Bioefficacy of novaluron 10EC in combination with urea against *Helicoverpa armigera* in chickpea

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Abstract

Experimental trials were conducted on the compatibility of urea 2% with insecticides of different groups viz., *monocrotophos 36SL @ 500 ml/ha, cypermethrin 25EC @ 125 ml/ha, quinalphos 25EC @ 1000 ml/ha and novaluron 10EC @ 375 ml/ha against larval population of* Helicoverpa armigera *in the field conditions on chickpea cultivar "HC-1" during* Rabi *season 2011-12 and 2012-13 at CCS Haryana Agricultural University, Hisar (Haryana). These insecticides were found compatible with urea. Minimum larval population of* H. armigera *was recorded in novaluron 10EC @ 375 ml/ha at 3, 7 and 10 days after spraying. Monocrotophos 36SL @ 500 ml/ha, quinalphos 25EC @ 1000 ml/ha and cypermethrin 25EC @ 125 ml/ha could not provide consistent results against* H. armigera*. The larval population, pod damage and incidence were statistically at par with insecticides and their combination. No phytotoxicity effect was observed on the leaves with urea application in combination with insecticides. Minimum per cent pod damage (7.3%), maximum grain yield (14.6 q/ha) and monetary returns (₹ 6265/ha) was realized from novaluron 10EC @ 375 ml/ha plus 2% urea as compared to other treatments.*

Keywords: Chickpea, Bt cotton, novaluron, urea, *Helicoverpa armigera*

Introduction

Chickpea (*Cicier arietinum* L.), commonly known as Bengal gram, is the third most important pulse crop of India in both area and production. In Haryana, total area under chickpea cultivation is 83.0 thousand ha and total production of 75.0 thousand tones with the average productivity of 904 kg/ha (Anonymous, 2014). Many insect pests have been noticed to attack chickpea crop at different crop growth stages, but gram pod borer, *H. armigera* is the single most important key pest responsible for the decrease in the productivity and can be accredited to the damage caused by gram pod borer (Singh and Yadav, 2009; Choudhury *et al*., 2013). *H. armigera* is distributed throughout India and is responsible for 50 to 60 per cent losses in grain yield (Balikai *et al*., 2001). Gram pod borer feeds voraciously from seedling stage to maturity of the crop. In India, losses caused by *H. armigera* on chickpea and pigeonpea fields exceeded ₹ 12,000 million per year as per survey carried out by ICRISAT (Anonymous, 1996). Number of insecticides belonging to different groups have been recommended for its control. Novaluron (insect growth regulator), recent benzolphenyl urea used worldwide, is a powerful suppressor of lepidopteran larvae by ingestion. It acts on insects of various orders by inhibiting chitin formation, thereby causing abnormal endocuticular deposition and abortive moulting leading to death of insect. Novaluron 10EC @ 1 ml/l water proved equally effective to quinalphos in chickpea (Saini *et al*., 2013). Application of 2% urea as spray at flowering initiation and 10 days thereafter or at pod initiation has been found to increase the grain yield by 30 per cent (Bhowmick, 2006). In the present study, an attempt has been made to visualize the compatibility of urea with insecticides so, that if insect appears at flower or pod initiation, spraying of insecticides with urea will help in increasing productivity and decreasing incidence of *H. armigera*.

Materials and methods

Experimental trials were conducted to study the biological compatibility of novaluron 10EC and other molecules in combination with urea 2 per cent on the larval population of *H. armigera* during *Rabi* season 2011-12 and 2012-13 at Pulses Research Farm, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Chickpea cv. HC-1 was sown as a test variety, at 30 X 10 cm spacing with net plot size of 2.1 X 4.2 m (7 of 4.2 m) in 2011-12 and 1.5 X 4.0 m (5 of 4.0 m) in 2012-13 in a randomized block design with three replications.

The crop was raised under recommended agronomical package of practices, except the plant protection measures (CCSHAU, 2010). Regular vigil on the experimental field for the appearance of *H. armigera* larvae was kept. When the larval population reached 1 larva/ meter row length (mrl), the spraying operation was initiated. Recommended dose of insecticides was mixed with water and to this solution, urea 2 per cent was added and mixed thoroughly. Nine treatments *viz*., monocrotophos 36SL @ 500 ml/ha, cypermethrin 25EC @ 125 ml/ha, quinalphos 25EC 1000 ml/ha, novaluron 10EC @ 375 ml/ha, monocrotophos 36SL @ 500 ml/ha mixed with 2 per cent urea, cypermethrin 25EC @ 125 ml/ha mixed with 2 per cent urea, novaluron 10EC @ 375 ml/ha mixed with 2 per cent urea, spray of 2 per cent urea alone and untreated control were applied. Observations on larval population were recorded at 1 days before spraying and 1, 3, 7, 10 and 14 days after spray.

