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Bioefficacy of a combiprodut Diafenthiuron 30% + Pyriproxyfen 8% SE against whitefly and its safety to natural enemies in cotton

SV Hugar, KP Gundannavar and SS Udikeri

Abstract

Field experiments were conducted at Agricultural Research Station, Dharwad Farm, Dharwad, Karnataka during *Kharif*, 2016 and 2017 on the evaluation of a combi product Diafenthiuron 30% + Pyriproxyfen 8% SE efficacy against whiteflies on cotton. The pooled data of two seasons as impact of three sprays revealed 89.00 per cent reduction in Diafenthiuron 30%+Pyriproxyfen 8% SE @ 1200ml/ha treatment followed by at 1000 ml/ha (85.20%), 800ml/ha (73.03%), Pyriproxifen 10% EC @ 100 ml/ha (65.75), Diafenthiuron 50 WP @ 600g/ha (63.09). The reduction was least with Diafenthiuron 30%+Pyriproxyfen 8% SE @ 600ml/ha (56.69). Similarly per cent reduction of white fly nymphs was observed with 81.30, 78.15, 65.32, 58.42, 55.67 and 54.02%, respectively. Per cent increase in yield over check (no protection) was also highest in Diafenthiuron 30% + Pyriproxyfen 8% SE @1200ml/ha (41.42%) followed by at 1000ml/ha (40.43%) and at 800ml/ha (28.98%), but net incremental cost benefit ratio was highest in Diafenthiuron 30% + Pyriproxyfen 8% SE at 1000ml/ha (1:2.03) followed by at 1200ml/ha (1:1.64) and at 800ml/ha (1:1.33). Hence, Diafenthiuron 30%+Pyriproxyfen 8% SE at 1000ml/ha could be used for the management of whiteflies without any phytotoxic effect on plants There was no significant difference between the untreated check and the test chemicals on the grubs and adults of coccinellids (2.15 to 2.80 per plant), number of chrysoperla (2.45 to 2.87 per plant) and per cent parasitization of whitefly nymphs by *Encarsia* spp. (21.60% to 23.08%). Under changing incidence pattern of insect pests, whitefly management with Diafenthiuron 30% + Pyriproxyfen 8% SE chemical would be quite ideal without compromise on natural control.

Keywords: Diafenthiuron, pyriproxyfen, whitefly, *Bemisia tabaci* cotton

Introduction

Cotton is the major fibre crop grown in India and plays a dominant role in agricultural and industrial sectors. Cotton contributes 70% of total fibre consumption in textile sector and 38% of the country's export, fetches over 42,000 crore ^[1]. The area and production of cotton during the year 2018-19 was 12 million ha and 362 lakh bales (170 kg of each bale), respectively ^[1]. During its growth period cotton is infested by around 148 insect pests, out of which 17 species are of major concern ^[2]. Among these insects, whitefly, *Bemisia tabaci* Gennadius (Hemiptera: Aleyrodidae), occupies a significant place and caused severe damage to the cotton crop. Whitefly is a complex cryptic species and destructive insect pest which is reported to attack and damage about 600 plant species ^[3]. Whitefly cause damage directly by feeding on plants phloem sap and also transmits plant viruses ^[4]. Honeydew secreted by them promotes the growth of fungi like sooty mold on fruits, flowers and other economically important plant parts which reduces their market value. Sooty mold on leaves inhibits photosynthesis and reduces the crop yield ^[4]. Whitefly feeding results in symptoms like chlorosis, withering and premature dropping of leaves and sometimes plant's death. Whiteflies transmitted plant viruses are responsible for over 40 diseases of important crops plants worldwide resulting in yield loss ranging from 10 to 100% which depends upon the factors like type of the crop, growing season, and abundance of the whiteflies ^[5].

