Plant Archives Vol. 6 No. 2, 2006 pp. 515-519 ISSN 0972-5210

# EFFECT OF ENVIRONMENTAL FACTORS DURING SEED DEVELOPMENT AND MATURATION ON SEED QUALITY IN *SORGHUM BICOLOR* (L.) MOENCH

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## Abstract

Studies were conducted to evaluate the effect of environmental conditions on physiological characteristics of seeds of sorghum genotypes *viz.*, CO 24, CO 25, CO 26 and JH 35 during seed development and maturation. In the present study, a steady decline in moisture content of the seed was observed. Length and width of seed increased rapidly between seven to 35 days after 50 per cent flowering. A steep increase in the dry weight of seed was registered between 14 and 35 days after 50 per cent flowering, beyond that the increase was gradual. Water absorption per cent declined from 16.5 to 12.0 per cent between 7 to 28 days and increasing steadily beyond 42 days (22.1 per cent) after 50 per cent flowering. The germination potential of seeds improved with seed development and maturity. The root length, shoot length, dry weight of seedling, field emergence, seed recovery, seed yield and vigour index were highest in seeds harvested at 35 and 42 days after 50 per cent flowering. Seed vigour as estimated through stress tests *viz.*, soaking seeds in ammonium chloride and D-manitol and accelerating ageing and exhaustion tests revealed the superiority of seeds having maximum germinability, vigour and viability at 35 and 42 days after 50 per cent flowering. These stages respectively correspond to physiological and harvestable maturity.

***Key words*** : Environmental factors, seed development, seed quality, sorghum.

## Introduction

The state of maturity of seed at harvest is known to be a major factor responsible for the variation in viability and size of seed and so the decision when to harvest is of great importance. The seed harvested at optimum maturity should be possessing maximum germination and vigour and there after declines due to various factors are expected (Harrington, 1972). Precise information on optimum stage of harvest based on physiological indices could enable the seed producer to overcome adverse effect of bad weather and thereby avoiding severe field seed losses. For determining the optimum stage of harvest it is essential to know the physical and physiological changes that occur during seed development and maturation under varying harvesting conditions, since harvesting conditions are the first and foremost factors that affect seed vigour, viability and storability, besides size, shape and uniformity (Pollock and Roos, 1972). Studies were carried out with two distinct maturity group of sorghum genotypes *viz.*, CO 24, CO 25, CO 26 (105 days) and JH 35 (120 days), to determine correct stage of physiological and harvestable maturity.

## Materials and Methods

The experiments were conducted in factorial complete randomized design. The sorghum genotypes selected for the study were sown in isolated plots arranged at random in three replications. Each plot consisted of ten rows, each eight meter long. The rows were spaced 45 cm apart and the plants within the rows were thinned to 15 cm spacing. A basal application of fertilizer (60 kg N/ha, 50 kg $P_2O_5$/ha and 50 kg $K_2O$/ha) was supplied in the from of urea, single super phosphate and muriate of potash. Top dressing with 40 kg N/ha was given at three weeks after sowing. The plots were irrigated as and when required depending upon soil moisture status. Necessary plant protection measures were taken to control pests and diseases.

The ear heads were tagged and labelled at 50 per cent flowering and harvested from 7 days to 63 days after 50 per cent flowering. A total of 7 harvests were made keeping the interval between each harvest as seven days.

The harvested seeds were cleaned and size graded with a 3 mm sieve and subjected to various, physical and physiological tests to probe the seed yield and quality at various stages of development and maturation.

The observations on moisture content of seeds by oven method, length and width of seeds, seed recovery, dry weight of 100 seeds and seed yield per plant were recorded. The seed quality in terms of physiological traits was evaluated with the help of water absorption (Maiti *et al.*, 1985); seed germination; root length and shoot length of seedlings, dry weight of seedlings (Anonymous, 1985), vigour index (Abdul-Baki and Anderson, 1973) and field emergence. The performance of seed under stress was evaluated through seed germination in chemical soak test (Vanderlip *et al.*, 1973), seed germination in D-manitol soak test (Lad, 1973), seed germination after accelerated ageing (Delouche and Baskin, 1973) and seed germination in exhaustion test.

## Results and Discussion

The investigations involved four sorghum genotypes *viz.*, CO 24, CO 25, CO 26 and JH 35 to determine the correct harvest stage of the crop that would enable the collection of maximum quantity of uniform sized seeds possessing very high quality attributes of germinability, vigour and storability.

