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Short Communication

Study of Seed Maturity and Storage Longevity in Three Sorghum Cultivars

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Sorghum [*Sorghum bicolor* (L.) Moench] is an important cereal crop grown in over 100 countries. The genebank at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India, conserves over 37,000 accessions of the crop under medium (4°C and 30% RH) and long-term (–20°C with 5+2% seed moisture content) storage conditions that minimize seed deterioration. The accessions are monitored for seed viability at regular intervals and those with percentage germination below 85 per cent are regenerated. During germplasm regeneration, seed should be harvested when the quality is at the maximum to ensure greater seed longevity during subsequent storage. Developing seeds attain maximum viability and vigour at physiological maturity (defined as the stage when seeds reach maximum dry weight during development) and they begin to age with, viability and vigour declining thereafter [1]. However, there is now considerable evidence from a wide range of crops including sorghum that seed quality continues to improve even after physiological maturity and especially, seeds attain maximum potential longevity some time after the end of the seed-filling period [2-6]. Consequently, it has been suggested that 'mass maturity' is a more appropriate term to describe the end of the seed filling period than physiological maturity [7].

The extent of improvement in potential longevity subsequent to mass maturity is known to be influenced by seed production environment [8]. At ICRISAT, sorghum germplasm is regenerated under irrigation during the post-rainy season. Sowings are usually made during October and seeds are harvested in late March and April, when moisture content drops below 15 per cent. However, It is not clearly known if the potential longevity of the seeds at this stage is at the maximum. Therefore, an experiment was conducted to investigate the changes in seed quality during ripening and determine the optimum harvest time to maximize potential longevity during regeneration of sorghum germplasm accessions and the results are reported here.

Three germplasm cultivars, IS 11758, IS 18758 and IS 19907, differing in flowering time and maturity were used in the study. They were sown in three replications using a Randomized Block Design (RBD) in vertisol at ICRISAT Center, Patancheru. Starting from seven days after anthesis (DAA) and at weekly intervals until 70 or 77 days, depending on the flowering duration, about 30 panicles were harvested at random from each replication for each sampling time. The seeds were gently separated from the glumes by hand and the dry weight, seed moisture content and percentage germination were determined according to the methods prescribed by Rao and Jackson [5]. Potential longevity of the seeds harvested between 28 and 70 DAA in IS 19907 and between 28 and

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77 DAA in IS 11758 and IS 18758 was studied by storing them at 35°C with 13±0.2 per cent moisture content. The moisture content was achieved by holding about 100 g of each seed lots for 7-10 days over saturated solution of sodium chloride (NaCl) in desiccators at 23-25°C. Each seed lot was then subdivided into 12-15 samples of 150-200 seeds, sealed in small laminated aluminum foil packets and then stored in an incubator maintained at 35°C. Progress in seed deterioration was studied by removing a sample every week and testing the sample for germination.

As crop development is strongly influenced by temperature, which varies from year to year and between locations, and thermal time provides a more reliable measure of seed quality development than the number of calendar days, seed ripening is also expressed in relation to cumulative thermal day degrees,

$$°Cd = \Sigma[(T_{Max}+T_{Min})/2-T_{Base}] \quad (1)$$

where, T_{Max} is the maximum daily temperature, T_{Min} is the minimum daily temperature and T_{Base} is the base temperature, which is 10°C for sorghum.

Differences were observed in the initiation of flowering among the three sorghum genotypes used in this study. For example, IS 19907 was the earliest to flower in 50 days after sowing, followed by IS 18758 at 60 days and IS 11758 at 71 days after sowing. In all the cultivars, the dry weight of seeds increased rapidly from 7 DAA until it reached the maximum at about 35 days. There was little change in dry weights of the seeds harvested at later dates. The mass maturity or the end of grain filling period was estimated by fitting a positive relation to the dry weight observations between 1 and 6 weeks and a horizontal line thereafter, and then assessing the day on which the two fitted lines intercept each other, as described by Rao and Jackson [5] (Fig. 1). The estimates of mass maturity thus determined were 34.3 days for IS 19907, 38.5 days for IS 18758 and 40.8 days for IS 11758, with a mean of 37.9±1.90. At mass maturity, the seed moisture content ranged between 36.6 and 33.2 per cent among the three cultivars with a mean of 34.8±0.97 per cent. In all the three cultivars, fresh seeds harvested at 7 DAA did not germinate. However, germinability