To manage this insect pest various methods like cultural, mechanical, physical, biological and chemical are used as components of integrated pest management. Among them, the chemical control is most popular weapon for quicker results. For the management of whitefly a number or insecticides of different groups have been used. However, due to high pest incidence levels, the cotton crop is subjected to increased pesticide applications, which have detrimental effects on the existing parasitic and predatory fauna ^[6].

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The chances of resistance problem increases year by year because of the repeated use certain insecticides solely. Many new generation insecticides are being used worldwide which are comparatively safer to environment and continuous efforts are needed to evaluate the new eco-friendly insecticides against this pest. The pyriproxyfen and Diafenthiuron are among the new chemistry with novel mode of action. Pyriproxyfen (4-phenoxyphenyl (RS)-2-(2-pyridyloxy) propyl ether) is a potent juvenile hormone analog that acts by suppressing embryogenesis, metamorphosis and inhibit adult formation. It has been found to be effective against variety of insect pests including whiteflies (Qureshi *et al.* 2009) [7] and Diafenthiuron is another potent insecticide which inhibits the oxidative phosphorylation and disrupts the ATP formation and was also found effective for management of whitefly in Bt cotton (Kalyan *et al.* 2017) [8].

Hence, combination of two insecticides having different mode of action play important role in delaying the development of resistance. Therefore, the objective of the present study was coined to know the effect of a combi product Diafenthiuron 30% + Pyriproxyfen 8% SE against whitefly and its safety to natural enemies in cotton.

Materials and methods

Field experiments were carried out for evaluation of Diafenthiuron 30%+Pyriproxyfen 8% SE against whiteflies in cotton at Agricultural Research Station, Dharwad Farm, UAS, Dharwad, Karnataka during *Kharif*, 2016 (First season) & *Kharif*, 2017 (Second season) randomized block design (RBD) with 7 treatments and three replications. The plot size of each treatment was 29.16m². The cotton hybrid ATM was dibbled at 90 cm X 60 cm spacing on 23/06/2016 and 14/07/2017. The test chemical, Diafenthiuron 30%+ Pyriproxyfen 8% SE was evaluated at four different doses viz., 600,800,1000, 1200 ml/ha. Pyriproxyfen 10% EC and Diafenthiuron 50% WP were used as standard comparative checks @ 1000 ml/ha and 600 g/ha respectively. There was one untreated control treatment for the comparison of all spray treatments.

The observations on number of whiteflies (both nymphs and adults) were made on five randomly selected plants in each treatment replication wise on 3, 7, and 10 days after each spray. Pre and post treatment observations on whitefly were recorded on 3 leaves selected from top, mid and bottom of selected plants in each plots. Based on these observations, mean insect population was worked out and statistically analyzed after square root transformation. The per cent reduction in insect population over untreated control was worked out treatment-wise using the formula of Henderson & Tilton (1955) [9]. To check the phyto toxic impact of test insecticide at different doses on naturally occurring predators in cotton ecosystem, the observations on numbers of natural enemies were recorded on five randomly selected plants in each replication in different treatments at 3, 7 and 10 days after each spray. Statistical analysis was performed after square root transformation.

For the observations on parasitisation of whiteflies in each of the treatments and untreated check, mainstem leaves at the fifth to seventh node from the plant top were inspected and the leaf containing the greatest number of large nymphs (Maximum infested leaves) was collected (Gerling *et al.*, 1980) [10] and examined in the laboratory under a stereomicroscope. Parasitized and unparasitized third and fourth instar nymphs were counted and recorded. An index of

parasitism was calculated as the quotient of the total number of parasitized nymphs and the total number of parasitized plus unparasitized third and fourth instar whiteflies. Statistical analysis was performed after arcsine transformation.

Seed cotton yield: A total of two pickings were made and data on cotton yield was summed up replication-wise for each treatment and subjected to ANOVA. The per cent increase in yield was worked out treatment-wise by using the formula: [(yield in treatment – yield in untreated check) ÷ (yield in untreated check)] x 100.

