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RESEARCH PAPER

Effect of biorationals on natural enemies in chilli ecosystem at Dharwad

MUNJ SUJAL SUHAS[1*], M. G. HEGDE[1], B. K. SUBHASH[1], R. HOSAMANI[2], J. A. HOSMATH[3] AND G. B. BALOL[4]

[1]Department of Entomology, [2]Department of Biotechnology, [3]Department of Agronomy
[4]Department of Plant Pathology College of Agriculture, Dharwad
University of Agricultural Sciences, Dharwad - 580 005, India
*E-mail: sujalmunj0398@gmail.com

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Abstract : The present study was carried out at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad during *kharif*, 2023-24 to assess the effect of various biopesticides on natural enemies associated with chilli thrips, *Scirtothrips dorsalis* (Hood) under field condition. The natural enemies recorded during trial were coccinellids, spiders and minute pirate bugs. Across the different treatments, all the entomopathogenic fingi showed non detrimental effect on natural enemies. However, lowest count of natural enemies was registered in spinosad treated plots followed by azadirachtin. Notably, the untreated check harbored the higher number of natural enemies per plant across both the seasons. This study provided the strong base for evaluation of harmless effects of EPF on natural enemies.

Key words: Azadirachtin Biorationals, Chilli, Entomopathogenic fungus, Natural enemies

Introduction

Chilli (*Capsicum annuum* L.), a member of the family Solanaceae is an economically and nutritionally important crop cultivated extensively across mild temperate, tropical, and subtropical regions of the world. In India, chilli is grown throughout the year as a major cash crop and is consumed in multiple forms including fresh green pods used raw in salads or as a cooked vegetable as well as in dried and processed forms. It is crucial element in Indian cuisine due to its characteristic pungency, flavour and colour. The pungency of chilli is attributed to capsaicin, a bioactive compound that is widely used in pharmaceutical formulations such as pain relief balms, in cosmetic preparations and also it has been reported to improved cardiovascular health and reduced risk of heart disease (Thamburaj and Singh, 2001). In addition, capsanthin, the principal red pigment in chilli imparts an attractive colour and is widely used in processed food products including jams, jellies and squashes.

Owing to its multifaceted uses, high consumer demand and economic value, chilli occupies a prominent position in Indian agriculture. The total production of green chilli in India is 5311.63 thousand MT from an area of 459.19 thousand hectare with a productivity of 11.57 MT per hectares. Karnataka is the second largest producer of green chili in India, following Andhra Pradesh with a total area of 22.80 thousand hectare, production of 279.39 thousand MT and that of productivity was 12.26 MT per hectare (Anon, 2025).

Chilli is attacked by a complex pest spectrum with more than 293 insect species reported to infest the crop (Anon, 1987). Out of all, *Scirtothrips dorsalis* (Hood) (Thysanoptera: Thripidae) is considered the most important pest of chilli causing substantial yield losses ranging from 30 to 90 per cent (Borah, 1987; Varadharajan, 1994). Infestation by this species is more severe during the vegetative stage of the crop, after which its population gradually declines towards crop maturity. The damage symptoms by thrips results in characteristic silver streaks and upward curling of leaves (Ananthakrishnan, 1971) and its population proliferate rapidly under dry weather conditions.

The repeated application of chemical insecticides in chilli cultivation has emerged as a major concern due to their adverse effects on associated natural enemy fauna. Moreover, the persistence of pesticide residues in chilli fruits poses serious risks to consumer health and also creates constraints for export markets. In this context, biorational insecticides particularly entomopathogenic fungi (EPF) have gained attention as eco-friendly alternatives, due to their target specificity and are less harmful to beneficial insects. Hence, the present study was undertaken to assess the impact and safety of selected biorational molecules on natural enemies associated with chilli thrips.

