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Effect of priming agents on seed qualities of chilli

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Abstract
Chilli seeds of two varieties, namely G_4 and Surajmukhi, were primed in various concentrations of GA_3 (1 ppm), KNO_3 (5%), Na2HPO4 (2%), PEG (10%), $ZnSO_4$ (1%), Ascorbic Acid (50 ppm), and Deionized H_2O for 24 hours. Following priming, germination tests were carried out between the paper, on top of the paper, and by the sand method. All priming treatments significantly improved germination performances (germination percentage and spread of germination), root length, shoot length, seedling dry weight, seedling vigor index-I, and seedling vigor index-II. All the priming agents showed a significant effect in increasing germination percent. In G_4 8 & Surajmukhi variety, the germination percentage was increased by 36.66% and 53.32% respectively. Root length increased by 6.01 cm in G_4 and 5.04 cm in the Surajmukhi variety, and shoot length increased by 0.9 cm and 0.7 cm, respectively. Like germination percent, root length, and shoot length, the priming agent had a positive effect in the case of seedling dry weight. In G_4 and Surajmukhi, dry weight increased by 7 and 12.4 mg, respectively.

Keywords: Vigour, priming, germination

1. Introduction
Hot pepper (*Capsicum annuum* L.), known as chili, is India's vital vegetable and spice crop. The yield of chili is much lower in third-world countries. Rapid and uniform emergences are essential prerequisites to increase crop yield, quality, and profit. In chi, li crops, its quality is a significant factor that determines the economic success of the crop. One of the leading causes for this poor yield is the need for a good stand establishment and reduced early growth, as stressed by the adverse environment. Germination and emergence of chili seeds are often slow and non-uniform under normal and stress conditions. Similarly, Andreoli and Khan (1999) [16] found slow and erratic emergence and establishment of chili seeds, especially under excellent conditions. Chilli and tomatoes have non-starchy endosperm, which offers a mechanical barrier to the growing embryo, resulting in poor germination. High germination and uniform stand establishment for chili production are essential to maintaining profitable yields. Improvement in stand establishment can be obtained through seed quality and enhancements, genetic improvement, and improved seeding techniques. Seed invigoration is a technique of seed enhancement. It includes pre-soaking of seeds that improve seed performance by rapid and uniform germination. These regular and vigorous seedlings resulted in faster and higher rates of germination and emergence in different crops (Farooq *et al*., 2007) [17], which also helps seedlings to grow in biotic or abiotic stress conditions. Such seed treatments result in synchronized emergence and uniform stand establishment, leading to improved yield. Each treatment has advantages and disadvantages and may have varying effects depending on plant species, stage of plant development, concentration/dose of priming agent, and incubation. Given the above facts, an experiment was designed to evaluate the impact of different chemicals on improving seed germination and vigor in chili.

2. Materials and Methods
2.1. Materials
2.1.1. Seed Source: The fresh seeds of two open pollinated varieties of chilli were used in the experiment was collected from different shops in Bhubaneswar.

2.1.2. Seed Priming Treatments: Brinjal seeds were primed/imbibed GA_3 (1 ppm), KNO_3 (5%), Na_2HPO_4 (2%), PEG (10%), $ZnSO_4$ (1%), Ascorbic Acid (50 ppm), and Deionized H_2O for 24 hours. After treatment, seeds were rinsed thoroughly with distilled water and dried back closer to original moisture level under shaded conditions. Non-primed tomato seeds were maintained as control for comparison.

2.1.3. Experimental Site: This experiment was conducted at Department of Seed Science and Technology Lab, Odisha University of Agriculture and Technology (OUAT), Chiplima.

2.2. Methods

2.2.1. Between Paper (BP) Methods: For the germination test, 100 seeds were randomly taken from each treatment of each variety along with control (dry seeds). Three replicates of 50 seeds were put in between double-layered rolled germination paper and control (dry seed), moistened with distilled water, and placed in a germinator at 25 °C. Seeds were considered germinated if the length of the radicle was 3mm long. Seedlings with short, thick, and spiral hypocotyl and stunted roots were considered abnormal. The germination percentage was calculated on the 14th day (Final count). Observation on germination percentage, root length, shoot length, and seedling dry weight recorded. Root length and shoot length were measured on the 14th day. Ten seedlings were taken to measure root length and shoot length, and the mean root length and shoot length were calculated. The same ten seedlings were dried in a hot air oven at 100 °C for 24 hours to calculate the seedling dry weight. Then, Vigour Index I (seedling length X germination %) and Vigour Index II (seedling dry weight X germination percentage) were calculated.

