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Research Article

Quantifying the influence of seed priming on germination and growth traits of Bitter gourd (*Momordica charantia* L.) varieties

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ABSTRACT

The uniform and quick germination of seeds is crucial for better growth, yield and quality traits of vegetable crops. Likewise, the seeds of the bitter gourd have a thick and hard seed coat, germination and field emergence are always problematic for this crop. One of the best, economical, readily available,method for reducing seed dormancy and promoting germination is pre-sowing seed treatment. Therefore, a field trail was conducted at Horticultural Garden, Sindh Agriculture University, Tandojam to explore the efficacy of seed primimg on bitter gourd germination and growth attributes. The experiment was run in a Randomized Complete Block Design (RCBD), consisted of two varieties, Karan and Jaunpur-I, and two priming sources, zinc solutions (0.1%, 0.3%, 0.5%, and 0.7% w/v) and distilled water. The seeds were primed for 24 hours. Additionally, the untreated seeds were used as control. The results revealed that seed priming treatments significantly influenced bitter gourd's growth traits ($P<0.05$), except for pH, TSS, ash, and moisture. Moreover, increasing zinc concentrations were associated with a decreasing pattern in seed germination and growth-related attributes. The optimal results were achieved with 0.1% zinc priming, showed 90% seed germination, minimum flowering time (44.33days), fresh fruit weight (152.57g), fruit length (18.54cm), fruit diameter (18.7cm), and fruit plant^{-1}(39.17). Notably, all parameters, except seed germination percentage, aligned closely with results obtained from distilled water priming. The varietal comparison revealed non-significant differences in most parameters except fresh fruit weight and pH, while the interaction between bittergourd varieties and seed priming treatments significantly influenced fruit length and fruits plant^{-1}. The study concluded that seed priming with the lowest concentration of 0.1% zinc effectively enhanced bittergourd germination and growth attributes. However, for optimal growth, zinc priming at 0.1% could be replaced by priming in distilled water.

Keywords: Bitter gourd, Germination, Hydro-priming, Karan and Jaunpur-I, Zinc concentrate solution.

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INTRODUCTION

The bitter gourd is summer vegetable in Pakistan; it is also known as Karela and belongs to Cucurbitaceae family. Bitter gourd has tremendous economic and dietary importance. Immature fruit is a good source of vitamin C and A. It is good source of blood cleanser and highly beneficial for diabetic patients (Yibchok et al., 2006). Studies have shown that Bitter melon has anti-carcinogenic property and can be used as a cyto-toxic agent against many types of cancers (Grover and Yadav 2004). This vegetable is commonly cultivated in Asia and various other

regions globally. While typically grown as an annual crop, it can also function as a perennial in regions with mild climates and winters that are free from frost. In the plains, the summer season crop is usually planted between January to June. The optimum temperature required for its germination is 25-28 ^{0}C (Yibchok et al., 2006).

Bitter gourd seeds are hard seeded, possess a thick seed coat and therefore possess high germinability, yet field emergence is always a problem. Measures such as seed soaking or priming before sowing can be employed to bypass this problem (Sarwar et al., 2017). Test results indicated that protective treatments of the seeds were better in terms of emergence from the ground to stand establishment of the crop as stated by Sarwar et al., (2017). This treatment offers several additional benefits, including: that the preconditioned seeds: (i) have lower seed rate, (ii) allow for the removal of non-viable seeds out right before sowing, and (iii) have a way of removing germinated but low vigor seeds before sowing. Research has shown that soaking seeds in water for short periods of time followed by drying before planting increased the rate of germination and early emergence, and hence, stronger seedlings and better crop yield were realized (Harris et al., 2002). On-farm seed priming is a simple, low-cost, and safe process to enhance seedling establishment and early crop growth. Every crop cultivar requires an optimal soaking time within a safe limit (Harris et al., 2002).

Seed priming resulted in better germination, faster emergence, stronger growth, earlier flowering, and higher yields (Sarwar et al., 2017). Rapidly germinating seedlings contribute to the development of a deep root system, enhancing the overall establishment of seedlings in numerous crops (Sarwar et al., 2017). Good seedling establishment is an important constraint to such crop production (Harris et al., 1999). Poor seed bed, low quality seed, environmental stresses such as high and low temperature and salinity constrains to good establishment include ((Ziaf et al., 2022; Sarwar et al., 2017; 2021; Towned et al., 1996). A healthy seedling establishment improves the crop health against weeds and also induces the environmental stress tolerance and improved the biomass and grain yields.

