SELECTION FOR HIGH DRY MATTER AND NONSTRUCTURAL CARBOHYDRATE CONTENTS IN ITALIAN RYEGRASS

J.P. Marais[1], M. de Figueiredo[1] and D.C.W. Goodenough[2]

[1] KwaZulu-Natal Department of Agriculture, Cedara, Private Bag X9059, Pietermaritzburg, South Africa, 3200

[2] Roodeplaat Grassland Institute, Agricultural Research Council, Private Bag X9059, Pietermaritzburg, South Africa, 3200

ABSTRACT

The objective of this investigation was to determine whether or not the selection parameters, dry matter and total nonstructural carbohydrate contents, in an Italian ryegrass (*Lolium multiflorum*) selection trial were linked to other traits affecting nutritive quality. Selected F3 plants had significantly higher dry matter and total nonstructural carbohydrate contents than the commercial control plants tested. Although differences in digestibility *in vitro* of selected plants and control cultivars were non-significant, the selected plants contained less acid detergent fibre and acid detergent lignin than the controls. Acid detergent fibre and acid detergent lignin, the main anti-quality factors associated with pasture grasses, do not appear to be positively linked to the dry matter and non-structural carbohydrate content of Italian ryegrass.

KEYWORDS

Italian ryegrass, nutritive value, dry matter content, nonstructural carbohydrates, acid detergent fibre, acid detergent lignin, digestibility *in vitro*

INTRODUCTION

The voluntary dry matter intake by ruminants decreases at dry matter contents less than ca. 200 g kg^{-1} fresh forage (John and Ulyatt, 1987; Meissner *et al.*, 1992). Furthermore, high concentrations of total nonstructural carbohydrates in forages improve their palatability and voluntary intake (Bailey, 1965). Certain growth characteristics of the plant, such as persistence, regrowth after defoliation, and resistance to drought and cold are also improved (Humphreys, 1989).

The dry matter content of Italian ryegrass (*Lolium multiflorum*) from pastures at the KwaZulu-Natal Department of Agriculture, Cedara, is usually well below 200 g kg^{-1} fresh forage, while the total non-structural carbohydrate content is often below 120 g kg^{-1} fresh forage towards the end of the growing season (Marais *et al.*, 1993), suggesting room for improvement. Since the nonstructural carbohydrate and dry matter contents of ryegrass not only show genotypic differences, but are also markedly affected by environmental factors (Marais *et al.* 1993), special precautions were required to minimise environmental effects in selection trials. These precautions will be discussed. Furthermore, in selecting for specific desirable characteristics, some less desirable features could be introduced, since certain genetic traits are linked on the same chromosomes. The aim of this investigation was to establish whether or not the dry matter and nonstructural carbohydrate contents are linked to other traits affecting nutritive quality.

PROCEDURE

The plants used in this cultivar selection programme were derived from the Italian ryegrass cultivars, Exalta, Titania, and Lemtal, which were relatively high in dry matter and nonstructural carbohydrate content. The programme was based on a polycross selection technique.

Six genetically identical replicates of 101 plants (F3) as well as six replicates of four control cultivars, Exalta, Midmar, Dargle and Boston were established in a spaced-plant nursery at 0.5 m centres using a simple random design. Basal P and K levels were restored to 20 and 150 mg kg^{-1} respectively prior to planting. Nitrogen was applied at a rate of 50 kg N ha^{-1} after each cut. Plants were irrigated at weekly intervals to an equivalent of 25 mm. Sampling of plants commenced at 12h00. Plants were cut in known order at a height of 50 mm above ground level every four weeks for dry matter determination and screening for total nonstructural carbohydrate content by near infra-red reflectance spectroscopy. The validity of the near infra-red estimates of total nonstructural carbohydrates was verified by wet chemistry (Marais, 1979). Samples were analysed for acid detergent fibre and acid detergent lignin (Van Soest, 1963), and digestibility *in vitro* (Minson & McLeod, 1972). The chemical composition of selected plants was compared with that of the control cultivars by means of analysis of variance. Inter-relations between chemical parameters were investigated using regression analysis.

