Indian Journal of Agricultural Sciences **93** (2): 229–232, February 2023/Short Communication
https://doi.org/10.56093/ijas.v93i2.124207

Physical characterization of morphologically diverse colour maize (*Zea mays*) seeds

BHARAT BHUSHAN[1]*, MANOJ KUMAR MAHAWAR[2], KIRTI JALGAONKAR[2], MANESH CHANDER DAGLA[1], PARDEEP KUMAR[1], YATHISH KR[1] and DHARAM PAUL CHAUDHARY[1]

ICAR-Indian Institute of Maize Research, Ludhiana, Punjab 141 004, India

Received: 24 May 2022; Accepted: 6 January 2023

Keywords: Germplasm, Kernels, Physical properties, Pigments, Projected area

In India, maize (*Zea mays* L.) is cultivated in two seasons, i.e., rainy (*kharif)* and post-rainy (*rabi)*. In *kharif* (2020) and *rabi* (2020–21), the production has been recorded as 21.56 and 10.09 million tonnes, respectively. The area and productivity as per Indian statistics were 9.89 million hectare and 3199 kg/ha, respectively. The methods of sowing or seeding play a crucial role in the final establishment of crop and individual plant stand. All this is dependent on interactions of seed with soil, soil moisture, seedling depth, sowing method, use of tools etc. Uniform placement of seeds increases crop yield and non-uniform spacing lead to lesser yield. To overcome this problem, precise spacing and drill depth mechanism for sowing of maize seed is always felt. The food processing operations at small and large scale are also dependent upon physical dimensions (Bolaji *et al.* 2018, Solanki *et al.* 2019a). Hence, study of physical properties of maize seeds for development of seeding tool is most important. However, a number of studies are reported on maize seeds (Tarighi *et al.* 2011, Ashwin *et al.* 2017, Brar *et al.* 2017, Soyoye *et al.* 2018) but there is no information available on physical properties of the colour maize seeds and its comparison with non-colour seeds. The aim of this study was to physically characterize the seeds in terms of dimensions and colour properties so that small tools like planters or graders can be designed from the available data of colour maize germplasm.

Seeds of colour maize: The imported and indigenous seeds of colour maize germplasm were selected to study the physical properties. The study was carried out at Central Institute for Research on Cotton Technology, Mumbai, Maharashtra and ICAR- Indian Institute of Maize Research, Ludhiana, Punjab during 2021–22. The accession numbers (EC 1008277, EC 1008284, EC 1008287, IC 77530, IC 327012, IC 328975, IIMR 11596 and IIMR 11180) with diverse colours (blue, red and white) were selected for the physical characterization.

The moisture in the seed samples was determined according to AOAC approved vacuum oven method (AOAC 1998). Since transportation, storage and handling operations of the seeds are performed in the moisture range (11–12%) so all the measurements were carried out at this moisture level. Test weight was determined for 5 random samples of each landrace on an electronic balance (M/s Metler Toledo, USA; ±0.001 g). One hundred seeds were counted manually and thereafter weighed on the electronic balance. Seeds were measured for their three principle axes using digital vernier callipers (M/s Mitutoyo, Japan; ±0.01 mm). Since the study was carried out on the colour seeds, it was necessary to find out the tristimulus pattern i.e., lightness, yellowness, redness or blueness of the maize seeds. In addition, chroma and hue of the seeds was also measured using the CIE hunter color lab system. Further, arithmetic mean diameter (AMD), geometric mean diameter (GMD) and sphericity of the seeds were calculated using the relationship as mentioned by Mohsenin (1980). The projected area perpendicular to longitudinal axis (L), intermediate axis (W), transverse axis (T), respectively and criteria projected area (CPA) for the whole seed were calculated as per the formulae used by Bibwe *et al.* (2022) and Altuntas and Mahawar (2022). The physical parameters were statistically analyzed using Statistical Packages for Social Sciences (SPSS-16). The correlation coefficient matrix was also retrieved from the same software.