In seed priming techniques, seeds are soaked in an osmotic solution or combined with a solid carrier that has a low metric potential. This allows the seeds to absorb water and go through the first stage of germination, but it prevents radicals from penetrating the seed coat. According to Varier et al. (2010), priming any crop seed requires understanding the safe limits of priming duration in order to achieve the best results. After priming, seeds are dried back to their original moisture content to allow for normal handling, storage, and planting. Therefore, the goal of the current study was to standardize the ideal seed priming time for bitter gourd.

MATERIALS AND METHODS

The experiment was conducted at Horticultural garden, Department of Horticulture, Sindh Agriculture University, Tandojam, during the year 2015. The experiment was laid out in Randomized Complete Block Design (RCBD) with factorial arrangements. There were a total of 12 treatments, and each treatment was replicated three times. The two Bitter gourd varieties were studied under different priming concentration of zinc solutions including SP1: Un-primed seeds (as control), SP2: Seed primed with distilled water, SP3: Seed primed with Zn @ 0.1%, SP4: Seeds primed with Zn @ 0.3%, SP5: Seed primed with Zn @ 0.5%, SP6: Seeds primed with Zn @ 0.7% for 24 hours. In control treatment, seeds were not soaked in water. The experiment was conducted in two stages: seed priming at the Postgraduate Laboratory of the Horticulture department, followed by planting of the primed seeds.

Data Recording

Germination%: The seed germination percentage was assessed daily for up to 15 days by observing the germinated seeds. The measurement followed a procedure using formula: **GP** = $\sum n/N \times 100$

Here, 'n' represents the number of germinated seeds at each counting, and 'N' is the total number of seeds in each treatment.

Days to Germination: Seeds were sown in trays filled with potting mix and placed with an optimal temperature and moisture. Daily observations were made to record the number of days required for seed germination, defined as the emergence of the seedling cotyledons above the soil surface.

Days to Flowering: Seedlings were transplanted in individual pots filled with fertile soil and placed in a greenhouse with appropriate light and temperature conditions. Flowering initiation was monitored daily, and the number of days from transplantation to the appearance of the first flower was recorded.

Fresh Weight of Fruit (g): The mature bitter gourd fruits used in this experiment were collected from plants that had been grown in similar environment. The fresh weight of each fruit was measured as early as possible after harvest using a digital weighing balance. Taking the fresh weight of fruit for all the treatment combinations the average weight of multiple fruits was estimated.

Fruit Length (cm): Some fruits were prepared by peeling them by taking out all the hard data around the fruits. In measuring the lengths of individual fruits, it was done according to the following steps; With the help of a ruler, the length of every fruit which has been picked was then noted with a view to recording the result immediately. The same course was followed for a representatives sample and then its performances were averaged.

Fruit Diameter (cm): To exclude extraneous material from the analysis, the selected fruits were prepared and the width, using the calipers was measured and the diameter noted. The same was done for the representative sample, and averages were then determined by the program used for the evaluations.

Fruits per plant: Fruits per plant were estimated based on actual counts made on five samples from each of the treatments and the means computed.

Fruit pH: The fruit was well rinsed, chopped and juice was squeezed out. The pH meter was calibrated using standard buffer solutions and electrode was inserted in bittergourd juice and the stabilized pH reading was recorded.

Fruit TSS (^{0}Brix): The TSS (Total Soluble Solids) was measured with a refractometer by placing a drop of the fruit extract onto the refractometer's glass surface. The refractometer was then held up to a light source, and the technician observed the resulting scale reading. This reading provided the concentration of total soluble solids in the fruit extract, offering a quantitative measure of the TSS content.

Ash%: The ash content was determined by subjecting a known weight of the fruit sample to a standard ashing procedure. The sample was incinerated at a high temperature to remove organic material, leaving behind the inorganic ash. The remaining ash was then quantitatively measured, and the ash content was calculated as the percentage of the initial weight of the fruit sample by using formula

Ash% = (ashed Weight)/ (Initial Weight) ×100

Moisture content (%): Moisture content was determined by weighing fruit sample, drying it in an oven until a constant weight was reached. The percentage of moisture loss from the initial weight was calculated by using formula: Moisture content%= (Initial Weight-Dry Weight)/ (Initial Weight) ×100

Data analysis

The collected data were organized manually for treatment wise and analysis of variance (ANOVA) was conducted using Statistix (2006). Subsequently, the Least Significant Difference Test (LSD) at a probability level 0.05 to assess differences between treatment means.

