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Effect of Priming on Seed Quality Parameters and Yield of Sorghum (*Sorghum bicolor* (L.) Moench)

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ABSTRACT: Physical constraints in sorghum cultivation are frequently beyond the control of resource-poor farmers in rainfed farming systems. Seed priming (soaking seed in water) on the farm has been proposed as a solution to this problem. A number of crops' seeds have benefited from presoaking or priming in terms of better germination, seedling establishment, and in some cases, stimulation of vegetative growth and therefore crop production. The field and lab experiments were conducted at Seed Research and Technology Centre, Hyderabad, to study the effects of priming with distilled water (H_2O), Potassium dihydrogen phosphate (KH_2PO_4) Potassium Nitrate (KNO_3), potassium chloride (KCl), sodium chloride (NaCl), and Pseudomonas fluorescens on plant stand and yield. In lab studies germination rate, speed of germination, shoot length, root length, seedling fresh weight, seedling dry weight, seed vigor index I and seed vigor index II were measured, while in field studies yield and yield parameters were recorded. Different priming treatments alleviated to varying degrees of germination enhancement and KNO_3 was the most effective treatment followed by KH_2PO_4 in both lab and field studies. It was determined from the findings that fresh seed lot of CSV 29 variety with priming treatment of hydration with KNO_3@2% for 6 h proved better on the majority of seed quality and seed yield parameters. Crop seeds can germinate healthily by using the right priming agents and techniques in future research and applications even under adverse soil and weather situations.

Keywords: Sorghum, seed priming, seed quality parameters and seed yield.

INTRODUCTION

Sorghum (*Sorghum bicolor* (L.) Moench) belongs to family *poaceae*, after wheat, rice, corn, and barley it is the fifth most significant cereal crop in the world. One of the main issues farmers who grow sorghum describe is poor crop stand establishment (Moradi *et al*., 2009). It may be caused by both biotic and abiotic causes. Abiotic influences includes poor seed quality, poorly prepared seedbed, unusual rainfall patterns, etc. Due to these abiotic restrictions, resource poor farmers cultivating in marginal conditions suffer more than other farmers (Bradford *et al*., 1990). Farmers who have limited resources and use the rainfed farming technique frequently have no control over the improvement of the physical restrictions on sorghum cultivation. On-farm seed priming, which involves soaking seed in water, has been proposed as a remedy for this issue. Ashraf and Foolad (2005) presented this low cost, low risk solution, and would be suitable for all farmers, regardless of their socioeconomic condition. Seeds that have been damaged by ageing or abiotic stress like salinity can be repaired by priming, improving germination performance (Jisha *et al*., 2012). Early seedling establishment and final yield are significantly influenced by healthy seed germination. The two main techniques for improving sorghum seed germination at the moment are seed coating and seed priming. Priming seeds is one of the most popular strategies and is primarily utilised by farmers (Chivasa *et al*., 2000). This pre-sowing procedure enables seeds to become partially hydrated without fully protruding radicles. Imbibition and activation, the first two steps of seed germination, are typically involved in seed priming, which ultimately results in a better seed germination rate and enhances germination uniformity (Bordolui *et al*., 2018). Under both favourable and unfavourable conditions, seed priming technology is employed to increase germination; however, its benefits may be more pronounced in the latter case (Hussain *et al.*, 2015).

Hydropriming, Halopriming, osmopriming, biopriming and thermopriming are the priming methods in use in different crops (Chakraborty and Bordolui 2021). Hydropriming involves soaking seeds in water, which helps to some extent with seed germination. Many studies have reported that hydropriming is effective in promoting seed germination even under salt stress (Haghighat *et al.,* 2014). In organic salts such as potassium, sodium, and calcium are used for halopriming through treatment with NaCl, KCl, KNO_3, $CaCl_2$, $CaSO_4$, etc. (Farooq *et al.,* 2017). Ions like KH_2PO_4 (osmopriming) and biopriming (*Trichoderma harzianum* Rifai., *Trichoderma viride* Pers., *Pseudomonas fluorescens* Migula., *Bacillus subtilis* Cohn along with priming agent like vermiculite.) are also used in many crops (Ankit *et al.,* 2017). Numerous studies have noted that these substances, which are accessible and reasonably priced, can enhance seed germination. Despite numerous reports of the positive benefits of various seed priming techniques, only a small number of researchers have looked at whether the aforementioned substances enhance sorghum seed germination. Hence the present study is taken up to (i) To assess the seed priming effects on grain yield and (ii) To study the impact of priming on seed quality parameters.

MATERIALS AND METHODS

The experiment was conducted in both lab and under field conditions during fall seasons of 2018, 2019, and 2020 at Seed Research and Technology Centre of Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad.

