Predicting the optimal stage of maximum seed quality during seed development and maturation in proso millet (*Panicum miliaceum* L)

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 Received: 12.10.2019/Accepted: 01.11.2019

ABSTRACT

Study on seed development and maturation is very important as these decide the seed quality of any seed crop. Present investigations were done to assess the maximum seed quality and physiological maturity stage of proso millet. The length and breadth of panicle, accumulation of fresh and dry weight of panicle and 1000-seed weight were higher at 28 days after anthesis (DAA) in proso millet and thereafter no increase was observed. The moisture content of panicle decreased with increase in stages of seed development and maturation. However the seed germination was not observed during physiological maturity stages which could be due to existence of dormancy in proso millet. The enzyme activities of á-amylase content, dehydrogenase activity and nutrient accumulation of carbohydrate, calcium and phosphorus content increased up to 28 DAA. Therefore it is advisable to harvest the seed crop of proso millet at 28 DAA which coincides with maximum seed quality.

Keywords: Seed development; proso millet; seed characters; days after anthesis; seed quality

INTRODUCTION

Study on tracing the duration and pattern of seed development and maturation is warranted for each and every crop as it varies from crop to crop. Seed development is the period between fertilization and maximum fresh weight accumulation. At the end of seed development, maturation begins and continues up to harvest (Abdul-Baki and Baker 1973). Seed maturation has been characterized as a process of dry matter accumulation ability followed by changes in moisture content, size and germination in addition to other physical, biochemical and morphological transformations (Delouche 1973).

Seed maturation is a prerequisite for germination and emergence of vigorous seedlings as it is the main component of seed quality (Perry 1982). Therefore seed crops should be harvested at physiological maturity stage where the seed quality traits are at their maximum. Research was done in various crops such as Narayanaswamy and Javaregowda (1989) in ragi, Ravindra Reddy (1994) in pearl millet, Tonapi et al (2006) in sorghum, Ghassemi-Golezani et al (2011) in maize, Dhobi et al (2015) in snake gourd and Kwankaew et al (2017) in rice. However during seed development and maturation the time of occurrence of maximum seed quality varies among crops.

Harvesting of any seed crop at appropriate stage is very essential for obtaining quality seeds (Demir et al 2008). If the seed crop is harvested too early it may lead to decreased yield and quality due to improper development of seed structures (Elias and Copeland 2001, Ekpong and Sukprakarn 2008). Also it should not be harvested too late as the seeds scatter and seed quality may be affected by ageing process. Environmental factors are unpredictable as sudden rainfall may result into in situ germination of seeds (Elias and Copeland 2001). Therefore the success behind seed production is predicting and harvesting of seeds at right time. Harvesting of seed crop at appropriate time results in production of high vigorous seeds (Demir and Balkaya 2005, Wang et al 2008).

Harvesting of seeds at optimum stage of maturity helps to obtain better quality seed. Quality of a seed basically depends on seed filling, metabolic and synthetic efficiency of the fertilized ovule during seed development and maturation (Harrington 1972). Studying the pattern of seed development and maturation enables seed producer to harvest the seed crop in time when the seed quality attributes are at maximum. Hence knowledge on development of seed from fertilization to maturity is valuable in quality seed production. The need to determine the appropriate harvesting period for proso millet to enhance and ensure its quality and viability is imperative. Hence this study tried in determine the physiological maturity stage of proso millet which is the appropriate time of harvesting in order to produce quality seeds.

MATERIAL and METHODS

The present investigations were carried out in Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu. The seeds of proso millet cv CO (PV) 5 (*Panicum miliaceum* L) obtained from the Department of Millets, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu formed the base material for the present investigations. The proso millet was raised in the field condition following all the recommended cultivation practices. During anthesis time the randomly selected panicles were tagged and harvested at weekly intervals. The parameters such as panicle characters, seed characters, germination test, enzymatic changes and nutrient accumulation were observed at each maturity stage to find out the optimum stage of physiological maturity.

The length of panicle was measured from the base to tip; maximum breadth of the panicle was also measured. The weight of freshly harvested panicles and seeds extracted was taken. The panicles and seeds after recording the fresh weight were dried in a hot air oven maintained at 103 ± 2°C for 16 ± 1 h. After cooling for 30 minutes in a desiccator, the dry weight was recorded. Moisture content of panicles and seeds was estimated by the method suggested by Anon (2011). 1000-seed weight was taken in an electronic balance. Germination test was conducted by following the procedure outlined in ISTA Seed Testing Rules with roll towel medium. α-amylase content was determined according to Paul et al (1970), dehydrogenase activity by Kittock and Law (1968), carbohydrate content by Somogyi (1952) and calcium and phosphorus content by Jackson (1973). The data obtained were statistically analysed following the methods described by Rangaswamy (2002).

RESULTS and DISCUSSION

As the maturation stage advanced, considerable increase in the length and breadth of panicles was observed (Plate 1). The maximum length (36.5 cm) and breadth (5.0 cm) of panicles were observed on 28 DAA. The maximum fresh weight (10.13 g) and maximum accumulation of dry weight (8.02 g) of panicles were observed on 28 DAA that significantly differed from other stages.

During the stages of physiological maturity, development of seeds was not observed until 7 DAA. The seed development was observed only from 14 DAA. Thereafter fresh and dry weight accumulation of seeds and 1000-seed weight tended to increase during the seed development and maturation period and reached maximum on 28 DAA and then slight decline was observed (Fig 1). During stages of seed development and maturation the moisture content of the seeds decreased.

With the advancement of seed development stages, increase in seed fresh weight was noticed which is in agreement with Varshney et al (2001) in Indian mustard and Ravichandran (2015) in birdwood grass. The moisture content from initial to later stages increased due to rapid uptake of water and nutrients and lead to cell division and elongation (Noggle and Fritz 1983).

