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Vermicompost Leach's Effect on Onion Seed Germination and Seedling Emergence in Response to Drought Stress

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A R T I C L E I N F O

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A B S T R A C T

The Seed Technology Division, BARI, Gazipur, Bangladesh carried out a lab experiment in 2020–2021 to find the best vermicompost treatment for enhancing seed germination and seedling emergence in an environment of drought stress. With 4 replications, the experiment used a 2-factorial completely randomized design. Five different amounts of priming were applied to onion seeds: hydropriming, 5% vermicompost priming (VCP), 10% VCP, 15% VCP, and untreated control. In addition, the onion seedlings were treated with 10% and 15% PEG, two different levels of drought stress. BARI Piaj-4 onion was the kind that was used. The findings demonstrated that, under drought-stressed situations, seed priming with vermicompost leach improved seed germination and seedling emergence percent. especially, the vermicompost leach at 10% under 10% PEG drought stress condition showed the best results in terms of promptness index (123), germination stress tolerance index (84.25%), seed germination (90%), seedling emergence percentage (81%), and seedling vigor index (614).

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Introduction

Crops nowadays face numerous biotic and abiotic challenges, with threats from adverse environmental conditions being the most significant (Jisha et al., 2012; Muhie, 2018). In many countries of the world including Bangladesh, abiotic stresses have a major negative impact on crop production (Joshi and Sawant, 2012). Seed germination and seedling stage are the most critical stages of crop that are influenced by environmental stress. Among the critical environmental factors, drought badly affect seed germination (Lianes et al., 2015, Thirusendura and Saraswathy, 2017). Environmental factors such as drought (Ahmad et al., 2015) and temperature stress have a significant impact on the growth and development of plants, resulting in harmful effects on yield and production (Prasad et al., 2008; Shao et al., 2009), which in turn threatens the survival of plants and ultimately affects yield (Masondo 2017, 2018). These stresses lead to various physiological, biochemical, and molecular changes and reactions that affect different cellular processes (Prasad et al., 2008). Drought affects the rate of transpiration, stomatal conductance, and relative water status of the leaf (Ullah et al., 2017). This poses a challenge to existing agronomic efforts aimed at addressing hunger, food insecurity, and malnutrition, particularly in countries where subsistence agriculture (Varshney et al., 2014) and commercial agriculture are the main means of livelihood. In agricultural terms, drought is defined as a physiological and edaphic condition that occurs when the available water for crops is insufficient for their transpiration requirements (Tuberosa 2012) and evaporation needs (IIyas et al., 2021). Additionally, excessive irrigation on the farm is considered uneconomical and unsustainable because it leads to wastage of water, energy, and labor. Risks associated with excessive irrigation include waterlogging and leaching of nutrients, resulting in low crop yield (Ahmad et al., 2015).

Unfavorable soil moisture during sowing often leads to poor seed germination, resulting in inconsistent seedling emergence. This, in turn, impacts stand establishment, leading to reduced yield (Mwale et al., 2003; Okcu et al., 2005). Seed priming is used as a good technique for improving seed germination and seedling performance under environmental stress condition (Joshi et al., 2012). In different vegetable crops, priming has been used successfully for improving seed quality (Ermis et al., 2016; Saranya et al., 2017). There are many priming agents used in improving seed germination, vermicompost is one of them. Vermicompost priming improved seed germination of *Brassica napus* seeds at salt stress conditions (Benazzouk et al., 2019). Onion (*Allium cepa* L.) is a spice crop and its seed lose viability and vigour at faster rates than seeds of most other crops, even at relatively optimum storage conditions (Ellis et al., 1996; Yapping et al., 2000) and germination of its seeds can be affected by extreme abiotic factors (Thirusendura and Saraswathy, 2017). Poor seed performance is one of the crucial factors that limit onion production and development. For enhancing seed germination and seedling emergence, vermicompost priming showed good result in onion (Muhie et al., 2020), in cucumbers (Edwards et al., 2006), marigolds (Shivsubramanian, 2004), lettuces, tomatoes and cucumbers (Edwards et al., 2006; Arancon et al., 2012), and beans and peas (Ievinsh et al., 2017). In Bangladesh there are 3.50 million hectares under drought condition and onion seed germination under drought stress is badly affected. Vermicompost priming can be a way of solving this problem. But literature about the influence of vermicompost priming enhancing seed germination and seedling emergence of onion under drought in Bangladesh is very sporadic. Therefore, the present study was undertaken to find out a suitable vermicompost leach treatment for better seed germination and seedling emergence under drought stress condition.

