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EFFECT OF OSMO PRIMING SEED TREATMENTS ON SEED QUALITY IN CERTAIN MINOR MILLETS

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Abstract

Minor millets are small-seeded grasses that are hardy and grow well in dry zones as rain-fed crops, under marginal conditions of soil fertility and moisture. They are one of the oldest foods known to humans and possibly the first cereal grain to be used for domestic purposes. Seed priming have various techniques for improving the performance of the growth, emergence, and yield of the crop. Osmo priming is one of the physiological methods that improves seed performance and provides faster and synchronized germination. It is an easy, low cost and low risk technique and recently being used to overcome the salinity and drought problem in agricultural lands. *In vitro* evaluation was carried out to study the effect of various osmo priming seed treatments on seed qualities in certain minor millets were carried out in the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University. Freshly harvested bulk seeds of certain minor millets of Varagu, Samai, Kuthiraivali, Tenai and Panivaragu were imposed with the following priming seed treatments i.e., unprimed, Water (hydro priming), NaCl @1 and 2 per cent, Mannitol @ 1 and 2 per cent, PEG @ -5 and -10 bar. During osmo priming, the seeds of above millets were soaked in above solution for 6 hrs by adopting the seed to solution ratio of 1:1 under ambient conditions. The treated seeds were evaluated for its seedling quality characters. The study revealed that the minor millet, varagu cv CO 3 and Kuthiraivali cv CO 1 seeds osmo primed with Mannitol @ 1 % for 6 h and Tenai cv. CO 6, Samai cv. CO 3 and Panivaragu cv. CO 4 seeds osmo primed with Mannitol @ 2 % for 6 h recorded higher seed qualities i.e., higher speed of emergence, germination percentage, seedling length, dry matter production and vigour index, when compared to other treatments.

Key words: Minor millets, Osmo priming, Seed quality

Introduction

Minor millets are small coarse of grains belongs to the family poaceae; most of the genera belongs to the sub-family panicoideae. It is characterized by their remarkable ability to survive in less fertile soil, drought-resistant, resistance to pests and diseases, short growing season and cultivated round the year and all over the world. The word millet is derived from the beginning of human civilization, millets are considered as first domesticated cereal. They represent a unique biodiversity component in the agriculture and food security systems of millions of poor farmers in the world. India occupies the first position in major production of minor millets. Millets are highly nutritious and has antioxidant properties which provide balanced nutrition Millets are generally grown on marginal land as rainfed crops and have a wider range of adaptation and can withstand certain degree of soil acidity and alkalinity stress due to moisture and temperature variations in soil from heavy to sandy infertile soils but often have low productivity (Vandana Misra *et al.,* 2014). Despite its superior nutritional quality it has received less attention compared to the major cereals. Seed is a living entity and is subjected to various environmental stresses which affect the quality. They are massively exposed to several difficult environmental conditions such as drought and salinity, which may strongly influence seedlings establishment (Figueiredo e Albuquerque and Carvalho, 2003). Seed sowing is considered as a sensitive and critical stage to cold, drought and salinity in plant's life cycle (Ghassemi-Golezani *et al.,* 2008). Efficient seed germination, rapid and uniform seedlings emergence lead to successful culture establishment (Chen and Arora, 2011). Seeds keeping their desiccation tolerance are then dehydrated and can be stored until final sowing. During subsequent germination, primed seeds exhibit a faster and more synchronized germination and young seedlings are often more vigorous and resistant to abiotic stresses than seedlings obtained from unprimed seeds. Priming improves seed germination performance by starting early processes of germination but not cell division (Yuan *et al.,* 2010). Metabolism that occurs during priming is not enough to cause radicle emergence (McDonald, 2000). There are two types of seed priming, in one type water penetrate freely into seed which is called hydropriming while in other type seed hydration is controlled. If controlled hydration is achieved through the addition of solute to water then it is called osmopriming or if a solid matrix is used to

provide controlled seed hydration then it is called solid matrix priming (Pill and Necker, 2001). Priming often involves soaking seed in predetermined amounts of water or limitation of the imbibition time. The imbibition rate could be somehow controlled by osmotic agents and referred as osmopriming. Osmopriming involves soaking seeds in osmotic solution with low water potential instead of pure water. Due to low water potential of osmotic solutions, water enters seed slowly which allows gradual seed imbibition and activation of early phases of germination but prevents radicle protrusion. Osmopriming strengthens the antioxidant system and increases seed germination potential, resulting in an increased stress tolerance in germinating seeds (Chen and Arora, 2011). Hence with the above background the present study were carried out to study the effect of various osmo priming seed treatment on seed qualities in certain minor millets i.e., kodo, foxtail, proso, little and barnyard millets.