2.2.2. Top of Paper (TP) Method: Seeds were randomly taken from each treatment of 5 varieties along with control (dry seeds). Three replicates of 30 seeds were kept on moist filter paper in a Petri dish and inside 15 germinators. The germination percentage was observed between the 5th and 14th day, and the germination speed was calculated.

2.2.3. Sand Method: For the field emergence test, ten seeds were randomly taken from each treatment of all five varieties along with control (dry seeds) and were sown in portrays (10X5) having coconut coir pith. The field emergence percentage count was done on the 14th day. Observations were recorded on field emergence percentage, root length, shoot length, and seedling dry weight. On the 14th day, the field's root length and shoot length emerged, and all varieties' seedlings were measured. Seedlings were kept inside a hot air oven for 24 hours at 100 °C, and seedling dry weight was measured.

3. Results and Discussion

3.1. Germination: In the G_4 variety of chili, the highest germination percent was found in ascorbic acid and PEG-primed seeds. In the Surajmukhi variety, GA_3 among all priming agents outperformed germination percentages. Non-primed seeds in the sand method were found to have the lowest germination percent in both the chili varieties.

Table 1: Germination percentage in brinjal.

Priming Treatment	G_4	Surajmukhi
BP GA_3 (1 ppm)	84.67	50.67
BP KNO_3 (5%)	84.00	49.33
BP Na_2HPO_4 (2%)	81.33	47.33
BP PEG (10%)	86.67	48.67
BP $ZnSO_4$ (1%)	78.00	47.33
BP AA (50 ppm)	86.67	48.00
BP Deionised H_2O	83.33	49.33
BP CONTROL	75.99	44.01
TP GA_3 (1 ppm)	77.77	73.33
TP KNO_3 (5%)	62.22	58.89
TP Na_2HPO_4 (2%)	70.00	58.89
TP PEG (10%)	70.00	63.33
TP $ZnSO_4$ (1%)	60.00	60.00
TP AA (50 ppm)	57.77	64.44
TP Deionised H_2O	68.89	62.22
TP CONTROL	56.67	53.34
SAND GA_3 (1 ppm)	63.33	70.00
SAND KNO_3 (5%)	60.00	56.67
SAND Na_2HPO_4 (2%)	53.33	60.00
SAND PEG (10%)	80.00	66.67
SAND $ZnSO_4$ (1%)	60.00	60.00
SAND AA (50 ppm)	86.67	63.33
SAND Deionised H_2O	66.67	63.33
SAND CONTROL	50.01	20.01
MEAN	65.92	52.53
S.E.m(±)	4.81	5.50
C.D. (0.05)	13.69	15.64
C.V. (%)	0.53	0.76

3.2. Root length: Na2HPO4 and GA_3 priming showed a considerable increase in the root length of the G_4 variety. Root length varied from 10.06 cm to 1.34 cm. The root length of GA_3, KNO_3, and $ZnSO_4$ primed seeds of the G_4 variety was at par in the BP method, and PEG, Ascorbic acid, and hydro-primed seeds were at par. The root lengths of GA_3, PEG, $ZnSO_4$, and Ascorbic acid-primed seeds in the TP method were at par. The root length of GA_3, KNO_3, and Na2HPO4 primed seeds was at par with the sand method. In the sand method, root length varied from 5.49 cm to 1.34 cm. KNO_3 and hydropriming showed increased root length in the Surajmukhi variety. GA_3 had a considerable mean effect on both chili varieties in increasing root length compared to control among all other priming agents. The mean effect of all the priming treatments in increasing root length of the G_4 variety was found to be at par except for $ZnSO_4$. The mean effect of GA_3 in increasing root length was better than all other priming agents.

Table 2: Root length in brinjal.

Priming treatment	G_4	Surajmukhi
BP GA_3 (1 ppm)	8.93	8.1
BP KNO_3 (5%)	8.35	7.91
BP Na_2HPO_4 (2%)	10.06	7.61
BP PEG (10%)	9.61	7.11
BP $ZnSO_4$ (1%)	8.12	7.39
BP AA (50 ppm)	9.5	7.8
BP Deionised H_2O	9.39	6.96
BP CONTROL	6.36	6.96
TP GA_3 (1 ppm)	9.77	9.16
TP KNO_3 (5%)	8.51	10.62
TP Na_2HPO_4 (2%)	8.96	8.93
TP PEG (10%)	9.76	8.65
TP $ZnSO_4$ (1%)	9.32	9.27
TP AA (50 ppm)	9.44	9.31
TP Deionised H_2O	8.86	10.45
TP CONTROL	7.47	7.89
SAND GA_3 (1 ppm)	5.71	6
SAND KNO_3 (5%)	5.51	6.51
SAND Na_2HPO_4 (2%)	5.49	6.35
SAND PEG (10%)	5.03	6.11
SAND $ZnSO_4$ (1%)	4.58	5.98
SAND AA (50 ppm)	4.77	5.72
SAND Deionised H_2O	4.83	5.69
SAND CONTROL	4.05	4.98
MEAN	7.1	7.09
S.E.m(±)	0.44	0.19
C.D. (0.05)	1.26	0.54
C.V. (%)	0.45	0.19

