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Standardization of Cob Drying Technology for Maintaining Vigour Potential of Maize Seeds

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ABSTRACT: An investigation was carried out with maize to evaluate the optimum stage of cob maturity, duration of drying and drying temperature for maintaining the germination and vigour potential of maize seeds in storage. The maize cobs harvested at different maturity stages viz. 95-100 days after sowing, 100-105 days after sowing and 105-110 days after sowing were subjected to mechanical drying at various temperatures *viz.,* 40°C, 45°C, 50°C and 55°C along with sun drying. To optimize the duration of drying, the cob moisture content was recorded at every two hours interval up to the safe seed moisture content of 12%. The maize cobs subjected to various drying temperatures of 40°C and 45°C taken lesser duration for drying compared to sun drying (50 h). However, the minimum duration of drying was recorded in 50°C (24 h) followed by 55°C (18 h). Maize cobs harvested at 100-105 days after sowing and dried at 40°C outperformed other drying treatments by recording higher viability, germination and vigour with low mechanical injury.

Keywords: Maize, harvest stage, drying temperature, duration

Maize (*Zea mays*) is known as the Queen of cereals because it has the highest genetic yield potential among the cereals. It is the most widely distributed crops of the world, having wider adaptability under varied agro-climatic conditions which is being grown in more than 150 countries. In India, it is emerging as third most important crop after rice and wheat. Among the cereal crops in India, maize ranks third in production (22.5 million tonnes) from 8.67 million hectares area and contributes to 2.4% of world production with almost 5% share in world cultivated area. It contributes nearly 9% in the national food basket. In India, 80% of area under maize cultivation is from the states *viz.,* Karnataka, Andhra Pradesh, Tamil Nadu, Rajasthan, Maharashtra, Bihar, Uttar Pradesh, Madhya Pradesh and Gujarat contribute for 85% of maize production (10).

The maize is cultivated throughout the year in all states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn and popcorn. Tamil Nadu performed well ahead of other major states in terms of productivity of Maize.

Maize suffers with heavy post-harvest losses estimated at 20 to 30%. The main causes of these losses are improper shelling, drying techniques, improper storage and handling. Drying of agricultural crops is done in most farms by sun-drying results into contamination by insects and dust. Natural seed drying is directly dependent on weather conditions. The disadvantage of the method lies in the need for intensive human labour, which in turn leads to poor operational performance. Therefore, there is need to introduce the mechanical driers provided that the seed quality characteristics would be retained better than using sun-drying method. During drying, temperature is too high or insufficient drying before storage leads to losses in quality, swelling and germination of seed to overcome those problems proper handling, proper drying before storage and storage facility should be moisture proof and adequately aired (10).

Artificial drying methods are more often used and are more easily adaptable to seed production techniques, affording fast and efficient removal of large amounts of moisture. The seed industry in India tries to reduce the risk of seed damage through mechanical injury because of high moisture during harvest and drying damage that frequently occur and it is not certain whether it is because of high temperature or high drying rates that cause injury. Even then seed industry is interested in accelerating the drying process by increasing drying temperature and reducing the duration of drying. So the seed injury has frequently occurred during drying of maize seeds.

In Tamil Nadu harvesting and drying stage of maize seeds mostly coincide with rain. Maize seeds have viviparous germination so if the seeds are not harvested at optimum stage and dried under specified range of temperature the quality and quantity of seeds may get reduced. Based on this above constraints this research focused on the optimum drying temperature and duration of drying for maintaining the seed quality.

MATERIALS AND METHODS

Genetically pure cobs of TNAU Maize Hybrid CO6 obtained from the Department of Farm Management, Tamil Nadu Agricultural University, Coimbatore formed as base material for the study.

Maize cobs (TNAU Maize Hybrid CO 6) were harvested at different stages of maturity and dried at various temperatures using mechanical drier (cabinet drier) along with sun drying. The treatment details are furnished below.