Material and methods

Field study was conducted at the Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad

Table 1. List of biorationals used for experiment

Treatment details	Dosage (g or ml/ l)
Beauveria bassiana (2×10^8 cfu/g)	2.0 g
Beauveria bassiana (2×10^8 cfu/g)	4.0 g
Metarhizium anisopliae (2×10^8 cfu/g)	5.0 g
Metarhizium anisopliae (2×10^8 cfu/g)	10 g
Lecanicillium lecanii (2×10^8 cfu/g)	2.0 g
Lecanicillium lecanii (2×10^8 cfu/g)	4.0 g
Beauveria bassiana + *Lecanicillium lecanii* (2×10^8cfu/g)	2g + 2g
Beauveria bassiana + *Lecanicillium lecanii* (2×10^8cfu/g)	4g + 4g
Azadirachtin 1500 ppm	3.0 ml
Spinosad 45 SC	0.25 ml
Untreated check	

under rainfed conditions during *kharif* 2023-24 and 2024-25 to evaluate the effect of biorationals on natural enemies of thrips in chilli. The experiment was laid out in a randomized block design (RBD) with three replications, comprising of nine biopesticide treatments along with a standard check and untreated control. Each plot of size 5 m × 5 m with a spacing of 75 cm × 60 cm was maintained. The variety *Byadgi dabbi* was used and crop was raised following the recommended package of practices of UAS, Dharwad. Treatments were initiated when natural enemies population was highest coincided with higher chilli thrips population. The commercial powder formulations of biopesticides obtained from Institute of Organic Farming, Dharwad while, botanical and spinosad procured from the retail pesticide shop in Dharwad. The details of the treatments are presented in Tables 1.

Method of observations

The visible natural enemies *i.e.,* predatory coccinellids (*Coccinella transversalis* (Fabricius) and *Cheilomenessexmaculata* (Fabricius)), spiders (*Neoscona sinhagadensis* (Tikader), *Gnaphosa poonaensis* (Tikader) and *Indoxysticus minutus* (Tikader)) and minute pirate bug population (*Orius* sp.) were recorded from whole plant of each of five randomly selected plants one day prior to imposition of treatments. Subsequent observations were taken at 1, 5, 10 and 15 days after spraying (DAS) to assess the post-treatment effects and expressed as the mean number of natural enemies per plant. Owing to their low abundance, data collected on population of natural enemies of both seasons were pooled and were subjected to the analysis of variance (ANOVA) after square root transformation (Table 2, 3 and 4).

Results and discussion

Natural enemies

First spray

The pooled data results of both years revealed that, The one day prior to spraying, population of natural

Table 2. Impact of biopesticides on natural enemies (After first spray)

