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Effect of Biorational Insecticides to Predatory Coccinellids and Spiders in Maize Ecosystem

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ABSTRACT

Field experiments were conducted at Agricultural Research station, Darsi during *Rabi* 2014-15 and *Rabi* 2015-16 to evaluate the effect of biorational insecticides on predatory coccinellids and spiders in maize ecosystem. Among the botanical pesticides, entomogenous microbes, insect growth regulators and natural insecticides, and untreated control recorded significantly highest numbers of predatory beetles, *Coccinella transversalis* F., *Cheilomenus sexmaculata* F.and spiders (1.41, 2.47 and 2.09 / plant) which is on par with *B. bassiana* (1.31, 2.17 and 1.94 / plant), *B. thuringieinsis* (1.29, 2.26 and 1.93 / plant), azadirachtin 10000 ppm (1.29, 2.31 and 1.92 per plant) and *M. anisopliae* (1.29, 2.24 and 1.88/ plant). Safety to predatory beetles *viz.*, *C. transversalis* and *C. sexmaculata* and predatory spiders was also exhibited by chlorantraniliprole 18.5% SC (0.98, 1.99 and 1.62 /plant), spinosad 45% SC (1.08, 1.87 and 1.54 /plant) and chlorantraniliprole 0.4% GR (0.87, 1.82 and 1.61 /plant), respectively which were on par with each other. Predatory activity was least in carbofuran 3G followed by monocrotophos 36% SL and novaluron 10% EC.

Keywords: *Biorational insecticides, Cheilomenus sexmaculata, Coccinella transversalis, Maize, Spiders.*

Lepidopteran stem borers are among the most damaging pests of maize (*Zea mays* L.) in the semi-arid countries and are a major constraint in realizing the yield potential of the crop. In India, the stem borer, *Chilo partellus* (Swinhoe) (Lepidoptera: Crambidae) is one of the most serious insect pests causing 24.3 to 36.3% loss in different agro-climatic regions of the country (Ganguli *et al*., 1997). Since maize is a highly remunerative crop, intensive plant protection measures involving use of a number of insecticides is of common practice. A large number of insecticides belonging to different groups *viz.*, the organochlorines, organophosphates, carbamates and synthetic pyrethroids have been widely used to curtail the pest (Dharmasena, 1993; Teli *et al*., 2007) with limited success. Chemical control is often effective on the neonate instars, before the larvae enter the stem (Reyes, 1987), therefore the timing of application is crucial for the successful management of the pest (Nwanze and Mueller, 1987). The extent of parasitism and predatism is often low, due to their susceptibility to insecticidal applications on the target pest (Songa *et al.,* 1999). Further, the concern over indiscriminate use of chemical pesticides and the adverse effect of pesticides on the environment warrant eco-friendly approaches in pest management programs (Ramesh *et al*., 2012). It is seldom borne in mind about implication of chemical spraying on the survival and development of natural enemies in or on the host body. Conservation of natural enemies of pest species has been considered vital component in formulating the integrated control strategies. The consensus has been that such system would be fairly stable and lower the pesticide load in the environment.

Biorational strategies employing insect growth regulators, natural products, botanical preparations and entomopathogenic microbials are gaining significance as possible alternative measures for the sustainable management of spotted stem borer in maize and also to mitigate the adverse effects on the environment. In many cases, alternative or ecofriendly method of insect pest management offer adequate level of control with less hazards and safe to non-target organisms. In the present study, the impact of predators due to the application of biorational insecticides were evaluated and presented.