RESULTS

Germination Percentage (%)

Germination of the seeds was significantly affected by various seed treatments. However varieties had no significant effect on seed germination. The interaction of varieties and seed priming treatments was also observed non-significant. Germination percentage was recorded reduced with increasing concentration of zinc that is from 0.1 to 0.7%. The highest mean seed germination (90%) was noted where seeds was primed with zinc solution @ 0.1%. These results are also at par with the results (86.67, 81.67%) obtained from the seeds primed in zinc solution @ 0.3 and 0.5%, respectively. Un-primed seeds had (50%) seed germination as compared to rest of the primed seeds.

Days to Germination: Days to germination were significantly affected by the seed priming treatments. However, bitter gourd varieties as a main factor and its interaction with the seed priming treatments were observed non-significant. The minimum mean days to germination (2.83) were observed from the seeds primed in distilled water (Hydropriming). These results are at par with the results obtained from each concentration of zinc primed seeds except the seeds primed in zinc solution @ 0.7%. Unprimed seeds took more time (5.67 days) to germination followed by the results of 4.17 days obtained from the seeds primed in zinc solution @ 0.7%.

Table 1. Effect of different concentrations of zinc seed priming on the germination percentage (%) and days to germination of bitter gourd varieties (Karan and Jaunpur I)

	Bitter gourd Varieties				**Bitter gourd varieties**	
Zn application	**Karan**	**Jaunpur I**	**Mean (T)**	**Karan**	**Jaunpur I**	**Mean (T)**
	Germination Percentage (%)			**Days to germination**		
Un-primed (Control)	36.67	63.33	50.00 D	5.33	6.00	5.67 A
SP Distilled water	70.00	60.00	65.00 CD	2.67	3.00	2.83 C

SP (0.1 Zn)	90.00	90.00	90.00 A	3.00	3.67	3.33 BC
SP (0.3 Zn)	86.67	86.67	86.67 A	3.33	4.00	3.67 BC
SP (0.5 Zn)	93.33	70.00	81.67 AB	3.33	4.00	3.67 BC
SP (0.7 Zn)	76.67	63.33	70.00 BC	4.33	4.00	4.17 B
Mean (B)	75.56	72.22		3.67	4.11	
$LSD_{0.05}$	9.3537		16.201	0.4950		0.8573
SE	4.5102		7.8120	0.2387		0.4134

SP=Seed priming; Mean (T) = Mean of treatment; Mean (B) = Mean of bitter gourd varieties; B= Bitter gourd; T=Treatment

Days to flowering: Days to flowering was significantly affected by various seed priming treatments. However bitter gourd varieties as a main factor and its interactive effect with seed priming treatments was observed non-significant. Maximum days to flowering (52.17) were observed from the plants where no priming of the seeds was done. These results are also at par with the results (49.33 days) obtained from plants where seeds were primed in zinc solution @ 0.5%. The minimum days to flowering (44.33) observed from the plants where seeds were primed in zinc solution @ 0.1%. These results are at par with the results (45 and 46 days) obtained from the plants where seeds were primed in distilled water (Hydropriming) and zinc solution @ 0.3%.

Fresh weight of the fruit: Fresh weight of the fruit was significantly affected by the seed priming treatments and bitter gourd varieties. The best results for fresh weight of the fruit (152.57 g) observed from the plants where seeds were primed at the lowest level of zinc i.e 0.1%. These results are at par with the results (128.69 and 126.74 g) obtained from the plants where seeds were hydroprimed and primed in zinc solution @ 0.3%, respectively. The minimum fresh weight of the fruits (92.04 g) was observed from the plants where no seed priming was done. On the basis of varietal comparison, Jaunpur I produced maximum fresh weight of the fruit (140.27 g) in comparison to Karan (96.77 g).

Fruit length (cm): The length of the fruit was significantly affected by various seed priming treatments and their interaction with varieties of the bitter gourd. However, varieties as a main factor had no influence on length of the fruit. The fruit length was observed decreased with the increasing levels of zinc i.e 0.1 to 0.7%. The maximum fruit length (18.54 cm) observed from the plants where seeds were primed in zinc solution @ 0.1%. These results are at par with the results (17.88 cm) obtained from the plants where seeds were primed in distilled water (Hydropriming). The minimum and similar results for fruit length (13.83 cm) were observed from the plants in response to the primed seeds where zinc was used @ 0.5 and 0.7%. Unpirmed seeds exhibited better results for length of the fruit (16.67 cm) as compared to the seeds primed with exceeded levels of zinc i.e 0.3 to 0.7%. On the basis of interaction of bitter gourd varieties and priming treatments, the Jaunpur I fruits had the highest length of the fruit (20.41 cm) in response to the priming treatment where seeds were primed in zinc solution @ 0.1%.