The length is major, width is intermediate and thickness is minor linear dimension. The range of major, intermediate and minor linear dimension was 7.11 to 11.82 mm, 7.17 to 9.31 mm and 5.51 to 7.19 mm, respectively. The landrace, EC 1008277 had the maximum major and intermediate dimension while EC1008284 had the highest minor and linear dimension (Fig 1). The linear physical dimensions especially length and width are essential for designing a tool or equipment for grading, handling or processing of seed (Li

[1]ICAR-Indian Institute of Maize Research, Ludhiana, Punjab; [2]ICAR-Central Institute for Research on Cotton Technology, Mumbai, Maharashtra. *Corresponding author email: bharat.bhushan@icar.gov.in

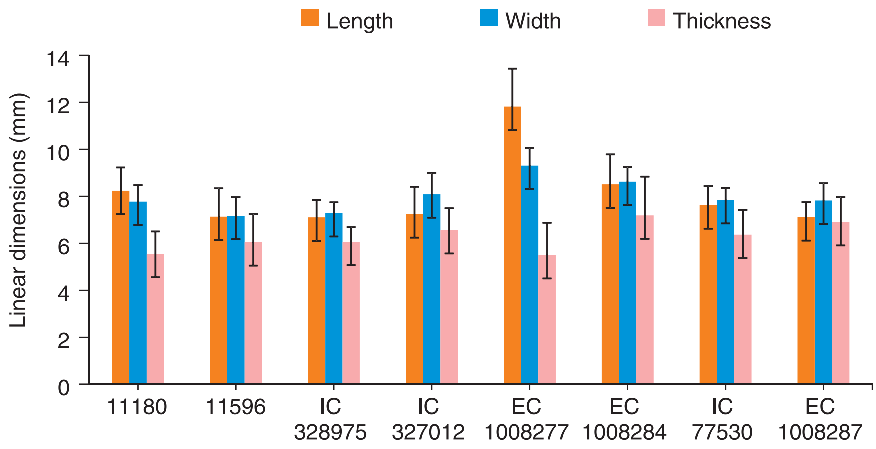

Fig 1 Variation in linear dimensions of diverse colour maize germplasm.

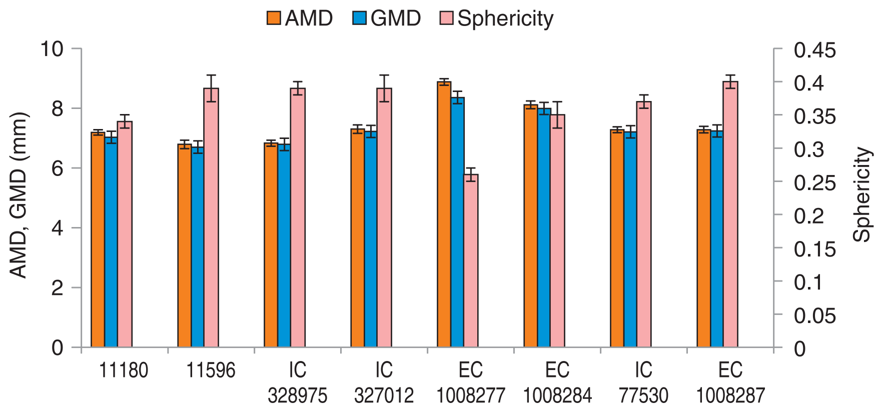

Fig 2 Variation in AMD, GMD and sphericity of diverse colour maize germplasm.