Number of larvae per meter row length (mrl) were counted from 3 random spots in a plot following drop sheet method. Average number of larvae per plot were transformed in to √ n+1 values and data on per cent pod damage were transformed in to angular transformed values before statistical analysis. Data obtained from field experiments were analyzed in randomized block design.

Results and discussion

Effect on larval population

During 2011-12, there was no variation in the larval population of *H. armigera* in different treatments before applying the insecticides and one day after first spray. However, significant difference in the larval population was recorded at 3 days after spray application of the insecticides. Minimum larval population was recorded in novaluron 10EC (1.1 larvae/ mrl) and it was statistically on par with monocrotophos 36SL, monocrotophos 36SL mixed with urea 2 per cent and novaluron 10EC mixed with urea 2 per cent. Higher larval population was recorded in cypermethrin 25EC, quinalphos 25EC and urea 2 per cent. Observations recorded at 7 days after application of insecticides revealed that the, minimum larval population was recorded in novaluron 10EC (2.1 larvae/ mrl) and it was statistically on par with novaluron 10EC plus urea 2 per cent (2.2 larvae/ mrl). At this stage, monocrotophos 36SL, monocrotophos 36SL plus urea 2 per cent, cypermethrin

Table 1. Evaluation of insecticides in combination with urea against *H. armigera* in chickpea during 2011-12

Treatments	Dosage (ml/ha)	Larval population/ per meter row length*						Per cent ** pod damage	Yield (q/ha)
		Pre-treatment	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS		
Monocrotophos 36SL	500	2.4 (2.1)	3.5 (2.3)	1.5 (1.9)	3.4 (2.3)	4.8 (2.6)	9.6 (3.4)	11.2 (19.5)	14.2
Cypermethrin 25EC	125	3.1 (2.3)	6.1 (2.9)	2.2 (2.0)	4.7 (2.6)	7.7 (3.1)	14.9 (4.1)	12.3 (20.5)	13.9
Quinalphos 25EC	1000	2.2 (2.1)	6.3 (2.9)	3.1 (2.3)	4.4 (2.5)	6.2 (2.9)	13.3 (3.9)	10.4 (18.7)	12.6
Novaluron 10EC	375	2.8 (2.2)	4.5 (2.6)	1.1 (1.8)	2.1 (2.0)	4.1 (2.5)	7.7 (3.1)	8.8 (17.3)	14.5
Monocrotophos + Urea 2%	500	2.0 (2.0)	5.7 (2.8)	1.5 (1.9)	3.1 (2.3)	5.1 (2.5)	13.6 (3.9)	8.8 (17.2)	14.8
Cypermethrin + Urea 2%	125	2.5 (2.1)	3.9 (2.4)	4.2 (2.5)	4.7 (2.6)	6.1 (2.9)	13.2 (3.9)	13.9 (21.9)	13.5
Novaluron + Urea 2%	375	1.8 (2.0)	5.7 (2.8)	1.8 (1.9)	2.2 (2.0)	4.1 (2.5)	5.5 (2.7)	7.3 (15.7)	14.7
Urea 2%	-	2.2 (2.1)	6.9 (3.0)	3.1 (2.3)	6.1 (2.8)	8.5 (3.2)	22.3 (4.9)	14.1 (22.1)	12.4
Untreated control	-	2.7 (2.2)	7.1 (3.0)	5.5 (2.7)	6.2 (2.9)	7.5 (3.1)	23.2 (5.0)	15.4 (23.0)	11.9
SEm ±	-	(0.1)	(0.2)	(0.1)	(0.1)	0.1)	(0.1)	(0.7)	0.5
CD at 5%	-	NS	NS	(0.2)	(0.2)	(0.2)	(0.2)	(1.8)	1.0

*Figures in parentheses are square root transformed values; **Figures in parentheses are angular transformed values
DAS = Days after spray

25EC and cypermethrin 25EC plus urea 2 per cent were found equally effective. At 10 days after spraying, all the insecticidal treatments were significantly superior over untreated control and treatment urea 2% alone (Table 1).

