NOTA BREVE

PHYSICAL AND RHEOLOGICAL PROPERTIES OF FORAGE CROPS WITH REFERENCE TO CUTTING

EL CORTE Y PROPIEDADES FÍSICAS Y REOLÓGICAS DEL FORRAJE

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ADDITIONAL KEYWORDS

Age. Moisture. Diameter. Shear. Maize. Sorghum.

PALABRAS CLAVE ADICIONALES

Edad. Humedad. Diámetro. Corte. Maíz. Sorgo.

SUMMARY

The cutting process of forage crops is greatly influenced by its physical and rheological properties. Beyond the physiological maturity stage, moisture content of forage crops such as sorghum and maize decreased sharply as the age of the plant increased, whereas, the stem diameter decreased with the ageing of the plants. The shear strength of maize and sorghum stems increased with the decrease in moisture content.

RESUMEN

El proceso de corte de los forrajes depende en gran medida de sus propiedades físicas y reológicas. Después de la madurez fisiológica, la humedad de dichos forrajes disminuye fuertemente a medida que aumenta la edad, y también el diámetro del tallo. La resistencia de corte aumentó al disminuir la humedad

INTRODUCTION

Harvesting of forage crops for timely feeding of the livestocks is one of the major problems faced in the dairy farms. Forage harvestor plays a major role in this regard by providing higher outputs at lesser time. Without knowing the optimum cutting energy requirement of forage crops, it is hardly possible to design an efficient forage harvesting machine. The cutting process is greatly influenced by the physical and rheological properties of crops. A system of forces act upon the plant material to fail it in shear to complete the cutting process. Some deformations due to bending and compression of stalks also accompany the shear failure which increases the energy expenditure for cutting. The ultimate shear density did not depend on crop type and moisture content (Bilanski, 1985). The ultimate shear strength was found to be inversely proportional to the dry matter density (Mohsenin, 1986). The shear force, strength and energy exhibited a general trend to increase in magnitude with

maize: Y= 211.43 - 1.433 X, r= -0.985

sorghum: Y= 220.92 - 1.375 X, r= -0.987

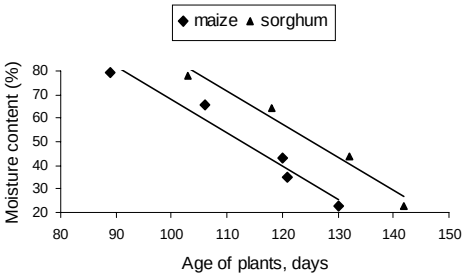

Figure 1. *Relation between the age of plant and moisture content of forage crops.* (Relación entre la edad de la planta y nivel de humedad de los forrajes).

maize: Y= 2.03 - 0.0043 X, r= -0.966

sorghum: Y= 2.15 - 0.0052 X, r= -0.998

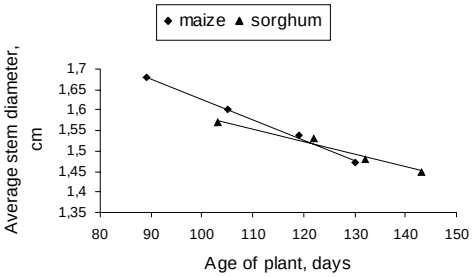

Figure 2. *Relation between age of plant and average stem diameter of forage crop.* (Relación entre la edad de la planta y diámetro medio del tallo).

plant maturity and from top to base of the stem (Shinners, 1987). All the mechanical properties of ryegrass were independent of shear velocity except the stem resistance to penetration (McRandal and McNulty, 1980). The cutting resistance of younger plants was significantly lower than the older plants, also the specific cutting energy increased with the stem diameter (Sitkei, 1986). The objectives of the research was to study the relationships between age and stem diameter, age and moisture content and moisture content and shear strength of maize and sorghum stem with respect to cutting.

MATERIALS AND METHODS

The moisture content, stem diameter and shear strength which are relevant properties to cutting were studied on two forage crops: Maize (Ganga-2) and Sorghum (SU-45).

The studies were carried out at four growth stages of the plants, that is, 90, 105, 119 and 130 days for maize and 102, 117, 131 and 142 days for sorghum. Three sample plants chosen randomly were taken for each of the determinations of moisture content, stem diameter and shear strenght with reference to different age of the plants. The measurements were taken at a height of 4.8 cm from the ground of the plant stem which was the height of cutting.

Moisture content of forage crops was determined by drying 20 mm long stems in a ventilated oven at 80ºC for 18 hours.

