Journal of Applied and Natural Science 8 (3): 1172– 1180 (2016)

JANS

Management of false wire worm, *Gonocephalum* beetle (Tenebrionidae: coleoptera) in chickpea raised under residual moisture conditions

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Received: January 05, 2016; Revised received: April 27, 2016; Accepted: July 08, 2016

Abstract: False wire worm, *Gonocephalum indicum*, incidence was observed for the first time in severe form in *Rabi* 2008-09 on chickpea, confined to saline tracts of Vidarbha (MS). *Gonocephalum* adults inflicts injury near collar region of chickpea resulting in collapsing and drying of plants translating into re-sowing of crop due to poor plant stand. Field study revealed 5.8 – 32.3% damaged plants with lowest damage in Module 9 (Seed treatment with clothianidin 2 gm/kg seed + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence), Module 10 (Application of phorate granules 10 kg/ha at sowing + spraying of chlorpyriphos 2 ml/liter water 20 days after crop emergence) and Module 11(Seed treatment with clothianidin 2 gm/kg seed + application of clothianidin granules 200 gm/ha 20 days after crop emergence) with 5.8, 6.2 and 8.7% affected plants. The % drying of plants due to injury was in the range of 4.3 – 21.6 % with lowest in Module 11, Module 10 and Module 9 with 4.3, 6.0 and 6.2 % drying of plants, respectively. Superiority of Module 9 (20.4 q/ha) and Module 11 (19.7 q/ha) was evident in yield, whereas, lowest yield was observed in control plot (13.2 q/ha). Module 9 and Module 11 registered higher net returns of Rs. 13887 and Rs. 9948 per ha, respectively, whereas, Module 9 and Module 10 had highest ICBR of 1: 6.0 indicating the suitability of modules in terms of bioefficacy and cost effectiveness for the management of *Gonocephalum* in problematic area.

Keywords: Chickpea, False wireworm, *Gonocephalum*, Modules for management

INTRODUCTION

Gonocephalum beetle, false wire worm is basically a soil inhibiting beetle, restricted to decaying organic matter. The association of *Gonocephalum* sp. with various crops is reported in review. *Gonocephalum* sp. along with two other false wireworms were found damaging groundnut pods in Gujarat (Kapadia, 1994) in Andhra Pradesh (Reddy *et al*., 1992) and as an occasional pest of groundnut in sub-Saharan Africa (Umeh *et al*., 2001). *G. simplex* was the earliest described and most destructive species and is known to damage maize seedlings in South Africa (Drinkwater, 1999) also on tobacco (Blair, 1990), whereas, of the fourteen genera of soil-inhabiting Tenebrionidae in maize fields in South Africa *Somaticus* and *Gonocephalum*, were most common (Drinkwater, 1989). *Gonocephalum* was reported as pest of canola [rape] in Victoria and Upper South East of South Australia (Miles *et al*., 1997). In Andhra Pradesh, adults of *Gonocephalum* sp. were found in large numbers in pitfall traps installed in fields of mature mixed crops of groundnut and pigeonpea on irrigated black soil (vertisol). (Reddy *et al*., 1992), whereas, International Crop Research Institute for Semi Arid Tropics ICRISAT, Hyderabad have reported incidence of *G. dorsogranosum* on chickpea.

Although, there are reports of *Gonocephalum* as a pest of pulses, oilseeds, cereals and vegetable crops in literature but it seldom cross the status of minor pest, But the incidence of *Gonocephalum* was observed for the first time in a severe form in *Rabi* 2008-09 on chickpea, critically confined to major chickpea growing saline tracts of vidarbha (MS). Since then it is a pest with regular appearance, although at varying intensity. The prevailing species of region was identified as *G. indicum* Karzab (Tenebrionidae: Coleoptera). The *Gonocephalum* life stages viz., egg, grub and pupal stage were confined to soil, whereas, adults were seen on ground damaging the crops. Adults prefer to hide in cracks and crevices during bright sunshine and were seen during early morning or at dusk near the crop. The *Gonocephalum* adults inflict the scooping up type of injury on tender chickpea plant stem near soil surface (collar region), resulting in collapsed plants of chickpea. Generally, the adults prefer early crop growth phase but was even observed on later stage, though on a lower intensity. The damaged seedlings in turn dry often translate into re- sowing of crop. Based on intensity, even up to 60 % or more with one to two re-sowings are observed in chickpea raised on residual moisture.

