DIMENSIONS DISTRIBUTION OF SOYBEAN (*Glycine max* L.) AND SUNFLOWER (*Helianthus annuus* L.) SEEDS

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Abstract
Some physical properties of six sunflower hybrid and six soybean varieties were measured and presented in this paper. The moisture content was constant value within one oil plant, so the physical properties were analyzed as a function of variety or hybrid. The affect of three axial seed dimension onto porosity, mass of 1000 kernels, bulk and true density were discussed too.
Key words: Physical properties, sunflower, soybean.

Introduction

Sunflower (*Helianthus annuus* L.) and soybean (*Glycine max* L.) are two basic crops which are considered as important source of highly nutrition oil for human and animal consumption in Serbia. According to data of government statistics office (Statistical Office of the Republic of Serbia, 2009) the sunflower was cultivated on 188,000 ha in the year 2008, and soybean on 144,000 ha. The gross production of sunflower was 454,000 tons, but 94% of total production was in Vojvodina province. The similar situation was with soybean with an annual production of 351,000 tons, when 93% of this amount was grown in Vojvodina. The total land area under those two oil crops was almost the same like wheat cultivation area. Food and feed industries have increasing demands for both crops because of their quality properties. Better market position affects that the total land area under soybean production is larger for 21% in the year 2008 compare to the 2005. These trends will be continued in next years, because there are no limited conditions. The storage capacity in Vojvodina province are significant (Babic Ljiljana, 2003), they were built continuously from sixth decade in last century, for other grains mainly.

The knowledge about soybean and sunflower physical properties is essential for adequate design the equipments for processing, drying and storing of grains (Babic, 2000) Kernels size distribution is important for cleaning, grading and separation. Bulk and true density, surface area and porosity determine the capacity of dryer, storage and transportation means, as well as the resistance to airflow during aeration (Mohsenin, 1980). Bulk density and porosity also affect the horizontal and vertical loads in the silos during storage, angle of repose is important in design handling system and their accessories.

Many authors were reported the results of soybean and sunflower seeds physical properties measurement. Mainly, they presented the dependence of physical properties and moisture content of the kernels. Deshpande et al (1993), Kibar and Ozturk (2008), Polat et al (2006) and Abubekir were studied soybean physical properties in that manner, while Tunde-Akintunde et al (2005) were comparing some physical properties of three differnet

soybean varieties. Physical properties of sunflower seeds were investigated by Gupta and Das (1997) in the moisture range 4-20%, and Esref and Naymi (2007). Gupta and Das reported about fracture resistance of sunflower seeds and kernel to compressive loading (Gupta and Das, 2000). Wild sunflower seeds were studied by Perez et al. (2007), high oleic sunflower seeds mechanical properties were reported by Santalla and Mascheroni (2003).

An objective of this study is to contribute to the knowledge of domestic selection sunflower and soybean seeds physical properties. Sixth varieties of soybean and sunflower hybrids were chosen for analyze in order to compare size distribution, sphericity, geometrical diameter, surface area, volume of a single kernel, 1000 kernels mass, true and bulk density, porosity and static coefficient of friction. The results of this measurement are data base for application during soybean and sunflower seeds processing.

Materials and methods

Samples

Sunflower (*Helianthus annuus* L.**)** bulk sample of seeds were 5 kg each. They were picked up from Institute of crop and vegetable – research farm, Novi Sad. The grains were brought to the Laboratory of Processing Engineering, Agricultural Faculty, University of Novi Sad. The varieties of domestic selection Šumadinka, Krajišnik, Bačvanin, Perun, Pobednik and H 111 were studied. The pale of seeds were cleaned manually to remove foreign matter, broken and immature kernels. The same procedure was carried out for soybean seeds as well. The initial moisture content of the sunflower and soybean seeds was pretty low, because they were discharged from the dryer outlet, before further processing. The seeds were sealed in low-density polyethylene bags and stored at low temperature of 3^0C. For the each test, the necessary amount of seed was taken out from refrigerator and allowed to worm up for approximately 3 hours. The measurement of length, width and thickness were done in randomly selected 90 sunflower and soybean seeds for each variety. The samples of soybean were produced on same research farm; varieties Afrodita, Valjevka, Balkan, Ana, Vojvođanka and Venera were tested.