Harrington (1972) defined physiological maturity as the stage when the seed attains its maximum dry weight. Dry weight of seed could be used for assessing the maturity of seed (Delouche 1973). Maximization in dry weight of seed is considered as an index of seed maturation (Abdul-Baki and Anderson 1973). The dry weight of developing seeds can be used to assess the maturity of the seeds as reported by Krishnakumary et al (2004) in melon, Rajasekaran (2004) in brinjal, Vijaya Geetha et al (2013) in mustard and Murali et al (2019) in marigold.

In the present study the decrease in moisture content of seeds as maturity advanced may be due to the utilization of water in various metabolic activities and removal of water by desiccation caused by surrounding environment. This is in conformity with earlier findings of Sreeramulu et al (1992) in groundnut,

Plate 1. Physiological maturity stages of proso millet

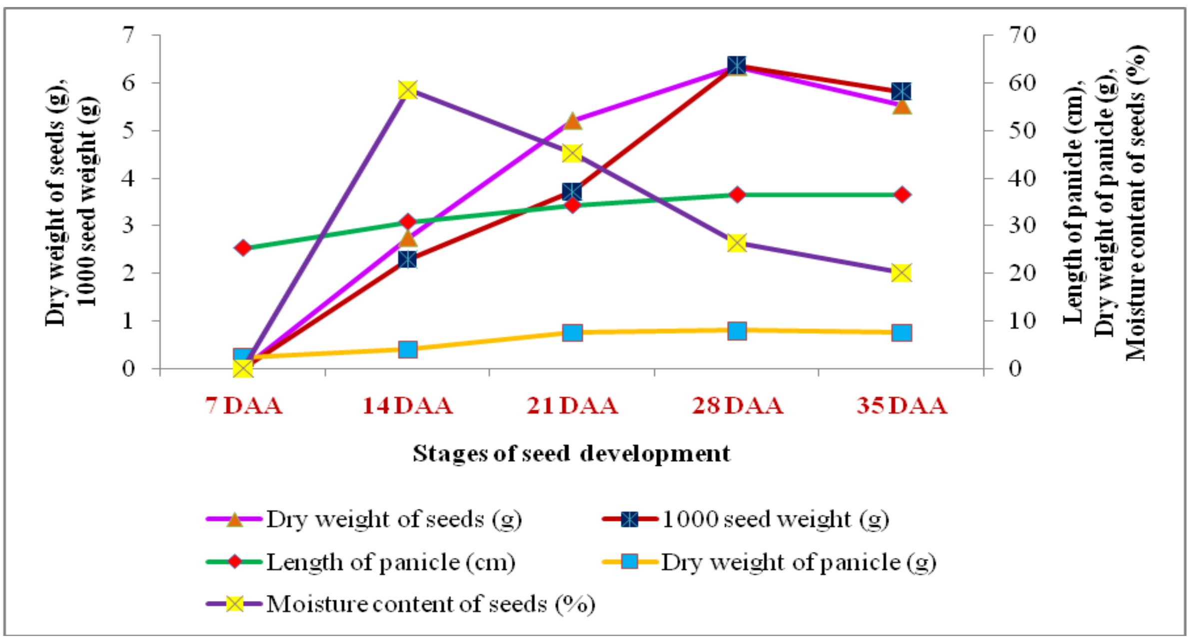

Fig 1. Panicle and seed characters of proso millet at various stages of seed development

Samnotra et al (2002) in okra, Chandran (2006) in wheat and Yang et al (2019) in sheepgrass.

The increase in 1000-seed weight coinciding with the faster accumulation of dry weight and decrease in moisture content indicated entering of seed into maturation stage. The study is in conformity with the results of Renganayaki (2001) in sunflower, Khattra and Singh (1995) in many crops, Reshma (2001) in hedge lucerne, Geetha (2001) in blou buffel, Kathiravan (2004) in jatropha and Tetteh (2018) in tomato. This might be due to the accumulation of water in the earlier stages and steady accumulation of dry matter in the later period of seed maturation. Increased 1000-seed weight during the course of maturation could be due to accumulation of dry weight and storage reserves. Increasing photosynthesis and translocation of assimilates to the sink (seeds) resulted in increased seed weight (Karthikeyan 2002).

As seeds were not developed during initial stage of development (7 DAA) the enzymatic changes

Table 1. Enzymatic changes and nutrient accumulation during seed development and maturation stage in proso millet

Stage of seed development (DAA)	α-amylase content (mg maltose/min)	Dehydrogenase activity (OD value)	Carbohydrate content (%)	Calcium content (%)	Phosphorus content (%)
7	-	-	-	-	-
14	1.23	0.163	25.3	0.75	0.10
21	2.89	0.250	43.8	1.10	0.28
28	4.86	0.325	69.4	1.83	0.44
35	4.86	0.325	69.4	1.83	0.44
Mean	2.76	0.212	41.5	1.10	0.25
SEd	0.034	0.002	0.488	0.012	0.003
$CD_{0.05}$	0.073	0.005	1.041	0.027	0.006

DAA= Days after anthesis

and nutrient accumulation were estimated during 14 DAA. As the seed maturation stages advanced, significant increase in α-amylase content, dehydrogenase activity, carbohydrate content, calcium content and phosphorus content of seeds was recorded (Table 1). The enzyme activities of á-amylase content and dehydrogenase activity and nutrient accumulation of carbohydrate, calcium and phosphorus increased up to 28 DAA in proso and thereafter enzyme activities and nutrient accumulation were not noted. The present findings are in agreement with the results of Raja (2003) in paddy and Ravichandran (2015) in birdwood grass.

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