Stages of maturity	Drying Treatments
S_1 95-100 Days After Sowing (50-55 Days After Silking)	D_1 Sun drying
	D_2 Mechanical drying at 40°C
S_2 100-105 Days After Sowing (55-60 Days After Silking)	D_3 Mechanical drying at 45°C
	D_4 Mechanical drying at 50°C
S_3 105-110 Days After Sowing (60-65 Days After Silking)	D_5 Mechanical drying at 55°C

To determine the optimum duration of drying, the cobs collected at different stages of maturity were subjected to drying at various temperatures and the moisture content was recorded at every two hours interval up to the safe seed moisture content of 12%. The duration of drying was optimized based on the time taken to dry the cobs to safe seed moisture content of 12% for mechanical shelling. Then, the dried cobs were subjected to shelling using maize sheller. The seeds were subjected to laboratory tests adopting factorial completely randomized design with four replications. The observations on following physiological and biochemical seed quality parameters were recorded.

Germination

The germination test was conducted in roll towel medium using the procedure outlined by ISTA (7). Four replicates of 100 seeds each were germinated in a germination room maintained at 25 ± 2°C temperature and 90 ± 3% RH. At the end of 7^{th} day of sowing, the number of normal seedlings in each replication was counted and the germination was calculated and expressed in%.

Root length

At the time of germination count, ten normal seedlings were selected at random from each replication and used for measuring the root length of seedlings. Root length was measured from the point of attachment of seed to the tip of primary root. The mean values were calculated and expressed in centimeter.

Shoot length

The seedlings used for measuring root length were also used for measuring shoot length. The shoot length was measured from the point of attachment of seed to tip of the leaf and the mean values were expressed in centimeter.

Dry matter production (DMP)

The ten normal seedlings were placed in a paper cover and dried in shade for 24 h and then, they were kept in an oven maintained at 103 ± 2°C for 16 ± 1 h. The dried seedlings were weighed and the mean values were expressed in g 10 $seedlings^{-1}$.

Vigour index

Vigour index values were computed using the following formula and the mean values were expressed in whole number (1).

Vigour index = Germination (%) × Seedling length (cm)

The data collected from various experiments were analyzed statistically adopting the procedure described by Panse and Sukhatme (4), wherever necessary, the per cent values were transformed to angular (Arc-sine) values before analysis. The critical differences (CD) were calculated at 5 per cent probability level. If the F test is non-significant it was indicated by the letters NS.

RESULT AND DISCUSSION

In the present experiment, the cobs dried under sun drying method taken more time for drying (50 h) when compared to mechanical drying. The more time taken by the sun drying might be due to slow rate of drying and removal of moisture from seed to environment was not in control manner and also depends upon the weather factors prevailed in the environment. The cobs dried at 50°C (24 h) and 55°C (18 h) taken short duration of drying due to increase in air temperature. Drying at low temperature, the temperature penetrates surface of seed to inside the seed slowly leads to slower release of moisture from seed. At high temperature drying

Table 1. The duration of drying observed at different maturity stages is tabulated below

Stages of maturity(S)	Initial cob moisture content (%)	Drying treatments (D)				
		Sun drying	40°C	45°C	50°C	55°C
		Duration of drying (h)				
S_1 - 95-100 DAS	34	50	42	38	24	18
S_2 - 100-105 DAS	27	38	30	24	22	16
S_3 - 105-110 DAS	20	28	24	22	20	14

Table 2. Influence of stages of maturity and drying treatments on germination (%) of maize seeds

Stages of maturity(S)	Drying treatments (D)					Mean
	Sun drying	40°C	45°C	50°C	55°C	
S_1 - 95-100 DAS	98(82.47)	98(81.87)	96(78.58)	86(68.02)	74(59.34)	90(71.56)
S_2 - 100-105 DAS	98(82.87)	98(82.87)	96(78.51)	88(69.75)	82(64.91)	92(73.57)
S_3 - 105-110 DAS	94(75.72)	94(75.60)	92(73.57)	87(68.95)	86(68.09)	91(72.54)
Mean	97(80.99)	97(80.99)	95(77.08)	87(68.95)	81(64.15)	91(72.54)
	S		D		S × D	
SEd	0.73		0.95		1.64	
CD (P=0.05)	1.48**		1.91**		3.31**	

(Figures in parenthesis indicate arcsine values)

Table 3. Influence of stages of maturity and drying treatments on root length (cm) of maize seeds

Stages of maturity (S)	Drying treatments (D)					Mean
	Sun drying	40°C	45°C	50°C	55°C	
S_1 - 95-100 DAS	25.59	26.73	24.69	25.97	25.00	25.60
S_2 - 100-105 DAS	25.79	27.58	26.51	25.79	24.78	26.09
S_3 - 105-110 DAS	24.89	26.52	25.77	26.78	22.91	25.37
Mean	25.42	26.94	25.66	26.18	24.23	25.69
	S		D		S x D	
SEd	0.22		0.29		0.51	
CD (P=0.05)	0.46**		NS		1.04**	

