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Effectiveness of novel insecticides against pink mealybug *Maconellicoccus hirsutus* Green on mulberry

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Abstract
Five novel insecticides along with dichlorvos as standard check were evaluated against pink mealybug, *Maconellicoccus hirsutus* (Green) under field conditions. The treatment dinotefuran 20 SG @ 0.25 g/l recorded the highest mealybug mortality at both 7 DAS (78.78 %) and 15 DAS (99.44 %) owing to its unique mode of action. Phytotoxicity symptoms assessed on mulberry revealed that all the insecticides except flonicamid 50 WG (0.15 and 0.3 g/l) had no phytotoxic effect on mulberry plants at both 7 and 15 DAS. Among the insecticides tested, dinotefuran 20 SG @ 0.12 g/l and azadirachtin 1 % @ 1 ml/l recorded maximum coccinellid beetle population per plant at 7 and15 DAS. Along with the effective management of mealybugs owing to lesser phytotoxicity, dinotefuran 20 SG @ 0.25 g/l also recorded higher leaf yield of 4,545.68 kg/ha/crop. Lowest leaf yield was recorded in flonicamid 50 WG @ 0.3 g/l (2,879.24 kg/ha/crop) due to phytotoxic symptoms at 15 DAS coinciding with the mulberry leaf harvest.

Keywords: Novel insecticides, *maconellicoccus hirsutus*, mulberry phytotoxicity

Introduction
Mulberry (*Morus alba* L.) foliage is the only food for the silkworm, *Bombyx mori* L. (Lepidoptera: Bombycidae). Many sucking pests cause damage to mulberry among which, pink mealybug causes severe damage leading to significant loss in mulberry leaf yield (12-25 %) by sucking the sap from vascular tissues cause depletion in nutritive value of mulberry [11]. Mealybugs are often referred to as "hard to kill" insects and are soft, small bodied sap feeders that constitute the second largest family of scale insects (Hemiptera: Coccoidea), with more than 2,000 described species [3]. Mealybug incidence caused an estimated loss in leaf yield of 4500 kg /ha /yr amounting to 34.24 per cent, thus depriving the farmer from rearing about 450 dfls /ha /yr (10-15 %) [9].
Among the insecticides used to manage the mealybugs, dichlorvos 76 EC (DDVP) is one of the oldest chemical molecule which is being predominantly used in sericulture. Being a contact and fumigant poison it is most effective on insects with biting and chewing mouth parts, but mealybug being a sucking pest, its mortality is due to the fumigant action only [8]. Dichlorvos is an excessive insecticide which has been notified for ban from import and manufacture with effective from January 2019 and complete ban from usage on all crops with effective from December 2020 [2]. Therefore, it is important to find molecules alternative to notified to be banned dichlorvos. Keeping these views in mind, the present investigation was carried out where five novel insecticides *viz*., buprofezin 25 SC, pymetrozine 50 WG, flonicamid 50 WG, dinotefuran 20 SG and azadirachtin 1% along with dichlorvos 76 EC as standard check in different dilution concentrations were evaluated against pink mealybug under field conditions.

Materials and methods
a) Experimental layout
The experiment was conducted at the Department of Sericulture, UAS, GKVK, Bengaluru with well-established mulberry garden of V_1 variety. The experiment was laid out in Randomized Block Design with 13 treatments, each replicated three times.

b) Treatment details
Insecticides like buprofezin 25 SC @ (1 ml/l and 2 ml/l), pymetrozine 50 WG @ (0.3 g/l and 0.6 g/l), flonicamid 50 WG @ (0.15 g/l and 0.3 g/l), dinotefuran 20 SG @

(0.12 g/l and 0.25 g/l), azadirachtin 1% @ (1 ml/l and 2 ml/l), dichlorvos 76 EC @ (1.32 ml/l and 2.63 ml/l) and untreated control were sprayed on the mulberry plants and care was taken by holding a polythene cover along the treated plants while spraying to ensure that there was no drifting of chemicals due to wind. Mealybugs were artificially inoculated to the mulberry plants 15 days after pruning by camel hair brush.

