Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLI
Broj 3, 2016.
Strane: 45 – 52

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLI
No. 3, 2016.
pp: 45 – 52

UDK: 631 (059)

Originalni naučni rad
Original scientific paper

DEVELOPMENT AND SELECTION OF SPOONS FOR METERING DEVICE OF ONION BULBLETS PLANTER

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Abstract: Engineering properties of onion bulblets of variety Agrifound Dark Red were determined for development of metering device of onion bulblets planter. The raw sample of onion bulblets was graded in three groups as small, medium and larger size sample according to their diameters (Polar and equatorial). The engineering properties like polar diameter, equatorial diameter, unit weight, geometric mean diameter, sphericity, shape factor and bulk density of onion bulblets of each sample size were determined at 74.00 % m. c. (w. b.) and found as 23.62 mm, 13.2 mm, 1.87 mm, 15.58 mm, 0.66, 0.56 g, 607.82 kg/m^3 respectively for small size sample, 27.9 mm, 19.54 mm, 3.91 mm, 21.30 mm, 0.70, 0.70 g, 664.47 kg/m^3 respectively for medium size sample and 31.58 mm, 28.71 mm, 5.70 mm, 28.64 mm, 0.91, 0.91 g, 685.60 kg/m^3 respectively for large size sample. The angles of repose for small, medium and large size sample were found to be 36.200, 34.210 and 33.510 respectively and values of rolling angle were as 10.21^0, 10.25^0 and 10.45^0 for small, medium and large size samples respectively. The values of shape factor were found as 0.56 (oblate in shape), 0.70 (oblate in shape) and 0.91(spherical in shape) for small, medium and large size sample onion bulblets respectively.

Key words*: onion bulblets, angle of repose, shape factor, rolling angle*

INTRODUCTION

Onion is scientifically known as *Allium cepa L.*, it is a species of family "Amaryllidaceae". It originates in the Yunnan province of China. Onion has been used throughout recorded history for both culinary and medicinal purposes. It has a characteristic pungent, spicy flavor that mellows and sweetens considerably with cooking.

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The production of onion in India is 14.56 million tonnes. In Madhya Pradesh, the total area under onion cultivation is approximately 33720 ha and productivity is 3.713 tonnes /ha. State of Maharashtra has highest area of cultivation (415,000 ha), with a production of 49, 04,000 tonnes. Madhya-Pradesh contributes 1021500 tonnes of onion with 58,300 ha area of cultivation. Though, the productivity of onion in Kerala was found to be highest (16.89 t/ha). The main region behind the reduced yield (3.71 t/ha) per ha in MP may be due to uncertainty in climatic conditions and lower level of mechanization [6].

Production of onions from bulblets is a late Kharif crop. This method is used for getting early crop in the kharif season so as to meet the demand of green onion for salad in early winter. For this purpose, small onion bulblets of kharif onion varieties like Agrifound Dark Red, Baswant 780, N-53 and Arka Kalyan raised in the previous season are used for planting. The best time of sowing of seeds for getting quality bulblets is mid-January to the beginning of February depending upon the area. The plants are left in the nursery bed up to April-May till their tops fall. Harvesting is done along with the tops and selected bulblets (1.0 to 3.00 cm in dia.) are stored till July in a well-ventilated house [6]. Such well stored bulblets are used for planting in the Kharif season.

The farmers are generally sowing onion bulblets by manual method, which is highly labor intensive and time consuming. Therefore, farmers are taking this vegetable/ medicinal crop in very small area. So, there is a need to develop a simple machine that can overcome the difficulty of onion bulblets sowing and reduce the labor requirement and cost of sowing. Generally, the onion seeds are sown in nursery and transplanted in the field with Row to row spacing of 15 cm and plant to plant spacing of 7 .5 cm to get optimum yield. The labour requirement in manual transplanting of onion seedlings is as high as 100-120 man-day/ha as 8.9 lakh seedlings per ha are to be transplanted [7].

Seed flow through a planter is dependent on size, shape, sphericity, density and angle of repose of seeds. In addition, the impact of seeds on the internal components of the planter is influenced by the coefficient of restitution of seeds on various impinging surfaces. Therefore, there is a necessity to find out the optimum design parameters of a planter by determining the relevant physical properties of three disparate kinds of crop seeds [3]. [5] determined physical properties such as density, diameters, mass, shape factor, specific gravity, surface area and volume of sweet onions. Although the physical and biometric properties of the crop affects the design parameters of the planter but there is no precise information available on engineering properties of onion crop relevant to design of onion planter.

