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Management of chickpea podborer, *Helicoverpa armigera* (Hubner) with a novel new insecticide, broflanilide 30% SC (BAS 450 01 I 300 SC)

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Abstract
Efficacy of different treatments *viz.,* Broflanilide 30% SC (BAS 450 01 I 300 SC) at different doses, Emamectin benzoate 5% SG @ 0.2g/l and lambda cyhalothrin 5 EC @ 1 ml/l was tested against *Helicoverpa armigera* larvae. The result revealed that Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i/ha was found sufficient in reducing the pod borers larval load, their damage to pods and registering good seed yield of chickpea.

Keywords: *Helicoverpa armigera,* chickpea, new insecticides, efficacy

Introduction
Chickpea, *Cicer arietinum* belongs to Leguminosae family is a very important pulse crop. India is the largest chickpea producer as well as consumer in the world. Chickpea is the world's third most important food legume. Chickpea production has increased during the past 30 years from 6.5 million tons (1978- 1980 average) to 9.6 million tons (2007-09) because of increase in grain yields yield from 630 to 850kg/ha during this period. It contains 25% proteins, which is the maximum provided by any pulse and 61.1% carbohydrates [4]. However, high yield is limited by the insect pests attacking chickpea. Among several insect pests attacking chickpea, *Helicoverpa armigera* appear in great number during vegetative growth and at pod formation stage of chickpea [6, 3, 1]. A single larva may destroy several pods before reaching to maturity and this pest is reported to cause damage to the extent of 5 to 40 per cent on pods of chickpea crop.

2. Material and Methods
Experimental details: Treatments and design of layout
The experiment was conducted at Krishi Vigyan Kendra, Gangavathi University of Agricultural Sciences, Raichur during rabi seasons of 2015 and 2016 in a Randomized Block Design (R.B.D.) with six treatments, each consisting of four replicates. The total number of plots was 24. The chickpea seeds of variety 'JG-11' were sown in plots of size 4 x 3 m2 with row spacing 30 cm and plant to plant distance 10 cm.
All the insecticides under study were applied as foliar spray using Knapsack sprayer. To determine the efficacy of chemicals, two sprays were conducted on chickpea. First spray was done at pod initiation stage and second spray after 15 days of first spray. The details of treatments with respective dose and method of application has been given in Table 1.

Table 1: Bioefficacy test against pod borer

S. No.	Treatment details	Dosage		
		g a.i./ha	Formulation / ha (ml or g)	Water volume (L)
T1	Broflanilide 30% SC (BAS 450 01 I 300 SC)	6	20	500
T2	(Broflanilide 30% SC) BAS 450 01 I 300 SC	12.6	42	500
T3	(Broflanilide 30% SC) BAS 450 01 I 300 SC	18	60	500
T4	Emamectin benzoate 5% SG	11	220	500
T5	Lambda cyhalothrin 5% EC	25	500	300-400
T6	Untreated control	-	-	-

Counting of larval population

Method of observation

1. Pod borer larval count on randomly selected 10 plants in each plot was made on one day before spray and 3, 7,10 & 14 days after spray each spray
2. Pod damage data at harvest was taken and per cent pod damage was worked out
3. Yield data at harvest was taken in each plot and converted to hectare basis
4. 10 plants were selected at random from each plot and the total number leaves of those showing phytotoxicity if any were counted & observations were made for symptoms like yellowing, leaf injury, vein clearing, wilting, necrosis, epinasty & hyponasty before spray, 3, 7 & 14 days after spray on 0-10 scales as, 0= no phytotoxicity, 1= 1 – 10%, 2= 11-20%, 3= 21 – 30%, 4= 31 – 40%, 5= 41 – 50%, 6= 51 – 60%, 7= 61 – 70%, 8= 71 – 80%, 9= 81 – 90% and 10= 91 – 100% phytotoxicity.

Results

Bioefficacy of Broflanilide 30% SC (BAS 450 01 I 300 SC) against pod borer (*Helicoverpa armigera*)

The bioefficacy data on Broflanilide 30% SC (BAS 450 01 I 300 SC) on *Helicoverpa* larval population count in chickpea is presented in Table 2.

