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Screening of insecticides for toxicity to rice hoppers and their predators

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ABSTRACT

Greenhouse studies were conducted at the Directorate of Rice Research, Hyderabad to assess the toxicity of selected insecticides to rice brown planthopper (BPH) Nilaparvata lugens (Stal) and white backed planthopper (WBPH) Sogatella furcifera (Horvath), green leafhopper (GLH) Nephotettix virescens (Distant) and their important predators viz. green mirid bug (GMB) Cyrtorhinus lividipennis (Reuter), brown mirid bug (BMB) Tytthus parviceps and veliid predator (VP) Microvelia douglasi atrolineata. The results showed that bifenthrin @ 50g a.i. ha^{-1} was less toxic to BPH the persistent toxicity (PT) being 1371 compared to GLH (PT 2507) and more toxic to BMB (PT 2667 for nymphs, PT 2800 for adults), GMB (PT 2800) and VP (PT 2800) than monocrotophos @ 500g a.i. ha^{-1} (PT for BPH 756, WBPH 1913, GLH 1623, BMB nymphs 1652, adults 2016, GMB 1960 and VP 931). Virtakao 40 WG, a combination product containing 20% chlorantraniliprole + 20% thiamethoxam @ 50 g a.i. ha^{-1} exhibited higher toxicity to BPH (PT 1184), WBPH PT 2914) and GLH (PT 3000) compared to monocrotophos @ 500 g a.i. ha ha^{-1}, but it was highly toxic to all the predators viz., BMB (PT nymphs 2513, adults 2793), GMB (PT 2800) and V.P (PT 2609). Pymetrozine, a new molecule belonging to pyridine azomethines group @ 125 g a.i. ha^{-1} exhibited higher toxicity to BPH (PT 1950) & WBPH (PT 2411) compared to monocrotophos @ 500g a.i. ha ha^{-1} but at the same time it was relatively less toxic to natural enemies viz., BMB (PT for nymphs 2303, adults 2737), GMB (PT 1582) Toxicity of insecticides to rice hoppers and predators and VP (PT 649). The implications of using these new products in rice ecosystem based on the present results for ecological safety are discussed.

Key words: *rice, leafhoppers, planthoppers, insecticide, toxicity, predators*

Rice planthoppers, brown planthopper (BPH) *Nilaparvata lugens* (Stal), whitebacked planthopper (WBPH) *Sogatella furcifera* (Horvath) and green leafhopper (GLH) *Nephotettix virescens* (Distant) are important insect pests attacking rice. Both the nymphs and adults of these hoppers suck the sap from the phloem and xylem resulting in drying up of the rice plant. Under field conditions, the damage by BPH and WBPH results in "hopper burn." Green leafhopper feeding results in wilting, yellowing and drying of the plant and it acts as a vector of rice tungro virus. If timely control measures are not taken up, the entire field could be damaged by the planthoppers. Green mirid bug *Cyrtorhinus lividipennis* (Reuter), brown mirid bug *Tytthus parviceps* (Reut) are important predators on the eggs and early instar nymphs of BPH (Upadhyay and Diwakar, 1983) and WBPH (Basilio and Heong 1990). The veliid bug *Microvelia douglasi atrolineata* (Bergroth) is found on water surface in flooded rice fields and feed on nymphs of BPH and WBPH (Gubbaiah *et al.,* 1987) falling on water.

Even though an insecticide is meant for controlling a specific insect pest, it is necessary to test their activity against the insect pests and natural enemies, which exist together in the ecosystem. There are several instances where the use of some insecticide molecules, particularly synthetic pyrethroids has led to resurgence of BPH and WBPH resulting in complete loss of rice crop. Destruction of natural enemies has been observed to be responsible for BPH resurgence (Heinrichs *et al*., 1982; Krishnaiah and Kalode 1986). Therefore, evaluation of new insecticides applied in the rice ecosystem for their toxicity to these predators is essential for assessing ecological implications of these insecticides in rice ecosystem. The present investigation was therefore, carried out to assess toxicity of selected new insecticides to the rice hoppers and their predators under controlled conditions in the greenhouse.