Due to high labor intensive works and higher wage rate the onion cultivation is discouraged by farmers day by day and hence, area also being reduced in Madhya Pradesh. To overcome such circumstances there is an urgent need to mechanize the planting techniques for the farmers. The present study is carried out to find essential engineering properties of onion bulblets for development of metering device for onion bulblets planter.

MATERIAL AND METHODS

Present study was conducted research farm of Department of Farm Machinery and Power Engineering, College of Agricultural Engineering, J.N.K.V.V., Jabalpur Madhya Pradesh situated between 220 21'and 240 8' N latitude and 780 21'and 800 58' E longitude at an altitude of 411.78 m above mean sea level. In this study variety Agrifound Dark Red of onion bulblets was selected. Various engineering properties of onion bulblet like physical properties, moisture content, Bulk density, angle of repose,

rolling angle etc. were observed. There are three replications were taken for each property. The grading of raw sample was done manually according to the physical appearance (shape and size) of the onion bulblets and three groups of whole sample were finalized as small size sample, medium size sampleand large size sample.The dimensions were measured at average 74.00 per cent moisture content (w.b.) of onion bulblet.

Physical properties of onion bulblets. The physical properties such as length, width, volume, weight, geometric mean diameter, angle of repose, and sphericity are necessary to design a machine used for handling of materials. Therefore, systematic study was done for these properties of onion bulblets with appropriate methods.

Equatorial (D_e) and Polar (D_p) diameter. There are two categories of onion bulblet diameter: polar diameter and equatorial diameter. Polar diameter is the distance between the onion crown and the point of root (bud) attachment to the onion bulblet. Equatorial diameter is the maximum width of the onion in a plane perpendicular to the polar diameter. The equatorial (D_e**)**, and polar diameter (D_p**)**, and thickness (T), of 15 bulblets from each onion bulblet sample were measured with a vernier caliper (least count 0.01 mm).

Average equatorial (D_e) and polar (P_e) diameter were calculated with following relationship [2].

$$D_e = \frac{\sum_{i=1}^{n} D_{ei}}{n};\ D_p = \frac{\sum_{i=1}^{n} P_{ei}}{n};\ T = \frac{\sum_{i=1}^{n} T_i}{n} \quad (1)$$

Geometric mean diameter (D_{gm}). The geometric mean diameter (D_p) was calculated by using the following relationship [2].

$$D_{gm} = \left(D_e D_p T\right)^{1/3} \quad (2)$$

Sphericity (ϕ). Sphericity defines the ratio of the diameter of a sphere of the same volume as that of the particle and the diameter of the smallest circumscribing sphere or generally the largest diameter of the particle [6]. This parameter shows the shape character of cloves relative to the sphere having the same volume.

$$Sphericity = \sqrt{\frac{Volume\ of\ the\ particle}{volume\ of\ circumdcribed\ sphere}} = \frac{\left(D_e D_p T\right)^{1/3}}{L} \quad (3)$$

Shape factor. The shape factor of any granular material is mainly required in designing machinery that utilize their sliding or rolling action for movement by gravity**.**

Shape factor is defined as the ratio of the equatorial diameter to the polar diameter. A spherical shaped onion bulblet had a shape factor equal to one. Oblate onion bulblet had a shape factor greater had one, and prolate onion bulblet had a shape factor less than one. The shape factor was calculated by using the following relationship [3].

$$Shape\ factor = \frac{Equatorial\ diameter(D_e)}{Polar\ diameter(D_p)} \quad (4)$$

If: $\text{Shape Factor (Fc)} < 1 ; \Rightarrow Oblate$

$\text{Shape Factor (Fc)} = 1 ; \Rightarrow \text{Spherical}$

And: $\text{Shape Factor(Fc)} > 1 ; \Rightarrow prolate$

Unit weight. To obtain the unit weight of a single bulblet, 15 onion bulblets were taken from each onion bulblets sample. Each onion bulblet was weighed one by one by using electronic balance of least count up to 0.01g.

Moisture content. Moisture content was determined on weight basis (w.b.). To determine the moisture content of sample, the onion bulblets were cut in thin slices of 1-2 mm. A 20 g sample of slices was weighted on an electronic balance to a precision of 0.01g, was oven dried to constant weight at 60 ± 2^{0}C [1].

$$\mathrm{M.C.(w.b.)} = \frac{W_w - W_d}{W_w} \text{ X } 100 \quad (5)$$

Bulk density. Bulk density is an important characteristic for design of seed box. Bulk density of onion bulblet sample was calculated by placing the sample of bulblets in a round cylinder of known volume (Core cutter, volume 1020.5 cm^3) without compaction, and then weighed. The bulk density was calculated as the ratio of weight and volume due to sample. Each sample size used for measuring bulk density and the average was calculated. The sample was weighed by using electronic balance with least count of 1.0 g. Bulk density was calculated by using the relationship as [5].

$$b_d = \frac{W_t}{L \text{ x } \left(\pi d^2/4\right)} \quad (6)$$

Angle of repose. The angle of repose is the angle between the base and the slope of the cone formed vertical fall of the granular material on a horizontal plane. It is an important characteristic in designing seed box [6].

