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Evaluation of the physical, mechanical and kinetic properties of some cereals and leguminous seeds in Benin republic

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Abstract

In order to design a seeder for direct sowing, a seed characterization study was conducted. The objective was to assess the physical, mechanical and kinetic properties of the most cultivated cereals and leguminous in Benin. Two varieties of *Zea mays*, four varieties of *Vigna unguiculata*, one variety of *Arachis hypogea*, one variety of *Cajanus cajan* and two varieties of *Glycine max*were studied. It was noticeda variation in physical parameters not only between species but also between varieties of the same species. All sphericity coefficients are greater than 0.7 with *C.cajan* which is more spherical (0.91±0.03) against the DMR ESR-W/QPM and 85 TZSR-W varieties of *Z.mays* which are the least spherical with 0.72±0.10 and 0.71±0.11 respectively. The rupture force generally increased from 14 to 720 N. Vigna TVX 32-36 is the most resistant with 633.3±75.72 N against 16.0±2.0 N for Arachis TS32-1 the least resistant. Overall, the falling speed decreased from 1.67 to 0 m/s on the rigid PVC, from 1.36 to 0 m/s on the black plate and from 1.67 to 0 m/s on the transparent hose when the angle of inclination increases from 20° to 70° relative to vertical. These parameters are essential for good sizing of the distribution system and the seed descent channels for a seeder.They can also be used for grains calibration and other use in agricultural engineering and food processing.

Keywords: Seeds, physical properties, mechanical properties, kinetic properties, Benin

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1. Introduction

Agriculture is important for African development. Subsistence agriculture is practiced by a majority of small farmers, yield differentials are profound and soil poverty and other constraints add to the difficulty in sustainable agriculture practices and difficulty to create income (FAO, 2015). Africa is the center of origin and a major producer of various cereals such as maize, sorghum, african rice (Macauley and Ramadjita, 2015) and leguminous crops such as cowpea, groundnuts and soybeans (IRAD, 2013). While cereals are staple foods for the majority of the population, leguminous could be an alternative to improve the nitrogen nutrition of humans and animals and for plant nutrient management which is environmentally safe and can efficiently reduce the fertilizer consumption in the developing countries (Pokhrel and Pokhrel, 2013).

In order to increase production, mechanization of production systems with respect the environment is necessary. For this purpose, the use of rapid technologies such as seeders appears necessary. Indeed, mechanical sowing contributes to the speed of the work and the good development of the crops (Azmon, 2013). It is done either with a conventional seeder or with a direct seeder. Whether done in conventional or direct sowing, the seed must be placed at a good depth and covered carefully. However, apart from the low germination rate sometimes attributable to poor seeding depth and seed recovery (Massicotte *et al.*, 2000), problems related to the distribution systems, namely the presence of two seeds per hole,fracture and lack of seeds on the line are also noticed. The severity of these problems is sometimes high and requires the farmer to monitor very intensively the field after sowing (Tits and Leveque, 2001). To remedy this, seed calibration have been created. However, these sizes are not the same for all countries and for varieties of the same species.

In Benin, the availability of certified seeds is not always effective, forcing producers to turn to previous harvests or sold on the market (Raunet, 2002) and whose physical, mechanical and kinetic properties are not known. For certified seeds, their calibration is not often uniform. Some seed producers continue to use rudimentary equipment, despite the availability of modern calibration equipment (Achigan-Dako *et al.*, 2014). This distorts the calibration and constitutes a constraint for the design of agricultural equipment. However, it is not possible to design and produce efficient equipment without a thorough knowledge of the physical and mechanical properties of the seeds because their efficiency and performance depend of them (Ahouansou *et al.*, 2012; Faleye *et al.*, 2013). In fact, beyond the opening and closing systems of the grooves, the characteristics of the seed distribution and descent systems constitute another technical aspect on the seeder. Thus, the physical parameters of the seeds (length, width and thickness) influence the dimensions of the selection holes at the distributors and the length and diameter of the descent systems on the seeders. These parameters, coupled with the seed kinetics, make it possible to minimize seed fractures, unseed holes and many plants on same holes (Soyoye *et al.*,2016).