MATERIAL AND METHODS

The experiment was laid out in a Randomized Block Design (RBD) with eleven treatments and replicated thrice including untreated control. The treatments include Azadirachtin (10,000 ppm), *Beauveria bassiana*, *Metarhizium anisopliae*, *Bacillus thuriengensis* (Halt 5%WP), Novaluron 10% EC, Spinosad 45% SC, Chlorantraniliprole 18.5%SC, Chlorantraniliprole 0.4%GR, Carbofuran 3G, Monocrotophos 36% SL and Untreated Control. The size of each plot was 16.8 m^2 with seven rows and 20 plants per row. The popular local hybrid 30v92 was selected for the experiment and was sown during *rabi* seasons of 2014-15 and 2015-16 with 0.6 x 0.3 m spacing between row to row and plant to plant. All the treatments were imposed two times, *i.e.,* 25th and 47th day after emergence of the crop. The data was recorded by selecting five plants randomly in each replication of the treatment leaving border rows. The observations on predatory coccinellid and spiders were recorded one day before treatment as pre-treatment count and at 7, 14 and 21 days after each spray as post-treatment counts. Observations recorded on 21st day after first spray served as the pre-treatment count for the second spray. The total number of predatory coccinellids and spiders were counted and expressed as number/plant. The mean population data duly transformed into the corresponding square root transformed values and was subjected to statistical analysis using the analysis of variance for randomized block design (Snedecor and Cochran, 1967). Critical difference values were calculated at 5 % probability level and the treatment mean values were compared using Duncan's Multiple Range Test (Duncan, 1951).

RESULTS AND DISCUSSION

Cumulative Effect of Biorational Insecticide Treatments on Natural Enemies during *Rabi* 2014-15 and *Rabi* 2015-16

During the period of investigation, the data was collected on natural enemies like lady bird beetles *viz*., *Coccinella transversalis* Fabricus and *Cheilomenus sexmaculata* Fabricus and spiders.

Effect on *Coccinella transversalis* Fabricius

The overall efficacy of biorational insecticides on coccinellid beetle, *C. transversalis* during two successive seasons (*Rabi* 2014-15 & 2015-16) were presented in Table 1. The differences in beetle population among the treatments were significant. Pooled data showed that among the treatments, untreated control recorded significantly highest number of beetles (1.41/plant) which was on par with *B. bassiana* (1.31/plant), *B. thuringiensis*, *M. anisopliae* and azadirachtin 10000 ppm (1.29/plant). These were significantly followed by spinosad 45% SC (1.08 /plant), chlorantraniliprole 18.5% SC (0.98/plant) and chlorantraniliprole 0.4% GR (0.87/plant). Bozsik and Andras (2006) showed that *B. thuringiensis* was safe for ladybird beetle adults. The least numbers of *C. septumpunctata* beetles were recorded with carbofuran 3G (0.68/plant) significantly followed by monocrotophos 36% SL (0.52/plant) and novaluron 10% EC (0.44/plant) which were at par. Adverse effects of chemical insecticides on natural enemies such as *C. septempunctata* in maize crop have also been reported by some earlier researchers (John *et al*., 2007 and Qiong *et al*., 2009).

Effect on *Cheilomenus sexmaculata* Fabricius

The overall efficacy of biorational insecticides on coccinellid beetle, *C. sexmaculata* during two successive seasons (*Rabi* 2014-15 & 2015-16) were presented in table 2. Number of predatory beetles per plant differed significantly among the treatments and significantly highest number was found in untreated control (2.47). This was followed by azadirachtin 10000 ppm (2.31/ plant), *B. thuringiensis* (2.26/plant) and *M. anisopliae* (2.24/plant) which were not different from one another and did not cause any adverse effect on grubs and adults of predatory coccinellid beetles. Next in the order of safety were *B. bassiana* (2.17/plant), chlorantraniliprole 18.5% SC (1.99/plant), spinosad 45% SC (1.87 /plant), chlorantraniliprole 0.4% GR (1.82/plant). The least numbers of *M. sexmaculatus* beetles were recorded with carbofuran 3G (1.10/plant) significantly followed by monocrotophos 36% SL (0.82/plant) and novaluron 10% EC (0.74/plant) which were at par indicating their least safety to predatory beetle population. In maize the colonies of sucking pests *viz*., aphids and shoot bugs will be mostly in leaf whorls than on the remaining plant parts, hence the whorl application of carbofuron has recorded less number of generalist predators compared to the remaining treatments mainly due to direct toxicity of insecticides on predatory beetle population. Moreover, chlorantraniliprole and spinosad are based on natural products which are target specific and safe to natural enemies (Raguraman and Uthamasamy, 2005; Jyoti and Goud, 2008 and Sharma and Kaushik, 2010). Galvan *et al*. (2005) recommended selective use of spinosad @ 0.2 per cent which facilitated conservation of predator *Harmonia axyridis* (Pallas) in integrated pest management of sweet corn. Chlorantraniliprole was found safer to the beneficial insects in the maize and other agro ecosystems with additional benefit of environmentally sound approach as propounded by Marchesini *et al*. (2008).

