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A Novel Insecticide Diafenthiuron 50WP against Cardamom Shoot and Capsule Borer *C. punctiferalis* Guenee

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A B S T R A C T

Diafenthiuron, a novel insecticide with different mode of action of energy production inhibition and IGR activity was found to be effective against *Conogethes punctiferalis* in field trials conducted and concluded that 800ga.i./ha concentration can be recommended. Supervised field experiments that conducted during January 2014 - April 2014 at Nedukandam, Idukki district, Kerala with the cardamom cultivars, Njellani (Green gold) revealed that diafenthiuron 50 WP (NS) as foliar application at 1600, 800 and 400 g a.i. ha^{-1} effected 77.07, 79.23 and 72.71 per cent reduction in capsule damage, and 77.86, 77.63 and 67.19 per cent reduction in shoot damage respectively, thirty days after three applications. No visual phytotoxic symptoms *viz*., leaf injury, wilting, vein clearing, necrosis, epinasty and hyponasty were observed with diafenthiuron 50 WP (NS) at 1600, 800 and 400 g. a.i. ha^{-1}.

Introduction

Cardamom, the Queen of all spices, has a history as old as human race. It is the dried fruit of a herbaceous perennial plant. Warm humid climate, loamy soil rich in organic matter, distributed rainfall and special cultivation and processing methods all combine to make Indian cardamom truly unique-in aroma, flavour, size and it has parrot green colour. The main harvest season of cardamom in India is between July-February. About 72 insect pests have been recorded on cardamom (Chakravarthy and Khan, 1987). The major pests of cardamom are thrips *Sciothrips cardamomi* Ramk, capsule borers viz., lycaenid borer *Jamides sp*, scolytid borer *Thamurgides cardamomi* Schaufuss, shoot/panicle/capsule borer *Conogethes punctiferalis* Guenee, hairy caterpillars viz., *Eupterote cardamomi* Renga, *Eupterote canaraica* Moore, *Eupterote fabia* (Cramer), *Eupterote testacea* Walk., *Lenodera vittata* Walk. and *Pericallia ricini* (Fab.), Apart from these pests, shoot fly, *Formosina flavipes* Mall., rhizome weevil, *Prodioctes haematicus* Chevr., root borer, *Hilarographa caminodes* Meyer, whiteflies, *Dialeurodes cardamomi* (David and Subr.), aphids, *Pentalonia nigronervosa* Coq., scales, mealy bugs and mites have been found to affect the crop in various seasons (Kumaresan

et al., 1987). Cardamom shoot and capsule borer (CSCB), C. *punctiferalis* has been an economic pest which feeds on the capsules, pseudostems and panicles causing more than 10 per cent yield loss under field conditions (Thyagaraj, 2002).

Diafenthiuron, a thio urea compound has a novel mode of action which inhibits and enhances biochemical sites such as respiration (Ishaaya *et al.,* 2001); inhibits mitochondrial action and energy metabolism (ATP synthesis) and moult inhibition and hence it is seen as a viable tool for managing insects and mites. A seven year study (2000-2007) made to analyse the variability, possible trends in the multiplicity and management of cardamom pests, climatic variables and productivity in cardamom based agroforestry system showed a trend of decreasing maximum temperature since 2000 and a reduction in the incidence of insect pests along with a decrease in natural enemy population due to calendar-based pesticide spraying (Murugan *et al.*, 2011).

Materials and Methods

A Field experiment was conducted at Nedukandam, Idukki district of kerela during January 2014 - April 2014 to evaluate the bioefficacy of diafenthiuron 50%WP (NS), applied as foliar spray against cardamom shoot and capsule borer, *C. punctiferalis* and its phytotoxicity. Field trials were laid out in randomized block design (RBD) in the farmer's holdings in Nedukandam, Kerela on the ruling variety of Njellani Green Gold as per the treatments given below and replicated thrice. Three sprays were given at 30 days interval and observations were made on the capsule damage, before the spray and on 10, 20 and 30 days after application. Though the damage caused by borer in shoots and capsules the incidence was assessed on capsule basis and expressed as per cent damage. Damage was assessed by counting total number of capsules per ten panicles in four clumps in a treatment and capsules showing bored holes for borer and scabs for thrips on 10, 20 and 30 days after each application to find the per cent damage. The per cent damage was subjected to statistical analysis adopting randomized block design using AGRES after converting it to arcsine percentage

Phytotoxicity tests for diafenthiuron

To evaluate the phytotoxicity (if any) caused by diafenthiuron 50%WP on cardamom, field experiment was conducted at Nedukandam, Kerela during December 2012 to March 2013. The experiments were conducted in a randomized block design with 4 clumps per treatment and with three replications using the variety Njellani Green Gold. Three different doses of 800, 1600, and 3200 g a.i. ha^{-1}. The plants were observed on 1, 3, 7, 10, 14 and 20 days after spraying as per the protocol of Central Insecticide Board Registration Committee (C.I.B.R.C) for the phytotoxic symptoms like Injury to leaftip and leafsurface,Wilting, Vein clearing, Necrosis, Epinasty and hyponasty.

