EFFECT OF SEED PRIMING BY CHITOSAN, BENZOIC ACID AND SALICYLIC ACID ON SEED-BORNE FUNGI OF JUTE

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ABSTRACT

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An investigation was conducted to assess the efficacy of seed priming by elicitors *viz*. chitosan, benzoic acid and salicylic acid for improving the health and quality of different varieties of jute seeds and compared with seed treating chemical Provax-200 WP (Carboxin +Thiram). Allelicitors at different concentrations reduced the prevalence of seed-borne fungi and increased the germination percentages of six different varieties of jute seeds. Nine fungal pathogens under seven genera *viz*. *Aspergillus flavus, A. niger, Penicillium* spp., *Botrytis cinerea, Fusarium moniliforme, F. oxysporum, Phoma* spp., *Colletotrichum corchori* and *Macrophomina phaseolina* were recorded. The highest germination of seed and lowest incidence of seed-borne fungal pathogens were recorded in 0.1 % chitosan solution followed by 0.03 % benzoic acid and 0.03 % salicylic acid solution. The association of seed-borne fungi of jute showed negative impact on seed germination. Among the elicitors used in this experiment, seed treatment with chitosan solution showed the highest enhancement of germination of jute seeds and suppressed the growth of seed-borne fungal pathogens suggesting the possibility of the use of chitosan as seed treatment to improve the health and quality of jute seeds.

Key words: Seed priming, chitosan, benzoic acid, salicylic acid, seed-borne fungi, jute seed

INTRODUCTION

Jute is popularly known as golden fiber in Bangladesh which supply about 70 % jute and related products in the global market. Jute (*Corchorus capsularis* L. and *C. olitorius* L.) is the main cash crop of Bangladesh (Islam 2014) and it has a great influence on socio-economic life of jute growers' in Bangladesh (Sarker 2016). There is a great scarcity of good quality healthy jute seeds in the country (Sheheli and Roy 2014). Jute seeds suffer from ten seed-borne diseases (Fakir 2001) those cause low germination and early infections of seedlings. Among the seed-borne fungal diseases, stem rot, black band and anthracnose caused by *Macrophomina phaseolina*, *Botryodiplodia theobromae* and *Colletotrichum corchori* respectively are transmitted through jute seeds (Ikata and Yoshida 1940).

Seed treatment is considered as the cheapest and safest method of plant disease control. It is indisputable that proper seed treatment can substantially improve the quality of seed and seedling with satisfactory increase in crop yield. Moreover, fungicide treatments are discouraged due to toxic residues and development of resistance in pathogens. Due to increasing concern of environment and health issue, scientists around the globe are now concentrating to exploit plant innate ability to overcome or withstand with surrounding hindrances caused by pest and pathogens. Induced resistance can be achieved in plants by different abiotic and biotic stimuli. Elicitors in plant biology are extrinsic or foreign molecules often associated with plant pests, diseases or synergistic organisms. This response results in the enhanced synthesis of metabolites which reduce damage and increase resistance to pest, disease or environmental stress (Tumpa *et al*. 2017). Chitosan (β-1,4 linked D-glucosamine) is a bio-polymer, can be commercially derived from various crustaceans commonly from the exoskeleton of shrimps and crabs (Khan *et al*. 2002). Salicylic acid and Benzoic acid are two synthetic products act as elicitor. Among synthetic chemical inducers, salicylic acid, sorbic acid and benzoic acid have been found to be active as

antimicrobial agents in various trials as disease resistance inducer. Also, they have been reported for inducing resistance against several plant pathogens (Abdel-Kareem *et al.* 1993, Abdel-Monaiem 2010, Abdel-Kader *et al.* 2012). These products can modulate various cellular function including reactive oxygen production, ion channel activity through phosphorylation and dephosphorylation of target protein, stomatal movement, upregulation of pathogenesis related genes (Khokon *et al*. 2010).

Seed priming is a controlled hydration technique in which seeds are soaked in water or low osmotic potential solution to a point where germination related metabolic activities begin in the seeds but radical emergence does not occur. Priming is a new technique of seed treatment that integrates biological (inoculation of seed with beneficial organism to protect seed) and physiological aspects (seed hydration) which recently recognized as alternative method for controlling many seed and soil-borne pathogens. Therefore, the objective of the research was to investigate the efficacy of seed priming by chitosan, benzoic acid and salicylic acid for controlling seed-borne fungi of jute.

MATERIALS AND METHODS

The experiments were conducted in the Laboratory of Biosignaling, Bioactive Compounds and Bioformulation, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. Jute seeds of six different varieties (CVL-1, BJC-2197, BJC-7370, CVE-3, O-3820 and O-72) were collected from Bangladesh Jute Research Institute (BJRI). The collected seeds were stored in zip lock bags under room condition for further studies. Blotter incubation method was followed according to ISTA rules for seed health testing and detection of seed-borne fungi (ISTA 2010). Temporary slides were prepared from the fungal colony and the fungi were identified under compound microscope with the keys of Ellis (1971) and Neergaard (1979). A total of 400 seeds were set for each treatment for testing germination (ISTA 2010). Germination of seeds was recorded at 10 days of incubation.

