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# Physical and Engineering Properties of Vegetable Seeds Relevant for Development of Protray Vacuum Seeder for Vegetable Nursery

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**ABSTRACT**

Physical and engineering properties of seeds are important to determine proper standards in design and development of sowing, planting, harvesting, grading, conveying and packaging systems. The physical properties namely linear dimensions, geometric mean diameter, sphericity, one thousand seed weight, bulk density and engineering properties in terms of angle of repose, co-efficient of static friction (using plywood, galvanized iron (GI) and mild steel (MS) sheet), terminal velocity for selected vegetable seeds viz., chilli, brinjal, tomato, capsicum and knol-khol were determined to design and develop a protray vacuum seeder to be used in vegetable nursery. Linear dimensions of seeds were measured by using electronic microscope assisted with Q-capture software and other properties were determined by following standard procedures. The length, width, thickness, geometric mean diameter and sphericity were found to be 4.08±0.03, 3.32±0.04, 0.44±0.01, 1.81±0.01 mm, 0.44±0.003 for chilli, 2.78±0.03, 2.55±0.02, 0.28±0.004, 1.26±0.01 mm, 0.45±0.003 for brinjal, 3.02±0.04, 2.06±0.02, 0.59±0.01, 1.53±0.01 mm, 0.51±0.005 for tomato and 4.28±0.03, 3.89±0.02, 0.54±0.01, 2.07±0.01 mm, 0.48±0.003 for capsicum seeds, respectively. Major and minor diameters, geometric mean diameter and sphericity were found to be 1.95±0.02, 1.69±0.02, 1.77±0.02 mm and 0.91±0.01 for knol-khol seeds, respectively. The one thousand seed weight and bulk density were found to be 5.53±0.09, 2.82±0.06, 2.68±0.07, 8.2±0.07, 2.97±0.26 g and 460.99±4.93, 540.03±8.66, 292.61±3.24, 401.68±4.43, 643.61±7.73 kg $m^{-3}$ for chilli, brinjal, tomato, capsicum and knol-khol seeds, respectively. Angle of repose and co-efficient of static friction of plywood, galvanized iron (GI) and mild steel were found to be 33.33±0.48 degree, 0.36±0.01, 0.38±0.01, 0.63±0.01 for chilli, 30.48±0.84 degree, 0.33±0.01, 0.37±0.01, 0.49±0.01 for brinjal, 40.63±1.01 degree, 0.38±0.01, 0.38±0.02, 0.54±0.01 for tomato, 27.66±0.75 degree, 0.36±0.02, 0.36±0.02, 0.55±0.01 for capsicum and 24.99±0.31 degree, 0.35±0.01, 0.28±0.01, 0.45±0.01 for knol-khol seeds respectively. Terminal velocity of chilli, brinjal, tomato, capsicum and knol-khol seeds were found to be 1.82±0.10, 1.84±0.15, 2.12±0.13, 2.06±0.13, and 1.66±0.04 m $s^{-1}$, respectively. The moisture content of seeds were found to be 11.26, 7.78, 7.82, 9.73 and 5.23 % for chilli, brinjal, tomato, capsicum and knol-khol seeds. These results were used in designing the two important parts viz., seed tray and seed pickup systems of protray vacuum seeder.

**Key words:** *physical properties, engineering properties, vegetable seeds, vegetable nursery*

The physical and engineering properties of seeds are important in the designing of agricultural machinery. Considering either bulk or individual units of the agricultural material, it is important to have an accurate estimation of shape, size, volume, density, specific gravity, surface area, and other mechanical characteristicsas designing parameters.

