# Effect of Drought Stress on Fibre Digestibility of Corn for Silage

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## Abstract

Limited information exists about the impact of drought stress on corn silage digestibility. The objective of this study was to determine the effect of irrigation on *in situ* NDF digestibility of corn tissues grown under controlled conditions in a greenhouse. Five commercial corn hybrids were planted in pots and grown in a greenhouse. Pots were subjected to an abundant or restricted irrigation regime. Leaf blades and stem internodes were collected from the upper and bottom portion of each hybrid. Tissue samples were incubated in the rumen of 3 rumen-cannulated cows for 0, 3, 6, 12, 24, 48, 96, and 240 hours. Drought stress did not affect the concentration of undigested neutral detergent fibre (uNDF) in upper or bottom internodes but slightly decreased in leaf blades (17.5 and 15.7% for abundant and restricted watering, respectively). The concentration of uNDF varied substantially among corn hybrids in upper internodes (13.4 to 28.3% uNDF), bottom internodes (21.5 to 42.3% uNDF), and blades (11.6 to 20.1% uNDF). Drought stress did not affect the fractional digestion rate (kd) of fibre in any tissue. The kd of fibre varied substantially among corn hybrids in upper (3.8 to 6.6%/h) and bottom internodes (4.2 to 6.7%/h) but did not vary in blades (3.8%/h). Significant interactions existed between irrigation treatment and corn hybrid for the effective ruminal degradation (ERD) of upper and bottom internodes. This interaction did not exist for blades. The ERD of fibre varied substantially among corn hybrids in blades (32.5 to 39.1%). The conclusions of this study are that drought-stressed corn had a marginal increase in fibre digestibility of blades but not in internodes, that drought stress had no effects on ERD of fibre within hybrids, and that the effect of drought stress on fibre digestibility of corn for silage is still inconclusive.

**Key words**: climate change; drought; fibre digestibility.

## Introduction

Limited and confusing information exists about the impact of drought stress on corn silage digestibility (Soderlund et al., 2012; Ferreira et al., 2020; 2021). In some countries, such as the US, there is a belief among farmers, nutrition consultants, and extension educators that water stress increases the digestibility of the fibre (Mahana and Thomas, 2011; Ferreira, 2020). Because of the difficulties associated with controlling environmental conditions (Farooq et al., 2009), controlled studies comparing the nutritional quality of drought-stressed and non-drought-stressed corn are limited (Ferreira et al., 2021).

Ferreira et al. (2021) reported that drought-stressed corn had a lower *in vitro* neutral detergent fibre digestibility in corn internodes than non-drought-stressed corn, although that effect did not exist in corn leaf blades. The latter observation suggested that the induced drought might not have been strong enough to exacerbate the effects of drought stress on neutral detergent fibre digestibility.

The objective of this study was to determine the effect of irrigation on *in situ* NDF digestibility **(ISNDFD)** of corn tissues grown under controlled conditions in a greenhouse.

## Methods and Study Site

Five commercial corn hybrids (3 conventional and 2 brown midrib) were planted in mini-pots at the Dairy Nutrition Laboratory. After emergence, 6 mini-pots per hybrid were transferred into 6 pots that were later placed in a greenhouse. Pots were subjected to 2 irrigation regimes, which consisted of either 600 or 300 mm of water for abundant **(A)** and restricted **(R)** irrigation, respectively.

At harvesting, leaf blades and stem internodes were collected from the upper (**UPPER**) and bottom (**BOTTOM**) portion of the plants. Tissue samples were dried at 55ºC and ground to pass through a 1-mm screen of a Wiley mill. Ground samples were inserted into acetone-rinsed porous bags (F57, Ankom Technology, Macedon, NY) and incubated in the rumen of 3 rumen-cannulated cows fed a total mixed ration containing 32% corn silage, 3% alfalfa hay, and 65% concentrate mix (DM basis). Bags were incubated for 0, 3, 6, 12, 24, 48, 96, and 240 hours.