c) Observations

Pre treatment count on 35th days after pruning and Post treatment count of mealybugs in the treated mulberry garden was taken to find out the mortality of mealybugs on 7th and 15th day after the spray on five plants per replication. Mealybug mortality and per cent reduction over control was calculated by following Henderson and Tilton formulae [6].

$$\text{Mortality of bugs (\%)} = \frac{\text{Population at pre count} - \text{Population after spray}}{\text{Population at pre count}} \times 100$$

$$\text{Protection over control (\%)} = \frac{\text{Population in control} - \text{Population after spray}}{\text{Population in the control}} \times 100$$

Phytotoxic symptoms like leaf injury on tips or surface, wilting of the plants, vein clearing or discolouration on the leaves, necrosis, epinasty and hyponasty were taken into consideration and observations were made on these symptoms on 7th and 15th DAS of insecticides. These symptoms were recorded based on the standard scoring method with 0-10 scale. The most predominantly found natural enemy of pink mealybug found in the mulberry ecosystem is *Cryptolaemus montrouzieri*, whose population was recorded before and after application of chemicals, in order to understand the impact of spraying insecticides on their population. Pre-treatment count was recorded prior to spraying and post treatment counts were recorded on 7th and 15th day after the spraying of insecticides. Coccinellid population preferably *C. montrouzieri* was counted with the help of magnifying hand lens on five plants in each of replication. Mulberry leaf yield was recorded in each replication to estimate the yield difference across treatments as a result of application of insecticides. Five plants which were maintained for recording the observations were harvested on 45 days after pruning. The leaves were picked manually and the weight of leaves harvested in each plot were recorded.

Plate 1: Spray of insecticides on mealybug infested mulberry plants

Results and discussion

Mealybug mortality (%)

The post-treatment count on 7 DAS recorded significantly highest mealybug mortality of 78.78 per cent in the treatment dinotefuran 20 SG @ 0.25 g/l. This was followed by the insecticide azardirachtin 1 % @ 2ml/l (72.34 %), dichlorvos 76 EC @ 2.63 ml/l (72.04 %), pymetrozine 50 WG @ 0.6 g/l (71.39 %), dinotefuran 20 SG @ 0.12 g/l (70.99 %), buprofezin 25 SC @ 1 ml/l (70.78 %), flonicamid 50 WG @ 0.3 g/l (70.59 %) and dichlorvos 76 EC @ 1.32 ml/l (69.41 %) which were statistically on par with each other. Buprofezin 25 SC @ 2 ml/l (66.44 %) and pymetrozine 50 WG @ 0.3 g/l (66.05 %) recorded on par values for mealybug mortality. Significantly lowest mealybug mortality among the insecticides treated on the 7 DAS was recorded in the treatment flonicamid 50 WG @ 0.15 g/l of about 56.60 per cent. At 15 DAS, there was significant difference between the treatment where dinotefuran 20 SG @ 0.25 g/l exhibited highest mealybug mortality (99.44 %) which was statistically on par with dichlorvos 76 EC @ 2.63 ml/l (98.94 %) and azardirachtin 1% @ 2 ml/l (97.71 %). Whereas flonicamid 50 WG @ 0.15 g/l exhibited the lowest mealybug mortality (82.75 %) (Table 1 and Fig.1)

Most of the insecticides assessed were found effective on mealybugs. Among the treatments dinotefuran 20 SG @ 0.25 g/l recorded the highest mealybug mortality at both 7 DAS (78.78 %) and 15 DAS (99.44 %) (Table 1 and Fig.1). This was followed by the same insecticide dinotefuran 20 SG applied at lower concentration of @ 0.12 g/l recording 70.99 per cent mortality at 7 DAS and 96.25 per cent at 15 DAS. dinotefuran 20 SG is a third generation neonicotinoid with strong systemic and translaminar action. Upon ingestion, it acts on the nervous system of the insect and disrupts the normal functioning of nervous system by mimicking the functions of acetylcholine. This molecule is known to be effective on multiple sucking insects in addition to mealybugs feeding on crops. These results are in conformity with the findings[5], where field experiment conducted for evaluation of dinotefuran at 15, 20, 25 and 30 g a i. per ha, along with imidacloprid at 25 g a.i. per ha, acephate at 400 g a.i. / ha against brown plant hopper of rice suggested that, dinotefuran 25 g a.i. per ha was found effective against brown plant hopper compared to other insecticides.