On the other hand, unlike research geared to seed processing, very few studies have been done to the mechanization of sowing of most cereals and leguminous in Benin. Moreover, the improvement of seed varieties now makes it impossible to use the old data used in the dimensioning of the distribution components of old seeders. It is therefore necessary to characterize the seeds currently used by the producers in order to dimension the sowing equipmentand to minimize the sowing defects. Given the importance of direct sowing in water and soil conservation (Abdellaoui *et al.*, 2011), the design of suitable equipment becomes necessary to facilitate its expansion. The present study aims to assess the physical, mechanical and kinetic characteristics of the seeds of some cereals and leguminous that are commonly cultivated in Benin with the aim to design a direct seeder in order to accompany the successful functioning of conservation agriculture. This is essential for environment preservation in the current context of climatic variability and rainfall peaks in West Africa and particularly in Benin (Perard *et al.*, 2001; Houndénou, 1999).

2. Material and methods

2.1 Plant material

The plant material used consists of a cereal : maize (*Zea mays*) with two varieties (DMR ESR-W / QPM and 85 TZSR-W); four leguminous: cowpea (*Vigna unguiculata*) with four varieties (TVX 32-36 ; IT96D-610 ; IT90K-372-1-2 and IT97K-499-35), Peanut (*Arachis hypogea*) with a variety (TS 32-1), pigeon pea (*Cajanus cajan*) with local variety and soybean (*Glycine max*) including two varieties (Jupiter and ISRA25 / 72). These crops are retained because they are part of the main dry and oilseed crops grown in Benin (UNDP and FAO, 2000). The choice of varieties is based on their frequency on the market, revealing their degree of production.

2.2 Determination of the physical characteristics of seeds

Physical characteristics such as length, width and thickness were measured using a calipers, Kema model 150 mm in length and with an accuracy of ± 0.02 mm. Data were collected on 50 seeds taken randomly from the seed lot of each variety of all species.

Arithmetic mean diameter (D_a), geometric mean diameter(D_g) and the sphericity (Φ)were calculated according to the following relationships (Kiani Deh Kiani *et al.*, 2008 ; Pomeranz *et al.*, 1985 ; Kibar and Kibar, 2017):

$$D_a = \frac{L + W + T}{3} \tag{1}$$

$$D_g = \left(L \times W \times T\right)^{\frac{1}{3}} \tag{2}$$

$$\Phi = \frac{\left(L \times W \times T\right)^{1/3}}{Max\ (L, W, T)} \tag{3}$$

with L: length, W: width and T: thickness.

One of the aspect ratio (R) is calculated using the equation of Maduako and Faborode (1990):

$$R_a = \frac{L}{W} \tag{4}$$

The masses were measured from an Ohaus Pioneer electronic balance and accurate ± 1 mg. The apparent volumes were taken using a graduated cylinder. The bulk density is calculated by:

$$\circ_a = \frac{m}{v_a} \tag{5}$$

where $\circ_a$ is the bulk density, m mass and v_a apparent volume.

To assess the moisture content, a sample of 50 seeds of each variety of different species was weighed to determine the initial fresh weight (M_f) using the previous electronic scale. The seeds are then dried in an oven at a temperature set at 60 ± 2 ° C during 24 hours in order to estimate the dry weight (M_d). The moisture content (W_c) of each sample was calculated as follows:

$$W_c = \frac{M_f - M_d}{M_d} \times 100 \tag{6}$$

2.3 Determination of mechanical characteristics

The rupture strength was ed using the PCE-FB10k dynamometer which measuring range10.000 N and precision ± 2 N. A sample of 50 seeds was taken at random. Each seed was compressed in the direction of thickness. The operation is stopped when a deformation or fracture of the seed is observed (Tavakoli *et al.*, 2009) and the maximum force applied to crush it is read on the dynamometer screen.

