Analyses of Accumulation of Crude Protein and Decrease in its Content in the Growth of Chloris gayana Kunth and Desmodium intortum (Mill.) Urb.

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https://doi.org/10.5109/24227

出版情報：九州大学大学院農学研究院紀要. 42 (3/4), pp.377-381, 1998-03. Kyushu University
バージョン：
権利関係：

J. Fac. Agr., Kyushu Univ., **42** (3·4), 377-381 (1998)

Analyses of Accumulation of Crude Protein and Decrease in its Content in the Growth of *Chloris gayana* Kunth *and Desmodium intortum* (Mill.) Urb.

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(*Received November 28, 1997 and accepted December 3, 1997*)

This study was conducted to analyze the accumulation of crude protein using equation (A) and to analyze the decrease in crude protein content using equation (B) in the growth of Rhodes grass (Rg) and Greenleaf desmodium (Gd).

$$\mathrm{ARCP} = \frac{1}{W} \cdot \frac{d(CP)}{dt}, \qquad \text{(A)}$$

where W = dry weight of forage (g/m^2) ($W_1 \neq W_2$), CP = amount of crude protein in forage (mg/m^2), ARCP = accumulation rate of *CP* per unit W.

$$\mathrm{DCPC} = \frac{1}{1000} \cdot \left(\frac{CP1}{W_1} - \frac{CP2}{W_2}\right) = \left(1 - \frac{W1}{W2}\right) \cdot \left\{\frac{1}{1000} \cdot \left(\frac{CP1}{W_1} - \frac{\overline{\mathrm{ARCP}}}{\mathrm{RGR_W}}\right)\right\}, \qquad \text{(B)}$$

where DCPC = the decrease in *CP* content, $(1 - W_1/W_2)$ = forage growth index [FG index], $\overline{\mathrm{RGR_w}}$ = mean relative growth rate of forage, $\overline{\mathrm{ARCP}}$ = mean ARCP, $(CP_1/W_1 - \overline{\mathrm{ARCP}}/\overline{\mathrm{RGR_w}})/1000$ = index for the decrease in the ratio of *CP* to W [DRCP index].
Each attribute was given a bar on it to show mean value over the interval of 28 days of regrowth.
The following results were obtained:
1. $\overline{\mathrm{ARCP}}$ over 28 day-growth for Rg was lower than that for Gd.
2. Larger DCPC in Rg compared with Gd was caused by higher FG index in Rg.
It was suggested that the present method gave a macro analysis of the accumulation of crude protein and the decrease in its content in the growth of tropical forages.

INTRODUCTION

Crude protein content as well as dry matter digestibility is of importance to the production from ruminants fed forages (Van Soest, 1982; Minson, 1990). As a forage plant grows its crude protein content generally falls. Analysis of this process is probably associated with the accumulation of crude protein and the decrease in its content that occur in the growth of forage. This process appears to be similar in part to the accumulation of digestible materials and the decrease in dry matter digestibility. Therefore, the method for analyzing the accumulation and content of crude protein might be expected to be similar in part to a method presented by Shimojo *et al.* (1998) to analyze the accumulation of digestible materials and the decrease in dry matter digestibility.

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This study was designed to present a method for analyzing the accumulation of crude protein and the decrease in its content in the growth of forages, and followed by an application to two tropical forages, a grass (*Chloris gayana* Kunth) and a forage legume (*Desmodium intortum* (Mill.) Urb.) whose indigestibility changes had been reported previously (Shimojo *et al.*, 1997).

METHODS FOR ANALYZING THE ACCUMULATION OF CRUDE PROTEIN AND THE DECREASE IN ITS CONTENT WITH FORAGE GROWTH

Accumulation of crude protein with growth of forage

Nitrogen absorbed from the soil by plant roots is used for the synthesis and accumulation of crude protein in forages. In the present study accumulation rate of crude protein per unit forage dry weight [ARCP] is described as follows:

$$\mathrm{ARCP} = \frac{1}{W} \cdot \frac{d(CP)}{dt}, \qquad (1)$$

where W = dry weight of forage (g/m^2), CP = amount of crude protein in forage (mg/m^2). The unit weight of W is expressed in grams (g), but CP is expressed in milligrams (mg) because its amount is very low compared to the amount of W.

Mean value of ARCP over the interval t_1 to t_2 is approximately as follows:

$$\overline{\mathrm{ARCP}} = \frac{\log_e W_2 - \log_e W_1}{W_2 - W_1} \cdot \frac{CP_2 - CP_1}{t_2 - t_1}, \qquad (2)$$

where e = the base of natural logarithm, $W_1 \neq W_2$.

Decrease in CP content with growth of forage

The decrease in CP content [DCPC] over the interval t_1 to t_2 is as follows:

$$\mathrm{DCPC} = \frac{1}{1000} \cdot \left(\frac{CP_1}{W_1} - \frac{CP_2}{W_2} \right). \qquad (3)$$

The right side of equation (3) is rewritten as follows:

$$\begin{aligned} \frac{CP_1}{W_1} - \frac{CP_2}{W_2} &= \frac{CP_1}{W_1} - \frac{CP_1 + \Delta CP}{W_1 + \Delta W} \\ &= \frac{CP_1 \cdot \Delta W}{W_1 \cdot (W_1 + \Delta W)} - \frac{\Delta CP}{W_1 + \Delta W} \\ &= \frac{CP_1 \cdot \Delta W}{W_1 \cdot W_2} - \frac{\Delta CP}{W_2} \\ &= \frac{\Delta W}{W_2} \left(\frac{CP_1}{W_1} - \frac{\Delta CP}{\Delta W} \right). \end{aligned} \qquad (4)$$

