- **Short communication**

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ACCELERATED SEED AGEING OF BARNYARD MILLET AND THEIR RESPONSE TO GRAIN YIELD

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Abstract

Relationship between the yield and physiological characters in accelerated aged seeds of two varieties and three advanced breeding lines of barnyard millet were tested. Two different methods of seed ageing process were used and a non-significant relationship between the methods was found. It indicates that either of this can be used for accelerated seed ageing process. All the lines showed clear deterioration during the ageing process and there was a clear difference between the different genotypes of barnyard millet. MDU 1 endured well and ACM- 12-110 deteriorated more during the ageing process. The germination per cent and vigour index showed a significantly high correlation with the single plant yield, whereas dry matter production showed a significant relationship with the green fodder yield.

Consumption of millets was very common during the Indian Bronze Age (4,500 BC). "The history repeats itself" as millets have gained its importance in the modern world as nutraceutical crops. Millets possess high levels of vitamins, minerals, proteins, amino acids, micronutrients and trace elements (Muthamilarasan *et al.* 2016). Millets also considered as the climate change resilient crops. Being C_4 photosynthetic crops, it owns potential to grow in poor nutrient soil, high temperature tolerant and drought tolerant regions. Recently, Barnyard millet is gaining its momentum due to short life span, can grow in extreme soil, climate change resilient nature and high nutritive value. It is a rich source of carbohydrate (65%) protein (11.1%), dietary fibre (9.8%) and it is capable of reducing blood glucose and lipid levels. It also possesses a rich source of iron (4.0 mg/100 g) and zinc (3.6 mg/100 g) content among other millets (Jayakodi *et al.* 2019).

Genetic resources prevailing among the crops will play a pivotal role in crop breeding and improvement. Hence, conservation of genetic resources is of utmost importance. Over seven million accessions of crop seeds are stored in gene banks globally (Nagel *et al.* 2015). In International Crop Research Institute for Semi-Arid Tropics (ICRISAT) alone have 743 barnyard millet accessions collected around nine countries and stored. Barnyard millet being the orthodox seed, its longevity can be enhanced by lowering the seed moisture content and storage temperature. Even though seeds are stored in lower temperature and moisture, seeds tend to deteriorate at slower phases (Kranner *et al.* 2010). Thus, major constrain in germplasm storage is the loss of seedling vigour due to ageing of the seed material. So far, effects of accelerated seed ageing on crop growth and yield were studied properly. Hence, present study was aimed to investigate the effects of accelerated seed ageing on yield parameters in barnyard millet.

One month old seeds of two varieties (Co (KV) 2 and MDU 1) and three advanced breeding lines (ACM-10-082, ACM-10-161 and ACM-12-110 - developed at TNAU, Madurai) of barnyard millet which were selected had initial moisture content 7.2 ± 0.2%. The seeds were subjected to accelerate seed ageing by keeping them in an ageing chamber maintained at a temperature of 40 ± 1°C and relative humidity of 100 %. The accelerated ageing process carried out in two ways, (A).

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Bulk seeds were kept on seed ageing chamber at the beginning and a small quantity of seeds (100) were taken on a daily basis for physiological and yield evaluation; (B). A small quantity of seeds (100) kept in the ageing chamber on daily basis and physiological evaluation was carried out as bulk in the last day. The accelerated seed ageing process lasted for 15 days. The physiological evaluation included in the study were germination per cent, root length, shoot length, seedling vigour, vigour index (ISTA 1999), yield and yield contributing characters. The germination test was carried out in three replications with 25 seeds each by roll towel method (ISTA 1999). Also, aged seeds were grown in a pot at the laboratory with standard pot mixture. The experimental data were statistically analyzed using Biovinci software version 1.1.5 (BioTutoring Inc., San Diego, California, USA).

The present study aimed to test the effect of accelerated seed ageing on storability of barnyard millet seeds. Among the two methods of accelerated seed ageing, both showed similar and non-significant results, indicating either of the methods can be used for accelerated seed ageing studies. Both the methods have their own positives and negatives during handling of seed material. The former gives a clear idea about the time to stop the accelerated seed ageing process and time of seed deterioration. The later has the advantage of handling the materials in bulk and also helps in minimizing the environmental errors as physiological evaluation had taken on the same day for all the materials.