Preparation of treatment solutions

The chitosan (0.30 %) stock solution was prepared with 3 g chitosan dissolved in concentrated acetic acid adding drop by drop until fully dissolved and then diluted with water to a volume of 1000 ml. The 0.30 % chitosan stock solution was used to prepare 0.02, 0.05 and 0.10 % chitosan solution for further study. Similarly, benzoic acid (0.30 %) stock solution was prepared with 3 g BA dissolved in concentrated glacial acetic acid adding drop by drop until fully dissolved and then diluted with water to a volume of 1000 ml. The stock solution was used to prepare 0.01, 0.02 and 0.03 % BA solution. The stock solution of 0.30 % salicylic acid was prepared with 3g SA dissolved in concentrated ethanol adding drop by drop until fully dissolved and then diluted with water to a volume of 1000 ml and then 0.01, 0.02 and 0.03 % SA solution was prepared.

Seed priming by chitosan, benzoic acid and salicylic acid solution

Seeds were immersed in the respective chitosan, benzoic acid and salicylic acid solution for 2 hrs at room temperature (25±2 °C). After draining off the treated solution the seeds were placed in blotting paper following ISTA rules for seed testing (ISTA 2010). The seed treated with Provax-200 WP @ 0.35% of seed weight, was considered as a positive control as per the method of Islam *et al.* (2001).

Statistical Analysis

The treatments were arranged in the laboratory in completely randomized design (CRD) with three replications. The percent values were converted into arcsine transformed value and the data were analyzed by using the M-STAT C statistical software.

RESULTS AND DISCUSSION

Effect of seed priming by chitosan, salicylic acid and benzoic acid on the association of fungi of jute seed

Seven fungal genera *viz. Aspergillus, Fusarium, Penicillium, Botrytis, Phoma, Colletotrichum* and *Macrophomina* were predominantly associated at various intensities with most of the jute seed samples in general (Table 1–6).

Jute seeds of variety CVL-1 yielded nine fungi *viz. A. flavus, A. niger, Penicillium* spp., *B. cinerea, F. moniliforme, F. oxysporum, Phoma* spp., *C. corchori* and *M. phaseolina* in control treatment, while the least seed borne fungal infections were recorded in 0.35 % Provax-200 WP, 0.03 % BAS followed by 0.02 % BAS and 0.03 % SAS (Table 1). *A. flavus* (18.67 %) was the most predominant fungus followed by *A. niger* (14.67 %), *Penicillium* spp. (10.67 %) and *B. cinerea* (9.33 %).

Seven different fungi *viz. A. flavus, A. niger, F. moniliforme, Penicillium* spp., *C. corchori, F. oxysporum* and *M. phaseolina* were detected in control treatment in the variety BJC-2197, while the least seed-borne fungi were recorded in 0.35 % Provax-200 WP, 0.02 % CS followed by 0.02 % BAS and 0.05 % CS (Table 2).

Table 1. Effect of seed priming on the prevalence of seed-borne of fungi (%) of jute seeds in CVL-1

