: 3054-3064.

Dubois, M., Giles K.A., Hamilton J.K., Rebes P.A. and Smith F. (1956). Colorimetric method for determination of sugars and related substances. Anal. Chem. **28**: 350-356.

NRC (1989). Nutrient requirement of cattle. National Academy of Science. Washington, DC.

Table 1 - Daily feed intake (FI, kg DM), water intake (WI, kg), mean heart rate (MHR, min^{-1}), O_2 pulse (ml/heart beat/kg $BW^{0.75}$) and energy expenditure (EE, MJ) in heifers fed complete mixed diets containing 0, 25 or 50% safflower hay.

	Percentage of safflower in ration (DM)			SEM	Statistical significance (P<)		
	0	25	50		Treatment	Heifer	Period
FI	6.39	6.34	6.36	0.17	0.98	0.18	0.30
WI	18.8	17.0	20.0	1.1	0.35	0.10	0.22
MHR	78.9	79.7	72.8	3.5	0.29	0.31	0.32
O^2 pulse	0.329	0.325	0.339	0.014	0.76	n.d.	n.d.
EE	60.7	61.3	56.4	2.6	0.33	0.09	0.32

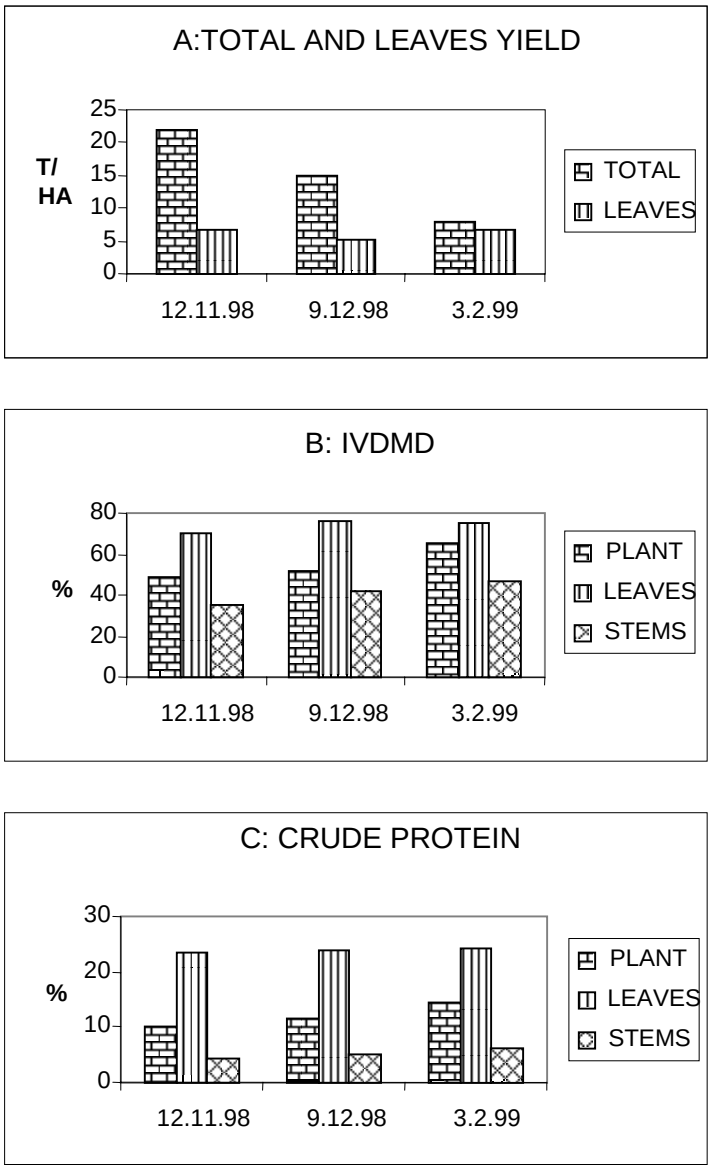

Figure1 - The effect of sowing time of safflower on total DM yield and leaves yield (t/ha) and on *in vitro* dry matter digestibility (IVDMD), crude protein (CP) of the whole plant and of leaves na stems.