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Effect of environmental factors on the digestibility and voluntary feed intake of kikuyu

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Abstract
Digestion trials using sheep and voluntary feed intake (VFI) trials using long yearling heifers in Calan gates were conducted in the spring, summer and autumn. Five years of digestibility data, amounting to 82 digestion trials, was pooled for this study. Voluntary intake data was pooled for the three years of intake trials, amounting to 38 intake trials. These data and the daily maximum temperatures, rainfall and evaporation recorded at and prior to the digestion and intake trials at Cedara were pooled, analysed using multiple regression techniques, and regressed on dry matter digestibilty and VFI, to examine the influence of environment on the nutritive value of the herbage and to develop simple linear regression models for predicting kikuyu quality and intake. Rainfall and temperature in the period of cutting (plot preparation) and fertilization had a negative effect on digestibility, irrespective of the stage of re-growth at harvesting, 20, 30 or 40 days later, and a combination of the two proved significant, accounting for the most variance in DMD. Temperature depressed DMD by 28.1 g/kg DM per degree rise in temperature (^{o}C). Temperatures recorded during the cutting and fertilization phase were highly negatively correlated to VFI, irrespective of stage of re-growth.

Keywords: *Pennisetum clandetinum*, DMD, VFI, environmental temperature, rainfall
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Introduction
Climatic factors such as temperature, water availability and high evaporative demand could cause differences in dry matter digestibility (Minson & McLeod, 1970; Minson, 1990). The effect of temperature, rainfall and evaporation on dry matter digestibility (DMD) and voluntary feed intake (VFI) were evaluated for kikuyu pasture in the KZN Midlands where kikuyu forms a significant part of the dairy farm fodder-flow.

Materials and Methods
Kikuyu pasture was fertilized at two levels of nitrogen, namely 50 and 200 kg N/ha, after mowing and clearing the plots, to induce low and high levels of nitrogen in the herbage. The subsequent growth was harvested at 20, 30 and 40 days of re-growth. These treatments were conducted in spring, summer and autumn, over several years. Five years of digestibility data, determined using the technique described by Juko *et al*. (1961), amounting to 82 digestion trials, was pooled for digestibility. Voluntary intake data, cut and fed using Calan feed gates (Broadbent *et al*., 1970), was pooled for the three years of intake trials, amounting to 38 intake trials.

The daily maximum temperatures, rainfall and evaporation recorded at and prior to the digestion and intake trials at Cedara were extracted from the database of the Institute for Soil, Climate and Water of the Agricultural Research Council. The temperatures recorded are abbreviated to T_0 for the mean temperature of actual trial period (harvesting), T_{-1} for the mean of the week prior to the trial period, T_{-2} for the mean of the second week prior to the trial period and T_{fert} for the mean temperatures at cutting and N fertilization. The rainfall recorded is abbreviated to R_0 for the mean rainfall of actual trial period, R_{-1} for the mean of the week prior to the trial period, R_{-2} for the mean of the second week prior to the trial period and R_{fert} for the mean rainfall at cutting and N fertilization. Similarly, evaporation figures are abbreviated as E_0, E_{-1}, E_{-2} and E_{fert}. Daily maximum temperature, rainfall and evaporation recorded during and prior to the trial periods were regressed on DMD (g/kg DM) and VFI (kg DM/100kg body weight), using the multiple linear regression techniques, including the stepwise regression analysis procedure of GenStat v9.1 (GenStat, 2006) to examine the influence of environment on the nutritive value of the herbage.

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Results

Rainfall and temperatures over the years were highly variable, ranging from very high rainfall seasons to a severe drought, when several trials could not be completed due to a lack of herbage. The autumn in growing season 4 was particularly hot, although rainfall was very close to normal.