Table 1: Efficacy of novel insecticides on mealybug mortality (%) in mulberry field condition

Treatments		Mealybug mortality (%)	
		7 DAS	15 DAS
T_1	Buprofezin 25 SC @ 1ml/l	70.78^{b}	95.84^{bc}
T_2	Buprofezin 25 SC @ 2 ml/l	66.44^{cd}	92.58^{de}
T_3	Pymetrozine 50 WG @ 0.3 g/l	66.05^{cd}	93.57^{d}
T_4	Pymetrozine 50 WG @ 0.6 g/l	71.39^{b}	96.36^{bd}
T_5	Flonicamid 50 WG @ 0.15 g/l	56.60^{e}	82.75^{f}
T_6	Flonicamid 50 WG @ 0.3 g/l	70.59^{b}	95.85^{bc}
T_7	Dinotefuran 20 SG @ 0.12 g/l	70.99^{b}	96.25^{bc}
T_8	Dinotefuran 20 SG @ 0.25 g/l	78.78^{a}	99.44^{a}
T_9	Azadirachtin 1 % @ 1 ml/l	63.34^{d}	90.71^{e}
T_{10}	Azadirachtin 1 % @ 2 ml/l	72.34^{b}	97.71^{ab}
T_{11}	Dichlorvos 76 EC @ 1.32 ml/l	69.41^{bc}	94.83^{cd}
T_{12}	Dichlorvos 76 EC @ 2.63 ml/l (std. check)	72.04^{b}	98.94^{a}
T_{13}	Untreated control	0.00^{f}	0.00^{g}
F-test		*	*
SE.m ±		1.365	0.808
CD at 5 %		3.984	2.183

*Significant at 5 %, DAS- Days after spraying.

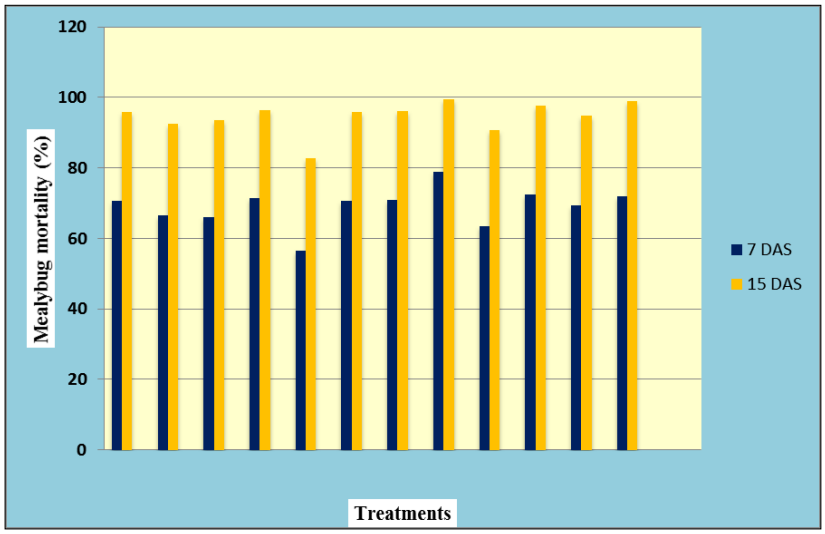

Fig 1: Effect of insecticides on mealybug mortality (%) in field on 7 DAS and 15 DAS

T_1- Buprofezin 25 SC @ 1ml/l
T_2- Buprofezin 25 SC @ 2 ml/l
T_3- Pymetrozine 50 WG @ 0.3 g/l
T_4- Pymetrozine 50 WG @ 0.6 g/l
T_5- Flonicamid 50 WG @ 0.15 g/l
T_6- Flonicamid 50 WG @ 0.3 g/l
T_7- Dinotefuran 20 SG @ 0.12 g/l
T_8- Dinotefuran 20 SG @ 0.25 g/l
T_9- Azadirachtin 1 % @ 1 ml/l
T_{10}- Azadirachtin 1 % @ 2 ml/l
T_{11}- Dichlorovas 76 EC @ 1.32 ml/l
T_{12}- Dichlorovas 76 EC @ 2.63 ml/l
T_{13}- Untreated control
DAS- Days after spraying