Results and Discussions

Adult whitefly population

The pre-treatment count of adult whiteflies was uniform across the various treatments and it gradually increased during the course of experiment as revealed from the population in the untreated check during the first season (2016-17). The results of various new molecules on white fly depicted in the table 1. The mean adult whitefly population per three leaves before imposition of treatments varied from 6.20 to 6.7 which were on par with each other. The mean observations of 3rd, 7th and 10th days after first spray in Diafenthiuron 30%+ Pyriproxyfen 8% SE @ 1200 ml/ha could register significantly low whitefly population (0.99) and was on par with its lower doses 1000 ml/ha. These treatments were significantly superior over other treatments. And significantly higher adult population (6.90) was noticed in untreated check. The maximum reduction of whiteflies was observed with Diafenthiuron 30%+ Pyriproxyfen 8% SE @ 1200 ml/ha (0.86adult whitefly /3 leaves) and Diafenthiuron 30%+ Pyriproxyfen 8% SE 1000 ml/ha (1.20 adult whitefly /3 leaves). Similar trend of observation was noticed even after second and third spray. After third spray mean whiteflies found to be least in Diafenthiuron 30%+ Pyriproxyfen 8% SE @ 1200 ml/ha (0.60 adult whitefly/ 3 leaves) and highest in untreated check (8.69 adult whitefly/ 3 leaves).

In the second season trial (2017-18) before the insecticidal treatment, the adult population of whitefly ranged from 6.33 to 7.42/3 leaves and the treatments were statistically on par with each other. The mean observations of 3rd, 7th and 10th days after first spray in Diafenthiuron 30%+ Pyriproxyfen 8% SE @ 1200 ml/ha could register significantly less whitefly population (1.43) and was on par with its lower doses 1000 ml/ha. Further these treatments were significantly superior over other treatments. However, significantly higher adult population (7.13) was noticed in untreated check (Table 2). The reduction in population of whitefly varied from 0.55 to 7.53 whitefly per three leaves in different treatments after first spray. The maximum reduction of whitefly was observed with Diafenthiuron 30%+ Pyriproxyfen 8% SE @ 1200 ml/ha (0.55 whitefly /3 leaves) and Diafenthiuron 30%+ Pyriproxyfen 8% SE 1000 ml/ha (1.20 whitefly /3 leaves). Similar trend of observation was noticed even after second and third spray.

Whitefly nymphs:

Further nymphs of whiteflies ranged from 6.88 to 7.15/3 leaves as pretreatment count and there was no significant difference among treatments during 2017 (Table 3). The mean observations of 3rd, 7th and 10th days after first spray in the test chemical @ 1200ml/ha, recorded significantly less nymphal population (1.79 /3 leaves) and was on par with its lower doses 1000 ml/ha (2.09 /3 leaves). These two treatments were

significantly superior over other treatments, followed by its lower doses of 800 ml/ha as well as Pyriproxyfen 10% EC @1000ml/ha and Diafenthiuron 50% WP @ 600 g/ha. However, significantly higher nymphal population (7.68/3 leaves) was noticed in untreated check. Similar trend of observation was noticed even after second and third spray.

Further during, 2017 also nymph population of whitefly ranged from 6.76 to 7.56/3 leaves as pretreatment count and there was no significant difference among treatments. The mean observations of 3rd, 7th and 10th days after first spray in the test chemical @ 1200ml/ha, recorded significantly less nymphal population (1.86/3 leaves) and was on par with its lower doses 1000 ml/ha (2.24/ 3 leaves) as presented in table 4. Further these two treatments were significantly superior over other treatments, followed by its lower doses of 800 ml/ha as well as Pyriproxyfen 10% EC @1000ml/ha and Diafenthiuron 50% WP @ 600 g/ha. However, significantly higher nymphal population (7.88 /3leaves) was noticed in untreated check. Similar trend of observation was noticed even after second and third spray. There was no adverse effect of Diafenthiuron 30%+ Pyriproxyfen 8% SE on major predators and parasitoid in cotton agro-ecosystem was found in both the season (Kharif, 2016 & 2017, Table 5).