Methods

The initial moisture content of all samples is determined by oven drying at 105 ± 1^0C until a constant weight was reached (Bio Materials Seed Quality Regulative, 1987). The dimensions of the kernel are L – length (mm), W – width (mm) and T – thickness (mm). They are measured by hand micrometer (last count 0.01 mm). The geometric mean diameter Dg (mm) of the seed is calculated by using following relationship (Mohsenin, 1980):

$$Dg = (LWT)^{1/3}$$

The surface area of a single kernel Ag (mm^2) is figure out by the help of geometric mean diameter using the expression (Babic Lj, 2000):

$$Ag = \pi\, Dg^2$$

The sphericity Φ – (%) of the kernel is count out (Mohsenin, 1980) by equation:

$$\Phi = \frac{(LWT)^{1/3}}{L}$$

The mass of the individual kernel is determined in an electronic balance to accuracy 0.001 g. The bulk density (ρ_b – kg/m^3) is the ration of sample mass and total volume of the sample and true density (ρ – kg/m^3) of the seeds is ration of sample weight and kernels volume. The total volume and volume of the seeds are measured by liquid displacement procedure. The sample is consisting of 500 kernels, after weighing it is pouring into measuring cylinder, so the total volume is recording. The distillate water immerses into cylinder, so the net volumetric water displacement of the seeds is recorded. The results of those surveying are using for bulk, true density and porosity calculating and determining the mean value of single kernel volume. The porosity of sample (ε - %) defines as the fraction of space in the bulk grain which is not occupied by the grain, the calculation is according to equation (Mohsenin, 1980):

$$\varepsilon = (1- \rho_b/ \rho)\ 100$$

Soybean and sunflower seed static coefficient of friction was determined against only one structural material – sheet of steel. The bulk of seed were placed on the inclined plane which can rotate in one point. The plane is lifting up until the kernels start to move. The angle between inclined plane and horizontal surface is determined as an angle α (^{0}) in degrees, therefore the static coefficient of friction μs (-) is calculated (Babic, 2000) from the following relationship:

$$\mu = \tan \alpha$$

Results and discussion

The results of three seed dimensions for six soybean varieties and six sunflower hybrids of the sample of 90 kernels are analyzing. The graphical presentation of those three dimensions is giving a better view on the frequency distribution of the kernels number within ranges. Fig 1 gives a good report about frequency of length, width and thickness, so six sunflower hybrids can be comparing. It is obviously that the most length kernel in

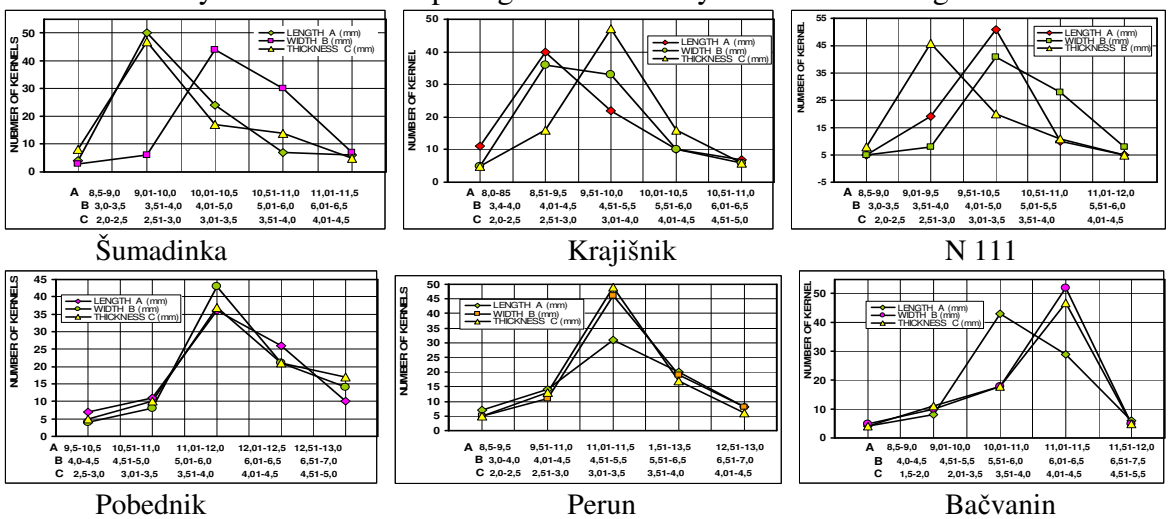

Fig 1. Frequency distribution curves of sunflower hybrids three size dimensions

the range of 11.0-12.0 mm has Bačvanin hybrid, even 48% of sample, while Pobednik and Perun have only 40% of the kernels in the same range. Hybrid H 111 has the best frequency of length dimension (56%) in the range 9.5-10.0 mm. The most width kernels in the range of 6.0-6.5 mm (even 58% of the sample) are Bačvanin seeds, than between 5.0-6.0 mm are 48% of Pobednik kernels. The other hybrids have frequency of 45-51% of the seeds in the range of 4.0-5.0 mm. Bačvanin hybrid measurements of third dimension – thickness show the largest frequency (52% of the total kernels) in the range 4.0-4,5 mm, while this dimension within other hybrids is between 2.5-3.5 mm. All six sunflower hybrids show the differences in size surveying, which indicate the shape of single kernel. It can be concluded that those hybrids of domestic selection have generally smaller values of all three dimension compare to results of Santalla and Mascheroni (2003), but similar to the results of Gupta and Das (1997). The surveying values of sunflower seeds dimensions reported by Esref and Nazmi (2007) indicated that Turkey's selection of that oil plant is more round shape.