Phytotoxicity

The death of leaf tissue *i.e.*, necrosis was observed on the mulberry leaves treated with flonicamid 50 WG @ 0.3 g/l about 0.67 which was followed by flonicamid 50 WG @ 0.15 g/l about 0.13 on 7 DAS (Table 2). Remaining insecticides did not exhibit any per cent necrosis symptoms. On 15 DAS flonicamid 50 WG @ 0.3 g/l recorded highest necrotic symptoms on mulberry leaf of about 7.60 and which was followed by flonicamid 50 WG @ 0.15 g/l which exhibited necrosis of about 4.87 (Fig.2). The rest of the chemicals did not exhibit any necrosis on the mulberry leaves. Epinastic symptoms on mulberry leaf were observed on the plants treated with flonicamid 50 WG @ 0.3 g/l (0.93) and it was followed by flonicamid 50 WG @ 0.15 g/l (0.13) after 7 days of spraying (Fig. 3). On the 15th day of spraying of the insecticide, highest epinastic symptoms was observed in the leaves treated with flonicamid 50 WG @ 0.3 g/l (2.07) and it was followed by flonicamid 50 WG @ 0.15 g/l (0.73). Rest of the insecticides showed zero per cent epinasty on both 7th and 15th day after spray of insecticides proving them to be safe to mulberry (Table 2).

The results demonstrated that all the insecticides except flonicamid 50 WG had no phytotoxic effect on mulberry plants at both 7 DAS and 15 DAS. Flonicamid 50 WG exhibited only necrosis and epinastic symptoms and did not show other symptoms such as leaf injury on tip or surfaces, wilting, vein clearing and hyponasty. These observed results suggest that though flonicamid is effective on mealybugs, it may not be suitable for application on mulberry plant owing to its phytotoxicity. Dinotefuran 20% SG @ 300 ml and 350 ml / ha was applied on tea bushes against tea mosquito bug, *Helopeltis theivora* (Heteroptera: Miridae), it did not produce any phytotoxic symptom on the tea bushes [7].

Table 2: Efficacy of insecticides on phytotoxicity on mulberry under field condition

Treatments		Phytotoxicity (Scoring method)[#]			
		Necrosis		Epinasty	
		7 DAS	15 DAS	7 DAS	15 DAS
T_1	Buprofezin 25 SC @ 1ml/l	0.00	0.00	0.00	0.00
T_2	Buprofezin 25 SC @ 2 ml/l	0.00	0.00	0.00	0.00
T_3	Pymetrozine 50 WG @ 0.3 g/l	0.00	0.00	0.00	0.00
T_4	Pymetrozine 50 WG @ 0.6 g/l	0.00	0.00	0.00	0.00
T_5	Flonicamid 50 WG @ 0.15 g/l	0.13	4.87	0.13	0.73
T_6	Flonicamid 50 WG @ 0.3 g/l	0.67	7.60	0.93	2.07
T_7	Dinotefuran 20 SG @ 0.12 g/l	0.00	0.00	0.00	0.00
T_8	Dinotefuran 20 SG @ 0.25 g/l	0.00	0.00	0.00	0.00
T_9	Azadirachtin 1 % @ 1 ml/l	0.00	0.00	0.00	0.00
T_{10}	Azadirachtin 1 % @ 2 ml/l	0.00	0.00	0.00	0.00
T_{11}	Dichlorovas 76 EC @ 1.32 ml/l	0.00	0.00	0.00	0.00
T_{12}	Dichlorovas 76 EC @ 2.63 ml/l (std. check)	0.00	0.00	0.00	0.00
T_{13}	Untreated control	0.00	0.00	0.00	0.00
	F-test	*	*	*	*
	SE.m ±	0.019	0.272	0.029	0.045
	CD at 5 %	0.055	0.780	0.082	0.128

*Significant at 5 %, DAS- Days after spraying.
[#] scoring: 0= none, 1=0-10%, 2= 11-20%; 3=21-30%; 4=31-40%; 5=41-50%; 6=51-60%; 7= 61-70%; 8= 71-80%; 9= 81-90%; 10=91-100%.

