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EFFICACY OF AFIDOPYROPEN AGAINST TOBACCO APHID, MYZUS PERSICAE NICOTIANAE (BLACKMAN) AND IMPACT ON NATURAL ENEMIES IN TOBACCO

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Tobacco aphid, *Myzus persicae nicotianae* (Blackman) is an important insect pest of tobaccos in India. Studies were conducted on the efficacy of a new molecule afidopyropen and its impact on the natural enemies of tobacco aphid in flue cured Virginia (FCV) tobacco (*Nicotiana tabacum*) cv. Siri at ICAR-Central Tobacco Research Institute farm, Rajahmundry, India. Results showed that all the treatments recorded cent per cent mortality at 4 DAS except pymetrozine. Studies on persistent residual toxicity to the tobacco aphid showed that the period of persistency was the longest (28 days) and the persistent toxicity index (PTI) was the highest (2276.68) for afidopyropen 0.05%. Afidopyropen is also relatively safe to natural enemies *viz.*, *Cheilomenes sexmaculata, Coccinella repanda, Xanthogramma scutellaris* and *Nesidiocoris tenuis* compared to imidacloprid and flupyradifurone. Afidopyropen was found to be very efficient not only in terms of its efficacy but also in increasing cured leaf yield by 30 per cent over untreated check. It can be a promising alternative to the existing insecticides for the management of tobacco aphids in tobacco.

INTRODUCTION

Tobacco aphid, *Myzus persicae nicotianae* Blackman (Hemiptera: Aphididae) is one of the important pests of tobacco in India. *Myzus persicae nicotianae* was first described by Blackman (1987) as a species different from the green peach aphid, *Myzus persicae* Sulzer *sensu stricto*. The tobacco adapted form is considered to be a distinct subspecies and is known as the tobacco aphid, *M. persicae nicotianae* Blackman (Margaritopoulos *et al.*, 2000). This tobacco aphid exhibits morphometric (Blackman and Eastop, 2007) and genetic differences with respect to *M. persicae* sensu stricto (Margaritopoulos *et al.*, 2007). Relative preference of *M. p. nicotianae* to tobacco has been demonstrated experimentally (Troncoso *et al.*, 2005), that its capacity to detoxify and overcome allelochemicals from tobacco plants has been key to specialization (Cabrera-Brandt *et al.*, 2021). *M. nicotianae* is presumably isolated from *M. persicae* by being permanently parthenogenetic. Tobacco aphid causes significant loss to tobacco directly by sucking the sap and honeydew deposition on which sooty mold grows and indirectly by vectoring Cucumber Mosaic Virus (CMV) disease (Sreedhar, 2020) adversely affecting the quality of tobacco. Fny strain of CMV (Fny-CMV) induces aphid attraction to the infected plants by changes in the emission of plant volatile compounds, increase aphid density on the CMV infected plants, and also increase birth of winged aphids to promote virus transmission to distant hosts (Donnelly *et al.*, 2019). Tobacco aphid causes an avoidable loss of cured leaf and bright leaf to an extent of 125 kg and 70 kg/ha respectively (CTRI, 1993). Application of insecticides against the insect pests remains indispensable and economical to minimize the losses. As the pest appears late in the season repeated application of certain insecticides to control the pest may lead to the buildup of residues. Neo-nicotinoids, imidacloprid and thiamethoxam were found effective and are widely used for management of the aphid on tobacco since more than two decades (Rama Prasad *et al.*, 1998; Sreedhar and Krishnamurthy, 2007). Studies have indicated the possibility of development of resistance in aphid species to these insecticides (Harlow and Lampert, 1990; Srigiriraju *et al.*, 2010). Also, use of neo-nicotinoids has been reported to cause adverse ecological effects (Ghosh and Jung, 2017).

Key Words: Afidopyropen, bioefficacy, insecticides, *Myzus persicae nicotianae,* natural enemies, tobacco aphid

