Effects of Moisture Content and Urea Fertilizer on Bending and Shearing Properties of Canola Stem

A. Esehaghbeygi, B. Hoseinzadeh, A.A. Masoumi

Abstract. *Bending stress, specific shearing energy, and Young's modulus of canola (*Brassica napus *L.) stems were investigated. The specific shearing energy using pendulum method and bending force were measured for four moisture content levels (35%, 43%, 50%, and 57%, w.b.), three varieties (Zarfam, Opera, and Okapi), and three nitrogen fertilizer levels (250, 400, and 550 kg ha^{-1}). The results of data analysis showed that the specific shearing energy increases and, bending stress and Young's modulus of canola stems decreased as the moisture content increased. The maximum value of the specific shearing energy was 3.94 MJ mm^{-2} for the Opera stems, while Zarfam with 3.27 MJ mm^{-2} had the minimum. The maximum value of the bending stress was 48.1 MPa for the Opera stems while Zarfam with 44.83 MPa had the minimum. The average of Young's modulus was found to be 3.80, 4.15, and 3.84 GPa for Zarfam, Okapi, and Opera varieties, respectively. The specific shearing energy decreased as the amount of nitrogen fertilizer increased. The maximum and minimum values of bending stress occurred with 400 and 550 kg ha^{-1} levels of nitrogen fertilizer, respectively.*

Keywords. *Canola, Shearing stress, Bending stress, Young's modulus.*

In order to improve the process of design and development, investigations of physic-mechanical properties and behavior of crops caused by machine operations are important. Study of the physical and mechanical properties of the canola stem is useful for suitable knife design in mowers, balers, and choppers to optimize harvesting machines. In addition, it seems to be justified not only by the possibility they yield for variety evaluation with respect to the lodging strength but also for the heritability of mechanical parameters observed by the breeders (Dolinski et al., 1989). The study of cutting energy requirements conducted on stalks of winter canola (Skubisz, 2001) has shown that cutting energy is related to stem mechanical and physical properties. Sakharov et al. (1984) reported that the force required to cut stretched stalks was 50% less than that for unbent stalks. A set of tests by Chancellor (1957) cutting 54% MC timothy at speed common to normal mowers (1.75 to 5.2 m s^{-1}) showed that speed had only a small effect on the cutting energy. For flail-type devices a slight decrease in energy was found with an increase in speed in forages (McRandal and McNulty, 1978). An increase in knife velocity will often increase the power losses caused by material acceleration and may increase other losses (Persson, 1987). In addition, Majumdar and Dutta (1982) stated that increased shearing velocity with rice and wheat, decreased the cutting force, and Khazaei et al. (2002) stated a decrease of specific shearing energy with increasing shearing speed with pyrethrum flowers. The present study was conducted to determine bending stress, Young's modulus, and specific shearing energy of canola stems as a function of moisture content, nitrogen fertilizer, and variety.

Material and Methods

Three varieties of winter canola (Zarfam, Opera, and Okapi) were cultivated in big flower vases under the same conditions for the stem shearing test and in the field of Shahrekord University with the same plant density, irrigation, and environment for bending test, separately. The magnitudes of the yield and plant height in Okapi were higher than Opera and Zarfam, respectively. Three levels of urea fertilizer (250, 400, and 550 kg ha^{-1}) were applied in three different stages (table 1). Analysis of variance was performed to examine the effects of canola variety, the amount of urea fertilizer, and stem moisture content levels (35%, 43%, 50%, and 57%, w.b.) on the specific shearing energy of canola stems and bending stress after plant senescence. A complete randomized block design and complete randomized design was used with five replications for bending stress, and stem shearing, respectively. The statistical package MINITAB Ver. 13.2 (Minitab Inc., State College, Pa.) was used. Means were compared using Duncan's multiple range tests (P<0.05). To determine the average moisture content of the canola stem on the date of the test, the specimens were weighed and dried at 103°C for 24 h in the oven and then reweighed (*ASABE Standards,* 2006). The experiments were conducted at average moisture content levels of 35%, 43%, 50%, and 57% w.b. after plant senescence during more days past. A digital micrometer was used to measure the stem thickness with 0.01-mm accuracy.

Submitted for review in February 2009 as manuscript number FPE 7896; approved for publication by the Food & Process Engineering Institute Division of ASABE in August 2009.

The authors are **Ali Esehaghbeygi,** Assistant Professor, Department of Farm Machinery, College of Agriculture, Isfahan University of Technology, Isfahan, Iran; **Bahram Hoseinzadeh,** Engineer, College of Agriculture, Shahrekord University, Shahrekord, Iran; and **Amin Allah Masoumi,** Assistant Professor, College of Agriculture, Isfahan University of Technology, Isfahan, Iran. **Corresponding author:** Ali Esehaghbeygi, Department of Farm Machinery, College of Agriculture, Isfahan University of Technology, Isfahan, 84156-83111, Iran; phone: +983113913473; fax: +983113913501; e-mail: esehaghbeygi@cc.iut.ac.ir.