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Determination of mass density module, crush resistance coefficient and cutting efficiency of rose (Rosa Damascene Mill)

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ABSTRACT

Having information about flowers' mechanical properties and behavior is necessary for designing automatic and mechanized farm equipment. The following properties are included in cutting cellular materials: compression, traction, bending, cutting density and friction.

In this research horticultural plant, herb pharmaceutical and nutritive Rose was used and for the first time crush resistance coefficient, mass density module and cutting efficiency of Rose were measured and reported. These properties depend on species, varieties, stem diameter, maturity level, moisture content and cellular structure. In this research the cutting theory and its related equations were used to determine the mass density Module, crush resistance coefficient and cutting efficiency of rose, scientifically called Rosa Damascene Mill, which is a shrub plant belonging to Rosaceae species. Then a completely randomized design with factorial experiment was used to investigate the effect of petal size (a parameter that represents the level of flower growth), the blade state (single and double blade), cutting bevel angle and cutting speed on the mentioned properties. The results showed a significant relationship between cutting bevel angle and mass density module, crush resistance coefficient and cutting efficiency of rose in a level of 5%; as the angle size increased the levels of mass density module, crush resistance coefficient and cutting efficiency of rose increased.

1. Introduction

Rose, scientifically called Rosa x damascena Mill., is a furry shrub (deciduous) which is one of the most important of the fragrant types of Rosaceae family (Kaul et al., 2009). Its petals contain extractable essence (Tabaei-Aghdaie and Rezaee, 2004). Its essence is the main material for manufacturing cosmetics and perfumes and it is medically useful for relaxation and curing depression and anxiety. The solution containing rose essence, water and methanol has Anti-HIV (Human Immunodeficiency Virus) effect (Assare et al., 2006). Rose essence, rose water (means Golab in Persian) and dried flower products are consumed domestically as well as exported to other countries (Assare et al., 2006).

In addition, rose petals have the highest essence quality and quantity (high percentage of geraniol and sitrenolol) and lowest wax compounds reducing essence. The rose flower is a branch of a flowering shrub with thorns, cylindrical shape without grooves, with compound leaves and deciduous petioles covered with nodulated fuzz. In this research the cutting theory and its related equations were used to determine the mass density module, crush resistance coefficient and cutting efficiency of rose proposed by Goryachkin (Bernacki et al., 1972). These coefficients are not reported so far for any crop. Cutting process involves a series of main cuttings, deformations or disruption methods, each one performed according to different rules.

The metal cutting efficiency is directly proportional to the plate cross-sectional area, but in plants due to the fibrous structure, the amount of efficiency depends on cutting direction and stem and does not depend on the cross-sectional area. Factors affecting the cutting power and energy can be divided into the following

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categories: the plant factors, which apart from the type of cutting tool, depend on plant properties and include the type of plant, plant moisture content, degree of maturity, the plant stem diameter and plant density (the amount of solids in the plant); Factors related to the procedure, including the feed rate, speed, material thickness, the initial density, cutting height, blade speed and other influencing factors; design factors including cutting width, the thickness of sharp edge, thickness of the blade, the angle of sharp blade, blade type, freedom distance, angle of inclination, slip angle, etc., (Persson, 1987).

Some studies have been carried out to assess the impact of each factor. In a study, Young module (The normal stress divided by linear strain (Beer et al., 2002)), cutting tension and bending tension of three levels of Nitrogen Fertilizer were determined in different moisture levels and three different varieties of canola. The results showed that the three studied traits decrease as moisture content increases (Hoseinzadeh and Shirneshan, 2012).

Comparison of mechanical properties of two varieties of rice showed that the mean of cutting resistance and bending tension and Young module have significant differences as the quantity changes in 5% level (Tavakoli et al., 2010). The effects of sharp angle, oblique angle, cutting speed and blade type (straight edge and jagged edges) on cutting resistance and used energy per area unit of Pyrethrum stem showed a significant impact of sharp and oblique angle at 1% on the cutting resistance and used energy in the stem area (Khazaei et al., 2002).

A research investigated cutting force and energy for maize stem. The results showed that in direct cutting, increase in speed leads to reduced cutting resistance and energy (Prasada and Gupta, 1975). In a study, the effect of moisture on the cutting stress and the energy per a surface unit in sunflower stalks were investigated. The results showed that the cutting stress in the lower stem is more than upper stem (Ince et al., 2005). In a study the effects of loading speed and ripeness on flexibility and pressure of corn stalk were evaluated. The results showed that with the increase in loading speed, both force energy and deterioration resistance increase (Chattopadhyay and Pandey, 1998).