Treatments	Number of natural enemies / plant																	
	1 DBS			1 DAS			5 DAS			10 DAS `			15 DAS			Mean		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	pooled
T_1	0.85	0.96	0.91	0.81	0.91	0.86	0.78	0.88	0.83	0.72	0.82	0.79	2.20	1.95	2.08	1.07	1.10	1.09
	(1.16)	(1.21)	(1.19)	$(1.14)^{b}$	$(1.19)^{b}$	$(1.17)^{b}$	$(1.13)^{c}$	$(1.17)^{c}$	$(1.15)^{c}$	$(1.10)^{d-h}$	$(1.15)^{fg}$	$(1.14)^{c}$	(1.64)	(1.57)	(1.61)			
T_2	0.79	0.98	0.89	0.77	0.94	0.86	0.71	0.77	0.81	0.68	0.73	0.72	2.12	1.93	2.03	1.01	1.07	1.04
	(1.14)	(1.22)	(1.18)	$(1.13)^{b}$	$(1.20)^{b}$	$(1.17)^{b}$	$(1.10)^{c}$	$(1.13)^{c}$	$(1.15)^{c}$	$(1.09)^{d-g}$	$(1.11)^{def}$	$(1.10)^{c}$	(1.62)	(1.56)	(1.59)			
T_3	0.81	0.91	0.86	0.79	0.81	0.80	0.76	0.91	0.77	0.75	0.86	0.77	2.21	1.94	2.08	1.06	1.09	1.08
	(1.14)	(1.19)	(1.17)	$(1.14)^{b}$	$(1.14)^{b}$	$(1.14)^{b}$	$(1.12)^{c}$	$(1.19)^{c}$	$(1.13)^{c}$	$(1.12)^{f-i}$	$(1.17)^{gh}$	$(1.13)^{c}$	(1.65)	(1.56)	(1.61)			
T_4	0.75	0.94	0.85	0.71	0.84	0.78	0.68	0.79	0.74	0.66	0.75	0.70	2.12	1.91	2.02	0.98	1.05	1.02
	(1.12)	(1.20)	(1.16)	$(1.10)^{b}$	$(1.16)^{b}$	$(1.13)^{b}$	$(1.09)^{c}$	$(1.14)^{c}$	$(1.12)^{c}$	$(1.08)^{c-f}$	$(1.11)^{def}$	$(1.10)^{c}$	(1.62)	(1.55)	(1.59)			
T_5	0.82	0.87	0.85	0.80	0.79	0.80	0.75	0.76	0.76	0.72	0.69	0.71	2.10	1.96	2.03	1.04	1.01	1.03
	(1.15)	(1.17)	(1.16)	$(1.14)^{b}$	$(1.14)^{b}$	$(1.14)^{b}$	$(1.12)^{c}$	$(1.12)^{c}$	$(1.12)^{c}$	$(1.10)^{c-h}$	$(1.09)^{cd}$	$(1.10)^{c}$	(1.61)	(1.57)	(1.59)			
T_6	0.76	0.89	0.83	0.70	0.82	0.76	0.67	0.77	0.72	0.65	0.70	0.69	2.17	1.93	2.05	0.99	1.02	1.01
	(1.12)	(1.18)	(1.15)	$(1.10)^{b}$	$(1.15)^{b}$	$(1.13)^{b}$	$(1.08)^{c}$	$(1.13)^{c}$	$(1.11)^{c}$	$(1.07)^{cde}$	$(1.10)^{cde}$	$(1.09)^{c}$	(1.63)	(1.56)	(1.60)			
T_7	0.78	0.97	0.88	0.74	0.90	0.82	0.71	0.80	0.76	0.62	0.71	0.72	2.13	1.90	2.02	1.00	1.06	1.03
	(1.13)	(1.21)	(1.17)	$(1.11)^{b}$	$(1.18)^{b}$	$(1.15)^{b}$	$(1.10)^{c}$	$(1.14)^{c}$	$(1.12)^{c}$	$(1.06)^{cd}$	$(1.10)^{cde}$	$(1.11)^{c}$	(1.62)	(1.55)	(1.59)			
T_8	0.80	0.98	0.89	0.76	0.79	0.78	0.74	0.72	0.73	0.58	0.62	0.69	2.15	1.92	2.04	1.01	1.01	1.01
	(1.14)	(1.22)	(1.18)	$(1.12)^{b}$	$(1.14)^{b}$	$(1.13)^{b}$	$(1.11)^{c}$	$(1.10)^{c}$	$(1.11)^{c}$	$(1.04)^{bc}$	$(1.06)^{c}$	$(1.09)^{c}$	(1.63)	(1.56)	(1.60)			
T_9	0.83	0.91	0.87	0.00	0.00	0.00	0.51	0.42	0.47	0.50	0.50	0.51	2.12	1.85	1.99	0.79	0.74	0.76
	(1.15)	(1.19)	(1.17)	$(0.71)^{a}$	$(0.71)^{a}$	$(0.71)^{a}$	$(1.00)^{b}$	$(0.96)^{ab}$	$(0.98)^{ab}$	$(1.00)^{b}$	$(1.00)^{b}$	$(1.00)^{ab}$	(1.62)	(1.53)	(1.58)			
T_{10}	0.79	0.99	0.89	0.00	0.00	0.00	0.33	0.33	0.33	0.40	0.39	0.46	1.83	1.80	1.82	0.67	0.70	0.69
	(1.14)	(1.22)	(1.18)	$(0.71)^{a}$	$(0.71)^{a}$	$(0.71)^{a}$	$(0.91)^{a}$	$(0.91)^{a}$	$(0.91)^{a}$	$(0.95)^{a}$	$(0.94)^{a}$	$(0.98)^{a}$	(1.53)	(1.52)	(1.53)			
T_{11}	0.82	0.92	0.87	1.10	0.99	1.05	1.44	1.17	1.31	2.05	1.42	1.74	2.28	1.99	2.14	1.54	1.30	1.42
	(1.15)	(1.19)	(1.17)	$(1.26)^{c}$	$(1.22)^{c}$	$(1.24)^{c}$	$(1.39)^{d}$	$(1.29)^{d}$	$(1.34)^{d}$	(1.60)j	$(1.39)^{j}$	$(1.50)^{d}$	(1.67)	(1.58)	(1.63)			
S.Em±	0.02	0.04	0.01	0.03	0.02	0.02	0.03	0.03	0.02	0.01	0.02	0.01	0.04	0.03	0.02	-	-	-
C.D. @5%	NS	NS	NS	0.08	0.07	0.05	0.07	0.08	0.07	0.04	0.05	0.04	NS	NS	NS	-	-	-
C.V. (%)	9.75	10.09	9.14	9.75	10.15	9.64	11.29	10.18	9.68	14.76	11.67	9.23	11.27	12.64	11.05	-	-	-