Effect on Predatory Spiders

The overall efficacy of biorational insecticides on spiders during two successive seasons (*Rabi* 2014-15 & 2015-16) were presented in table 3. In the pooled mean analysis the differences in spider population among the treatments were significant. Among the treatments, untreated control recorded significantly highest numbers of spiders per plant (2.09) which is on par with *B. bassiana* (1.94), *B. thuringiensis* (1.93), azadirachtin 10000 ppm (1.92) and *M. anisopliae* (1.88). These were followed by other biorational insecticides, chlorantraniliprole 18.5% SC (1.62/ plant), chlorantraniliprole 0.4% GR (1.61/plant) and spinosad 45% SC (1.54 /plant) which were on par with each other. The least numbers of spiders were recorded with carbofuran 3G (1.05/plant) followed by monocrotophos 36% SL (0.88/plant) and novaluron 10% EC (0.77/plant).

The safest biorational insecticide to enhance the predatory activity of spiders in the present study was found with *B. thuringiensis*, azadirachtin and entomopathogenic fungi *viz*., *B. bassiana* and *M. anisopliae*. Next safer biorationals recorded were chlorantraniliprole and spinosad. The reason for this might be the reduction in availability of number of host larvae thus indirectly lowering the predator activity. Earlier reports by Chatterjee and Mondal (2009) indicated the highest number of spiders with flubendiamide (9.33/10 plants) followed by spinosad (8.67/10 plants) and emamectin benzoate (8.33/10 plants). Flubendamide (1.12 and 1.20 per five plants), spinosad (1.02 and 1.17 per five plants), emamectin benzoate (0.82 and 0.90 per five plants) and indoxacarb (0.79 and 0.85 per five plants) were safest and recorded the highest number of natural enemies *viz*., spiders and ladybird beetles (Jyothi *et al*., 2016). On contrary to this Muddasir *et al*. (2015) reported that the reduction in spider population was more in spinosad (19.60%) when compared to control (1.22%). In the present study the least numbers of spiders were recorded with carbofuron which was in agreement with Ogah *et al*. (2011) and Joon-Ho and Seung-Tae (1996) who reported 100 per cent mortality of spiders and also with monocrotophos as they destroy the target species can knock off the predators as well.

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Table 1 Cumulative influence of biorational insecticides on *C. transversalis* in maize during *rabi* 2014-15 and 2015-16 (pooled data)