In a study on the bending and shear properties of Alvand type wheat stem it was concluded that the shear stress of wheat stem reduces when the moisture content of the wheat stem is decreased. With the increase in cutting height, the stem shear force decreases. Compared with a ridged edge blade, a straight edge blade causes less shear stress (Eshaghbeygi et al., 2009).

In a study to measure the static and dynamic forces for cutting Persian white rice stalks, the results showed that the cutting force decreases with increasing moisture content. Shear resistance decreases with the increasing in shear speed. In addition, oblique angle of the blade and the blade type did not have any significant effect on the cutting resistance of rice stem (Tabatabaee-Koloor and Borgheie, 2006).

Although rose is economically one of the most important herbal fragrant plants in Iran and rose gardening and extracting its essence has a history of more than one thousand year, and also the land area devoted to its cultivation all over Iran is more than 4000 hectare (Soleymanpoor et al., 2005), yet no study has been taken to investigate the cutting properties of this plant.

This study examines some of the cutting properties of this plant that show how this flower must be cut. The results of this research can be used as basic data input to design machines for harvesting rose flower.

2. Materials and methods

In this study, rose flower were obtained from the fields of Agriculture faculty, Razi University of Kermanshah in spring 2011. Then

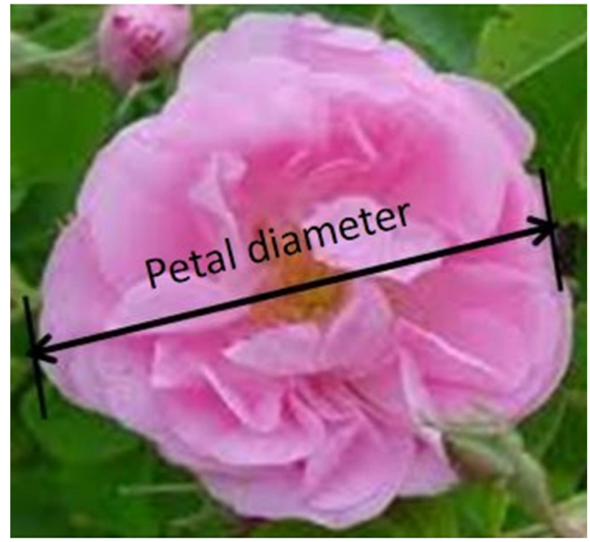

Fig. 1. Petal diameter.

the samples were taken to the Laboratory of physical and mechanical properties, Department of Mechanics of agricultural machinery. Leaves were removed prior to measuring and doing the tests. To measure the diameter of the samples a digital caliper with an accuracy of 0.01 mm was used. Samples were classified in three different categories based on the flower petals diameters (55–60, 60–65 and 65–70 mm) which is a parameter indicating the flower's growth rate (Fig. 1). Some sample stalks were weighed using a digital scale with an accuracy of about 0.01 g; then those stalks were put within an oven with a temperature of 103 °C for 24 h. They were weighed once again and moisture content was calculated on the basis of previous fresh weight.

The cutting test was used to determine the mechanical properties of cutting rose. The tests were conducted using tensile-compression test machine (Zwick/roell universal testing machine); the measuring accuracy was ±0.001 N. The cutting jaw was designed and constructed. To enhance the cutting force, a slider page with three speeds of 150, 250 and 350 mm/minute was loaded. The cutting process was done using single-blade and double blade machine with three different cutting bevel angles of zero, 25° and 45°. A sharp blade with a sharp angle of 1.7° was used. The blade and a counter shear used for one blade cutting and two blade used for double blade cutting (by substituting counter shear with another blade). The cutting force applied was measured and force-deformation changes were recorded until the time samples were ruptured (Fig. 2).

Fig. 3 is a diagram of static force-displacement that shows the changes in static force of layer of thick plant stems with a thickness of h. The horizontal axis represents the blade path through the thickness of h. h' is the blade path in primary crushing of the object and A' and A surfaces show the energy in crushing and cutting the stem respectively. Goryachkin presented below equation for showing the relationship between crushing and the layer thickness (Bernacki et al., 1972).

$$A\prime = \lambda \frac{h\prime}{h} \tag{1}$$

λ: module and mass density of the object (N.mm)

A: cutting energy surface (N mm)

A': crushing energy surface (N mm)h: length of crushing & cutting (mm)h': length of crushing (mm)