Seed cotton yield:

During 2016 and 2017 the seed cotton yield varied in accordance with suppression of whiteflies. The pooled yield data (Table 6) clearly indicated that highest seed cotton yield was observed in all the insecticidal treated plots over untreated check. Significantly highest seed cotton yield was recorded in the plots treated with combination product of Diafenthiuron 30%+ Pyriproxyfen 8% SE @ 1200 ml/ha (1268 kg/ha) and was on par with its lower doses at 1000ml/ha (1259 kg/ha), followed by individual Pyriproxyfen 10% EC @1000ml/ha (1113 kg/ha) and Diafenthiuron 50% WP @ 600 g/ha (1123 kg/ha). Significantly lower yield (896 kg/ha) was registered in untreated check.

Diafenthiuron 30%+Pyriproxyfen 8% SE @ 1000 ml/ha recorded higher incremental cost benefit ratio (ICBR) and net incremental cost benefit ratio (NICBR) of 3.03 and 2.03, respectively compared to remaining treatments (Table 7).

In the present investigation, Diafenthiuron 30% +

Pyriproxyfen 8% SE @ 1200 ml/ha and 1000 ml/ha - found highly effective against whiteflies in Bt cotton. A combi-product of same insecticides with slight difference in strength (diafenthiuron 25% + pyriproxyfen 5% SE) has been reported to be highly effective against aphids, leafhoppers, whiteflies and thrips in Bt cotton ^[11] earlier. Diafenthiuron 50 WP @ 500 g/ha was one of the treatment showed excellent performance in managing the population of whitefly (*B. tabaci*) ^[12]. Maximum mean seed cotton yield of 3101 kgha-1 with the highest net profit of Rs. 51,381 ha⁻¹ was obtained in difenthiuron 50 WP @ 300 g a.i. /ha against jassids and whiteflies infesting *Bt* cotton ^[8].

Pyriproxyfen (61.54%) showed maximum mortality of whiteflies followed by imidacloprid (58.79%); acetamiprid (58.24%) after 24 hours of spraying. Pyriproxyfen (77.39%) exhibited maximum mortality followed by diafenthiuron (75.62%); imidacloprid (75.27%) and acetamiprid (74.91%) after 48 hours ^[13]. Diafenthiuron 50 WP @ 312 g a.i./ha was the most promising treatment in reducing population of whiteflies (*B. tabaci*) after both sprays followed by spiromesifen 240 SC @ 150 g a.i./ha as compared to standard checks thiamethoxam 25 WG @ 25g a.i./ha and triazophos 40 EC @ 500 g a.i./ha in green gram ^[14]. Similarly, in cotton Pyriproxyfen 10.8 EC @ 200 ml/acre showed the highest overall reduction of whiteflies (67.31±1.27%) followed by Nitenpyram 10 SL @ 200 ml/acre (63.39±1.56%), Diafenthiuron 500SC @ 200 ml/acre (61.46±2.10%), Acephate 75 SP @ 250g/acre (59.55±2.48%) and Acetamiprid 20 SP @ 200 ml/acre (48.16±2.87%) when compared with control plot (8.00±0.37), respectively ^[15]. Lee *et al.*, (2002) ^[16] found that, chitin synthesis inhibitors (pyriproxyfen and novaluron) were very effective against immature stages of *B. tabaci* and were relatively low effective against the adults of *B. tabaci* and *A. gossypii* and Vija Kumar *et. al.* (2019) ^[17] concluded that pyriproxyfen 10EC and spiromesifen 22.9SC have good nymphicidal action while flonicamid 50WP and diafenthiuron 50WP have adulticidal action. Recently, *B. tabaci* has developed resistance to some of neonicotinoids ^[18, 19], therefore, mixture of diafenthiuron with pyriproxyfen could be used to manage this pest effectively.