Seed maturation refers to the morphological, physiological and functional changes that occur from the time of fertilization until the matured ovules (seeds) are ready for harvest (Delouche, 1973). Seed development is the period between fertilization and maximum fresh weight of seed, and seed maturation begins at the end of seed development and continues up to harvest (Abdul-Baki and Baker, 1973). The transmisson and scanning electron microscopy studies relating to developmental morphology has revealed that, the period immediately following the fertilization is a time of rapid development in the sorghum caryopsis (Glennie *et al.*, 1984). The endosperm expands crushing the nucleus and inner integument. The cells of the ovary wall expand and elongate to from the pericarp. By the soft dough stage, the endosperm gains most of its storage materials and thereafter considerable loss of grain moisture occurs. During the early stages of development, the endosperm cell walls will have extensive pittings to allow efficient translocation, after which the cell walls become intact.

### Physiological changes in seed

In the present study, a steady and gradual decline in moisture content of the seed was observed from seventh day till maturity during the seed development and maturation phases (fig. 1a). This is in conformity with earlier findings (Kersting *et al.*, 1961 and Collier, 1963). In fact moisture content of cotyledons was found to be a good index of morphological maturity (Merouani *et al.*, 2003). In tall fescue seeds moisture content was decreased from 64.09 per cent to 21.71 per cent during seed development and maturation phase (Ma *et al.*, 2002). Slow rate of grain moisture loss during the periods of wet weather was observed in several grain sorghum varieties and hybrids (Collier, 1963). In fact, moisture reduction is a heritable character modified by environment (Hauller and Russel, 1961) and bulk of water is lost through biological pathways and also by physical means. The decrease in moisture content of the developing seed is a corollary of moisture equilibrium occurring between seed and its surrounding atmosphere (Delouche, 1973). Hence, varieties CO 24 and CO 26 lost seed moisture faster than varieties CO 25 and JH 35, since they belong respectively to short and long duration groups. A seed moisture content of around 25 per cent and 16 per cent were reached respectively at 35 and 42 days after 50 per cent flowering in case of varieties CO 25 and JH 35. Varietal differences were significant in respect of seed moisture content in variety CO 26 (31.5 per cent) which recorded lowest moisture content followed by CO 24 (31.7 per cent), JH 35 (33.9 per cent) and CO 25 (34.3 per cent). In line with this, varietal differences in sorghum with regard to rate of moisture reduction during seed maturation have also been noticed (Palaniappan and Vijayakumar, 1976).

Seed size measured in terms of length and width is a reflection of seed maturity. With seed development and maturation, length and width of seed increased rapidly between seven to 35 days after 50 per cent flowering. The increased seed size in terms of length and width of seed was reached by 35 and 42 days after 50 per cent flowering respectively in varieties CO 24, CO 26 and CO 25, JH 35. The high proportion of small size seed recovered from the earliest harvest may be due to poor accumulation of food reserves. In sorghum, maximum seed size was recorded during maturity (Singh, 1981). Wrinkling in seeds due to early harvesting might be one of the indicators of low seed quality (Petionov, 1959).

### Seed recovery and dry matter accumulation

Seed recovery, in fact, is an indirect reflection of seed size and efficiency in terms of grain filling. Hence, there was a gradual increase in recovery of seeds with its peak at 35 and 42 days after 50% flowering respectively in varieties CO 24, CO 26 and CO 25, JH 35 (fig. 1a). Increase in seed recovery during seed development and maturation has also been reported by Singh (1981). Seed recovery was highest in variety CO 24 (94.8 per cent) followed by CO 25 (93.4 per cent), CO 26 (92.6 per cent) and JH 35 (92.3 per cent). In addition, seed recovery was maximum in rabi (93.6 per cent) season followed by summer (93.3 per cent) and Kharif seasons (93 per cent) at 42 days after 50 per cent flowering.