The reports of resowing of crop due to higher damage to crop translating in poor crop stand are not uncommon. This invasive pest,which once was a minor pest has made it mandatory to take up plant protection measures. There is no specific recommendation for the management of *Gonocephalum*, except *adhoc* recom-

ISSN : 0974-9411 (Print), 2231-5209 (Online)

mendation of application of phorate granule 10G @ 10 kg/ha before sowing, thus, present study was carried out to evaluate the efficacy of different insecticide modules as well as their cost effectiveness so as to formulate the management strategy for *Gonocephalum* in chickpea.

MATERIALS AND METHODS

The evaluation of insecticide modules against false wireworm, *Gonocephalum* on chickpea was carried out at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during *Rabi* 2010-11 to 2012-13. Taking into consideration the nature of damage and incidence interval it was felt necessary to evaluate efficacy of different insecticides in a module form. Twelve treatments (Table 1) replicated thrice were subjected to evaluation in randomized block design. The experiment was planned to compare the efficacy of seed treatment, application of insecticide granules in soil, foliar application of insecticides and combinations thereof to work out best possible module for the management of false wireworm in chickpea.

JAKI 9218 was used as test variety, with gross plot of 2.1 × 4.2m (7 rows) and net plot of 1.5 × 4.0 m (5 rows), sown at 30×10 cm. The crop was raised under rainfed condition with recommended package of practices and adoption of plant protection measures were as per the treatments. Foliar application of insecticides was made with knapsack sprayer (spray volume of 500 L/ha) as per the treatment details.

The efficacy of insecticide was attributed to % plants injured by *Gonocephalum*, 10 and 20 days after application of first and second treatment of the module. Similarly, observations on % plant drying due to *Gonocephalum* injury at 20 days after application of first and second treatment of the module was assessed. Total number of plants per meter row length (MRL) and plants affected by *Gonocephalum* were recorded to work out % affected plants in various treatments, 10 and 20 days after application of treatments of the module.

Net plot yield was extrapolated to per hectare yield. The total cost of plant protection comprised of prevailing market price of insecticides per ha, labour and sprayer charges. Net monetary realization of a treatment comprised of increase in yield as a function of treatment over control and prevailing market price. Net profit of treatment was worked out by deducting the total cost of plant protection from net monetary realization. Incremental cost benefit ratio (ICBR) was worked out as a ratio of net profit to the cost of plant protection, which exhibits the economic viability for cost effective management of *Gonocephalum* on chickpea.

RESULTS AND DISCUSSION

Per cent plants injured by *Gonocephalum*:

10 days after application of first treatment of the module: Per cent plants affected by *Gonocephalum* adults injury, ten days after application of first treatment of the module had a range of 4.1 – 19.4 % (Table 2). The lowest damage was recorded in Module 4 (Application of phorate granules 10 kg/ha at sowing) which in turn was at par with Module 3 (Application of clothianidin granules 200 gm/ha at sowing) with 4.1 and 5.0 % plants injured by adults, respectively. Soil application of insecticides was superior over seed treatment modules. The control plot had highest percentage of (19.4 %) affected plants.

20 days after application of first treatment of the module: Plants affected with *Gonocephalum* adults, 20 days after application of first treatment of module was in the range of 5.9 to 27.7 % (Table 2). The lowest damage was recorded in Module 4 (Application of phorate granules 10 kg/ha at sowing) followed by Module 3 (Application of clothianidin granules 200 gm/ha at sowing) and Module 9 (Seed treatment with clothianidin 2 gm/kg seed) with 5.9, 6.4 and 9.6 % affected plants, respectively, whereas, the control plot had highest percentage (27.7 %) of affected plants by *Gonocephalum*.