The forage stem diameter was determined with the help of a slide calliper having a least count of 0.1 mm.

maize: Y= 1.39 + 0.0035 X, r= 0.975

sorghum: Y= 1.34 + 0.0032 X, r= 0.991

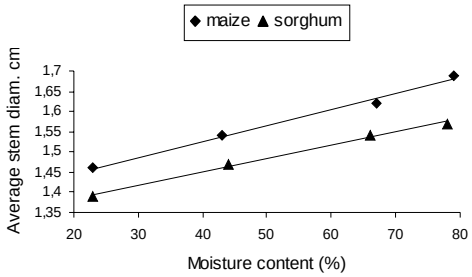

Figure 3. *Relation between moisture content and average diameter of stem.* (Relación entre humedad y diámetro medio del tallo).

maize: Y= 3.328 - 0.037 X, r= -0.962

sorghum: Y= 4.40 - 0.035 X, r= -0.995

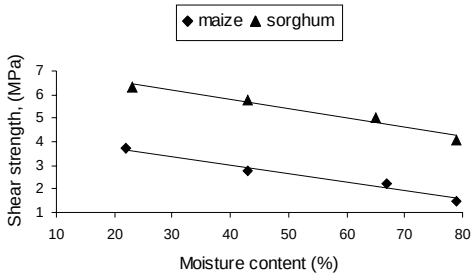

Figure 4. *Relation between moisture content and shear strength of forage crops.* (Relación entre la humedad y resistencia al corte de los forrajes).

Three repeated measurements were taken for individual stems to get the average value.

The shear strength of forage stems was determined with the help of a direct shear testing set up.

The experimental set up consisted of a wooden jig having a male part (dimensions 400 mm x 50 mm x 80 mm) and a female part (dimensions 480 mm x 100 mm x 80 mm). Holes of diameters of 10, 15, 20 and 25 mm were made in both male and female parts of the jig. One end of the female part of the jig was fixed and other end of the male part was connected to a load cell which was further connected to horizontal jack.

When the handle of the jack was rotated, the load cell and the male part tend to move horizontally creating a shearing action at two areas of cross section of the plant stem. The horizontal jack was further rotated until the plant stem failed in shear. The load corresponding to the failure of the stem by shear was recorded with the help of a load indicator. The shear strength of the plant stem was determined by using the equation:

$$S = \frac{2P \times 10^{-6}}{\pi D^2}$$

where,

S = ultimate shear strength of stem, MPa

P = shearing load, N

D = average stem diameter, m

RESULTS AND DISCUSSION

Out of different ages of the forage crops studied, the first growth stage for both the crops was considered for

green forage and was at the physiological maturity stage whereas the remaining three growth stages were considered for dry forage. The maturity level had a negative linear correlation with the moisture content for both the crops as shown in **figure 1**. It may be due to the fact that as the crop reaches maturity stage, the vegetative growth is negligible and moisture uptake from the soil slows down.

The diameter of the crop stems showed a negative linear correlation with the age of the plants as shown in **figure 2**. The rate of decrease in stem diameter was higher in maize than that of sorghum. It was 9.4 percent for maize and 5.6 percent for sorghum. This is because of the decrease in moisture content when the age of the plant advances from maturity stage and also reduction in volume due to the shrinkage of the plant tissues.

The moisture content of both the crops studied showed a positive linear correlation with the stem diameter as shown in **figure 3**. The rate of decrease of stem diameter was 5.09 percent for maize and 4.39 percent for sorghum.

The relationship between the moisture content and the shear strength of stems illustrated in **figure 4** showed a negative linear correlation. The measured values of shear strength were 1.57 MPa to 3.64 MPa for maize stems and 4.04 MPa to 6.18 MPa for sorghum stems. These values are well within the range of 0.4 MPa to 18.13 MPa as given by Mohsenin (1986).

CONCLUSIONS

The following conclusions are drawn from the present study.

1. Beyond the physiological maturity stage, further increase in the plant age decreased the stem diameter. It was 9.4 percent for maize and 5.6 percent for sorghum stem.

2. The moisture content decreased sharply as the plant age increases beyond the physiological maturity stage.

3. The shear strength increased at the rate of 3.89 percent and 3.63 percent for sorghum and maize respectively when the moisture content decreased from 80 to 20 percent.

REFERENCES

Bilanski, W.K. 1985. Mechanics of bulk forage deformation with application to wafering. *Trans. ASAE,* 28: 697-701.

McRandal and McNulty. 1980. Mechanical and physical properties of grasses. *Trans. ASAE,* 23: 816-821.

Mohsenin, M. 1986. Physical properties of plant and animal materials, Gordon and Breach Science Publishers, New York.

Shinners, K.J. *et al.* 1987. Evaluating longitudinal shear as a forage macerated technique. *Trans. ASAE,* 30: 18-21.

Sitkei, G. 1986. Mechanics of Agricultural materials. Elsvier Science Publishers, Amsterdam.

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