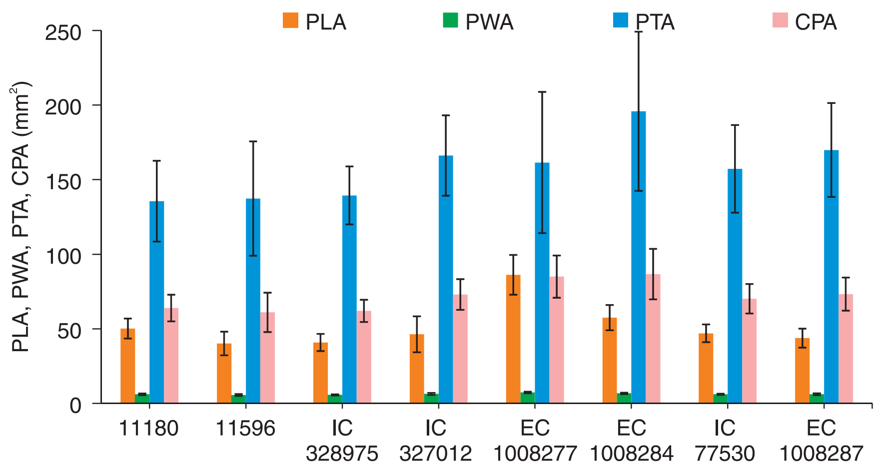

Fig 3 Variation in PLA, PWA, PTA and CPA of diverse colour maize germplasm.

et al. 2019).The linear dimensions are helpful in separation of unwanted material from sample of choice through sieve or grader (Falalu *et al.* 2015). Also, it is useful to note that, the width and thickness of seeds has importance in terms of its drying characteristics. Similar studies on physical parameters of maize have been reported where size of the seed has been shown the best determinant for the co-efficient of friction (Atere *et al.* 2016, Soyoye *et al.* 2018).

The AMD and GMD ranged from 6.79 to 8.88 mm and 6.70 to 8.36 mm, respectively (Fig 2). The geometric mean diameter from 5.02 to 9.13 mm has been reported (Soyoye *et al.* 2018). The accession EC 1008277 had the highest AMD and GMD. The shape of biological material determines its cooling and heat taking capacity. The shape such as angular or circular seeds also decides its mobility on the conveyer belt or in running water channel (Findura *et al.* 2018). The sphericity ranged from 0.26 to 0.40 mm among the studied landraces but the exotic accession EC 1008287 had the highest sphericity value of 0.40 mm. The sphericity for maize ranged from 0.50 to 0.95 (Soyoye *et al.* 2018). The variation in the sphericity tells that the cell for the seeding plate could be semi-circular or slant type corresponding to the linear dimensions, as suggested by Brar *et al.* (2017).

The PLA (projected area perpendicular to longitudinal axis) and PWA (projected area perpendicular to intermediate axis) of studied colour maize landraces ranged from 40.15 to 86.20 and 5.63 to 7.31, respectively. However, EC 1008277 had the highest PLA and PWA. The PTA (projected area perpendicular to transverse axis) and CPA (criterion projected area) ranged from 135.56 to 195.78 and 61.03 to 86.67, respectively (Fig 3). However, the accession EC 1008284 had the highest PTA and CPA. The morphologically diverse set of seeds can be segregated by one tool using different grading filters. Neither the seed companies nor the researchers grade the maize seeds on the basis of morphology. The physical attributes are dependent on the moisture content and the moisture in the seeds can vary the dimensions to different extent (Yenge *et al.* 2018, Solanki *et al.* 2019b).

The tristimulus pattern of selected landrace was evaluated in terms of lightness, chroma and hue. The EC 1008277 had the highest L value (data not shown) whereas IC 0077530 had the lowest L value which shows its darkness in colour shade. The local Indian landrace IC 0011595 having highest 'a' value depicted its redness whereas negative 'a' value of EC 1008287 shows its greenish shade. The lowest 'b' value of EC 1008284 confirmed the blue landrace. The accession IIMR 11595 had the highest chroma whereas the exotic accession EC 1008287 had