DBS – Day before spraying; DAS – Days after spraying;
Figures in parenthesis are square root transformed values;
Means followed by same letter in the column do not differ significantly by DMRT (p=0.05).

enemies were found statistically similar in all treatments and ranged between 0.83 to 0.91 number per plant. Their count was nil in spinosad 45 SC @ 0.25 ml (T_{10}) and azadirachtin 1500 ppm (T_9) at 1 DAS. All the biopesticides treated plots recorded moderate number of natural enemies (0.76 to 0.86 number/plant). At 5 DAS, untreated check supported the higher population of natural enemies (1.31/ plant) and least was found in T_{10} (0.33/ plant). Similar trend of natural enemies count was recorded in different treatments at ten days of spray. The count of natural enemies was not differed significantly at 15 DAS among treatments (Table 2).

Second spray

The pooled data results pertaining to second spray also showed similar trend as observed in the individual seasons. Highest count of 1.44 per plant was noticed in the untreated check at 1 DAS. No natural enemies were detected in T_{10} and T_9 treatments while rest of the treatments noted statistically at par natural enemies population. Similarly, by 5 DAS, highest numbers of 1.35 per plant natural enemies were recorded in untreated check and that of lowest was in T_{10} and T_9 (0.31 and 0.49/plant, respectively). Further similar trend of observations was recorded at 10 DAS. The untreated check supported the highest numbers of 1.24 natural enemies per plant (Table 3).

Third spray

As like in second spray, no natural enemies were observed in T_{10} and T_9, while rest of treatments were statistically at par with untreated check at a day after spray. Likewise at 5 and 10 DAS, higher number of natural enemies were found in untreated check (0.88 and 0.82/plant). This was closely followed by biopesticides treatments with 0.63 to 0.70 per plant at 5 DAS and 0.40 to 0.68 per plant at 10 DAS (Table 4).

The present study demonstrated that biorational treatments were relatively safe to natural enemies during both years of investigation. Nevertheless, spinosad 45 SC @ 0.25 ml and azadirachtin 1500 ppm @ 3.0 ml adversely affected natural enemy populations across all spray

Table 3. Impact of biopesticides on natural enemies (After second spray)