Materials and Methods

This laboratory experiment was conducted during 2020-2021 at Seed Technology Division, BARI, Gazipur, Bangladesh, to investigate the most effective vermicompost treatment on seed germination and seedling emergence under water deficit condition. The experiment was carried out in a 2-factorial completely randomized design. The drought stimulator used was polyethylene glycol with a molecular weight of 6000 (PEG-6000). Drought was applied on onion seeds variety BARI Piaj-4 with 10% and 15% PEG-6000 concentrations. A total of five priming levels were applied that included untreated control, 5% vermicompost priming (VCP), 10% VCP, 15% VCP and hydropriming. Onion seeds were subjected to drought stress, using vermicompost starter leach, following the protocols of Muhie et al., (2020).

Vermicompost priming (VCP) was done using a solid matrix priming method. Treatments were conducted by mixing onion seed: vermiculite No. 5: vermicompost leach (w:w:w) at 2:1:3, in plastic boxes. Boxes were kept at 15ºC for 2 days in the dark. The same ratio was used with distilled water in hydropriming (HP). Non-primed (NP) dry seeds were used as a control for primed treatments. Seeds were dried near to initial moisture content after VCP and HP treatments. Drought stress was stimulated using polyethylene glycol-6000 (PEG) at different concentrations (W: V) at par treatment. Onion seeds (four replicates of 50 seeds) were placed on filter paper in 90 mm-diameter Petri dishes containing 3 ml of PEG solution. The dishes were sealed with parafilm to prevent moisture loss. Germination was carried out at 20°C for 12 days according to ISTA (2017). Seeds were considered germinated when the radicle would emerge 2 mm.

The seedling emergence test was carried out in three replicates of 25 seeds each in plastic trays for 21 days. The appearance of the cotyledon above the coco dust was considered as the emergence criterion. Trays were kept at 20±2°C. Trays were watered with the appropriate solutions during the test. The Promptness index (PI) and germination stress tolerance index (GSI) were calculated using the following formulae given by Ashraf et al., (2006).

PI= nd2(1.00) + nd4 (0.75) + nd6 (0.50) + nd8 (0.25),

n= is the number of seeds emerged at day d.

GSI(%)=(PI of stressed seed/PI of control seeds) × 100.

For measuring those indices, a sole non treated control treatment i.e., non-drought and non-primed treatment was conducted excluding 10 priming and drought stress treatment combinations. The seedling vigor index (SVI) was calculated by multiplying the average seedling length (cm) by seedling emergence percent according to Abdul Baki and Anderson (1973). The germination rate index (GRI) was calculated using the formula given by Al-Mudaris (1998).

GRI = G1/1+G2/2+ …….+Gi/I,

G1= is the germination percentage at day 1,
G2= is the germination percentage at day 2, and so on.

Recorded data were analyzed statistically with the help of Statistics 10 software. Treatment means were compared following the Least Significant Difference (LSD) Test and t-test.

Results and Discussion

Effect of Priming

Priming showed significant differences in seed germination percentage, seedling emergence percentage, average seedling length, seedling vigor index, and germination rate index of onion seed irrespective of drought stress (Table 1). Vermicompost priming had a positive impact on seed germination and increased the germination percentage of onion seed over non-primed and hydroprimed seed. Maximum seed germination (78%) was observed in 10% vermicompost priming and it was statistically similar with 5% vermicompost priming (74% seed germination). Non-primed seed showed minimum germination percentage (63%) which was 19.23% less seed germination compared to Vermicompost priming at 10% whereas hydropriming noted 12.82% less seed germination from that treatment. There was an increment of seed germination of onion at 5% VCP and 10% VCP, after that seed germination was decreased. The researcher said that at lower concentrations of VCP, seed germination increased due to increasing enzyme activities, but later on decreased due to the adverse effect of higher salt accumulation. A similar trend was observed in the case of seedling emergence percentage, seedling length, seedling vigor index, and germination rate index. The highest seedling emergence percentage (71%) was noted in 10% VCP, and lowest (55%) in non-primed seed. Vermicompost priming at 10% improved by 29.09% seedling emergence over non primed seed, whereas hydropriming increased by 9.09% seedling emergence. Stimulatory effects of enhancing seed germination and seedling emergence have been mentioned in different crops such as cucumbers (Edwards et al., 2006), lettuces, tomatoes, and cucumbers (Edwards et al., 2006; Arancon et al., 2012, and beans and peas (Ievinsh et al., 2017). The positive effect of VCP enhancing germination and seedling emergence of onion seeds might be due to the high activity of enzymes (Arancon et al., 2012) in addition to the presence of an adequate concentration of macro-and micro-nutrients, growth-promoting hormones like auxin and gibberellins (Pant et al., 2009). The highest average seedling length (6.96 cm) was observed in 10% VCP treatment which was statistically at par with 15% VCP treatment (6.90 cm), but the lowest average seedling length (4.96 cm) was noted in nonprimed control treatment. Maximum seedling vigor index (497) was found in 10% VCP treatment and the minimum was in nonprimed control treatment (278). The highest germination rate index (19.28) was observed in 10% VCP treatment which was statistically at par with 5% VCP treatment (18.09), but the lowest GRI (14.96) was noted in nonprimed control treatment.