2.4 Evaluation of falling speed of the seeds

Three materials were used to characterize the seed falling speed. It is a rigid PVC tube with an external diameter of 32 mm, a black plate (sheet steel) with 1 mm as thickness and a transparent hose with an external diameter of 28 mm. The length used for each material is 500 mm. Each material is inclined at three angles of inclination: 20°, 50° and 70° relative to the vertical. The time taken by each seed to fall 50 mm was timed for the variety of each species depending on the materials and angle of inclination (Figure 1). The speed is obtained by the relation:

$$V = \frac{d}{t} \tag{7}$$

With V the falling speed of the seeds, t the time taken to traverse the distance d.

3. Statistical analysis

An Analysis of Variance was performed on the calculated parameters. The factors studied are the dimensions, the resistance and the falling speed of the seeds. Newman and Keuls test was used for the multiple comparison of means. Pearson correlation test was performed between the dimensions of the seeds. The different analyzes and tests are carried out in the statistical software R. The differences are considered as significant at 95% confidence level ($p < 0.05$).

4. Results

4.1 Physical properties of seeds

Table 1 shows the different physical parameters measured on the seeds. In general, a significant difference between the varieties of the same species is noticed, and then between the species. It noticed that the seeds have very variable formes in view of these differences in length, width and thickness. This variation in shape is higher for species showing the highest standard deviations: *A. hypogea* and *V. unguiculata* (IT96D-610) for length and the two varieties of *Z. mays* for thickness.

On the other hand, the moisture content has varied between species. The variation between the varieties of the same species isnon significant. The low moisture content is observed at *Z. mays var*. DMR ESR-W / QPM (3.34 ± 0.17 %) and highest at *G. max var*. Jupiter (7.90 ± 2.82 %). With the exception of *Z. mays*, there was a large variation in the mass between varieties of other species. However, the only variation noted in volume concerns only varieties of *V. unguiculata*(Table 1). Table 2 shows the arithmetic and geometric diameters and the sphericity of seeds. The analysis of Table 2 shows that the different diameters and coefficient varied significantly between species. However, apart from the varieties of *V. unguiculata*, the above parameters were almost unchanged between the varieties of the other seeds. Moreover, all seeds have a sphericity greater than 0.70. The seeds of *C. cajan* is the most spherical and those of *Z. mays* the least spherical (Table 2). Table 3 shows the relationships between seed size and correlations. For almost all the seeds.The length exceeds the width which itself is greater than the thickness. The majority of the ratios is less than 2. The ratios close to 1 in case for *C. cajan* and *G. max* are a good indicator of the low variability between their dimensions. However.These ratios are more or less greater than 2 for the two varieties of *Z. mays* and the variety IT97K-499-35 of *V. unguiculata*. On the other hand, with the exception of the varieties of *Z. mays* and *A. hypogea*, there are strong correlations between the dimensions of other species (Table 3).

Table 1 : Mean and standard error of physical parameters per seed unit, followed by SNK test differentiation groups

