The Bioscan 10(3): 1073-1077, 2015
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.in

EFFECT OF NEONICOTINOID INSECTICIDES ON PREDATORY COCCINELLIDS IN COWPEA AND GREEN GRAM

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KEYWORDS
Neonicotinoids
Coccinellids
Cowpea
Green gram

Received on :
07.05.2015

Accepted on :
26.08.2015

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ABSTRACT
Field experiments were conducted during *summer* and *kharif*, 2013 to investigate the effect of neonicotinoid insecticides on predatory coccinellids in cowpea and green gram. The population of predatory coccinellids recorded at weekly intervals in all the treatments of neonicotinoid insecticides *viz*., imidacloprid, thiamethoxam and acetamiprid as seed treatment (ST) alone and in combination with one (at 30 days after germination (DAG)) or two (at 30 and 45 DAG) foliar sprays showed non-significant results during both seasons. Hence, these insecticides are safer to the predatory coccinellids in cowpea and green gram. However, relatively lower population of the coccinellids were recorded in the combination treatments (ST combined with one or two foliar sprays) than ST alone. Among the sole treatments (ST alone), highest number of coccinellids were found in acetamiprid followed by imidacloprid and thiamethoxam and the similar trend was observed in case of ST combined with foliar spray at 30 DAG and ST combined with foliar spray at 30 and 45 DAG indicating that acetamiprid was more safer to the coccinellids followed by imidacloprid and thiamethoxam.

INTRODUCTION

Neonicotinoid insecticides are one of the widely used groups of insecticides against the sucking pests like aphids, whiteflies, thrips and leaf hoppers. Cowpea and green gram are two major pulse crops widely cultivated in India. The seedlings of cowpea and green gram are severely attacked by several sucking insect pests like aphid, leafhopper and whitefly. Early season pests can be managed by seed treatments and the late season pests can be controlled by foliar sprays. Therefore, neonicotinoid insecticides as seed treatment and in combination with foliar sprays can be an effective option for the control of sucking insect pests of cowpea and green gram.

In addition to the bioefficacy of any insecticide against the target pest(s), its safety to predators in the crop ecosystem is one of the major ecological concerns. The safety of the insecticides to the predators plays a decisive role in incorporating the insecticide in Integrated Pest Management programmes. Coccinellid predators are the important group of predators of the sucking pests like aphid, leaf hopper and whitefly in cowpea and green gram. Many species of coccinellid predators such as *Cheilomenes sexmaculata* (Fab.), *Harmonia octomaculata* (Fab.) and *Coccinella transversalis* Fab. have been reported in cowpea and green gram from Anand region, Gujarat (Tank *et al*., 2007 and Chakraborty *et al*., 2013). Safe nature of neonicotinoid insecticides to the predatory coccinellids have been reported by many researchers in various crops (Vadodaria *et al*., 2001; Acharya *et al*., 2002 and Ameta *et al*., 2005). However, the information on this aspect particularly for the combination treatments (ST in combination with foliar spray) in cowpea and green gram is absent.

Therefore, field experiments were conducted with the objective to investigate the safety of neonicotinoid insecticides *viz*., imidacloprid, thiamethoxam and acetamiprid as seed treatment alone and in combination with foliar spray to the coccinellid predators in cowpea and green gram.

MATERIALS AND METHODS

In order to assess the safety of neonicotinoid insecticides to coccinellid predators in cowpea (variety: Gujarat cowpea-1) and green gram (variety: Meha), field experiments were conducted in randomized block design during *kharif* and *summer,* 2013 in the agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat with ten treatments and three replications. Population of the coccinellids was recorded as described by Anitha (2007) with slight modifications. Five plants were selected randomly from each net plot and the number of coccinellids (grubs and adults) was recorded at weekly intervals. Based on these observations, the mean number of coccinellids per plant was calculated. The treatments evaluated were:

T_1 : Seed treatment (ST) with imidacloprid 600 FS @ 5 ml/ Kg seed *i.e.*, 3 g a.i./kg seed

T_2 : T_1 + Foliar spray of imidacloprid 17.8 SL (0.008 % - 40 g a.i./ha) at 30 days after germination (DAG)

T_3 : T_1 + Foliar spray of imidacloprid 17.8 SL (0.008 %- 40 g a.i./ha) at 30 and 45 DAG

T_4 : ST with thiamethoxam 35 FS @ 5 ml/kg seed *i.e.* 1.5 g a.i./Kg seed

T_5 : T_4 + Foliar spray of thiamethoxam 25 WG (0.01 % - 50 g a.i./ha) at 30 DAG

T_6 : T_4 + Foliar spray of thiamethoxam 25 WG (0.01 % - 50 g a.i./ha) at 30 and 45 DAG