A steep increase in the dry weight of 100 seeds was registered between 14 and 35 days after 50% flowering, marked the seed development phase, and beyond that the increase was gradual and non-significant which indicated the maturation phase of sorghum caryopsis (fig. 1a). In fact, physiological maturity is that stage where there is maximum accumulation of dry matter in the seed (Harington, 1972, Singh and Deshpande, 1989, and Ma *et al.*, 2002). The physiological maturity stage closely coincided with the formation of a dark closing layer in the placental area near sorghum kernel attachment, concomitant with maximum dry weight accumulation (Subramanian, *et al.*, 1973 and Maiti *et al.*, 1985). In agreement with the previous observation, in the present study also, the dark layer formation was perceptible sporadically on the 35$^{th}$ day and evidently on the 42$^{th}$ day conjointly with maximum dry matter accumulation in varieties CO 24 (3.07g), CO 26 (2.79g) at 35 days after 50 per cent flowering and in varieties CO 25 (2.98g), JH 35 (2.78g) at 42 days after 50 per cent flowering. Conformity results using 14 c labelled assimilate by Eastin *et al.*, (1973) has correlated the external visual dark layer appearance with the cut off of assimilated translocation to the caryopsis. The duration to attain physiological maturity in sorghum genotypes takes 30-45 days after anthesis respectively for maximum dry matter accumulation. Similar observation has also been reported in sorghum (Reddy and Narayana, 1977). In agreement with previous observations, in the present study, variety CO 24 recorded the highest dry weight of 100 seeds (2.25g) followed by CO 25 (2.20g) and JH 35 (1.95g).

**Seed yield**

The seed yield per plant in the present study was significantly influenced by seasons and stage of harvest. Higher seed yields were obtained at 35 and 42 days after 50 per cent flowering in varieties CO 24, CO 26 and CO 25, JH 35 respectively (fig. 1a). This is in conformity with the findings of Rabago *et al.*,(1969). Seed yield per plant was the highest in variety in CO 26 (92.4g/plant) followed by CO 25 (90.16g/plant), CO 24 (87.21g/plant) and JH 35 (84.94g/plant). Rabi season recorded the highest seed yield (89.1g/plant) followed by summer (88.79g/plant) and kharif seasons (88.51g/plant). This is mainly due to the highest dry weight of 100 seeds recorded at 35 and 42 days after 50 per cent flowering in all the three seasons.

**Water absorption**

Water absorption percentage declined gradually between seven to 28 days (from 16.5 to 12.0 per cent) after 50 per cent flowering before increasing steadily until and after 42 days (22.1 per cent) after 50 per cent flowering. Among the varieties, JH 35 recorded maximum water absorption (22.9 per cent) followed by CO 26 (22.6 per cent), CO 25 (22.2 per cent) and CO 24 (19.3 per cent). Water absorption pattern was quite erratic as for as seasons are concerned (Maiti *et al., 1985).*

The germination potential of seeds improved with advanced development and maturity. A seven day old seed in variety CO 25 in summer season could germinate to an extent of 1.3 per cent which increased gradually with development and maturation. Thus, seed germination manifested the seed vigour to a large extent even before attaining complete maturity (Kersting *et al.*,1961). In the present study, the seed germination was maximum at 35 and 42 days after 50 per cent flowering respectively in varieties CO 24, CO 26 and CO 25, JH 35 (fig. 1b). Evidently, it is clear that the seeds harvested at physiological maturity recorded maximum germination than seeds harvested at full maturity (Dahatonde and Adaho, 1978; saibabu and Hussaini, 1984; Krishnaswamy and Ramaswamy, 1985; Maiti *et al., 1985).* Varietal differences as observed in the present study have also been reported by earlier workers (Apichatbootra, 1979 and Maiti *et al., 1985).* In the present study, seeds from summer season recorded significantly higher germination (63.9 per cent) followed by kharif (63.3 per cent) and rabi seasons (61.2 per cent). This is mainly due to the dry weather with nil to low rainfall that prevailed during seed maturation phase, which exerts a pressure in warding off fungal invasion during seed development and maturation (Agrawal, 1980).

The root length, shoot length, dry weight of seedling, field emergence and vigour index were highest in seeds harvested at 35 and 42 days after 50 per cent flowering respectively in respect to varieties CO 24, CO 26 and CO 25, JH 35 (fig. 1b). This is in agreement with earlier research finding (Mungnishah and Nakamura, 1984). Peak field emergence maintained up to 71 days after 50 per cent flowering in sorghum (Shrivastava, 1968). Varietal