Materials and Methods

The present investigations were carried out in the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University to study the influence of various osmo priming seed treatments on seed quality in certain minor millets. Genetically pure seeds of small millets *viz*., Foxtail millet (Tenai) cv. CO 6 (*Setaria italica* Beauv.), Little millet (Samai) cv. CO 3 (*Panicum Miliare* L.), Kodo millet (Varagu) cv. CO 3 (*Paspalum scrobiculatum* L.), Proso millet (Panivaragu) cv. CO 4 (*Panicum miliaceum* L.) Barnyard millet (Kudiraivali) cv. CO 1. (E*chinochloa frumentacea* Link.) were obtained from the Centre of Excellence in Millets, TNAU, Athiyandal, Thiruvannamalai constituted the basic material for the study. Freshly harvested bulk seeds of above minor millets were imposed with the following seed treatments for 6 hours adopting the seed to solution ratio of 1:1.

T_0 - Control (Unprimed)
T_1 - Water (hydro priming)
T_2 - NaCl @ 1 %
T_3 - NaCl @ 2 %
T_4 - Mannitol @ 1 %
T_5 - Mannitol @ 2 %
T_6 - Poly Ethylene Glycol - @ 5 bar
T_7 - Poly Ethylene Glycol - @ 10 bar

The seeds primed differentially as above were evaluated for the following seed quality characters., viz., Imbibition rate (%), speed of emergence (Maguire, 1962), germination percentage (ISTA, 1999), shoot length (ISTA, 1999), root length (ISTA, 1999), drymatter production (ISTA, 1999) and vigour index (Abdul-Baki and Anderson, 1973) under laboratory condition. The data were statistically analyzed as per the method of Panse and Sukhatme (1985).

Result and Discussion

Seed priming or osmo conditioning is one of the physiological methods that improves seed performance and provides faster and synchronized germination. Stand establishment is of primary importance for optimizing field production of any crop plant. Emergence and establishment are the two basic requirements for the successful seed programme as they offer scope not only for uniformity in the field but also for full exploitation of yield potential of the crop (Austin *et al.,* 1973). Rapid germination and emergence are essential for successful crop establishment, for which seed priming could play an important role. Seed priming is an effective technology to enhance rapid and uniform emergence and to achieve high vigour, leading to better stand establishment and yield. It is a simple and low cost hydration technique in which seeds are partially hydrated to a point where pre-germination metabolic activities start without actual germination, and then re-dried until close to the original dry weight. In the present study, the seeds of small millets seeds soaked in different osmoticants *viz.*, NaCl, Mannitol and PEG in two different concentrations (1, 2% and -5, -10 bar) for 6 hours adopting the seed to solution ratio of 1:1 and observed for the imbibition rate, speed of emergence, germination and seedling quality characters revealed that seeds primed with osmoticants exhibited lower imbibition rate and the seedling quality characters were in higher order than unprimed and hydroprimed seed, but among them mannitol recorded higher germination and associated seedling Vigour. The seeds soaked in mannitol @ 1% and 2% for 6 h was able to germinate earlier. The seeds primed with mannitol @ 1% for 6 h produced higher speed of emergence (69.3), germination percentage (94%), seedling length (19.1 cm), dry matter production (46.6 mg) and vigour index (1795) and speed of emergence (75.9), germination percentage (93%), seedling length (22.6 cm), dry matter production (24.6 mg) and vigour index (2102) when compared to unprimed seed and other treatments in respect with Varagu and Kudiraivali (Table 1 and 2). The seeds primed with mannitol @ 2% for 6 h produced higher speed of emergence (36.2), germination percentage (89%), seedling length (17.5 cm), dry matter production (19.9 mg) and vigour index (1558) in Tenai, speed of emergence (82.9), germination percentage (89%), seedling length (15.1 cm), dry matter production (19.8 mg) and vigour index (1344) in Samai and speed of emergence (50.8), germination percentage (96 %), seedling length (23.5 cm), dry matter production (41.7 mg) and vigour index (2256) in Panivaragu when compared to unprimed seed and other treatments