Table 1: Bio-efficacy of Diafenthiuron 30%+ Pyriproxyfen 8% SE against adult whitefly (2016)

S. No.	Treatments	Dose/ha	No. of adult whitefly /3 leaves									
			I Spray			II Spray			III Spray			
			DBS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
1	Diafenthiuron 30%+ Pyriproxyfen 8% SE	600 ml	6.20 (2.59)	3.86 (2.09)	3.06 (1.89)	3.26 (1.94)	3.20 (1.92)	2.80 (1.82)	3.00 (1.87)	2.70 (1.79)	2.60 (1.76)	2.80 (1.82)
2	Diafenthiuron 30%+ Pyriproxyfen 8% SE	800 ml	6.53 (2.65)	2.86 (1.83)	2.06 (1.60)	2.26 (1.66)	2.00 (1.58)	1.80 (1.52)	2.00 (1.58)	1.80 (1.52)	1.60 (1.45)	1.80 (1.52)
3	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1000 ml	6.27 (2.60)	1.80 (1.52)	0.82 (1.15)	1.20 (1.30)	1.00 (1.22)	0.80 (1.14)	0.72 (1.10)	1.00 (1.22)	0.72 (1.10)	0.60 (1.05)
4	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1200 ml	6.47 (2.64)	1.46 (1.40)	0.66 (1.08)	0.86 (1.17)	0.70 (1.10)	0.60 (1.05)	0.70 (1.10)	0.80 (1.14)	0.60 (1.05)	0.40 (0.95)
5	Pyriproxyfen 10% EC	1000 ml	6.33 (2.61)	3.28 (1.94)	2.48 (1.73)	2.68 (1.78)	2.40 (1.70)	2.20 (1.64)	2.40 (1.70)	2.20 (1.64)	2.00 (1.58)	2.20 (1.64)
6	Diafenthiuron 50% WP	600 g	6.70 (2.68)	3.62 (2.03)	2.82 (1.82)	3.02 (1.88)	2.70 (1.79)	2.46 (1.72)	2.66 (1.78)	2.40 (1.70)	2.26 (1.66)	2.46 (1.72)
7	Untreated check	-	6.40 (2.63)	6.68 (2.68)	6.90 (2.72)	7.12 (2.76)	7.40 (2.81)	7.68 (2.86)	7.88 (2.89)	8.28 (2.96)	8.60 (3.02)	9.20 (3.11)
	S.Em±	-	NS									
	CD at 5%	-	0.26	0.27	0.36	0.22	0.21	0.10	0.18	0.16	0.21	0.21

Values in parenthesis are $\sqrt{X + 0.5}$ and arcsine transformed values; DBS-Day Before Spray; DAS-Days After Spray; C.D. (p=0.05)

Table 2: Bio-efficacy of Diafenthiuron 30%+ Pyriproxyfen 8% SE against adult whitefly on cotton (2017)