Digestion kinetic parameters were estimated using the NLIN procedure of SAS (SAS version 9.4, SAS Institute Inc., Cary, NC) and according to the model ISNDFD = $\{(100 - \text{uNDF}) \times [1 - e^{(-kd \times T)}]\}$, where T is

the time of fermentation in hours, uNDF is the undigested NDF as a percent of initial NDF after 240 h of fermentation, and *kd* is the fractional disappearance rate per hour of the potentially digestible NDF **(pdNDF)**. The effective ruminal degradability was determined as ERD = {pdNDF ÷ [*kd*/(*kd*+*kp*)]}, where *kp* is the passage rate considered at 5%/h.

The experiment was designed and analysed as a randomized complete block design with a 2 × 5 factorial arrangement of treatments with 3 replicates. The model included the effects of cow (random; 2 degrees of freedom, **df**), irrigation treatment (fixed; 1 df), corn hybrid (fixed; 4 df), the irrigation treatment by hybrid interaction (fixed; 4 df), and the random residual error (18 df). Protected multiple comparisons were performed according to the method of Tukey, and significant statistical difference was declared at $P < 0.05$.

## Results

Due to the limited amount of tissue harvested, we did not analyse data for the BOTTOM leaf blades **(Table 1)**. Drought stress did not affect the concentration of uNDF in UPPER or BOTTOM internodes but slightly decreased it in UPPER leaf blades (17.5 and 15.7% for A and R, respectively). The concentration of uNDF varied substantially among corn hybrids in UPPER internodes (13.4 to 28.3% uNDF), BOTTOM internodes (21.5 to 42.3% uNDF), and UPPER blades (11.6 to 20.1% uNDF). No interactions existed between irrigation treatment and corn hybrid for uNDF concentration. Drought stress did not affect the fractional digestion rate of fibre in any tissue. The fractional digestion rate of fibre varied substantially among corn hybrids in UPPER internodes (3.8 to 6.6%/h) and BOTTOM internodes (4.2 to 6.7%/h) but did not vary in UPPER blades (3.8%/h). No interactions existed between irrigation treatment and corn hybrid for the fractional digestion rate of fibre. Significant interactions existed between irrigation treatment and corn hybrid for the effective ruminal degradation of UPPER and BOTTOM internodes. This interaction did not exist for UPPER blades. The effective ruminal degradation of fibre varied substantially among corn hybrids in UPPER blades (32.5 to 39.1%).

**Table 1.** Main effects of *in situ* ruminal fibre digestion kinetics of 5 corn hybrids grown in a greenhouse at 2 irrigation regimes [600 and 300 mm of water for abundant (A) and restricted (R) irrigation, respectively].

