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Improving field emergence performance of soybean by sand matrix priming

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ABSTRACT

This study was carried out to improve the field emergence of soybeans using sand as a priming solid matrix. The experimental design was a Randomized complete block design (RCBD) with three replications where plant and row spacing was 5 cm × 5 cm and soybean seed was sown in 5 cm depth in the soil during 2020-21 and 2021-22 in the field of Oilseed Research Center and the laboratory of Seed Technology Division, Bangladesh Agricultural Research Institute (BARI). The ratio of water:seed:sand was 1:2:2 on a volume basis. Seeds were indiscriminately strung in the dank sand after incubated at 25ºC for 24 hr, 48 hr, 72 hr and 96 hr in darkness. Results revealed that sand matrix priming methods and duration raised the emergence performance of leaf area, number of leaves, shoot length, root length, dry matter, etc. Sand matrix priming for 24 hours plays an important role in improving the emergence and yield of soybeans. The relative possibility of emergence and yield was increased by 123% and 112%, respectively, in 2020-21 and 120% and 118%, respectively in 2021-22. Therefore, sand matrix priming is simple, low cost and environmentally friendly, which might promote respiratory metabolism and endogenous hormones, which would conjointly promote the emergence performance of soybeans.

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I. Introduction

Soybean (*Glycine max* L.) is an important legume seed that contributes to 25% of the global edible oil, where 2/3 of the world's livestock feeds as protein concentrate. It has been recorded that the plantation and use of soybeans could be marked back to the beginning of China's agricultural age, where medical composition, dating back 6000 years, mentions its utilization for human consumption (Krishnamurthy and Shivashankar, 1975). Priming of seed has been successfully demonstrated to improve germination and emergence in seeds of many crops (Dell'Aquila and Taranto. 1986; Donaldson, 1996). Giri et al. (2003) stated that the seed priming technique is a technique that is applied before germination in a specific environment and is partially hydrated to a point where germination processes begin, but radical emergence does not occur (Kaur et al., 2002). Talebian et al. (2008) reported that seed priming techniques improved germination speed, germination vigour, seedling establishment and yield. Several investigations showed that seed priming increases the yield of corn (*Zea mays* L.) (Subedi and Ma, 2005), canola (*Brassica napus* L.) (Farhoudi and Sharifzadeh, 2006), rice (*Oryza sativa* L.) (Harris et al., 2005).

Sand matrix priming (SMP) is a technique of pre-sowing controlled seed hydration treatment where seeds are incorporated with the sand carrier with low matric potential that allows them to assimilate water and go through the first stage of origination but not allow radical protrusion through the seed coat. After sand matrix priming, the seeds are exsiccated to enable normal handling, storage and sowing (Mehta et al., 2013). The first processes engaged in sand matrix priming are the early beginning of RNA, protein synthesis and polyribosome formation. The functions of many enzymes engaged in mobilizing storage reserves are triggered. During sand matrix priming, the volume of water of the seed increases by 35 to 40 percent of its weight, which is enough to activate the biochemical events and advance seed germination processes without radical emergence.

Furthermore, the products of these changes push the following desiccation, which is available on re-imbibration of water during seed sowing, enabling the completion of seed germination rapidly, which helped to a uniform crop stand and synchronized flowering/fruiting. Moreover, sand matrix priming enhanced metabolic repair processes in deteriorated seeds under invigoration that occur before the beginning of the seed germination process (Varier et al., 2010). Sand matrix is a pre-sowing treatment that allows physiological conditions that make it more useful for the seed to germinate. SMP also implies a simple procedure that hydrates seeds partially in a controlled environment followed by seed drying so that processes of germination start without a radical appearance (Paparella et al., 2015). This simple pre-sowing process can enhance the emergence of radicle, pace of germination, seedling vigour and uniform establishment by changing various physiological and metabolic activities (Eisvand et al., 2011). During priming, de novo synthesis of amylase is documented (Lee and Kim, 2000), which has been correlated with higher seed vigour (Basra et al., 2006). For this study, the priming technique and priming duration for a specific crop is an area worth exploring to develop crop establishment and productivity in a wide range of environmental conditions and undertaken to study the effect of sand matrix priming on the germination, growth and yield of soybeans.