The per cent leaf injury was calculated using the formula,

$$\text{Per cent leaf injury} = \frac{\text{Total grade points}}{\text{Max. Grade x No. of leaves observed}} \times 100$$

Results and Discussion

The results of field and laboratory experiments conducted to assess the bioefficacy of diafenthiuron 50WP (NS) against the cardamom shoot and capsule borer and its its phytotoxicity. The mean damage to capsules by CSCB before application ranged between 12.20 and 12.80 per cent (Table 1) and was not significant. After first spray, at ten days after application (DAA), reduction in damage was noticed in treated plots (12.20 to

12.80%) while the untreated control registered 12.20 per cent. At 20 DAA, diafenthiuron 50 WP (NS) at the highest dose of 1600 g a.i. ha^{-1} recorded the lowest of 12.00 per cent damage to capsules which was on compared with its lower dose of 400 g a.i. ha^{-1} (12.40%) and diafenthiuron 50 WP (ES) 800 g a.i. ha^{-1} (12.05%). The standard checks, quinalphos 25 EC 600 g a.i. ha^{-1} and 1200 g a.i. ha^{-1} recorded 18.00, 11.75 and 11.75 per cent damage. At 30 DAA, diafenthiuron 50 WP (NS) 1600 g a.i. ha^{-1} recorded 11.55 per cent damage to capsules and was on par with lower dose of 800 g a.i. ha^{-1} which recorded 11.70 per cent damage and diafenthiuron 50 WP (ES) 800 g a.i. ha^{-1} (11.90%). The standard checks, quinalphos 25 EC 600g a.i. ha^{-1} and quinalphos 25 EC 1200g a.i. ha^{-1} recorded 11.70 and 11.55 per cent damage respectively while untreated check recorded the highest of 21.50 per cent. The per cent reduction over check obtained maximum in diafenthiuron 50 WP 1600 g a.i. ha^{-1} (30.26%) followed by standard quinalphos 25% EC at 1200 g a i. ha^{-1}(Table 1 & Fig 1)

The second application was given thirty days after the first application. The trend in efficacy of different treatments in respect of per cent reduction in borer damage was similar to that of first application (Table 2 & Fig 2). Diafenthiuron 50 WP (NS) 1600 and 800 g a.i. ha^{-1} recorded 66.58% and 64.03% after 30 Days after first application.

The third spray was taken up thirty days after the second application, when the damage level reached 8.25 to 9.00 per cent in the treatments and 29.00 per cent in untreated check. Trend in reduction of capsule damage continued to be similar as that of second application. Based on reduction of capsule damage over untreated check, the descending order of efficacy of different treatments are: diafenthiuron 50 WP (NS) 800 g a.i. ha^{-1} (79.23%), 1600 g a.i. ha^{-1} (77.07%), quinalphos 25 EC 1200 g a.i. ha^{-1} (76.96%), quinalphos 25 EC 600g a.i. ha^{-1}(76.19), diafenthiruon 50 WP ES 800 g a.i. ha^{-1} (76.41 %), diafenthiruon 50 WP (NS) 400 g a.i. ha^{-1} (72.71) (Table 3 & Fig 3).

Table.1 Effect of diafenthiuron 50% WP (NS) on capsule damage by *C. punctiferalis* (Location – Nedukandam) – First Application

Treatments	Dose (g a.i. ha^{-1})	Per cent capsule damage					
		PTC	10DAA	20DAA	30DAA	Mean	Percent reduction over check
Diafenthiuron 50 % WP NS (1.6 g L^{-1})	400	12.50	12.50^{ab} (20.70)	12.40^{ab} (20.61)	12.15^{b} (20.39)	12.35	28.32
Diafenthiuron 50% WP NS (3.2 g L^{-1})	800	12.63	12.63^{b} (20.81)	12.00^{b} (20.26)	11.70^{ab} (20.01)	12.11	29.72
Diafenthiuron 50% WP NS (6.4 g L^{-1})	1600	12.45	12.45^{c} (20.66)	12.05^{d} (20.31)	11.55^{a} (19.86)	12.02	30.26
Standard Diafenthiuron 50% WP (3.2 g L^{-1})	800	12.40	12.40^{b} (20.61)	11.95^{b} (20.22)	11.90^{ab} (20.17)	12.08	29.87
Standard Quinalphos 25% EC (7.2 ml L^{-1})	600	12.68	12.68^{ab} (20.86)	11.75^{ab} (20.04)	11.70^{ab} (20.01)	12.04	30.10
Standard Quinalphos 25% EC (14.4 ml L^{-1})	1200	12.80	12.80^{ab} (20.96)	11.75^{ab} (20.04)	11.55^{ab} (19.86)	12.03	30.16
Untreated check	-	12.20	12.20^{c} (20.44)	18.00^{c} (25.14)	21.50^{c} (27.62)	17.23	

Mean of three observations; PTC – Pretreatment count,
Figures in parentheses are arc sin transformed values, in a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

Table.2 Effect of diafenthiuron 50% WP (NS) on capsule damage by *C. punctiferalis* (Location - Nedukandam) – Second Application