T_7 : ST with acetamiprid 20 SP @ 20 g/kg seed *i.e.*, 4 g a.i./ Kg seed

T_8 : T_7 + Foliar spray of acetamiprid 20 SP (0.01% - 50 g a.i./ha) at 30 DAG

T_9 : T_7 + Foliar spray of acetamiprid 20 SP (0.01% - 50 g a.i./ha) at 30 and 45 DAG

T_{10}: Untreated Control (Water spray)

Recommended dosages of fertilizers were applied and other agronomic practices were done. The data on the predatory coccinellids were statistically analyzed after applying square root transformation by following Steel and Torrie (1980) using ANOVA technique.

RESULTS

The predatory coccinellids were noticed on cowpea and green gram starting from 14 DAG till 56 DAG during *kharif* season. Population of predatory coccinellids in cowpea during *kharif* season (Table 1) indicated that there was no significant difference among the treatments and relatively higher numbers of coccinellids were recorded in untreated control than the insecticide treatments during weekly observations. However, pooled over periods data during *kharif* revealed significant variation in coccinellid numbers among different treatments. Significantly lesser number of predatory coccinellids was found in the treatments of neonicotinoids (0.75 to 1.09 coccinellids per plant) compared to the untreated control (1.35 coccinellids per plant). Higher number of coccinellids was observed in the plots where seed treatment alone was done than the combination treatments of seed dressing coupled with either one (30 DAG) or two (30 and 45 DAG) foliar sprays. These data highlighted slight deleterious effect of neonicotinoids on the coccinellids particularly for foliar sprays. Among the sole treatments (seed treatment alone), highest number of predators were recorded in acetamiprid treated plots (1.09 coccinellids per plant) followed by imidacloprid and thiamethoxam (0.99 and 0.94 coccinellids per plant respectively) and the similar trend was observed in case of ST combined with foliar spray at 30 DAG and ST combined with foliar spray at 30 and 45 DAG. It indicates that acetamiprid is safer to the predatory coccinellids than imidacloprid and thiamethoxam.

The data on the population of predatory coccinellids in green gram at weekly intervals during *kharif* season (Table 2) indicated non-significant differences among the treatments as observed in cowpea. However, relatively higher number of coccinellids was recorded in untreated control than the insecticide treatments. From the pooled over periods data, it was revealed that significantly higher number of coccinellids was found in the untreated control (1.43 coccinellids per plant) than the neonicotinoid insecticide treatments (0.78 to 1.16 coccinellids per plant). The population of coccinellids was higher in the sole treatments (seed treatment alone) than the combination treatments (seed dressing coupled with either one or two foliar sprays). Relatively higher number of the predatory coccinellids was recorded in acetamiprid treated plots followed by imidacloprid and thiamethoxam as noticed in case of cowpea. The highest number of coccinellids were recorded in acetamiprid treated plots (1.16 coccinellids per plant) followed by imidacloprid and thiamethoxam (1.06 and 0.96 coccinellids per plant respectively) among the sole treatments (seed treatment alone). ST combined with foliar spray at 30 DAG and ST combined with foliar spray at 30 and 45 DAG also followed the similar trend.

The predatory coccinellids were noticed starting from 28 DAG till 56 DAG on cowpea and green gram during *summer* (Table

Table 1: Effect of neonicotinoid insecticides on predatory coccinellids in cowpea during *Kharif,* 2013