Table 2. Effect of different concentrations of zinc seed priming on the days to flowering, fresh fruit weight (g) and fruit length (cm) of bitter gourd varieties (Karan and Jaunpur I)

Bitter gourd varieties				**Bitter gourd varieties**			**Bitter gourd varieties**		
Zn application	***Karan***	***Jaunpur I***	**Mean (T)**	***Karan***	***Jaunpur I***	**Mean (T)**	***Karan***	***Jaunpur I***	**Mean (T)**
	Days to Flowering			**Fresh Fruit weight (g)**			**Fruit length (cm)**		
Un-primed (Control)	51.00	53.33	52.17 A	72.39	111.69	92.04 B	17.33 bcd	15.00 defg	16.67 B
SP Distilled water	45.00	45.00	45.00 CD	107.90	149.47	128.69 AB	17.67 bc	18.100 ab	17.88 A
SP (0.1 Zn)	44.33	44.33	44.33 D	144.16	160.97	152.57 A	16.67 bcde	20.41 a	18.54 A
SP (0.3 Zn)	45.00	47.00	46.00	109	144.16	126.74	15.67	15.67	15.67

			BCD	31		AB	cdef	cdef	B
SP (0.5 Zn)	50.33	48.33	49.33 AB	42.15	142.18	92.16 B	13.33 fg	14.33 efg	13.83 C
SP (0.7 Zn)	48.33	47.67	48.00 BC	104.69	133.16	118.92 AB	15.00 defg	12.67 g	13.83 C
Mean (B)	47.33	47.61		96.77	140.27		15.94	16.03	
LSD$_{0.05}$	2.0578		3.5642	0.9632		1.6683	0.9632		1.6683
SE	0.9923		1.7186	0.4644		0.8044	0.4644		0.8044

SP=Seed priming; Mean (T) =Mean of treatment; Mean (B) =Mean of bitter gourd varieties; B= Bitter gourd; T=Treatment

Fruit diameter (cm): The fruit diameter was significantly affected by the seed priming treatments. However, no effect of varieties was recorded for fruit diameter. The interaction of bitter gourd varieties and seed priming treatments was also non-significant. The fruit diameter observed decreased with the increasing levels of zinc i.e. from 0.1 to 0.7%. The maximum mean fruit diameter (18.71 cm) was observed in response to the priming treatment where seeds were primed in zinc solution @ 0.1%. These results are statistically similar with the results (17.05 cm) obtained from the plants where seeds were primed in distilled water (hydroprimed). The minimum fruit diameter (13.67 cm) was recorded from the plants where no priming was done.

Fruits per plant: Varied responses for number of fruits per plants were observed. Fruits per plant were significantly affected by various seed priming treatments. The interaction of seed priming treatments with bitter gourd varieties was also observed significant. However, number of fruits per plant was not affected by the varieties as a main factor. The maximum mean number of fruits (39.17) per plant was observed from the plants where seeds were primed in zinc solution @ 0.1%. However, these results are at par with the results viz. (36.83 and 36.33) fruits per plant where seeds were soaked in zinc solution @ 0.3 and distilled water. The number of fruits per plants decreased when concentration of zinc solution was increased. The minimum number of fruits (25.17) per plant was obtained from the plants where priming was not done. On the basis of interaction of the bitter gourd varieties and seed priming treatments, maximum number of fruits (47) per plant was observed from the plants of Karan variety where seed priming was done in distilled water.

Fruit pH: The pH of the fruit was not significantly affected by seed priming treatments. However, bitter gourd varieties had varied pH levels. The interaction of the varieties and seed priming treatments was also observed non-significant. The mean pH of seed priming treatments ranges from 6.53 to 6.88. On the basis of varietal comparison, Karan fruits had high pH (6.98) as compared to Jaunpur I (6.45).