MATERIALS AND METHODS

The investigation was carried out at DRR, Rajendranagar, Hyderabad with the insecticides Bifenthrin (Talstar) 10 EC @ 50g a.i. ha^{-1}, Rynaxypyr 200g + Thiamethoxam 200g (Virtakao) 40 WG at 3 doses *viz*., 40 g a.i. ha^{-1}, 50 g a.i. ha^{-1} and 60 g g a.i. ha^{-1}, Pymetrozine (Pymetrozine) 50 WG at 3 doses *viz*., 100g a.i ha^{-1}, 125g a.i ha^{-1}, 150g a.i ha^{-1}, as sprays along with standard check insecticide Monocrotophos (Monocrown) 36 WSC @ 500 g a.i ha^{-1} and water spray without any insecticide. Bifenthrin was already tested for other insect pests of rice and the dose was standardized so only the recommended dose was tested in the present study. Pymetrozine and Rynoxypyr + thiamethoxam were tested at different doses to standardize the dose as they have not been tested in the rice ecosystem. All the treatments were replicated four times. The tests were carried out under controlled glasshouse conditions at a temperature of 30 ± 5^0 C and RH of 60 $\pm$ 10% by following the methods of Jhansi Lakshmi *et al*. (2001a, 2001b) and Krishnaiah *et al*. (2001).

Rice hoppers reared on 45 day old TN1 rice plants in wooden cages in the glasshouse were used in the experiment. The predatory mirid bugs viz., *C. lividipennis* and *T. parviceps* were separately reared on TN1 rice plants exposed to the BPH for oviposition to obtain nymphs or adults of specific age. *M. douglasi atrolineata* was collected from stagnant water in the tanks near the glasshouse and reared in the plastic pots and trays by providing planthopper nymphs as the food and the adult *Microvelia* were collected for toxicity studies.

The insecticides at specific concentrations were sprayed up to run-off stage on 40 day old potted TN1 rice plants and the test insects (BPH, WBPH, GLH) were confined separately on these plants at 1, 7, 14, 21 and 28 days after spraying and separate sets were maintained for each day of confinement. Effect of insecticides on mirid bugs was studied by exposing rice plants for oviposition by BPH for 3 days before spraying for test releases at 1 and 7 days after spraying, where as they were subjected to oviposition by BPH after spraying in case of releases at 14, 21 and 28 days after spraying to avoid death of BPH adults before oviposition. Twenty third instar nymphs or 3 days old adults were confined each time within mylar cages. Observations on mortality were recorded after 24, 48 and 72 hours of release of insects at all days of releases i.e 1, 7, 14, 21 and 28 days after spraying. The toxicity tests were conducted for nymphs of hoppers (BPH, WBPH and GLH) and for nymphs and adults of mirid bugs. Separate experiments were conducted with nymphs and adults.

The insecticide emulsions/solutions at specific concentrations were made in water (Table 1). Ten ml of each of the emulsion/solution was added to 1 litre of water contained in a 2 litre capacity plastic pot so that the concentration in ppm was $1/100^{th}$ of the original concentration used for other insects such as hoppers and mirid bugs. Twenty *Microvelia* adults were released on the water surface and covered with muslin cloth. Brown planthopper nymphs were provided as prey. Mortality was recorded at 24, 48 and 72 hours after release of *Microvelia* at 1, 7, 14, 21 and 28 days after treating with insecticides.

Persistent toxicity (PT) values were calculated for each insecticide and each exposure period viz. 24, 48 and 72 hours separately according to Pradhan (1967). Persistent toxicity (PT) value is the product of average percent mortality and the period in days up to which the insecticide exhibited toxicity to the predator. PT values were subjected to square root transformation and analyzed in CRBD. (Cochran and Cox 1957).