Treatments	Number of natural enemies / plant																	
	1 DBS			1 DAS			5 DAS			10 DAS			15 DAS			Mean		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
T_1	1.36	1.52	1.44	1.27	1.22	1.25	1.15	1.13	1.14	0.89	0.92	0.82	1.10	1.08	1.09	1.15	1.17	1.16
	(1.36)	(1.42)	(1.39)	$(1.33)^b$	$(1.31)^c$	$(1.32)^b$	$(1.28)^c$	$(1.28)^c$	$(1.28)^c$	$(1.18)^{gh}$	$(1.19)^{efg}$	$(1.15)^c($	1.26)	(1.26)	(1.26)			
T_2	1.29	1.48	1.39	1.20	1.23	1.22	1.05	1.07	1.06	0.77	0.81	0.79	1.18	0.99	1.09	1.10	1.12	1.11
	(1.34)	(1.41)	(1.38)	$(1.30)^b$	$(1.32)^c$	$(1.31)^b$	$(1.24)^c$	$(1.25)^c$	$(1.25)^c$	$(1.13)^{de}$	$(1.14)^{cd}$	$(1.14)^c$	(1.30)	(1.22)	(1.26)			
T_3	1.38	1.47	1.43	1.30	1.20	1.25	1.19	1.11	1.15	0.99	0.93	0.83	1.14	1.05	1.10	1.20	1.15	1.18
	(1.37)	(1.40)	(1.39)	$(1.34)^b$	$(1.30)^c$	$(1.32)^b$	$(1.30)^c$	$(1.27)^c$	$(1.29)^c$	$(1.22)^i$	$(1.20)^{fgh}$	$(1.16)^c$	(1.28)	(1.24)	(1.26)			
T_4	1.29	1.49	1.39	1.22	1.23	1.23	1.10	1.02	1.06	0.79	0.78	0.79	1.10	1.03	1.07	1.10	1.11	1.11
	(1.34)	(1.41)	(1.38)	$(1.31)^b$	$(1.32)^c$	(1.32b)	$(1.26)^c$	$(1.23)^c$	$(1.25)^c$	$(1.14)^{def}$	$(1.13)^c$	$(1.14)^c$	(1.26)	(1.24)	(1.25)			
T_5	1.40	1.56	1.48	1.33	1.27	1.30	1.23	1.10	1.17	0.85	0.82	0.78	1.18	1.04	1.11	1.20	1.16	1.18
	(1.38)	(1.44)	(1.41)	$(1.35)^b$	$(1.33)^c$	$(1.34)^b$	$(1.32)^c$	$(1.26)^c$	$(1.29)^c$	$(1.16)^{d-g}$	$(1.15)^{cde}$	$(1.13)^c$	(1.30)	(1.24)	(1.27)			
T_6	1.30	1.42	1.36	1.26	1.16	1.21	1.17	1.16	1.17	0.76	0.91	0.84	1.11	1.01	1.06	1.12	1.13	1.13
	(1.34)	(1.39)	(1.37)	$(1.33)^b$	$(1.29)^c$	$(1.31)^b$	$(1.29)^c$	$(1.29)^c$	$(1.29)^c$	$(1.12)^d$	$(1.19)^{de}$	$(1.16)^c$	(1.27)	(1.23)	(1.25)			
T_7	1.33	1.54	1.44	1.29	1.29	1.29	1.11	1.03	1.07	0.67	0.87	0.79	1.16	1.06	1.11	1.11	1.16	1.14
	(1.35)	(1.43)	(1.39)	$(1.34)^b$	$(1.34)^c$	$(1.34)^b$	$(1.27)^c$	$(1.24)^c$	$(1.26)^c$	$(1.08)^c$	$(1.17)^{cdef}$	$(1.14)^c$	(1.29)	(1.25)	(1.27)			
T_8	1.30	1.50	1.40	1.23	1.24	1.24	1.08	1.06	1.07	0.58	0.80	0.76	1.12	1.02	1.07	1.06	1.12	1.09
	(1.34)	(1.41)	(1.38)	$(1.32)^b$	$(1.32)^b$	$(1.32)^b$	$(1.26)^c$	$(1.25)^c$	$(1.26)^c$	$(1.04)^b$	$(1.14)^{cd}$	$(1.12)^c$	(1.27)	(1.23)	(1.25)			
T_9	1.32	1.44	1.38	0.00	0.00	0.00	0.58	0.40	0.49	0.53	0.64	0.59	1.13	1.00	1.07	0.71	0.70	0.70
	(1.35)	(1.39)	(1.37)	$(0.71)^a$	$(0.71)^a$	$(0.71)^a$	$(1.04)^{ab}$	$(0.95)^{ab}$	$(1.00)^{ab}$	$(1.01)^b$	$(1.07)^b$	$(1.04)^b$	(1.28)	(1.22)	(1.25)			
T_{10}	1.37	1.45	1.41	0.00	0.00	0.00	0.40	0.21	0.31	0.38	0.32	0.35	0.82	0.96	0.89	0.59	0.59	0.59
	(1.37)	(1.40)	(1.39)	$(0.71)^a$	$(0.71)^a$	$(0.71)^a$	$(0.95)^a$	$(0.84)^a$	$(0.90)^a$	$(0.94)^a$	$(0.91)^a$	$(0.93)^a$	(1.15)	(1.21)	(1.18)			
T_{11}	1.41	1.57	1.49	1.37	1.51	1.44	1.39	1.31	1.35	1.28	1.20	1.24	1.23	1.01	1.12	1.34	1.32	1.33
	(1.38)	(1.44)	(1.41)	$(1.37)^b$	$(1.42)^d$	$(1.40)^c$	$(1.37)^c$	$(1.35)^d$	$(1.36)^c$	$(1.33)^d$	(1.30)i	$(1.32)^d$	(1.32)	(1.23)	(1.28)			
S.Em±		0.02	0.02	0.03	0.02	0.02	0.01	0.03	0.04	0.03	0.01	0.01	0.02	0.04	0.03	0.01	-	-
C.D. @5%		NS	NS	NS	0.05	0.06	0.04	0.10	0.11	0.10	0.03	0.04	0.05	NS	NS	NS	-	-
C.V. (%)		7.68	9.57	8.21	9.64	8.67	8.41	12.07	11.61	9.13	13.76	12.89	10.32	12.67	11.37	9.05	-	-

