Bleaching powder [$Ca(OCl)_2$], a new option for management of Stem rot of Jute (*Corchorus olitorius* L. and *C. capsularis* L.) caused by *Macrophomina phaseolina* (Tassi) Goid

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To search for an alternative option against stem rot of jute (*Corchorus olitorius* L. and *C. capsularis* L.) caused by *Macrophomina phaseolina* (Tassi) Goid., experiment was carried out using bleaching powder or calcium hypochlorite [$Ca(OCl)_2$]. In field experiment, bleaching powder were applied as soil application at different doses @ 5 - 150 kg/ha and sowing was done with normal NPK fertilizers after gestation period of 2 - 15 days in randomized block design with three replications on a new jute variety, JRO 8432 at main farm of CRIJAF, Nilganj, Barrackpore, India, during normal cropping season of 2012-13. The radial growth of *M. phaseolina* was completely checked in food poisoning technique *in vitro* at 5000 ìg/ml of bleaching powder both at 24 and 48 hours after incubation. At lower dose growth inhibition decreased. At 100 and 1000 ìg/ml, 87.3, 93.3 % and 93.6, 96.6 inhibitions were observed after 24 and 48 hours, respectively. During further incubation of 24 hrs at a concentration of 5000 ìg/ml of bleaching powder, no fresh growth was observed indicating inhibition of *M. phaseolina* completely. In the experimental field, out of all the doses of bleaching powder, soil application @ 30 kg/ha 7 days ahead of sowing was found best against jute stem rot with highest dry fibre yield compared to check (with no soil application) and higher (50 – 150 kg/ha) and lower (5 – 20 kg/ha) doses in all the four dates (30 – 120 DAS) of observations. It restricted stem rot of jute to 2.1 and 6 % as compared to 15.1 and 24 % in untreated check at 90 – 120 DAS, respectively. As the dose of soil application of bleaching powder increased from @ 5 – 120 kg/ha, the jute stem rot decreased slowly reaching minimum at 30 kg/ha indicating that this dose being most effective against jute stem rot.

Key words: Bleaching powder, $Ca(OCl)_2$, stem rot, jute, *Corchorus olitorius*, *C. capsularis, Macrophomina phaseolina*

INTRODUCTION

Macrophomina phaseolina (Tassi) Goid. is an extremely notorious fungal plant pathogen causing enormous loss to crop production worldwide affecting a large number of agricultural crops grown under high temperatures and water stress. Its management is becoming more and more difficult due to its versatility of three different forms, namely, *Rhizoctonia bataticola* as sclerotial stage, *Orbilia obscura* as teleomorph (not observed in jute) and most common and damaging phase in jute being *M. phaseolina* as pycnidial stage. Its host range includes crops belonging to family poaceae (like, rice, corn), leguminosae (like, chickpea, lentil, field pea, urdbean, mungbean), solanaceae (like, brinjal, tomato, potato, chili) and many other ornamental plants.

Jute, also called golden fibre, is cultivated as pre-*kharif* crop mainly in the eastern India in West Bengal, Bihar and Assam contributing 77, 17.1 and 5.5% of National production, respectively (Anonymous, 2013). Stem rot caused by *M. phaseolina* is economically the most important disease affecting both yield and quality of fibre and seed in both

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cultivated species, namely, *Corchorus olitorius* L. and *C. capsularis* L. in all jute growing areas in India and other countries. Stem rot is the common name but the pathogen may infect any part of the plant at any stage of growth right from germination to harvest producing various symptoms, like, damping-off, seedling blight, leaf blight, stem rot, collar rot, root rot, stem break and spot on pod especially in seed crop (Roy *et al*. 2008). The disease is nightmare for both researchers and farmers due to its devastating nature. It is seed, soil as well as air borne and its management targets manipulation of soil, pre-sowing seed treatment and foliar spraying of fungicides or judicious integration of all.