Table 1 Correlation coefficient matrix among physical parameters in selected colour maize germplasm

	l	w	t	m	AMD	GMD	Sphericity	PLA	PWA	PTA	CPA	L	a	b	c
w	0.866**														
t	-0.456	-0.012													
m	0.962**	0.959**	-0.235												
AMD	0.914**	0.984**	-0.065	0.979**											
GMD	0.847**	0.983**	0.076	0.943**	0.989**										
Sphericity	-0.983**	-0.820*	0.535	-0.930**	-0.864	-0.791*									
PLA	0.990**	0.923**	-0.350	0.986**	0.956**	0.903**	-0.960**								
PWA	0.867**	1.000**	-0.011	0.959**	0.984**	0.983**	-0.819*	0.924**							
PTA	0.198	0.624	0.771*	0.430	0.575	0.686	-0.112	0.314	0.624						
CPA	0.660	0.924**	0.355	0.820*	0.907**	0.957**	-0.584	0.746*	0.924**	0.866**					
L	0.695	0.426	-0.785*	0.565	0.444	0.332	-0.744*	0.638	0.425	-0.339	0.099				
a	-0.486	-0.633	-0.160	-0.524	-0.622	-0.661	0.494	-0.519	-0.631	-0.530	-0.645	-0.282			
b	0.411	0.063	-0.889**	0.256	0.079	-0.052	-0.473	0.331	0.062	-0.651	-0.280	0.867**	0.222		
c	0.150	-0.209	-0.818*	0.001	-0.187	-0.314	-0.202	0.067	-0.208	-0.769*	-0.503	0.601	0.59	0.916**	1
h	0.470	0.557	0.104	0.501	0.569	0.585	-0.451	0.493	0.556	0.444	0.571	0.469	-0.834*	0.033	-0.325

& ** denotes 0.05% and 0.01% level of significance

L, length; L, lightness; a, redness; b, yellowness; c, chroma; h, hue; w, width; t, thickness; m, mass; GMD, gravimetric mean of diameter; AMD, arithmetic mean diameter; PLA, projected area perpendicular to longitudinal axis; CPA, criteria projected area; PWA, projected area perpendicular to intermediate axis; PTA, projected area perpendicular to transverse axis.

the maximum hue. However, the chroma and hue ranged from 1.63 to 15.84 and 26.80 to 92.81, respectively. The seeds with similar physical attributes like colour can be pooled in one group through clustering methods and then comprehensively evaluated (Tang *et al.* 2021). The other morphological characters like dent corn or quality traits like waxy corn or sweet corn also have been considered for comparative evaluation on the physical basis (Coskun *et al.* 2006, Sharma *et al.* 2017). We also observed variable correlation among different parameters (Table 1). Significant effect of landraces or genotypes on the physical properties of maize reported here coincides with the earlier report of Idowu and Onifade (2021).

From the present study it is concluded that that the physical properties of diverse colour germplasm are also diverse. Since the matrix shows overlaps and interweaving, it may be presumed that one physical parameter can have its effect on a number of other parameters but to a varying magnitude.

SUMMARY

The manual seeding, harvesting and processing operations are the most labour intensive and the current practices have many drawbacks. The physical properties of seeds play an important role for designing or fabricating tools or devices which are meant for various crop management operations. Therefore, the physical properties of the maize seeds such as mass, geometric mean of diameter, arithmetic mean of diameter, sphericity and projected areas of length, width and thickness were studied at Central Institute for Research on Cotton Technology, Mumbai, Maharashtra and ICAR-Indian Institute of Maize Research, Ludhiana, Punjab during 2021–22 for the futuristic development of many tools for promising lines of colour maize germplasm.

REFERENCES

AOAC. 1998. *Official Methods of Analysis*. Washington DC, United States of America: Association of Official Analytical Chemists.