Plate 2: Phytotoxicity symptoms exhibited by flonicamid 50 WG @ 0.3 g/l on 7 DAS on mulberry

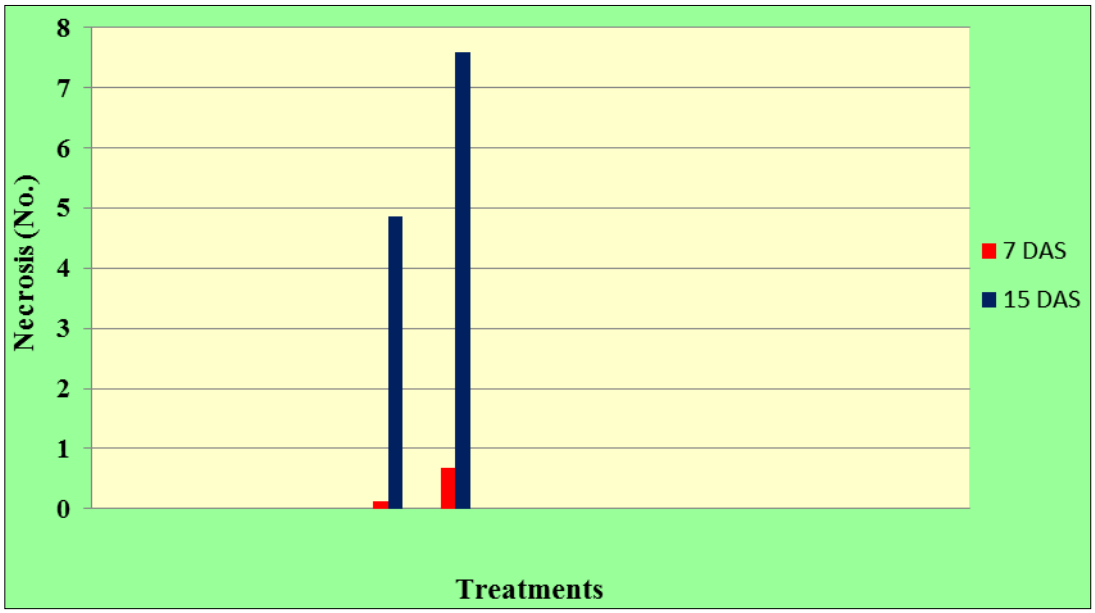

Fig 2: Phytotoxicity (necrosis) on insecticide treated mulberry plants on 7 DAS and 15 DAS

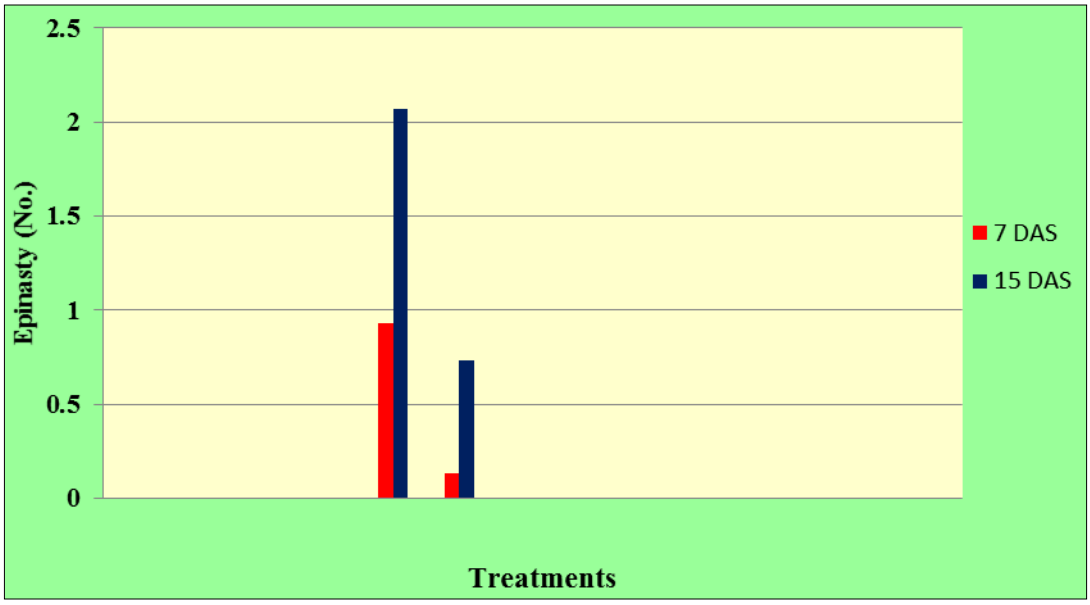

Fig 3: Phytotoxicity (epinasty) on insecticide treated mulberry plants on 7 DAS and 15 DAS

