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Evaluation of dormancy breaking methods on improvement of germination in barnyard millet (*Echinochloa frumentaceae* L.) var. MDU 1

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Abstract
Seed dormancy is the resting period or state of inhibited growth of seeds after physiological maturity. It is also an adoption mechanism to overcome stress conditions. The fresh seeds of barnyard millet (*Echinochloa frumentaceae*) var. MDU 1 recorded 28% germination immediately after harvest. Hence, freshly harvested seeds were subjected to different dormancy breaking treatments and analyzed for physiological seed quality parameters. Seeds were treated with growth regulators GA_3 and NAA at different concentrations. Acid scarification (dilute H_2SO_4) was attempted independently and in combination with KNO_3 and also with growth regulators and untreated seeds served as control. The results revealed that combined treatment of scarification with dilute sulphuric acid for 10 min followed by KNO_3 @ 3% for 12 h and GA_3 @ 500 ppm for 12 h registered highest germination with vigorous seedling growth.

Keywords: Barnyard millet, dormancy, fresh seeds, gibberellic acid, potassium nitrate

Introduction
Barnyard millet (*Echinochloa frumentaceae* L.) is the fastest growing crop among all millets which is known for their fast maturity, high storability, and the ability to grow on poor soils (Yabuno, 1987). In seed production program, the readiness of seed to germinate for further multiplication is much ensured. The crops from Poaceae family have different levels of dormancy in caryopsis, spikelet or glumes, impermeable seed coats and due to chemical inhibitors present in the seed coat or glumes (Baskin and Baskin, 2004). Dormancy is the inability of a seed to germinate in a specified time period when exposed under favorable conditions for germination. Overcoming the dormancy of freshly harvested seeds is a pre-requirement for maintaining the germination and plant population in the field. Effectiveness of dormancy breaking method usually varies among species and it is strongly influenced by nature of dormancy. Seed dormancy often can be broken by treatments that stimulate embryo metabolism, increase the permeability of seed coats to oxygen and water, and reduce the mechanical resistance to growth of the embryo. The seeds of barnyard millet are small and light grey in color. The germination of freshly harvested seeds of barnyard millet is inhibited due to the presence of growth inhibitors like abscisic acid in the glumes (Venkatesan *et al*., 2018). Seed dormancy is positively correlated with seed coat color due to phenolic compounds. The dormancy of cereal caryopsis might be controlled by phenolic compounds through their inhibitory effects on germination (Weidner and Paprocka, 1997). In this contest, the present study was carried out to evaluate the dormancy breaking treatments on germination and vigour of barnyard millet var. MDU 1.

Materials and Methods
Seed dormancy breaking studies on barnyard millet var. MDU 1 were carried out at the Department of Seed Science and Technology, Agricultural College and Research Institute, Madurai. Freshly harvested seeds were given with dormancy breaking treatments after drying the seeds to 10% moisture content. Seeds were treated with the following dormancy breaking methods *viz*., T_1 – Soaking in water for 24 h, T_2 – Oven drying at 40°C for 6 h, T_3 – Acid Scarification with dilute H_2SO_4 @ 100 ml/kg of seeds for 10 min (50 ml of H_2SO_4 in 100ml of water), T_4 –$KN0_3$ @ 2% for 12 h, T_5 - $KN0_3$ @ 3% for 12 h, T_6 - $KN0_3$ @ 5% for 12 h, T_7 - GA_3 @ 100 ppm for 12 h, T_8 - GA_3 @ 300 ppm for 12 h, T_9 - GA_3 @ 500 ppm for 12 h, T_{10} – NAA @ 100 ppm for h, T_{11} - NAA @ 200 ppm for 12 h, T_{12} - NAA @ 300 ppm for 12 h.