Treatments	Dose (g a.i. ha^{-1})	Per cent capsule damage					
		PTC	10 DAA	20 DAA	30 DAA	Mean	Percent reduction over check
Diafenthiuron 50 % WP NS (1.6 g L^{-1})	400	12.15	11.15^{b} (19.50)	10.50^{b} (18.90)	10.00^{c} (18.43)	10.55	60.68
Diafenthiuron 50% WP NS (3.2 g L^{-1})	800	11.70	10.20^{ab} (18.62)	9.75^{ab} (18.19)	9.00^{bc} (17.45)	9.65	64.03
Diafenthiuron 50% WP NS (6.4 g L^{-1})	1600	11.55	9.65^{a} (18.09)	9.00^{a} (17.45)	8.25^{a} (16.69)	8.97	66.58
Standard Diafenthiuron 50% WP (3.2 g L^{-1})	800	11.90	9.45^{ab} (17.90)	8.85^{a} (17.30)	8.65^{bc} (17.10)	8.98	66.52
Standard Quinalphos 25% EC (7.2 ml L^{-1})	600	11.70	9.75^{ab} (18.19)	9.10^{ab} (17.55)	8.85^{bc} (17.30)	9.23	65.59
Standard Quinalphos 25% EC (14.4 ml L^{-1})	1200	11.55	9.80^{ab} (18.24)	8.95^{ab} (17.40)	8.90^{b} (17.35)	9.22	65.65
Untreated check	-	21.50	24.00^{c} (29.33)	27.50^{c} (31.62)	29.00^{d} (31.62)	26.83	

Mean of three observations; PTC – Pretreatment count,
Figures in parentheses are arc sin transformed values.
In a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

Table.3 Effect of diafenthiuron 50% WP (NS) on capsule damage by *C. punctiferalis* (Location - Nedukandam) – Third Application

Treatments	Dose (g a.i. ha^{-1})	Per cent capsule damage					
		PTC	10 DAA	20 DAA	30 DAA	Mean	Percent reduction over check
Diafenthiuron 50 % WP NS (1.6 g L^{-1})	400	10.00	8.50^{c} (16.95)	8.25^{c} (16.69)	7.95^{c} (16.37)	8.23	72.71
Diafenthiuron 50% WP NS (3.2 g L^{-1})	800	9.00	6.90^{b} (15.22)	6.00^{b} (14.17)	5.90^{b} (14.05)	6.27	79.23
Diafenthiuron 50% WP NS (6.4 g L^{-1})	1600	8.25	7.25^{a} (15.62)	6.80^{a} (15.11)	6.70^{a} (15.00)	6.92	77.07
Standard Diafenthiuron 50% WP (3.2 g L^{-1})	800	8.65	7.25^{bc} (15.62)	7.10^{b} (15.43)	7.00^{b} (15.34)	7.12	76.41
Standard Quinalphos 25% EC (7.2 ml L^{-1})	600	8.85	7.60^{b} (16.00)	7.10^{b} (15.45)	6.85^{b} (15.17)	7.18	76.19
Standard Quinalphos 25% EC (14.4 ml L^{-1})	1200	8.90	7.20^{b} (15.56)	6.90^{b} (15.22)	6.75^{bc} (15.05)	6.95	76.96
Untreated check	-	29.00	32.00^{d} (34.44)	30.00^{d} (33.21)	28.50^{d} (32.26)	30.17	

Mean of three observations PTC– Pretreatment count DAA –Days after application
Figures in parentheses are arc sin transformed values
In a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

Table.4 Effect of diafenthiuron 50% WP (NS) on shoot damage by *C. punctiferalis* (Location - Nedukandam) – First Application

Treatments	Dose (g a.i. ha^{-1})	Per cent shoot damage					
		PTC	10 DAA	20 DAA	30 DAA	Mean	Percent reduction over check
Diafenthiuron 50 % WP NS (1.6 g L^{-1})	400	18.52	18.52^{abc} (25.48)	18.00^{ab} (25.10)	18.00^{c} (25.10)	18.17	22.50
Diafenthiuron 50% WP NS (3.2 g L^{-1})	800	16.90	16.90^{a} (24.27)	16.25^{a} (23.77)	16.00^{ab} (23.57)	16.38	30.14
Diafenthiuron 50% WP NS (6.4 g L^{-1})	1600	16.95	16.95^{ab} (24.31)	16.70^{a} (24.12)	14.90^{a} (22.70)	16.18	30.99
Standard Diafenthiuron 50% WP (3.2 g L^{-1})	800	18.50	18.50^{abc} (25.47)	18.00^{ab} (25.10)	17.00^{bc} (24.35)	17.00	27.51
Standard Quinalphos 25% EC (7.2 ml L^{-1})	600	20.00	20.00^{c} (26.56)	19.00^{b} (25.84)	17.50^{c} (24.72)	18.83	19.69
Standard Quinalphos 25% EC (14.4 ml L^{-1})	1200	16.50	16.50^{a} (23.96)	16.20^{a} (23.73)	16.10^{ab} (23.65)	16.27	30.63
Untreated check	-	22.25	18.90^{bc} (28.14)	22.50^{c} (28.31)	25.60^{d} (30.39)	23.45	