T_1- Buprofezin 25 SC @ 1ml/l
T_2- Buprofezin 25 SC @ 2 ml/l
T_3- Pymetrozine 50 WG @ 0.3 g/l
T_4- Pymetrozine 50 WG @ 0.6 g/l
T_5- Flonicamid 50 WG @ 0.15 g/l
T_6- Flonicamid 50 WG @ 0.3 g/l
T_7- Dinotefuran 20 SG @ 0.12 g/l
T_8- Dinotefuran 20 SG @ 0.25 g/l
T_9- Azadirachtin 1 % @ 1 ml/l
T_{10}- Azadirachtin 1 % @ 2 ml/l
T_{11}- Dichlorovas 76 EC @ 1.32 ml/l
T_{12}- Dichlorovas 76 EC @ 2.63 ml/l
T_{13}- Untreated control
DAS- Days after spraying

Effect of spraying insecticides on natural enemies of mealybugs

The major natural enemy of mealybug that was observed in the mulberry field was *Cryptolaemus montrouzieri* which belong to the family coccinellidae and come under the order coleoptera. Pre and post treatment count of the coccinnellid beetle was recorded from 5 plants per replication and values were averaged.

Among the treatments flonicamid 50 WG @ 0.3 g/l showed none *i.e.*, zero coccinellid population per plant both in 7 and 15 DAS (Table 3). In the untreated control the coccinellid population was found highest in both 7th (6.67 /plant) and 15th (7 /plant) day after spraying. On 7 DAS of insecticides dinotefuran 20 SG @ 0.12 g/l and azadiractin 1 % @ 1 ml/l recorded higher *C. montrouzieri* population (3.67 /plant) which was on par with dinotefuran 20 SG @ 0.25 g/l (3.33 /plant), dinotefuran 20 SG @ 0.12 g/l (3.67 /plant), buprofezin 25 SG @ 1 ml/l (3.33 /plant) and pymetrozine 50 WG @ 0.6 g/l which exhibited the coccinellid population of 2.67 per plant. Among the insecticide treatment on 15 DAS pymetrozine 50 WG @ 0.6 g/l recorded highest coccinellid population of 4.67 per plant, which was statistically on par with dinotefuran 20 SG @ 0.25 g/l and azardirachtin 1 % @ 1 ml/l which exhibited coccinellid population of 4 per plant, buprofezin 25 SC @ 1 ml/l (3.67 /plant), dichlorvos 76 EC @ 2.63 ml/l (3.33 /plant) and dinotefuran 20 SG @ 0.12 g/l (3 /plant) (Table 3 and Fig. 4).

Flonicamid is known to act on insects also as a repellant along with its action on stylet penetrations. The observed results suggested that flonicamid insecticide adversely affected the coccinellid beetles at both recommended and lower concentrations. As coccinellid beetle is a biting and chewing type of insect, and flonicamid acts on stylets, the observed effect on beetles could be due to repellant action. Another selective homopteron feeding blocker, pymetrozine 50 WG recorded highest coccinellid beetle population along with dinotefuran at the recommended doses. Pymetrozine chemical does not possess repellant action as seen in case of flonicamid. Therefore, it appears that there is no significant direct action of these two chemicals on coccinellid beetles and the observed low coccinellid beetle population in flonicamid could be due to repellency action. Similarly, [4] the flonicamid exhibited small amount of repellency which affected the population of coccinellids in Bt cotton ecosystem. Pymetrozine represents an insecticide type that has been confirmed as having reduced impacts on non-target and beneficial insects on crops which is very much essential in the case of mulberry [10].