Among various methods of management of jute stem rot, use of botanicals (De, 2012a), fungicides (De, 2012c; De, 2014b; De *et al.* 2010; 2014), host resistance (De and Mandal, 2012 a and b), balanced NPK fertilizer (De, 2014a and 2015), and manipulation of date of sowing (De, 2012b; De, 2013) were most important. However, no nonconventional option was earlier tried against this disease, especially targeting soil borne inoculum.

To search for a suitable alternative method to pollution encouraging deadly fungicides, experiments were carried out using bleaching powder against stem rot of jute caused by *M*. *phaseolina* both *in vitro* and in the fields.

MATERIALS AND METHODS

Bioassay of bleaching powder or calcium hypochlorite [$Ca(OCl)_2$] was carried out *in vitro* against *M. phaseolina* (isolated from jute stem rot infected plant and purified) on potato dextrose agar (PDA) using standard food poisoning technique at 0 to 5000 μg/ml concentrations after incubation at 28 + 1 ^{0}C for 24 - 48 hours and growth inhibition percentage was noted. A field experiments was also carried out with soil application of bleaching powder at different doses @ 5 - 150 kg/ha and sowing of seeds was done after gestation period of 2 - 15 days with full P + full K +1/3 N as basal during sowing + 1/3 N at 30 DAS + 1/3 N at 60 DAS in randomized block design with three replications on a new jute variety, JRO 8432 (*Shakti Tossa)* at main farm of CRIJAF, Nilganj, Barrackpore, India during two consecutive cropping seasons, 2013 -14. The soil of the experimental field was neutral in nature (pH 6.5 - 7.5) and sandy loam in texture. The inoculum density of *M. phaseolina* was 3.4×102 colony forming units at the surface up to 5 cm depth, gradually decreasing with the depth. Except soil application of bleaching powder at different dose, standard package of agronomic practices for commercial cultivation of jute crop were followed. No other plant protection measure/ chemical was applied. Incidence of stem rot was carefully monitored throughout the cropping season and percentage incidence of stem rot was noted at fortnightly intervals starting from 30 days after sowing (DAS) after final thinning and manual weeding of crop using following formula.

$$\text{Stem rot incidence (\%)} = \frac{\text{Number of infected plants}}{\text{Total number of plants observed}} \text{ X } 100$$

RESULTS AND DISCUSSION

Effect of bleaching powder on M. phaseolina in vitro

In food poisoning technique *in vitro,* full growth of 90 mm of *M. phaseolina* was observed in untreated check plate after 48 hours of incubation. The radial growth of *M. phaseolina* was slowly decreased with increasing concentration of bleaching powder in the PDA. It was completely checked with no visible mycelial growth at 5000 μg/ml of bleaching powder both at 24 and 48 hours after incubation. As dose was lowered to 2.0 μg/ml, growth inhibition decreased to 65.8% at 24 hrs and 76.1% at 48 hrs. At 10, 100 and 1000 μg/ml concentration of bleaching powder, 80.9, 87.3, 93.6 and 87.7, 93.3, 96.6 % growth inhibitions of *M. phaseolina* were observed after 24 and 48 hours of incubation, respectively. During further incubation of 24 hrs at a concentration of 5000 μg/ml of bleaching powder, no fresh growth was observed indicating inhibition of *M. phaseolina* completely. But in concentration lower than 5000 μg/ml, fresh growth of *M. phaseolina* was noted in spite of presence of bleaching powder in the media (Table 1).

Effect of bleaching powder on stem rot of jute in the field during 2013

In the field, the stem rot incidence was lowest in soil application of bleaching powder @ 30 kg/ha 7 days ahead of jute sowing in all the four dates (30 – 120 DAS) of observations. It restricted stem rot of jute to 2.1 and 6 % only as compared to 15.1

Table 1: Effect of bleaching powder [$Ca(OCl)_2$] on mycelial growth of *Macrophomina phaseolina* (Tassi) Goid causing stem rot of jute *(Corchorusolitorius* L. and *C. capsularis* L.) after 24 -48 hours of incubation *in vitro*