During the year 2012-13 there was also no variation in the larval population of *H. armigera* in different treatments before applying the insecticides and one day after first spray. However, significant difference in the larval population was recorded at 3 days after first spray of the insecticidal application. Minimum larval population was recorded in monocrotophos 36SL, and cypermethrin 25EC (1.0 l/ mrl) and these were statistically on par with all other treatments except untreated control (Table 2). At 7 days after first spray, minimum larval population was recorded in monocrotophos 36SL mixed with urea 2 per cent (0.4 l/ mrl) and it was statistically on par with monocrotophos 36SL, cypermethrin 25EC, quinalphos 25EC, novaluron 10EC and cypermethrin 25EC mixed with urea 2 per cent. After 10 days of first spray, minimum larval population (0.7 larvae/ mrl) was observed in novaluron 10EC plus urea 2 per cent. It was statistically on par with cypermethrin 25EC and quinalphos 25EC, novaluron 10EC, cypermethrin 25EC plus urea 2 per cent, monocrotophos 36SL plus urea 2 per cent and monocrotophos 36SL. Maximum larval population was recorded in urea 2 per cent alone (1.7 larvae/ mrl) and untreated control (2 larvae/ mrl). Non-significant difference in the larval population was recorded at 14 days after first spray.

All the insecticidal treatments were significantly superior over untreated control (2.4 larvae/ mrl) and 2 per cent urea (2.5 larvae/ mrl) at one day after second spray. However, novaluron 10EC plus urea 2 per cent and monocrotophos 36SL registered lowest larval population of 0.7 and 0.9 larvae per meter row length. These were significantly superior to urea 2 per cent alone and untreated control. Minimum larval population was recorded in novaluron 10EC mixed with urea 2 per cent (1.6 larvae/ mrl) at 3 days after second spray and it was statistically on par with novaluron 10EC and monocrotophos 36SL. Maximum larval population (2.8 and 2.7 larvae/ mrl) was recorded in urea 2 per cent alone and untreated control. At 7 days after second spray, minimum larval population (2 larvae/ mrl) was recorded in novaluron 10EC and it was statistically on par with novaluron 10EC plus urea 2 per cent, cypermethrin

Table 2. Evaluation of insecticides in combination with urea against *H. armigera* in chickpea during 2012-13

Treatments	Dosage (ml/ha)	Larval population per meter row length at*											Per cent pod damage**	Yield (q/ha)
			First spray					Second spray						
		Pre-treatment	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS	1 DAS	3 DAS	7 DAS	10 DAS	14 DAS		
Monocrotophos 36SL	500	0.6 (1.2)	0.3 (1.2)	1.0 (1.4)	0.6 (1.3)	1.4 (1.6)	1.1 (1.5)	0.9 (1.4)	2.0 (1.7)	2.8 (2.0)	5.5 (2.6)	16.6 (4.2)	9.8 (18.2)	11.8
Cypermethrin 25EC	125	0.6 (1.2)	0.4 (1.2)	1.0 (1.4)	0.6 (1.3)	0.8 (1.3)	1.0 (1.4)	1.2 (1.5)	2.3 (1.8)	2.6 (1.9)	4.9 (2.4)	16.8 (4.2)	9.2 (17.7)	10.4
Quinalphos 25EC	1000	0.2 (1.1)	0.5 (1.2)	1.3 (1.5)	0.8 (1.3)	0.8 (1.3)	0.8 (1.3)	1.1 (1.5)	2.3 (1.8)	3.0 (2.0)	5.2 (2.5)	10.4 (3.4)	10.0 (18.4)	13.2
Novaluron 10EC	375	0.9 (1.4)	0.5 (1.2)	1.3 (1.5)	0.9 (1.4)	1.0 (1.4)	0.8 (1.3)	1.2 (1.5)	1.7 (1.6)	2.0 (1.7)	3.8 (2.2)	6.3 (2.7)	8.7 (17.5)	13.3
Monocrotophos + Urea 2%	500	0.5 (1.2)	0.3 (1.1)	1.2 (1.5)	0.4 (1.2)	1.4 (1.6)	1.3 (1.5)	1.0 (1.4)	2.3 (1.8)	2.8 (2.0)	5.2 (2.5)	9.8 (3.3)	11.5 (19.8)	11.4
Cypermethrin + Urea 2%	125	0.3 (1.1)	0.3 (1.1)	1.2 (1.5)	0.6 (1.3)	1.1 (1.5)	1.2 (1.5)	1.0 (1.4)	2.3 (1.8)	2.5 (1.9)	4.1 (2.3)	9.2 (3.2)	10.9 (19.2)	11.8
Novaluron + Urea 2%	375	0.8 (1.3)	0.2 (1.1)	1.6 (1.6)	1.1 (1.5)	0.7 (1.3)	1.5 (1.5)	0.7 (1.3)	1.6 (1.6)	2.5 (1.9)	3.9 (2.2)	7.2 (2.9)	10.3 (18.7)	14.5
Urea 2%		0.3 (1.1)	0.3 (1.1)	1.8 (1.7)	1.3 (1.5)	1.7 (1.6)	1.7 (1.6)	2.5 (1.9)	2.7 (1.9)	3.3 (2.1)	5.7 (2.6)	16.6 (4.2)	15.0 (22.8)	10.3
Control	-	0.8 (1.3)	0.7 (1.3)	2.0 (1.7)	1.4 (1.6)	2.0 (1.7)	1.8 (1.7)	2.4 (1.9)	2.8 (2.0)	3.4 (2.1)	6.4 (2.7)	17.2 (4.3)	16.6 (24.0)	10.0
SEm±	-	NS	NS	(0.1)	(0.1)	(0.1)	NS	(0.1)	(0.1)	(0.1)	(0.2)	(0.1)	(1.2)	0.7
CD at 5%	-	-	-	(0.3)	(0.2)	(0.3)	-	(0.2)	(0.2)	(0.2)	(0.4)	(0.2)	(2.6)	1.5