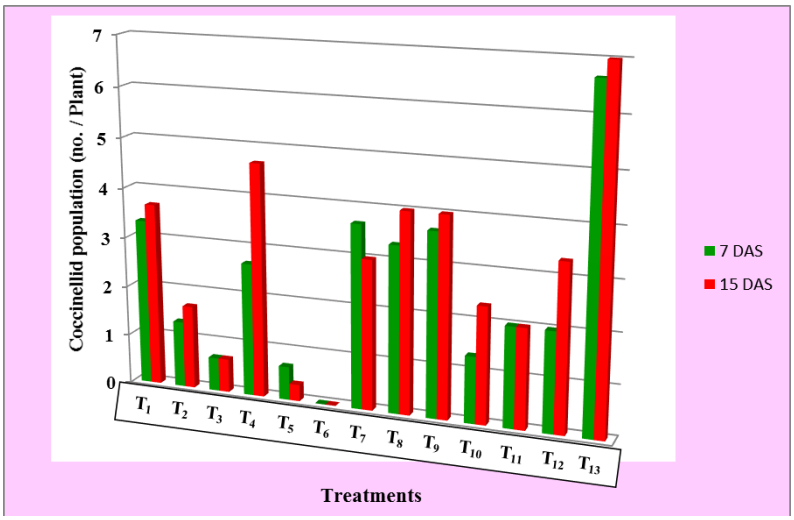

Fig 4: Coccinellid population on insecticide treated mulberry plants on 7 DAS and 15 DAS

T_1- Buprofezin 25 SC @ 1ml/l
T_2- Buprofezin 25 SC @ 2 ml/l
T_3- Pymetrozine 50 WG @ 0.3 g/l
T_4- Pymetrozine 50 WG @ 0.6 g/l
T_5- Flonicamid 50 WG @ 0.15 g/l
T_6- Flonicamid 50 WG @ 0.3 g/l
T_7- Dinotefuran 20 SG @ 0.12 g/l
T_8- Dinotefuran 20 SG @ 0.25 g/l
T_9- Azadirachtin 1 % @ 1 ml/l
T_{10}- Azadirachtin 1 % @ 2 ml/l
T_{11}- Dichlorovas 76 EC @ 1.32 ml/l
T_{12}- Dichlorovas 76 EC @ 2.63 ml/l
T_{13}- Untreated control
DAS- Days after spraying

Effect of application of insecticides on mulberry leaf yield (kg/ ha/ crop)

Mulberry leaf yield was recorded on 45th day after pruning, the highest leaf yield was recorded in the treatment dinotefuran 20 SG @ 0.25 g/l (4,545.43 kg/ha/crop) which was statistically on par with the mulberry leaf yield of the treatments dichlorvos 76 EC @ 2.63 ml/l (4,536.42 kg/ha/crop), azadirachtin 1 % @ 2 ml/l (4,486.43 kg/ha/crop), pymetrozine 50 WG @ 0.6 g/l (4,388.29 kg/ha/crop), dinotefuran 20 SG @ 0.12 g/l (4,351.26 kg/ha/crop), buprofezin 25 SC @ 1 ml/l (4,267.94 kg/ha/crop), flonicamid 50 WG @ 0.15 g/l (4,203.13 kg/ha/crop) and dichlorvos 76 EC @ 1.32 ml/l (4,129.07 kg/ha/crop). The least leaf yield was recorded in the treatment flonicamid 50 WG @ 0.3 g/l (2,879.24 kg/ha/crop) which was on par with buprofezin 25 SC @ 2 ml/l (3416.20 kg/ha/crop), azadirachtin 1 % @ 1 ml/l (3147.72 kg/ha/crop) and untreated control (2,684.82 kg/ha/crop).

Among the insecticide treated plants, the highest leaf yield was recorded in the treatment dinotefuran 20 SG @ 0.25 g/l (4,545.68 kg/ha/crop). Spraying of dinotefuran 20 SG @ 0.25 g/l resulted in significant reduction in mealybug population when recorded both at 7 DAS and 15 DAS. Therefore, maximum yield in this treatment was recorded due to effective control of mealybugs. On the contrary, lowest leaf yield was recorded in the treatment flonicamid 50WG @ 0.3 g/l (2,879.24 kg/ha/crop). Though, this chemical gave effective control of mealybugs, it was also found to be phytotoxic on plants. The untreated control also recorded lowest yield of 2684 kg/ha/crop along with insecticide, flonicamid 50 WG@0.3g/l. When no sprays were given in untreated control treatment, the mealybug population increased over a period of time and the maximum mealybugs population was recorded at 15 days after imposition of treatments. Due to severe incidence of mealybug infestation, tukra incidence in this treatment was very prominent. And the lowest mulberry leaf yield in an untreated control treatment is attributed to this reason.