The digestibility of the herbage was not affected by the temperature or rainfall during the duration of the digestion trial (at harvesting). However, the temperatures recorded in the week prior (T_{-1}) to the trial had a negative impact on digestibility, although only accounting for little of the variability in DMD. A combination of the temperature data proved significant and improved the variance in DMD accounted for as indicated in the following equations:

$DMD = 979 - 13.8 (T_{-1})$; P <0.001; $R^2 = 0.167$; n = 82
$DMD = 1336 - 9.286 (T_{-1}) - 7.477 (T_{-2}) - 12.002 (T_{fert})$; P <0.001; $R^2 = 0.318$; n = 82

Rainfall in the week prior to the trial had no impact on digestibility, while the rainfall in the second week prior to the digestion trial tended to improve digestibility, but accounted for very little of the variability in digestibility. A combination of the rainfall data proved significant and improved the variance in DMD accounted for, as indicated in the following equations:

$DMD = 629 + 0.479 (R_{-2})$; P = 0.051; $R^2 = 0.03$; n = 82
$DMD = 643 + 0.396 (R_{-1}) + 0.891 (R_{-2}) - 1.059 (R_{fert})$; P <0.001; $R^2 = 0.307$; n = 82

Evaporation also exerted a significant effect on digestibility, although it accounted for little of the variation in DMD as described in the following equations:

$DMD = 579 + 12.9 (E_0)$; P = 0.04; $R^2 = 0.039$; n = 82
$DMD = 755 - 22.1 (E_{-2})$; P <0.001; $R^2 = 0.13$; n = 82

High evaporation rates at cutting and feeding enhanced DMD. Evaporation rates 2 weeks prior to cutting and feeding have negative effects on DMD, the opposite effect to rainfall at 2 weeks prior to harvesting.

Surprisingly, the rainfall and temperature in the period of cutting and fertilization had the largest effect on digestibility, irrespective of the stage of re-growth at harvesting (20, 30 or 40 days) and a combination of the two proved significant, accounting for the most variance in DMD. These equations are given below:

$DMD = 672 - 0.83 (R_{fert})$; P <0.001; $R^2 = 0.168$; n = 82
$DMD = 1063 - 17.7 (T_{fert})$; P <0.001; $R^2 = 0.23$; n = 82
$DMD = 1090 - 0.826 (R_{fert}) - 17.6 (T_{fert})$; P <0.001; $R^2 = 0.40$; n = 82

When combined, only the rainfall and temperature at fertilization proved significant factors in a multiple regression predicting DMD. This combination of rainfall and temperature at cutting and fertilization accounted for 40 % of the variability found in the digestibility of the kikuyu. Including evaporation rates with the rainfall and temperature data increased the variability accounted for slightly, as indicated in the following equation:

$DMD = 1141.8 - 0.74 (R_{fert}) - 16.6 (T_{fert}) - 15.6 (E_{-2})$; P <0.001; $R^2 = 0.465$; n = 82

In terms of temperature, the longer term mean temperature, namely for the month (mth 0) during which the trial was conducted and even the month prior to that (mth-1), was highly correlated to digestibility, as indicated in the following equation:

$DMD = 1325 - 28.17 (T_{mth\ 0})$; P < 0.001; $R^2 = 0.23$; n = 82
$DMD = 1242 - 24.6 (T_{mth-1})$; P < 0.001; $R^2 = 0.22$; n = 82
$DMD = 1533 - 19.6 (T_{mth\ 0}) - 17.01 (T_{mth-1})$; P < 0.001; $R^2 = 0.23$; n = 82

The negative effect of temperature on digestibility is consistent with, but higher than the response recorded by Minson & McLeod (1970) who found that DMD was depressed by 11.4 g/kg DM per degree rise in temperature (^oC).

The voluntary intake of kikuyu was not correlated to the temperature or rainfall recorded during the actual intake trial, similar to digestibility. Rainfall in the week prior to the trial tended to be positively related to voluntary intake, but accounting for very little of the variability in intake, as quantified in the following equation:

$VFI = 2.10 + 0.008 (R_{-1})$; $P = 0.056$; $R^2 = 0.07$; $n = 38$

Rainfall occurring during the cutting and fertilization period was not significantly correlated to VFI, unlike the effect on digestibility. The daily maximum temperatures recorded in the week prior to the intake trials were negatively correlated to intake, similar to the effect on digestibility. Surprisingly, the temperatures recorded during the cutting and fertilization phase were highly correlated to VFI, irrespective of stage of re-growth, accounting for some 40% of the variability in intake. A combination of the temperature data proved significant and improved the variance in DMD accounted for as indicated in the following equations:

