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Germinability and seedling vigor of pearl millet seeds harvested at different stages of maturity

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ABSTRACT

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The effect of seed maturity on germinability and seedling vigor was studied in four cytoplasmic male sterile lines of pearl millet (*Pennisetum glaucum* (L.) R. Br.). The male sterile plants were crossed with pollen from respective maintainer lines, and developing seeds at different stages of maturity were harvested. Fresh weight of seeds increased gradually to a maximum in 28–35 days and then decreased. Maximum dry-matter accumulation in grain occurred at 28–35 days after pollination when the average moisture content was 22.7%. Seeds of some lines harvested at 10 days after pollination germinated, but the highest percentage germination was observed at 35 days in all lines. The maximum mean seedling vigor occurred at 35 days and coincided with the maximum dry weight of the seeds. Germplasm collectors can collect germinable seeds much earlier than the time of accumulation of maximum dry matter. However, for conservation, it is desirable to store mature seeds with maximum germination and vigor.

INTRODUCTION

To conserve the fast-vanishing plant genetic resources, seeds are stored in man-made genebanks. At the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), nearly 100 000 germplasm samples of its mandate crops are conserved in cold chambers maintained at 4°C and 20% relative humidity (RH). Pre-harvest factors, such as the degree of seed maturity, influence germinability and vigor, which in turn affect the potential longevity of seeds (Justice and Bass, 1978). During germplasm collection missions, collectors often encounter fields with crops at different stages of maturity because of either genotypic differences in crop duration or differ-

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ences in planting time. From the storage point of view, although it is desirable to collect fully mature seeds, if information on germinability in relation to degree of seed maturity is available, immature seeds can also be collected in order to save the expenses on another mission for collecting late-maturing lines. Therefore, knowledge on seed maturity in relation to seed quality is important to genebank managers and germplasm collectors. However, little information of this type is available for pearl millet (*Pennisetum glaucum* (L.) R. Br.), although the course of grain development has been studied (Fussell and Pearson, 1978). We report in this paper, changes in fresh weight, dry weight, moisture content, germinability and vigor of seeds harvested at different stages of maturity in diverse male sterile lines of pearl millet.

MATERIALS AND METHODS

The experiment was conducted during the post-rainy season (November–March), as the seeds for conservation at the ICRISAT genebank are obtained from crops grown during that time each year. Rain-free days during the post-rainy season, and low ambient temperature and relative humidities during harvest, facilitate the production of good quality seeds which are free from grain molds. In pearl millet, flowering within a spike extends from 3–5 days which leads to differences in age of the seeds harvested. To overcome this variation, seeds of the same age from a given spike were obtained through controlled pollination of male sterile plants.

Four cytoplasmic male sterile (CMS) lines of pearl millet of diverse origin, plant height and seed size were used in this study. Each line was planted on 17 November 1989 in a block of eight rows, 4 m long and spaced 75 cm apart. Six rows of the corresponding maintainer line were planted after every CMS-line block. Emerging spikes from the CMS plants were enclosed in parchment paper bags and when the maximum number of receptive stigmas appeared, they were crossed with pollen collected from the corresponding maintainer line. After pollination, the spikes were tagged and bagged again to prevent further pollination and to ensure that all seeds produced on the spike were of the same age. The pollinations were made so that spikes of different maturities could be harvested at about the same time to minimise environmental effects on seed maturation. For example, spikes which were pollinated first were harvested late, while those pollinated at later dates were harvested early. The duration of flowering was extended by encouraging the production of tillers, by removing some spikes before anthesis and by irrigation and fertilizer application.

Developing seeds were sampled at 10, 14, 21, 28, 35, 42 and 49 days after pollination (DAP). The mean daily temperature during seed maturation (from first pollination to last harvest) was 22.5°C. The mean thermal time (accumulated temperature) from pollination to harvest of seeds of different

maturities, calculated above a base temperature of 10°C (Ong, 1983), varied from 133.0 to 620.6°Cday. The fresh weight, dry weight, moisture content and germinability were determined for each sampling time. From each CMS line, a minimum of 10 spikes were collected in plastic bags and brought to the laboratory for observations. Fresh-weight determination was based on 200 seeds (two replicates of 100 each), randomly selected from all the spikes collected for each sampling time, and expressed in g/100 seeds. The same seeds were dried in a ventilated oven at 105°C for 24 h to determine the dry weight (g/100 seeds) and moisture percentage (wet weight basis).

Viability of fresh seeds was assessed by germinating 200 seeds (as two replicates of 100 seeds) on moist filter papers (Whatman 181) in petri dishes. The seeds were incubated at 20/30°C for 16/8 h per day for 15–30 days and germination percentages were calculated as recommended by the International Seed Testing Association (ISTA, 1985).

The remainder of the seeds in each treatment was placed in perforated trays and dried in a drying cabinet at 15°C and 15% RH for 1 week. To determine the influence of seed maturity on seedling vigor, dried seed lots were sown as two replicates each of 50 seeds in polypropylene cups, containing a sterilized soil mixture of loam, peat and sand in the ratio of 2:1:1. The cups were kept in a growth chamber maintained at 25°C with 12 h daylight. Fourteen days after planting, the seedlings that emerged were cut at ground level and oven dried at 105°C for 24 h to determine the dry weight (g/100 seedlings) which was used as a measure of seedling vigor.