Table 2: Effect of Broflanilide 30% SC (BAS 450 01 I 300 SC) on pod borer, *Helicoverpa armigera* larval population (2015)

Treatments details	Mean larva / 10 plant								
	I spray					II spray			
	1 DBS	3DAS	7DAS	10 DAS	15 DAS	3DAS	7DAS	10 DAS	15 DAS
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 6 g.a.i./ha	10.35	4.15	2.15	4.19	6.23	1.34	1.96	2.12	2.56
	(3.29)	(2.16)	(1.61)	(2.16)	(2.58)	(1.36)	(1.57)	(1.6)	(1.74)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i./ha	11.45	2.28	1.23	3.92	5.56	0.72	0.22	1.3	1.72
	(3.46)	(1.65)	(1.31)	(2.10)	(2.46)	(1.10)	(0.85)	(1.34)	(1.49)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i./ha	10.76	1.96	1.22	3.96	5.28	0.55	0.22	1.12	1.37
	(3.36)	(1.57)	(1.31)	(2.11)	(2.39)	(1.02)	(0.85)	(1.27)	(1.37)
Emamectin benzoate 5% SG @ 11g.a.i./ha	10.98	3.12	2.85	5.95	7.23	1.42	2.12	2.45	2.65
	(3.39)	(1.89)	(1.82)	(2.54)	(2.77)	(1.39)	(1.60)	(1.71)	(1.76)
Lambda cyhalothrin 5% EC @ 25 g.a.i./ha	11.23	4.12	3.52	6.12	7.56	2.26	3.12	3.45	3.75
	(3.42)	(2.12)	(2.00)	(2.57)	(2.83)	(1.65)	(1.89)	(1.98)	(2.05)
Untreated control	10.9	12.50	13.5	14.50	12.6	13.50	12.8	13.50	12.90
	(3.38)	(3.60)	(3.73)	(3.86)	(3.61)	(3.73)	(3.64)	(3.73)	(3.66)
SEM+	0.05	0.12	0.11	0.13	0.15	0.09	0.09	0.12	0.10
CD at 5%	0.15	0.36	0.35	0.4	0.46	0.26	0.26	0.35	0.31

Values in parenthsis are $\sqrt{x+1}$ transformed

Note: DBS= Days Before Spray, DAS= Days After Spray

First season

The pod borer larval population one day before 1st spray in the experimental field was not differed significantly among the plots indicating uniform distribution of larvae and it was above the economic threshold level. The larval load after spray varied among the treatments and it was lowest (1.96 /10 plants) in Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i/ha and highest in untreated control (13.50/10 plants) on 3rd day of 1st spray. Among the Broflanilide 30% SC dosages tested, the Broflanilide 30% SC (BAS 450 01 I 300 SC) sprayed @ 18 g.a.i/ha recorded significantly less number of larvae and was on par with Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i/ha. Emamectin benzoate 5% SG@ 11 g.a.i/ha, and lambda cyhalothrin 5% EC @ 25 g.a.i/ha on 3, 7, 10, and 15 days after I spray. The efficacy trend of Broflanilide 30% SC (BAS 450 01 I 300 SC) remained same even after II spray.

Second season

The pod borer larval population one day before 1st spray in the experimental field was not differed significantly among the treatments indicating uniform distribution of larvae and it was above the economic threshold level. The larval load after spray varied among the treatments and it was lowest (2.80 /10 plants) in Brolanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i/ha and highest in untreated control (11.90/10 plants) on 3rd day of 1st spray. Among the Brolanilide 30% SC (BAS 450 01 I 300 SC)dosages tested, the Brolanilide 30% SC (BAS 450 01 I 300 SC) sprayed @ 18 g.a.i/ha recorded significantly less number of larvae and was on par with Brolanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i/ha followed by Emamectin benzoate 5% SG@ 11 g.a.i/ha, and lambda cyhalothrin 5% EC @ 25 g.a.i/ha on 3, 7, 10, and 15 days after I spray. The efficacy trend of Brolanilide 30% SC (BAS 450 01 I 300 SC) remained same even after II spray (Table 2a).

Table 2a: Effect of Brolanilide 30% SC (BAS 450 01 I 300 SC) on pod borer, *Helicoverpa armigera* larval population (2016)

Treatments details	Mean larva / 10 plant								
	I spray					II spray			
	1 DBS	3DAS	7DAS	10 DAS	15 DAS	3DAS	7DAS	10 DAS	15 DAS
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 6 g.a.i./ha	10.05	4.53	2.69	4.10	6.43	1.18	0.91	1.68	1.98
	(3.25)	(2.23)	(1.78)	(2.14)	(2.63)	(1.30)	(1.19)	(1.48)	(1.57)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i./ha	9.88	3.00	1.40	3.13	5.43	0.65	0.48	0.58	0.82
	(3.22)	(1.87)	(1.37)	(1.90)	(2.43)	(1.07)	(0.99)	(1.04)	(1.15)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i./ha	10.13	2.80	1.19	3.08	4.78	0.53	0.36	0.47	0.79
	(3.26)	(1.79)	(1.28)	(1.89)	(2.29)	(1.01)	(0.93)	(0.98)	(1.14)