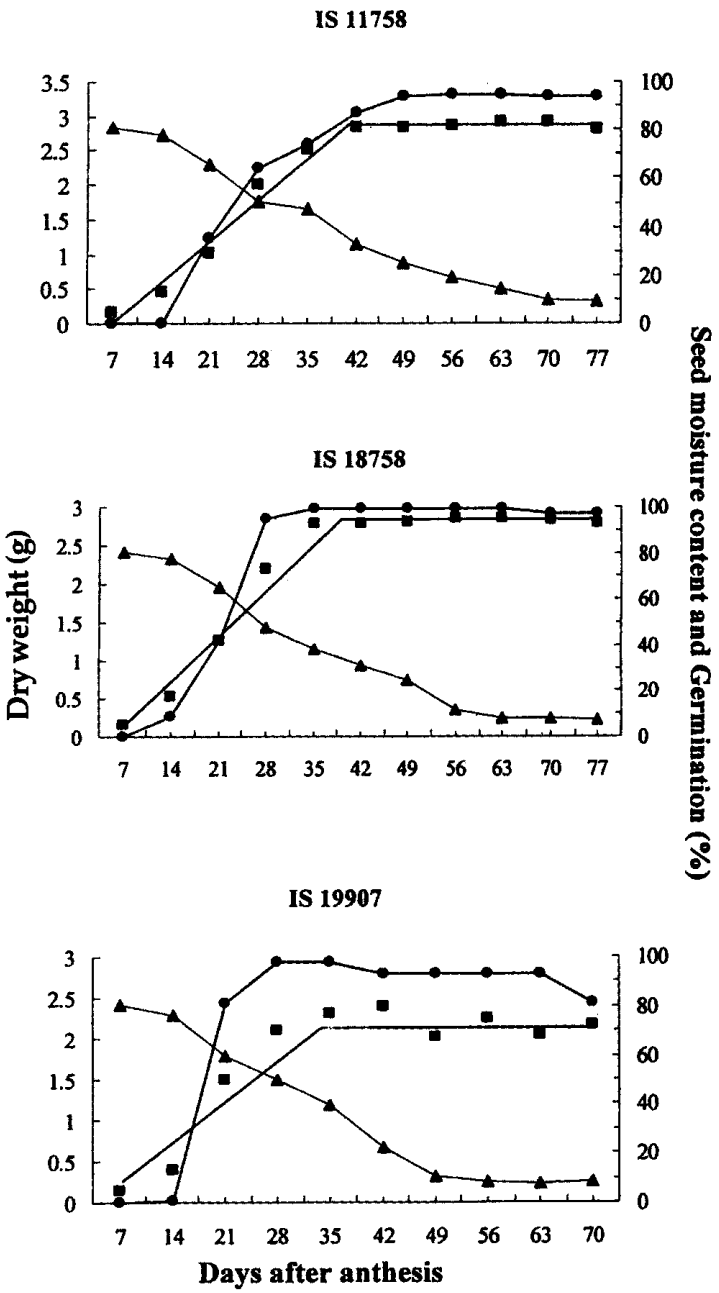

Fig. 1. Changes in mean dry weight (■), moisture content (▲) and germinability (●) during seed development in three cultivars of sorghum

increased from 14 DAA and reached the maximum by 28 DAA in IS 18758 and IS 19907 and 42 DAA in IS 11757 (Fig. 1).

All seed lots deteriorated gradually during storage at 35°C, but differences were observed in the rate of loss of viability among the seed lots harvested at different stages of maturity within each cultivar. The seed survival data were subjected to probit analysis and the differences in potential longevity of seeds of various maturities were compared by using the values of seed lot constant

(K_i), which is provided by the intercept of the seed survival curves according to the equation,

$$v = K_i - p/\sigma \quad (2)$$

where, v is the probit percentage germination after p days of storage and s is the standard deviation of the frequency of seed deaths in time [9].