RESULTS AND DISCUSSION

There were some differences between the lines for various characters studied within each sampling time. However, for the purpose of this paper, to visualize the trend, the means of all four lines for each character were plotted against sampling time in Fig. 1. Fresh weight of developing seeds gradually increased for most lines till 28 days after pollination and subsequently decreased. There was a gradual reduction in the mean moisture content of the seeds from 68 to 11% as they advanced in maturity (Fig. 1). The trend of fresh-weight accumulation and moisture-content decrease was similar for all lines.

Averaged over lines, dry-matter accumulation (g/100 seeds) gradually increased from 0.12 g on the 10th day to 0.98 g on the 35th day (Fig. 1). The mean moisture content at maximum dry weight was about 23%. Genotypic differences were observed however; the moisture content was 34% in T 239A and 21% in DSA 105A. Maximum dry-matter accumulation, which indicates physiological maturity of seeds, was associated with the appearance of a black region on the seeds. Fussell and Pearson (1978) reported the effective grain-filling period in pearl millet to be 37–44 days and the appearance of the black

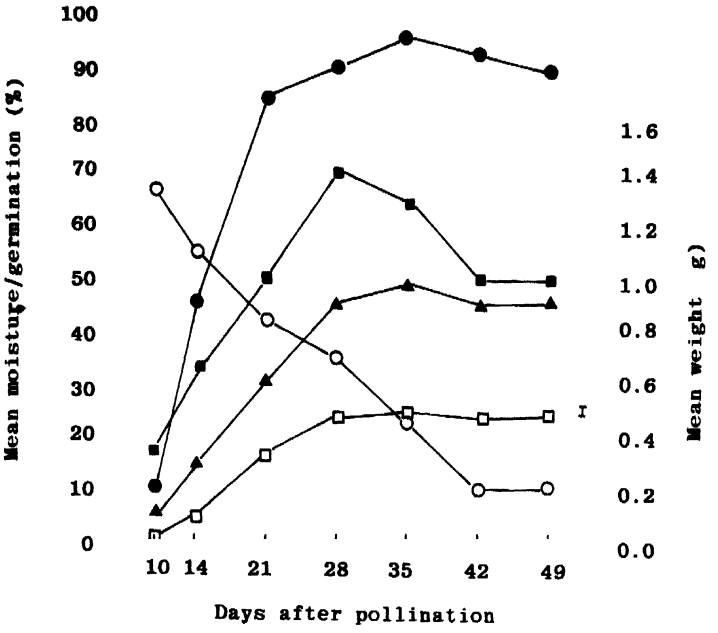

Fig. 1. The mean fresh weight (■), dry weight (▲), moisture content (○), germination and seedling dry weight (□) of developing seeds of four pearl millet lines at different days after pollination. Vertical bars represent LSD at $P=0.05$ for the characteristic denoted.

region in the seeds between 38 and 45 days. Their crop was grown in Camden, Australia, where the mean daily temperature at maturity was reported as 14.5°C. At Patancheru on the other hand, the maximum dry-matter accumulation was obtained within 35 DAP, probably because of higher temperatures (mean 22.5°C) during seed maturation.

Some germination (6–28%) was observed in the seeds harvested 10 days after pollination in all lines, except DSA 105A. In a previous study of pearl millet, seeds harvested 10 days after anthesis had failed to germinate (Vanangamudi, 1987). Germination percentage varied among the lines during early stages of seed maturation. Nevertheless, it increased to a maximum as the seeds approached physiological maturity and germinability of near mature or mature seeds did not differ significantly among the lines. The ability of 10-day-old seeds to germinate indicates complete development of their embryos. The mean maximum germination of 96% that occurred at 35 days after pollination corresponded with maximum dry-weight accumulation in the seeds (Fig. 1).

Seedling vigor gradually increased when grown from seed of increasing age up to about 35-day-old seeds (Fig. 1). Fresh seeds harvested 10 days after pollination failed to emerge, although in some lines they germinated when sown after drying. This was also true for seeds of DSA 105A harvested 14

days after pollination. Seedling vigor was found to be closely correlated with dry weight of seeds ($r=0.95$). Vanangamudi (1987) reported that pearl millet seeds attain physiological maturity 30–40 days after anthesis. Dry matter accumulation and seedling vigor were maximum at this stage. In other studies with sorghum, the emergence of seeds harvested at 12 and 18 days after pollination was significantly higher when compared to 9-day-old seeds. Maximum seedling vigor was obtained from 27- and 33-day-old seeds (Kersting et al., 1961; Weible et al., 1982).

The present findings should be of interest to plant breeders, geneticists and germplasm collectors. Pearl millet seed can be harvested considerably before the time of maximum dry-weight accumulation with little loss in viability, allowing more generations to be raised within a given time frame. Germplasm collectors, who often encounter crops in different stages of maturity in farmers' fields, can safely collect germinable seeds much earlier than physiological maturity. However, immature seeds are known to lose viability faster than mature seeds during storage (Justice and Bass, 1978). Therefore for seed conservation, physiological maturity seems to be essential since germinability and vigor were maximum at that time.

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