DAS = Days after spray;*Figures in parentheses are square root transformed values;**Figures in parentheses are angular transformed values

25EC plus urea 2 per cent and cypermethrin 25EC. An increase in the larval population was recorded at 10 days after second spray. All the insecticides were significantly superior to untreated control and on par with each other. However, the minimum larval population (3.8 larvae/ mrl) was recorded in novaluron 10EC and novaluron 10EC plus urea 2 per cent (3.9 larvae/ mrl). After 14 days of second spray, minimum larval population (6.3 larvae/ mrl) was recorded in novaluron 10EC treated plots and it was statistically on par with novaluron 10EC plus urea 2 per cent (7.2 larvae/ mrl). Treatment cypermethrin 25EC, monocrotophos 36SL and urea 2 per cent alone were found ineffective in reducing the larval population of *H. armigera* and registered maximum larval population 16.8 and 16.6 larvae/ mrl, respectively.

Per cent pod damage

During 2011-12, minimum pod damage by *H. armigera* was recorded in novaluron 10EC @ 375 ml/ha mixed with urea 2 per cent (7.3%) and it was statistically on par with novaluron 10EC @ 375 ml/ha and monocrotophos 36SL @ 500 ml/ha mixed with urea 2% (8.8%).

During 2012-13, minimum pod damage was recorded in novaluron 10EC (8.7%) and it was statistically on par with cypermethrin 25EC (9.2%), monocrotophos 36SL (9.8%), quinalphos 25EC (10.0%), novaluron 10EC plus urea 2 per cent (10.3%), cypermethrin 25EC plus urea 2 per cent (10.9%) and monocrotophos 36SL plus urea 2 per cent (11.5%). The maximum per cent pod damage was recorded in urea 2 per cent (15.0%) and untreated control (16.6%).

Grain yield

During 2011-12, maximum grain yield was realized when crop was sprayed with monocrotophos 36SL @ 500 ml/ha mixed with urea 2 per cent (14.8 q/ha) and it was statistically on par with novaluron 10EC @ 375 ml/ha mixed with urea 2 per cent (14.7 q/ha), novaluron 10EC @ 375 ml/ha (14.5 q/ha), monocrotophos 36SL @ 500 ml/ha (14.2 q/ha) and cypermethrin 25EC @ 125 ml/ha (13.9 q/ha). Minimum grain yield was realized from urea 2% (12.4 q/ha) and it was statistically at par with quinalphos 25EC @ 1000 ml/ha (12.6 q/ha) and cypermethrin 25EC @ 125 ml/ha mixed with urea 2% (13.5 q/ha).