Rolling angle. To determine the rolling angle, the onion bulblet to be tested was kept at the center of the tilting top drafting table (horizontal platform) in most stable position (on their base), then by tilting the platform/table top at minimum speed, the platform inclined until the onion bulblets begins to roll. At this position, the angle of inclination of platform/table top was noted. This was the value of rolling angle for that onion bulblet. There were 15 onion bulblets randomly selected for each sample size [2].

Statistical analysis. The statistical analysis of various parameters like equatorial diameter, polar diameter, geometric mean diameter, Sphericity, Shape factor, Unit weight, Moisture content, Bulk density, angle of repose and rolling angle was done on the basis of standard deviation (SD) and coefficient of variance (CV) at five percent level of significant.

RESULTS AND DISCUSSIONS

Physical properties of bulblet sample. Table1 shows the physical characteristics of onion bulblets of small, medium and large size sample used in laboratory and field evaluation tests of the metering device

Small size sample. The polar diameter range was found to be 21.1 to 25.5 mm with the average diameter of 23.62 mm. The SD and coefficient of variance were calculated to be 1.55 and 5.8 % respectively. Similarly equatorial diameter varied from 10.0 to 14.5 mm with average of 13.2 mm. The SD and coefficient of variance were calculated to be 1.31 cm and 6.2 %, respectively. Geometric mean diameter and sphericity were found to be 15.58 and 0.66 on average of 10 onion bulblets. The SD of geometric mean diameter and sphericity were found to be 1.31 and 0.03, respectively. The coefficient of variance for geometric mean diameter and sphericity was observed to be 5.6 and 3.2, respectively. The shape factor range from 0.47 to 0.62 with 0.56 mean value .The mean of shape factor was less than one so that onion bulblets of small size bulblets were oblate in shape. By using these data the shape of cup was taken as elliptical. The dimensions were measured at average 74.00 per cent moisture content (w.b.) of onion bulblet.

Medium size sample. The polar diameter range was found to be 26.1 to 30.0 mm with the average value of 27.90 mm. The SD and coefficient of variance were calculated to be 1.32 and 5.8 %, respectively. Similarly equatorial diameter varies from 15.1 mm to 23.4 mm with average of 19.54 mm. The SD and coefficient of variance were calculated to be 3.15 cm and 6.2 %, respectively. The geometric mean diameter and sphericity were found to be 0.76 and 0.70 on average of 10 onion bulblets. The SD of geometric mean diameter and sphericity was found to be 0.06 and 3.2, respectively. The coefficient of variance for geometric mean diameter and sphericity was observed to be 3.2 and 9.6 %, respectively. The shape factor ranges from 0.58 to 0.79 with 0.70 mean. The mean of shape factor was less than one so that medium size onion bulblets were oblate in shape. By using these data the shape of cup was taken as elliptical. The dimensions were measured at average 74.00 % moisture content (w.b.) of onion bulblets.

Large size sample *Medium size sample* *Small size sample*

Figure 1. Onion bulblets samples

Table 1. Physical properties of onion bulblet sample

Particulars		*Polar diameter, (mm)*	*Equatorial diameter, (mm)*	*Unit weight, (g)*	*Geometric mean diameter (mm)*	*Sphericity*	*Shape factor*
Small	*Range*	*21.1- 25.5*	*10.0-14.5*	*1.20-2.57*	*14.93-17.85*	*0.59-0.64*	*0.47-0.62*
	Mean	*23.30*	*12.25*	*1.89*	*16.39*	*0.62*	*0.55*
	SD	*1.55*	*1.31*	*0.51*	*1.31*	*0.03*	*0.04*
	CV(%)	*5.8*	*6.2*	*28.6*	*5.6*	*3.2*	*4.7*
Medium	*Range*	*26.1- 30.0*	*15.1-23.4*	*3.06- 4.45*	*16.98-25.32*	*0.73-0.87*	*0.58-0.79*
	Mean	*28.05*	*19.25*	*3.76*	*21.15*	*0.80*	*0.69*
	SD	*1.32*	*3.15*	*0.53*	*0.06*	*0.08*	*0.08*
	CV(%)	*5.8*	*6.2*	*28.4*	*3.2*	*9.6*	*9.6*
Large	*Range*	*30.2- 35.0*	*24.8-30.0*	*5.01- 6.49*	*25.63-30.51*	*0.85-0.97*	*0.8-1.0*
	Mean	*32.60*	*27.40*	*5.75*	*28.07*	*0.91*	*0.90*
	SD	*1.51*	*1.71*	*0.55*	*1.39*	*0.04*	*0.05*
	CV(%)	*6.00*	*6.00*	*28.00*	*5.60*	*3.20*	*6.00*