Resorting to non-pesticidal approaches such as augmentative release of natural enemies may prove ineffective against high densities of aphid populations (Rabasse and Van Steenis, 1999). Hence new pesticide molecules have to be evaluated and utilized to produce residue free tobacco. Therefore, there is an urgent need to find alternative molecules for the effective management of aphids. Afidopyropen, a novel insecticide, is a derivative of pyripyropene A, which is produced by the filamentous fungus *Penicillium coprobium* (Leichter *et al.*, 2013; Horikoshi *et al.*, 2022). It is a novel member of a group of insecticides known as chordotonal organ TRPV channel modulators and belongs to the chemical class- Pyropenes. The toxin binds to the target site, overstimulates and inactivates vanilloid-type transient pressure receptor channels in insects. The consequence of this activity is to inhibit sap-sucking ability to feed, resulting in starvation and death. Another insecticide Flupyradifurone is a new insecticide representing the novel butenolide class of insecticides, showing an excellent safety profile. The discovery of flupyradifurone was inspired by the butenolide scaffold in naturally occurring stemofoline a derivative from the plant *Stemona japonica* (Jeschke *et al.*, 2015). Flonicamid, a pyridine carboxamide compound with systemic as well as trans laminar activity rapidly inhibits the feeding behaviour of aphids, has a different mode of action to that of neo-nicotinoids and is reported to be relatively safe to the natural enemies (Morita *et al.*, 2007, Chinna Babu Naik *et al.*, 2017). Pymetrozine, a pyridine azomethine compound, blocks stylet penetration of aphids causing immediate cessation of feeding. It is having high degree of selectivity, low mammalian toxicity and safety to nontarget arthropods (Reber Sechser and Bourgeois, 2002). Sulfoxaflor represent a new class of insecticides sulfoximines classified for use against sap-feeding insects.It is an agonist at insect nicotinic acetylcholine receptors (nAChRs) and functions in a manner distinct from other insecticides acting at nAChRs (Zhu *et al.*, 2011). Thus, in view of the problems associated with sole reliance on imidacloprid and thiamethoxam for the management of aphids in tobacco, it is essential to evaluate the efficacy of new chemistry molecules with different modes of action and their impact on the natural enemies of aphid in Virginia tobacco.

MATERIALS AND METHODS

A replicated field experiment was conducted for two seasons in planted flue cured Virginia tobacco cv. Siri at the institute during 2018-20 to evaluate the efficacy of new molecule, afidopyropen 50 DC against tobacco aphid *M.p. nicotianae* at two doses *viz.*, 0.05% & 0.375% along with flupyradifurone 18.09 SL @ 0.026%, sulfaxaflor 21.8 SC @ 0.007%, flonicamid 50 WG @ 0.02% and pymetrozine 50 WG @ 0.02%. The experiment was laid out in randomized block design with 3 replications in plots measuring 5.6 X 4.9 m with a row to row and plant to plant distance of 70 cm. The treatments were imposed using the knapsack sprayer fitted with hollow cone nozzle. To maintain optimum level of aphid infestation, 5 plants per plot were infested with 100 aphids/ plant coinciding with the natural occurrence of aphids on tobacco. Observations on the aphid population were made on 5 plants from each plot following the method of Sreedhar *et al.* (1993) modified from Kalra and Gupta (1986). The number of aphids on a top, middle and bottom leaf of a plant pertains to a particular index (0-6).

Index	**Aphid Population**
0	0
1	1-50
2	51-250
3	251-500
4	501-1000
5	1001-2000
6	2001-3000

If the aphid population on 3 leaves of a plant, pertains to the indices say 0,1,2; then the upper and lower limits of each index would be summed and the resultant divided by 2. The corresponding aphid population on the three leaves of a plant would then be summed up to get the number of aphids per plant (0 + (1+50)/2 + (51+250)/2). The mean of aphid population from five plants would be considered as the Average aphid population per plot. Such observations on aphid population were recorded before spraying as well as 2, 4, 8 and 16 days after spray (DAS). Yield data on cured tobacco leaf, bright leaf and grade index were collected. The data on aphid population in different treatments and the yield data were subjected to statistical analysis of variance (ANOVA) as per Gomez and Gomez (1984).

Studies were conducted to understand the persistent residual toxicity of afidopyropen 50 DC 0.05% & 0.0375%, flupyradifurone 18.09 SL @ 0.026%, sulfoxaflor 21.8 SC @ 0.007%, flonicamid 50 WG @ 0.02% and pymetrozine 50 WG @ 0.02% against tobacco aphids. Fifty day old plants were sprayed with respective insecticides, hundred aphids were released on each plant and mortality was recorded at 24 hrs interval till the mortality dropped to zero. The persistent residual toxicity was determined by slightly modifying the method suggested by Pradhan (1967) and as used by Sreedhar *et al.* (1999) subsequently.

Observations on predator population were recorded on 5 randomly selected plants per plot on whole plant basis. The data on population count were used to work out per cent reduction in population over untreated control by using the following formula and the data were subjected to statistical analysis of variance (ANOVA).

untreated plot
– population in in
treatment
Per cent reduction
Population in
of predators = ____________________ X 100
100