Several investigators determined the physical properties of seeds at various moisture contents such as, Ucer (2010) investigated some moisture-dependent physical properties of red pepper (capsicum) seed namely, linear dimensions, thousand seed mass, projected area, sphericity, bulk density, true density, porosity, terminal velocity and static coefficient of friction against different materials. Jadhav measured size of tomato and cabbage seeds by analysing with 'Adobe Photoshop CS4' package by acquiring the digital images with a flatbed scanner. The shape of seeds was expressed in terms of roundness by calculating number of pixels covered by digital image of seed area having 300 dpi.Gaikwad (2007) determined physical and aerodynamic properties ofcapsicum (Nun3019) and tomato (GS-600). The size ofthe seeds was specified by maximum diameter. A TIFF image of cluster of 20 randomly selected seeds was used to measure dimensions of the seed using image analysis software 'Aequitas'.Akintunde (2004) and Salawu (2014) determined some physical properties of sesame seed and snake tomato respectively using standard procedures. The present

study was carried out to determine physical properties namely linear dimensions, geometric mean diameter, sphericity, one thousand seed weight, bulk density and engineering properties in terms of angle of repose, co-efficient of static friction (using plywood, galvanized iron (GI) and mild steel (MS) sheet), terminal velocity of chilli, brinjal, tomato, capsicum and knol-khol seeds.

The physical properties of the seed like length, width were assisted in determining the selection of the diameters of the picking needles whereas the seed properties like mass of the seeds and terminal velocity was assisted in establishing the minimum suction pressure required for picking the seeds. Angle of repose, co-efficient of static friction (using plywood, galvanized iron (GI) and mild steel (MS) sheet) were important in sowing, planting, harvesting, grading and conveying sytems.

## MATERIAL AND METHODS

### Moisture content

Moisture content of seeds were checked using oven drying method.Samples were kept in oven at 130Ú for 2 hours (AOAC, 1976).

### Physical properties of seeds

Physical properties of seeds relevant to the design of the protray vacuum seeder were determined as explained below:

### Size

Seed size is characterized as seed length, width and thickness for flat seeds and major, minor diameters for round seeds. These factors were considered as important for determining the inner diameter of the orifice of seed pick up nozzles/ needles. One hundred seeds were randomly as sample from each seed. Linear dimensions of seeds as mentioned above were measured by using electronic microscope assisted with Q-capture software.

### Geometric mean diameter and Sphericity

Geometric mean diameter (D)and sphericity (S) for flat seeds were calculated by using following equation(Mohsenin, 1970).

$D = (l*b*t)^{1/3}$ and $S = \frac{(l*b*t)1/3}{l}$

Where, l – Length,
b – Breadth and
t – Thickness

### One thousand seed weight

The weight of the seed directly influences the suction pressure needed to pick up the seed.One thousand seeds were randomly selected and weighed using an electronic balance. This procedure was repeated for five times.

### Bulk density

The volume of seed holder depends upon the bulk density of seeds. Bulk density of seeds wasdetermined by ratio ofweight of seeds in container (kg) and volume of container ($m^3$).This procedure was repeated for five times.

### Angle of repose

The angle of repose of seeds were measured by “emptying method”.This procedure was repeated for five times.

### Co-efficient of static friction

The coefficient of static friction ($\mu_s$) of seeds were determined by inclined plane method. The test surfaces used were plywood, galvanised iron and mild steel.This procedure was repeated for five times.

### Terminal velocity

Terminal velocity of seeds were required for establishing the minimum negative pressure level for design of the pneumatic seeder.Terminal velocity was measured by using wind tunnel apparatus. For each experiment, a sample was dropped into the air stream from the top of the air column, up from which air was blown to suspend the material in the air stream. The air velocity near the location of the seed suspension was measured by anemometer at the inlet side. The procedure was repeated for five times.

## RESULTS AND DISCUSSION

Mean and standard error mean of seeds are given in Table. 01 and the properties were discussed below.The moisture content found was 11.26, 7.78, 7.82, 9.73 and 5.23 % for chilli, brinjal, tomato, capsicum and knol-khol seeds respectively on dry basis.Length, width and thickness of seeds ranged from 2.78±0.03 to 4.28±0.03, 2.06±0.02 to 3.89±0.02, 0.28±0.004 to 0.59±0.01 mm.