Treatments	Prevalence of seed-borne fungi (%)								
	Aspergillus niger	*Aspergillus flavus*	*Fusarium moniliforme*	*Fusarium oxysporum*	*Colletotrichum corchori*	*Penicillium* spp.	*Macrophomina phaseolina*	*Botrytis cinerea*	*Phoma* spp.
Control	14.67 (22.51a)	18.67 (25.59a)	6.67 (14.96a)	4.00 (11.53b)	2.67 (9.40b)	10.67 (19.06a)	2.67 (9.40b)	9.33 (17.78a)	4.00 (11.53b)
CS(0.02%)	10.67 (19.06b)	13.33 (21.41b)	4.00 (11.53bc)	2.67 (9.40c)	1.33 (6.62c)	9.33 (17.78b)	1.33 (6.62c)	5.33 (13.34b)	1.33 (6.62c)
CS(0.05%)	9.33 (17.78bc)	10.67 (19.06b)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)	6.67 (14.96c)	0.00 (14.47a)	2.67 (9.40d)	0.00 (14.47a)
CS(0.10%)	6.67 (14.96cd)	6.67 (14.96c)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)	4.00 (11.53f)	0.00 (14.47a)	0.00 (14.47b)	0.00 (14.47a)
BAS(0.01%)	6.67 (14.96cd)	10.67 (19.06b)	5.33 (13.34ab)	1.33 (6.62d)	0.00 (14.47a)	10.67 (19.06a)	1.33 (6.62c)	4.00 (11.53c)	0.00 (14.47a)
BAS(0.02%)	4.00 (11.53de)	6.67 (14.96c)	4.00 (11.53bc)	0.00 (14.47a)	0.00 (14.47a)	6.67 (14.96c)	0.00 (14.47a)	1.33 (6.62e)	0.00 (14.47a)
BAS(0.03%)	2.67 (9.400e)	4.00 (11.53d)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)	5.33 (13.34de)	0.00 (14.47a)	0.00 (14.47b)	0.00 (14.47a)
SAS(0.01%)	9.33 (17.78bc)	16.67 (24.09a)	4.00 (11.53bc)	0.00 (14.47a)	1.33 (6.62c)	5.33 (13.34e)	0.00 (14.47a)	2.67 (9.40d)	1.33 (6.62c)
SAS(0.02%)	6.67 (14.96cd)	4.00 (11.53d)	2.67 (9.40c)	0.00 (14.47a)	0.00 (14.47a	5.33 (13.34e)	0.00 (14.47a)	1.33 (6.62e)	0.00 (14.47a)
SAS(0.03%)	4.00 (11.53 de)	2.67 (9.40d)	1.33 (6.62d	0.00 (14.47a)	0.00 (14.47a)	4.00 (11.53f)	0.00 (14.47a)	0.00 (14.47b)	0.00 (14.47a)
Provax-200 WP(0.35%)	0.00 (14.47cd)	0.00 (14.47c)	0.00 (14.47a	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47cd)	0.00 (14.47a)	0.00 (14.47b)	0.00 (14.47a)
$LSD_{0.05}$	3.24	2.64	2.23	2.08	1.33	1.08	1.32	1.21	0.796
CV%	12.47	9.22	10.58	9.44	6.22	4.27	6.20	5.92	3.68

Values within the same column having a common letter(s) do not differ significantly (P=0.01)
CS = chitosan solution, BAS = benzoic acid solution, SAS= salicylic acid solution
Figure in the parentheses are arcsine transformed value

Table 2. Effect of seed priming on the prevalence of seed-borne of fungi (%) of jute seeds in BJC-2197

Treatments	Prevalence of seed-borne fungi (%)						
	Aspergillus niger	*Aspergillus flavus*	*Fusarium moniliforme*	*Fusarium oxysporum*	*Colletotrichum corchori*	*Penicillium* spp.	*Macrophomina phaseolina*
Control	22.67 (28.42a)	22.67 (28.42a)	8.00 (16.42a)	5.33 (13.34a)	6.67 (14.96a)	6.67 (14.96a)	2.67 (9.40b)
CS(0.02%)	10.67 (19.06b)	14.67 (22.51b)	2.67 (9.40d)	2.67 (9.40b)	4.00 (11.53b)	4.00 (11.53c)	0.00 (14.47a)
CS(0.05%)	6.67 (14.96c)	10.67 (19.06c)	0.00 (14.47b)	0.00 (14.47a)	1.33 (6.62d)	2.67 (9.40d)	0.00 (14.47a)
CS(0.10%)	4.00 (11.53e)	6.67 (14.96d)	0.00 (14.47b)	0.00 (14.47a)	0.00 (14.47a)	1.33 (6.62e)	0.00 (14.47a)
BAS(0.01%)	9.33 (17.78b)	10.67 (19.06c)	1.33 (6.62e)	2.67 (9.40b)	2.67 (9.40c)	5.33 (13.34b)	0.00 (14.47a)
BAS(0.02%)	6.67 (14.96c)	5.33 (13.34d)	0.00 (14.47b)	1.33 (6.62c)	1.33 (6.62d)	2.67 (9.40d)	0.00 (14.47a)
BAS(0.03%)	5.33 (13.34d)	4.00 (11.53e)	0.00 (14.47b)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)
SAS(0.01%)	4.00 (11.53e)	10.67 (19.06c)	4.00 (11.53c)	1.33 (6.62c)	4.00 (11.53b)	2.67 (9.40d)	0.00 (14.47a)
SAS(0.02%)	2.67 (9.40f)	5.33 (13.34d)	2.67 (9.40d)	0.00 (14.47a)	2.67 (9.40c)	1.33 (6.62e)	0.00 (14.47a)
SAS(0.03%)	1.3 (6.62g)	4.00 (11.53e)	0.00 (14.47b)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)
Provax-200 WP(0.35%)	0.00 (14.47cd)	0.00 (14.47d)	0.00 (14.47b)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)	0.00 (14.47a)
$LSD_{0.05}$	1.31	1.58	1.33	1.06	0.778	0.608	1.54
CV%	5.25	5.47	6.14	5.21	3.95	3.16	6.47

Values within the same column having a common letter(s) do not differ significantly (P=0.01)
CS = chitosan solution, BAS = benzoic acid solution, SAS= salicylic acid solution
Figure in the parentheses are arcsine transformed value

Table 3. Effect of seed priming on the prevalence of seed-borne of fungi (%) of jute seeds in BJC-7370