Mean of three observations PTC– Pretreatment count DAA –Days after application
Figures in parentheses are arc sin transformed values
In a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

Table.5 Effect of diafenthiuron 50% WP (NS) on shoot damage by *C. punctiferalis* (Location - Nedukandam) – Second Application

Treatments	Dose (g a.i. ha^{-1})	Per cent shoot damage					
		PTC	10 DAA	20 DAA	30 DAA	Mean	Percent reduction over check
Diafenthiuron 50 % WP NS (1.6 g L^{-1})	400	18.00	16.50^{d} (30.98)	15.50^{d} (30.32)	14.80^{d} (29.86)	15.60	49.49
Diafenthiuron 50% WP NS (3.2 g L^{-1})	800	16.00	14.50^{b} (29.66)	14.00^{bc} (29.33)	12.25^{ab} (28.14)	13.58	56.16
Diafenthiuron 50% WP NS (6.4 g L^{-1})	1600	14.90	12.15^{a} (28.07)	11.50^{a} (27.62)	10.00^{a} (26.56)	11.22	64.00
Standard Diafenthiuron 50% WP (3.2 g L^{-1})	800	17.00	14.50^{b} (29.66)	14.25^{bc} (29.50)	12.10^{bc} (28.72)	13.62	56.02
Standard Quinalphos 25% EC (7.2 ml L^{-1})	600	17.50	15.20^{c} (30.13)	14.20^{bc} (29.46)	13.50^{bc} (28.99)	14.30	53.78
Standard Quinalphos 25% EC (14.4 ml L^{-1})	1200	16.10	14.00^{b} (29.33)	13.50^{b} (28.99)	13.00^{b} (28.82)	13.50	55.98
Untreated check	-	25.60	28.60^{e} (38.23)	28.50^{e} (38.35)	32.50^{e} (38.43)	29.87	

Mean of three observations PTC– Pretreatment count DAA –Days after application
Figures in parentheses are arc sin transformed values
In a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

Table.6 Effect of diafenthiuron 50% WP (NS) on shoot damage by *C. punctiferalis* (Location - Nedukandam) – Third Application

Treatments	Dose (g a.i. ha^{-1})	Per cent shoot damage					
		PTC	10 DAA	20 DAA	30 DAA	Mean	Percent reduction over check
Diafenthiuron 50 % WP NS (1.6 g L^{-1})	400	14.80	14.80 (21.55)	13.50 (20.26)	12.00 (19.18)	12.10	67.19
Diafenthiuron 50% WP NS (3.2 g L^{-1})	800	12.25	9.75^{b} (17.59)	8.00^{b} (15.58)	7.00^{b} (15.42)	8.25	77.63
Diafenthiuron 50% WP NS (6.4 g L^{-1})	1600	10.00	10.00^{a} (17.45)	9.00^{a} (16.42)	8.00^{a} (15.89)	8.17	77.86
Standard Diafenthiuron 50% WP (3.2 g L^{-1})	800	12.10	12.10 (19.46)	11.10 (17.95)	9.50 (17.20)	9.78	73.47
Standard Quinalphos 25% EC (7.2 ml L^{-1})	600	13.50	13.50 (20.70)	12.50 (19.36)	11.00 (17.70)	10.92	70.40
Standard Quinalphos 25% EC (14.4 ml L^{-1})	1200	13.00	13.00 (20.26)	12.00 (18.43)	10.00 (17.45)	10.33	71.98
Untreated check	-	32.50	32.50 (35.36)	33.50 (38.35)	38.50 (38.43)	36.88	

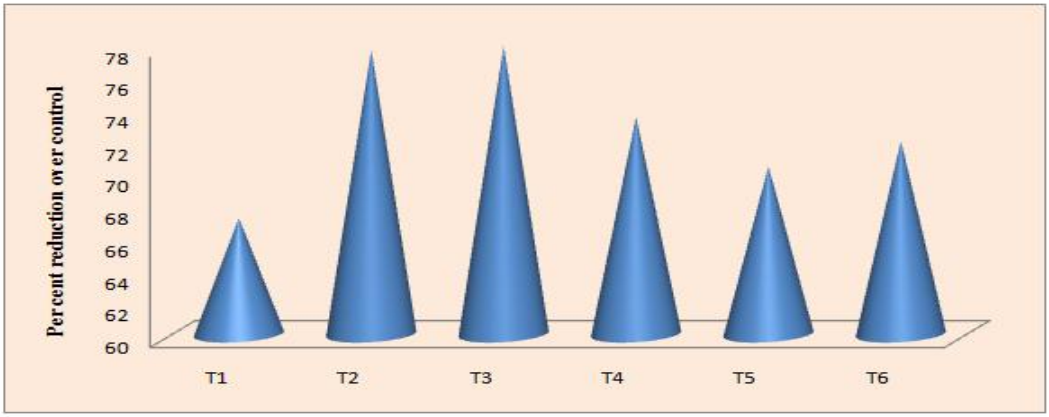
Mean of three observations; PTC – Pretreatment count DAA –Days after application
Figures in parentheses are arc sin transformed values
In a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