Treatments	No. of coccinellids/plant (at indicated days after germination)							
	14	21	28	35	42	49	56	Pooled
T_1	*0.98(0.46)	1.01(0.52)	1.40 (1.46)	1.45 (1.60)	1.35 (1.32)	1.28 (1.14)	1.11 (0.73)	1.22 (0.99)
T_2	0.97(0.44)	1.05(0.60)	1.43 (1.54)	1.33 (1.27)	1.26 (1.09)	1.25 (1.06)	1.05 (0.60)	1.19 (0.92)
T_3	0.98(0.46)	1.02(0.54)	1.42 (1.52)	1.33(1.27)	1.24 (1.04)	1.17 (0.87)	0.97 (0.44)	1.16 (0.84)
T_4	0.91(0.33)	0.98 (0.46)	1.38 (1.40)	1.45 (1.60)	1.33 (1.27)	1.27 (1.11)	1.07 (0.64)	1.20 (0.94)
T_5	0.94(0.38)	0.98 (0.46)	1.37 (1.38)	1.26 (1.09)	1.20 (0.94)	1.20 (0.94)	1.08 (0.67)	1.15 (0.82)
T_6	0.94(0.38)	0.97 (0.44)	1.37 (1.38)	1.27 (1.11)	1.22 (0.99)	1.13 (0.78)	0.94 (0.38)	1.12 (0.75)
T_7	1.02(0.54)	1.05 (0.60)	1.43 (1.54)	1.49 (1.72)	1.37 (1.38)	1.33 (1.27)	1.14 (0.80)	1.26 (1.09)
T_8	1.01(0.52)	1.08 (0.67)	1.45 (1.60)	1.35 (1.32)	1.28 (1.14)	1.30 (1.19)	1.02 (0.54)	1.21 (0.96)
T_9	1.02(0.54)	1.05 (0.60)	1.44 (1.57)	1.37 (1.38)	1.30 (1.19)	1.19 (0.92)	0.98 (0.46)	1.19 (0.92)
T_{10}	1.07(0.64)	1.17 (0.87)	1.54 (1.87)	1.60 (2.06)	1.49 (1.72)	1.40 (1.46)	1.22 (0.99)	1.36 (1.35)
SEm ±								
T (Treatment)	0.08	0.08	0.12	0.11	0.11	0.09	0.07	0.03
P (Period)	-	-	-	-	-	-	-	0.03
T × P	-	-	-	-	-	-	-	0.10
CD at 5 %								
T	NS	NS	NS	NS	NS	NS	NS	0.09
P	-	-	-	-	-	-	-	0.09
T × P	-	-	-	-	-	-	-	NS
CV (%)	13.77	13.87	14.39	14.29	15.00	12.11	11.43	13.88

*Figures are $\sqrt{x+0.5}$ transformed values and those in parentheses are re-transformed values; NS: Non-significant

Table 2: Effect of neonicotinoid insecticides on predatory coccinellids in green gram during *kharif,* 2013

Treatments	No. of coccinellids/plant (at indicated days after germination)							
	14	21	28	35	42	49	56	Pooled
T_1	*0.94 (0.38)	1.04 (0.58)	1.35 (1.32)	1.51 (1.78)	1.47 (1.66)	1.35 (1.32)	1.07 (0.64)	1.25 (1.06)
T_2	0.93 (0.36)	1.05 (0.60)	1.35 (1.32)	1.28 (1.14)	1.40 (1.46)	1.33 (1.27)	1.05 (0.60)	1.20 (0.94)
T_3	0.94 (0.38)	1.05 (0.60)	1.33 (1.27)	1.30 (1.19)	1.42 (1.52)	1.16 (0.84)	1.01 (0.52)	1.17 (0.87)
T_4	0.90 (0.31)	0.98 (0.46)	1.30 (1.19)	1.49 (1.72)	1.35 (1.32)	1.33 (1.27)	1.10 (0.71)	1.21 (0.96)
T_5	0.91 (0.33)	0.97 (0.44)	1.28 (1.14)	1.27 (1.11)	1.31 (1.22)	1.28 (1.14)	1.14 (0.80)	1.16 (0.84)
T_6	0.90 (0.31)	0.98 (0.46)	1.27 (1.11)	1.27 (1.11)	1.30 (1.19)	1.14 (0.80)	1.04 (0.58)	1.13 (0.78)
T_7	1.02 (0.54)	1.02 (0.54)	1.44 (1.57)	1.56 (1.93)	1.52 (1.81)	1.37 (1.38)	1.08 (0.67)	1.29 (1.16)
T_8	1.02 (0.54)	1.02 (0.54)	1.43 (1.54)	1.35 (1.32)	1.44 (1.57)	1.33 (1.27)	1.07 (0.64)	1.24(1.04)
T_9	1.05 (0.60)	1.01 (0.52)	1.45 (1.60)	1.33 (1.26)	1.45 (1.60)	1.20 (0.94)	1.00 (0.50)	1.21 (0.96)
T_{10}	1.11 (0.73)	1.20 (0.94)	1.53 (1.84)	1.66 (2.25)	1.60 (2.06)	1.42 (1.52)	1.20 (0.94)	1.39 (1.43)
SEm ±								
T (Treatment)	0.07	0.07	0.11	0.11	0.11	0.11	0.08	0.03
P (Period)	-	-	-	-	-	-	-	0.03
T × P	-	-	-	-	-	-	-	0.10
CD at 5 %								
T	NS	NS	NS	NS	NS	NS	NS	0.09
P	-	-	-	-	-	-	-	0.09
T × P	-	-	-	-	-	-	-	NS
CV (%)	12.60	12.03	14.30	13.29	13.17	15.29	12.69	13.68