Effect of Drought Stress

Even with priming, all elements of onion seed germination and seedling growth were significantly impacted by dry stress in the experiment. The results indicated that at 10 PEG, drought stress increased seed germination (82%), seedling emergence (72%), average seedling length (6.80 cm), seedling vigor index (496), and germination rate index (20.07). On the other hand, when compared to 10% PEG, the usage of 15% PEG dramatically decreased the proportion of seeds that germinated, the emergence of seedlings, the average length of seedlings, the seedling vigor index, and others. Muscolo et al. (2014) also observed that decreased root length, seedling tissue water content, and seed germination % were caused by water stress. The investigation also revealed that the germination process's enzyme activity declined, especially that of α-amylase and α-glucosidase, which were most adversely impacted by osmotic stress.

Interaction Effect

The Interaction effect of priming and drought stress was found nonsignificant on seed germination percentage, seedling emergence percentage, and germination rate index of onion, but found significant on average seedling length and seedling vigor index (Table 3). Though insignificant, seeds of onion treated with 10% vermicompost priming along with 10% polyethylene glycol gave the highest seed germination percentage (90%) and it was statistically similar with 5% vermicompost priming with 10% polyethylene glycol (86% seed germination). So, there was a great scope for increasing seed germination percentage by using vermicompost leach under drought-stress conditions. Non-primed seeds of onion treated with 15% PEG showed the lowest seed germination percentage (52%) and it was 42.22% lower compared to 10% vermicompost priming along with 10% polyethylene glycol. The highest seedling emergence percentage (81%) was noted in 10% VCP treatment under 10% PEG condition, and non-primed seeds of onion treated with 15% PEG showed the lowest seedling emergence percentage (46%) which was 43.21% lower compared to 10% vermicompost priming along with 10% polyethylene glycol. The longest average seedling length (7.58 cm) was observed in 10% VCP treatment under 10% PEG condition, and it was statistically similar (7.48 cm) with 15% VCP treatment under 10% PEG condition, and non-primed seeds of onion treated with 15% PEG showed the shortest average seedling length (4.15 cm). Similarly, the highest seedling vigor index (614) was noted in 10% VCP treatment under 10% PEG condition.

Table 1. Effect of priming on seed germination, seedling emergence, seedling length, seedling vigor index and germination rate index of onion

Priming	Seed germination (%)	Seedling emergence (%)	Seedling length (cm)	SVI	GRI
Non Priming	63	55	4.96	278	14.96
5% VCP	74	65	6.38	417	18.09
10% VCP	78	71	6.96	497	19.28
15% VCP	70	64	6.90	445	17.16
Hydropriming	68	60	5.75	349	16.64
$LSD_{0.05}$	3.8	3.95	0.27	26.0	1.32
CV (%)	5.3	6.15	4.23	6.38	7.48

Where, VCP means vermicompost priming, SVI means seedling vigor index, GRI means germination rate index

Table 2. Effect of drought stress on seed germination, seedling emergence, seedling length, seedling vigor index and germination rate index of onion

Drought stress	Seed germination (%)	Seedling emergence (%)	Seedling length (cm)	SVI	GRI
10% PEG	82	72	6.80	496	20.07
15% PEG	59	53	5.59	298	14.38
t value	2.42	2.50	0.17	16.45	0.84
CV (%)	5.3	6.15	4.23	6.38	7.48

Where, PEG means polyethylene glycol 6000

Table 3. Interaction effect of priming and drought stress on seed germination, seedling emergence, seedling length, seedling vigor index and germination rate index of onion

