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Some physical properties of sugarbeet seed

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Abstract

Various physical properties of sugarbeet seed were determined as a function of moisture content. The lengths of the major, medium and minor axes varied from 4.61 to 5.30, 3.82 to 4.36 and 2.20 to 2.38 mm, respectively, as the moisture content increased from 8.4 to 14.0% d.b. In the same moisture range, the arithmetic and geometric mean diameters increased from 3.54 to 4.02 and 3.38 to 3.80 mm, respectively. Studies on rewetted sugarbeet seed showed that the sphericity decreased from 0.734 to 0.717, whereas thousand seed mass and projected area increased from 12.60 to 13.41 g and 12.1 to 15.6 mm^2, respectively, with increase in moisture content from 8.4 to 14.0% d.b. The bulk density, true density and porosity decreased from 447 to 418 $kg\,m^{-3}$, 962 to 851 $kg\,m^{-3}$ and 53.6 to 50.9%, whereas terminal velocity and angle of repose increased from 5.6 to 6.6 ms^{-1} and 17.6 to 25.0°, respectively, as the moisture content increased from 8.39 to 14.00% d.b. The static coefficient of friction increased on four structural surfaces namely, rubber (0.687–0.790), plywood (0.480–0.608), galvanised metal (0.392–0.434) and aluminium (0.279–0.388) in the moisture range from 8.4 to 14.0% d.b.

Keywords: Sugarbeet seed; Physical properties; Moisture content; Terminal velocity; Angle of repose; Static coefficient of friction

1. Introduction

Sugarbeet (*Beta vulgaris* L.) belongs to the family Chenopodiaceae. It is biennial plant which is essentially vegetative during the first year of growth and requires over-wintering to induce reproductive development in the following year (Vandergeten et al., 2004).

Sugar is produced from sugar cane and sugarbeet in 120 countries in the world. White sugar production in the world was approximately 145 million tonnes in 2003 of which 26% was produced from sugarbeet and 74% from sugar cane.

White sugar is produced from sugarbeet in Turkey and sugarbeet was cultivated on 283,750 ha with a production of 13 million tonnes in 2003. Resulting white sugar production was 1.6 million tonnes (Anonymous, 2003).

Since sugarbeet seed used today is almost exclusively a monogerm seed, the seed provided for growers needs to be of the highest biological quality and uniformity. Most of the processing methods employed are still traditional. There is the need to develop appropriate technologies for its processing. In order to design equipment for handling, aeration, storing and processing sugarbeet seed, it is necessary to determine its physical properties as a function of moisture content. However, no published literature was found on the detailed physical properties of sugarbeet seed and their relationship with moisture content. The object of this study was to investigate some moisture-dependent physical properties of sugarbeet seed, namely size, sphericity, projected area, thousand seed mass, bulk density, true density, porosity, terminal velocity, angle of repose, and static coefficient of friction, in the moisture range from 8.4 to 14.0% d.b.

2. Materials and methods

2.1. Sample preparation

The sugarbeet seeds, variety Kassandra, were procured from the Sugarbeet Seed Processing Factory in Ankara, Turkey. The seeds were cleaned manually to remove foreign matter, broken and immature seeds. The initial

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Nomenclature

a	major axis, mm
A, B	intercept and regression coefficient
A_p	projected area, mm^2
b	minor axis, mm
c	medium axis, mm
D_a	arithmetic mean diameter, mm
D_g	geometric mean diameter, mm
H	vertical depth at the centre of sample, mm
m_{1000}	thousand seed mass, g
M	moisture content of sample, % d.b.
M_f	final moisture content of sample, % d.b.
M_i	initial moisture content of sample, % d.b.
Q	mass of water to be added, kg
R	radius of spread of the sample, mm
R^2	coefficient of determination
V_t	terminal velocity, m s^{-1}
W_i	initial mass of sample, kg
α	angle of tilt, deg
ε	porosity, %
θ	angle of repose, deg
μ	coefficient of friction
ρ_b	bulk density, kg m^{-3}
ρ_t	true density, kg m^{-3}
ϕ	sphericity, decimal

moisture content of the seeds was determined by using a standard hot air oven method on samples of at least 15 g at 105 ± 1 °C for 24 h (USDA, 1970; Gupta and Das, 2000). The average moisture content of the seeds was found to be 8.4% d.b.

Seed samples of the desired moisture levels were prepared by adding the amount of distilled water calculated from the following relationship (Balasubramanian, 2001):

$$Q = \frac{W_i(M_f - M_i)}{(100 - M_f)}, \qquad (1)$$

where Q is the mass of water to be added in kg; W_i is the initial mass of the sample in kg; M_i is the initial moisture content of the sample in % d.b. and M_f is the final moisture content of the sample in % d.b.

The samples were sealed in separate polythene bags and kept in a refrigerator at 5 °C for 15 days for the moisture to distribute uniformly throughout the sample. Before starting a test, the required quantity of seed was taken out of the refrigerator and allowed to warm up to room temperature for about 2 h (Shepherd and Bhardwaj, 1986; Nimkar and Chattopadhyay, 2001).

The physical properties of the seeds were investigated at four moisture levels of 8.4, 9.8, 11.9 and 14.0% d.b. These values are within the range of moisture contents encountered for sugarbeet seed from harvest to storage. It is recommended that for storage the moisture content for sugarbeet seed should be under 13% (Adıyaman, 2000; Er and Uranbey, 2000).

2.2. Seed dimensions, sphericity and projected area measurement

To determine the average size of the seed, a sample of 100 seeds was randomly picked and the three principal dimensions namely, major, medium and minor axes were measured using a micrometer with an accuracy of 0.01 mm.

The average diameter of seed was calculated by using the arithmetic mean and geometric mean of the three axial dimensions. The arithmetic mean diameter D_a and geometric mean diameter D_g of the seed were calculated by using the following relationships (Mohsenin, 1970):

$$D_a = (a + b + c)/3, \qquad (2)$$

$$D_g = (abc)^{1/3}, \qquad (3)$$

where a is the major axis, b is the medium axis and c is the minor axis in mm.

The sphericity (ϕ) of seeds was calculated by using the following relationship (Mohsenin, 1970):

$$\phi = \frac{(abc)^{1/3}}{a}. \qquad (4)$$

The projected area of the seed was measured by the image analysis method (Dursun, 2001; Sahoo and Srivastava, 2002).

2.3. Thousand seed mass, bulk density, true density and porosity measurement

The thousand seed mass was determined by means of a digital electronic balance having an accuracy of 0.001 g. Five samples, each consisting of 1000 seeds, were randomly taken for each moisture content and weighed.

The bulk density of the sugarbeet seed at four different moisture levels was determined by filling a circular container of 500 ml in volume with the seed from a height of 150 mm at a constant rate and then weighing the contents. No separate manual compaction of seeds was performed (Singh and Goswami, 1996; Sacilik et al., 2003). The bulk density was calculated from the mass of the seeds and the volume of the container.

The true density, as a function of moisture content, was determined using the toluene displacement method. Toluene (C_7H_8) was used in place of water because it is absorbed by seeds to a lesser extent. The volume of toluene displaced was found by immersing a weighed quantity of