INTRODUCTION

Since the harvesting of forage always involves some mechanical action on the forage material, a knowledge of the mechanical properties of forage materials is necessary in the design of forage machinery. Prince et al. (4) state that cutting in a conventional mower occurs by a combination of crushing and tearing rather than by direct shear. This indicates that the tensile properties of forage materials are of importance.

Prince (3) reports values of 35 microinches per inch (average) for ultimate strain and 4434 psi (average) for ultimate stress of air-dry alfalfa stems. Halyk et al. (2) report values of ultimate stress of alfalfa stems ranging from 1260 to 5240 psi with moisture content and dry matter density accounting for 80% of the variability in the results.

This is a report of a study to determine the tensile strength, tensile modulus of elasticity and tensile breaking energy of alfalfa stems and to determine the relationship of these parameters to other physical properties of the stem material.

EQUIPMENT

A small testing machine (figure 1) with a fixed crosshead speed of 0.050 ipm was used in all tests; therefore, all results are for the quasi-static condition.

The jaws shown in figure 1 were developed to grip the stem specimens during testing. They were milled from solid steel blocks and a 1/4-inch layer of foam rubber was bonded to the jaw faces. A holding jig for the two pairs of jaws was constructed to provide support for the jaws during tightening and to facilitate the placement of the jaws and stem in the testing machine without danger of buckling the test length.

The lower jaws were attached by knife edge supports to a bonded strain gauge cantilever beam force transducer. Excitation and signal amplification for this transducer was provided by a Sanborn carrier preamplifier. The amplified signal was fed to the X-channel of a Moseley X-Y recorder.

A continuous record of stem elongation was provided by a photoelectric extensometer which was developed especially for this study. The design of the extensometer was such as to introduce a minimum of instrument error due to spring forces and instrument inertia. The signal from the extensometer was fed to the Y-channel of the X-Y recorder. Thus, the curve traced by the recorder was a continuous record of applied force and stem elongation.

Stem diameter was determined by means of a shadowgraph technique reported by Bilanski et al. (1).
preparation for the next test. The weighed sample was oven-dried and reweighed. These weights were used in moisture content and density determinations.

DATA REDUCTION

A measure of subjective judgment was required during one stage of data interpretation. Modulus of elasticity calculations required a value for the slope of the force-elongation curve; this was determined from a line of best fit as shown in figure 2.

For those stems which broke at a node within the test section, values of ultimate tensile force and ultimate tensile stress were determined.

The area under the elastic curve was determined using a planimeter. This value was used to determine the breaking energy of the stem specimen. This parameter was expressed in pound-inches per inch of stem length.

All data were subjected to a partial linear regression analysis to determine which tensile parameters best characterized the alfalfa stem and by what factors these parameters were affected. From the results of the regression analysis and observations made during the experimentation the following statements are made.

CONCLUSIONS

Since all tensile failures within the test section took place at the node, the node has the lowest tensile strength. This reaffirms a conclusion reached by Halyk et al. (2).

The ultimate tensile force fell between 20.8 and 62.9 lb. and varied directly with stem linear density (dry basis). See figure 3.

The ultimate tensile stress fell between 1660 and 8370 psi and varied directly with the stem bulk density (dry basis). See figure 4.

The input energy to cause tensile failure fell between 0.0496 and 0.6806 lb.-in. per inch of stem length and varied directly with linear density (dry basis).

The tensile modulus of elasticity fell between $1.33 \times 10^5$ and $9.87 \times 10^5$ psi and varied directly with bulk density (dry basis). See figure 5.

Low correlation coefficients for the regression equations relating moisture to the tensile parameters indicated that moisture content is not consistent in its effect on tensile properties.

REFERENCES