Concentration (µg/ml)	After 24 hours of incubation		After 48 hours of incubation	
	Radial growth (mm)*	% inhibition	Radial growth (mm)*	% inhibition
Check	31.50	-	90.00	-
2.0	10.75	65.87	21.50	76.11
5.0	8.25	73.81	15.50	82.78
10.0	6.00	80.95	11.00	87.78
50.0	5.00	84.13	7.50	91.67
100.0	4.00	87.30	6.00	93.33
500.0	3.00	90.48	5.00	94.44
1000.0	8.00	93.65	3.00	96.67
5000.0	0.00	100.00	0.00	100.00
CD (P=0.05)	0.71	-	0.84	-
SEm±	0.35	-	0.41	-

*Mean of four replications

Table 2 : Effect of soil application of bleaching powder [$Ca(OCl)_2$] on stem rot of jute (cv JRO 8432)in the field during 2013

	Treatments	Incidence (%) of stem rot of jute at*				% reduction of stem rot
		30 DAS	60 DAS	90 DAS	120 DAS	
T_1	Soil application @ 5 kg/ha and sowing after 2 days	0.21 (2.36)	0.61 (4.41)	3.46 (10.71)	8.27 (16.67)	65.51
T_2	Soil application @ 10 kg/ha and sowing after 2 days	0.22 (2.69)	0.48 (3.94)	2.70 (9.40)	7.37 (15.74)	69.34
T_3	Soil application @ 20 kg/ha and sowing after 2 days	0.25 (2.24)	0.56 (4.30)	2.29 (8.44)	6.97 (14.98)	71.00
T_4	Soil application @ 30 kg/ha and sowing after 7 days	0.12 (1.97)	0.39 (4.12)	2.16 (8.37)	6.02 (14.14)	74.95
T_5	Soil application @ 50 kg/ha and sowing after 7 days	0.26 (2.87)	0.74 (4.24)	2.30 (8.66)	6.10 (14.26)	74.62
T_6	Soil application @ 80 kg/ha and sowing after 10 days	0.22 (2.63)	0.79 (4.97)	2.95 (9.62)	6.39 (14.47)	73.41
T_7	Soil application @ 100 kg/ha and sowing after 15 days	0.31 (2.44)	0.68 (5.47)	3.11 (9.41)	6.83 (14.84)	71.58
T_8	No soil application (Check)	0.50 (3.99)	2.32 (8.75)	15.16 (22.90)	24.04 (29.33)	-
	CD (P=0.05)	(2.17)	(2.54)	(3.91)	(3.44)	-
	SEm+	(1.03)	(1.21)	(1.86)	(1.64)	-

*Figures in the parentheses represent angular conversion values

and 24 % in untreated check at 90 – 120 DAS, respectively. As the dose of soil application of bleaching powder increased from @ 5 – 100 kg/ ha, the incidence of jute stem rot decreased slowly reaching minimum at 30 kg/ha indicating that this dose was most effective against jute stem rot. In soil application of bleaching powder @ 50, 80 and 100 kg/ha, the incidences of jute stem rot were 6.1, 6.3 and 6.8% only, respectively, at 120 DAS compared to 24% in check where no soil application of bleaching powder was done. Bleaching powder @ 30 kg/ha exhibited highest stem rot reduction of 74.9%, it was followed by 74.6, 73.4 and 71.5% at 50, 80 and 100 kg/ha respectively, compared to check (Table 2).

The incidence of stem rot increased over time during the growth period of jute crop in all the treatments and check as well. In case of bleaching powder @ 30 kg/ha, stem rot began with 0.1% at 30 DAS and it later slowly increased to 2.1% at 90 DAS and finally to 6% at 120 DAS. Bleaching powder @ 5 and 100 kg/ha showed stem rot of 0.2 and 0.3 % at 30 DAS, 3.4 and 3.1 % at 90 DAS and

Table 3: Effect of soil application of bleaching powder [$Ca(OCl)_2$] on stem rot of jute (cv JRO 8432) in the field during 2014