Table 3. Effect of different concentrations of zinc seed priming on the fruit diameter (cm), fruits per plant and fruit pH of bitter gourd varieties (Karan and Jaunpur I)

Bitter gourd varieties				**Bitter gourd varieties**			**Bitter gourd varieties**		
Zn application	***Karan***	***Jaunpur I***	**Mean (T)**	***Karan***	***Jaunpur I***	**Mean (T)**	***Karan***	***Jaunpur I***	**Mean (T)**
	Fruit diameter (cm)			**Fruits per plant**			**Fruit pH**		
Un-primed (Control)	12.67	14.67	13.67 D	26.00 e	24.33 e	25.17 D	6.79	6.54	6.67
SP Distilled water	18.10	16.00	17.05 AB	47.00 a	25.67 e	36.33 ABC	6.61	6.45	6.53
SP (0.1 Zn)	20.43	17.00	18.71 A	40.00 abc	38.33 abcd	39.17 A	7.11	6.64	6.88
SP (0.3 Zn)	15.00	14.33	14.67 CD	29.67 cde	44.00 ab	36.83 AB	7.14	6.40	6.77
SP (0.5 Zn)	14.33	15.00	14.67	34.33	23.67 e	29.00	7.11	6.36	6.74

			CD	bcde		BCD			
SP (0.7 Zn)	15.67	15.67	15.67 BC	27.33 de	29.33 cde	28.33 CD	7.11	6.33	6.72
Mean (B)	16.03	15.44		34.06	30.89		6.98	6.45	
LSD$_{0.05}$	1.1086		1.9202	4.7015		8.1433	0.2807		4862
SE	0.5346		0.9259	2.2670		3.9266	0.1353		0.2344

SP=Seed priming; Mean (T) =Mean of treatment; Mean (B) =Mean of bitter gourd varieties; B= Bitter gourd; T=Treatment

Fruit TSS (^{0}Brix): There was no significant differences were observed for total soluble solids (TSS) in response to the seed priming treatments. However, varieties had significant effects on TSS. The interaction of bitter gourd varieties and seed priming treatments was observed non-significant. The mean TSS ranges from 2.90 to 3.33^{0}Brix. The maximum TSS 3.32 Brix were recorded from the fruits of variety Karan as compared to the Jaunpur I (2.93 Brix).
Fruit Ash (%): The ash of the fruit was not significantly affected by the seed priming treatments and bitter gourd varieties. The interaction of the varieties and seed priming treatments was also observed non-significant. The mean ash percentage ranges from 0.81 to 0.88. On the basis of varieties, ash percentage ranges from 0.84 to 0.86.
Fruit moisture: Fruit moisture was not affected by the various seed priming treatments and bitter gourd varieties. The interaction of the bitter gourd varieties and seed priming treatments was also observed at par. The moisture percentage of seed priming treatments ranges from 87.95 to 89.28. Variety wise moisture percentage ranges from 88.54 to 88.84.

Table 4. Effect of different concentrations of zinc seed priming on the fruit TSS (^{0}Brix), Ash (%) and Moisture (%) of bitter gourd varieties (Karan and Jaunpur I)

Bitter gourd varieties				**Bitter gourd varieties**			**Bitter gourd varieties**		
Zn application	***Karan***	***Jaunpur I***	**Mean (T)**	***Karan***	***Jaunpur I***	**Mean (T)**	***Karan***	***Jaunpur I***	**Mean (T)**
	Fruit TSS (^{0}Brix)			**Ash (%)**			**Moisture (%)**		
Un-primed (Control)	3.67	2.68	3.18	0.85	0.83	0.84	87.67	89.13	88.40
SP Distilled water	3.47	2.59	3.03	0.84	0.78	0.81	89.26	89.30	89.28
SP (0.1 Zn)	3.60	2.82	3.21	0.88	0.89	0.88	89.97	89.00	89.04
SP (0.3 Zn)	3.11	2.82	2.96	0.85	0.87	0.86	88.33	89.00	88.66
SP (0.5 Zn)	3.27	3.39	3.33	0.80	0.88	0.84	88.67	88.93	88.80
SP (0.7 Zn)	2.79	3.02	2.90	0.80	0.88	0.84	87.33	88.57	87.95
Mean (B)	3.32	2.93		0.84	0.86		88.54	88.84	
LSD$_{0.05}$	0.3627		0.6282	0.0386		0.0668	1.4286		2.4744
SE	0.1749		0.3029	0.0186		0.0322	0.6889		1.1931

SP=Seed priming; Mean (T) =Mean of treatment; Mean (B) =Mean of bitter gourd varieties; B= Bitter gourd; T=Treatment