Table.7 Phytotoxic effect of diafenthiuron 50 %WP on cardamom - Experiment I (Location- Nedukandam)

S.No.	Treatments	Dose (%)	Phytotoxicity rating *					
			Leaf injury	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
1.	Diafenthiuron50%WP	0.08	0	0	0	0	0	0
2.	Diafenthiuron50%WP	0.16	0	0	0	0	0	0
3.	Diafenthiuron50%WP	0.32	0	0	0	0	0	0
4.	Untreated check	-	0	0	0	0	0	0

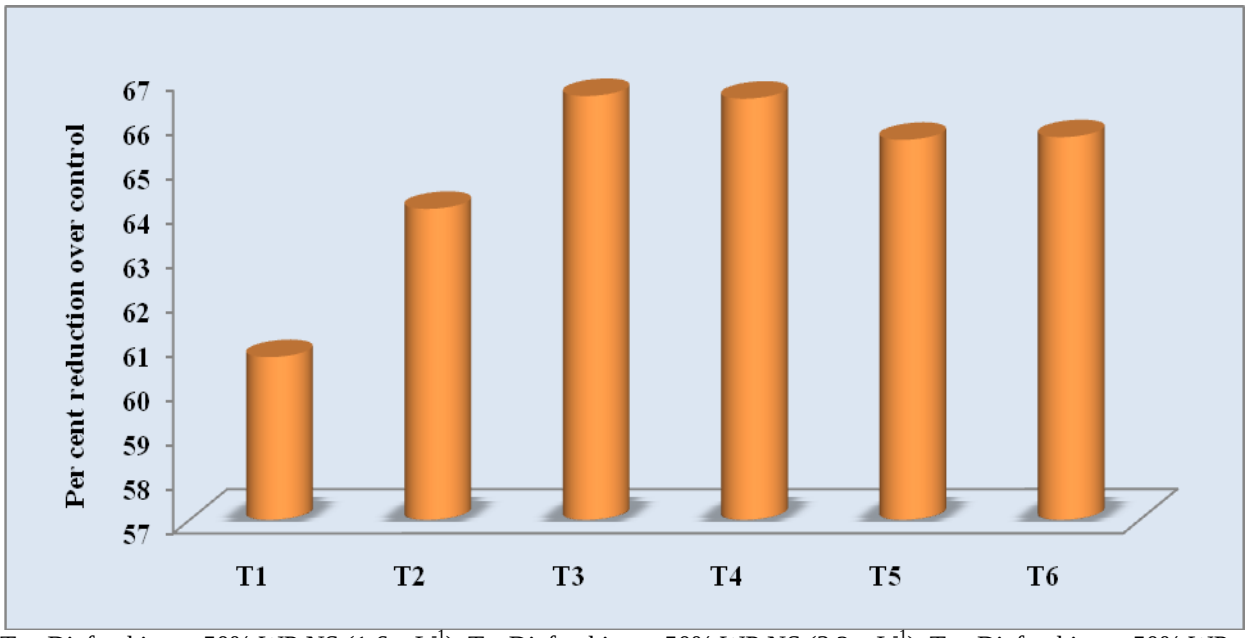
(Mean of five observations); Observed on 1, 3, 7, 10, 14 and 20 days after spraying

Fig.1 Effect of diafenthiuron 50% WP (NS) on capsule damage by *C. punctiferalis* (Location – Nedukandam) – First Application