10 days after application of second treatment of the module: After application of second insecticide component of module the % plants affected with *Gonocephalum* beetle injury was in the range of 2.2 – 22.8 % (Table 3). The lowest damage was recorded in Module 10 (Application of phorate granules 10 kg/ha at sowing + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence) with 2.2 % affected plants and was significantly superior over rest. Application of Module 9 (Seed treatment with clothianidin 2 gm/kg seed + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence) and Module 11(Seed treatment with clothianidin 2 gm/kg seed + application of clothianidin granules 200 gm/ha 20 days after crop emergence) had statistically comparable ability to repress the % affected plants to 4.5 and 6.0 %, respectively and were significantly superior over rest. The control plot registered highest percentage (23.1 %) of affected plants.

20 days after application of second treatment of the module: Plants affected by *Gonocephalum* adults, 20 days after application of second treatment of modules was in the range of 5.8 – 32.3 % (Table 3). The lowest damage was recorded in Module 9 (Seed treatment with clothianidin 2 gm/kg seed + spraying of chlorpyriphos 2 ml/liter water 20 days after crop emergence) and was in turn at par with Module 10 (Application of phorate granules 10 kg/ha at sowing + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence) with 5.8 and 6.2 % affected plants, respectively,whereas, the control plot had highest percentage (32.3 %) of affected plants.

Per cent plants drying due to *Gonocephalum* injury

20 days after application of first treatment of the module: The % dried plants due to *Gonocephalum* injury was in the range of 3.9 – 13.4 % (Table 4) with

Table .1 Details of various modules and cost of plant protection for the management of *Gonocephalum.*

Module	Module details	Cost of insecticide (Rs)/ kg/l	Cost of insecticide per ha (Rs)	Cost of module (Rs)	Labour @Rs. 120/ day	Application cost of module
1	Seed treatment with chlorpyriphos 20 EC @ 5 ml/kg seed	270	90	90	0	90
2	Seed treatment with clothianidin 50 WDG @ 2 gm/kg seed	14000	1680	1680	0	1680
3	Application of clothianidin granules 50 WDG @ 200 gm/ha at sowing	14000	2800	2800	120	2920
4	Application of phorate granules 10 G @ 10 kg/ha at sowing	55	550	550	120	670
5	Spaying of chlorpyriphos 20 EC @ 2 ml/liter water 20 days after crop emergence	270	270	270	360	630
6	Application of clothianidin granules 50 WDG @ 200 gm/ha 20 days after crop emergence	14000	2800	2800	120	2920
7	Application of phorate granules 10 G @ 10 kg/ha 20 days after crop emergence	55	550	550	120	670
8	Seed treatment with chlorpyriphos 20 EC @ 5 ml/kg seed followed by spaying of chlorpyriphos 20 EC @ 2 ml/liter water 20 days after crop emergence	270 270	90 270	360	360	720
9	Seed treatment with clothianidin 50 WDG @ 2 gm/kg seed followed by spaying of chlorpyriphos 20 EC @ 2 ml/liter water 20 days after crop emergence	14000 270	1680 270	1950	360	2310
10	Application of phorate granules 10 G @ 10 kg/ha at sowing followed by spaying of chlorpyriphos 20 EC @ 2 ml/liter water 20 days after crop emergence	55 270	550 270	820	480	1300
11	Seed treatment with clothianidin 50 WDG @ 2 gm/kg seed followed by application of clothianidin granules 50 WDG @ 200 gm/ha 20 days after crop emergence	14000	1680 2800	4480	120	4600
12	Control	-	-	-	-	-

lowest % drying in Module 3 (Application of clothianidin granules 200 gm/ha at sowing) which had statistically comparable effect with application of Module 4 (Application of phorate granules 10 kg/ha at sowing), Module 9 (Seed treatment with clothianidin 2 gm/kg seed) and Module 2 (Seed treatment with clothianidin 2 gm/kg seed) with 3.9, 4.6, 4.7 and 5.0 % drying of plants, whereas, untreated plot had 13.4 % drying of plants.