RESULTS AND DISCUSSION

This insecticide, bifenthrin, a synthetic pyrethroid had very high degree of initial toxicity against BPH, WBPH and GLH registering 100% mortality within 24 hours exposure, similar to the check insecticide monocrotophos (100% kill within 24 hours). However, with regard to persistent toxicity (PT) bifenthrin was moderately toxic against BPH (PT value of 797 at 24 hrs exposure), highly toxic against WBPH (1902) and GLH (2111) and significantly superior to monocrotophos with PT values for BPH, WBPH and GLH were 569, 1157 and 1201, respectively (Tables 1, 2 and 3). Krishnaiah and Kalode (1986) also reported that synthetic pyrethroids like deltamethrin, cypermethrin and fenvalerate are relatively less toxic to BPH compared to GLH, which corroborated with the present findings.

Table 1. Relative safety and persistent toxicity of insecticides to nymphs of brown planthopper

Treatment	Conc.of a.i. ha^{-1}	% mortality Released on the same day after spraying			Persistent Toxicity		
		24 hours after release	48 hours after release	72 hours after release	24 hours after release	48 hours after release	72 hours after release
Bifenethrin 10EC	50g	100(89.96)a	100(89.96)a	100(89.96)a	797(28.2)b	971(31.1)d	1371(36.9)c
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	40g	76.3(60.9)b	87.5(69.4)b	98.8(86.7)a	343(18.2)e	801(28.3)ef	1227(34.9)c
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	50g	80(63.6)b	91.3(73.2)b	100(89.96)a	470(20.6)de	889(29.8)de	1184(34.3)c
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	60g	81.3(64.4)b	93.8(77.5)b	100(89.96)a	575(23.9)cd	923(30.4)de	1388(37.2)c
Pymetrozine 50WG	100g	8.8(16.8)d	22.5(28.1)d	48.8(44.3)c	600(24.5)bc	1136(33.6)c	1875(43.2)b
Pymetrozine 50WG	125g	13.8(21.6)c	46.3(42.8)c	71.3(57.6)b5	729(26.9)bc	1393(37.3)b	1950(44.2)b
Pymetrozine 50WG	150g	21.3(27.3)c	52.5(46.6)c	71.3(57.7)b	1227(35)a	1934(43.9)a	2416(49.2)a
Monocrotophos 36WSC	500g	100(89.9)a	100(89.96)a	100(89.96)a	569(23.8)cd	700(26.5)f	756(27.5)d
Untreated control		0(0)	0(0)	0(0)	0(0)f	0(0)g	0(0)e

Note: Figures in parenthesis are transformed values
Figures in a column followed by the same letter are not significantly different at P=0.05

Bifenthrin recorded very high initial toxicity (100% kill within 24 hours) to nymphs and adults of BMB, adults of GMB, similar to monocrotophos. However, with regard to VP, bifenthrin registered high toxicity (100% kill with in 24 hrs) compared to check insecticide monocrotophos, which registered only 31% mortality during the corresponding period. Bifenthrin was highly toxic to all the three predators exhibiting very high PT values ranging from 2597 to 2800 compared to the check insecticide monocrotophos (PT

Table 2. Relative safety and persistent toxicity of insecticides to nymphs of white backed planthopper

Treatment	Conc.of a.i. ha^{-1}	% mortality Released on the same day after spraying			Persistent Toxicity		
		24 hours after release	48 hours after release	72 hours after release	24 hours after release	48 hours after release	72 hours after release
Bifenethrin 10EC	50g	100(89.96)a	100(89.96)a	100(89.96)a	1902(43.6)bc	2368(48.7)bc	2791(52.8)ab
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	40g	100(89.96)a	100(89.96)a	100(89.96)a	1725(41.5)c	2261(47.5)cd	2711(52)ab
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	50g	100(89.96)a	100(89.96)a	100(89.96)a	2223(47.1)a	2668(51.7)a	2914(53.9)a
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	60g	100(89.96)a	100(89.96)a	100(89.96)a	2079(45.6)ab	2561(50.6)ab	2829(53.2)a
Pymetrozine 50WG	100g	15(21.5)b	40(39.1)c	88.8(71.4)b	1393(37.3)d	2143(46.3)cd	2748(52.4)ab
Pymetrozine 50WG	125g	21.3(26.5)b	42.5(40.9)bc	73.8(59.2)d	1227(35)e	1827(42.7)d	2411(49.1)c
Pymetrozine 50WG	150g	17.5(24.7)b	50(44.9)b	81.3(64.6)c	1495(38.6)d	2170(46.6)cd	2748(52.4)ab
Monocrotophos 36WSC	500g	100(89.96)a	100(89.96)a	100(89.96)a	1157(34)e	1602(40)e	1913(43.7)d
Untreated control		0(0)c	0(0)d	0(0)e	0(0)f	0(0)f	0(0)e