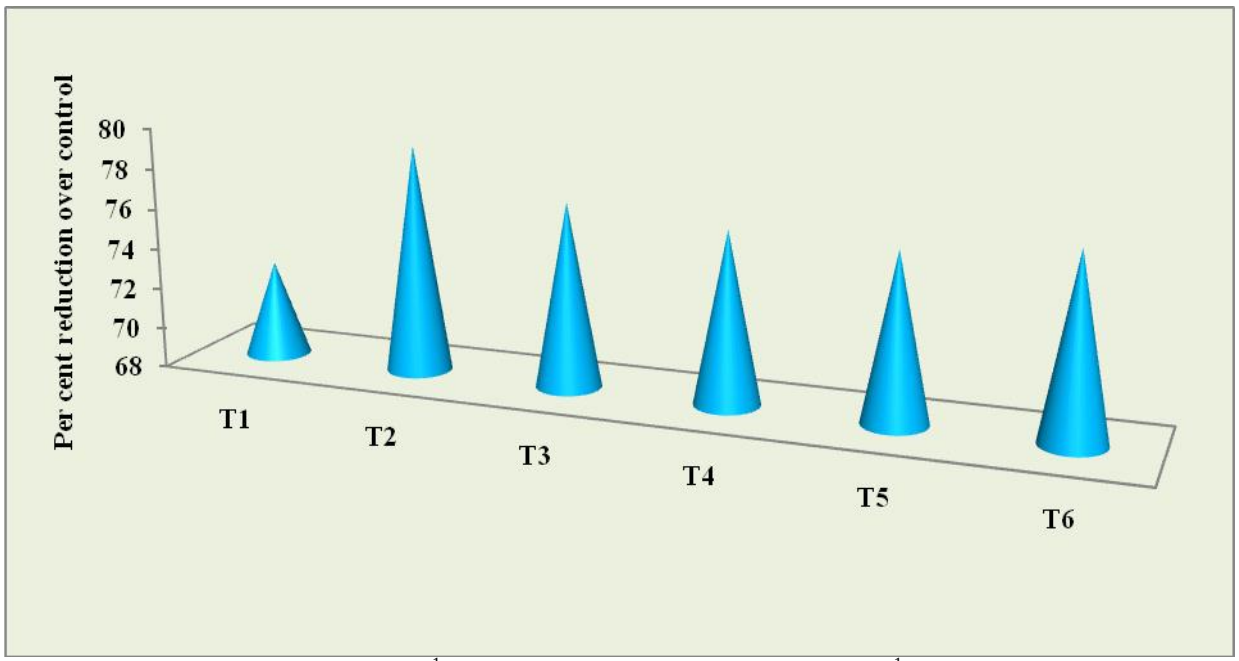
T_1 - Diafenthiuron 50%WP NS (1.6g L^{-1}), T_2- Diafenthiuron 50% WP NS (3.2 g L^{-1}), T_3 - Diafenthiuron 50% WP NS (6.4g L^{-1}), T_4 - Standard Diafenthiuron 50%WP(3.2g L^{-1}), T_5 - Standard Quinalphos 25%EC (7.2ml L^{-1}), T_6 - Standard Quinalphos 25% EC (14.4 ml L^{-1})

Fig.2 Effect of diafenthiuron 50% WP (NS) on capsule damage by *C. punctiferalis* (Location -Nedukandam) – Second Application



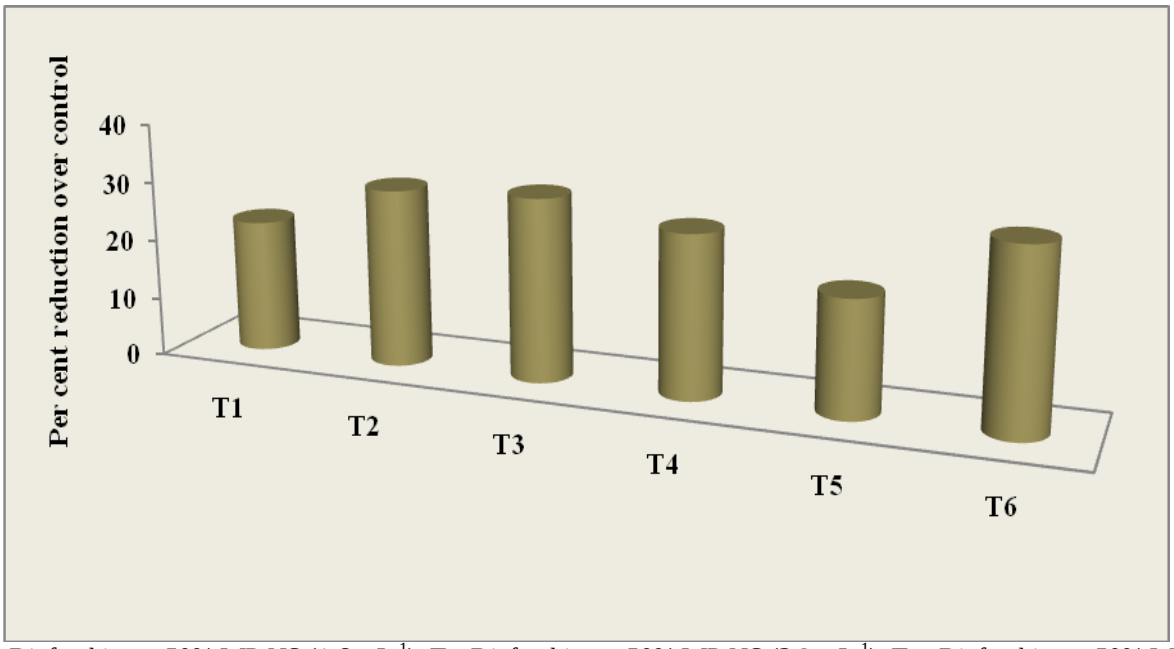
T_1 - Diafenthiuron 50% WP NS (1.6 g L^{-1}), T_2- Diafenthiuron 50% WP NS (3.2 g L^{-1}), T_3 - Diafenthiuron 50% WP NS (6.4g L^{-1}), T_4 - Standard Diafenthiuron 50% WP (3.2 g L^{-1}), T_5 - Standard Quinalphos 25% EC (7.2 ml L^{-1}), T_6 - Standard Quinalphos 25% EC (14.4 ml L^{-1})

Fig.3 Effect of diafenthiuron 50% WP (NS) on capsule damage by *C. punctiferalis*(Location - Nedukandam) – Third Application