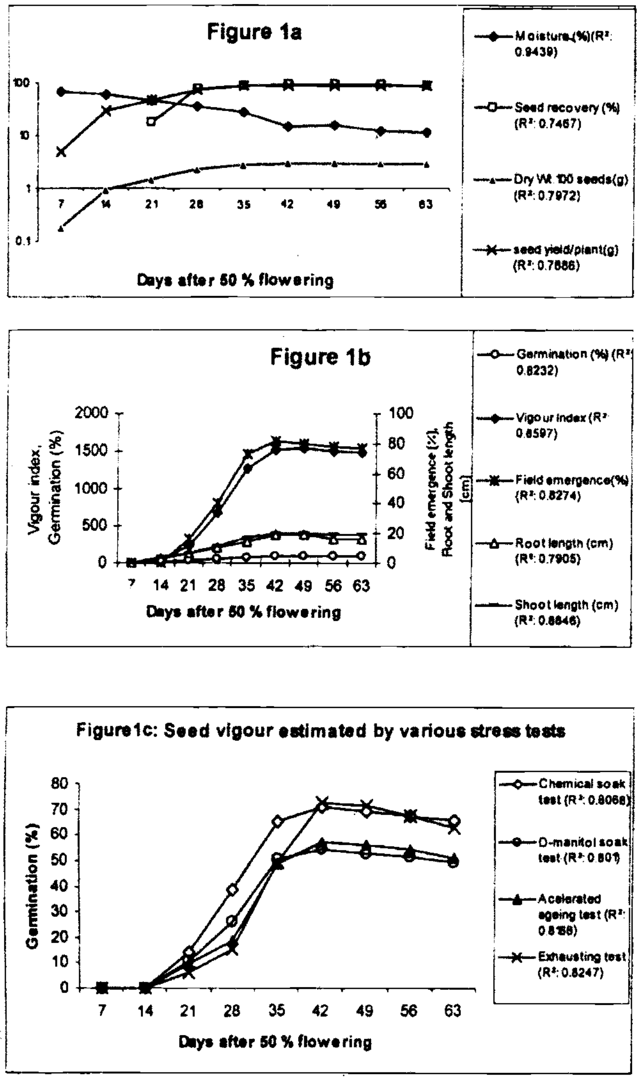


**Fig. 1 :** Physiological changes in *Sorghum* during seed development and maturation.

differences with respect to root and shoot length, dry weight of seedlings, field emergence and vigour indices were significantly higher in rabi season followed by summer and kharif seasons.

Seed vigour as estimated through stress tests by soaking the seed in ammonium chloride and D-manitol solution and by subjecting them to accelerated ageing and exhaustion test has clearly brought out the superiority of mature seeds by recording maximum germination at 35 and 42 days after 50 per cent flowering respectively in varieties CO 24, CO 26 and CO 25, JH 35 (fig. 1c) in rabi season (ammonium chloride treated: 45.2 per cent, D-manitol solution treated: 34.1 per cent, accelerated ageing: 34.8 per cent, exhaustion test: 40.8 per cent) followed by summer (ammonium chloride treated: 43.1 per cent, D-manitol solution treated: 33.1 per cent, accelerated ageing: 32.5 per cent, exhaustion test: 37.8 per cent) and kharif seasons (ammonium chloride treated: 42.4 per cent, D-manitol solution treated: 31.2 per cent, accelerated ageing: 31.0 per cent, exhaustion test: 36.8 per cent). Under such stresses, seeds started germinating only from 21 days after 50 per cent flowering, thus indicating inferior nature of immature seeds during early part of seed development and maturation. Therefore, it becomes apparent that there is an inbuilt mechanism in developing seed conditions and post-harvest operations after-reaching the physiological maturity when the change in cell membrane and disorganization of cell organelles takes place (Matthews, 1976). Evidently, the sum total of all the seed attributes as reflected in seed germination under stress conditions is an indirect indication of the superiority of physiologically matured seeds.

## Conclusion

The present study on the effect of environmental conditions during harvesting conditions on physical and physiological changes in sorghum during seed development and maturation has indicated that 'physiological maturity' attained is at 35 and 42 days after 50 per cent flowering respectively in varieties CO 24, CO 26 and CO 25, JH 35 concomitant with low moisture content at around 25 per cent with maximum accumulation of dry weight. However, seeds cannot be harvested at physiological maturity owing to higher moisture content of around 25 per cent which makes combine and harvesting quite difficult by causing damage to seeds during harvesting and processing. Hence, a stage beyond physiological maturity, which can be designated as 'harvestable maturity', seems to be the best stage for harvesting the seed crop. Since moisture content of around 16 to 18 per cent at this stage makes combing and harvesting of seed crop easier. Moreover, the damage to seeds during harvesting and processing is very meagre due to the hardened pericarp and highly and processing. Therefore, it is evident from the present study that 'harvestable maturity' is attained at 42 and 49 days after 50 per cent flowering respectively in varieties CO 24, CO 26 and CO 25, JH 35 (one week after physiological maturity). The study has also brought out the supremacy of rabi season followed by summer and kharif seasons for quality seed production.

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