Treatments	Prevalence of seed-borne fungi (%)								
	Aspergillus niger	*Aspergillus flavus*	*Fusarium moniliforme*	*Fusarium oxysporum*	*Colletotrichum corchori*	*Penicillium* spp.	*Macrophomina phaseolina*	*Botrytis cinerea*	*Phoma* spp.
Control	14.67 (22.51a)	12.00 (20.26a)	13.33 (21.41a)	10.67 (19.06a)	1.33 (6.62b)	9.33 (17.78a)	2.67 9.40b)	12.00 (20.26a)	8.00 (17.09a)
CS(0.02%)	13.33 (21.41b)	10.67 (19.06ab)	2.67 (9.40d)	5.33 (13.34b)	0.00 (14.47a)	5.33 13.34b)	1.33 6.62c)	6.67 (14.96b)	0.00 (14.47b)
CS(0.05%)	9.33 (17.78d)	6.67 (14.96c)	1.33 (6.62e)	4.00 (11.53c)	0.00 (14.47a)	2.67 (9.40d)	0.00 14.47a)	6.67 (11.53cd)	0.00 (14.47b)
CS(0.10%)	5.33 (13.34g)	5.33 (13.34c)	0.00 (14.47b)	2.67 (9.40d)	0.00 (14.47a)	1.33 (6.62e)	0.00 14.47a)	4.00 (9.40de)	0.00 (14.47b)
BAS(0.01%)	12.00 (20.26c)	6.67 (14.96c)	4.00 (11.53c)	6.67 (14.96b)	0.00 (14.47a)	4.00 (11.53c)	0.00 14.47a)	2.67 (13.34bc)	2.67 (9.40d)
BAS(0.02%)	9.33 (17.78d)	4.00 (11.53d)	2.677 (9.40d)	5.33 (13.34b)	0.00 (14.47a)	2.67 (9.40d)	0.00 14.47a)	5.33 (9.40de)	1.33 (6.62e)
BAS(0.03%)	6.67 (14.96e)	2.67 (9.40e)	2.67 (9.40d)	4.00 (11.53c)	0.00 (14.47a)	0.00 (14.47b)	0.00 14.47a)	1.33 (6.62e)	0.00 (14.47b)
SAS(0.01%)	9.33 (17.78d)	9.33 (17.78b)	4.00 (11.53c)	2.67 (9.40d)	0.00 (14.47a)	2.67 (9.40d)	1.33 6.62c)	4.00 (11.53cd)	4.00 (11.53c)
SAS(0.02%)	5.33 (13.34fg)	6.67 (14.96c)	1.33 (6.62e)	1.33 (6.62e)	0.00 (14.47a)	0.00 (14.47 b)	0.00 14.47a)	2.67 (9.40de)	1.33 (6.62e)
SAS(0.03%)	2.67 (9.40h)	4.00 (11.53d)	1.33 (6.62e)	0.00 (14.47b)	0.00 (14.47a)	0.00 (14.47 b)	0.00 14.47a)	1.33 (6.62e)	0.00 (14.47b)
Provax-200 WP(0.35%)	0.00 (14.47ef)	0.00 (14.47c)	0.00 (14.47b)	0.00 (14.47b)	0.00 (14.47a)	0.00 (14.47 b)	0.00 14.47a)	0.00 (14.47b)	0.00 (14.47b)
$LSD_{0.05}$	1.08	1.62	0.675	1.59	1.00	1.60	1.57	2.58	1.29
CV%	3.84	6.47	3.61	7.46	4.31	7.66	7.36	13.14	6.07

Values within the same column having a common letter(s) do not differ significantly (P=0.01)
CS = chitosan solution, BAS = benzoic acid solution, SAS= salicylic acid solution
Figure in the parentheses are arcsine transformed value

The prevalence of *A. flavus* (22.67 %) and *A. niger*(22.67 %) was the most predominant followed by *F. moniliforme* (8.00 %), *Penicillium* spp. (6.67 %) and *C. corchori* (6.67 %).

In the variety BJC-7370 of jute, nine fungi *viz*. *A. niger, F. moniliforme, A. flavus, B. cinerea, F. oxysporum*, *Penicillium* spp., *Phoma* spp., *M. phaseolina* and *C. corchori* were detected in control treatment, while the least association of seed-borne fungi were recorded in 0.35 % Provax-200 WP, 0.03 % SAS followed by 0.1 % CS and 0.02 % SAS (Table 3). The prevalence of *A. niger* (14.67 %) was the most prevalent followed by *F. moniliforme* (13.33 %), *A. flavus* (12.00 %) and *B. cinerea* (12.00 %).