S. No.	Treatments	Dose/ha	No. of adult whitefly /3 leaves									
			I Spray				II Spray			III Spray		
			DBS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
1	Diafenthiuron 30% + Pyriproxyfen 8% SE	600 ml	6.29 (2.79)	4.34 (2.17)	4.54 (2.21)	4.56 (2.24)	3.35 (1.96)	2.92 (1.85)	3.26 (1.94)	2.81 (1.82)	2.52 (1.79)	2.75 (1.80)
2	Diafenthiuron 30% + Pyriproxyfen 8% SE	800 ml	7.18 (2.77)	3.54 (2.01)	3.57 (2.02)	2.26 (1.66)	2.15 (1.63)	1.94 (1.56)	2.34 (1.69)	1.72 (1.49)	1.54 (1.43)	1.76 (1.50)
3	Diafenthiuron 30% + Pyriproxyfen 8% SE	1000 ml	6.75 (2.69)	2.34 (1.69)	2.10 (1.61)	1.20 (1.30)	1.21 (1.31)	1.15 (1.28)	1.34 (1.36)	1.07 (1.25)	0.81 (1.44)	0.72 (1.55)
4	Diafenthiuron 30% + Pyriproxyfen 8% SE	1200 ml	7.42 (2.81)	1.87 (1.54)	1.56 (1.44)	0.55 (1.07)	1.20 (1.30)	0.72 (1.10)	0.95 (1.20)	0.94 (1.41)	0.73 (1.32)	0.56 (1.16)
5	Pyriproxyfen 10% EC	1000 ml	7.31 (2.76)	4.22 (2.15)	4.39 (2.19)	4.51 (2.22)	2.82 (1.82)	2.51 (1.73)	2.79 (1.81)	2.37 (1.69)	2.22 (1.65)	2.34 (1.66)
6	Diafenthiuron 50% WP	600 g	7.10 (2.61)	4.21 (2.20)	4.31 (2.24)	4.44 (2.25)	2.54 (1.74)	2.76 (1.81)	2.85 (1.83)	2.52 (1.74)	2.37 (1.69)	2.53 (1.74)
7	Untreated check	-	6.33 (2.61)	6.64 (2.67)	7.21 (2.78)	7.53 (2.83)	7.10 (2.76)	7.37 (2.81)	7.95 (2.91)	7.19 (2.77)	7.72 (2.87)	8.72 (3.04)
	S.Em±	-	NS	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.04
	CD at 5%	-		0.12	0.13	0.12	0.12	0.13	0.12	0.11	0.11	0.12

Values in parenthesis are $\sqrt{X} + 0.5$ and arcsine transformed values; DBS-Day Before Spray; DAS-Days After Spray; C.D. (p=0.05)

Table 3: Bio-efficacy of Diafenthiuron 30%+ Pyriproxyfen 8% SE against whitefly nymph on cotton (2016)

S. No.	Treatments	Dose/ha	No. of whitefly nymphs/3 leaves									
			I Spray				II Spray			III Spray		
			DBS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
1	Diafenthiuron 30%+ Pyriproxyfen 8% SE	600 ml	7.04 (2.75)	4.62 (2.26)	3.86 (2.09)	4.06 (2.14)	4.00 (2.12)	3.66 (2.04)	3.80 (2.07)	3.50 (2.00)	3.44 (1.98)	3.60 (2.02)
2	Diafenthiuron 30%+ Pyriproxyfen 8% SE	800 ml	6.92 (2.72)	3.68 (2.04)	2.86 (1.83)	3.06 (1.89)	2.80 (1.82)	2.64 (1.77)	2.80 (1.82)	2.60 (1.76)	2.42 (1.71)	2.60 (1.76)
3	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1000 ml	7.02 (2.74)	2.64 (1.77)	1.62 (1.46)	2.00 (1.58)	1.80 (1.52)	1.66 (1.47)	1.52 (1.42)	1.80 (1.52)	1.68 (1.48)	1.40 (1.38)
4	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1200 ml	6.88 (2.72)	2.24 (1.66)	1.46 (1.40)	1.66 (1.47)	1.50 (1.41)	1.48 (1.41)	1.50 (1.41)	1.60 (1.45)	1.42 (1.39)	1.20 (1.30)
5	Pyriproxyfen 10% EC	1000 ml	6.95 (2.73)	4.04 (2.13)	3.28 (1.94)	3.48 (1.99)	3.20 (1.92)	3.08 (1.89)	3.20 (1.92)	3.00 (1.87)	2.84 (1.83)	3.00 (1.87)
6	Diafenthiuron 50% WP	600 g	7.15 (2.77)	4.40 (2.21)	3.62 (2.03)	3.82 (2.08)	3.50 (2.00)	3.22 (1.93)	3.46 (1.99)	3.20 (1.92)	3.04 (1.88)	3.26 (1.94)
7	Untreated check	-	7.00 (2.74)	7.44 (2.82)	7.69 (2.86)	7.92 (2.90)	8.20 (2.95)	8.42 (2.99)	8.68 (3.03)	9.08 (3.10)	9.48 (3.16)	10.00 (3.24)
	S.Em±	-	NS	0.15	0.08	0.14	0.12	0.06	0.04	0.08	0.09	0.07
	CD at 5%	-		0.46	0.24	0.42	0.36	0.19	0.13	0.24	0.27	0.21