	Treatments	Incidence (%) of stem rot of jute at*				% reduction of stem rot
		30 DAS	60 DAS	90 DAS	120 DAS	
T_1	Soil application @ 5 kg/ha and sowing after 2 days	0.11 (1.55)	0.45 (3.82)	3.71 (11.09)	10.38 (18.79)	61.88
T_2	Soil application @ 10 kg/ha and sowing after 2 days	0.05 (0.75)	0.28 (2.98)	3.11 (10.14)	9.10 (17.56)	66.58
T_3	Soil application @ 20 kg/ha and sowing after 2 days	0.06 (0.84)	0.24 (2.76)	3.23 (10.34)	7.92 (16.34)	70.91
T_4	Soil application @ 30 kg/ha and sowing after 7 days	0.06 (0.78)	0.22 (2.62)	3.05 (10.05)	5.15 (13.11)	81.08
T_5	Soil application @ 50 kg/ha and sowing after 7 days	0.11 (1.52)	0.17 (2.35)	4.08 (11.65)	6.33 (14.57)	76.75
T_6	Soil application @ 80 kg/ha and sowing after 10 days	0.05 (0.76)	0.22 (2.63)	4.91 (12.71)	6.74 (15.03)	75.24
T_7	Soil application @ 100 kg/ha and sowing after 15 days	0.13 (1.17)	0.23 (2.71)	3.96 (11.44)	8.12 (16.55)	70.17
T_8	Soil application @ 120 kg/ha and sowing after 15 days	0.11 (1.52)	0.16 (2.31)	3.44 (10.68)	7.43 (15.79)	72.71
T_9	Soil application @ 150 kg/ha and sowing after 15 days	0.06 (0.82)	0.19 (2.49)	4.29 (11.93)	7.71 (16.07)	71.68
T_{10}	No soil application (Check)	0.54 (4.56)	4.31 (11.98)	14.59 (22.45)	27.23 (31.44)	-
	CD (P=0.05)	(2.26)	(0.82)	(1.73)	(1.37)	-
	SEm±	(1.08)	(0.39)	(0.82)	(0.65)	-

*Figures in the parentheses represent angular conversion values

finally at 120 DAS, 8.2 and 6.8 % stem rot were observed. In check, the jute stem rot grew rapidly from initial 0.5% at 30 DAS, 2.3% at 60 DAS to 15.1% at 90 DAS and finally reached a peak of 24% at 120 DAS (Table 2).

Effect of bleaching powder on stem rot of jute in the field during 2014

Among all soil treatments with application of 5- 150 kg/ha bleaching powder, jute stem rot was lowest in case of 30 kg/ha (applied 7 days ahead of jute sowing) with 3 and 5.1 % disease at 90 and 120 DAS, respectively. This was followed by soil application @ 50, 80 and 100 kg/ha with 4, 4.9, 3.9 and 6.3, 6.7, 8.1% disease, respectively, at 90 and 120 DAS. Higher doses of soil application of bleaching powder of 120 and 150 kg/ha were also tried but their effect on jute stem rot was almost at par with lower doses of 10 – 80 kg/ha with 3.4, 4.2 and 7.4, 7.7% jute stem rot, respectively, at 90 and 120 DAS as compared to check with 14.5 and 27.2 % disease. Application of lower doses of bleaching powder @ 5, 10 and 20 kg/ha was less effective on jute stem rot than that of higher doses and they showed 3.7, 3.1, 3.2 and 10.3, 9.1, 7.9% disease at 90 and 120 DAS, respectively. Percentage reduction of jute stem rot compared to untreated check was also highest in case of pre-sowing bleaching powder application @ 30 kg/ha (81%) and it was followed by 50 kg/ha (76.7%), 80 kg/ha (75.2%) and 120 kg/ha (72.7%) (Table 3).