T. No.	Insecticide	Dose / ha	Mean population numbers / plant							
			First application				Second application			Pooled Mean
			PTC	7 DAT	14 DAT	21 DAT	7 DAT	14 DAT	21 DAT	
T1	Azadirachtin (10,000 ppm)	0.02%	0.60 (0.77)	1.03 (1.01)^{a}	1.27 (1.12)^{ab}	1.20 (1.09)^{ab}	1.37 (1.17)^{a}	1.40 (1.18)^{a}	1.47 (1.21)^{b}	1.29 (1.13)^{a}
T2	*Beauveria bassiana*	10^{8} spores	0.63 (0.78)	1.10 (1.03)^{a}	1.30 (1.13)^{ab}	1.30 (1.13)^{ab}	1.33 (1.16)^{a}	1.37 (1.17)^{a}	1.47 (1.21)^{b}	1.31 (1.15)^{a}
T3	*Metarhizium anisopliae*	10^{8} spores	0.67 (0.82)	0.97 (0.98)^{a}	1.40 (1.18)^{a}	1.13 (1.05)^{bc}	1.43 (1.20)^{a}	1.20 (1.10)^{ab}	1.63 (1.27)^{ab}	1.29 (1.14)^{a}
T4	*Bacillus thuriengensis* (Halt 5%WP)	1 kg	0.47 (0.67)	1.00 (1.00)^{a}	1.03 (1.02)^{ab}	1.30 (1.14)^{ab}	1.40 (1.18)^{a}	1.33 (1.15)^{a}	1.67 (1.29)^{ab}	1.29 (1.14)^{a}
T5	Novaluron 10% EC	500 ml	0.53 (0.72)	0.37 (0.61)^{c}	0.57 (0.75)^{c}	0.47 (0.68)^{f}	0.33 (0.58)^{d}	0.43 (0.66)^{e}	0.47 (0.68)^{d}	0.44 (0.66)^{e}
T6	Spinosad 45% SC	150 ml	0.53 (0.72)	0.60 (0.77)^{b}	1.13 (1.05)^{ab}	1.07 (1.03)^{bc}	0.90 (0.93)^{b}	1.23 (1.11)^{ab}	1.53 (1.23)^{b}	1.08 (1.03)^{b}
T7	Chlorantraniliprole 18.5% SC	150 ml	0.50 (0.71)	0.50 (0.71)^{bc}	0.97 (0.98)^{b}	1.13 (1.06)^{b}	1.03 (1.01)^{b}	0.87 (0.93)^{c}	1.37 (1.17)^{b}	0.98 (0.99)^{bc}
T8	Chlorantraniliprole 0.4% GR	10 kg	0.57 (0.75)	0.47 (0.67)^{bc}	1.03 (1.02)^{ab}	0.90 (0.94)^{cd}	0.47 (0.68)^{cd}	0.97 (0.98)^{bc}	1.37 (1.17)^{b}	0.87 (0.92)^{c}
T9	Carbofuran 3G	10 kg	0.57 (0.75)	0.50 (0.70)^{bc}	0.63 (0.79)^{c}	0.73 (0.85)^{de}	0.57 (0.75)^{c}	0.70 (0.84)^{cd}	0.93 (0.97)^{c}	0.68 (0.82)^{d}
T10	Monocrotophos 36% SL	800 ml	0.67 (0.82)	0.40 (0.63)^{bc}	0.47 (0.67)^{c}	0.60 (0.77)^{ef}	0.43 (0.65)^{cd}	0.57 (0.75)^{de}	0.67 (0.82)^{cd}	0.52 (0.73)^{e}
T11	Untreated control	—	0.57 0.75)	1.00 (1.00)^{a}	1.33 (1.16)^{ab}	1.47 (1.22)^{a}	1.40 (1.18)^{a}	1.20 (1.10)^{ab}	2.03 (1.43)^{a}	1.41 (1.19)^{a}
	SEm±		**0.02**	**0.05**	**0.08**	**0.03**	**0.05**	**0.05**	**0.04**	**0.02**
	CD (P=0.05)		**NS**	**0.15**	**0.17**	**0.12**	**0.14**	**0.14**	**0.17**	**0.08**
	CV (%)		**2.05**	**10.67**	**10.53**	**7.26**	**8.62**	**8.36**	**8.72**	**4.73**

Values in parentheses are square root transformed values DAT – Days after treatment, NS: Non Significant, PTC – Pre Treatment Count

Bt – *Bacillus thuriengensis* Serovar Kurstaki H 3a, 3b, 3c; 5% WP, Halt, $5X10^{7}$ spore/mg, make - Biostadt

In a column means followed by same alphabet do not differ significantly by CD (P=0.05)

Table 2 Cumulative influence of biorational insecticides on *C. sexmaculata* in maize during *rabi* 2014-15 and 2015-16 (pooled data)