20 days after application of second treatment of the module: During this phase the % dried plants due to injury was in the range of 3.8 – 18.2 % (Table 4) with lowest % drying in Module 9 (Seed treatment with Clothianidin 2 gm/kg seed + Spaying of chlorpyriphos 2 ml/liter water 20 days after emergence) with 3.8 % dried plants. Module 10 (Application of phorate granules 10 kg/ha at sowing + spaying of chlorpyriphos 20 ml/liter water 20 days after emergence) and Module 11 (Seed treatment with clothianidin 2 gm/kg seed + application of clothianidin granules 200 gm/ha 20 days after emergence) were the next effective modules with 4.3 and 4.6 % drying of plants and were at par with the superior treatment. Highest loss of plant population was evident in control plot, indicating damage potential of the pest.

Yield: Data in Table 5 revealed superiority trend of Module 9 (Seed treatment with clothianidin 2 gm/kg seed + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence) and Module 11(Seed treatment with clothianidin 2 gm/kg seed + application of clothianidin granules 200 gm/ha 20 days after crop emergence) in case of chickpea yield with yield level of 20.4 and 19.7 q/ha and were statistically at par. Application of Module 3 (Application of clothianidin granules 200 gm/ha at sowing) was next in order of ability to translate into higher yield and was at par with Module 6 (Application of clothianidin granules 200 gm/ha 20 days after crop emergence) and Module 10 (Application of phorate granules 10 kg/ha at sowing + spaying of chlorpyriphos 2 ml/liter water 20 days after emergence) with yield of 17.8, 17.3 and 17.2 q/ha, respectively. Lowest yield was recorded in control plot (13.2 q/ha).

Net profit and ICBR: Higher net returns (Table 5) were realized due to application of Module 9 (Seed treatment with clothianidin 2 gm/kg seed + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence), Module 11(Seed treatment with clothianidin 2 gm/kg seed + application of clothianidin granules 200 gm/ha 20 days after crop emergence) and Module 10 (Application of phorate granules 10 kg/ha at sowing + spaying of chlorpyriphos 2 ml/liter water 20 days after

Table 2. Mean % plants with *Gonocephalum* injury – 10 and 20 days after application of first treatment of the module.

Module	Treatment details	10 days after application of first treatment of the module*			Pooled Mean	20 days after application of first treatment of the module**			Pooled Mean
		2010-11	2011-12	2012-13		2010-11	2011-12	2012-13	
1	Seed treatment with chlorpyriphos @ 5 ml/kg seed	11.0	8.8	7.4	9.1	21.7	11.7	10.4	14.6
2	Seed treatment with clothianidin @ 2 gm/kg seed	7.0	7.3	4.3	6.2	17.0	10.4	8.3	11.9
3	Application of clothianidin granules @ 200 gm/ha at sowing	6.3	5.8	2.8	5.0	5.0	8.1	6.1	6.4
4	Application of phorate granules @ 10 kg/ha at sowing	3.0	6.3	3.0	4.1	3.0	8.7	6.1	5.9
5	Spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	11.3	18.0	13.9	14.4	23.3	22.3	17.6	21.1
6	Application of clothianidin granules @ 200 gm/ha 20 days after crop emergence	15.0	20.0	14.9	16.6	22.7	25.5	15.5	21.2
7	Application of phorate granules @ 10 kg/ha 20 days after crop emergence	13.0	19.8	13.5	15.4	25.7	25.7	20.7	24.0
8	Seed treatment with chlorpyriphos @ 5 ml/kg seed followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	8.0	8.3	6.7	7.7	20.0	10.9	10.4	13.8
9	Seed treatment with clothianidin @ 2 gm/kg seed followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	9.0	6.3	4.9	6.7	15.0	8.4	5.4	9.6
10	Application of phorate granules @ 10 kg/ha at sowing followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	6.0	9.3	6.9	7.4	11.7	12.1	8.5	10.8
11	Seed treatment with clothianidin @ 2 gm/kg seed followed by application of clothianidin granules @ 200 gm/ha 20 days after crop emergence	7.0	7.8	6.4	7.1	13.0	10.2	7.9	10.4
12	Control	19.0	22.3	16.8	19.4	30.0	29.0	24.0	27.7
F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE±m		2.3	2.5	2.2	0.087	2.4	2.0	2.3	1.41
CD at 5%		6.7	7.3	6.4	0.256	7.1	5.9	6.8	4.13
CV %		14.5	12.6	9.1	8.60	21.5	15.8	12.6	11.37

* data subjected to square root transformations ** data subjected to arc sine transformations

Table 3. Mean % plants with *Gonocephalum* injury – 10 and 20 days after application of second treatment of the module.