When progress of jute stem rot was considered over time, it was observed that in check where no intervention was done, jute stem rot made a quick rise in its incidence from initial 0.5% at 30 DAS, to 4.3% at 60 DAS, to 14.5% at 90 DAS and finally it reached a peak of all time high of 27.2 % at 120 DAS. But the progress of jute stem rot was slow in all the treatments with soil application of bleaching powder @ 5 – 150 kg/ha. At 5 kg/ha, the disease increased from 0.1% at 30 DAS to 3.7% at 90 DAS to10.3% at 120 DAS. At 10 – 20 kg/ha, the disease increased from 0 at 30 DAS to 0.2% at 60 DAS, 3% at 90 DAS and finally to 9.1 and7.9% at 120 DAS, respectively. The growth of jute stem rot was slowest in case of soil application of bleaching

Table 4: Pooled effect of bleaching powder [$Ca(OCl)_2$] on stem rot of jute (cv JRO 8432)in the field during 2013-14

	Treatments	% Stem rot of jute at (pooled mean of two years) *				% reduction of stem rot	Dry fibre yield (q/ha)
		30 DAS	60 DAS	90 DAS	120 DAS		
T_1	Soil application @ 5 kg/ha and sowing after 2 days	0.16 (2.03)	0.53 (4.15)	5.31 (13.32)	9.33 (17.78)	63.62	18.67
T_2	Soil application @ 10 kg/ha and sowing after 2 days	0.14 (2.07)	0.38 (3.49)	4.39 (12.09)	8.24 (16.67)	67.86	19.99
T_3	Soil application @ 20 kg/ha and sowing after 2 days	0.16 (1.74)	0.40 (3.62)	3.91 (11.40)	7.44 (15.77)	70.97	22.19
T_4	Soil application @ 30 kg/ha and sowing after 7 days	0.09 (1.66)	0.37 (3.46)	3.68 (11.06)	5.58 (13.65)	78.23	26.22
T_5	Soil application @ 50 kg/ha and sowing after 7 days	0.18 (2.45)	0.45 (3.53)	4.35 (12.03)	6.22 (14.43)	75.76	25.01
T_6	Soil application @ 80 kg/ha and sowing after 10 days	0.13 (2.03)	0.50 (4.03)	5.41 (13.43)	6.57 (14.82)	74.39	24.10
T_7	Soil application @ 100 kg/ha and sowing after 15 days	0.22 (1.99)	0.62 (4.32)	5.09 (13.03)	7.48 (15.82)	70.84	21.16
T_8	Soil application @ 120 kg/ha and sowing after 15 days	0.11 (1.52)	0.16 (2.31)	3.44 (10.68)	7.43 (15.79)	71.02	23.10
T_9	Soil application @ 150 kg/ha and sowing after 15 days	0.06 (0.82)	0.19 (2.49)	4.29 (11.93)	7.71 (16.07)	69.92	20.30
T_{10}	No soil application (Check)	0.57 (4.30)	3.32 (10.49)	14.88 (22.68)	25.64 (30.42)	-	12.43
	CD (P=0.05)	(2.06)	(1.71)	(1.28)	(2.18)	-	0.91
	SEm±	(4.15)	(3.04)	(2.28)	(1.04)	-	0.43

*Figures in the parentheses represent angular conversion values

powder @ 30 kg/ha with only 0 at initial level to 0.2% at 60 DAS, 3% at 90 DAS and finally to a level of 5.1% at 120 DAS, indicating its most effectiveness across the crop duration against jute stem rot (Table 3).

Pooled effect of bleaching powder on stem rot of jute in the field during 2013-14
Effect on stem rot of jute

Jute stem rot during the maturity of the crop at 120 DAS was lowest (5.5%) in case of pre-sowing bleaching powder application @ 30 kg/ha and it reduced the disease to 78.2% as compared to check. This was followed by 50, 80, 20 and 100 kg/ha bleaching powder with 6.2, 6.5, 7.4 and 7.5 % jute stem rot and they reduced the disease by 75.7, 74.3, 70.9 and 70.8% as compared to check, respectively. Bleaching powder application @ 5 - 20 kg/ha exhibited 9.3, 8.2 and 7.4% jute stem rot at 120 DAS and correspondingly reduced the disease by 63.6, 67.8 and 70.9%. Out of all the doses of bleaching powder, soil application @ 30 kg/ha was the best against jute stem rot compared to