Species	Varieties	Length (mm)	Width (mm)	Thickness (mm)	Moisture content (%)	Mass (mg)	Volume (ml)	Bulk density (mg/ml)
Zea mays	DMR ESR-W/QPM	10.35±1.12[a]	8.81±0.73[a]	4.60±1.31[c]	3.34±0.17[c]	279.07±8.05[b]	0.53±0.0[a]	527.38
	85 TZSR-W	11.31±1.44[a]	9.04±0.81[a]	4.87±1.1[c]	3.55±0.01[c]	283.31±1.17[b]	0.54±0.08[a]	523.034
Vigna unguiculata	TVX 32-36	8.22±0.78[b]	6.62±0.48[c]	5.14±0.41[c]	4.67±1.54[abc]	134.20±4.95[e]	0.24±0.0[d]	571.06
	IT96D-610	8.02±1.69[b]	6.68±0.87[c]	4.67±0.43[c]	7.46±0.02[ab]	135.76±2.15[e]	0.26±0.01[d]	517.63
	IT90K-372-1-2	10.36±1.28[a]	7.69±0.78[b]	6.16±0.74[b]	6.65±0.07[abc]	210.49±13.36[c]	0.44±0.0[b]	478.39
	IT97K-499-35	9.71±1.32[a]	6.81±0.64[c]	4.92±0.70[c]	7.48±0.05[ab]	172.44±3.68[d]	0.35±0.05[c]	492.68
Arachis hypogea	TS 32-1	10.54±2.95[a]	6.72±0.58[c]	7.21±0.81[a]	4.36±0.04[abc]	308.0±0.54[a]	0.58±0.04[a]	535.65
Cajanus cajan	Local variety	5.84±0.43[d]	5.86±0.52[d]	4.6±0.39[c]	5.99±0.62[abc]	102.49±3.75[g]	0.17±0.0[d]	597.28
Glycine max	Jupiter	6.98±0.41[bcd]	5.87±0.52[d]	4.70±0.37[c]	7.90±2.82[a]	122.39±1.03[ef]	0.20±0.0[d]	624.97
	ISRA25/72	6.20±0.54[cd]	5.68±0.42[d]	4.22±0.56[c]	4.92±0.08[abc]	97.34±1.04[g]	0.2±0.04[d]	486.70

In a column, the means with different letters are significantly different (p<0.001) according to Newman and Keuls test.

Table 2 : Mean and standard error of seed form parameters followed by SNK test differentiation groups

Species	Varieties	Arithmetic diameter (mm)	Geometric diameter (mm)	Sphericity
Zea mays	DMR ESR-W/QPM	7.92±0.52^{a}	7.41±0.60^{ab}	0.72±0.10^{c}
	85 TZSR-W	8.41±0.52^{a}	7.87±0.62^{a}	0.71±0.11^{c}
Vigna unguiculata	TVX 32-36	6.66±0.48^{b}	6.53±0.46^{c}	0.80±0.04^{bc}
	IT96D-610	6.46±0.96^{bc}	6.29±0.88^{cd}	0.80±0.08^{bc}
	IT90K-372-1-2	8.07±0.88^{a}	7.88±0.85^{a}	0.76±0.03^{bc}
	IT97K-499-35	7.15±0.81^{b}	6.87±0.78^{bc}	0.71±0.05^{c}
Arachis hypogea	TS 32-1	8.16±1.30^{a}	7.94±1.13^{a}	0.78±0.13^{bc}
Cajanus cajan	Local variety	5.43±0.40^{d}	5.39±0.40^{e}	0.91±0.03^{a}
Glycine max	Jupiter	5.85±0.38^{cd}	5.77±0.39^{de}	0.83±0.03^{b}
	ISRA25/72	5.37±0.49^{d}	5.29±0.50^{e}	0.85±0.03^{ab}

In a column, the means with different letters are significantly different ($p<0.001$) according to Newman and Keuls test.