Seeds scarified with dilute sulphuric acid for 10 min were again soaked in $KN0_3$, GA_3 and NAA at different concentrations with the soaking duration of 12 h as follows.T_{13} - $KN0_3$ @ 2%, T_{14} - $KN0_3$ @ 3%, T_{15} - $KN0_3$ @ 5%, T_{16} - GA_3 @ 100 ppm, T_{17} - GA_3 @ 300 ppm,T_{18} - GA_3 @ 500 ppm for 12 h, T_{19} - Soaking in NAA @ 100 ppm for 12 h, T_{20} - Soaking in NAA @ 200 ppm, T_{21} - NAA @ 300 ppm. T_{22} - Aged naturally at ambient condition for 30 days for the release of dormancy. Untreated fresh seeds served as Control (T_0). The experiment was conducted in a completely randomized block design and replicated thrice. The seeds were subjected to germination test in paper medium at the temperature of 25 ± 2°C and 95 ± 3% RH with the germination period of 14 days (ISTA, 1990). Seeds were evaluated for germination (ISTA 1999), shoot length (cm), root length (cm), dry matter production per 10 seedlings (g), speed of germination (Maguire 1962) [7] and seedling vigour (Abdul-Baki and Anderson 1973) [1].

The data obtained were analyzed by the 'F' test of significance following the methods described by Panse and Sukhatme (1985). Wherever necessary, the percent values were transformed to angular (arc-sine) values before analysis. The critical differences (CD) were calculated at 5 percent probability level.

Results and Discussion

Freshly harvested barnyard millet seeds of variety MDU 1 recorded poor germination (28%) (Table 1) at 25°C but registered a viability percentage of 96% (Plate 1) when evaluated with TZ solution at 1% concentration for 2 h, indicating the presence of seed dormancy. Pre sowing dormancy breaking seed treatments registered significant differences on speed of germination, germination and vigor of the seeds compared to untreated seeds.

Germination was further improved to 56% when the seeds were soaked in water at laboratory temperature for 24 h. Soaking seeds in water might have leached out the water soluble inhibitors present in the seed coat which resulted in improved germination. Similar results were observed in *Cenchrus sp* (Geetha, 2001) [4]. Improvement in germination was minimum when seeds were oven dried at 40°C and acid scarified with dil. H_2SO_4 for 10 min, but seedling emergence was increased to the level of 17% compared to control. Increase in temperature might have increased the respiration or cause seed coat perturbations allowing for increased oxygen diffusion in seeds (Crocker, 1906). Germination in species of Cenchrus, Panicum, and Sorghum was stimulated by high temperature (Adkins *et al*., 2002). Similarly, disruption of lemma and palea due to scarification had also improved the permeability of seed coat apart from removal of specific inhibitors present in the seed coat. Marginal improvement in germination of seeds due to scarification or soaking indicate the presence of some other mode of dormancy other than physical or chemical dormancy.

This was evident when the seeds were treated with KNO_3 @ 3%, which have improved germination to the level 72%. KNO_3 may cause biosynthesis of auxin which ultimately triggers the growth of embryo (Khan *et al*., 1999) and the increase in germination percentage may be due to raised ambient oxygen levels and availability of less oxygen for citric acid cycle (Bewley and Black, 1983) [2]. Suppression of germination at higher concentrations of KNO_3 has been reported in *Cenchrus sp* (Geetha, 2001) [4], *Salvia cyanescens* (Yucel and Yilmaz, 2009) and *Gladiolus alatus* (Ramzan *et al.*, 2010) due to delayed imbibition. Similarly barnyard millet seeds treated with KNO_3 @ 5% was less effective than lower concentration. Seeds treated with GA_3 500 ppm recorded the highest germination of 88% (Table 1). The superior performance of GA_3 in breaking seed dormancy may be due to the activation of enzymes required for the energy generation leading to growth of the embryo. Birgit *et al*. (2005) [3] proved that growth hormones release enzymes that break down carbohydrates, proteins and fats, which in turn release free sugars and also counteracts with inhibitors. When seeds stored at room temperature for one month recorded improved germination (72%). This may be due to alterations in respiration or actions by reactive oxygen species and antioxidants (Adkins *et al*., 2002). Seeds treated with NAA @ 300 ppm showed significant improvement in germination percentage but was low compared to other dormancy breaking treatments. The poor performance of naphthalene acetic acid may be due to reduced abscisic acid deactivation and poor stimulatory effect of growth hormones (Liu *et al*., 2013). The acid scarified seeds soaked in KNO_3 @ 3% for 12 h recorded the highest germination 88%. Similar results were reported in fodder sorghum cv COFS 29 Shanmugavalli *et al*., 2007 [8]. This was followed by acid scarified seeds with GA_3 @ 500ppm which registered 83 percent germination. Acid scarified seeds softens seed coat and increase the chemical penetration and this was in wild oat (Hsiao, 1979; Hsiao and Quick, 1984) and indiangrass (Watkinson and Pill, 1998).