The main factor which intimidating the seed quality is a genetic nature of the seed (Dahuja 2015). All the five genotypes showed clear deterioration during the ageing process and there was a clear difference among the different genotypes of barnyard millet taken for the study (Fig. 1A, B, C, D). Kapoor *et al.* (2010) reported the germplasm difference in accelerated seed ageing. The moisture content of the seed material increased throughout the process of accelerated ageing and is endorsed by the absorption of moisture by the seed during ageing process where seeds are kept at 100 % relative humidity. Similar results were reported by various experts Venkatesan *et al.* (2018). The initial germination per cent of the different genotypes (control) ranged from 94-98 % and all the genotypes showed a decreased trend in germination per cent during the accelerated ageing process. ACM-12-110 showed maximum reduction in germination per cent (from 95 to 28 %) and is followed by ACM-10-161 (from 94 to 31 %). MDU 1 endured well during the ageing process as the germination per cent reduced from 98 to 63 per cent only. Similar results of reduced germination per cent were reported by Sujatha *et al.* (2012).

In the control, MDU 1 possess the shoot length of 11.45 cm, root length of 13.45 cm, vigour index of 2341 and dry matter production of 20.2 mg (Fig. 1A). In CO_2, control had shoot length of 9.13 cm, root length of 14.1 cm, vigour index of 2137 and dry matter production of 23.5 mg (Fig. 1B). In ACM-10-161, control had shoot length of 9.46 cm, root length of 11.26 cm, vigour index of 1658 and dry matter production of 23.7 mg (Fig. 1C). In ACM-10-082, control was observed with shoot length of 11.88 cm, root length of 13.44 cm, vigour index of 2076 and dry matter production of 20.9 mg (Fig. 1D). In the control, ACM-12-110 possess with shoot length of 9.81 cm, root length of 12.31 cm, vigour index of 1991 and dry matter production of 20.1 mg (Fig. 1E). Root length, shoot length, vigour index and dry matter production of one to two days aged seeds showed little increase over control and reduced drastically during the remaining period of accelerated ageing (Venkatesan *et al.* 2018). This might be due to freshness of the seed material and initial temperature rise would have boosted the metabolic activity. Among the genotypes studied, MDU 1 showed the highest grain yield of 45.2 g per plant in control, and CO (KV) 2 showed the highest fodder yield of 357.12 g per plant in the control. The single plant yield and green fodder yield of all the genotypes reduced in relation with the time of accelerated seed ageing. This might be due to the degradation of the metabolic process and macromolecules like proteins, lipids and DNA which may resulted from a reaction caused by reactive oxygen species

(ROS) (Waterworth *et al.* 2010). The results of various barnyard millets lines to seed ageing were picturized in the Fig. 1 as hierarchical heat map clustering.

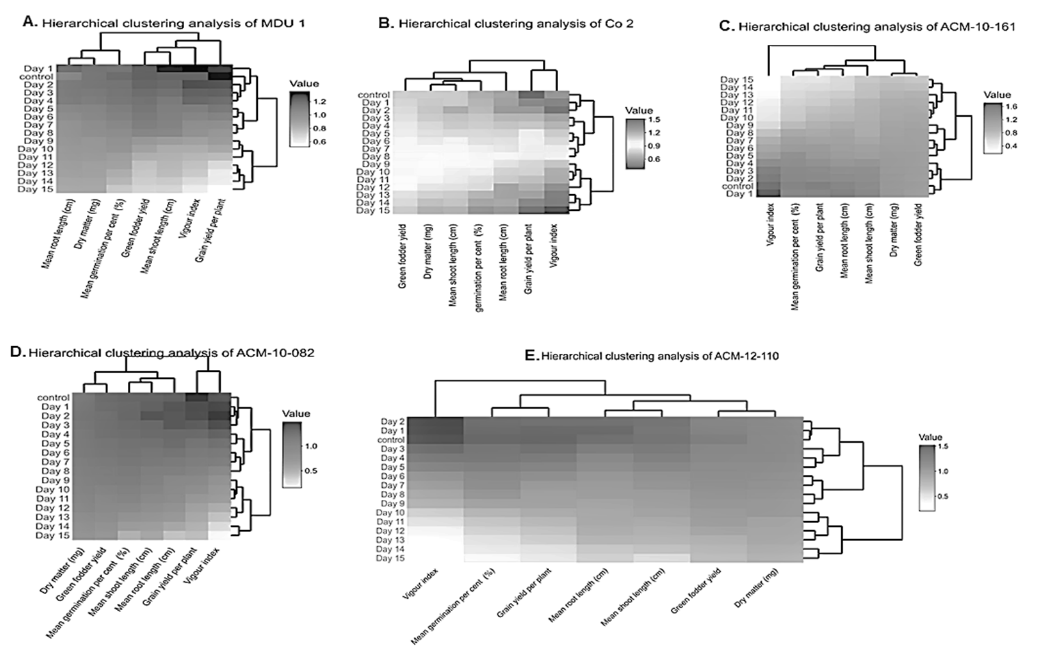

Fig. 1. Hierarchical heatmap clustering based on accelerated seed ageing in barnyard millet (A) MDU 1, (B) CO (KV) 2, (C) ACM-10-161, (D) ACM-10-082 and (E) ACM-12-110.