Table 3 : Relationship between seed size andcorrelations

	Varieties	Ratio		
		L/W	L/T	W/T
Zea mays	DMR ESR-W/QPM	1.18±0.13 (0.35)^{NS}	2.40±0.65 (-0.44)^{NS}	2.03±0.48 (-0.18)^{NS}
	85 TZSR-W	1.27±0.24 (-0.46)^{NS}	2.44±0.67 (-0.10)^{NS}	1.90±0.24 (0.79)**
Vigna unguiculata	TVX 32-36	1.24±0.08 (0.77)**	1.61±0.17 (0.36)^{NS}	1.29±0.09 (0.63)*
	IT96D-610	1.19±0.13 (0.91)***	1.71±0.26 (0.81)**	1.43±0.08 (0.94)***
	IT90K-372-1-2	1.35±0.12 (0.69)*	1.68±0.08 (0.94)***	1.25±0.09 (0.80)**
	IT97K-499-35	1.42±0.12 (0.82)**	1.98±0.24 (0.69)*	1.40±0.13 (0.72)*
Arachis hypogea	TS 32-1	1.56±0.38 (0.51)^{NS}	1.45±0.33 (0.60)^{NS}	0.94±0.05 (0.88)***
Cajanus cajan	Local variety	1.00±0.07 (0.68)*	1.27±0.08 (0.67)*	1.27±0.07 (0.82)**
Glycine max	Jupiter	1.20±0.09 (0.49)^{NS}	1.49±0.08 (0.80)**	1.25±0.07 (0.75)*
	ISRA25/72	1.09±0.05 (0.84)**	1.48±0.12 (0.87)***	1.36±0.12 (0.88)***

Each number in parenthesis is the correlation value between the two parameters. NS: Not significant at 95% confidence level ($p>0.05$). * significant at 95% ($p<0.05$). ** significant at 99% ($p<0.01$). *** significant at 99.9% ($p<0.001$) based on Pearson correlation test.

4.2 Mechanical seed property

Table 4 summarizes the fracture force of each seed. Table 4 shows that the rupture effort varied greatly between the majority of the varieties of species and then of one species to another. The minimum breakdown stress varies from 14 N for *A. hypogea* TS 32-1 to 580N for *V. unguiculata* TVX 32-36. The maximum force varie from 18 N to 720 N respectively for the same varieties. *V. unguiculata* TVX 32-36 is the most resistant (633.3 ± 75.72 N) against *A. hypogea* TS 32-1 least resistant of fracture (16.0 ± 2.0 N) (Table 4).

4.3 Seed kinetics

Figure 1 shows the evolution of falling speed of the seeds as a function of the type of material and the angles of inclination. The analysis of variance revealed a significant difference between speeds according to the type of material and the angle of inclination for each variety of species on the one hand; and between the varieties then the species on the other hand (p = 0.000). For all varieties, falling speeds decrease as the angle of inclination increases. These speeds are zero at 70 ° inclination on the PVC for all *Z. mays* and *V. unguiculata*; on the black sheet for *Z. mays* and on the transparent hosefor the DMR ESR-W / QPM variety of *Z. mays* and the variety IT97K-499-35 of *V. unguiculata* (Figure 1).

Table 4 : Rupture efforts perseed

	Varieties	Minimum fracture force (N)	Maximum fracture force (N)	Average of fracture force (N)
Zea mays	DMR ESR-W/QPM	290	362	319.3±37.81[b]
	85 TZSR-W	237	270	253.0 ±16.52[c]
Vigna unguiculata	TVX 32-36	580	720	633.3±75.72[a]
	IT96D-610	115	132	122.3±8.74[de]
	IT90K-372-1-2	56	80	69.33±12.22[e]
	IT97K-499-35	112	160	132.0±24.98[de]
Arachis hypogea	TS 32-1	14	18	16.0±2.0[f]
Cajanus cajan	Local variety	140	170	154.0±15.1[d]
Glycine max	Jupiter	94	124	104.0±17.32[de]
	ISRA25/72	106	112	108.7±3.1[de]

Means with different letters are significantly different ($p<0.001$) according to Newman and Keuls test.

5. Discussion

5.1 Physical properties of seeds

The three dimensions of all seeds species (length. width and thickness) differ clearly and in decreasing order from length, width to thickness except for *C. cajan* (Table 1). The dimensions obtained on maize are closer to those obtained by Tarighi *et al.* (2011) which are respectively L: 11.33 ± 0.49 mm, W: 7.93 ± 0.55 mm, T: 4.69 ± 0.33 mmat 5.15 % moisture of *Z. mays* yellow variety similar to 85 TZSR-W. The sphericity of maize obtained in this study (0.71 to 0.72) at 3.44 to 3.55 as moisture content are higher than those obtained by Ashwin Kumar *et al.* (2017) which increased from 0.63 to 0.67 as the moisture content increased from 12 to 20%.