Large size sample. The polar diameter range was found to be 32.2 mm to 35.0 mm with the average value of 31.58 mm. The SD and coefficient of variance was calculated to be 1.51 and 6.0 % respectively. Similarly equatorial diameter varies from 24.8 to 30.0 mm with average of 28.71 mm. The SD and coefficient of variance was calculated to be 1.71 cm and 6.0 % respectively. The geometric mean diameter and sphericity were found

to be 21.30 mm and 0.70 on average of 10 onion bulblets. The SD of geometric mean diameter and sphericity was found to be 1.39 and 0.04 respectively. The coefficient of variation for geometric mean diameter and sphericity was observed to be 5.6% and 3.2% respectively. The shape factor ranges from 0.8 to 1.0 with 0.70 mean value .The mean of shape factor (0.91) was approximately equal to one so that onion bulblets of large size sample were spherical in shape. By using these data the shape of cup was taken as round. The dimensions were measured at average 74.00 % moisture content (w.b.) of onion bulblet.

Bulk density of onion bulblets. Bulk density of onion bulblets sample was shown in fig.1. The bulk density of small, medium and large size bulblet sample were 607.82, 664.47 and 685.60 kg/m^3 respectively. Average weight of sample was found to be 666.01g and the bulk density obtained 652.63 kg/m^3. The bulk density varies from 607.82 to 685.60 kg/m^3. It was observed that the bulk density of bulblets is increases with increase in bulblet size.

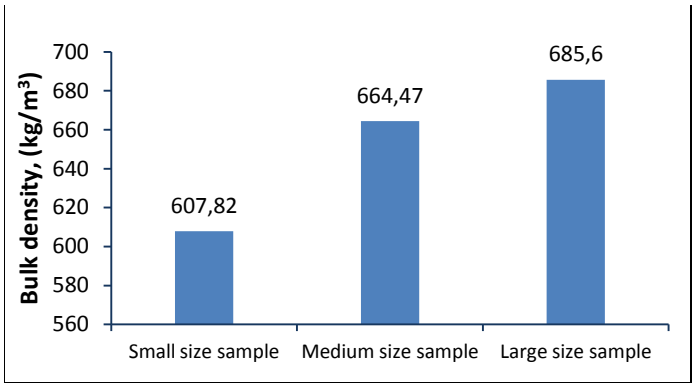

Figure 2. Bulk density of onion bulblets

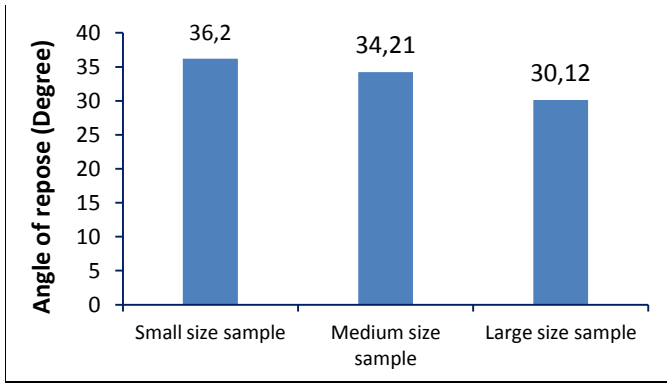

Figure 3. Rolling angle of onion bulblets

Angle of repose. Angle of repose for onion bulblets sample was shown in Fig.3. The angle of repose for three graded samples were found 36.2^0, 34.21^0 and 30.12^0 for small, medium and large samples respectively, with standard variation of 3.10 and 9.25 % coefficient of variance. The results revealed that as size of bulblet is increases the angle of repose decreased.

