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INFLUENCE OF pH AND EC OF WATER ON THE EFFICACY OF *BACILLUS THURINGIENSIS* VAR. *KURSTAKI* AGAINST *SPODOPTERA LITURA* IN TOBACCO NURSERIES

S. GUNNESWARA RAO AND U. SREEDHAR

Central Tobacco Research Institute, Rajahmundry – 533 105

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In agriculture water is mainly used for irrigation and the other major usage is for spraying plant protection chemicals. The quality of water used in agriculture generally depends on the total concentration of dissolved salts and pH. For evaluating the quality of water electrical conductivity (taken as measure of soluble salt content), chlorides and pH are measured. In tobacco cultivation the permissible limits of water for irrigation are EC <0.4 dS/m and pH 6.5-7.5 (Krishnamurthy and Nagarajan, 2001). In highly alkaline water (pH>8) many chemicals undergo a process called alkaline hydrolysis. This process causes the breakdown of the active ingredient into other compounds which can reduce the effectiveness of the pesticide over time. Very acidic water can also affect the stability and physical properties of some pesticide formulations. Similarly water with high salt concentration may denature the crystal protein in *B.t* formulations (Fast, 1981). However in many tobacco growing areas when the water is used for spraying in plant protection interventions, these limitations are going unnoticed and water suitability for spraying particularly for different biopesticides needed experimental investigation. Hence, experiments were conducted in tobacco nursery using water with different pH and EC on the efficacy of *Bacillus thuringeinsis* var.*kurstaki* (NBAII strain) against tobacco caterpillar to determine permissible limits of pH and EC.

Aluminum chloride (for low pH) and sodium bicarbonate (for high pH) were used to prepare water with pH 5, 6, 7, 8 and 9. *B.t.k* @ 1.5 l/ha was added to the water with different pH and used for spraying. Different EC levels (0.5 -6.0 dS/m) were obtained by mixing sodium chloride in required quantities. *B.t.k* was mixed with water with different pH @ 1.5 l/ha and applied in one m^2 nursery beds after the release of twenty 2nd instar *S. litura* larvae reared on tobacco on each nursery bed. Four replications were maintained with five treatments and one control (water spray). Observations were taken on per cent seedlings damaged at 3 and 7 days and number of larvae dead and diseased at seven days after application of treatments.

EC of spray solutions

Significant differences were not found with respect to seedling damage among different treatments (EC) at 3 days (Table 1) after spraying and all were superior to control (no spray). At 7 days also the same trend continued (Table 2). Regarding the recovery of diseased larvae all treatments showed equal incidence of the disease caused by *B.t.k* and were not affected by E.C concentration ranging from 0.5 to 6.0 dS/m (Table 3). All the treatments were superior to control without spray. Significant differences between the two seasons were observed with respect to seedling damage. Sodium and chloride ions in the spray solutions do not denature the crystal protein whereas calcium, magnesium and barium ions in the solution destabilize the crystal toxin (Fast, 1981). It was concluded from the two seasons results that B.t.*k* was not affected in aqueous solutions with EC ranging from 0.5 to 6.0 dS/m.

pH of spray solutions

Pooled data indicates that at pH levels from 5 to 8, seedling damage was not significantly varied at 3 and 7 days after spraying. At pH 9 the damage was significantly higher at 7 days. Significant differences were observed with respect to recovery of *B*.t.*k*. affected larvae. Higher per cent recovery of diseased larvae was noticed at pH 7, distilled water and pH 8 and lowest in control (no spray) followed by pH 9. Evidence of experimental results showed that harm might have occurred to the *B.t* toxin or spores with increase in pH of spray

Table 1: Effect of water quality (EC) on *B.t.k.* - seedlings damaged at 3 days (%)

S. No	Treatments (dS/m)	2009	2010	Pooled
1.	E.C. 0.5	11.27	11.89	11.58
2.	E.C. 1.0	12.41	11.27	11.84
3.	E.C. 2.0	14.04	12.77	13.46
4.	E.C. 4.0	9.26	14.89	12.07
5.	E.C. 6.0	10.39	15.59	12.99
6.	Distilled water	13.29	10.39	11.84
7.	Control	14.04	16.76	15.40
	SEm±	**16.06**	**1.22**	
	CD(P= 0.05)	**3.27**	**3.76**	
	CV (%)	**15.20**	**15.89**	
	Pooled			
		SEm±	**CD (P= 0.05)**	**CV%(A)- 24.11**
	Season means	**0.67**	**0.00**	**CV%(B)- 15.60**
	Treatment means	**0.81**	**2.37**	
	S x T	**1.15**	**3.35**	

Table 2: Effect of water quality (EC) on *B.t.k* - seedlings damaged at 7 days (%)