Nine seed-borne fungi *viz*. *A. niger, F. moniliforme, C. corchori, A. flavus, Penicillium* spp., *B. cinerea, F. oxysporum* and *Phoma* spp. were detected in case of control treatment in variety CVE-3. The least seed-borne fungal infections were recorded in 0.35 % Provax-200 WP, 0.03 % SAS and 0.03 % BAS followed by 0.1 % CS and 0.02 % BAS (Table 4). *Aspergillus niger* (22.67 %) was the most predominant fungus followed by *F. moniliforme* (21.33 %), *C. corchori* (17.33 %), *A. flavus* (10.67 %) and *Penicillium* spp. (10.67 %).

The jute variety O-3820 showed association of seven fungi *viz*. *Penicillium* spp., *A. flavus, F. moniliforme, A. niger, F. oxysporum*, *B. cinerea* and *Phoma* spp. in the control treatment, while the least seed-borne fungal infections were recorded in 0.35 % Provax-200 WP, 0.03 % SAS followed by 0.03 % BAS and 0.1 % CS (Table 5). The most prevalent seed-borne fungus was *Penicillium* spp. (25.33 %) followed by *A. flavus* (21.33 %), *F. moniliforme* (13.33 %), *A. niger* (10.67 %).

Jute seeds of O-72 showed the association of seven fungi *viz*. *Penicillium* spp., *A. flavus, F. moniliforme, A. niger, Phoma* spp., *F. oxysporum* and *B. cinerea* in control treatment, while the least association of seed-borne fungi were recorded in 0.35 % Provax-200 WP, 0.03 % SAS and 0.03 % BAS followed by 0.01 % BAS and 0.02 % SAS (Table 6). The prevalence of *Penicillium* spp. (25.33 %) was the most prevalent followed by *A. flavus* (22.67 %), *F. moniliforme* (17.33 %), *A. niger* (13.33 %).

Effect of seed priming by elicitors on germination of jute seeds

Effects of all elicitor treatments as seed priming of jute had positively increased seed germination compared to untreated control (Figure 1). Benzoic acid solution (0.03 %) and Provax-200 WP (0.35 %) significantly increased (78 % over control) germination of CVL-1 jute seeds followed by T_1, T_4 and T_7 (72 %). In case of BJC-2197 jute seeds, chitosan solution (0.10 %), benzoic acid solution (0.03 %), salicylic acid solution (0.03 %) significantly increased germination percentage (72 %) compared to control (66.67 %) followed by T_2, T_8 and T_{10} (69.33 %). In variety BJC-7370, a significant increment in germination percentage (72 %) was recorded in chitosan solution (0.10 %), salicylic acid solution (0.02 %), salicylic acid solution (0.03 %) compared to control followed by T_8 and T_9 (69.33 %). In case of CVE-3 jute seeds, salicylic acid solution (0.03 %) significantly increased germination percentage (89.33 %) compared to control (68 %) followed by T_7, T_8 and T_{10} (86.67 %). Salicylic acid solution (0.03 %) significantly increased germination percentage (97.00 %) compared to control (72 %) followed by T_3, T_6 and T_8 (94.67 %) in variety O-3820. In case of O-72 jute seeds, salicylic acid solution (0.03 %) significantly increased germination percentage (94.67 %) compared to control (69.33 %) followed by T_8 (93.33 %).

Jute seeds were affected by nine seed-borne fungi belonging to seven genera. Seed-borne fungi of jute commonly found in all jute varieties in the present investigation. Fakir (2001) reported that jute suffered from 12 different diseases among them 10 were seed-borne. In general, all the elicitors showed reduction in seed-borne fungal association to some extent in different varieties of jute. Seed priming mediated by benzoic acid @ 0.03 % showed significant reduction in seed-borne fungal association which was statistically similar to seed treatment by Provax-200 WP @ 0.35 % concentration. Considerable reduction of fungal association was also found in seed priming by benzoic acid @ 0.02 % and salicylic acid @ 0.03 %. In variety BJC-2197 and BJC-7370, seed priming by salicylic acid @ 0.03 % resulted potential suppression of seed-borne fungi which was comparable to seed treatment by Provax-200 WP @ 0.35 % followed by salicylic acid @ 0.02 %. Chitosan @ 0.10 % also showed promising growth suppression of seed-borne fungi in BJC-7370. In the rest of the jute varieties *viz*. CVE-3, O-3820 and O-72, salicylic acid @ 0.03 % and seed treatment by Provax-200 WP @ 0.35 % showed similar and significant reduction of seed-borne fungal association. It is evident from the present investigation that priming of jute seeds by all the elicitors had potential impact on management of fungal association. It was previously reported that some organic elicitors like chitosan and yeast elicitor showed complete inhibition of mycelial growth and thereby reduced the incidence of seed-borne fungal pathogens (Tumpa *et al*. 2017, Tumpa *et al*. 2018).