RESULTS AND DISCUSSION

Bioefficacy of Afidopyropen

Afidopyropen, flupyradifurone, sulfoxaflor, flonicamid and pymetrozine recorded drastic reduction in the aphid population at 2 DAS. Afidopyropen 0.05% and flonicamid 0.02% recorded least aphid population (2.76) during 2018-19. Except pymetrozine (1.49), all the treatments recorded cent per cent mortality of aphids by 4 DAS. Similar results were obtained during the two seasons (Table 1). During 2019-20, at 2 DAS flupyradifurone 18.09 SL @ 0.026% recorded least aphid population (2.76) followed by afidopyropen 0.05% and flonicamid (3.06). However, all the treatments remained at par with each other and significantly superior to untreated control. All the treatments recorded cent per cent mortality at 4 DAS except pymetrozine (1.98). At 8 DAS pymetrozine also recorded cent per cent mortality. Vafaie and Grove (2018) observed rapid reduction in the number of aphids per plant by 3 DAT in an ornamental plant *Impatiens hawkeri*, which was treated with afidopyropen. Subsequently, Joseph (2020) recorded considerable mortality of *M. persicae* with afidopyropen on rose plants. Effectiveness of flupyradifurone (Saude *et al.*, 2018; Sreedhar, 2020), sulfoxaflor (Brittany *et al.*, 2019; Sreedhar, 2020), flonicamid (Sreedhar, 2020) and pymetrozine (Margaritopoulos *et al.*, 2010; Sreedhar, 2020) was reported against aphids on tobacco and various other crops.

Insecticide Persistent toxicity

Persistent toxicity values were higher for afidopyropen, sulfoxaflor and flupyradifurone (Table 2). All the treatments except pymetrozine recorded cent per cent mortality up to 16 days after treatment. The period of persistency was also longest (28 days) for afidopyropen 0.05%, whereas it was 26 days for afidopyropen 0.0375%, sulfoxaflor, flupyradifurone and flonicamid, and it was 24 days for pymetrozine. The persistent toxicity index (PTI) was the highest (2276.68) for afidopyropen 0.05%, followed by sulfoxaflor (2166.84) and flupyradifurone (2140.84). The order of persistency was afidopyropen 0.05% > sulfoxaflor > flupyradifurone > afidopyropen 0.0375% > flonicamid > pymetrozine.

Safety towards Natural enemies

Relative safety of the insecticides to the predators was evaluated on tobacco (Table 3). Results revealed that afidopyropen, sulfoxaflor, pymetrozine, flonicamid and thiamethoxam were relatively safe compared to imidacloprid and flupyradifurone to the predators *viz.*, *Cheilomenes sexmaculata*, *Coccinella repanda*, *Xanthogramma scutellaris* and *Nesidiocoris tenuis*. Among the treatments, the reduction in population of *C. sexmaculata* was highest (80.6%) in imidacloprid followed by flupyradifurone (40.8%) and thiamethoxam (52.6%) which was significantly high compared to sulfoxaflor (34.6%), afidopyropen (34.8%) pymetrozine (37.6%) and flonicamid

Table 1: Bioefficacy of afidopyropen 50 DC against tobacco aphids in FCV tobacco 2018-20

Treatment	Mean aphids/ plant									
	Prespray		2 DAS		4 DAS		8 DAS		16 DAS	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Afidopyropen 50 DC 0.05 %	1021.5	1113.2	2.76 (8.37)	3.58 (11.79)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Afidopyropen 50 DC 0.0375 %	1061.5	1061.5	3.06 (9.79)	3.06 (8.37)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Flupyradifurone 17.09 SL 0.026%	1004.8	1018.2	3.28 (9.79)	2.76 (6.63)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Sulfoxaflor 21.8 SC 0.007 %	1044.8	1021.5	3.06 (6.63)	3.28 (9.79)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Flonicamid 50 WG 0.02%	1083.2	1028.5	2.76 (8.37)	3.06 (8.37)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Pymetrozine 50 WG 0.02 %	1021.5	1083.2	3.58 (11.79)	3.81 (13.49)	1.49 (1.22)	1.98 (2.92)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)
Control	1028.1	1044.8	36.73 (1349)	35.40 (1251)	38.09 (1449)	38.95 (1516)	59.10 (3492)	50.22 (2520)	63.61 (4051)	63.20 (3993)
S.Em ±	72.7	60.1	0.60	0.65	0.50	0.44	0.82	0.87	0.71	0.74
CD (*p*=0.05)	NS	NS	1.85	1.99	1.52	1.34	2.52	2.69	2.18	2.26
CV%	12.22	9.89	12.16	14.29	12.34	11.56	14.39	18.89	12.45	12.90

Table 2: Persistent residual toxicity of afidopyropen against tobacco aphid, *Myzus nicotianae*