S. No	Treatments (dS/m)	2009	2010	Pooled
1.	E.C. 0.5	14.71	16.72	15.71
2.	E.C. 1.0	13.16	15.17	14.16
3.	E.C. 2.0	14.04	14.89	14.46
4.	E.C. 4.0	12.02	16.01	14.02
5.	E.C. 6.0	10.39	16.26	13.33
6.	DW	14.04	17.07	15.55
7.	Control	23.54	32.13	27.83
	SEm±	**1.11**	**1.21**	
	CD (P= 0.05)	**3.42**	**3.72**	
	CV (%)	**13.27**	**11.48**	
	Pooled			
		SEm±	**CD (P= 0.05)**	**CV%(A)- 26.29**
	Season means	**0.947**	**3.70**	**CV%(B)- 12.28**
	Treatment means	**0.82**	**2.41**	
	S x T	**1.17**	**3.40**	

solutions beyond 8. Currier and Bruke (1989) reported that extreme pH affected plant resident microbes. It was observed by Gill *et al.* (1992) that toxins of *B.t.k* HD-1.Cry I toxins are soluble at pH 9.5 which occurs in the midgut of lepidoptran larvae. Low solubility conditions of spray solutions reduce damage to the B.*t* spores by sunlight. However, crystal toxin is not affected by UV light (Cantwell, 1967). The range of pH for low solubility of the toxin is 5 to 8.5. After ingestion by larvae, crystals are solubilized in the alkaline pH of the midgut and soluble toxins are activated by gut enzymes. Cry toxins then bind to specific membrane receptors, oligomerize and perforate the intestinal membrane, leading to larval death (Bravo *et al.*, 2011). Disease incidence on *S. litura* was highest at pH 7 and pH 8 Hence, it can be concluded that *B.t.k.* formulations can be sprayed

Table 3: Effect of water quality (EC) on *B.t.k* against *S. litura* in tobacco nursery - diseased larvae (%)

S. No	Treatments (dS/m)	2009	2010	Pooled
1.	E.C. 0.5	10.44	21.36	15.90
2.	E.C. 1.0	9.99	20.75	15.37
3.	E.C. 2.0	16.59	24.80	20.69
4.	E.C. 4.0	11.89	24.53	18.21
5.	E.C. 6.0	12.91	22.97	17.94
6.	DW	10.44	20.50	15.47
7.	Control	0.00	8.55	4.27
	SEm±	**5.88**	**1.33**	
	CD (P= 0.05)	**NS**	**4.09**	
	CV (%)	**85.28**	**11.28**	

Table 4: Effect of water quality (pH) on *B.t.k.* seedlings damaged at 3 days (%)

S. No	Treatments	2009	2010	Pooled
1.	p^H 5	11.93	6.96	9.44
2.	p^H 6	11.99	7.65	9.82
3.	p^H 7	10.49	8.69	9.59
4.	p^H 8	11.47	7.28	9.38
5.	p^H 9	13.72	7.33	10.52
6.	Distilled water	10.49	8.74	9.61
7.	Control	18.71	14.89	16.80
	SEm ±	**0.78**	**0.83**	
	CD (P= 0.05)	**2.40**	**2.55**	
	CV (%)	**10.66**	**16.41**	

Table 5: Effect of water quality (PH) on *B.t.k.* - seedlings damage at 7 days (%)

S. No	Treatments	2009	2010	Pooled
1.	p^H 5	17.38	17.43	17.40
2.	p^H 6	17.33	15.42	16.38
3.	p^H 7	12.74	12.64	12.69
4.	p^H 8	16.71	15.65	16.18
5.	p^H 9	19.93	18.71	19.32
6.	Distilled Water	14.14	13.12	13.63
7.	Control	23.29	27.01	25.15
	SEm±	**0.72**	**0.81**	
	CD (P= 0.05)	**2.22**	**2.50**	
	CV %	**7.21**	**8.26**	

Table 6: Effect of water quality (p^H) on *B.t.k.* against *S. litura* in tobacco nursery diseased larvae (%)

S. No	Treatments	2009	2010	Pooled
1.	p^H 5	10.44	19.52	14.98
2.	p^H 6	16.59	20.04	20.81
3.	p^H 7	21.13	29.97	25.55
4.	p^H 8	16.20	26.78	21.49
5.	p^H 9	4.30	16.34	10.32
6.	Distilled water	16.59	27.68	22.13
7.	Control	4.30	13.44	8.87
	SEm±	**2.68**	**1.21**	
	CD (P=0.05)	**8.25**	**3.72**	
	CV %	**36.28**	**9.28**	

in water with pH 7 to 8 for the safe entry of spores and toxin to the target site *i.e.* the midgut of the larva and result in effective control of the pest in tobacco nurseries (Tables 4-6)

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