T. No.	Insecticide	Dose / ha	Mean population numbers / plant							
				First application			Second application			Pooled
			PTC	7 DAT	14 DAT	21 DAT	7 DAT	14 DAT	21 DAT	Mean
T1	Azadirachtin (10,000 ppm)	0.02%	1.57 (1.25)	1.87 $(1.36)^{a}$	2.27 $(1.50)^{a}$	2.17x $(1.48)^{a}$	2.23 $(1.49)^{ab}$	2.63 $(1.62)^{a}$	2.70 $(1.64)^{ab}$	2.31 $(1.52)^{ab}$
T2	*Beauveria bassiana*	10^{8} spores	1.53 (1.22)	1.93 $(1.38)^{a}$	1.90 $(1.37)^{a}$	2.07 $(1.43)^{a}$	2.07 $(1.44)^{ab}$	2.57 $(1.59)^{a}$	2.50 $(1.58)^{b}$	2.17 $(1.47)^{bc}$
T3	*Metarhizium anisopliae*	10^{8} spores	1.50 (1.22)	1.97 $(1.39)^{a}$	1.90 $(1.37)^{a}$	2.10 $(1.44)^{a}$	2.23 $(1.49)^{ab}$	2.57 $(1.60)^{a}$	2.70 $(1.64)^{ab}$	2.24 $(1.50)^{ab}$
T4	*Bacillus thuriengensis* (Halt 5%WP)	1 kg	1.57 (1.25)	1.97 $(1.39)^{a}$	2.00 $(1.42)^{a}$	2.13 $(1.46)^{a}$	2.27 $(1.51)^{ab}$	2.67 $(1.63)^{a}$	2.53 $(1.59)^{ab}$	2.26 $(1.50)^{ab}$
T5	Novaluron 10% EC	500 ml	1.47 (1.21)	0.80 $(0.89)^{c}$	0.90 $(0.95)^{b}$	0.83 $(0.90)^{d}$	0.53 $(0.72)^{d}$	0.70 $(0.84)^{c}$	0.70 $(0.84)^{d}$	0.74 $(0.86)^{f}$
T6	Spinosad 45% SC	150 ml	1.57 (1.25)	1.07 $(1.03)^{bc}$	1.93 $(1.38)^{a}$	2.03 $(1.43)^{ab}$	1.20 $(1.10)^{c}$	2.43 $(1.56)^{a}$	2.57 $(1.60)^{ab}$	1.87 $(1.36)^{d}$
T7	Chlorantraniliprole 18.5% SC	150 ml	1.33 (1.15)	1.23 $(1.11)^{b}$	1.93 $(1.38)^{a}$	1.93 $(1.39)^{ab}$	1.83 $(1.35)^{b}$	2.57 $(1.60)^{a}$	2.43 $(1.56)^{b}$	1.99 $(1.40)^{cd}$
T8	Chlorantraniliprole 0.4% GR	10 kg	1.57 (1.25)	1.00 $(1.00)^{bc}$	1.77 $(1.32)^{a}$	1.70 $(1.31)^{b}$	1.33 $(1.15)^{c}$	2.47 $(1.57)^{a}$	2.63 $(1.62)^{ab}$	1.82 $(1.35)^{d}$
T9	Carbofuran 3G	10 kg	1.67 (1.29)	1.10 $(1.05)^{bc}$	0.87 $(0.93)^{b}$	1.20 $(1.10)^{c}$	0.70 $(0.82)^{d}$	1.37 $(1.16)^{b}$	1.37 $(1.15)^{c}$	1.10 $(1.05)^{e}$
T10	Monocrotophos 36% SL	800 ml	1.77 (1.32)	1.17 $(1.07)^{b}$	0.70 $(0.83)^{b}$	0.97 $(0.98)^{cd}$	0.50 $(0.69)^{d}$	0.80 $(0.88)^{c}$	0.77 $(0.87)^{d}$	0.82 $(0.90)^{f}$
T11	Untreated control	—	1.70 (1.30)	2.30 $(1.52)^{a}$	2.23 $(1.48)^{a}$	2.10 $(1.44)^{a}$	2.43 $(1.56)^{a}$	2.73 $(1.66)^{a}$	3.00 $(1.74)^{a}$	2.47 $(1.57)^{a}$
	SEm±		**0.04**	**0.05**	**0.07**	**0.05**	**0.06**	**0.06**	**0.05**	**0.03**
	CD (P=0.05)		**NS**	**0.16**	**0.19**	**0.13**	**0.18**	**0.20**	**0.15**	**0.08**
	CV (%)		**7.87**	**7.37**	**9.13**	**5.89**	**9.08**	**8.14**	**6.11**	**3.59**

Values in parentheses are square root transformed values DAT – Days after treatment, NS: Non Significant, PTC – Pre Treatment Count

Bt – *Bacillus thuriengensis* Serovar Kurstaki H 3a, 3b, 3c; 5% WP, Halt, $5X10^{7}$ spore/mg, make - Biostadt

In a column means followed by same alphabet do not differ significantly by CD (P=0.05)

Table 3 Cumulative influence of biorational insecticides on predatory spiders during *rabi* 2014-15 and 2015-16 in maize (pooled data)