Plant Materials. Seeds of sorghum cultivar CSV 29 were obtained from the IIMR, Hyderabad. The germination rate of these seeds is above 95% under favourable conditions.

Priming Methods. Hydro priming: Priming with distilled water.

Halo priming: Soaking of seeds in a solution of inorganic salts *i.e*. NaCl, KCl, KNO_3

Osmo priming: Soaking of seeds in a solution of ions *i.e.* KH_2PO_4

Bio priming: Inoculation with *pseudomonas fluorescens*

Treatment and Experimental design. The experiment was conducted with six treatments tested with one control. The lab and field experiments were conducted in a completely randomized block design with four replications.

Seed priming (6 hrs.) with the following treatments

T_0– Control, T_1– Nacl (2%), T_2 –KH_2PO_4 (2%), T_3 – KNO_3(2%)

T_4– KCl (2%), T_5 – Pseudomonas (5%) and T_6 – Hydro priming with distilled water

Experimental procedures

Priming of seeds. A 1.5% NaOCl solution was used to surface sterilize uniform sorghum seeds for 3 minutes. The seeds were then surface dried after being washed five times with distilled water. First, seeds with no priming were used to determine the sorghum seed germination. For the preparation of primed solutions measured quantity of each chemical was taken in a beaker. Separate amounts of each chemical were introduced while swirling continuously to 1000 ml of distilled water. The final composition of the solution will be a stock solution of each chemical in one liter (1000 ppm). To prevent contamination, muslin material was placed over the flasks containing the chemicals. For the preparation of Potassium chloride (KCl-2.0%) solution 20 g KCL was taken in a measuring flask and made up to 1000 ml. distilled water, while for (2.0%) Sodium chloride (NaCl) solution 20 g NaCl salt was taken in a measuring flask and made up to 1000 ml with distilled water and Potassium di-hydrogen phosphate (KH_2PO_4) solution 20 g was taken in a measuring flask and made up to 1000 ml with distilled. PNext, sterilized seeds were primed with HP, sodium chloride solutions (NaCl), potassium chloride solutions (KCl), potassium nitrate solutions (KNO_3), and Potassium dihydrogen phosphate (KH_2PO_4) for 6 h at 25°C in the dark. 1:5 (w/v) was the seed to solution ratio for the seeds to be primed, and the seeds were air dried to their original moisture content (13%, w/w) after priming; while unprimed seeds were used as check treatment for comparison.

For inoculation with *Pseudomonas,* in the current study, 100 grams of sorghum seeds received a biocontrol agent treatment. Seeds were pre-soaked in sterile distilled water before being coated with 5% concentration bio control agent powder formulations and moist vermiculite in a 2:1 ratio (2 parts vermiculite to 1 part seed). The coating was then well blended to ensure a consistent finish. These seeds were dried in the shade and kept in plastic bags at 25°C for 24 hours. Using the paper towel method, the germination of the treated seeds was examined in 4 replications, each with 100 seeds. The experiment was conducted using a completely randomized design. Each treatment was made in to 2 seed sets one for lab evaluation and another for field evaluation. Each treatment was reproduced four times with 100 seeds for lab evaluation, and the experiment was set up with a fully randomized design to track seedling quality indicators.

Statistical Analysis. The observation on the characters *viz*., Germination percent (ISTA 2016), Speed of germination, Shoot length (cm), Root length (cm), Seedling length (cm), seedling Fresh weight (g), seedling dry weight (g), Seedling vigour index I, Vigor index II (Abdul-Baki and Anderson 1973) recorded were subjected to statistical analysis for calculating analysis of variance, range, mean, critical difference and coefficient of variation (Fisher, 1996).

RESULTS AND DISCUSSION

Laboratory studies. The findings showed that treatments had an impact on all attributes examined and that there was a highly significant difference between the control (non-primed seeds) and the primed seeds (Table 1). The values of seed germination traits were significantly lower in the control than in the KCL, KNO_3, KH_2PO_4 and Pseudomonas treatment. All seedling characteristics, including germination percentage, speed of germination, root length, shoot length, seedling length, fresh weight, dry weight, and seedling vigour index I and II, were significantly impacted by KNO_3 2.0% concentration. Treatment T_3 KNO_3 2.0% revealed a significantly greater germination percent (97.61), followed by T_2 (94.25) primed with KH_2PO_4 2.0%. T_0 reported a minimum germination percentage of 88.33 with the unprimed control (Table 2).