*Figures are $\sqrt{x + 0.5}$ transformed values and those in parentheses are re-transformed values; NS: Non-significant

Table 3: Effect of neonicotinoid insecticides on predatory coccinellids in cowpea during *summer*, 2013

Treatments	No. of coccinellids/plant (at indicated days after germination)					
	28	35	42	49	56	Pooled
T_1	*0.94(0.38)	1.02 (0.54)	1.08 (0.67)	1.01 (0.52)	0.91 (0.33)	0.99 (0.48)
T_2	0.93(0.36)	0.91 (0.33)	1.05 (0.60)	1.04 (0.58)	0.90 (0.31)	0.97 (0.44)
T_3	0.95(0.40)	0.93 (0.36)	1.02 (0.54)	0.94 (0.38)	0.95 (0.40)	0.96 (0.42)
T_4	0.91(0.33)	0.98 (0.46)	1.05 (0.60)	1.05 (0.60)	0.93 (0.36)	0.98 (0.46)
T_5	0.91(0.33)	0.90 (0.31)	1.01 (0.52)	1.04 (0.58)	0.94 (0.38)	0.96 (0.42)
T_6	0.90(0.31)	0.90 (0.31)	1.02 (0.54)	0.93 (0.36)	0.91 (0.33)	0.93 (0.36)
T_7	0.95(0.40)	1.05 (0.60)	1.11 (0.73)	0.98 (0.46)	0.95 (0.40)	1.01 (0.52)
T_8	0.97(0.44)	0.95 (0.40)	1.10 (0.71)	1.02 (0.54)	0.94 (0.38)	1.00 (0.50)
T_9	0.95(0.40)	0.96 (0.42)	1.08 (0.67)	0.98 (0.46)	0.87 (0.26)	0.97 (0.44)
T_{10}	1.05(0.60)	1.08 (0.67)	1.17 (0.87)	1.08 (0.67)	0.98 (0.46)	1.07 (0.64)
SEm ±						
T (Treatment)	0.07	0.08	0.07	0.07	0.06	0.03
P (Period)	-	-	-	-	-	0.02
T × P	-	-	-	-	-	0.08
CD at 5 %						
T	NS	NS	NS	NS	NS	NS
P	-	-	-	-	-	0.06
T × P	-	-	-	-	-	NS
CV (%)	13.10	13.94	12.11	11.91	11.61	12.56

*Figures are $\sqrt{x + 0.5}$ transformed values and those in parentheses are re-transformed values; NS: Non-significant

3 and 4). The data on coccinellids recorded during *summer* season revealed non-significant differences among the treatments in cowpea and green gram during weekly intervals. The pooled over periods data also gave non-significant results. However, relatively less number of coccinellids was recorded in neonicotinoid insecticide treatments (0.36 to 0.52 and 0.42 to 0.64 coccinellids per plant in cowpea and green gram respectively) than the untreated control (0.64 and 0.75 coccinellids per plant in cowpea and green gram respectively) in the pooled data. Data also indicated that the population of coccinellids was relatively low during *summer* compared to *kharif* season, as the activity of the coccinellid grubs was not noticed during *summer* season. The inactive adult coccinellids were found sheltering on the foliage and inflorescence of green gram and cowpea. This might be the reason for non-significant results in the pooled data as the adult beetles may have undergone dormancy or a state of arrested development to overcome the hot summer conditions.

DISCUSSION

The present study indicated that all the tested neonicotinoid insecticides were safer to the predatory coccinellids. Katole and Patil (2000) reported that imidacloprid and thiamethoxam as seed treatment and foliar spray was safer to the predatory coccinellids in cotton and the seed treatments recorded higher population of the predators as compared to foliar sprays, which is in conformity with the present results. The safer nature of neonicotinoid insecticides as seed treatment to the coccinellid predators in cotton have been reported by many earlier

Table 4: Effect of neonicotinoid insecticides on predatory coccinellids in green gram during *summer*, 2013