(Table 3, 4 and 5). The probable reason for early emergence of the mannitol osmoprimed seed may be the completion of pre-germinative metabolic activities and metabolic repair processes making the seed ready for radicle protrusion and the germination of seed soon after planting compared with untreated dry seed (Al- Mudaris and Jutzi, 1999). These findings agreed with Khalil *et al.* (2001) and Arif *et al.* (2008), who reported that priming reduced days to germination. But the performances of other osmoprimed seed, irrespective of the seedling quality characters were also slightly lower with hydroprimed seed but slightly higher than unprimed seed. In the present study also, among the osmoticants, the response was more with mannitol than with polyethylene glycol and sodium chloride and the adverse effects of polyethylene glycol obtained on germination were due to osmotic effect rather than specific ion accumulation as reported by Hosseini *et al*. (2003). The suitability of sodium chloride for priming and invigouration in maize also reported by Bakht *et al*. (2010). However, Sadeghian and Yavari (2004) reported that the highest concentration of Nacl decreased the seedling growth and germination rates on sugar beet seed.

The promotory effect observed in the mannitol osmo primed seed for speed of emergence and germination parameters has been referred to the invigorating effect of presoaking. The low water potential of the mannitol osmo priming treatment allows partial seed hydration so that pre-germination metabolic processes begin but germination is inhibited (Bennett *et al.,* 1992; McDonald, 2000; Pill and Necker, 2001). When the primed seed are planted in the field, they usually exhibit rapid and uniform germination. Mannitol osmopriming not only improves seed germination but also enhances general crop performance under non saline or saline conditions. This osmopriming operation all solutions aerated with aquarium pump and improved germination and seedling vigor than that control and other treatments. Numerous biochemical changes have been reported in mannitol osmo-primed seeds of different plant species. In tomato, for instance, a space is developed in the primed seed that facilitates water uptake, thereby accelerating the speed of germination (Argerich, 1989). Also, during priming, the embryo expands considerably and compresses the endosperm, deforming the tissues that have lost flexibility due to dehydration (Liptay and Zariffa, 1993). It has been proposed that mannitol priming causes considerable invigoration of the dry seed (Heydecker and Coolbear, 1978). The mannitol osmo priming also has been shown to induce nuclear DNA synthesis in the radical tip cells in tomato (Liu *et al.,* 1997) and several other plant species, including maize (*Zea mays L.*) (Garcia *et al.,* 1995). Osmopriming has been shown to activate processes related to cell cycle. In wild rye (*Leymus chinensis*) seeds, for example, priming with 5% mannital for 12 h resulted in increase in the activity of superoxide dismutase (SOD) and peroxidase (POD) and a rapid increase in the respiratory intensity, which were associated with an increase in germination vigor (Jie *et al.,* 2002). Osmopriming may also contribute to rapid seed germination by reducing the mechanical restraint of endosperm on developing embryo (Mayer and Mayber, 1989). It was determined that mannitol osmotic priming of tomato seed increased the endo-beta mannanase activity in the endosperm cap and decreased its mechanical restraint on the germinating embryo (Toorop *et al.,* 1998). A strong correlation was observed between lowering of the mechanical restraint and the activity of endo-beta-mannanase.

The mannitol primed seeds significantly showed the increased emergence percentage, rate of emergence, root length and seed vigor in all amaranth cultivars. Trigin cultivar showed the best performance among cultivars. Total seed protein, POD and PPO were also increased significantly by seed priming. Almont and Plainsman cultivars exhibited high protein content and POD activity. PPO activity increased by seed priming comparing to controls for Amont, Plainsman and Mercado cultivars, but for Trigin cultivar, no increase was detected. The highest increase in PPO activity was observed in Mercado cultivar (Moosavi *et al.,* 2009). Research on mannitol osmo priming has proved that crop seeds primed with water germinated early, root and shoot development started rapidly, grew more vigorously and seedling length was also significantly greater than non- primed seeds. It could also improve the performance of crop by alleviating the effect of salts under saline soil conditions (Mohammadi *et al.,* 2008). Enzymes such as amylases, proteases, and in some cases, lipases, play vital roles in the early growth and development of embryo. Any increase in the activity of these enzymes may result in early vigorous growth and good crop establishment. It has been demonstrated that osmopriming affects the activity of these enzymes in the germinating seed of different plant species. For example, in muskmelon (*Cucumis melo*), seed osmo conditioned with mannitol @ 5 % showed enhanced activity of dehydrogenase and amylase and improved germination under non- saline conditions (Srinivasan *et al.,* 1999). In oilseed crops, the glyoxylate pathway, which converts lipids into sugars, plays an important role in the early development of embryo (Taiz and Zeiger, 2002). This Osmo conditioning also enhanced the activity of ATPase in the germinating seed of peanut primed with PEG. Furthermore, acid phosphatase and RNA syntheses were significantly higher in embryonic