Table 4. Influence of stages of maturity and drying treatments on shoot length (cm) of maize seeds

Stages of maturity(S)	Drying treatments (D)					Mean
	Sun drying	40°C	45°C	50°C	55°C	
S_1 - 95-100 DAS	14.21	17.16	16.54	16.55	15.75	16.04
S_2 - 100-105 DAS	15.71	18.98	17.63	14.18	14.28	16.16
S_3 - 105-110 DAS	13.67	17.02	14.27	13.79	10.86	13.92
Mean	14.53	17.72	16.15	14.84	13.63	15.37
	S		D		S x D	
SEd	0.09		0.12		0.20	
CD (P=0.05)	0.18**		0.24**		0.41**	

Table 5. Influence of stages of maturity and drying treatments on dry matter production (g seedlings^{-10}) of maize seeds

Stages of maturity(S)	Drying treatments (D)					Mean
	Sun drying	40°C	45°C	50°C	55°C	
S_1 - 95-100 DAS	1.231	1.342	1.267	1.229	1.198	1.253
S_2 - 100-105 DAS	1.340	1.433	1.422	1.397	1.342	1.387
S_3 - 105-110 DAS	1.113	1.123	1.106	1.098	1.076	1.103
Mean	1.228	1.299	1.265	1.241	1.205	1.248
	S		D		S x D	
SEd	0.008		0.010		0.018	
CD (P=0.05)	0.16**		0.021**		0.036*	

Table 6. Influence of stages of maturity and drying treatments on vigour index of maize seeds

Stages of maturity(S)	Drying treatments (D)					Mean
	Sun drying	40°C	45°C	50°C	55°C	
S_1 - 95-100 DAS	3900	4301	3958	3657	3016	3766
S_2 - 100-105 DAS	4047	4563	4237	3517	3203	3918
S_3 - 105-110 DAS	3625	4093	3684	3489	2938	3566
Mean	3857	4319	3960	3554	3052	3750
	S		D		S x D	
SEd	22.53		29.08		50.38	
CD (P=0.05)	45.38**		58.59**		101.48**	

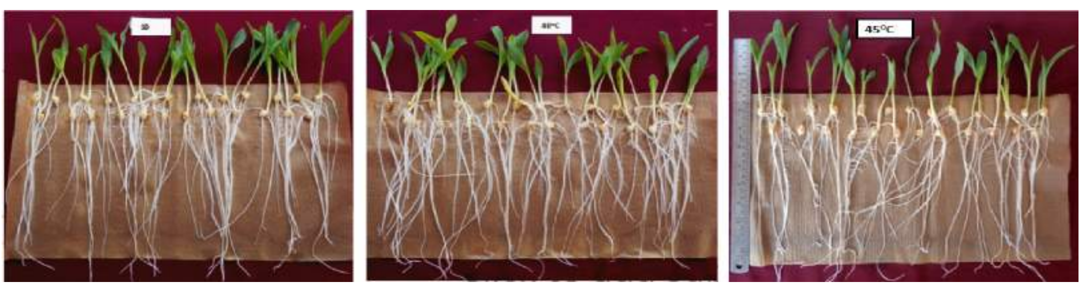

Plate 1. Influence of drying treatments on seedling vigour of maize collected at 95-100 DAS

Plate 2. Influence of drying treatments on seedling vigour of maize collected at 100-105 DAS

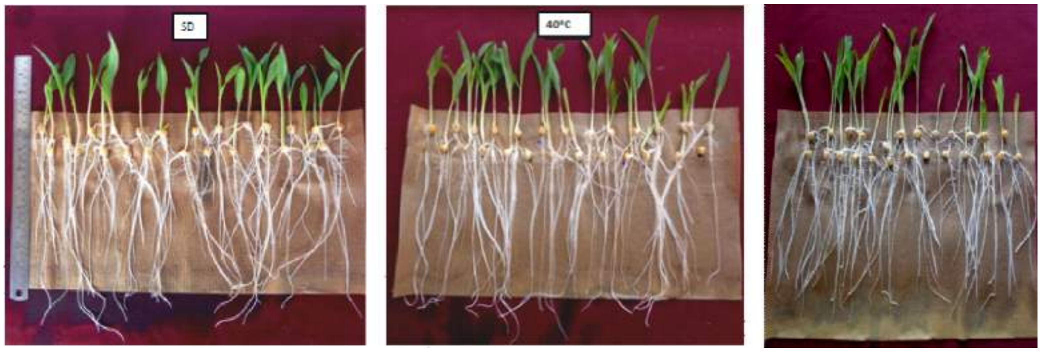

Plate 3. Influence of drying treatments on seedling vigour of maize collected at 105-110 DAS