Emamectin Benzoate 5% SG @ 11g.a.i./ha	9.83	3.45	2.35	5.15	6.58	1.32	1.10	1.49	1.88
	(3.21)	(1.98)	(1.69)	(2.37)	(2.64)	(1.35)	(1.26)	(1.41)	(1.54)
Lambda cyhalothrin 5% EC @ 25 g.a.i./ha	10.08	4.73	3.80	5.30	7.03	2.19	1.76	1.98	2.20
	(3.25)	(2.28)	(2.07)	(2.40)	(2.73)	(1.64)	(1.50)	(1.57)	(1.64)
Untreated control	9.80	11.90	12.60	13.75	14.78	12.98	13.20	13.65	14.50
	(3.21)	(3.51)	(3.62)	(3.77)	(3.90)	(3.67)	(3.70)	(3.76)	(3.87)
SEM+	NS	0.13	0.10	0.09	0.14	0.08	0.81	0.11	0.12
CD at 5%	NS	0.40	0.32	0.28	0.43	0.25	0.25	0.33	0.37

Values in parenthsis are $\sqrt{x+1}$ transformed

Note: DBS= Days Before Spray, DAS= Days After Spray

Pod damage by gram pod borer

First season

Significantly lesser pod damage was found in plots received Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i/ha (4.13%) followed by Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i/ha (5.19%) which were on par with standard checks viz., Emamectin benzoate 5% SG @ 11 g.a.i/ha (6.86%) and lambda cyhalothrin 5% EC @ 25 g.a.i/ha (8.72%). The pod damage by pod borers was maximum (21.23%) in untreated control (Table 3).

Table 3: Effect of Broflanilide 30% SC (BAS 450 01 I 300 SC) on gram pod borer larval population (2015)

Treatments	Pod damage (%)	Yield (Kg/ha)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 6 g.a.i./ha	8.32	1410
	(16.71)	
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i./ha	5.19	1525
	(13.14)	
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i./ha	4.13	1580
	(11.55)	
Emamectin Benzoate 5% SG @ 11g.a.i./ha	6.86	1377
	(15.1)	
Lambda cyhalothrin 5% EC @ 25 g.a.i./ha	8.72	1291
	(17.16)	
Untreated control	21.23	1038
	(27.41)	
SEM+	0.91	0.19
CD at 5%	2.73	0.58

Values in parenthsis are arcsin transformed.

Second season

Significantly less pod damage was found in plots received Brolanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i/ha (4.99%) followed by Brolanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i/ha (5.88%) which were on par with standard checks viz., emamectin benzoate 5% SG @ 11 g.a.i/ha (6.47%) and lambda cyhalothrin 5% EC @ 25 g.a.i/ha (9.701%). The pod damage by pod borers was maximum (21.74%) in untreated control (Table 3a).

Table 3a: Effect of Brolanilide 30% SC (BAS 450 01 I 300 SC) on gram pod borer larval population (2016)

Treatments	% pod damage	Yield (kg/ha)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @6 g.a.i./ha	8.78	1358
	(17.21)	
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i./ha	5.88	1495
	(14.00)	
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i./ha	4.99	1535
	(12.83)	
Emamectin Benzoate 5% SG @ 11g.a.i./ha	6.47	1367
	(14.65)	
Lambda cyhalothrin 5% EC @ 25 g.a.i./ha	9.01	1213
	(17.45)	
Untreated control	21.74	1041
	(27.76)	
SEM+	0.88	0.33
CD at 5%	2.68	0.99

Values in parenthsis are arcsine transformed.

Yield

The significantly highest yield of chickpea was registered in Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i/ha treated plot (1587 kg/ha) which was at par with Broflanilide 30% SC (BAS 450 01 I 300 SC) treated @ 12.6 g a.i./ha (1522 kg/ha), Broflanilide 30% SC (BAS 450 01 I 300 SC) treated @ 6 g.a.i/ha (1410 kg/ha), standard checks., Emamectin benzoate 5% SG@ 11 g.a.i/ha (1377 kg/ha) and lambda cyhalothrin 5% EC @ 25 g.a.i/ha (1291 kg/ha). The lowest seed yield of 1038 kg/ha recorded from untreated control (Table 2).During second season, Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i/ha treated plot (1535 kg/ha) which was at par with Broflanilide 30% SC (BAS 450 01 I 300 SC) treated @ 12.6 g a.i./ha (1495 kg/ha),

Brolanilide 300 SC (BAS 450 01 I 300 SC) treated @ 6 g.a.i/ha (1358 kg/ha), standard checks., emamectin benzoate 5% SG@ 11 g.a.i/ha (1367 kg/ha) and lambda cyhalothrin 5% EC @ 25 g.a.i/ha (1213 kg/ha). The lowest seed yield of 1041 kg/ha recorded from untreated control (Table 3 & 3a).