| | Irrigation | | Hybrid | | | | | | *P* < | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | R | H1 | H2 | H3 | H4 | H5 | SEM | I | H | I × H |
| *Upper internodes* | | | | | | | | | | | |
| pdNDF,† % NDF | 75.7 | 76.9 | 75.7 | 72.6 | 86.6 | 71.7 | 74.7 | 1.5 | 0.31 | 0.01 | 0.76 |
| uNDF,‡% NDF | 24.3 | 23.1 | 24.3 | 27.4 | 13.4 | 28.3 | 25.3 | 1.5 | 0.31 | 0.01 | 0.76 |
| kd,§ %/h | 4.5 | 5.2 | 3.8 | 3.8 | 4.5 | 6.6 | 5.2 | 0.5 | 0.10 | 0.01 | 0.07 |
| ERD,¶ % | 34.5 | 38.5 | 33.2 | 30.9 | 40.2 | 40.3 | 37.8 | 2.2 | 0.01 | 0.01 | 0.04 |
| *Bottom internodes* | | | | | | | | | | | |
| pdNDF, % NDF | 63.9 | 66.0 | 64.7 | 60.4 | 78.5 | 63.4 | 57.7 | 1.6 | 0.23 | 0.01 | 0.42 |
| uNDF, % NDF | 36.1 | 33.0 | 25.3 | 39.6 | 21.5 | 36.6 | 42.3 | 1.6 | 0.23 | 0.01 | 0.42 |
| kd, %/h | 5.1 | 5.5 | 4.2 | 5.9 | 4.5 | 6.7 | 5.4 | 0.5 | 0.35 | 0.02 | 0.28 |
| ERD, % | 31.6 | 33.8 | 29.0 | 32.0 | 36.9 | 35.8 | 29.7 | 1.5 | 0.13 | 0.01 | 0.05 |
| *Upper blades* | | | | | | | | | | | |
| pdNDF, % NDF | 82.5 | 84.3 | 79.9 | 82.6 | 88.4 | 80.2 | 85.9 | 1.0 | 0.02 | 0.01 | 0.33 |
| uNDF, % NDF | 17.5 | 15.7 | 20.1 | 17.4 | 11.6 | 19.8 | 14.1 | 1.0 | 0.02 | 0.01 | 0.33 |
| kd, %/h | 3.8 | 3.9 | 3.5 | 3.9 | 4.0 | 3.9 | 3.9 | 0.5 | 0.42 | 0.30 | 0.21 |
| ERD, % | 35.3 | 36.5 | 32.5 | 35.7 | 39.1 | 34.8 | 37.3 | 2.7 | 0.14 | 0.01 | 0.23 |

†pdNDF = potentially digestible neutral detergent fibre.

‡uNDF = undegraded neutral detergent fibre (after 240 h of fermentation).

§kd = fractional digestion rate of pdNDF.

¶ ERD = effective ruminal degradation.

## Discussion

Evaluating the effect of drought stress on fibre digestibility is a difficult task. From one side, it is extremely hard to control environmental conditions to induce and manage drought stress (Farooq et al., 2009). From the other side, growing plants in controlled environments, such as water exclusion shelters or greenhouses, may affect the growing conditions in unusual ways. In this study, for example, we observed very strange looking corn plants with very thin stem internodes, even to the point of needing some assisted support to avoid lodging.

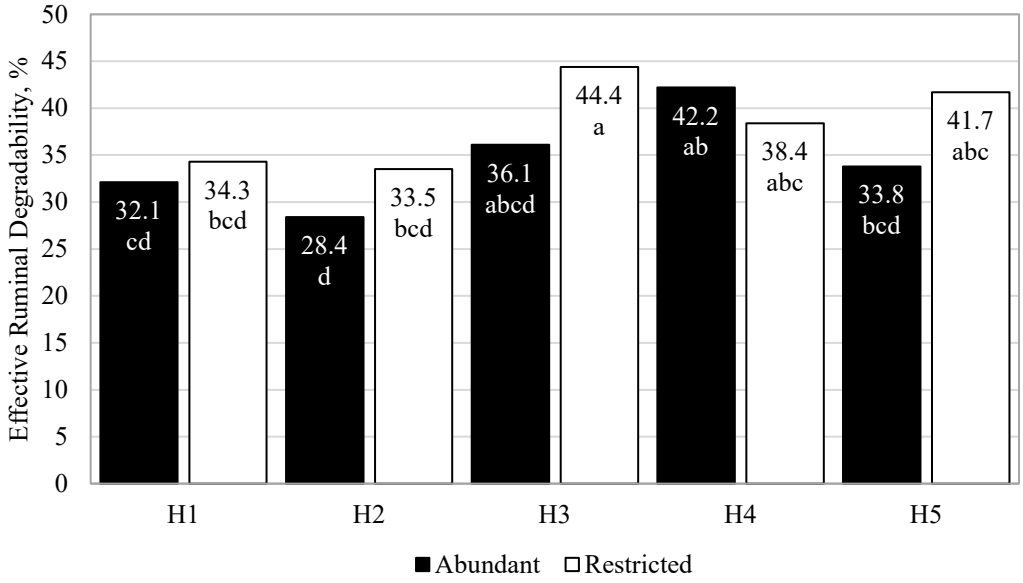


**Figure 1.** Effective ruminal degradation of neutral detergent fibre of upper stem internodes from 5 corn hybrids grown in a greenhouse at 2 irrigation regimes (600 and 300 mm of water for abundant and restricted irrigation).