During 2012-13, maximum grain yield was recorded in novaluron 10EC @ 375 ml/ha plus urea 2 per cent (14.5 q/ha) and it was statistically at par with novaluron 10EC @ 375 ml/ha (13.3 q/ha) and quinalphos 25EC @ 1000 ml/ha (13.2 q/h), respectively. It was followed by cypermethrin 25EC @ 125 ml/ha plus urea 2 per cent (11.8 q/ha), monocrotophos 36SL @ 500 ml/ha (11.8 q/ha) and monocrotophos 36SL @ 500 ml/ha plus urea 2 per cent (11.4 q/ha). Treatment cypermethrin 25EC @ 125 ml/ha

Table 3. Effect of different insecticidal treatments on yield of chickpea, net profit and their cost benefit ratio

Treatments	Av. yield (q/ha)	Increase yield over control (q/ha)	Value of the additional grain yield (₹/ha)	Cost of treatment (₹/ha)	Net profit (₹/ha)	Cost benefit ratio
Monocrotophos 36SL	13.0	2.1	5047.0	780	4267.0	1:5.5
Cypermethrin 25EC	12.2	1.2	3013.5	640	2373.5	1:3.7
Quinalphos 25EC	12.9	2.0	4826.5	1330	3496.5	1:2.6
Novaluron 10EC	13.9	3.0	7252.0	2563	4689.0	1:1.8
Monocrotophos + Urea 2%	13.1	2.1	5218.5	870	4348.5	1:5.0
Cypermethrin + Urea 2%	12.6	1.7	4140.5	730	3410.5	1:4.7
Novaluron + Urea 2%	14.6	3.6	8918.0	2653	6265.0	1:2.4
Urea 2%	11.3	0.4	980.0	90	890.0	1:9.9
Control	10.9	-	-	-	-	-
SEm±	0.6	-	-	-	-	-
CD at 5%	1.3	-	-	-	-	-

Input	Cost (₹)
Monocrotophos 36SL	280/l
Cypermethrin 25EC	560/l
Quinalphos 25EC	415/l
Novaluron 10EC	2750/l
Chickpea grain	2450/q
Labour charges	250/labour/ha/day
Urea 2%	300/50 kg

and urea 2 per cent alone registered minimum grain yield of 10.4 q/ha and 10.3 q/ha, respectively. The findings are in accord with Saini *et al*., (2013) who reported that the novaluron even at the lowest dose (18.75 g a.i./ha) proved comparable/ superior to the standard check, quinalphos and was significantly superior at higher dose (37.5 g a.i./ ha) in reducing the larval population of *H. armigera* and pod damage in chickpea crop. The results are in line with the findings of Patil *et al*., (2007), who reported that the minimum larval incidence of 1.68 larvae/ mrl was recorded in novaluron 10EC @ 100 g/ha at 3 days after sowing while, treatment proclaim 5SG @ 11 g a.i./ha was found more effective in reducing the pod damage (3%). Wavare *et al*., (2008) reported that different concentrations of novaluron 10EC suppressed all developing stages of *H. armigera*. The contrasting results were reported by Lal and Rohilla (2008), who reported that spraying of 2 per cent urea @ 250 l/ ha at flower initiation in chickpea crop followed by endosulfan 35EC @ 1 l/ ha at pod initiation and spraying of endosulfan 35EC @ 1 l/ ha tank mixed with 2 per cent urea at pod initiation registered lower *H. armigera* larval population at 14 days after spray.

Cost benefit ratio

The data on seed yield, net monetary returns and cost benefit ratio are presented in Table 3. The data on seed yield showed that the seed yield in all the insecticidal treatments were significantly superior over untreated control. However, the highest grain yield of chickpea (14.6 q/ha) was realized in novaluron 10EC plus urea 2 per cent and it was statistically on par with spray of novaluron 10EC (13.9 q/ha).

Data on net monetary returns suggests that application of novaluron 10EC @ 375 ml/ha plus urea 2 per cent recorded highest net monetary returns of ₹ 6265/ ha. Treatment novaluron 10EC @ 375 ml/ ha was the next best treatment registered ₹ 4689/ ha net monetary return. Results are in conformity with the findings narrated by Saini *et al*., (2013), who reported that maximum grain yield of chickpea (14.5 q/ ha) as well as net profit (₹ 7095/ ha) was realized in novaluron 10EC @ 37.5 g a. i./ ha sprayed plots.

The contrasting results were observed by Lal and Rohilla (2008), who reported that the highest seed yield of 17.3 q/ ha in chickpea was recorded from the plots sprayed with urea 2 per cent in 250 l water/ ha followed by application of endosulfan 35EC @ 1 l/ ha at pod initiation. Singh and Ali (2005) reported that highest yield of chickpea was obtained in endosulfan 0.07% (25 q/ha) followed by *HaNPV*-450 LE/ha (23.7 q/ha) and Bt 1 per cent (24 q/ha).

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Received : 16-01-2015 Accepted : 10-02-2016