T. No.	Insecticide	Dose / ha	Mean population numbers / plant							
				First application			Second application			Pooled
			PTC	7 DAT	14 DAT	21 DAT	7 DAT	14 DAT	21 DAT	Mean
T1	Azadirachtin (10,000 ppm)	0.02%	1.10	1.63	1.80	1.83	2.00	2.07	2.17	1.92
			(1.04)	(1.27)^{a}	(1.34)^{ab}	(1.35)^{a}	(1.41)^{ab}	(1.43)^{ab}	(1.47)^{ab}	(1.38)^{a}
T2	*Beauveria bassiana*	10^8 spores	1.30	1.67	1.77	1.70	2.00	2.13	2.37	1.94
			(1.14)	(1.28)^{a}	(1.33)^{ab}	(1.30)^{a}	(1.41)^{ab}	(1.45)^{a}	(1.53)^{ab}	(1.39)^{a}
T3	*Metarhizium anisopliae*	10^8 spores	1.27	1.63	1.90	1.73	1.97	1.83	2.23	1.88
			(1.12)	(1.27)^{a}	(1.38)^{ab}	(1.32)^{a}	(1.40)^{ab}	(1.35)^{ab}	(1.49)^{ab}	(1.37)^{a}
T4	*Bacillus thuriengensis*	1 kg	1.30	1.83	1.80	1.80	1.97	2.10	2.10	1.93
	(Halt 5%WP)		(1.14)	(1.35)^{a}	(1.34)^{ab}	(1.33)^{a}	(1.40)^{ab}	(1.45)^{ab}	(1.44)^{ab}	(1.39)^{a}
T5	Novaluron 10% EC	500 ml	1.30	0.80	0.90	1.00	0.57	0.67	0.67	0.77
			(1.14)	(0.89)^{b}	(0.95)^{c}	(0.99)^{b}	(0.75)^{e}	(0.82)^{e}	(0.82)^{d}	(0.88)^{d}
T6	Spinosad 45% SC	150 ml	1.13	0.90	1.70	1.70	1.17	1.63	2.13	1.54
			(1.06)	(0.94)^{b}	(1.30)^{ab}	(1.30)^{a}	(1.08)^{d}	(1.27)^{abc}	(1.45)^{ab}	(1.24)^{b}
T7	Chlorantraniliprole 18.5% SC	150 ml	1.37	1.03	1.57	1.87	1.63	1.70	1.90	1.62
			(1.16)	(1.00)^{b}	(1.25)^{b}	(1.37)^{a}	(1.27)^{bc}	(1.30)^{abc}	(1.37)^{b}	(1.27)^{b}
T8	Chlorantraniliprole 0.4% GR	10 kg	1.40	1.00	1.83	1.70	1.33	1.60	2.17	1.61
			(1.19)	(0.99)^{b}	(1.35)^{ab}	(1.30)^{a}	(1.15)^{cd}	(1.26)^{bc}	(1.47)^{ab}	(1.26)^{b}
T9	Carbofuran 3G	10 kg	1.43	0.87	0.90	1.00	0.83	1.30	1.40	1.05
			(1.20)	(0.93)^{b}	(0.95)^{c}	(0.99)^{b}	(0.91)^{e}	(1.13)^{cd}	(1.18)^{c}	(1.02)^{c}
T10	Monocrotophos 36% SL	800 ml	1.27	0.93	0.57	1.07	0.80	1.03	0.90	0.88
			(1.13)	(0.97)^{b}	(0.75)^{d}	(1.03)^{b}	(0.89)^{e}	(1.01)^{d}	(0.94)^{d}	(0.93)^{cd}
T11	Untreated control	—	1.27	1.63	2.03	2.07	2.37	2.00	2.43	2.09
			(1.13)	(1.27)^{a}	(1.42)^{a}	(1.44)^{a}	(1.53)^{a}	(1.41)^{ab}	(1.56)^{a}	(1.44)^{a}
	SEm±		**0.04**	**0.07**	**0.04**	**0.07**	**0.05**	**0.08**	**0.04**	**0.05**
	CD (P=0.05)		**NS**	**0.22**	**0.15**	**0.17**	**0.16**	**0.19**	**0.17**	**0.10**
	CV (%)		**7.64**	**11.23**	**7.67**	**8.26**	**8.26**	**8.59**	**7.34**	**4.95**

Values in parentheses are square root transformed values DAT – Days after treatment, NS: Non Significant, PTC – Pre Treatment Count
Bt – *Bacillus thuriengensis* Serovar Kurstaki H 3a, 3b, 3c; 5% WP, Halt, $5X10^7$ spore/mg, make - Biostadt
In a column means followed by same alphabet do not differ significantly by CD (P=0.05)

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