3.3. Shoot length: Hydropriming increased shoot length considerably as compared to control. Hydropriming recorded maximum value after KNO_3 priming in the G_4 variety. Na2HPO4 and PEG increased shoot length, followed by GA_3 and hydropriming in the case of the Surajmukhi variety. In both varieties, unprimed seeds in the sand method recorded the shortest shoot length. The mean effect of KNO_3 was most effective in increasing shoot length, followed by hydropriming.

3.4. Seedling dry weight: The G_4 variety of chili priming with PEG, the recorded maximum dry weight was followed by Ascorbic acid priming and hydropriming. The control of the sand method showed the lowest dry weight. In the Surajmukhi variety, $ZnSO_4$ priming recorded the highest dry weight, followed by hydropriming in the BP method, like the G_4 variety control of the sand method, which recorded the least dry weight. The mean effect of hydropriming and $ZnSO_4$ priming was found to be pronounced for all the priming agents.

Table 3: Shoot length in brinjal.

Priming treatment	G_4	Surajmukhi
BP GA_3 (1 ppm)	8.1	8.2
BP KNO_3 (5%)	7.9	7.9
BP Na_2HPO_4 (2%)	7.6	7.6
BP PEG (10%)	7.1	7.1
BP $ZnSO_4$ (1%)	7.4	7.5
BP AA (50 ppm)	7.8	7.7
BP Deionised H_2O	7.0	7.4
BP CONTROL	7.0	6.9
TP GA_3 (1 ppm)	9.2	9.3
TP KNO_3 (5%)	10.6	9.3
TP Na_2HPO_4 (2%)	8.9	9.6
TP PEG (10%)	8.7	9.7
TP $ZnSO_4$ (1%)	9.3	9.2
TP AA (50 ppm)	9.3	9.5
TP Deionised H_2O	10.5	8.9
TP CONTROL	7.9	7.5
SAND GA_3 (1 ppm)	6.0	6.0
SAND KNO_3 (5%)	6.5	5.9
SAND Na_2HPO_4 (2%)	6.4	6.8
SAND PEG (10%)	6.1	6.1
SAND $ZnSO_4$ (1%)	6.0	6.0
SAND AA (50 ppm)	5.7	6.3
SAND Deionised H_2O	5.7	6.2
SAND CONTROL	5.0	4.3
MEAN	7.41	7.09
S.E.m(±)	0.26	0.08
C.D. (0.05)	0.74	0.22
C.V. (%)	0.25	0.08

Table 4: Seedling dry weight in brinjal.

Priming treatment	G_4	Surajmukhi
BP GA_3 (1 ppm)	27.7	14.3
BP KNO_3 (5%)	28.0	17.7
BP Na_2HPO_4 (2%)	22.0	15.3
BP PEG (10%)	33.0	15.0
BP $ZnSO_4$ (1%)	26.0	24.7
BP AA (50 ppm)	28.7	21.0
BP Deionised H_2O	28.3	22.3
BP CONTROL	25.0	16.0
TP GA_3 (1 ppm)	28.3	15.0
TP KNO_3 (5%)	26.3	14.3
TP Na_2HPO_4 (2%)	19.3	14.7
TP PEG (10%)	22.0	15.7
TP $ZnSO_4$ (1%)	23.0	19.0
TP AA (50 ppm)	22.0	19.0
TP Deionised H_2O	19.7	19.3
TP CONTROL	19.0	16.0
SAND GA_3 (1 ppm)	21.7	15.3
SAND KNO_3 (5%)	26.0	15.0
SAND Na_2HPO_4 (2%)	27.3	14.3
SAND PEG (10%)	24.3	14.7
SAND $ZnSO_4$ (1%)	23.0	14.7
SAND AA (50 ppm)	20.0	16.3
SAND Deionised H_2O	20.3	15.7
SAND CONTROL	16.0	12.3
MEAN	22.37	17.08
S.E.m(±)	1.23	0.25
C.D. (0.05)	3.5	0.71
C.V. (%)	0.4	0.11

3.5. Seedling vigour index- I (SV-I): Ascorbic acid and GA_3 priming in G_4 variety recorded maximum SV-I value and unprimed seeds in sand method recorded the lowest. SV-I in G_4 was ranged between 1498.2 to 450.9. In Surajmukhi variety GA_3 priming showed significant increase in SV-I and was recorded highest against least SV-I value of control in sand method. Mean effect of GA_3 was found to be more pronounced among all priming agents.