The highest values for germination percentage (97.61%), speed of germination (35.24), shoot length (16.27), root length (12.63), seedling-length (SL) (28.9), seedling-dry-weight (SDW) (0.21), seedling-vigor-index-1 (SVI-1) (2820.99) and seedling-vigor-index-2 (SVI-2) (20.50) were recorded in response to seed priming using KNO_3 followed by priming with KH_2PO_4 for 6 h priming over the unprimed seeds (control treatment). These results were strengthened by similar findings of Ray *et al.* (2022 a, b)

The next best priming method for sorghum seed vigour augmentation was discovered to be osmopriming with KH_2PO_4, which enhanced all the traits compared to control and other treatments (Chauhan *et al.,* 2016). With the exception of NaCl treatment, other priming treatments were found to be superior to those of untreated seeds and produced better results for the majority of the traits. Similar results were also observed by Nisha *et al.* (2021) suggest that seed priming with various potassium sources can improve the quality and establishment of seedlings in sorghum genotypes.

Although the effects of the various priming agents varied in this investigation, all of them in some way encouraged the germination of sorghum seeds. According to Anisa *et al.* (2017), seed priming with KNO_3, KCl, and KH_2PO_4 increased maize shoot fresh weight and dry weight. In order to improve germination and normal seedling growth of sorghum under salt stress, seed priming with distilled water raised the germination index, root and shoot length, and dry weight (Haghighat *et al*., 2014). In accordance with the findings of this study, these results demonstrate that a variety of chemicals can be utilised as seed priming agents and can improve seed germination as suggested by Shantharaja and Devaraju (2021).

Field studies. The trail was laid out in randomized block design with four replications. Recommended package of practices and need based plant protection measures were taken up. Observations were recorded on Days to 50% flowering , Plant height (cm), Days to maturity, Panicle weight (g), Test wt. (g), Grain yield / plant (g), Grain yield / ha (kg).

During the 3 years under study the treatments differed significantly for all the characters studied except for 1000 seed weight (Table 3). The treatments imposed showed significance for all the characters studied. The study reveals that the treatment with KNO_3 recorded highest grain yield/plant (134.6) followed by KH_2PO_4 (126.3g), hydropriming (106.1g), and control (77.7g). The findings of this study suggest that priming with KNO_3 and KH_2PO_4 could enhance every aspect of sorghum seedling emergence and growth. Under less-than-ideal soil moisture circumstances, the danger of a poor stand establishment can be reduced by using pre-germinated seeds and seed priming. The easy, affordable, and practical practise of priming seeds can hasten flowering by roughly 5-7 days and improve plant stability (Anish and Bordolui 2022).

Priming is the method used to improve stand establishment in several crops. On farm seed priming significantly improved the yield of sorghum and also priming helped to decrease dry spell, pest and disease effect on crop (Li *et al*., 2011). Shehzad *et al*. (2012) found that halopriming with $CaCl_2$ and KNO_3 could enhance some sorghum seedling development and emergence metrics, while Khan *et al.* (2014) has opined differently. Many crops, including maize, wheat, rice, and canola, can benefit from seed priming treatment because it promotes greater germination and establishment (Chivasa *et al*., 2000). According to Nisha *et al*. (2021), the optimal morphological growth parameters for sorghum are produced at an optimum concentration of 80 μM $NH_4C_2H_3O_2$ salt.

It is clear that priming seeds of various crops can reduce the negative impact on germination and seedling establishment and, in certain situations, can increase crop production. Presoaking seeds hydrates proteins and membranes and kickstarts a number of metabolic processes. These are halted by drying the seeds or removing the moisture, but they resume when the seeds take in water a second time. Presowing treatments trigger the start of the early metabolic processes, and redying seeds stops but does not reverse the early phases of germination, reducing the time it takes for seeds to germinate if favourable conditions are present (Pratik *et al.,* 2022).

One of the most popular potassium source for agricultural crops is potassium chloride, and Cl is regarded as a crucial micronutrient for optimum growth (Ankit *et al*., 2017). For the purpose of promoting *Poaceae* plant germination, emergence, and growth, potassium chloride has been used as the osmoticum (Wondimu *et al*., 2018). In wheat, seed priming with nitrate solutions improved the quality of the seeds and field establishment (Farooq *et al*., 2017). Potassium permanganate has oxidising capabilities and can be used as an antibacterial or an ethylene neutralizer. It assisted certain bean seeds that had been stored for 20 to 44 years in sprouting (Nidhi *et al.,* 2018). It was discovered that on-farm seed priming with KH_2PO_4 increased yield and profit for many crops produced on P deficient soils while also improving fertiliser use efficiency (Anisha *et al*., 2017).