Drought stress × Priming		Seed germination (%)	Seedling emergence (%)	Seedling length (cm)	SVI	GRI
10% PEG	Non Priming	74	63	5.58	366	18.05
	5% VCP	86	74	6.65	496	20.82
	10% VCP	90	81	7.58	614	22.84
	15% VCP	80	75	7.48	562	19.56
	Hydropriming	78	69	6.50	448	19.08
15% PEG	Non Priming	52	46	4.15	191	11.86
	5% VCP	62	56	6.10	342	15.36
	10% VCP	65	60	6.35	381	15.72
	15% VCP	60	52	6.33	329	14.76
	Hydropriming	58	50	5.00	250	14.21
$LSD_{0.05}$		NS	5.59	0.38	36.78	1.87
CV (%)		5.3	6.15	4.23	6.38	7.48

Where, VCP means vermicompost priming, and PEG means polyethylene glycol 6000

Table 4. Effect of priming and drought stress treatments on promptness index and germination stress tolerance index of onion seed

Drought stress × Priming		Promptness Index	Germination Stress Tolerance Index (%)	Changes in GSI over control (%)
10% PEG	Non Priming	106	72.60	-27.40
	5% VCP	121	82.88	-17.12
	10% VCP	123	84.25	-15.75
	15% VCP	118	80.82	-19.18
	Hydropriming	106	72.60	-27.40
15% PEG	Non Priming	69	47.26	-52.74
	5% VCP	91	62.33	-37.67
	10% VCP	93	63.70	-36.30
	15% VCP	97	66.44	-33.56
	Hydropriming	85	58.22	-41.78
Control		146	100.00	0.00
$LSD_{0.05}$		14.65		
CV (%)		9.70		

Non-primed seeds of onion treated with 15% PEG showed the lowest seedling vigor index (191) and it was 68.89% lower compared to 10% vermicompost priming along with 10% polyethylene glycol. The highest germination rate index (22.84) was noted in 10% VCP treatment under 10% PEG condition. Non-primed seeds of onion treated with 15% PEG showed the lowest germination rate index (11.86) which was 48.07% lower compared to 10% vermicompost priming along with 10% polyethylene glycol.

Effect of Stress Treatments on Germination Stress Tolerance Index

The promptness index of onion seeds was significantly influenced by priming and drought stress treatments, as shown in Table 4. The highest promptness index (146) was observed in the sole control treatment, which means there was no drought stress and no priming treatment. The promptness index decreased to 21.37% and 40.41% under 10% PEG and 15% PEG, respectively, compared to the sole control treatment. The lowest reduction of the promptness index (15.76%) was noted in the 10% VCP treatment under 10% PEG drought stress conditions. Similarly, the lowest reduction in the germination stress tolerance index (15.75%) was found in the 10% VCP treatment under 10% PEG drought stress conditions. The reduction in the germination stress tolerance index was lower in 10% PEG compared to 15% PEG, in primed seeds compared to non-primed seeds, and within the priming treatments, 10% VCP was lower compared to hydropriming.

The greater amount of nutrients in vermicompost (VC) may improve germination compared to seeds that are only hydroprimed. This was particularly observed during the seedling emergence test. According to Ievinsh et al., (2017), the beneficial properties of vermicompost are due to the mineral nutrient forms available to plants. Vermicompost contains organic acids such as humic and fluvic acids (Shivsubramanian, 2004). Humic substances from vermicompost have hormone effects on plants (Arancon et al., 2012; Rajashekhar et al., 2017). The improvement obtained from the vermicompost-based primer (VCP) was greater for seed germination (%), seedling emergence (%), seedling length (cm), SVI and GRI. This was observed during both germination and emergence under stress conditions.This suggests that the VCP primer may help restore seed senescence (Burgass and Powell, 1984). In conclusion, vermicompost priming has the potential to improve germination and emergence of onion seed seedlings under abiotic stresses.

Conclusion

In drought-stressed conditions, seed priming with vermicompost leach has a positive effect on increasing seed germination, seedling emergence percentage, length, seedling vigor index, and germination rate index while lowering less promptness index and germination stress tolerance index. When it came to seed germination (90), seedling emergence (81%), seedling vigor index (614), germination rate index (22.84), promptness index (123), and germination stress tolerance index (84.25%), seed priming with 10% vermicompost combined with 10% PEG performed better than any other treatment combinations. In terms of seed germination (52%), seedling emergence (46%), seedling vigor index (191), germination rate index (11.86), promptness index (69), and germination stress tolerance index (47.26%), non-priming seeds containing 15% PEG performed the worst.

Declarations

Competing Interest

Authors have declared that there is no conflicts of interest exist.

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