Here the ratio of ARCP to relative growth rate of forage [$\mathrm{RGR_w}$] is taken up as follows:

$$\begin{aligned} \frac{\mathrm{ARCP}}{\mathrm{RGR_w}} &= \frac{\dfrac{1}{W} \cdot \dfrac{d(CP)}{dt}}{\dfrac{1}{W} \cdot \dfrac{dW}{dt}} \\ &= \frac{d(CP)}{dW}. \end{aligned} \qquad (5)$$

Thus, the following relation is obtained,

$$\frac{\Delta CP}{\Delta W} = \frac{\overline{ARCP}}{RGR_w}, \qquad (6)$$

where $\overline{ARCP}$ = mean ARCP over the interval t_1 to t_2, $\overline{RGR_w}$ = mean RGRw over the interval t_1 to t_2.

Inserting equation (6) into equation (4) gives

$$\frac{CP_1}{W_1} - \frac{CP_2}{W_2} = \left(1 - \frac{W_1}{W_2}\right) \cdot \left(\frac{CP_1}{W_1} - \frac{\overline{ARCP}}{RGR_w}\right). \qquad (7)$$

Then, the following equation for DCPC is given

$$\begin{aligned} DCPC &= \frac{1}{1000} \cdot \left(\frac{CP_1}{W_1} - \frac{CP_2}{W_2}\right) \\ &= \left(1 - \frac{W_1}{W_2}\right) \cdot \left\{\frac{1}{1000} \cdot \left(\frac{CP_1}{W_1} - \frac{\overline{ARCP}}{RGR_w}\right)\right\}, \end{aligned} \qquad (8)$$

where $W_1 \neq W_2$, $(1 - W_1/W_2)$ = forage growth index [FG index], $(CP_1/W_1 - \overline{ARCP}/\overline{RGR_w})/1000$ = index for the decrease in the ratio of CP to W [DRCP index].

DCPC is originally expressed using a complex of W and CP which are connected inseparably (equation (3)). As FG index refers only to the forage production that is taken compulsorily out of the complex, DRCP index as the partition factor inevitably includes RGR_w to complete the inseparable connection. Thus, equation (8) shows that DCPC is expressed as the product of FG index and DRCP index.

APPLICATION OF ANALYTICAL METHODS TO TWO TROPICAL FORAGES

Forage samples

Characteristics of Rhodes grass (*Chloris gayana* Kunth) and Greenleaf desmodium (*Desmodium intortum* (Mill.) Urb.) are shown in Table 1. Rhodes grass (Rg) and Greenleaf desmodium (Gd) were cut at 35 and 63 days of regrowth after the first cut and discard followed immediately by the dressing of a compound fertilizer ($N:P_2O_5:K_2O$ = 14:14:14%) at a rate of 1.0 kg/a for each element.

Table 1. Characteristics of Rhodes grass (Rg) and Greenleaf desmodium (Gd).

Forages	Rg		Gd	
Regrowth (days)	35	63	35	63
Dry weight of forage: W (g/m^2)	225.56	515.00	190.00	315.28
Amount of crude protein: CP (mg/m^2)	22450.0	27850.0	30540.0	40080.0
CP content in forage (g/g)	0.0995	0.0541	0.1607	0.1271

Crude protein: determined using Kjeldahl method.

Accumulation of CP in the growth of two forages

The results for the analysis of the accumulation of *CP* in Rg and Gd in the growth from 35 to 63 days are shown in Table 2a.

ARCP over 28 day-growth for Rg was lower than that for Gd (0.5501 versus 1.3773). This difference may be due to the increased amount of nitrogen in Gd that has been fixed from the air by symbiotic root nodule bacteria.

Table 2. Analyses of accumulation of crude protein and the decrease in its content in the growth of Rhodes grass (Rg) and Greenleaf desmodium (Gd).

a) Analysis of accumulation of CP in the growth of Rg and Gd.

Forages Interval (days)	Rg(A) 28	Gd(B) 28	A/B
ARCP (mg/g/day)	0.5501	1.3773	0.3994

ARCP: accumulation rate of *CP* per unit *W*.

b) Analysis of the decrease in *CP* content in the growth of Rg and Gd.

Forages Interval (days)	Rg(A) 28	Gd(B) 28	A/B
DCPC	0.0455	0.0336	1.3523
FG index	0.5620	0.3974	1.4144
DRCP index	0.0809	0.0846	0.9561

DCPC: the decrease in *CP* content.
FG index: forage growth index.
DRCP index: index for the decrease in the ratio of *CP* to *W*.

Decrease in CP content with growth of two forages

The results for the analysis of DCPC in the growth of Rg and Gd are shown in Table 2b. DCPC over 28 day-growth in Rg (0.0455) was larger compared with that in Gd (0.0336). FG index was higher in Rg than in Gd (0.5620 versus 0.3974). DRCP index showed little difference between two forages (0.0809 versus 0.0846). Therefore, larger DCPC in Rg compared with Gd was caused by higher FG index in Rg. This suggests that higher rate of growth causes a larger reduction in the concentration of *CP* in Rg, when compared with Gd.

Conclusions

It is suggested from this study that the present method gives a macro analysis of the accumulation of crude protein and the decrease in its content in the growth of tropical forages. The present analytical method should be applied to other tropical and temperate forages.

ACKNOWLEDGEMENTS

We wish to thank Dr. Mitsuhiro Furuse who encouraged us during the writing this paper and Mr. Yasukatsu Yano for his skilled technical assistance in the present work.

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