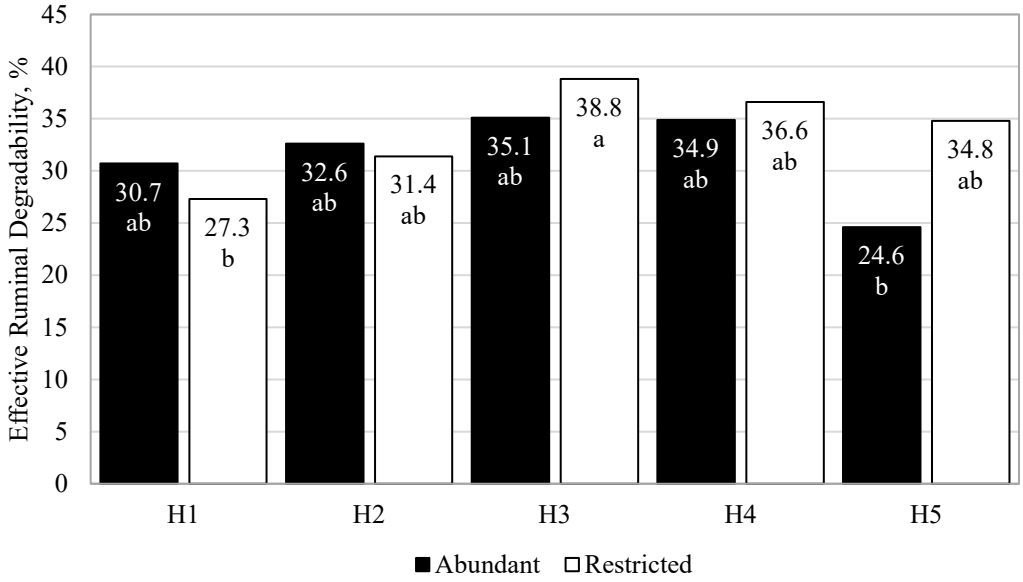


**Figure 2.** Effective ruminal degradation of neutral detergent fibre of bottom stem internodes from 5 corn hybrids grown in a greenhouse at 2 irrigation regimes (600 and 300 mm of water for abundant and restricted irrigation).

In a recent study, Ferreira et al. (2021) concluded that drought stress did not increase neutral detergent fibre digestibility after seeing a marginal decrease in neutral detergent fibre digestibility in drought-stressed

corn internodes and claimed that such result is contrary to the belief of the industry. To follow up, this study was designed to better control the growing conditions. Based on the uNDF concentration after 240 h of fermentation, drought stress marginally increased fibre digestibility in upper leaf blades but not in stem internodes. This observation does not agree with that from Ferreira et al. (2021). After analysing the interactions between irrigation and hybrid on effective ruminal degradability (**Figures 1 and 2**), a pattern can be observed indicating that drought stress increased fibre digestion kinetics, although no statistical differences between irrigation treatments were observed within the same hybrid. The observations of the current study agree with those reported by Soderlund et al. (2012), who reported increases of neutral detergent fibre digestibility from 50 to 55% with decreasing irrigation. However, different to this study and the previous study (Ferreira et al. 2021), Soderlund et al. (2012) measured fibre digestibility in whole plants, a procedure that may confound structural composition of the plant with fibre digestibility at the tissue level.

## Conclusions

From this study we conclude three things. First, drought-stressed corn had a marginal increase in fibre digestibility of leaf blades but not in stem internodes. Second, when comparing irrigation treatments within hybrids, drought stress had no effects on effective ruminal degradation of fibre. Finally, and more broadly, the effect of drought stress on fibre digestibility of corn for silage is still inconclusive and deserves further investigation.

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