Altuntas E and Mahawar M K 2022. Mass modeling of potato cultivars with different shape index by physical characteristics. *Journal of Food Process Engineering* **45**(10). https://doi.org/10.1111/jfpe.14126

Ashwin K B, Rao P V K J and Edukondalu L. 2017. Physical properties of maize grains. *International Journal of Agriculture Sciences* **9**(27): 4338–41.

Atere A O, Olalusi A P and Olukunle O J. 2016. Physical properties of some maize varieties. *Journal of Multidisciplinary Engineering Science and Technology* **3**(2): 3874–80.

Bibwe B, Mahawar M K, Jalgaonkar K, Meena V S and Kadam D M 2022. Massmodeling of guava (cv. Allahabad safeda) fruit with selected dimensional attributes: Regression analysis approach. *Journal of Food Process Engineering* **45**(3): e13978. https://doi.org/10.1111/jfpe.13978

Bolaji O T, Awonorin S O, Sanni L O and Shittu T A. 2018. Modelling of mechanical properties of five maize varieties at critical processing conditions in the production of fermented slurry-ogi. *International Journal of Food Properties* **21**(1): 1619–32.

Brar I S, Anoop A K, Khurana R and Gautam A. 2017. Studies on physical properties of maize (*Zea mays* L.) seeds. *International Journal of Current Microbiology and Applied Sciences* **6**(10): 963–70.

Coskun M B, Yalcın I and Ozarslan C. 2006. Physical properties of sweet corn seed (*Zea mays saccharata* Sturt.). *Journal of Food Engineering* **74**: 523–28.

Falalu RJ, Ahmad R K and Getso R B. 2015. Determination of some Engineering properties of maize grain. *Proceedings of second international interdisciplinary conference on global initiatives for integrated development*, Chukwuemeka Odumegwu University, Igbariam Campus, Nigeria, September 2–5.

Findura P, Kristof K, Jobbagy J, Bajus P and Malaga-Tobola U. 2018. Physical properties of maize seed and its effect on sowing quality and variable distance of individual plants. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis* **66**(1): 0035–0042.

Idowu D O and Onifade T B. 2021. Investigation of effect of maize varieties on selected physical properties. *Journal of Agricultural and Crop Research* **9**(1): 8–16.

Li L, Hu R, Li L, Yuan Z, Sun S, Jiang X, Gu R and Wang J. 2019. Physical character-based grading of maize seeds. *Seed Science and Technology* **47**(3): 281–99.

Mohsenin N N. 1980. *Physical Properties of Plant and Animal Materials*. Gordon and Breach Science Publishers, New York.

Sharma V, Basu S, Lal S K, Anand A, Hossain F and Munshi A D. 2017. Comparison of physical and physiological properties of specialty maize inbred lines. *Chemical Sciences Reviews and Letters* **6**(23): 1758–63.

Solanki C, Saha D and Singh R. 2019a. Moisture dependent physical properties of dehusked unsplitted pigeon pea. *Journal of Food Safety and Food Quality* **70**(4): 117–23.

Solanki C, Devi M and Gupta R K. 2019b. Evaluation of physical properties of oat grain (*Avena sativa*). *Chemical Science Review and Letters* **8**(29): 142–15.

Soyoye B O, Ademosun O C and Agbetoye L A S. 2018. Determination of some physical and mechanical properties of soybean and maize in relation to planter design. *Agricultural Engineering International*: *CIGR Journal* **20**: 81–89.

Tang H, Xu C, Jiang Y, Wang J, Wang Z and Tian L.2021. Evaluation of physical characteristics of typical maize seeds in a cold area of north china based on principal component analysis. *Processes* **9**: 1167.

Tarighi J, Mahmoudi A and Alavi N. 2011. Some mechanical and physical properties of corn seed (Var. DCC 370). *African Journal of Agricultural Research* **6**(16): 3691–99.

Yenge G B, Kad V P and Nalawade S M. 2018. Physical properties of maize (*Zea mays* L.) grain. *Journal of Krishi Vigyan* **7**: 125–28.