For the varieties of *V. unguiculata*, the normal dimensions vary as follows: L: 6-10 mm, W: 4-7 mm and T: 3-5 mm (Henshaw, 2008); comparable to the results of this study with the exception of the variety IT90K-372-1-2 where the thickness is 6.16 ± 0.74 mm. The results about*G. max* are also close to those obtained by Kibar and Öztürk (2008) where L: 7.32 ± 0.39 mm, W: 6.79 ± 0.41 mm, T: 5.78 ± 0.34 mm, D_a: 6.60 mm and D_g: 6.57 mm. However, overall the variability of seed length appears to be greater than that of width and thickness given the standard deviations. Kibar (2016) obtained different grain moisture contents for corn grains at different storage times, which are close to the results of this study. The mean arithmetic diameters of varieties of *V. unguiculata* IAR-339-1 ; *V. unguiculata*IT86D-1010 and Ife brown increased respectively from 7.84 to 10.08 mm ; 9.14 to 11.52 mm and 7.69 to 9.87 mm (Arthur, 2009); with geometric diameters always less than the arithmetic diameters. These values are superior to the results of this study with a compliance with the relationship between the two diameters. The high coefficient of variation of the thickness led Bockstaller (1993) to use the thickness instead of sphericity as a criterion to sort the seeds according to the form. This sphericity (Table 2) previously used by Pomeranz *et al.* (1985) to characterize the form is based on the assumption that the grain is an ellipsoid of maximum length L, width W and thickness T and that this coefficient would be equal to 1 if the grain was a perfect sphere.Generally, the sphericity depend of moisture content and there is an increasing trends for sphericity with moisture content (Barnwal *et al.,* 2012).Because the real form of the seeds is in some cases similar to a prism (*Z. mays*), in other cases a sphere (*C. cajan* and *G. max*) and with all intermediates and irregular forms (*V. unguiculata* and *A. hypogea*), there is no direct link between the sizing of cereals and leguminous studied. This makes to think of a conception of specific distribution system to each species.

However, an approximation of the dimensions of certain varieties and / or species would make it possible to overcome this obstacle and to design a distributor for varieties and species with similar characteristics. Moreover, these dimensions increase with the increase in the moisture content of the seeds (Davies and Zibokere, 2011). This is what Henshaw, (2008) found with *Z. mays* var. IAR-339-1 whose length increased by 87% (9.80 to 13 mm) and 74% (12 to 15 mm) for *V. unguiculata* var. IT86D-1010. An average sphericity value greater than 0.78 is a good value for sowing results (Tits and Leveque, 2001). For almost all seeds, the ratios (L / W ; L /T and W / T) are less than 2 (Table 3). This means that if we use the largest dimension of the seed to design the hole of distribution system there is less risk for doubloon. However, these ratios are greater than 2 for the two varieties of *Z. mays* and the variety IT97K-499-35 of *V. unguiculata* if we account their standard error. This suggests the risk of selecting two seeds when sowing. On the other hand, with the exception of the varieties of *Z. mays* and *A. hypogea,* there are strong correlations between the dimensions of other species.

The calibration based on the passage of the grains by grids with holes of variable size and form is the method used in seed production. However, this method used by many authors does not suggest any connection between size and real seed size and merit a reflection (Bockstaller, 1993).