II. Materials and Methods

Seed materials

Seed material (BARI Soybean-6) was collected from the Oilseed Research Center (ORC), Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. For priming sand material was used. Fresh sand passing through a sieve with a mesh size of 0.8 mm was sterilized at 180^{0}C for 1 hr. After that, the sand was cooled and sterile water was added to make the ratio of water: seed: sand 1:2:2 on a volume basis. Seeds were uniformly embedded in the wet sand and incubated at 25^{0}C for 24h, 48h, 72h and 96h in darkness. The ratio of water volume, seed volume and sand volume were determined by trial and error method. Then, the seeds were cleaned and air-dried at room temperature at 25^{0}C for 4 hr.

Field emergence test

The field emergence test was guided using a randomized complete block design with three replications and 100 seeds for each treatment. The plant and row spacing was 5 cm × 5 cm. Seeds were sown in soil 5 cm deep when the average temperature was 22.5^{0}C and the average relative water content was 72% at the sowing season (January) in 2021 and 2022. The number of seedlings that emerged was higher than 2 cm, recorded every day until no further emergence 21 days after sowing.

Seedling characteristics, yield attributes and yield

The data were collected based on seedling height, number of leaves and leaf area, measured 21^{st} days after sowing. The recorded data on days to 50 percent emergence, total emergence (%), plant height

21st at days after sowing (cm), days to 1st female flower appearance, node at which 1st female flower appeared (number), days to 1st picking, harvest duration (days), fruit length (cm), fruit weight (g), number of fruits per plant, pod per plant, seeds per plant and hundred seed weight (g), fruit yield/plant (kg), fruit yield/plot (kg) and fruit yield/hectare (kg) which were taken on five randomly selected plants from each replication.

Data analysis
The recorded data were organized for analysis of variance (ANOVA) using STAT-10 software. The least significant difference (LSD) was used to separate and compare treatment means at a 5% probability level. Correlation analysis was computed to generate information about the association of yield and other parameters.

III. Results and Discussion

The highest field emergence (93% and 85%) was recorded in T_1 (24h) treatment in both 2021 and 2022, respectively, which were statistically identical to T_2 (48 hr) treatment. The lowest emergence (67% and 21%) was recorded in T_4 (96 hr) treatment, it might be due to the sprouting of seeds during the period of priming. The highest leaf area (31.66 and 30.79) and the number of leaves (24 and 23) were recorded in T_1 (24 hr) treatment and the lowest were in T_4 (96 hr) treatment. The highest shoot length (12.3 and 12.7) was recorded in T_3 (72 hr) treatment, root length (2.9 and 3.9) in T_1 treatment and dry matter (1.05 and 1.03) of seedlings was recorded in T_1 (24 hr) and T_4 treatment in 2021 and 2022 respectively. The highest relative possibility of emergence (123 and 115) was obtained from T_1 (24 hr) treatment and T_4 (96 hr) treatment showed a negative relative possibility (Table 01).

Table 1. Emergence and seedling characteristics

Treatment	Field emergence (%)			Rel. pos of field emergence			Leaf area (mm)			No. of leaves		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
T_0 Control (0 hr)	77	71	74	100	100	100	25.77	29.9	27.83	21	22	22
T_1 (24 hr)	93	85	89	123	120	121	31.66	30.79	31.22	24	23	24
T_2 (48 hr)	89	82	85.5	115	115	115	30.88	30.1	30.49	23	23	23
T_3 (72 hr)	82	66	74	116	93	104	27.44	29.3	28.37	23	22	23
T_4 (96 hr)	67	21	44	97	30	63	23.22	31.87	27.54	20	22	21
LSD (0.05)	5.02	6.97					0.292	NS		2.6	NS	
CV (%)	3.25	4.21					3.99			8.28		

(Rel. Pos.> Relative possibility)

Table 1. Continued...

Treatment	Shoot length (cm)			Root length (cm)			Dry matter (g)		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
T_0 Control (0 hr)	10.8	11.2	11.0	2.2	3.2	2.7	0.85	0.91	0.88
T_1 (24 hr)	11.9	11.8	11.85	2.9	3.7	3.3	1.05	0.98	1.15
T_2 (48 hr)	11.9	11.1	11.5	2.8	3.9	3.3	0.98	0.92	0.95
T_3 (72 hr)	12.3	12.3	12.3	2.5	3.1	2.8	0.99	0.96	0.97
T_4 (96 hr)	11.0	12.7	11.35	2.8	3.0	2.9	0.83	1.03	0.93
LSD (0.05)	0.9	1.1		NS	NS		0.2	0.34	
CV (%)	5.86	4.98		18.21			12.35	9.87	

(Rel. Pos.> Relative possibility)