An analysis of variance of the estimates of seed lot constant showed significant differences between cultivars and the different harvest times ($P < 0.01$). However, the interaction between harvest times and cultivars was not significant ($P > 0.05$). Potential longevity (K_i) increased between 28 and 70 DAA depending on cultivar and decreased slightly in later stages of maturity. Differences in potential longevity were found to be marginal for the seeds harvested between 56 and 70 DAA in IS 19907 and between 63 and 77 DAA in IS 11758 and 18758 ($P > 0.05$). Changes in potential longevity during seed maturation were described more objectively by fitting third degree polynomials to the mean values of K_i and the time to attain maximum potential longevity was estimated from the coefficients of the fitted regression line for each cultivar as described in Rao and Jackson [5] (Fig. 2). Thus, maximum potential longevity was attained at 66 DAA in IS 19907, 74 DAA in IS 11758 and 76 DAA in IS 18758, with a mean time of 72.0±3.06 DAA, which was about 35 days after the mean mass maturity. The mean moisture content at this stage was found to range between 7 and 9 per cent among the cultivars.

During this study, the mean maximum and minimum temperatures from sowing to the last harvest date were recorded as 30.8°C and 14.5°C, respectively. The cumulative thermal day degrees or thermal time from anthesis to mass maturity was measured to be between 343 and 437°Cd (mean = 388±27.2) and thermal time from mass maturity to storage maturity ranged from 359 to 452°Cd with a mean of 414±28.1°Cd between the three cultivars. Thus, averaged over cultivars, the mean thermal time from anthesis to storage maturity was found to be 802±50.6°Cd. It is interesting to note that the early flowering cultivar (IS 19907) also matured faster and attained maximum potential longevity in shorter time than the other two cultivars.