Table 4. Effect of seed priming on the prevalence of seed-borne of fungi (%) of jute seeds in CVE-3

Treatments	Prevalence of seed-borne fungi (%)							
	Aspergillus niger	*Aspergillus flavus*	*Fusarium moniliforme*	*Fusarium oxysporum*	*Colletotrichum Corchori*	*Penicillium* spp.	*Botrytis cinerea*	*Phoma* spp.
Control	22.67 (28.42a)	10.67 (19.06a)	21.33 (27.50a)	5.33 (13.34a)	17.33 (24.59a)	10.67 (19.06a)	5.33 (13.34a)	2.67 (9.40b)
CS(0.02%)	10.67 (19.06b)	8.00 (16.42b)	6.67 (14.96bc)	4.00 (11.53b)	13.33 (21.41b)	6.67 (14.96b)	0.00 (14.47a)	0.00 (14.47a)
CS(0.05%)	8.00 (16.42bc)	6.67 (14.96bc)	5.33 (13.34bcd)	0.00 (14.47a)	9.33 (17.78c)	4.00 (11.53cd)	0.00 (14.47a)	0.00 (14.47a)
CS(0.10%)	5.33 (13.34d)	5.33 (13.34cd)	2.67 (9.40de)	0.00 (14.47a)	6.67 (14.96de)	2.67 (9.40de)	0.00 (14.47a)	0.00 (14.47a)
BAS(0.01 %)	9.33 (17.78b)	6.67 (14.96bc)	4.00 (11.53cd)	4.00 (11.53b)	8.00 (16.42cd)	8.00 (16.42ab)	2.67 (9.40b)	0.00 (14.47a)
BAS(0.02 %)	5.33 (13.34d)	4.00 (11.53de)	2.67 (9.40de)	2.67 (9.40c)	5.33 (13.34e)	5.33 (13.34bc)	0.00 (14.47a)	0.00 (14.47a)
BAS(0.03 %)	4.00 (11.53d)	2.67 (9.40e)	1.33 (6.62e)	1.33 (6.62d)	2.67 (9.40f)	4.00 (11.53cd)	0.00 (14.47a)	0.00 (14.47a)
SAS(0.01 %)	10.67 (19.06b)	4.00 (11.53de)	8.00 (16.42b)	1.33 (6.62d)	13.33 (21.41b)	5.33 (13.34bc)	1.33 (6.62c)	1.33 (6.62c)
SAS(0.02 %)	9.33 (17.78b)	2.67 (9.40e)	5.33 (13.34bcd)	0.00 (14.47a)	6.67 (14.96de)	4.00 (11.53cd)	0.00 (14.47a)	0.00 (14.47a)
SAS(0.03 %)	4.00 (11.53d)	1.33 (6.62f)	4.00 (11.53cd)	0.00 (14.47a)	5.33 (13.34e)	1.33 (6.62e)	0.00 (14.47a)	0.00 (14.47a)
Provax-200 WP(0.35%)	0.00 (14.47cd)	0.00 (14.47bc)	0.00 (14.47bc)	0.00 (14.47a)	0.00 (14.47de)	0.00 (14.47bc)	0.00 (14.47a)	0.00 (14.47a)
$LSD_{0.05}$	2.82	2.09	3.62	1.58	2.40	2.90	1.58	1.54
CV%	10.02	9.56	15.84	7.79	8.55	13.24	7.08	6.82

Values within the same column having a common letter(s) do not differ significantly (P=0.01)
CS = chitosan solution, BAS = benzoic acid solution, SAS= salicylic acid solution
Figure in the parentheses are arcsine transformed value

Table 5. Effect of seed priming on the prevalence of seed-borne of fungi (%) of jute seeds in O-3820

Treatments	Prevalence of seed-borne fungi (%)						
	Aspergillus niger	*Aspergillus flavus*	*Fusarium moniliforme*	*Fusarium oxysporum*	*Penicillium* spp.	*Botrytis cinerea*	*Phoma* spp.
Control	10.67	21.33	13.33	6.67	25.33	2.67	2.67
	(19.06a)	(27.50a)	(21.41a)	(14.96a)	(30.21a)	(9.40b)	(9.40b)
CS(0.02%)	9.33	18.67	9.33	4.00	17.33	0.00	1.33
	(17.78a)	(25.59a)	(17.78bc)	(11.53b)	(24.59b)	(14.47a)	(6.62c)
CS(0.05%)	5.33	10.67	8.00	2.67	14.67	0.00	0.00
	(13.34bc)	(19.06b)	(16.42cd)	(9.40c)	(22.51c)	(14.47a)	(14.47a)
CS(0.10%)	4.00	8.00	5.33	0.00	9.33	0.00	0.00
	(11.53cd)	(16.42 c)	(13.34ef)	(14.47a)	(17.78e)	(14.47a)	(14.47a)
	6.67	6.00	10.67	2.67	14.67	0.00	1.33
BAS(0.01%)	(14.96b)	(14.96cd)	(19.06b)	(9.40c)	(22.51c)	(14.47a)	(6.62c)
	4.00	6.67	8.00	1.33	10.67	0.00	0.00
BAS(0.02%)	(11.53cd)	(13.34de)	(16.42cd)	(6.62d)	(19.06d)	(14.47a)	(14.47a)
	2.67	5.33	6.67	0.00	6.67	0.00	0.00
BAS(0.03%)	(9.40d)	(11.53e)	(14.96de)	(14.47a)	(14.96f)	(14.47a)	(14.47a)
	5.33	4.00	5.33	1.33	9.33	1.33	0.00
SAS(0.01%)	(13.34bc)	(9.40f)	(13.34ef)	(6.62d)	(17.78e)	(6.62c)	(14.47a)
	5.67	2.67	4.00	0.00	5.33	0.00	0.00
SAS(0.02%)	(13.77bc)	(6.62g)	(11.53fg)	(14.47a)	(13.34g)	(14.47a)	(14.47a)
	0.00	0.00	2.67	0.00	4.00	0.00	0.00
SAS(0.03%)	(14.47b)	(14.47cd)	(9.40g)	(14.47a)	(11.53h)	(14.47a)	(14.47a)
Provax-200	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WP(0.35%)	(14.47b)	(14.47cd)	(14.47de)	(14.47a)	(14.47fg)	(14.47a)	(14.47a)
$LSD_{0.05}$	2.21	2.09	2.29	1.55	1.14	1.82	1.53
CV%	9.32	7.86	8.88	7.72	3.55	8.09	7.21