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value 453 to 1191). The product Virtakao 40WG, even at 50g a.i ha^{-1}, was found to be less effective against BPH initially resulting in 80% mortality after 24 hrs compared to 100% kill in monocrotphos. However, Virtakao at 50 g a.i ha^{-1} resulted in 100% mortality by 72 hrs revealing that the product is slow acting against BPH. Similar trend was observed in persistent toxicity also. The PT value for 24 hrs exposure was 470 while for 72 hrs exposure it was 1184, compared to monocrotophos where the corresponding values were 569 and 756, respectively (Table 1). Against WBPH and GLH, Virtakao at 50 g a.i. ha^{-1} recorded PT values of 2223 and 2754, respectively compared to the corresponding values of 1157 and 1201 in case of monocrotophos (Tables 2 and 3). With regard to natural combination product (Virtakao 40WG) containing chlorantraniliprole and thiamethoxam at 50g a.i ha^{-1} is more effective against the sucking pests viz., BPH, WBPH and GLH, compared to check insecticide, monocrotophos at 500g a.i. ha^{-1} . At the same time, the combination product is more toxic to all the predators tested. Thus, it is clear that chlorantraniliprole + thiamethoxam has more pest suppressing ability than monocrotophos but is not safe for the tested predators.

The toxicity of chlorantraniliprole+ thiamethoxam against hopper pests appears to be mainly due to thiamethoxam (Ghosh et al., 2009) as chlorantraniliprole is effective against the lepidopterans such as *Cnaphalocrocis medinalis* and *Scirpophaga*

Table 3. Relative safety and persistent toxicity of insecticides to nymphs of green leafhopper

Treatment	Conc.of a.i. ha^{-1}	% mortality: Released on the same day after spraying, 24 hours after release	48 hours after release	72 hours after release	Persistent Toxicity: 24 hours after release	48 hours after release	72 hours after release
Bifenethrin 10EC	50g	100(89.96)a	100(89.96)a	100(89.96)a	2111(38.4)b	2395(48.9)b	2507(50.1)b
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	40g	100(89.96)a	100(89.96)a	100(89.96)a	2695(51.9)a	2936(54.2)a	3000(54.8)a
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	50g	100(89.96)a	100(89.96)a	100(89.96)a	2754(52.5)a	3000(54.8)a	3000(54.8)a
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	60g	100(89.96)a	100(89.96)a	100(89.96)a	2850(53.4)a	3000(54.8)a	3000(54.8)a
Pymetrozine 50WG	100g	35(41)b	36.3(36.5)bc	58.8(50.2)c	483(21.5)d	851(28.7)e	1484(38.4)d
Pymetrozine 50WG	125g	15(22.2)d	30(33.2)bc	50(44.9)c	566(23.8)cd	1055(32.5)de	1623(40.3)d
Pymetrozine 50WG	150g	24(29.1)c	41.3(39.9)b	72.5(58.9)b	980(31.3)bc	1543(39.3)c	2116(45.9)c
Monocrotophos 36WSC	500g	100(89.96)a	100(89.96)a	100(89.96)a	1201(34.7)b	1390(35)d	1623(40.3)d
Untreated control		0(0)e	0(0)d	0(0)d	0(0)e	0(0)f	0(0)e