movement of temperature from surface of seed to inside the seed is faster so removal of moisture content was faster. The maize cobs dried at drying temperatures of 40°C and 45°C taken lower duration of drying compared to the sun drying but higher duration than 50°C and 55°C. Artificial drying of seed is simply a way of accelerating the rate of natural movement (diffusion) of water from inside of the seed to the surface (3). Diffusion rate depends on seed size and composition, speed of surface evaporation, temperature, initial moisture level, seed coat permeability and time.

The rate of moisture migration from center to surface of the seed is influenced by temperature, pericarp thickness, chemical composition of seed and seed coat permeability. The rate of moisture removal from the surface of seed is influenced by degree of surface saturation, relative humidity and temperature of drying air. If evaporation from the seed surface occurs too rapidly it can damage the embryo, therefore seed should be dried carefully to arrest stress damage due to heat (2). Natural drying method resulted in lower seed germination and vigor than the artificial drying (8). In natural drying, a reduction in germination was due to the weather conditions during drying. Apart from these, other aspects may have influenced the results, such as the low drying speed which may have maintained the respiration rate at higher levels. This affects germination and vigor, due to the fact that bound water remains for longer periods inside the seed, which in turn produces gases and vapour in the intergranular space increases the exposure time to the drying conditions. The temperature and relative humidity also not in control under sun drying the drying time was not in control. In spite of its limitations, natural drying is still widely adopted in agriculture for being cheaper. Whereas, green chilies dried in the open sun drying method were found to be degraded in its quality since the chilies were infected by fungus and bacteria, damaged by birds and animals and carried away by wind (9).

The germination potential is considered to be an important parameter for assessing the potentiality of seeds. The present investigation proved that the maize cobs harvested at 100-105 DAS (S_2) and dried at 40°C recorded higher germination of 97% and field emergence of 97 per cent recording 19 and 20% increase over seeds dried at 55°C. Maize cobs dried at 55°C resulted in cell membrane breakage and seed coat integrity damage leads to decrease in germination and field emergence in the high temperature drying. Safe drying temperature can be decided based on the initial moisture content of the seed and he concluded that the optimum drying temperature for maintaining seed viability is about 38 to 43°C.

Seed quality attributing characters are the best indicator of seed vigour. Similar trends in the results of the seed quality attributing characters like root length and shoot length were observed in cobs harvested at 100-105 DAS (S_2) and dried at 40°C recording 11% and 30% increases over the cobs dried at 55°C. Vigour of seedlings is usually characterized by length of the seedlings after a period of growth. The computed vigour index, which is the totality of performance, has been regarded as a good index to measure the quality of seeds. In the present study, the per cent of vigour index increased in 40°C recording 41% increases over the cobs dried at 55°C.

The present study also proved that maize cobs dried at 40°C recorded higher dry matter production recording 7.8% over the maize cobs dried at 55°C. The maximum dry weight accumulation occurs between 25% and 32% moisture content with some decline at later harvests. Germination was unaffected by temperatures up to 45°C regardless of maturity. Early harvested seeds dried at 45°C temperature results in reduction of seedling dry weight whereas the seed dried at 50°C showed significant reduction in germination than the 45°C and over drying reduces the dry matter (5 and 6).

CONCLUSION

The maize cobs subjected to various drying temperatures of 40°C and 45°C taken lesser duration for drying compared to sun drying (50 h). However, the minimum duration of drying was recorded in 50°C (24 h) followed by 55°C (18 h). Maize cobs dried at 40ºC outperformed other drying treatments by recording higher germination (%) and seedling vigour. The maize cobs harvested at 100-105 days and dried at 40ºc outperformed other treatments by recording higher germination (%), dry matter production and seedling vigour.

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