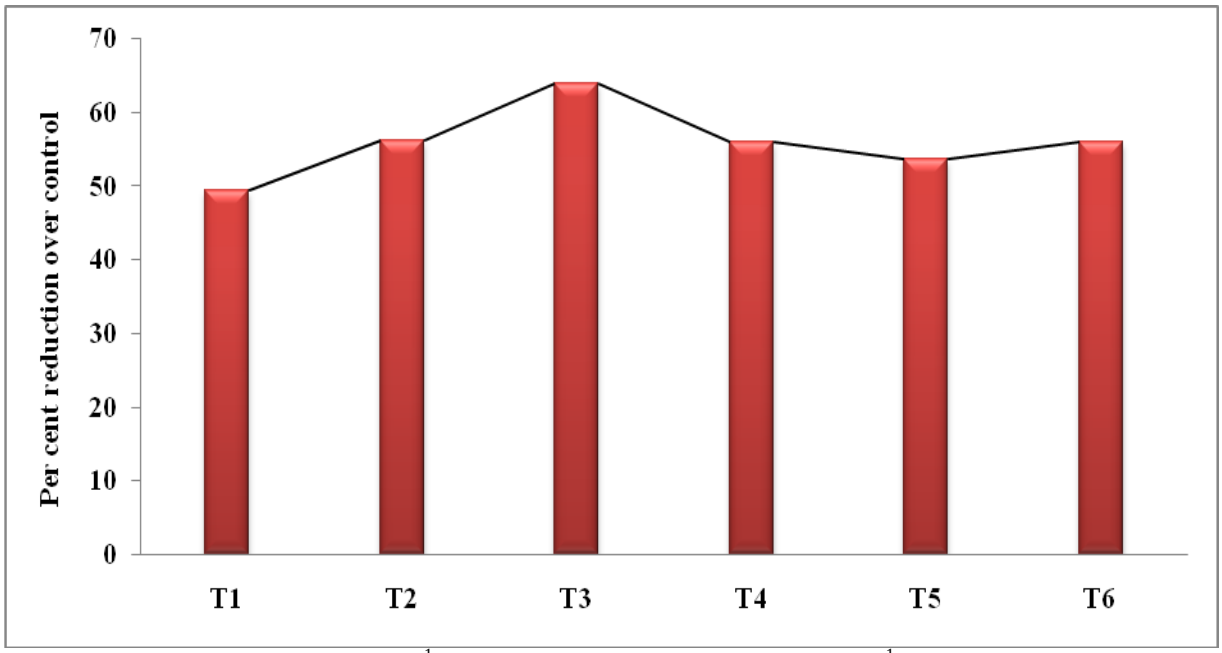
T_1 - Diafenthiuron 50% WP NS (1.6 g L^{-1}), T_2- Diafenthiuron 50% WP NS (3.2 g L^{-1}), T_3 - Diafenthiuron 50% WP NS (6.4g L^{-1}), T_4 - Standard Diafenthiuron 50% WP (3.2 g L^{-1}), T_5 - Standard Quinalphos 25% EC (7.2 ml L^{-1}), T_6 - Standard Quinalphos 25% EC (14.4 ml L^{-1})

Fig.4 Effect of diafenthiuron 50% WP (NS) on shoot damage by *C. punctiferalis* (Location -Nedukandam) – First Application



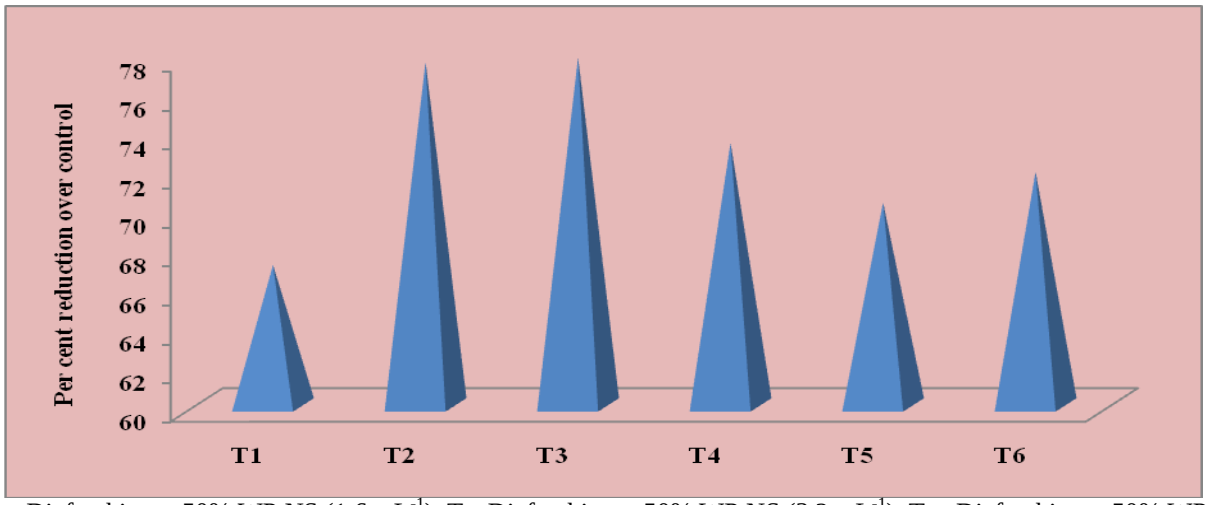
T_1 - Diafenthiuron 50% WP NS (1.6 g L^{-1}), T_2- Diafenthiuron 50% WP NS (3.2 g L^{-1}), T_3 - Diafenthiuron 50% WP NS (6.4g L^{-1}), T_4 - Standard Diafenthiuron 50% WP (3.2 g L^{-1}), T_5 - Standard Quinalphos 25% EC (7.2 ml L^{-1}), T_6 - Standard Quinalphos 25% EC (14.4 ml L^{-1})