Note: Figures in parenthesis are transformed values
Figures in a column followed by the same letter are not significantly different at P=0.05

enemies, Virtakao registered high PT values for BMB nymphs (2240) and BMB adults (1938) compared to monocrotophos (888 and 811 for BMB nymphs and adults respectively) (Tables 4 and 5). For GMB adults as well as VP, Virtakao exhibited higher toxicity (PT vales of 2800 and 1451, respectively) compared to monocrotophos (1191 and 453 respectively) (Tables 6 and 7). Thus the above results clearly shows that the spp (Nauen 2006) and less toxic to these sucking pests. However, the toxic effects towards natural enemies could be due to both the molecules present in the combination product, Virtakao. This seems to be so because the molecules like indoxacarb, spinosad and even flubendiamide (belonging to diamide group similar to chlorantraniliprole), which are mainly targeted against Lepidopteran pests like stem borer and leaf folder in

Table 4. Relative safety and persistent toxicity of insecticides to the nymphs of *T. parviceps*

Treatment	Conc.of a.i. ha^{-1}	% mortality Released on the same day after spraying			Persistent Toxicity		
		24 hours after release	48 hours after release	72 hours after release	24 hours after release	48 hours after release	72 hours after release
Bifenethrin 10EC	50g	100(89.9)a	100(89.9)a	100(89.9)a	2597(50.9)a	2632(51.3)a	2667(51.7)a
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	50g	100(89.9)a	100(89.9)a	100(89.9)a	2240(47.3)b	2247(47.4)b	2513(50.1)b
Pymetrozine 50WG	125g	21(31.2)b	50(44.9)b	73.8(59.4)b	1204(34.7)c	1435(37.9)c	2303(47.9)c
Monocrotophos 36WSC	500g	100(89.9)a	100(89.9)a	100(89.9)a	888.6(29.8)d	1391(37.24)c	1652(40.6)d
Untreated control		0(0)c	0(0)c	0(0)c	0(0)e	0(0)d	0(0)e

Note: Figures in parenthesis are transformed values
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rice ecosystem exhibit moderate to high degree of toxicity to BMB, GMB and VP, which are the predators of planthoppers (Jhansilakshmi *et. al*., 2010).

Pymetrozine at 125g a.i ha^{-1} registered 14% mortality in BPH within 24 hours exposure, which reached 71% by 72 hours, as compared to 100% mortality in monocrotophos within 24 hours. However, pymetrozine registered good persistent toxicity (PT value of 729) for 24 hrs exposure period, which increased to 1950 for 72 hrs exposure. The corresponding values for monocrotophos were 569 and 756, respectively. Thus pymetrozine appears to be slow acting on the insect but possess excellent persistent toxicity against BPH (Table 1). The toxicity against WBPH also revealed more or less similar trend (Table 2). However, against GLH, pymetrozine at 125 g a.i ha^{-1} exhibited poor initial toxicity (50% mortality at 72 hrs exposure). Pymetrozine was less effective (PT value of 566 at 24 hrs) compared to monocrotophos (PT value of 1201 at 24 hrs). Pymetrozine gave excellent control of planthoppers in paddy rice under field conditions in Japan. And the persistent toxicity was observed upto 4 weeks after foliar spray (Sato *et al.* 1996). Pymetrozine showed good efficacy (LC50<4.50 mg L^{-1}) against WBPH suggesting that the above insecticide was potential alternative to highly toxic insecticides for field trials (Li *et al.* 2009).

Pymetrozine was less toxic to BMB nymphs and adults initially killing 50 to 53% of exposed insects at 48 hrs exposure compared to 100% mortality in

Table 5. Relative safety and persistent toxicity of insecticides to adults of *Tytthus parviceps*

Treatment	Conc.of a.i. ha^{-1}	% mortality Released on the same day after spraying			Persistent Toxicity		
		24 hours after release	48 hours after release	72 hours after release	24 hours after release	48 hours after release	72 hours after release
Bifenethrin 10EC	50g	100(89.6)a	100(89.6)a	100(89.6)a	2800(52.9)a	2800(52.9)a	2800(52.9)a
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	50g	100(89.6)a	100(89.6)a	100(89.6)a	1938(44)b	2422(49.2)b	2793(52.9)a
Pymetrozine 50WG	125g	15(22.6)b	52.5(46.4)b	90(71.8)b	819(28.5)c	1883(43.4)c	2737(52.3)a
Monocrotophos 36WSC	500g	100(89.6)a	100(89.6)a	100(89.6)a	811(28.3)c	1624(40.3)d	2016(44.9)b
Untreated control		0(0)c	0(0)c	0(0)c	0(0)d	0(0)e	0(0)c