Values within the same column having a common letter(s) do not differ significantly (P=0.01)
CS = chitosan solution, BAS = benzoic acid solution, SAS= salicylic acid solution
Figure in the parentheses are arcsine transformed value

Table 6. Effect of seed priming on the prevalence of seed-borne of fungi (%) of jute seeds in 0-72

Treatments	Prevalence of seed-borne fungi (%)						
	Aspergillus niger	*Aspergillus flavus*	*Fusarium moniliforme*	*Fusarium oxysporum*	*Penicillium* spp.	*Botrytis cinerea*	*Phoma* spp.
Control	13.33	22.67	17.33	6.67	25.33	2.67	9.33
	(21.41a)	(28.42a)	(24.59a)	(14.96a)	(30.21a)	(9.40b)	(17.78a)
CS(0.02%)	6.67	13.33	8.00	2.67	13.33	0.00	5.33
	(14.96b)	(21.41b)	(16.42b)	(9.40c)	(21.41b)	(14.47a)	(13.34c)
CS(0.05%)	4.00	9.33	5.33	1.33	8.00	0.00	2.67
	(11.53c)	(17.78c)	(13.34de)	(6.62d)	(16.42e)	(14.47a)	(9.40e)
CS(0.10%)	2.67	5.33	4.00	0.00	6.67	0.00	1.33
	(9.40d)	(13.34e)	(11.53f)	(14.47a)	(14.96f)	(14.47a)	(6.62f)
	1.33	6.67	5.33	4.00	10.67	1.33	4.00
BAS(0.01%)	(6.62e)	(14.96d)	(13.34e)	(11.53b)	(19.06c)	(6.62c)	(11.53d)
	0.00	5.33	4.00	2.67	9.33	0.00	1.33
BAS(0.02%)	(14.47b)	(13.34e)	(11.53f)	(9.40c)	(17.78d)	(14.47a)	(6.62f)
	0.00	4.00	2.67	0.00	5.33	0.00	0.00
BAS(0.03%)	(14.47b)	(11.53f)	(9.40g)	(14.47a)	(13.34g)	(14.47a)	(14.47b
	2.67	2.67	6.67	0.00	8.00	0.00	2.67
SAS(0.01%)	(9.40d)	(9.40g)	(14.96c)	(14.47a)	(16.42e)	(14.47a)	(9.40e)
	1.33	1.33	4.00	0.00	6.67	0.00	1.33
SAS(0.02%)	(6.62e)	(6.62h)	(11.53f)	(14.47a)	(14.96f)	(14.47a)	(6.62f)
	0.00	0.00	1.33	0.00	4.00	0.00	0.00
SAS(0.03%)	(14.47b)	(14.47de)	(6.62h)	(14.47a)	(11.53h)	(14.47a)	(14.47b)
Provax-200	0.00	0.00	0.00	0.00	0.00	0.00	0.00
WP(0.35%)	(14.47b)	(14.47de)	(14.47cd)	(14.47a)	(14.47f)	(14.47a)	(14.47b)
$LSD_{0.05}$	0.925	1.35	1.12	0.833	1.08	0.776	0.882
CV%	0.315	0.461	0.380	0.284	0.367	0.265	0.301

Values within the same column having a common letter(s) do not differ significantly (P=0.01)
CS = chitosan solution, BAS = benzoic acid solution, SAS= salicylic acid solution
Figure in the parentheses are arcsine transformed value