DISCUSSION

The effect of seed priming treatment differed significantly for seed germination percentage % which was observed increased with decreasing concentration of zinc. Seed soaking enhances germination by triggering biochemical responses, including seed coat permeability increase and enzyme release. This process inhibits growth inhibitors,

initiating hydrolysis and promoting germination (Farooq et al., 2009). However, the bitter gourd varieties had non-significant effect on seed germination and with its interaction with seed priming, our finding relates with (Saleem et al., 2014) who observed the interaction between varieties and seed priming duration was non-significant. Variations between bitter gourd varieties are attributed to their genetic potential. Seed priming in lower concentrated zinc solution significantly decreased the emergence time over un-primed seeds (control). Our findings are in line with (Bukhari et al., 2021) who reported that 0.3% zinc sulphate solution has higher emergence index as compared to control group.

Jamil et al., (2016) also concluded that rehydration causes early emergence due to the fact that all pre germinative processes for germination had already occurred in seeds thus the seed soaking minimized the emergence time. However the bitter gourd varieties as the main factor and its interaction with the seed priming treatment were observed non-significant, the possible fact might be the environmental factor. Seed priming has been documented to induce early flowering, signifying a transition from the vegetative to the reproductive phase in the growth of crops. In our study according to mean values the highest number of days to flowering were recorded in plants of un-primed (control) while the lower concentrated zinc solution showed early flowering, our findings also align with (Singh et al., 2022) who recorded that the lower dose of boron enhanced early female flowering. Generally seed soaking effected the early flowering which ultimately influenced the maturity period (Saleem et al., 2014). Sooner the flower appears, earlier the yield and more are the profits (Baig et al., 2019). Primed seeds exhibit accelerated emergency, shortened time to flowering and yield higher output in cucumber and wheat (Harris et al., 2001; Ziaf et al., 2022). However the bitter gourd varieties had non-significant effect for number of days to flowering, this may be due to inherit characteristics of the varieties. The study revealed that fresh weight of fruit and fruit length in jaunpur I variety showed significant result under lower dose of SP (0.1 Zn) as compared to Karan variety shown in (Table 2).

The present investigations are agreed with the findings of (Singh et al., 2022) who observed that the lower dose of boron recorded maximum fruit weight and fruit length. The fruit diameter was also recorded maximum to SP (0.1 Zn) statistically the similar results were also obtained on plant with SP distilled water whereas the variety had no significant results, our findings aligns with (Singh et al., 2022) who described that the lower dose of boron recorded maximum fruit diameter. The maximum number of fruit per plant was obtained on the plant where SP (0.1 Zn) was applied whereas on the variety karan showed best results under SP distilled water. (El-Baky et al., 2010) also reported the maximum number of fruit/ vine obtained by the use of micronutrients (Zn & Fe) in bitter gourd. Similarly findings have been reported by (Abubaker et al., 2010; Verma et al., 1984; Mamnoie et al., 2014; Oga and umekwe 2015) who discovered that an application of 4 ppm of boron demonstrated superiority in enhancing female flower production, leading to a significant increase in both the number of fruits per plant and the average weight of fresh fruit in two varieties of bottle gourd. The Bitter melon undergoes fruit splitting and ripening during post-harvest changes, causing a decrease in the amount of edible flesh, as reported by (Ziaf et al., 2022; Zong et al., 1993).

Seed priming treatment had non-significant impact on fruit pH, but bitter gourd varieties showed varying pH levels. The TSS% were obtained in range 2.90 to 3.31 in seed priming whereas the variety karan showed maximum TSS % as compared to jaunpur I, (Kumar et al., 2012) also reported that the maximum TSS% was obtained by the use of zinc & iron on bitter gourd. The Ash% and moisture% had no significance with seed priming treatment and bitter gourd varieties. The differences in moisture and ash% among M. charantia may be due to genetic and agricultural variations. Maximum germination and growth responses for bitter gourd were recorded at 0.1% zinc seed priming. It is apparent that hydropriming, in the form of SP distilled water, may have better growth advantages.

CONCLUSION

This study found that Seed priming with 0.1% zinc enhances the germination and growth of bitter gourd varieties Karan and Jaunpur I. Higher concentrations of zinc suppressed germination and growth. Jaunpur I variety generally performed better across multiple parameters. The study highlights the importance of carefully considering seed priming conditions to optimize bitter gourd germination and growth, and recommends further field-based research to validate these findings.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

COMPETING OF INTEREST

The authors declare that the research was carried without any commercial or financial relationships that could be construed as a potential conflict of interest.

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