Fig.5 Effect of diafenthiuron 50% WP (NS) on shoot damage by *C. punctiferalis* (Location -Nedukandam) – Second Application



T_1 - Diafenthiuron 50% WP NS (1.6 g L^{-1}), T_2- Diafenthiuron 50% WP NS (3.2 g L^{-1}), T_3 - Diafenthiuron 50% WP NS (6.4g L^{-1}), T_4 - Standard Diafenthiuron 50% WP (3.2 g L^{-1}), T_5 - Standard Quinalphos 25% EC (7.2 ml L^{-1}), T_6 - Standard Quinalphos 25% EC (14.4 ml L^{-1})

Fig.6 Effect of diafenthiuron 50% WP (NS) on shoot damage by *C. punctiferalis* (Location -Nedukandam) – Third Application



T_1 - Diafenthiuron 50% WP NS (1.6 g L^{-1}), T_2- Diafenthiuron 50% WP NS (3.2 g L^{-1}), T_3 - Diafenthiuron 50% WP NS (6.4g L^{-1}), T_4 - Standard Diafenthiuron 50% WP (3.2 g L^{-1}), T_5 - Standard Quinalphos 25% EC (7.2 ml L^{-1}), T_6 - Standard Quinalphos 25% EC (14.4 ml L^{-1})

At 10 and 20 DAA after third spray, the damage ranged from 6.90 to 32.00 per cent and 6.90 to 8.50 per cent in diafenthiuron 50 WP (NS) treated plots. Diafenthiuron 50 WP (NS) 800 g a.i. ha^{-1} per cent recorded the least damage of 20.00 per cent at 30 DAA which was on par with lower dose of 1600 g a.i. ha^{-1} (77.07%) and diafenthiuron 50 WP (ES) 800 g a.i. ha^{-1} (76.41 %)(Fig 4,5 &6). The order of efficacy of the chemicals in controlling the shoot damage in terms of per cent reduction over control was diafenthiuron 50 WP (NS) 1600 g a.i. ha^{-1} per cent (77.86%) > diafenthiuron 50 WP (NS) 800 g a.i. ha^{-1} per cent (77.63%) > > diafenthiuron 50 WP (ES) 800 g a.i. ha^{-1} (73.47%) > quinalphos 25 EC 1200 g a.i. ha^{-1} (71.98) > diafenthiuron 50 WP (ES) 400 g a.i. ha^{-1} per cent 67.19%)(Table 6)

These findings were similar to that of Rajabaskar (2003), who found a cumulative reduction of 81.51 per cent in CSCB damage during 2002-2003 in Lower Palani Hills with diafenthiuron 0.16 per cent. Meanwhile, Stanley (2007) reported that diafenthiuron at 0.16 per cent recorded 61.85, 86.72 and 93.80 per cent reduction of capsule damage in trial conducted at Devarshola, Gudalur. Earlier reports on the effectiveness of diafenthiuron against lepidopteran pests like *Plutella xylostella* L.in cabbage (Ellis *et al.,* 1992). Different formulations of quinalphos *viz*., AF, CS and EC tested by Valarmathi (1997) proved that quinalphos 25 EC at 0.025 per cent effected only 14.3 per cent mean reduction on capsule damage by CSCB, as against the highest of AF and CS.

Kubendran (2012) reported that, after three rounds of application, flubendiamide 240 + thiacloprid 240 – 480 SC ^{RM} at 7.2 + 7.2 and 6.0 + 6.0 g a.i. hl^{-1}, thiodiarb 70WP + thiacloprid 240 SC^{TM} at 42.0 +6.0 g a.i. $hl^{-1}$and flubendiamide 480 SC at 6.0 g a.i. hl^{-1} recorded minimum shoot damage of CSCB ranging from 8.12 to 9.25, 15.15 to 16.79 and 11.11 to 14.59 per cent in I, II and III seasons respectively. Meanwhile, Stanley (2007) reported that diafenthiuron at 0.16 per cent recorded 61.85, 86.72 and 93.80 per cent reduction of capsule damage in trial conducted at Devarshola, Gudalur. Ranjith (2009) reported that the Diafenthiuron 50 WP (NS) at 800 and 400 g a.i. ha^{-1} proved its

efficacy against CSCB and reduced the shoot damage level up to 82.39, 85.46 and 80.04, 84.95 per cent at both locations *viz*., Murukkadi and Onnamile respectively.

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