axes and cotyledons of osmo-conditioned seed compared to control seed. Thus, mannitol osmopriming may contribute to improved germination rate in part by increasing various enzyme activities. Osmopriming has been shown to activate processes related to cell cycle. In wild rye (*Leymus chinensis*) seed, priming with 30% PEG and 3% mannital for 24 h resulted in increase in the activity of superoxide dismutase (SOD) and peroxidase (POD) and a rapid increase in the respiratory intensity, which were associated with an increase in germination vigor (Jie *et al*., 2002). This finding was in agreement with the similar findings by Sunil kumar *et al.,* (2016) in Mungbean and Lamichaney *et al.,* (2018) in Chick pea. Hence, the study revealed that effect of osmo priming seed treatments on seed quality in certain minor millets, the varagu cv CO 3 and kuthiraivali cv CO 1 seeds osmo primed with Mannitol 1% for 6 h and Tenai cv. CO 6, Samai cv. CO 3 and Panivaragu cv. CO 4 seeds osmo primed with Mannitol 2 % for 6 h recorded higher seed qualities i.e., higher speed of emergence, germination percentage, seedling length, dry matter production and vigour index in drought condition, when compared to other treatments.

Table 1 : Effect of Various Osmo Priming treatments on Seed Quality in Tenai cv. CO 6

Treatments	Imbibition rate (%)	Speed of emergence	Germination (%)	Seedling length (cm)	Dry matter production 10 seedlings^{-1} (mg)	Vigour index
T_0 –Control (Unprimed)	-	28.4	74 (60.66)	15.1	16.2	1117
T_1- Water (hydro priming)	21	32.8	84 (69.73)	15.7	18.1	1319
T_2- Nacl @ 1 %	17	32.4	78 (62.02)	16.3	18.7	1271
T_3- Nacl @ 2 %	17	26.4	80 (63.43)	16.0	19.3	1280
T_4-Mannitol @ 1 %	18	33.2	86 (63.43)	16.8	19.2	1445
T_5 Mannitol @ 2 %	19	36.2	89 (6.02)	17.5	19.9	1558
T_6- PEG @- 5 bar	17	25.2	82 (64.89)	15.9	18.4	1304
T_7 - PEG @ -10 bar	16	29.4	82 (62.02)	16.4	18.9	1345
Mean	18	30.5	82 (64.15)	16.2	18.4	1330
SEd	0.08	0.14	(0.30)	0.08	0.08	6.26
CD(P=0.05)	0.17	0.28	(0.60)	0.16	0.16	12.59

(Figures in the parenthesis are Arcsine transformed value)

Table 2 : Effect of Various Osmo Priming treatments on Seed Quality in Tenai cv. CO 3

Treatments	Imbibition rate (%)	Speed of emergence	Germination (%)	Seedling length (cm)	Dry matter production 10 seedlings^{-1} (mg)	Vigour index
T_0 –Control (Unprimed)	-	46.4	78 (62.02)	16.8	38.2	1310
T_1- Water (hydro priming)	12	58.6	88 (73.57)	17.1	40.2	1505
T_2- Nacl @ 1 %	16	58.8	80 (63.43)	17.4	39.6	1392
T_3- Nacl @ 2 %	18	57.6	80 (63.43)	17.6	41.8	1408
T_4-Mannitol @ 1 %	21	69.3	94 (75.82)	19.1	46.6	1795
T_5 Mannitol @ 2 %	19	63.6	89 (71.56)	17.5	40.9	1558
T_6- PEG @- 5 bar	16	52.0	86 (66.42)	18.0	43.5	1548
T_7 - PEG @ -10 bar	18	62.0	80 (63.43)	17.9	44.1	1432
Mean	17	58.5	84 (67.21)	17.7	41.9	1491
SEd	0.09	0.30	(0.29)	0.09	0.22	5.98
CD(P=0.05)	0.19	0.61	(0.57)	0.18	0.45	12.02