Effect of Broflanilide 30% SC (BAS 450 01 I 300 SC) on natural enemies

Natural enemy population in all the Broflanilide 30% SC treated plots were found on par with standard check treatments (Table 4 & 4a).

Table 4: Effect of Broflanilide 30% SC (BAS 450 01 I 300 SC) on natural enemies population

Treatment details	Natural enemies (Population/10 plants)	
	Chrysoperla	***Coccinella spp.***
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 6 g.a.i./ha	0.12	0.15
	(0.79)	(0.80)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i./ha	0.4	0.12
	(0.93)	(0.79)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i./ha	0.13	0.16
	(0.79)	(0.81)
Emamectin benjoate 5% SG @ 11g.a.i./ha	0.13	0.14
	(0.79)	(0.80)
Lambda cyhalothrin 5% EC @ 25 g.a.i./ha	0.18	0.13
	(0.82)	(0.79)
Untreated control	0.56	0.45
	(1.03)	(0.97)
SEM+	0.05	0.04
CD at 5%	0.15	0.12

Table 4a: Effect of Brolanilide 30% SC (BAS 450 01 I 300 SC) on natural enemies population

Treatment details	Natural enemies (Population/10 plants)	
	Chrysoperla	***Coccinella spp.***
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 6 g.a.i./ha	0.10	0.12
	(0.77)	(0.79)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i./ha	0.08	0.12
	(0.76)	(0.79)
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 18 g.a.i./ha	0.11	0.13
	(0.78)	(0.79)
Emamectin benjoate 5% SG @ 11g.a.i./ha	0.11	0.14
	(0.78)	(0.80)
Lambda cyhalothrin 5% EC @ 25 g.a.i./ha	0.13	0.16
	(0.79)	(0.81)
Untreated control	0.35	0.48
	(0.92)	(0.98)
SEM+	0.03	0.04
CD at 5%	0.11	0.12

Values in parenthsis are $\sqrt{x+1}$ transformed

Phytotoxicity of Broflanilide 30% SC (BAS 450 01 I 300 SC)

The phytotoxic effect of Broflanilide 30% SC (BAS 450 01 I 300 SC) was assessed on bengalgram using 500 liters water/ha and high-volume sprayer which was recommended. There was no phytotoxic effect on plant as it was evidenced by not causing any of the phytotoxic symptoms at the dose indicated in Table 5 & 5a.

Table 5: Phytotoxicity effect of Broflanilide 30% SC (BAS 450 01 I 300 SC) on Bengalgram (2015 & 2016)

Treatment details	Phytotoxicity observations at 1,3,5,7 and 10 days after first spray						
	Yellowing	Leaf injury	Vein clearing	Wilting	Necrosis	Epinasty	Hyponasty
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i./ha	*0.0	0.0	0.0	0.0	0.0	0.0	0.0
Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 25.2 g.a.i./ha	0.0	0.0	0.0	0.0	0.0	0.0	0.0
UTC	0.0	0.0	0.0	0.0	0.0	0.0	0.0

*No phytotoxicity symptoms were observed on sprayed crops.

Discussion

Chickpea yield found decreasing day by day due to many factors among which damage caused by larvae of *H. armigera (Hub.)* is one among the major factor. The efficacy of different treatments against *H. armigera* larvae was determined on the basis of number of larvae per five plants. The data revealed that all the treatments were significantly superior over control. The results revealed that Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i/ha was found sufficient in reducing the pod borers larval load, their damage to pods and registering good seed yield of chickpea followed by Emamectin benzoate and lambda cyhalothrin. Broflanilide being a new group of insecticide belonging to the group of meta-diamide exhibits high activity on lepidopteran pests thus giving maximum control of *H. armigera* in chickpea ecosystem (Hiroyuki 2019) [2]. Minimum larval population was recorded for lambda cyhalothrin in cotton crop, thus supporting our findings [5].

Conclusion

It may concluded from the present investigation that the incidence of *H. armigera* in chickpea starting from early stage of flowering till to the harvest. The approaches for chemical management of *H. armigera* were
found effective than control. The plots sprayed with Broflanilide 30% SC (BAS 450 01 I 300 SC) @ 12.6 g.a.i/ha was found sufficient in reducing the pod borers larval load, their damage to pods and registering good seed yield of chickpea. These treatments Broflanilide 30% SC (BAS 450 01 I 300 SC @ 6, 12.6 and 18 g.a.i.ha) were also at par with standard checks. This chemical recorded on par population of natural enemies as that of all other treatments used in the experiment for *Crysoperla* and coccinellids activity. This product does not cause any phytotoxicity symptoms on chickpea. Hence, Broflanilide 30% SC (BAS 450 01 I 300 SC) spray is found optimum for the management of gram pod borer @ 12.6 g.a.i./ha and to get optimum protection of crop from this pest.

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