Acid scarified seeds soaked in KNO_3 @ 3% for 12 h have shown highest speed of germination (13.83), root length (24.60 cm), shoot length (7.2 cm) and dry matter production (0.44 gm) compared to other treatments (Table 1). Nitrogenous compounds modify hormone levels by inducing expression of enzymes that catalyze abscisic acid deactivation and gibberellic acid biosynthesis which resulted in increased growth of seedlings. The next better performance of seedlings was recorded in seeds soaked with GA_3 @ 500ppm. Gibberilic acid enabled the extra supply of reducing sugars which increased the rate of starch break down resulting in increased growth rate of seedlings (Paleg, 1960). Acid scarified seeds treated with GA_3 @ 500ppm also showed significant improvement in the root length (21.75 cm) and shoot length (6.14 cm). Seeds treated with GA_3 @ 300 ppm recorded better seedling growth as compared to control. When the seeds soaked in KNO_3 @ 3% for 12 h also recorded increased speed of germination (8.75), root length (19.15 cm), shoot length (5.40 cm) and dry matter production (0.031) as compared to control. When the acid scarified seeds treated were soaked in NAA @ 300 ppm produced improved speed of germination and other parameters which could be due to involvement of auxins. The untreated seeds recorded lowest speed of germination (3.08), root length (14.05 cm), shoot length (3.72 cm) and dry matter production (0.019 gm) (Table 1). The vigour index values were also expressed the superiority of acid scarified seeds with KNO_3 @ 3% and GA_3 @ 500ppm in relieving the dormancy of seeds. There was pronounced increase in the vigor index when the acid scarified seeds were soaked in GA_3 @ 500ppm for 12 h. When the acid scarified seeds were treated with NAA @ 300ppm also showed significant improvement in vigor index as compared to control. The lowest vigor index was registered in untreated seeds.

Table 1: Show the germination root shoot Length

Treatment	Germination (%)	Root Length (cm)	Shoot Length (cm)	Vigour Index I	Vigour Index II
T_0	28 (31.94)	14.05	3.72	497	0.532
T_1	56 (48.44)	17.20	4.15	1195	1.568
T_2	45 (42.13)	15.27	4.15	873	0.990
T_3	47 (43.28)	15.53	4.10	922	0.987
T_4	65 (53.73)	18.20	4.73	1490	1.885
T_5	72 (58.05)	19.15	5.20	1753	2.232
T_6	69 (56.16)	18.72	4.90	1629	2.001
T_7	74 (59.34)	19.50	5.40	1842	2.516
T_8	80 (63.43)	20.93	6.01	2155	3.280
T_9	88 (69.73)	23.82	6.64	2680	3.784
T_{10}	38 (38.05)	15.25	4.20	739	0.798
T_{11}	50 (45.00)	16.85	4.37	1061	1.200
T_{12}	59 (50.18)	17.52	4.48	1298	1.534
T_{13}	75 (60.00)	19.60	5.60	1890	2.625
T_{14}	88 (69.73)	24.60	7.20	2798	3.872
T_{15}	78 (62.02)	20.20	5.80	2028	2.964
T_{16}	77 (61.34)	19.86	5.72	1969	2.618
T_{17}	81 (64.15)	20.50	5.95	2142	2.997
T_{18}	83 (65.65)	21.75	6.14	2314	3.486
T_{19}	53 (46.72)	17.16	4.62	1154	1.431
T_{20}	58 (49.60)	17.37	4.17	1249	1.624
T_{21}	60 (50.76)	17.80	4.76	1353	1.500
T_{22}	70 (56.79)	18.90	5.14	1682	2.100
Mean	54.211	18.68	5.09	1596.21	2.1108
S.Ed	1.1778	0.4734	0.1127	30.6933	0.0482
CD(0.05)	2.3708	0.9529	0.2268	61.7837	0.0971