DBS – Day before spraying; DAS – Days after spraying;

Figures in parenthesis are square root transformed values; Means followed by same letter in the column do not differ significantly by DMRT (p=0.05).

applications. This reduction in counts of natural enemies may be attributed to the decreased availability of thrips as prey on treated plants which could limit the growth and development of natural enemies along with direct adverse effects of these compounds on beneficial arthropods. Likewise, Galvan *et al*. (2005) documented that direct spray of spinosad caused higher mortality rates in larvae of *Harmonia axyridis* (Pallas). Biopesticides treated plots showed moderate number of natural enemies and did not show detrimental effect on their abundance across all the observation days and remained statistically on par with each other. This study suggests that EPFs did not show any significant impact on their population. This may be due to their selective virulence against target pests and also lower persistence under the field conditions and thereby minimize their impact and ensure safety against natural enemies. However, untreated check supported the highest population of natural enemies across the sprays and all days of observations.

Similar findings were reported by Thungrabeab and Tongma (2007) Derakhshan *et al.* (2007), Sayed *et al.* (2021) and Rizwana *et al.* (2024), who demonstrated that *B. bassiana*, *V. lecanii* and *M. anisopliae* were non-pathogenic to predator *Coccinella undecimpunctata* and did not adversely affect its biological parameters.

Conclusion

It could be concluded that plots treated with spinosad and azadirachtin were showed negative effect on predators. Entomopathogenic fungi (EPF) such as *B. bassiana*, *L. lecanii*, *M. anisopliae* were found to be safer and harmless for natural enemies during both *kharif* seasons. The results confirms that these EPF did not have any detrimental effect on natural enemy populations and can be effectively integrated into chilli pest management programs to conserve their natural enemies population.

Table 4. Impact of biopesticides on natural enemies (After third spray)