Table 5: Seedling vigour index-I in brinjal.

Priming treatment	G_4	Surajmukhi
BP GA_3 (1 ppm)	1444.1	848.7
BP KNO_3 (5%)	1364.2	803.9
BP Na_2HPO_4 (2%)	1436.3	816.4
BP PEG (10%)	1449	806
BP $ZnSO_4$ (1%)	1208.9	713.8
BP AA (50 ppm)	1498.2	719.9
BP Deionised H_2O	1363	714.7
BP CONTROL	1012.3	597
TP GA_3 (1 ppm)	1470.8	1399
TP KNO_3 (5%)	1186.3	1087.3
TP Na_2HPO_4 (2%)	1252.9	1102.9
TP PEG (10%)	1288.6	1243.9`
TP $ZnSO_4$ (1%)	1117.1	1129.1
TP AA (50 ppm)	1088.8	1160.4
TP Deionised H_2O	1329	1168.8
TP CONTROL	869.8	778.6
SAND GA_3 (1 ppm)	746.8	791.3
SAND KNO_3 (5%)	726.6	648.5
SAND Na_2HPO_4 (2%)	632.6	774
SAND PEG (10%)	895.3	769.6
SAND $ZnSO_4$ (1%)	630.6	688
SAND AA (50 ppm)	902.7	759.6
SAND Deionised H_2O	700	759.3
SAND CONTROL	450.9	177.9
MEAN	1021.2	809.3
S.E.m(±)	107.5	93.7
C.D. (0.05)	305.7	266.4
C.V. (%)	0.7	0.8

3.6. Seedling vigour index- II (SV-II): In G_4 variety priming with PEG recorded maximum SV-II value. Hydropriming and ascorbic acid priming in Surajmukhi variety shown considerable increase in SV-II against control. Mean effect of PEG and ascorbic acid was higher compared to effect of other priming agents.

Table 6: Seedling vigour index-II in brinjal.

Priming treatment	G_4	Surajmukhi
BP GA_3 (1 ppm)	2341.3	724.6
BP KNO_3 (5%)	2354.6	872.6
BP Na_2HPO_4 (2%)	1790.0	726.0
BP PEG (10%)	2866.6	727.3
BP $ZnSO_4$ (1%)	2029.3	1160.0
BP AA (50 ppm)	2476.0	999.3
BP Deionised H_2O	2366.6	1047.3
BP CONTROL	1899.9	703.9
TP GA_3 (1 ppm)	2205.5	1097.7
TP KNO_3 (5%)	1641.1	837.7
TP Na_2HPO_4 (2%)	1355.5	862.2
TP PEG (10%)	1541.1	996.6
TP $ZnSO_4$ (1%)	1373.3	1141.1
TP AA (50 ppm)	1270.0	1227.7
TP Deionised H_2O	1352.2	1205.5
TP CONTROL	1076.6	906.6
SAND GA_3 (1 ppm)	1196.6	1083.3
SAND KNO_3 (5%)	1553.3	856.6
SAND Na_2HPO_4 (2%)	1453.3	856.6
SAND PEG (10%)	1920.0	983.3
SAND $ZnSO_4$ (1%)	1366.6	893.3
SAND AA (50 ppm)	1750.0	1036.6
SAND Deionised H_2O	1360.0	990.0
SAND CONTROL	799.9	259.9
MEAN	1617.6	872.9
S.E.m(±)	181.8	116.3
C.D. (0.05)	517.1	330.7
C.V. (%)	0.8	0.9

3.7. Speed of germination

In G_4 and Suajmukhi variety of chilli PEG and GA_3 primed seeds found to have maximum speed of germination respectively and non-primed seeds recorded slowest.

4. Conclusion

Priming treatments exhibited marked influence on seed germination and seedling growth of chilli. The seed germination and seedling growth parameters showed variation in their performance with respect to different priming treatments but all the treatments were observed to be having positive effects in increasing seed quality parameters of chill.

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