The frequency distribution of 90 sunflower kernels surveying results of length, width and thickness is normal distribution. The statement is confirmed by Pirson's χ^2 test (STATISTICA, 2008) for all three dimensions which is quite usual for bio materials measurement (Fig 2). The test also certifies the surveying accuracy and samples adequacy. It can be concluded that smallest kernel has Krajišnik sunflower hybrid, the width and thickness are almost the same values. Those dimensions indicate the shape of this hybrid

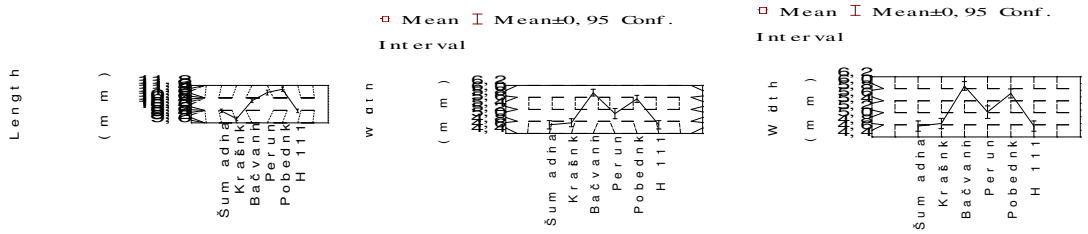

Fig 2. Length, width and thickness mean value intervals with 95% confidence for sunflower hybrids

like ovate (Mohsenin, 1980). It is possible to make the same assertion for Pobednik hybrid, as well as for Perun kernels.

The frequency distribution of three dimensions for six soybean varieties is presented in Fig 3. Varieties Valjevka, Vojvođanka and Ana have the very similar kernel dimensions.Within all three varieties the length is in range 6.2-6.6 mm with frequency from 37 to 50% seeds in the sample. The width of all three types is between 5.2-5.8 mm, the span of kernels is between 38 to 50% of total tested numbers. The same observation is with the third dimension. Afrodita and Balkan are varieties with largest seed length; two other dimensions are similar to other types of soybean. Pirson's χ^2 test (STATISTICA, 2008) for all three soybean dimensions confirm normal distribution, like with the sunflower seeds.

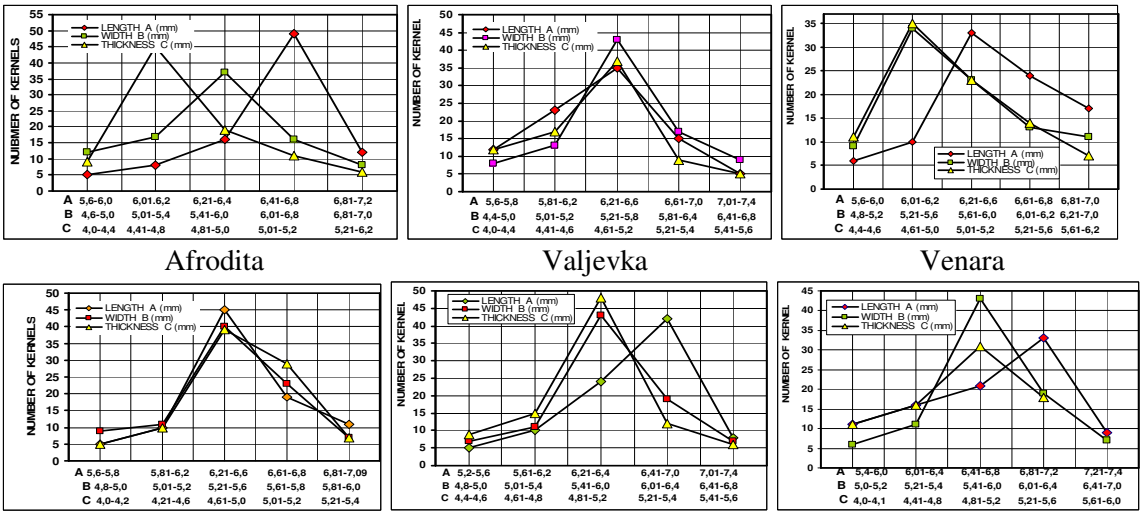

Fig 3. Frequency distribution curves of soybean varieties kernel three dimensions

The length measurement results of soybean varieties are in agreement with Potal at al (2006) at the same kernel moisture content and Kibar and Ozturk (2008). Six soybean domestic selections have generally lower values of kernel width and thickness compare to Kibar and Ozuk, while those two dimensions are similar with study results of Potal at al (2006).