Note: Figures in parenthesis are transformed values
Figures in a column followed by the same letter are not significantly different at P=0.05

Table 6. Relative safety and persistent toxicity of insecticides to the adults of *C. lividipennis*

Treatment	Conc.of a.i. ha^{-1}	% mortality Released on the same day after spraying			Persistent Toxicity		
		24 hours after release	48 hours after release	72 hours after release	24 hours after release	48 hours after release	72 hours after release
Bifenethrin 10EC	50g	100(89.9)a	100(89.9)a	100(89.9)a	2800(52.92)a	2800(52.92)a	2800(52.92)a
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	50g	100(89.9)a	100(89.9)a	100(89.9)a	2800(52.92)a	2800(52.92)a	2800(52.92)a
Pymetrozine 50WG	125g	17.5(24.2)b	30(32.9)c	42.5(40.3)b	355(18.5)c	1008(31.67)c	1582(39.75)c
Monocrotophos 36WSC	500g	100(89.9)a	77.5(68.9)b	100(89.9)a	1191(34.45)b	1442(37.89)b	1960(44.22)b
Untreated control		0(0)b	0(0)c	0(0)c	0(0)d	0(0)d	0(0)d

Note: Figures in parenthesis are transformed values
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monocrotophos within 24 hrs. However, persistent toxicity of pymetrozine towards BMB nymphs and adults (PT value of 1453 and 1883 respectively) was comparable to monocrotophos (1391 and 1624 respectively) (Tables 4 and 5). To GMB adults, pymetrozine was less toxic initially (43% mortality at 72 hrs) compared to monocrotophos (100% with in 24 hrs). Even the persistent toxicity of pymetrozine towards GMB (PT value of 1582 at 72 hrs) was less than monocrotophos (1960) (Table 6). Pymetrozine was less toxic to VP initially (53% kill at 72 hrs) and also recorded less PT (649) while the corresponding values for monocrotophos were 70% and 931, respectively (Table7).

From the above results, it is clear that pymetrozine is a good insecticide against BPH and WBPH in rice ecosystem as its persistent toxicity is very high although the compound was slow acting initially. Relatively lower toxicity towards major predators of planthoppers viz., BMB, GMB and VP is another additional and favourable point for use of pymetrozine at the dose of 125 g a.i ha^{-1} in rice ecosystem. As already discussed, in-built mammalian safety and low dosage rate (125g a.i. ha^{-1}) which is one fourth of the dosage of monocrotophos (500g a.i ha^{-1}) should be additional favourable points for use of pymetrozine in rice ecosystem against planthopper pests, as a substituent to monocrotophos.

Table 7. Relative safety and persistent toxicity of insecticides to *Microvelia douglasi*

Treatment	Conc.of a.i. ha^{-1}	% mortality Released on the same day after spraying			Persistent Toxicity		
		24 hours after release	48 hours after release	72 hours after release	24 hours after release	48 hours after release	72 hours after release
Bifenethrin 10 EC	50g	100(89.9)a	100(89.9)a	100(89.9)a	2800(52.9)a	2800(52.9)a	2800(52.9)a
Rynaxypyr 200g + Thiamethoxam 200g/kg 40WG	50g	100(89.9)a	100(89.9)a	100(89.9)a	1451(38.1)b	1617(40.2)b	2069(45.5)b
Pymetrozine 50WG	125g	7.5(11.3)c	37.5(37.5)c	52.5(46.5)c	93(6.7)d	362(18.9)d	649(25.4)d
Monocrotophos 36WSC	500g	31.3(33.9)b	52.5(46.4)b	70(56.9)b	453(21.3)c	676(25.9)c	931(30.5)c
Untreated control		0(0)d	0(0)d	0(0)d	0(0)e	0(0)e	0(0)e

Note: Figures in parenthesis are transformed values
Figures in a column followed by the same letter are not significantly different at P=0.05

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