Treatments	No. of coccinellids/plant (at indicated days after germination)					
	28	35	42	49	56	Pooled
T_1	*0.97(0.44)	1.11(0.73)	1.13(0.78)	1.05(0.60)	0.95(0.40)	1.04(0.58)
T_2	0.98(0.46)	1.05(0.60)	1.08(0.67)	1.02(0.54)	0.98(0.46)	1.02(0.54)
T_3	0.98(0.46)	1.02(0.54)	1.07(0.64)	0.98(0.46)	0.91(0.33)	0.99(0.48)
T_4	0.95(0.40)	1.08(0.67)	1.11(0.73)	1.04(0.58)	0.94(0.38)	1.02(0.54)
T_5	0.94(0.38)	1.01(0.52)	1.05(0.60)	1.07(0.64)	0.93(0.36)	1.00(0.50)
T_6	0.93(0.36)	0.99(0.48)	1.05(0.60)	0.95(0.40)	0.89(0.29)	0.96(0.42)
T_7	1.01(0.52)	1.14(0.80)	1.14(0.80)	1.08(0.67)	0.97(0.44)	1.07(0.64)
T_8	1.01(0.52)	1.05(0.60)	1.11(0.73)	1.05(0.60)	0.98(0.46)	1.04(0.58)
T_9	1.02(0.54)	1.05(0.60)	1.13(0.78)	1.01(0.52)	0.95(0.40)	1.03(0.56)
T_{10}	1.10(0.71)	1.17(0.87)	1.20(0.94)	1.14(0.80)	1.02(0.54)	1.12(0.75)
SEm ±						
T	0.09	0.10	0.10	0.08	0.08	0.03
P	-	-	-	-	-	0.03
T × P	-	-	-	-	-	0.09
CD at 5 %						
T	NS	NS	NS	NS	NS	NS
P	-	-	-	-	-	0.08
T × P	-	-	-	-	-	NS
CV (%)	15.33	15.65	15.89	13.11	14.88	15.08

*Figures are $\sqrt{x+0.5}$ transformed values and those in parentheses are re-transformed values; NS: Non-significant

researchers like Vadodaria *et al.*, 2001 (imidacloprid and thiamethoxam) and Patel *et al.*, 2008 (imidacloprid) which also corroborates with the present findings.

According to Anitha (2007), imidacloprid and thiamethoxam was safer to the predatory coccinellids in okra and higher number of predatory coccinellids was found in seed treatment than the foliar sprays of these insecticides similar to the trend observed in the present study. Sitaramaraju *et al.* (2010) studied the effect of imidacloprid and thiamethoxam seed treatments on coccinellids in cotton and it was found that population of ladybird beetles was higher in untreated control and it was at par with thiamethoxam and imidacloprid which also support the present results.

The present results are also in line with Bharpoda *et al.* (2014) who reported that foliar spray with imidacloprid and thiamethoxam were safer to the coccinellids (grubs and adults) in cotton. Similarly, Bharani *et al.* (2015) reported that foliar spray with imidacloprid and thiamethoxam in tomato was safer to the predatory coccinellids, however highest number of coccinellids was recorded in the untreated control followed by the treatments of entomopathogenic fungi (*Verticillium lecanii* and *Beauveria bassiana*). These reports corroborate with the present results.

Satpute *et al.* (2002) observed the seed treatment with thiamethoxam and imidacloprid in cotton was not only safe but also attracted the population of coccinellids which support the present findings even though none of the tested insecticides were found to be attracting the predators. Similarly, Kannan *et al.* (2004) also reported that seed treatment of transgenic cotton with imidacloprid were safe and also attracted predatory coccinellids. Naranjo and Akey (2005) reported that the predator : prey ratios in cotton generally increased with the use of acetamiprid compared with the untreated control whereas in the present study, it was found that the population of the predators was lesser in the neonicotinoid insecticide treatments compared to the untreated control. The disagreement in the results may be due to the fact that various other predators were also included in their study in addition to the coccinellids.

On the other hand, Awasthi *et al.* (2013) reported that acetamiprid was the most toxic insecticide to the predatory coccinellids in cotton followed by imidacloprid among all the tested insecticides based on their LC_{50} values under laboratory conditions whereas in the present study, it was found that acetamiprid was relatively safer than imidacloprid. This discrepancy in the results might be due to the reason that the present study was carried out under field conditions.

From the above results, it can be concluded that neonicotinoid insecticides (imidacloprid, thiamethoxam and acetamiprid) as seed treatment alone and in combination with foliar spray for the management of sucking pests in cowpea and green gram crop are safer to predatory coccinellids even though these treatments have a slight adverse effect on the coccinellids particularly for combination treatments (seed treatment combined with one or two foliar sprays). These insecticides can be safely included in integrated pest management programmes in cowpea and green gram with respect to their safety to predatory coccinellids.

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