The correlation studies between various physiological characters and yield parameters revealed that there is a positive correlation among all the characters studied and it is presented in Table 1. The germination per cent (0.809) and vigour index (0.808) showed a significantly high positive correlation with the single plant yield. Dry matter production showed the highest positive correlation with the green fodder yield. It is followed by the germination per cent and grain yield per plant. Likewise, positive correlation between dry matter production and green fodder yield were observed by Navaselvakumaran *et al.* (2019).

Table 1. Correlation between yield and physiological parameters of barnyard millet accelerated aged seeds.

Characters	% Germination	Shoot length (cm)	Root length (cm)	Vigour index	Dry matter	Green fodder yield (g)	Grain yield/ plant (g)
Grain yield/plant (g)	0.809	0.765	0.758	0.808	0.664	0.740	1.000
Green fodder yield (g)	0.687	0.552	0.589	0.633	0.877	1.000	0.740
Dry matter	0.742	0.607	0.614	0.631	1.000	0.877	0.664
Vigour index	0.939	0.930	0.98	1.000	0.631	0.633	0.808
Root length (cm)	0.908	0.896	1.000	0.980	0.614	0.589	0.758
Shoot length (cm)	0.900	1.000	0.896	0.93	0.607	0.552	0.765
% Germination	1.000	0.900	0.908	0.939	0.742	0687	0.809

The simple linear regression analysis between the vigour index and grain yield per plant was represented in Fig. 2. The coefficient of determination between vigour index and grain yield per plant was 65.25 % with regression equation Y = 0.011 X + 11.46. The results of multiple regression analysis between a dependent variable (grain yield per plant, Y) and independent variables (germination per cent, X_1; shoot length, X_2; root length, X_3; vigour index, X_4; dry matter production, X_5; and green fodder yield, X_6) gave the equation $Y = 0.102\ X_1 + 0.887\ X_2 - 1.11\ X_3 + 0.008\ X_4 - 0.734\ X_5 + 0.099\ X_6$ with a coefficient of determination was 76.17.

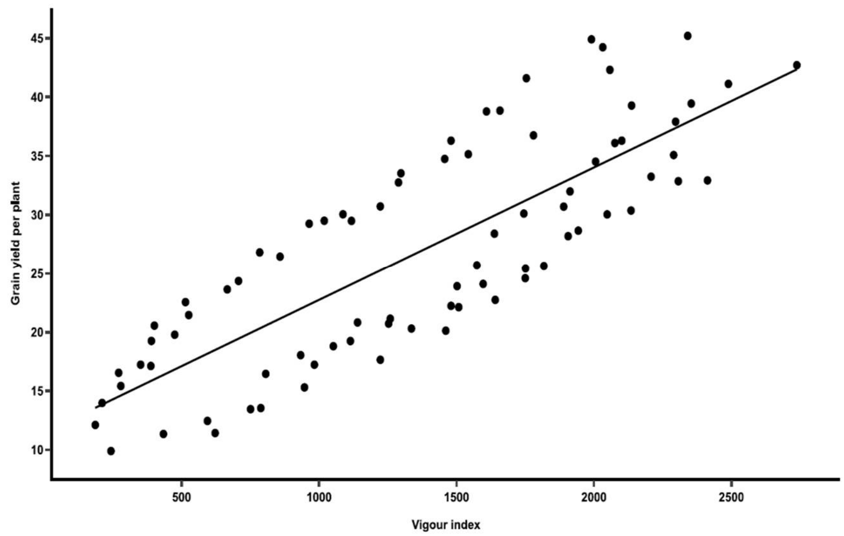

Fig. 2. Simple linear regression analysis between the vigour index and grain yield per plant.

It can be concluded that MDU 1 required 12 days, CO (KV) 2 required 9 days, ACM-10-161 required 6 days, ACM-12-110 required 7 days and ACM-10-082 required 9 days to deteriorate 75% (Indian Minimum Seed Certification Standards) of germination per cent and other physiological parameters. Grain yield per plant and green fodder yield was recorded high in MDU1 and CO2, respectively. Furthermore, physiological and yield parameters showed a parallel relationship as more number of days in accelerated seed ageing, more the reduction in grain yield and fodder yield per plant. Before storing seeds in gene banks, a clear idea should be needed on the physiological, biochemical and genetic nature of the seed to store it for a longer period. Consequently, more number of genotypes and different ageing conditions should be used to draw the conclusion on the longevity of seeds. Under changing unpredictable climate, knowledge about barnyard millet genotypes response to high temperature would be of valuable information.

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