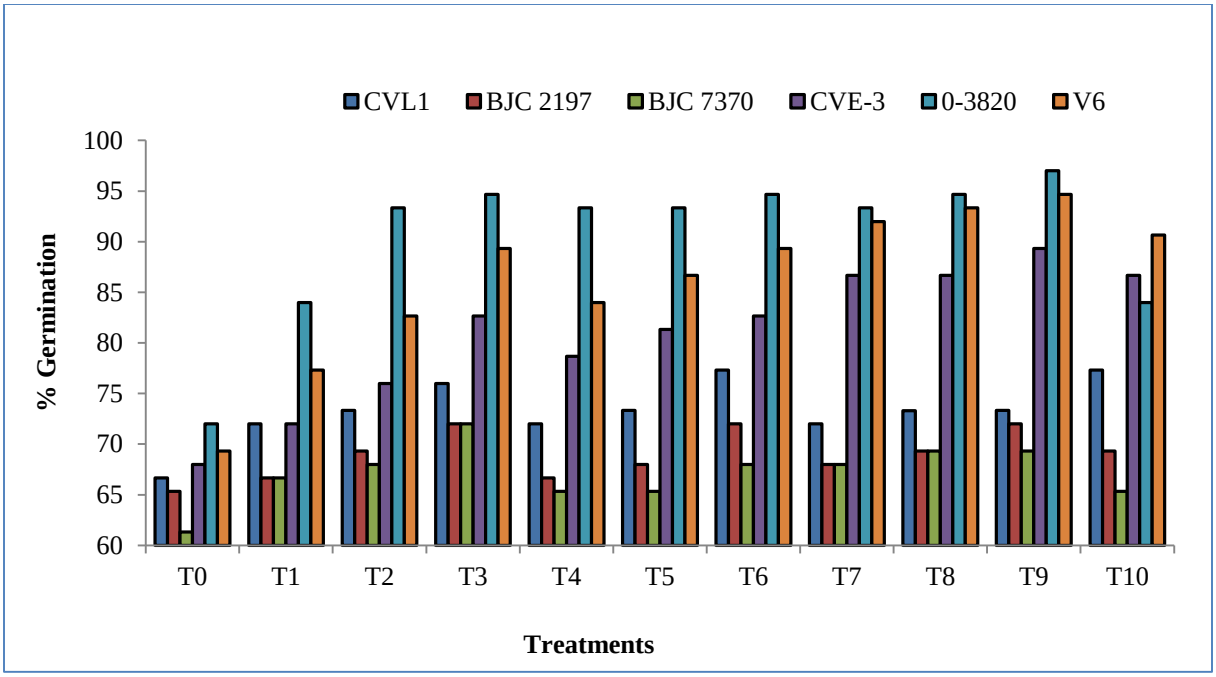

Figure 1. Effect of seed priming by chitosan, benzoic acid and salicylic acid on germination of different varieties of jute seeds [T0 = Control, T1 = CS (0.02 %), T2 = CS (0.05 %), T3 = CS (0.10 %), T4 = BAS (0.01 %), T5 = BAS (0.02 %), T6 = BAS (0.03 %), T7 = SAS (0.01 %), T8 = SAS (0.02 %), T9 = SAS (0.030 %), T10 = Provax-200 WP (0.35%), CS = chitosan solution, BAS = benzoic acid solution, SAS= salicylic acid sol]

The findings of the present investigation was in conformity with EI-Mahady *et al.* (2015), where they reported that salicylic acid reduced fungal seed infection in a dose-dependent manner followed by propionic acid and benzoic acid. It was reported that benzoic acid inhibited mycelial growth of *Rhizoctonia solani*, *Sclerotinia sclerotiorum*, *Phytopthora capsici* and *Pyricularia oryzae* (Yoon *et al*. 2012) which was also in support of the present findings. The findings of the present investigation was in conformity with Mondol *et al*. (2018), where they also reported that chitosan, salicylic acid and benzoic acid suppress the growth of *Magnaporthe oryzae triticum* under *in-vitro* condition.

Germination of jute seeds were significantly influenced by all elicitors. The effect was not variety dependent. In most cases salicylic acid @ 0.03 %, benzoic acid @ 0.03 % and chitosan @ 0.10 % significantly increased germination percentage of jute seeds. The findings of the present investigation were in agreement with Lian-Ju *et al*. (2014), who reported that, chitosan coating increased seed germination, plant growth and wheat yield efficiently.

Thus, it can be concluded that chitosan, salicylic acid and benzoic acid is effective for priming jute seeds to reduce the seed-borne association of *Aspergillus, Penicillium, Botrytis, Fusarium, Phoma, Colletotrichum* and *Macrophomina*. These elicitors also enhance the germination percentage of jute seeds. Therefore, as an alternative to chemical fungicides these elicitors could be used for management of seed-borne infection of jute seeds. Present research also provides an impression that the elicitors can be formulated for commercial production and makes it available for the farmers for sustainable seed production of jute.

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