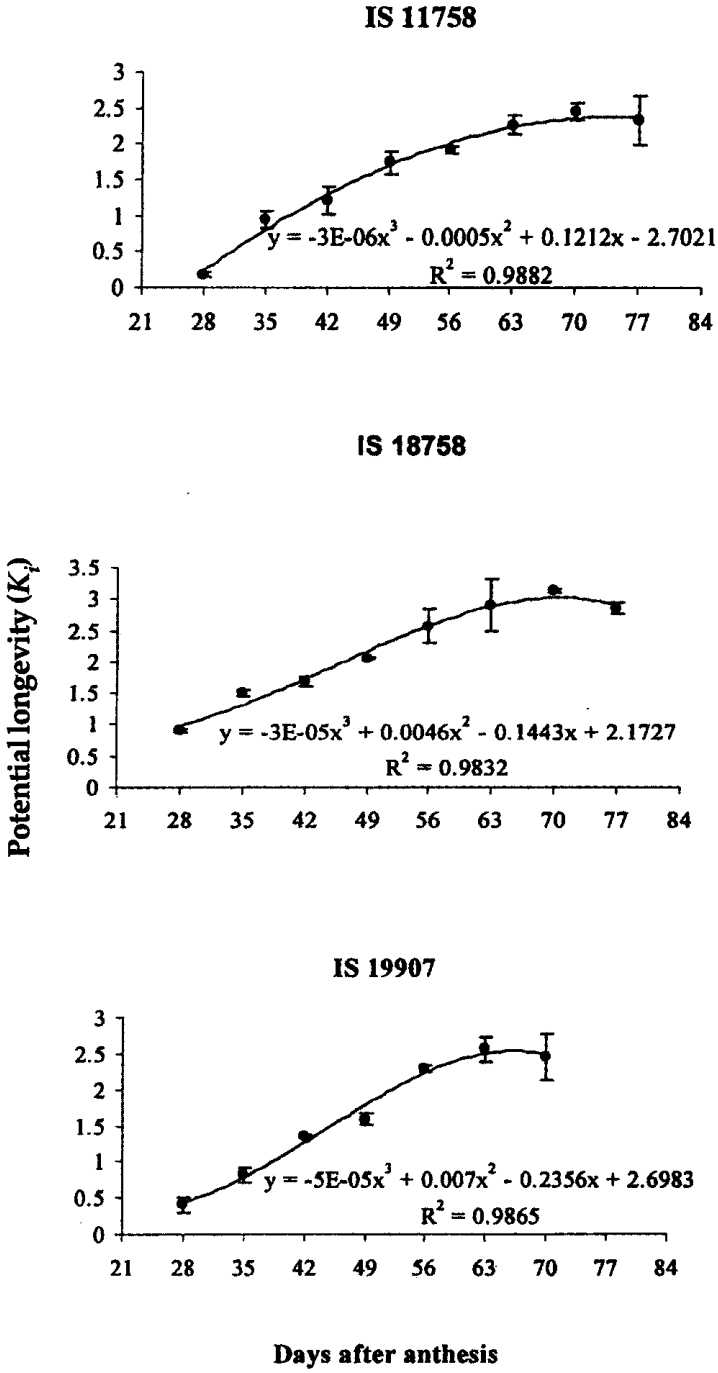

Fig. 2. Changes in mean potential longevity (estimate of seed lot constant K_i of viability eqn. $v = K_i - p/\sigma$) of seed lots harvested at different stages of maturity in three sorghum cultivars. Bar represents the SE of the mean of three replications

The results presented here suggest that potential longevity of sorghum seeds continues to increase after the end of grain filling period and seeds with maximum potential longevity can be harvested at about 72+3.7 DAA, which corresponds to an accumulated mean thermal time of 802±50.6°Cd after anthesis. However, as the seed moisture contents at the stage are very low (7-9%),

the possibility of mechanical damage during threshing is likely to be very high. Considering the potential risk (rain, pests and diseases) associated with field environment and the fact that the differences in potential longevity are minimal, it is prudent to harvest the seeds at the earliest opportunity i.e. between 56 and 63 DAA, depending on maturity of the cultivar, which corresponded to a thermal time between 601 and 700°Cd, with a mean of 654±28.7°Cd after anthesis. The seed moisture content at this stages of maturity is likely to be around 12 per cent, benign for threshing without mechanical damage. Present studies, however, are limited to only three cultivars and the enormous genetic diversity in the sorghum germplasm collection warrants that further investigations are made using a diverse range of cultivars before adopting this as a standard harvesting time.

REFERENCES

1. HARRINGTON, J.F. (1972). Seed storage and longevity. In: *Seed Biology,* Vol. III, ed. T.T. Kozlowski, pp. 142-145. Academic Press, New York.

2. RAO, N.K., S. APPA RAO, M.H. MENGESHA & R.H. ELLIS (1991). Longevity of pearl millet (*Pennisetum glaucum R.* Br.) seeds harvested at different stages of maturity. *Ann. Appl. Biol.* **119:** 97-103.

3. PIETA FILHO, C. & R.H. ELLIS (1991). The development of seed quality in spring barley in four environments. I. Germination and longevity. *Seed Sci. Res.*, **1**: 163-177.

4. ZANAKIS, G.N., R.H. ELLIS & R.J. SUMMERFIELD (1994). Seed quality in relation to seed development and maturation in three genotypes of soyabean (*Glycine max*). *Exp. Agr.*, **30:** 139-156.

5. RAO, N.K. & M.T. JACKSON (1996). Seed longevity of rice cultivars and strategies for their conservation in genebanks. *Ann. Bot.*, **77**: 251-260.

6. DEL FUEYO, P.A., R.A. SANCHEZ, & R.L. BENECH-ARNOLD (2003). Seed longevity in two sorghum varieties with contrasting dormancy level prior to harvest. Seed *Sci. & Technol.*, **31:** 639-650.

7. ELLIS, R.H. & C. PIETA FILHO (1992). Seed development and cereal seed longevity. Seed *Sci. Res.*, **2**: 9-15.

8. ELLIS, R.H., T.D. HONG & M.T. JACKSON (1993). Seed production environment, time of harvest and the potential longevity of seeds of three cultivars of rice (*Oryza sativa* L.). *Ann. Bot.*, **72**: 583-590.

9. ELLIS, R.H. & E.H. ROBERTS (1980). Improved equations for prediction of seed longevity. *Ann. Bot.*, **45**: 13-30.