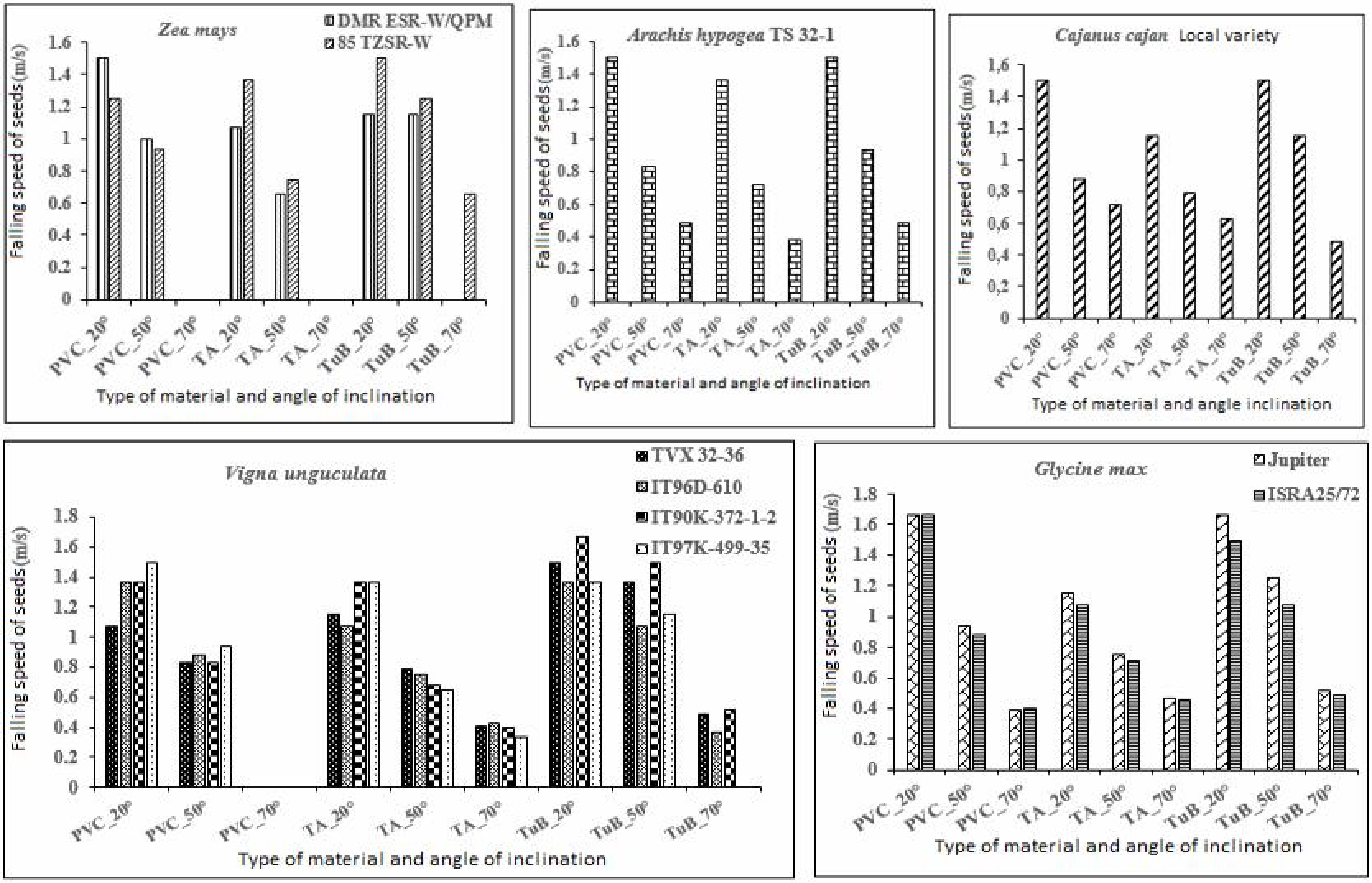

Fig. 1 Seed falling speed according to material type and angle of inclination
Legend : PVC_20°: rigid PVC tube inclined at 20 °; TA_20°: black sheet inclined at 20°; TuB_20°: transparent hose inclined at 20°.