Treatments	Number of natural enemies / plant																	
	1 DBS			1 DAS			5 DAS			10 DAS			15 DAS			Mean		
	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled	2023	2024	Pooled
T_1	1.02	0.91	0.97	0.83	0.82	0.80	0.58	0.68	0.63	0.52	0.67	0.60	0.71	0.68	0.70	0.73	0.75	0.74
	(1.23)	(1.19)	(1.21)	(1.15)^{b}	(1.15)^{b}	(1.15)^{b}	(1.04)^{c}	(1.09)^{c}	(1.07)^{c}	(1.01)^{def}	(1.08)^{ghi}	(1.05)^{def}	(1.10)	(1.09)	(1.09)			
T_2	1.04	0.88	0.96	0.86	0.86	0.86	0.57	0.72	0.65	0.54	0.58	0.56	0.74	0.75	0.75	0.75	0.76	0.75
	(1.24)	(1.17)	(1.21)	(1.17)^{b}	(1.17)^{b}	(1.17)^{b}	(1.03)^{c}	(1.10)^{c}	(1.07)^{c}	(1.02)^{efg}	(1.04)^{ef}	(1.03)^{de}	(1.11)	(1.12)	(1.12)			
T_3	0.97	0.84	0.91	0.79	0.83	0.81	0.69	0.70	0.70	0.60	0.69	0.65	0.75	0.69	0.72	0.76	0.75	0.76
	(1.21)	(1.16)	(1.19)	(1.14)^{b}	(1.15)^{b}	(1.15)^{b}	(1.09)^{c}	(1.10)^{c}	(1.10)^{c}	(1.05)^{ghi}	(1.10)j	(1.07)^{efg}	(1.12)	(1.09)	(1.11)			
T_4	0.93	0.85	0.89	0.78	0.87	0.83	0.65	0.62	0.64	0.53	0.60	0.57	0.72	0.68	0.7	0.72	0.72	0.72
	(1.20)	(1.16)	(1.18)	(1.13)^{b}	(1.17)^{b}	(1.15)^{b}	(1.07)^{c}	(1.06)^{c}	(1.07)^{c}	(1.01)^{def}	(1.05)^{fg}	(1.03)^{de}	(1.10)	(1.09)	(1.10)			
T_5	1.02	0.90	0.96	0.89	0.82	0.86	0.61	0.71	0.66	0.56	0.64	0.68	0.69	0.76	0.73	0.75	0.77	0.76
	(1.23)	(1.18)	(1.21)	(1.18)^{b}	(1.15)^{b}	(1.17)^{b}	(1.05)^{c}	(1.10)^{c}	(1.08)^{c}	(1.03)$^{e-h}$	(1.07)^{gh}	(1.09)^{fg}	(1.09)	(1.12)	(1.11)			
T_6	0.98	0.89	0.94	0.80	0.91	0.86	0.59	0.66	0.63	0.50	0.52	0.51	0.70	0.70	0.70	0.71	0.74	0.73
	(1.22)	(1.18)	(1.20)	(1.14)^{b}	(1.19)^{b}	(1.17)^{b}	(1.04)^{c}	(1.08)^{c}	(1.06)^{c}	(1.00)^{de}	(1.01)^{de}	(1.01)^{d}	(1.10)	(1.10)	(1.1)			
T_7	1.04	0.82	0.93	0.87	0.80	0.84	0.60	0.71	0.66	0.47	0.57	0.52	0.71	0.74	0.73	0.74	0.73	0.73
	(1.24)	(1.15)	(1.20)	(1.17)^{b}	(1.14)^{b}	(1.16)^{b}	(1.05)^{c}	(1.10)^{c}	(1.08)^{c}	(0.98)^{d}	(0.99)^{d}	(1.01)^{d}	(1.10)	(1.11)	(1.11)			
T_8	0.91	0.93	0.92	0.75	0.84	0.80	0.61	0.69	0.65	0.38	0.41	0.40	0.72	0.71	0.72	0.67	0.72	0.70
	(1.19)	(1.20)	(1.20)	(1.12)^{b}	(1.16)^{b}	(1.14)^{b}	(1.05)^{c}	(1.09)^{c}	(1.07)^{c}	(0.94)^{bc}	(0.95)^{bc}	(0.95)^{bc}	(1.10)	(1.10)	(1.1)			
T_9	1.01	0.86	0.94	0.00	0.00	0.00	0.29	0.26	0.28	0.35	0.36	0.36	0.67	0.63	0.65	0.46	0.42	0.44
	(1.23)	(1.17)	(1.20)	(0.71)^{a}	(0.71)^{a}	(0.71)^{a}	(0.89)^{ab}	(0.87)^{ab}	(0.88)^{ab}	(0.92)^{b}	(0.93)^{b}	(0.93)^{b}	(1.08)	(1.06)	(1.07)			
T_{10}	0.99	0.95	0.97	0.00	0.00	0.00	0.16	0.16	0.16	0.27	0.29	0.28	0.60	0.59	0.60	0.40	0.40	0.40
	(1.22)	(1.20)	(1.21)	(0.71)^{a}	(0.71)^{a}	(0.71)^{a}	(0.81)^{a}	(0.81)^{a}	(0.81)^{a}	(0.88)^{a}	(0.89)^{a}	(0.88)^{a}	(1.05)	(1.04)	(1.05)			
T_{11}	1.02	0.92	0.97	1.00	0.90	0.95	0.91	0.85	0.88	0.84	0.80	0.82	0.74	0.76	0.75	0.90	0.85	0.87
	(1.23)	(1.19)	(1.21)	(1.22)^{c}	(1.18)^{b}	(1.20)^{c}	(1.19)^{d}	(1.16)c	(1.18)^{d}	(1.16)j	(1.14)k	(1.15)h	(1.11)	(1.12)	(1.12)			
S.Em±	0.03	0.02	0.01	0.02	0.02	0.01	0.03	0.02	0.02	0.01	0.01	0.01	0.04	0.04	0.01	-	-	-
C.D. @5%	NS	NS	NS	0.06	0.05	0.04	0.08	0.07	0.07	0.03	0.03	0.04	NS	NS	NS	-	-	-
C.V. (%)	8.56	7.41	9.69	10.78	11.45	9.49	11.48	9.78	9.02	13.54	12.97	10.51	10.56	10.54	8.53	-	-	-

DBS – Day before spraying; DAS – Days after spraying;
Figures in parenthesis are square root transformed values;
Means followed by same letter in the column do not differ significantly by DMRT (p=0.05).

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