The surveying results of other physical properties measurement are in table 1. The sphericity of Bačvanin (Φ=0,59) and Perun (Φ=0,57) sunflower hybrids are largest values compare to others, an explanation lies down in values of axial dimensions. Both have kernel's width and thickness values almost the same, which cause the shape more to be like

Table 1. Six sunflower hybrids and soybean varieties physical properties with standard deviation

	Moisture content	Dg	Ag	Sphericity	1000 kernels
Sunflower hybrids	(%)	(mm)	(mm^2)	(-)	(g)
Šumadinka	7.3±0.78	5.14±0.52	83.82±9.92	0.52±0.52	69.88±2.81
Krajišnik	11.6±0.25	5.32±0,59	89.88±19.41	0.57±0.06	54.00±1.06
Bačvanin	11.1±0.12	6.29±0,63	125.50±22,13	0.59±0.56	57.92±1.24
Perun	10.6±0.23	5.71±0.61	103.39±22.7	0.51±0.43	59.32±0.42
Pobednik	10.6±0.22	6.31±0.48	125.80±18.81	0.55±0.05	79.36±1.28
H 111	9.6±1.22	5.14±0.52	83.92±16.91	0.52±0.06	59.06±0.59
Soybean varieties					
Afrodita	6.1±0.92	5.58±0.9	98.18±14,21	0.86±0.04	135.06±9.73
Valjevka	5.9±0.73	5.47±0.37	94.27±12.66	0.87±0.4	136.03±7.21
Balkan	6.1±0.28	5.73±0.43	103.41±15.51	0.87±0.5	127.21±4.74
Ana	6.2±1.15	5.71±0.35	102.25±12.65	0.87±0.5	165.32±8.73
Vojvođanka	6.2±0.41	5.48±0.26	94.48±9.98	0.86±0.04	155.06±12.78
Venera	6.6±0.72	5.65±0.42	100.67±14.6	0.87±0.03	143.12±7.32

	Bulk density	True density	Porosiy	μ
Sunflower hybrids	(kg/m^3)	(kg/m^3)	(-)	(-)
Šumadinka	419.4±3.84	649.5±5.74	0.354±1.22	0.243±0.07
Krajišnik	398.9±2.75	581.28±1.96	0.314±0.78	0.243±0.12
Bačvanin	330.92±4.87	502.60±4.28	0.341±0.02	0.214±0.06
Perun	424.63±7.82	642.41±8.92	0.339±0.04	0.237±0.04
Pobednik	449.86±11.28	701.20±9.12	0.358±0.12	0.225±0.07
H 111	435.35±12.79	663.89±17.28	0.344±0.01	0.227±0.06
Soybean varieties				
Afrodita	665.32±10.12	1058.79±10.24	0.371±0.6	0.140±0.04
Valjevka	654.42±0.74	1059.32±7.21	0.372±0.2	0.140±0.21
Balkan	625.61±7.37	948.54±9.54	0.340±0.4	0.140±0.37
Ana	691.71±14.35	1122.03±18.7	0.383±0.7	0.122±0.48
Vojvođanka	702.71±4.32	1160.62±10.12	0.394±0.01	0.137±0.04
Venera	701.5±7.32	1134.79±12.72	0.381±0.04	0.111±0.02

ovate. The largest geometric diameter is with Pobednik hybrid so the largest value of bulk and true density were observed. The lowest sphericity values are measured with Vojvođanka and Afrodita soybean varieties, which indicate larger differences in three axial dimensions. Geometric diameters of those two varieties are smaller (5.48 and 5.58 mm) compare to others. The mass of 1000 kernels with Afrodita (135.06 g) is lower than Vojvođanka (155.06 g) which influence on bulk and true density values. The largest geometric diameter and surface area are measured with Balkan variety, but the mass of 1000 kernels is modest, as well as the values of bulk and true density.

Conclusion

Six domestic genetic selections of soybean varieties and the same number of sunflower hybrids physical properties were tested. Three seed axial dimensions, geometric diameter and kernel surface area, sphericity, porosity, bulk and true density and static coefficient of friction for all analyzed varieties and hybrids were presented and discussed an affect of seed dimensions on the other physical properties.

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