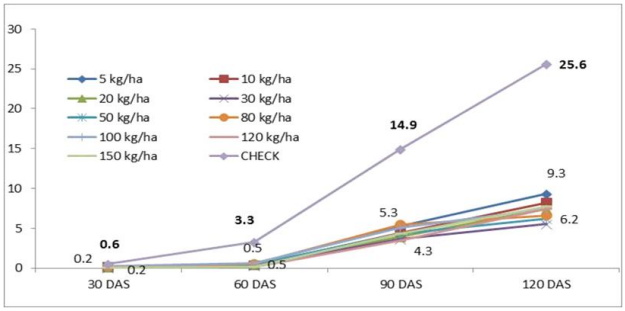

Fig.1: Effect of soil application of bleaching powder [$Ca(OCl)_2$] on stem rot of jute (cv JRO 8432) in the field during 2013-14

check (with no soil application) and other doses (Table 4).

Effect on dynamics of stem rot of jute

Initially at 30 DAS, there was no statistically significant difference in jute stem rot among various treatments including check but as the crop grew older, there was marked difference among various doses (5 – 150 kg/ha) of soil application of bleaching powder. In check, jute stem rot had a rapid progress from initial 0.5% to 3.3 % at 60 DAS,

to 14.8% at 90 DAS and finally reached a peak of 25.6% at the end of cropping season at 120 DAS. The increase of jute tem rot was slowest in bleaching powder application @ 30 kg/ha and it was zero initially and later progressed very slowly to only 0.3% at 60 DAS, to 3.6% at 90 DAS and finally to 5.5 % at 120 DAS. The disease progressed from initial 0.1% to 5.3% at 90 DAS and to 9.3 % at120 DAS in case of 5 kg/ha. Jute stem rot progressed from initial very low level to 3.9% at 90 DAS and to 7.4% at120 DAS in case of 20 kg/ha. In 50- 150 kg/ha, jute stem rot was very low up to 60 DAS of crop growth after that it gradually increased to 3 - 5% at 90 DAS and finally to 6 – 7 % at maturity of the crop (Figure 1; Table 4).

Bleaching powder, stem rot of jute and time

After application of bleaching powder a period of time was given as gestation period to allow the chemical to work in soil before sowing seeds of the crop. This also releases the deleterious toxic chemicals from soil and saves the newly emerged plumules and radicles from seeds in soil. Sowing immediately after application of bleaching powder may damage to the new and young seedlings due to toxic active oxygen and chlorine molecules emanating from hypochlorous acid produced from bleaching powder decomposition in soil.

Initially at 30 and 60 DAS there was no major difference in jute stem rot incidence among various treatments and effect of bleaching powder was only marginal among different doses of bleaching powder up to 90 DAS. However, at the maturity of the crop at 120 DAS, marked variation was observed in jute stem rot incidence among various treatments, indicating soil application of bleaching powder @ 30 kg/ha (applied 7 days ahead of jute sowing) was most effective soil treatment against jute stem rot compared to check (with no soil application) and higher (50 – 150 kg/ha) and lower (5 – 20 kg/ha) doses (Table 4). As dose increased from @ 5 – 150 kg/ha, stem rot decreased slowly reaching minimum at 30 kg/ha indicating that this dose being most effective.

Soil application of bleaching powder and dry fibre yield of jute

Dry fibre yield of jute was higher in plots where stem rot incidence was lower as a consequence of soil application of bleaching powder resulting in reduction in damage caused by stem rot and vice versa. The dry fibre yield of jute was highest (26.2 q/ha) in case of soil application @ 30 kg/ha 7 days ahead of sowing and it was correlated with lowest stem rot incidence (5.5%). This was followed by soil application @ 50 kg/ha, 80 kg/ha and 120 kg/ha, respectively, with 25, 24.1 and 23.1 q/ha dry fibre yield and these plots also showed less damage by stem rot disease. Soil application @ 5 kg/ha, 10 kg/ha, 20 kg/ha, 100 kg/ha and 150 kg/ha resulted in dry fibre yield of 18.6, 19.9, 22.1, 21.6 and 20.3 q/ha, respectively. Lowest dry fibre yield of 12.4/ha was recorded in check plot with no soil application of bleaching powder. The fibre yield in check plot was lowest because almost one quarter of jute plants were killed by stem rot here (Table 4).