Mod-ule	Treatment details	10 days after application of second treatment of the module*			Pooled Mean	20 days after application of second treatment of the module**			Pooled Mean
		2010-11	2011-12	2012-13		2010-11	2011-12	2012-13	
1	Seed treatment with chlorpyriphos @ 5 ml/kg seed	18.0	18.9	21.1	19.3	29.7	26.1	18.9	24.9
2	Seed treatment with clothianidin @ 2 gm/kg seed	14.3	15.1	11.1	13.5	22.7	23.4	16.6	20.9
3	Application of clothianidin granules @ 200 gm/ha at sowing	8.3	10.8	12.4	10.5	14.3	17.9	12.9	15.0
4	Application of phorate granules @ 10 kg/ha at sowing	13.3	14.7	18.9	15.6	30.7	22.8	14.0	22.5
5	Spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	7.7	8.3	11.1	9.0	13.3	18.7	14.2	15.4
6	Application of clothianidin granules @ 200 gm/ha 20 days after crop emergence	16.7	7.5	13.3	12.5	21.3	12.6	13.2	15.7
7	Application of phorate granules @ 10 kg/ha 20 days after crop emergence	11.3	9.3	10.7	10.4	16.0	14.6	11.4	14.0
8	Seed treatment with chlorpyriphos @ 5 ml/kg seed followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	10.0	9.0	10.1	9.7	13.3	11.9	10.7	12.0
9	Seed treatment with clothianidin @ 2 gm/kg seed followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	2.3	3.2	8.0	4.5	6.3	5.5	5.6	5.8
10	Application of phorate granules @ 10 kg/ha at sowing followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	2.7	3.8	0.0	2.2	3.0	10.8	4.9	6.2
11	Seed treatment with clothianidin @ 2 gm/kg seed followed by application of clothianidin granules @ 200 gm/ha 20 days after crop emergence	9.0	3.7	5.2	6.0	13.7	6.8	5.6	8.7
12	Control	20.7	20.8	26.9	22.8	31.7	35.0	30.1	32.3
F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE±m		2.5	2.8	1.4	0.170	2.5	2.4	1.6	0.904
CD at 5%		7.2	8.3	4.1	0.497	7.2	7.0	4.8	2.651
CV %		16.4	13.9	22.0	15.87	18.4	13.1	14.0	11.81

* data subjected to square root transformations ** data subjected to arc sine transformations

Table 4. Mean % plants dried after *Gonocephalum* injury –20 days after application of treatment of the module.

Module	**Treatment details**	**20 days after application of first treatment of the module***			**Pooled Mean**	**20 days after application of second treatment of the module***			**Pooled Mean**
		2010-11	**2011-12**	**2012-13**		**2010-11**	**2011-12**	**2012-13**	
1	Seed treatment with chlorpyriphos @ 5 ml/kg seed	5.7	8.2	4.2	6.0	4.7	16.5	16.8	12.7
2	Seed treatment with clothianidin @ 2 gm/kg seed	4.3	7.4	3.2	5.0	4	15	12.0	10.3
3	Application of clothianidin granules @ 200 gm/ha at sowing	2.7	6.1	2.9	3.9	2.7	11.8	10.5	8.3
4	Application of phorate granules @ 10 kg/ha at sowing	4	6.4	3.5	4.6	5	14.6	13.0	10.9
5	Spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	2.3	14.3	9.5	8.7	2.3	12.3	14.3	9.6
6	Application of clothianidin granules @ 200 gm/ha 20 days after crop emergence	5	16.2	10.4	10.5	3.7	8.7	14.0	8.8
7	Application of phorate granules @ 10 kg/ha 20 days after crop emergence	3.3	16.3	10.3	10.0	3.3	9.8	14.3	9.1
8	Seed treatment with chlorpyriphos @ 5 ml/kg seed followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	3	7.7	7.4	6.0	2.3	8.3	10.4	7.0
9	Seed treatment with clothianidin @ 2 gm/kg seed followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	1	6.2	7.0	4.7	0.7	4.5	6.3	3.8
10	Application of phorate granules @ 10 kg/ha at sowing followed by spaying of chlorpyriphos @ 2 ml/liter water 20 days after crop emergence	2.3	8.4	8.5	6.4	0.7	7.6	4.5	4.3
11	Seed treatment with clothianidin @ 2 gm/kg seed followed by application of clothianidin granules @ 200 gm/ha 20 days after crop emergence	2.7	7.3	8.7	6.2	2.3	5.3	6.2	4.6
12	Control	7.7	18.2	14.4	13.4	6	21.7	27.0	18.2
F test		Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE±m		2.4	2.0	2.2	0.145	2.0	2.0	1.9	0.105
CD at 5%		7.1	5.8	6.4	0.425	5.8	5.8	5.4	0.309
CV %		14.8	20.1	22.2	17.03	10.3	18.5	17.2	11.25