Treatment	Per cent mortality (DAT)									Period of Persistency (P)	Persistent Toxicity Index (PTI)
	4	8	16	20	22	24	26	28	30		
Afidopyropen 50 DC 0.05%	100	100	100	89.2	64.4	42.0	18.8	5.2	0	28	2276.68
Afidopyropen 50 DC 0.0375%	100	100	100	72.2	52.0	24.8	10.2	0	0	26	2138.0
Flupyradifurone 17.09 SL 0.026%	100	100	100	76.6	50.8	24.0	10.6	0	0	26	2140.84
Sulfoxaflor 21.8 SC 0.007%	100	100	100	80.4	56.0	26.2	12.0	0	0	26	2166.84
Flonicamid 50 WG 0.02%	100	100	100	70.2	40.0	16.8	4.4	0	0	26	2082.6
Pymetrozine 50 WG 0.02%	100	100	92.8	52.2	26.2	8.2	0	0	0	24	1950.00

Table 3: Relative toxicity of insecticides on the predators of *M.nicotianae*

Treatment	Per cent reduction of predators over control			
	C. Sexmaculata	***C.repanda***	***X. scutellarae***	***N.tenuis***
Afidopyropen 50 DC @ 0.0375%	34.8	40.2	30.8	32.8
Flupyradifurone17.09 SL 0.026%	40.8	50.2	40.2	36.6
Sulfoxaflor21.8 SC 0.02%	34.6	40.6	36.8	30.8
Flonicamid 50 WG 0.02%	40.0	44.6	38.4	32.2
Pymetrozine 50 WG 0.02%	37.6	38.4	26.8	28.4
Imidacloprid 17.8 SL 0.005%	80.6	78.8	76.8	60.6
Thiamethoxam 25 WG 0.005%	52.6	50.2	58.2	46.8
S.Em ±	1.5	1.6	1.2	2.2
CD (p=0.05)	4.2	4.4	3.4	6.4

(40.4%). As regards *C.repanda*, imidacloprid, flupyradifurone and thiamethoxam recorded higher reduction compared to others. In case of *X. scutellaris*, highest reduction of 76.8 per cent was recorded in imidacloprid followed by thiamethoxam (58.2%). The least reduction was observed in sulfoxaflor and pymetrozine (26.8%) followed by afidopyropen (30.8%) and flonicamid (38.4%). The reduction in *N.tenuis* population was also little in sulfoxaflor (24.6%) followed by pymetrozine (28.4%) afidopyropen (30.0%) and flonicamid (30.8%). Similarly, Koch *et al.* (2019) observed that afidopyropen was non-toxic to adults or third instars of the coccinellid predator, *Hippodamia convergens*, while evaluating bioefficacy against *Aphis glycines* (Matsumura) in soybean. Horikoshi *et al.* (2022) reported that afidopyropen mitigates population of aphids, whiteflies without affecting non target organisms, such as honeybees, natural enemies and other beneficial insects.

Effect on Tobacco Yield parameters

As indicated in Table 4, during the first season afidopyropen @ 0.05% recorded highest cured leaf yield of 2450 kg/ha by 30% over control, followed by flupyradifurone with 2446 kg/ha (29% higher yield over control), afidopyropen @ 0.0375% (2440 kg/ha) and flonicamid (2436 kg/ ha). Similarly bright leaf yield was higher for afidopyropen (1290 kg/ha), flupyradifurone (1280), and flonicamid (1266) respectively. Grade indices with afidopyropen, flupyradifurone and flonicamid were 1516, 1510 and 1490 respectively. During the second season 2019-20 also, afidopyropen @ 0.05% recorded highest cured leaf yield of 2020 kg/ha, followed by flupyradifurone (2015 kg/ha), afidopyropen @ 0.0375 (2010 kg/ha) and (flonicamid 2005 kg/ha), compared to untreated check (1790 kg/ha). The selectivity of afidopyropen, sulfoxaflor, pymetrozine and flonicamid will be useful in conservation of native natural enemies of aphid. Based on the field efficacy, persistent toxicity studies, relative safety to the native predators in tobacco ecosystem and the yield parameters, afidopyropen 50 DC could be a promising insecticide when used at 0.05% to manage tobacco aphid.

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Table 4: Efficacy of afidopyropen 50 DC on tobacco yield parameters 2018-20

Treatment	Yield Parameters					
	Cured leaf		Bright leaf		Grade Index	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
Afidopyropen 50 DC 0.05%	2450	2020	1290	1110	1516	1700
Afidopyropen 50 DC 0.0375%	2440	2010	1276	1100	1494	1690
Flupyradifurone17.09 SL 0.026%	2446	2015	1280	1104	1510	1694
Sulfoxaflor21.8 SC 0.007%	2430	1996	1260	1080	1480	1650
Flonicamid 50 WG 0.02%	2436	2005	1266	1095	1490	1670
Pymetrozine 50 WG 0.02%	2320	1900	1220	990	1430	1600
Control (untreated)	1890	1790	840	700	1020	1200
S.Em ±	90	80	76	51	98	76
CD (p=0.05)	274	246	240	156	299	220

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