Frequency distributions of length, width and thickness for all seeds are given in Figs. 3,4,5,6 and 7 respectively**.** It was observed that in case of chilli48percent of seeds had length of about 3.5 mm, 47percent of seeds had width of about 4.5 mm and 29 percent of seeds had thickness of 4 mm

**Tab. 1. Mean and standard error of physical properties of some seeds**

| Property | Chilli | Brinjal | Tomato | Capsicum | Knol-khol |
|---|---|---|---|---|---|
| Length/major dia. (mm) | 4.08±0.03 | 2.78±0.03 | 3.02±0.04 | 4.28±0.03 | 1.95±0.02 |
| Width/minor dia. (mm) | 3.32±0.04 | 2.55±0.02 | 2.06±0.02 | 3.89±0.02 | 1.69±0.02 |
| Thickness (mm) | 0.44±0.01 | 0.28±0.004 | 0.59±0.01 | 0.54±0.01 | –- |
| Geometric mean diameter | 1.81±0.01 | 1.26±0.01 | 1.53±0.01 | 2.07±0.01 | 1.77±0.02 |
| Sphericity | 0.44±0.003 | 0.45±0.003 | 0.51±0.005 | 0.48±0.003 | 0.91±0.01 |
| Thousand seed weight (g) | 5.53±0.09 | 2.82±0.06 | 2.68±0.07 | 8.2±0.07 | 2.97±0.26 |
| Bulk density (kg $m^{-3}$) | 460.99±4.93 | 540.03±8.66 | 292.61±3.24 | 401.68±4.43 | 643.61±7.73 |
| Angle of repose (degrees) | 33.33±0.48 | 30.48±0.84 | 40.63±1.01 | 27.66±0.75 | 24.99±0.31 |
| Co-efficient of static friction (ply wood) | 0.36±0.01 | 0.33±0.01 | 0.38±0.01 | 0.36±0.02 | 0.35±0.01 |
| Co-efficient of static friction (GI) | 0.38±0.01 | 0.37±0.01 | 0.38±0.02 | 0.36±0.02 | 0.28±0.01 |
| Co-efficient of static friction (MS) | 0.63±0.01 | 0.49±0.01 | 0.54±0.01 | 0.55±0.01 | 0.45±0.01 |
| Terminal velocity (m $s^{-1}$) | 1.82±0.10 | 1.84±0.15 | 2.12±0.13 | 2.06±0.13 | 1.66±0.04 |