RESULTS AND DISCUSSION

The total nonstructural carbohydrate values obtained by infra-red reflectance spectroscopy were strongly correlated ($r = 0.95$) with values obtained by wet chemistry. The trial was evenly irrigated on the day prior to sampling to reduce variation in water stress on the plants, which could markedly increase the dry matter and total nonstructural carbohydrate content of the tissue. Three cuts were made during the growing season. At the third cut some plants were already in a reproductive phase, while others were still in the vegetative state. In order to ensure valid comparisons, the results of only the first two cuts were used for selection purposes. Plants were sampled after 12.00 noon when changes over time in daily TNC values were minimal. The dry matter and total nonstructural carbohydrate content did not change significantly during the sampling period of three hours for cuts one and two. However, under hot, dry conditions both dry matter and total nonstructural carbohydrate content could increase substantially with time. In order to make valid comparisons between plants under these circumstances, allowance should be made for compositional changes over time.

The 17 selected high dry matter plants had mean dry matter and total nonstructural carbohydrate contents of 213.6 and 178.1 g kg^{-1} respectively, compared to 186.6 and 207.1 g kg^{-1} respectively for the 16 high nonstructural carbohydrate selections (Table 1). These values were significantly higher ($P < 0.001$) than the values for each of the control cultivars. All the control cultivars contained significantly ($P < 0.001$) more acid detergent fibre and acid detergent lignin than the selected high dry matter and nonstructural carbohydrate plants. Differences between the digestibility *in vitro* of the selected and control plants were non-significant.

Since different plant characters are often linked on the same chromosomes, the selection for a high dry matter and nonstructural carbohydrate content may result in the introduction of other characteristics which could have positive or negative effects on the nutritive quality of the selected plant. In *Lolium perenne* a high nonstructural carbohydrate content was linked to a greater susceptibility to crown rust, *Puccinia coronata* (Breese and Davies,1970). In the present investigation several plants were discarded due to rust susceptibility.

Results presented in Table 2 show a significant positive correlation ($r = 0.62$, $P < 0.01$) between dry matter and total nonstructural carbohydrate content. The main factors which could reduce the nutritive value of Italian ryegrass are an increase in acid detergent fibre and lignin content and a reduction in digestibility. However, results show significant positive trends ($r = 0.39$ and $r = 0.46$, $P < 0.05$) between digestibility *in vitro* and dry matter and total nonstructural carbohydrate contents respectively. The dry matter and total nonstructural carbohydrate contents were poorly correlated with the acid detergent fibre content and showed a non-significant negative trend with the acid detergent lignin content. The dry matter and total nonstructural carbohydrate content of Italian ryegrass therefore do not appear to be positively linked to the main anti-quality factors associated with pasture grasses.

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Table 1
Chemical composition of selected high dry matter and nonstructural carbohydrate plants used in polycross, as compared to control cultivars.

Sample	Chemical composition (g kg^{-1})				
	TNC	DM	Digestibility *In vitro*	Acid detergent fibre	Acid detergent lignin
Selected plants					
High dry matter (DM)	178.1	213.6	700	222	35
High total nonstructural carbohydrates (TNC)	186.6	207.1	711	220	34
Controls					
Boston	126.2	158.6	702	265	53
Dargle	123.3	157.2	710	290	49
Midmar	120.6	155.2	685	252	52
Exalta	118.6	170.4	683	224	41
LSD (P<0.01) (selected plants vs controls)	41.7	17.4	28.4	31.5	12.2

Table 2
Correlation coefficients from linear equations for quality parameters measured in a *Lolium multiflorum* spaced-plant selection trial.

Parameters	**Correlation matrix**				
	DM	TNC	Digest.	ADF	ADL
Dry matter content (DM)	1.000				
Total nonstructural carbohydrate content (TNC)	0.619 **	1.000			
Digestibility in vitro (Digest.)	0.389 **	0.461 **	1.000		
Acid detergent fibre (ADF)	0.105	0.251	- 0.077 NS	1.000	
Acid detergent lignin (ADL)	- 0.161	- 0.204	- 0.361 *	0.202	1.000

Degrees of freedom 42 ; NS = P>0.05; * = P<0.005; ** = P<0.01