Values in parenthesis are $\sqrt{X} + 0.5$ and arcsine transformed values; DBS-Day Before Spray; DAS-Days After Spray; C.D. (p=0.05)

Table 4: Bio-efficacy of Diafenthiuron 30%+ Pyriproxyfen 8% SE against whitefly nymph on cotton (2017)

S. No.	Treatments	Dose/ha	No. of whitefly nymphs/3 leaves									
			I Spray				II Spray			III Spray		
			DBS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS	3 DAS	7 DAS	10 DAS
1	Diafenthiuron 30%+ Pyriproxyfen 8% SE	600 ml	7.56 (2.84)	5.13 (2.37)	4.12 (2.15)	4.25 (2.18)	4.15 (2.16)	3.79 (2.7)	3.92 (2.10)	3.31 (1.98)	3.28 (1.94)	3.45 (1.99)
2	Diafenthiuron 30%+ Pyriproxyfen 8% SE	800 ml	7.24 (2.78)	4.26 (2.18)	3.12 (1.90)	3.27 (1.94)	2.73 (1.80)	2.81 (1.82)	2.67 (1.78)	2.47 (1.72)	2.34 (1.69)	2.33 (1.68)
3	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1000 ml	7.17 (2.77)	2.75 (1.50)	1.79 (1.51)	2.19 (1.64)	1.73 (1.49)	1.70 (1.48)	1.43 (1.39)	1.67 (1.47)	1.51 (1.42)	1.34 (1.36)
4	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1200 ml	7.17 (2.77)	2.39 (1.70)	1.62 (1.46)	1.56 (1.44)	1.40 (1.38)	1.34 (1.36)	1.37 (1.37)	1.46 (1.40)	1.30 (1.34)	1.12 (1.29)
5	Pyriproxyfen 10% EC	1000 ml	6.76 (2.19)	4.67 (2.27)	3.62 (2.3)	3.65 (2.04)	3.32 (1.95)	3.12 (1.90)	3.27 (1.94)	2.94 (1.85)	2.76 (1.81)	3.11 (1.90)
6	Diafenthiuron 50% WP	600 g	6.83 (2.71)	4.57 (2.25)	3.76 (2.06)	4.11 (2.15)	3.44 (1.98)	3.30 (1.95)	3.52 (2.00)	3.14 (1.91)	3.19 (1.92)	3.36 (1.96)
7	Untreated check	-	7.49 (2.83)	7.66 (2.86)	7.73 (2.89)	8.24 (2.95)	8.17 (2.94)	8.79 (3.04)	8.97 (3.07)	8.16 (2.94)	8.72 (3.04)	9.74 (3.20)
	S.Em±	-	NS	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
	CD at 5%	-		0.13	0.12	0.13	0.12	0.12	0.12	0.12	0.12	0.13

Values in parenthesis are $\sqrt{X} + 0.5$ and arcsine transformed values; DBS-Day Before Spray; DAS-Days After Spray; C.D. (p=0.05)

Table 5: Relative effect of Diafenthiuron 30%+ Pyriproxyfen 8% SE against natural enemies present in cotton eco-system