**Fig. 1. Vegetable seeds used in study**

**Fig. 2. Measurement of Linear dimensions with microscope assisted with Q-capture software**

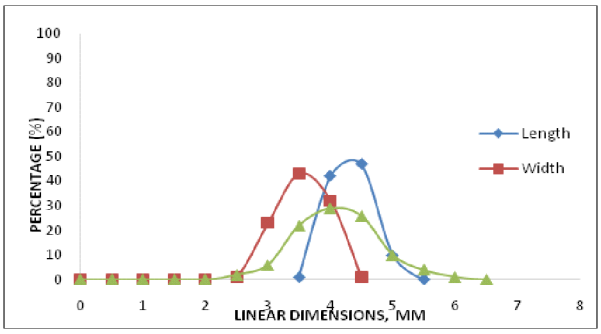


**Fig. 3. Frequency distribution curves length, width, thickness of linear dimensions of chilli seeds**

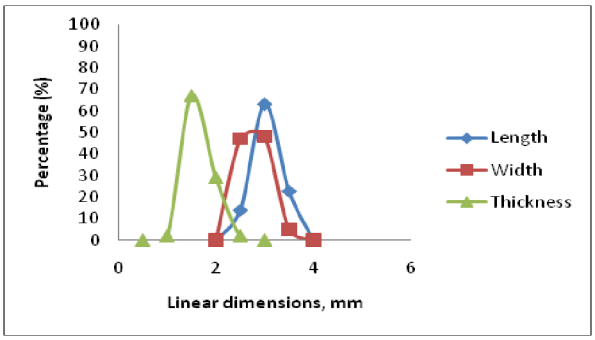


**Fig. 4. Frequency distribution curves length, width, thickness of linear dimensions of brinjal seeds**

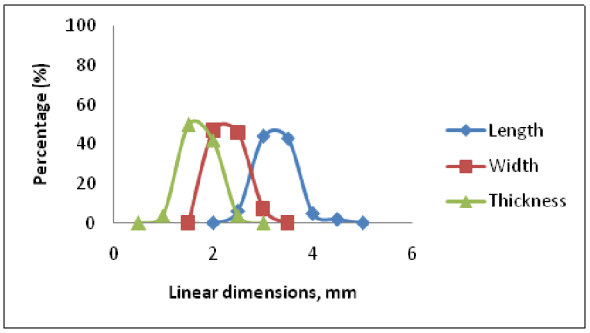


**Fig. 5. Frequency distribution curves length, width, thickness of linear dimensions of tomato seeds**

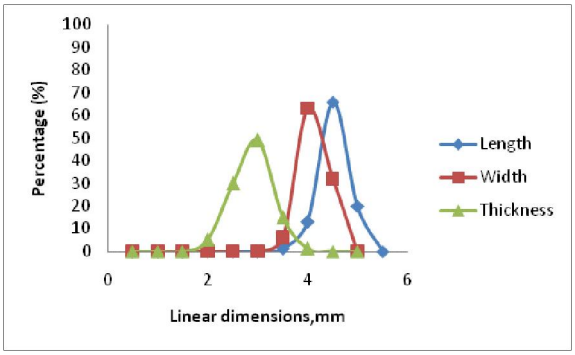


**Fig. 6. Frequency distribution curves length, width, thickness of linear dimensions of capsicum seeds**

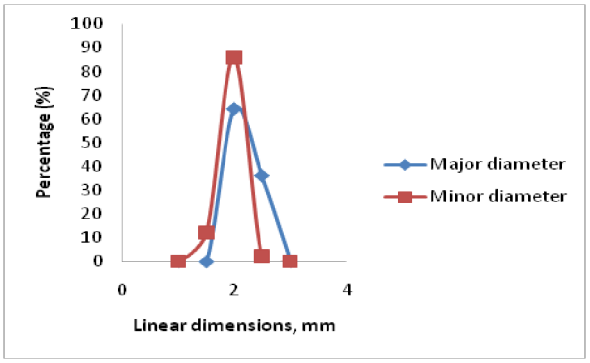


**Fig.7. Frequency distribution curves length, width, thickness of linear dimensions of knol-khol seeds**

(Fig.3).In case of brinjal 63 percent of seeds had length of 3 mm, 48 percent of seeds had width of 3 mm and 67 percent of seeds had thickness between 1.5 mm (Fig.4).In case of tomato 44 percent of seeds had length of 3 mm, 47 percent of seeds had width of2 mm and 50percent of seeds had thickness of about 1.5 mm (Fig.5).In case of capsicum66 percent of seeds had length of 4.5 mm, 63 percent of seeds had width of 4 mm and 49 percent of seeds had thickness of 3 mm (Fig.6).In case of knol-khol64 and 86 percent of seeds had major and minor diameter of 2 mm (Fig.7).

Geometric mean diameter and sphericity ranged from 1.26±0.01 to 2.07±0.01 and 0.44±0.003 to 0.91±0.01. Thousand seed weight ranged from 2.68±0.07 to 8.2±0.07 g while corresponding bulk density ranged from 292.61±3.24 to 643.61±7.73 kg $m^{-3}$. Angle of repose ranged from 24.99±0.31 to 40.63±1.01. Co-efficient of static friction using plywood, galvanized iron and mild steel ranged from 0.33±0.01 to 0.38±0.01, 0.28±0.01 to 0.38±0.02 and 0.45±0.01 to 0.63±0.01. Terminal velocity ranged from 1.66±0.04 to 2.12±0.13.

## CONCLUSION

The Physical and engineering properties were carried out for chilli, brinjal, tomato, capsicum and knol-khol seeds. This is one of the primary data for designing agricultural equipment for sowing, handling and post-harvest.

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