Table 3: Efficacy of insecticides on natural enemy (coccinellid) population and leaf yield of mulberry (V_1)

Treatments		Coccinellid population (No./plant)		Leaf yield per plants (kg/ha/crop)
		7 DAS	15 DAS	
T_1	Buprofezin 25 SC @ 1ml/l	3.33^{bc}	3.67^{bcd}	4267.94^{ab}
T_2	Buprofezin 25 SC @ 2 ml/l	1.33^{def}	1.67^{efgh}	3416.20^{cd}
T_3	Pymetrozine 50 WG @ 0.3 g/l	0.67^{ef}	0.67^{fgh}	3656.91^{bc}
T_4	Pymetrozine 50 WG @ 0.6 g/l	2.67^{bcd}	4.67^{b}	4388.29^{a}
T_5	Flonicamid 50 WG @ 0.15 g/l	0.67^{ef}	0.33^{gh}	4203.13^{ab}
T_6	Flonicamid 50 WG @ 0.3 g/l	0.00^{f}	0.00^{h}	2879.24^{de}
T_7	Dinotefuran 20 SG @ 0.12 g/l	3.67^{b}	3.00^{bcde}	4351.26^{a}
T_8	Dinotefuran 20 SG @ 0.25 g/l	3.33^{bc}	4.00^{bc}	4545.68^{a}
T_9	Azadirachtin 1 % @ 1 ml/l	3.67^{b}	4.00^{bc}	3147.72^{cde}
T_{10}	Azadirachtin 1 % @ 2 ml/l	1.33^{def}	2.33^{cdef}	4486.43^{a}
T_{11}	Dichlorvos 76 EC @ 1.32 ml/l	2.00^{cde}	2.00^{defg}	4129.07^{ab}
T_{12}	Dichlorvos 76 EC @ 2.63 ml/l (std. check)	2.00^{cde}	3.33^{bcde}	4536.42^{a}
T_{13}	Untreated control	6.67^{a}	7.00^{a}	2684.82^{e}
F-test		*	*	*
SE.m ±		0.460	0.617	220.770
CD at 5 %		1.342	1.800	644.383

*Significant at 5 %, DAS- Days after spraying

Conclusion

The selected insecticides were sprayed at two different concentrations on mulberry plants infested with mealybug among which the treatment dinotefuran 20 SG @ 0.25 g/l recorded the highest mealybug mortality at both 7 DAS (78.78 %) and 15 DAS (99.44 %) owing to its unique mode of action. Phytotoxicity symptoms assessed on mulberry revealed that all the insecticides except flonicamid 50 WG (0.15 and 0.3 g/l) had no phytotoxic effect on mulberry plants at both 7 DAS and 15 DAS. Though flonicamid is effective on mealybugs, it may not be suitable for application on mulberry plant owing to its phytotoxicity. Safety to major natural enemies of pink mealybug on mulberry was assessed and highest coccinellid beetle population was recorded on untreated plants both during 7 DAS and 15 DAS. Among the insecticides tested, dinotefuran 20 SG @ 0.12 g/l and azadirachtin 1 % @ 1 ml/l recorded maximum coccinellid beetle population per plant at 7 DAS and15 DAS. Lowest coccinellid beetle population was reported by 0.15 g /l of flonicamid 50 WG both at 7 DAS due to its repellency action on insects. Along with the effective management of mealybugs owing to lesser phytotoxicity, dinotefuran 20 SG @ 0.25 g/l recorded higher leaf yield of 4,545.68 kg/ha/crop. On the contrary lowest leaf yield was recorded in the treatment flonicamid 50WG @ 0.3 g/l (2,879.24 kg/ha/crop) due to phytotoxic symptoms which were more conspicuous and prominent at 15 DAS coinciding with the mulberry leaf harvest.

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