$VFI = 5.68 - 0.139 (T_{-1})$; $P = 0.01$; $R^2 = 0.14$; $n = 38$
$VFI = 6.54 - 0.187 (T_{fert})$; $P < 0.001$; $R^2 = 0.42$; $n = 38$
$VFI = 8.57 - 0.097 (T_{-1}) - 0.173 (T_{fert})$; $P < 0.001$; $R^2 = 0.497$; $n = 38$

In contrast to digestibility, when temperature and rainfall data was combined to predict VFI, rainfall did not contribute significantly to the regression equation.

Evaporation at harvesting and at cutting and fertilization was also related to VFI, as indicated below:

$VFI = 1.49 + 0.163 (E_0)$; $P = 0.012$; $R^2 = 0.138$; $n = 37$
$VFI = 1.31 + 0.196 (E_{fert})$; $P = 0.002$; $R^2 = 0.206$; $n = 37$

However, due to highly significant correlations between temperature and evaporation at cutting and fertilization and at harvesting these variables could not be included together in a regression.

Discussion

Minson (1990) stated that seasonal differences in DMD could be a result of changes in temperature, water availability and light. The negative effect of temperature on digestibility recorded for this kikuyu data is higher than that recorded for other species, namely; -11.4 g/kg by Minson & MacLeod (1970) -18 g/kg by Deinum & Dervin (1976) and -5.6 g/kg by Wilson & Minson (1980). It is of interest to note that the effects of temperature and rainfall appear to be implicated when the pasture is fertilized rather than at harvesting.

A lag effect appears to exist between the effect of rainfall on the digestibility or intake of kikuyu, with rainfall the week prior to harvesting shown to be positively associated with both DMD and VFI. Rainfall in the week of harvesting had no effect on DMD or VFI, possibly due to rainfall during the harvesting period only contributing to extra-cellular water, rather than intracellular water. Minson & McLeod (1970) also noted that DMD was negatively correlated to mean daily temperature the month prior to cutting (r = -0.97), as was total evaporation (r = -0.91).

An examination of the correlations between the environmental factors and herbage DM content show that the rainfall at fertilization was negatively correlated to the DM of the herbage at harvesting, while the maximum daily temperatures at fertilization and in the weeks prior to harvesting are negatively associated with the DM content of the herbage at harvesting. The highest correlation was recorded at fertilization. Evaporation at fertilization and at harvesting was positively associated with the DM content of the herbage. Crude protein content of the herbage has been negatively associated with DMD and VFI. Both the temperature (0.21) and rainfall (0.19) at fertilization is positively associated with CP levels at harvesting, while the evaporation at fertilization was negatively associated (-0.41) with CP at harvesting. These factors are possibly indicated in the absorption of nitrates at fertilization, high rainfall and temperature positively associated with N uptake by the plant, while high evaporation reduced the uptake of N by the plant.

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It is of interest to note that the factors generally positively associated with grass growth and productivity, namely, N fertilization, rainfall and heat (temperature) were negatively related to DMD and VFI. This poses a dilemma for the pasture farmer, as both the quantity of pasture grown and its quality are important for economic animal production. This data appears to confirm the commonly held belief that a dry year is good for animal production, relative to wet years. Similarly, Wilson (1981a; b) found that, for tropical species, drought or slight moisture stress increased digestibility relative to well-watered forage. Snaydon (1972) concluded that increased water supply decreased the digestibility of lucerne, which was contrary to the general assumption that irrigated lucerne was more digestible than dry-land lucerne. However, Garwood *et al.* (1979) found no consistent effect of water on the digestibility of temperate grasses.

Conclusion

The effect of environment on digestibility and intake is of concern considering global warming. Temperature decreased digestibility by 4.4% and intake by 15% for every degree rise in temperature. The implications on livestock production are considerable, reducing potential milk yields by approximately 36% for one degree rise in temperature if grazing pasture alone.

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