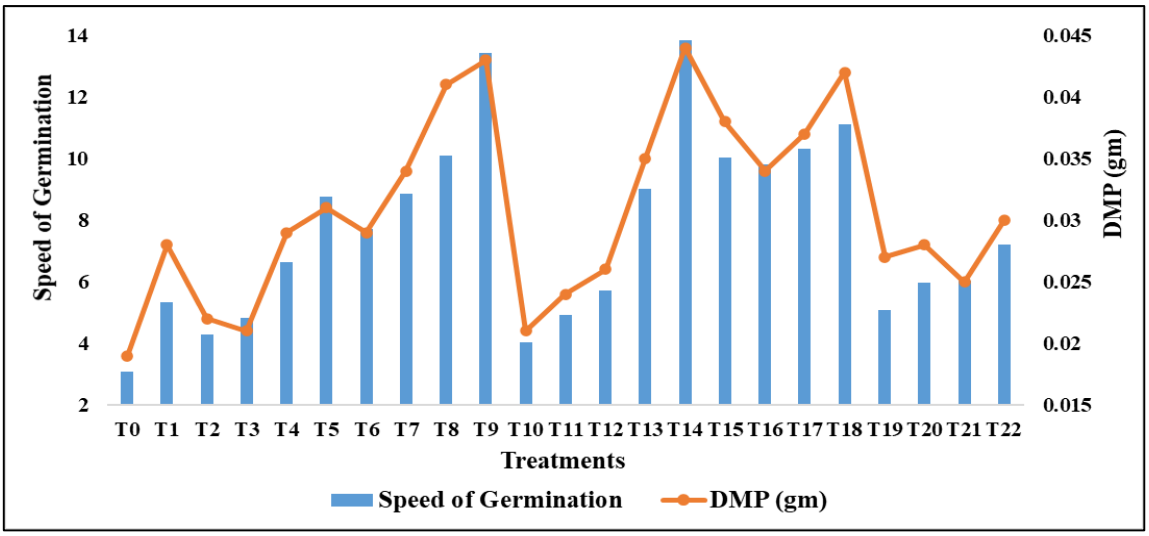

Fig 1: Dormancy breaking treatments on speed of germination and dry matter production (gm) of barnyard millet var. MDU 1

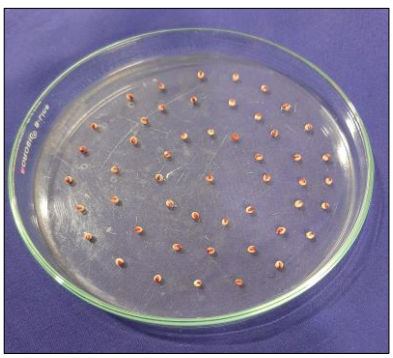

Plate 1: Viable seeds at 1% TZ for 2 h

Conclusion

Though the study indicated that the dormancy can be broken by GA_3 500 ppm, in consideration with cost efficiency it could be concluded that an effective strategy for breaking seed dormancy and enhancing the germination rate of barnyard millet var. MDU 1 is through a combination of acid scarified seeds (dilute H_2SO_4) for 10 min with KNO_3 @ 3% for 12 h.

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