Pseudomonas fluorescens treatment improved germination, seedling vigour, plant height, leaf area, capacity for tillering, test weight (measured for 1000 seeds), and yield. Five days were reduced to the amount of time needed for blossoming (Jacob *et al.,* 2021). Under real-world circumstances, the isolates also successfully produced resistances against the downy mildew illness. Bacterial inoculants can improve seedling emergence, boost germination rates, and shield plants against disease (Ankit *et al.,* 2017). Ghobadi *et al.* (2012) reported that PGPR inoculation of wheat seed improved the germination and growth of the seedlings. Our research showed that seed treatment with *Pf* enhanced seed germination and seedling vigour compared to the control (Warren and Bennet 1999). These results might result from increased hormone production, such as that of auxins and gibberellins (Rajjou *et al.,* 2012). There is a growing demand for disease management strategies that are ecologically sound as agricultural operations become more sustainable. *Pseudomonas* found in soil have a number of promising traits that make them more effective biocontrol agents (Jyothi *et al.,* 2021). Even though this study is just a beginning, it advances our knowledge of and ability to use *P. fluorescens* as a biofertilizer and biocontrol agent, ultimately enhancing the plant's vigour (Saiteja *et al.,* 2021).

Table 1: Analysis of variance for seedling characters in sorghum.

Characters	Mean square	
	Treatments (df=6)	Error (df=21)
Germination percentage	31.07*	9.03
Speed of germination	43.21**	2.67
Energy of emergence	201.33*	62.45
Root length	6.92**	0.68
Shoot length	11.51**	0.72
Seedling length	39.21**	0.59
Seedling fresh weight	0.01**	0.00
Seedling dry weight	0.00**	0.00
Seed vigour index I	416789.02**	9968.73
Seed vigour index II	39.85**	2.75

* Significant at 5%level of significance; ** Significant at 1%level of significance

Table 2: Effect of priming on seedling quality parameters of Sorghum (pooled analysis of 3 years).

Treatment	Germination	Speed of germination	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Seedling fresh weight (g)	Seedling dry weight (g)	Vigour index I	Vigour index II
T_0	88.33	24.00	10.01	9.25	19.26	0.85	0.11	1701.36	9.72
T_1	88.00	28.87	10.85	10.03	20.88	0.88	0.12	1837.44	10.56
T_2	94.25	32.06	14.54	11.99	26.53	0.95	0.18	2500.45	16.97
T_3	97.61	35.24	16.27	12.63	28.9	1.12	0.21	2820.99	20.50
T_4	92.07	30.37	13.71	11.20	24.91	0.94	0.19	2293.64	17.49
T_5	91.54	29.86	12.87	11.95	24.82	0.95	0.17	2272.23	15.56
T_6	91.02	29.50	12.88	11.00	23.88	0.89	0.18	2173.58	16.38
SE (d)	2.10	1.29	0.58	0.56	0.57	0.01	0.01	75.25	1.05
SEM	1.52	0.75	0.49	0.41	0.40	0.01	0.00	55.01	0.91
CD @ 5%	4.75	2.68	1.45	1.16	1.25	0.05	0.03	149.99	2.89

Table 3: Effect of priming on seed yield and its attributes of sorghum (pooled analysis of 3 years).

Treatment	Days to 50% flowering	Pl. height (cm)	Panicle weight (g)	Days to maturity	1000 seed wt. (g)	Grain yield/plant (g)	Total Grain yield (Kg/Ha)
T_0	76.5	183.63	82.7	121.0	33.08	77.7	1029.69
T_1	76.00	228.17	77.37	115.00	31.33	75.7	1006.76
T_2	71.00	231.10	80.03	115.00	34.75	126.3	1616.13
T_3	70.00	242.53	96.93	111.00	35.65	134.6	1747.87
T_4	73.00	237.77	84.43	116.00	33.90	112.8	1443.64
T_5	70.00	236.03	91.53	118.00	35.53	111.4	1578.29
T_6	73.00	240.97	89.97	115.00	34.10	106.1	1372.46
CD	2.83	11.01	5.12	2.54	NS	9.10	102.8
CV	1.41	2.51	3.69	1.82	4.30	6.79	11.64

CONCLUSION

- Halopriming was an inherent part of treating seeds with 2% KNO_3 for six hours, and it greatly influenced the seed emergence and ultimately yield improvement.
- Seed priming, with its ease of use and lack of need for expensive machinery and chemicals, can be utilized as an easy way to deal with issues relating to subpar seed germination and seedling establishment, which supports in sustaining agriculture.
- It's important to note that the scope of our research was restricted to a particular grown sorghum type. It will be beneficial to test various varieties under both field and glasshouse trials for this work, keeping in mind that various sorghum types may respond differently to these treatments.

FUTURE SCOPE

- Choosing the right priming chemicals and techniques for next studies and applications helps guarantee that agricultural seeds germinate healthily even in adverse situations.
- Uncertainty surrounds the ways by which seed priming affects how germination and seedling growth occur. Therefore, before using the strategy in the field, more research at the physiological, biochemical and molecular levels is still needed to understand how priming affects sorghum seeds.

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Conflict of Interests. None.

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