Table 2. Rolling angle of onion bulblets sample

Particulars	*Small*	*Medium*	*Large*
Range	*9.7^0-10.5^0*	*9.9^0-10.6^0*	*10.1^0-10.7^0*
Mean	*10.21^0*	*10.25^0*	*10.45^0*
SD	*0.24*	*0.26*	*0.17*
CV (%)	*2.37*	*2.53*	*1.64*

Rolling angle. Rolling angle of onion bulblets were shown in Tab. 2. The rolling angle of small, medium and large size bulblet were 607.82, 664.47 and 685.60 kg/m^3 respectively. The value of rolling angle for small, medium and large size bulblet sample ranges from 9.7^0-10.5^0, 9.9^0-10.6^0 and 10.1^0-10.7^0 were observed respectively. On an average rolling angle for small, medium and large size bulblet 10.21^0, 10.25^0 and 10.45^0 was observed respectively. The results revealed that rolling angle was increased with onion bulblet size as per [2].

CONCLUSIONS

This work focuses on some engineering properties of onion bulblets such as equatorial and polar diameters, geometric mean diameter, Sphericity, Shape factor, unit weight, moisture content, bulk density, angle of repose and rolling angle etc. The following conclusions could be made

1. The polar diameter and equatorial diameter of onion bulblets of small size onion bulblets sample were found to be 23.62 mm and 13.2 mm, respectively on average of 10 bulblets at 74.00 % moisture content. The unit weight of onion bulblets was calculated to be 1.87 g with a CV of 28.60 %. The shape factor and geometric diameter were found as 1.31 and 0.04, respectively.
2. The small and medium size bulblets were oblate whereas, the large size sample was spherical in shape.
3. The maximum rolling angle was10.45^0 for large size sample bulblets.
4. The polar diameter and equatorial diameter of onion bulblets of medium size onion bulblets sample were found to be 27.90 mm and 19.54 mm, respectively on average of 10 bulblets at 74.00 % moisture content. The unit weight onion bulblet was calculated to be 3.91 g with a CV of 28.4 %. The shape factor and geometric diameter were found as 0.08 and 0.06 respectively.
5. The polar diameter and equatorial diameter of onion bulblets of large size onion bulblets sample were found to be 31.58 mm and 28.71 mm, respectively on average of 10 bulblets at 74.00 % moisture content. The unit weight of an onion bulblet was calculated to be 5.70 g with a CV of 28.00 %. The shape factor and geometric diameter were as 0.05 and 1.39 respectively.
6. The bulk density of the onion bulblets varies from 607.82-685.60 kg/m^3 and the mean angle of repose was found to be 33.51^0.

BIBLIOGRAPHY

[1] AOAC, 1970. Official Methods of Analysis of the Association of Official Analytical Chemists, Washington D. C. pp.211.

[2] Bahnasawy, A.H., El-Haddad, Z.A., El-Ansary, M.Y., Sorour, H.M. 2004. Physical and mechanical properties of some Egyptian onion cultivars. *Journal of Food Engineering,* 62: 255-261.

[3] Khura, T.K., Mani, I., Srivastava, A.P. 2010. Some Engineering Properties of Onion Crop Relevant to Design of Onion Digger. *Journal of Agricultural Engineering*, 47(1): 1-8.

[4] NHRDF, 2012. Database National Horticulture research and development Foundation Nasik. [10-11-2012].

[5] Pandiselvam, R., Thirupathi, V., 2014. Important engineering properties of paddy. *Agricultural Engineering*, 4, pp 73-8.

[6] Rathinakumari, A.C., Jesudas, D.M., Physical and mechanical properties of onion sets (Allium cepa, L.). *International Journal of Tropical Agriculture*, 33(2): 817-823

ODREĐIVANJE TEHNIČKIH SVOJSTAVA ZA RAZVOJ MERNOG UREĐAJA SADILICE LUKA

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Sažetak: Tehnička svojstva crnog luka su određena radi razvoja mernog uređaja za sadilicu luka. Sirovi uzorci su bili podeljeni u 3 grupe: mali, srednji i krupni. Osobine su: polarni i ekvatorijalni prečnik, težina, sferičnost, factor oblika i rasuta gustina. Uglovi mirovanja za male, srednje i velike veličine uzorka su 36.200, 34.210 i 33.510, a vrednosti ugla kotrljanja su bili 10.21^0, 10.25^0 i 10.45^0 za male, srednje i velike uzorke veličine respektivno. Vrednosti faktora oblika su bili 0.56, 0.70 i 0,91 za male, srednje i velike uzorke, respektivno.

Ključne reči*:glavice luka, ugao polaganja, factor oblika, ugao kotrljanja*

Prijavljen: *Submitted*:	03.11.2015.
Ispravljen: *Revised*:	
Prihvaćen: *Accepted*:	19.09.2016.