Solid (sand) matrix priming along (Rush, 2008) or in combination with fungicides (Baird et al., 2010) or biological agents (Callan et al., 2005; Harman et al., 2012) helps to promote the rate and uniformity of emergence of soybean seeds. Copeland et al. (2010) stated that both laboratory and field performance were generally improved by seed treatment over untreated soybean seeds. Many endeavours have been made to relate standard germination to field emergence in several crops where a close association between two characters was reported in corn and soybean (Sherif, 1953). Seed priming increases germination rate, faster emergence and better stand establishment (Farooq et al., 2006). The present study revealed that the technology of sand priming can promote the field emergence performance of soybeans. Hu et al. (2005) stated that sand priming is a technique that helps improve germination percentage, germination index, seedling height, root length, number of roots, root dry weight and so on. From this study, the recorded data showed that the field emergence performance decreased with the increase of priming time (24 hr, 48 hr, 72 hr and 96 hr).

Priming had a significant effect recorded in all the field parameters under study except plant height and pod length (Table 02). Days to flowering and days to maturity ranged from 61-63 and 58-60 and 104-107 and 108-110, respectively, in 2021 and 2022. In the case of 24 hours, sand matrix priming of BARI Soybean-6 produced the highest number of pods per plant (66 and 65) and the lowest in 96 hours of priming (53 and 51), which led to an increase in total yield. 1000 seed weights (112.8 g and 104g) were also highest in 24 hours of seed priming. The maximum yield of BARI Soybean-6 was recorded in 24 hours of seed priming (1988 kg per ha and 1954 kg per ha) which is 12% 18% higher compared to the non-primed control (Table 02).

Sand matrix priming for 24 hr reduces 3 days to mature seeds without affecting 1000 seed weight and yield in both two tears. The number of internodes has a great influence on the end product. A higher number of internodes produces a higher number of pods and ultimately produces a higher yield. Primed seed's growth is faster than unprimed seeds. Arun et al. (2017) stated that priming helps to increase the growth and yield of summer cowpeas. Soybean seeds primed have hastened and synchronized the emergence and increased the yield (Arif et al., 2008).

Table 02. Mean field performance of yield contributing characters of soybean during Rabi, 2020-21 and 2021-22.

Treatment	Days to flowering			Days to maturity			Plant height (cm)			Pods/plant (no.)			Pod length (cm)		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
T_0 Control (0 hr)	63	60	62	106	110	108	43	46.8	44.5	59	61	60	3.7	3.9	3.8
T_1 (24 hr)	61	58	60	104	108	106	47	45.6	46.0	66	65	65	3.7	3.9	3.8
T_2 (48 hr)	61	59	60	105	109	107	46	46.6	46.0	57	58	57	3.7	3.8	3.7
T_3 (72 hr)	62	59	61	107	109	108	43	51.0	47.0	59	53	56	3.6	3.4	3.5
T_4 (96 hr)	63	60	62	107	110	109	42	43.4	42.5	53	51	52	3.7	3.2	3.4
LSD (0.05)	1.1	0.8		1.3	1.6		Ns	1.4		7.6	5.9		Ns	Ns	
CV (%)	0.9	3.7		0.7	0.60		6.5	12.69		6.9	9.83		5.2	7.04	

Table 2. Continued...

Treatment	1000 seed weight (g)			Yield (kg/ha)			Rel. Pos. of yield		
	2020-21	2021-22	Mean	2020-21	2021-22	Mean	2020-21	2021-22	Mean
T_0 Control (0 hr)	98.3	89	93.5	1770	1629	1700	100	100	100
T_1 (24 hr)	112.8	104	108	1988	1919	1954	112	118	115
T_2 (48 hr)	100.3	98	99	1942	1802	1872	110	111	111
T_3 (72 hr)	97.8	96	96.5	1656	1343	1500	94	82	88
T_4 (96 hr)	108.7	110	109	1642	1272	1457	93	78	85
LSD (0.05)	11.7	8.6		106.3	98.4				
CV (%)	6.1	3.9		4.2	7.8				

V. Conclusion

Sand matrix priming is an environmentally safe and effective technology that can easily be applied and adopted by farmers and boost crop performance under unfavourable conditions. Sand matrix priming is an inexpensive technique that can maximize the seed performance. Our results show that sand priming can promote seed germination and field emergence, where sand matrix priming for 24 hours showed higher field emergence performance (22% over control) of soybean as well as yield contributing characters like pods/plant, 1000 seed weight and seed yield (15% over control). Further, sand matrix priming is more effective and gaining importance due to the controlled release. So, it can be concluded that sand matrix priming is a technique for sustainable agriculture.

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