* data subjected to square root transformations

Table 5: Grain yield and Incremental Cost Benefit Ratio of various modules under evaluation**.**

Module	Yield (q/ha)				Increase in yield over control (q/ha)				Cost of increased yield (Rs./ha)				Application cost of module (Rs./ha)	Net Profit (Rs./ha)				ICBR			
	10-11	11-12	12-13	Mean	10-11	11-12	12-13	Mean	10-11	11-12	12-13	Mean		10-11	11-12	12-13	Mean	10-11	11-12	12-13	Mean
1	17.0	14.5	8.5	13.3	0.1	0.2	0.1	0.1	230	460	171	287	90	140	370	81	197	1 : 1.6	1 : 4.1	1 : 0.9	1 : 2.2
2	18.6	15.7	12.2	15.5	1.7	1.4	3.8	2.3	3848	3220	8299	5122	1680	2168	1540	6619	3442	1 : 1.3	1 : 0.9	1 : 3.9	1 : 2.0
3	20.2	17.9	15.2	17.8	3.3	3.6	6.8	4.6	7657	8280	14948	10295	2920	4737	5360	12028	7375	1 : 1.6	1 : 1.8	1 : 4.1	1 : 2.5
4	18.7	15.9	10.8	15.1	1.8	1.6	2.4	1.9	4120	3680	5194	4331	670	3450	3010	4524	3662	1 : 5.1	1 : 4.5	1 : 6.8	1 : 5.5
5	17.6	14.8	9.6	14.0	0.7	0.5	1.2	0.8	1610	1150	2689	1816	630	980	520	2059	1186	1 : 1.6	1 : 0.8	1 : 3.3	1 : 1.9
6	20.6	17.4	13.8	17.3	3.7	3.1	5.4	4.1	8474	7130	11807	9137	2920	5554	4210	8887	6217	1 : 1.9	1 : 1.4	1 : 3.0	1 : 2.1
7	18.1	16.3	10.8	15.1	1.2	2.0	2.4	1.9	2760	4600	5256	4205	670	2090	3930	4586	3535	1 : 3.1	1 : 5.9	1 : 6.8	1 : 5.3
8	18.6	15.6	10.6	14.9	1.7	1.3	2.2	1.7	3910	2990	4864	3921	720	3190	2270	4144	3201	1 : 4.4	1 : 3.2	1 : 5.8	1 : 4.4
9	23.0	21.4	16.7	20.4	6.1	7.1	8.3	7.2	13915	16330	18346	16197	2310	11605	14020	16036	13887	1 : 5.0	1 : 6.1	1 : 6.9	1 : 6.0
10	20.6	17.5	13.5	17.2	3.7	3.2	5.1	4.0	8510	7360	11293	9054	1300	7210	6060	9993	7754	1 : 5.5	1 : 4.7	1 : 7.7	1 : 6.0
11	21.6	18.6	18.8	19.7	4.7	4.3	10.4	6.5	10922	9890	22831	14548	4600	6322	5290	18231	9948	1 : 1.4	1 : 1.2	1 : 4.0	1 : 2.2
12	16.9	14.3	8.4	13.2	0.0	0.0	0.0	0.0	0	0	0	0	-	-	-	-	-	--	--	--	-
F test	Sig	Sig	Sig	Sig																	
SE±m	0.880	0.878	0.539	0.315																	
CD at 5%	2.581	2.575	1.580	0.885																	
CV %	19.68	21.81	13.03	17.59																	