There are three major components of spread of jute stem rot, namely, seed, soil and air-borne pycnidiospores. A number of good fungicides are available for management of seed and air- borne pycnidiospores (De, 2012c; De, 2014b and De *et al.* 2010). However, for management of soil component, no chemical and physical treatment (deep ploughing, soil solarization) was feasible except pre-sowing application of lime or gypsum, especially, in acid soils. Therefore, soil application of bleaching powder followed by jute sowing after a gestation period of few days would emerge as new and strong alternative method for management of *M. phaseolina* causing stem rot of jute and many other agricultural and horticultural crops.

The reason for reduction of jute stem rot using bleaching powder may be attributed to increased soil pH due to formation of $Ca(OH)_2$ (lime) and adding calcium to soil, besides direct detrimental effect on pathogen itself. The broad-spectrum effectiveness of bleaching powder is due to its chemical reaction with microbes. Rather than acting in an inhibitory or toxic fashion, like antibiotics, bleaching powder quickly reacts with microbial cells, irreversibly denatures anddestroys many pathogens. Bleaching powder reacts with a microbe's heat shock proteins, stimulating their role as intra-cellular chaperone and causing the microorganism to form into clumps (much like an egg that has been boiled) that will eventually die off. Bleaching powder's base acidity compromises a microbial lipid membrane, a reaction similar to popping a balloon (Wikipedia, 2015). The range of micro-organisms effectively killed by bleaching

powder is extensive, making it an extremely versatile disinfectant.

Atmospheric carbon dioxide and water react with bleaching powder ($Ca(OCl)_2$) to release hypochlorous acid which gives a characteristic smell to the bleaching powder. Hypochlorous acid decomposes readily to atomic oxygen. This atomic oxygen acts as bleaching agent through oxidation $a(OCl)_2 + H_2O + CO_2 \rightarrow CaCO_3 + CaCl_2 + 2HClO$ hypochlorous acid HCl–OHCl + [O] atomic oxygen 2HCl + [O] - $H_2O + Cl_2$ chlorine.

In another way, H_2CO_3 from CO_2 and moisture on the bleaching powder acts on the $CaCl_2$ to release some HCl which acts on the HClO releasing Chlorine (Wikipedia, 2015):

$HClO + HCl \rightarrow H_2O + Cl_2$ or $CaCl_2 + 2HClO = Ca(OH)_2 + 2Cl_2$ chlorine formation

Bleaching powder @ 50 g/ sq m was effective against bacterial wilt of potato caused by *Pseudomonas solanacearum* (=*Ralstonia solanacearum)* (Verma and Shekhawat, 1991). Bleaching powder @ 12 kg/ha was effective against bacterial wilt of potato caused by *Ps. solanacearum* (Arora, 2012). Stable bleaching powder (Klorocin) @ 12.5 kg/ha as soil application was effective against bacterial blight of rice caused by *Xanthomonas campestris* var. *campestris* (Ganeshan *et al*. 1988). Bleaching powder @ 15 kg/ha was effective against bacterial wilt of tomato caused by *Ps. solanacearum*. Bleaching powder @ 50 g/ sq m was effective against black leg, wilt and soft rot of potato caused by *Ps. solanacearum*. Soil drenching with bleaching powder @ 2 g /l was effective against bacterial soft rot of banana. Drenching bleaching powder @ 16.5 kg /ha was effective against bacterial stalk rot of maize (Thind and Payak, 1972). Stable bleaching powder (containing 35 % chlorine) @ 1000 ppm was effective against black leg and soft rot of potato caused by *Erwinia caratovora* ssp. *caratovora* (Saini and Parashar, 1980). Stable bleaching powder @ 30 kg/ha was effective against powdery scab of potato caused by *Spongspora subterranea* (Hamidullah *et al*. 2002). Soil application of bleaching powder @ 20 kg/ha was also effective against bacterial blight of pomegranate.

Soil application of bleaching powder could be a new promising option for the management of *M*. *phaseolina* not only in jute but also many other susceptible crops in organic agriculture, in future.

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