(Figures in the parenthesis are Arcsine transformed value)

Table 3 : Effect of Various Osmo Priming treatments on Seed Quality in Kuthiraivali cv. CO 1

Treatments	Imbibition rate (%)	Speed of emergence	Germination (%)	Seedling length (cm)	Dry matter production 10 seedlings^{-1} (mg)	Vigour index
T_0 –Control (Unprimed)	-	65.2	78 (62.02)	20.6	19.4	1607
T_1- Water (hydro priming)	26	76.1	84 (68.02)	21.3	22.8	1789
T_2- NaCl @ 1 %	18	68.9	86 (68.02)	21.2	21.9	1823
T_3- NaCl @ 2 %	17	63.8	82 (64.89)	20.8	23.4	1706
T_4-Mannitol @ 1 %	20	75.9	93 (73.57)	22.6	24.6	2102
T_5 Mannitol @ 2 %	19	68.2	88 (69.73)	21.7	22.7	1910
T_6- PEG @- 5 bar	14	59.0	86 (68.02)	20.9	22.1	1797
T_7 - PEG @ -10 bar	10	57.8	83 (64.89)	21.9	22.8	1818
Mean	18	66.9	85 (67.21)	21.4	22.5	1819
SEd	0.11	0.31	(0.36)	0.10	0.09	8.19
CD(P=0.05)	0.22	0.63	(0.73)	0.19	0.19	16.48

(Figures in the parenthesis are Arcsine transformed value)

Table 4 : Effect of Various Osmo Priming treatments on Seed Quality in Samai cv. CO 3

Treatments	Imbibition rate (%)	Speed of emergence	Germination (%)	Seedling length (cm)	Dry matter production 10 seedlings^{-1} (mg)	Vigour index
T_0 –Control (Unprimed)	-	55.2	76 (60.66)	12.9	15.5	980
T_1- Water (hydro priming)	18	76.3	84 (66.42)	14.6	17.4	1226
T_2- NaCl @ 1 %	19	74.3	83 (68.02)	14.5	17.8	1204
T_3- NaCl @ 2 %	17	75.7	82 (68.02)	14.1	19.1	1156
T_4-Mannitol @ 1 %	17	80.4	86 (68.02)	14.6	18.4	1256
T_5 Mannitol @ 2 %	19	82.9	89 (69.73)	15.1	19.8	1344
T_6- PEG @- 5 bar	12	76.7	85 (64.89)	14.3	17.9	1216
T_7 - PEG @ -10 bar	12	74.6	83 (66.42)	14.4	16.9	1195
Mean	17	74.0	84 (66.42)	14.3	17.7	1201
SEd	0.09	0.39	(0.29)	0.06	0.07	4.04
CD(P=0.05)	0.19	0.78	(0.59)	0.13	0.14	8013

(Figures in the parenthesis are Arcsine transformed value)

Table 5 : Effect of Various Osmo Priming treatments on Seed Quality in Panivaragu cv. CO 4

Treatments	Imbibition rate (%)	Speed of emergence	Germination (%)	Seedling length (cm)	Dry matter production 10 seedlings^{-1} (mg)	Vigour index
T_0 –Control (Unprimed)	-	46.4	80 (63.43)	20.4	35.9	1632
T_1- Water (hydro priming)	19	50.6	92 (73.57)	22.3	38.7	2052
T_2- NaCl @ 1 %	13	48.0	92 (73.57)	21.7	37.7	1996
T_3- NaCl @ 2 %	16	42.8	94 (78.46)	22.1	38.3	2077
T_4-Mannitol @ 1 %	16	50.0	91 (73.57)	21.9	36.3	1993
T_5 Mannitol @ 2 %	17	50.8	96 (78.46)	23.5	41.7	2256
T_6- PEG @- 5 bar	10	46.8	94 (81.87)	22.4	39.4	2106
T_7 - PEG @ -10 bar	9	46.8	92 (73.57)	22.9	38.5	2107
Mean	14	47.7	91 (73.57)	22.2	38.3	2027
SEd	0.07	0.27	(0.39)	0.11	0.19	10.56
CD(P=0.05)	NS	0.55	(0.79)	0.22	0.39	21.23

(Figures in the parenthesis are Arcsine transformed value)

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