crop emergence) with Rs. 13887, Rs. 9948 and Rs. 7754 per ha, respectively. Lowest net returns were realized due to application of Module 1 (Seed treatment with chlorpyriphos 5 ml/kg seed) with 197 Rs/ha. In terms of Incremental Cost Benefit Ratio (Table 5), application of Module 9 (Seed treatment with clothianidin 2 gm/kg seed + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence), Module 10 (Application of phorate granules 10 kg/ha at sowing + spaying of chlorpyriphos 2 ml/liter water 20 days after crop emergence) had higher ICBR of 1:6.0. It was followed by application of Module 4 (Application of phorate granules 10 kg/ha at sowing) and Module 7 (Application of phorate granules 10 kg/ha 20 days after crop emergence) with ICBR of 1:5.5 and 1:5.3, respectively. Although, treatments with application of clothianidin granules revealed more field efficacy, they lagged in cost effectiveness parameter on the basis of higher cost of insecticide.

Although, present findings could not be compared for the want of literature, review suggest Clothianidin is a novel neonicotinoid insecticide acting as an agonist of nicotinic acetylcholine receptor (nAChR). Clothianidin is highly active against coleopterous pests,since it possesses excellent root systemic properties (Ohkawara *et al*., 2002). Clothianidin has been extensively used for seed treatment against major insect pests of maize, canola and other crops. The compound enters the transpiration stream through the roots of newly germinating seedlings and developed plants. Pests become intoxicated mainly through ingestion of protected plant tissues and stop feeding immediately (Schwarz *et al.*, 2002). In field trials, clothianidin exhibited excellent control of insect pests by soil application and seed treatment. In tests for control of corn rootworm (*Diabrotica* spp.), clothianidin demonstrated a consistent reduction of root damage. Clothianidin also showed excellent control of most important secondary pests of maize when used as seed treatment. The compound has good activity against wireworm (*Melanotus* spp.), seed corn maggot (*Hylemya platura* [*Delia platura*]), flea beetle (*Chaetocnema pulicaria*) and white grub (*Lachnosterna implicita* [*Phyllophaga implicita*]). The compound also showed good activity for black cutworm (*Agrotis ypsilon* [*Agrotis ipsilon*]). Control of corn rootworm and secondary pests resulted in a significant increase in yield up to 17.6% on the average compared to the control plots (Schwarz et al., 2002), thus supporting the present findings

Thiamethoxam, the neonicotinoid was found efficient in control of all important soil-dwelling and early leaf-feeding pests like wireworms, false wireworms, flea beetles, pea weevils, colorado potato beetles. Hofer *et al*. (2001) also confirmed the utility of neonicotinoides in management of false wireworms. Also the reports of efficacy of clothianidin against turf pests, termites and white grubs strengthen the present findings.

Chloropyriphos is also an effective insecticide for soil borne pest viz., termites on account of its contact and fumigant action. The use of insecticides *viz*., chlorpyrifos, terbufos, furathiocarb and thiodicarb in the control of false wireworms is recommended by Robertson, 1993 which is in corroboration with present outcome.

Conclusion

From the present study it can be concluded that Seed treatment with clothianidin 2 gm/kg seed followed by spaying of chlorpyriphos 2 ml/liter water, 20 days after crop emergence and Application of phorate granules 10 kg/ha at sowing followed by spraying of chlorpyriphos 2 ml/liter water, 20 days after crop emergence were most promising modules in terms of lower % damaged plants, higher yield, higher net money returns and higher cost effectiveness and can be recommended for the management of *Gonocephalum* in chickpea.

ACKNOWLEDGEMENTS

Authors are thankful to Dr. V.V. Ramamurthy, National Coordinator, Network Project on Insect Biosystematics, Entomology Division, Indian Agriculture Research Institute, New Delhi.

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