For the same author, two extreme and theoretical cases make it possible to approach the notion of caliber: if all the grains were of spherical or cylindrical form, the caliber would be defined by the diameter of the hole corresponding to maximum diameter of the seeds which can pass through the grid. For this purpose,a single measurable criterion, in this case the diameter, would be sufficient to define the size. But if it is a parallelepipedic form, the grain can then cross the grid only by appearing in front of the hole by its smallest surface (Bockstaller. 1993). This is not that simple. Tests based on the efficiency of seed selection with distributors sized according to length, width, thickness, arithmetic diameter or geometry by varieties and species are required. This must be based on the present results relating to these parameters.

5.2 Mechanical property of seeds

The fracture forces varied greatly between the majority of the varieties of species and then of species to another (Table 4). The fracture stress along the thickness decreases from 347.5 to 226.2 N for *Z. mays* when its moisture content increases from 5.15 to 22% (Tarighi *et al.*, 2011). This is same thingwith in this study. As regards *V. unguiculata*, Henshaw (2008) found a rupture force ranging from 60 to 80 N. This is not verified in this studyexcept for the variety IT90K-372-1-2 for which this force ranged from 56 to 80 N. It may be related to the moisture content which varied between the most resistant variety (4.67 ± 1.54%) and the least resistant to fracture (6.65 ± 007%). This is harmony with Obi *et al.* (2014) which reported a inversely proportional relationship between the fracture force and the moisture content which ranged successively from 159.10 to 69.30 N and 10% to 25% for *C. cajan*. According to the same authors, this would result from the fact that the seed of *C. cajan* would have a soft texture when its moisture content is high.Davies and Zibokere, (2011) found that the fracture forces ranges from 64 ti 40 N for IAR-339-1, 63 to 38 N for IT86D-1010 and 70 to 46 N for Ife Brown, and they conclued that the decrease observed from fracture force at higher moisture content showed that cowpea is sensitive to moisture content.

Moreover, the seed form has an influence on their mechanical strength. Indeed, grain breakage is favored by the angularity of the particles. Grain fracture increases with angularity for granitic gravel after a triaxial test (Ovalle, 2013). This is due to the fact that the angular grains have fewer points of contact between particles and therefore transmit higher forces with respect to rounded grains under the same macro-mechanical stress. Similarly, geometric irregularities or angular grain tips are more sensitive to fractures and attrition.

5.3 Seed kinetics

As the angle of inclination increases, the falling speedof seeds decrease depending on the type of material and the angle of inclination for each variety of each species (Figure 1). The ideal would be to have a high speed for a fast fall of seeds. However, the positioning of the descent tubes between the hopper and the opening systems is not always linear. The descent is more rapid firstly for the transparent hose followed by the rigid PVC. These speeds are even zero at 70° inclination on all materials for some species. This reveals the margins to be observed in the inclination of the tubes and also raises the problem of the friction coefficient of the seeds on the walls of the tubes. These parameters make it possible to determine the ideal length and the adequate angle of inclination of the seed descent channels for an accurate fall of the seeds in the bottom of the seed bed.

6. Conclusion

The present study on the characterization of seeds made it possible to assess the physical, mechanical and kinetic properties of the most cultivated cereals and legumous in Benin. This work shows that for most of the studied seeds the lengths are greater than the widths which themselves exceed the thicknesses. The sphericity are greater than 0.7 with more ratios less than 2 except for*Zea mays* varieties. The fracture forces varies from 14 to 720 N with the varieties of Vigna as the most resistant and *Arachis hypogea* the least resistant. The falling speed depends on the type of material and generally decreases from 1.67 to 0 m/s as the angle of inclination increases from 20° to 70° relative to vertical. Based on the results of this study, different distribution organs can be fabricatedwith a certain number of varieties and / or species. A good design of a seeder remains subject to the knowledge of these parameters.These parameters are also essential for other use needing grain size, grain calibration and other use in agricultural engineering and food processing.

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