S. No.	Treatments	Dose/ha	First season 2016					Second season 2017				
			Coccinellids		<i>Chrysoperlazastrow isillemi</i>		Parasitisation by <i>Encarsiaspp</i>	Coccinellids		<i>Chrysoperlazastrow isillemi</i>		Parasitisation by <i>Encarsiaspp</i>
			PTC	10 days after last spray	PTC	10 days after last spray	Nymph parasitisation (%)	PTC	10 days after last spray	PTC	10 days after last spray	Nymph parasitisation (%)
1	Diafenthiuron 30%+ Pyriproxyfen 8% SE	600 ml	2.47 (1.68)	2.33 (1.72)	2.73 (1.80)	2.60 (1.76)	23.50 (28.98)	1.93 (1.56)	1.97 (1.57)	2.21 (1.65)	2.42 (1.71)	22.37 (28.22)
2	Diafenthiuron 30%+ Pyriproxyfen 8% SE	800 ml	2.60 (1.69)	2.40 (1.76)	2.80 (1.81)	2.67 (1.78)	24.25 (29.49)	1.87 (1.54)	2.17 (1.63)	2.18 (1.65)	2.24 (1.66)	23.19 (28.28)
3	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1000 ml	2.53 (1.66)	2.27 (1.74)	2.67 (1.78)	2.53 (1.74)	23.75 (29.13)	2.17 (1.63)	2.22 (1.65)	2.37 (1.69)	2.44 (1.71)	22.49 (28.30)
4	Diafenthiuron 30%+ Pyriproxyfen 8% SE	1200 ml	2.40 (1.62)	2.13 (1.70)	2.60 (1.76)	2.47 (1.72)	23.50 (28.98)	2.30 (1.67)	2.41 (1.71)	2.32 (1.68)	2.42 (1.71)	21.12 (29.35)
5	Pyriproxyfen 10% EC	1000 ml	2.67 (1.70)	2.40 (1.78)	2.87 (1.83)	2.73 (1.80)	24.00 (29.31)	2.57 (1.75)	2.70 (1.79)	2.45 (1.72)	2.59 (1.76)	22.16 (28.09)
6	Diafenthiuron 50% WP	600 g	2.47 (1.64)	2.20 (1.72)	2.67 (1.78)	2.53 (1.74)	23.75 (29.15)	2.33 (1.68)	2.42 (1.71)	2.43 (1.71)	2.54 (1.74)	19.45 (26.16)
7	Untreated check	-	2.73 (1.83)	2.87 (1.80)	2.93 (1.85)	2.80 (1.82)	23.75 (29.13)	2.45 (1.72)	2.76 (1.81)	2.78 (1.81)	2.93 (1.85)	20.47 (26.89)
	CD at 5%	-	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Values in parenthesis are $\sqrt{X} + 0.5$ and arcsine transformed values, PTC- Pre Treatment count, C.D. (p=0.05)

Table 6: Seed cotton yield as influenced by white protection using different insecticides

Sl. No.	Treatments	Dose/ha	2016	2017	Pooled Yield (Kg/ha)	Increase in yield over check (%)
			Seed cotton Yield (Kg/ha)	Seed cotton Yield (Kg/ha)		
1	Diafenthiuron 30% + Pyriproxyfen 8% SE	600 ml	1265	989.78	1127.39	25.72
2	Diafenthiuron 30% + Pyriproxyfen 8% SE	800 ml	1268	1045.23	1156.62	28.98
3	Diafenthiuron 30% + Pyriproxyfen 8% SE	1000 ml	1351	1167.45	1259.23	40.43
4	Diafenthiuron 30% + Pyriproxyfen 8% SE	1200 ml	1376	1160.23	1268.12	41.42
5	Pyriproxyfen 10% EC	1000 ml	1273	953.36	1113.18	24.14
6	Diafenthiuron 50% WP	600 g	1271	976.38	1123.69	25.31
7	Untreated check	-	1013	780.43	896.72	0.00
	S.Em±	-	33.72	18.65	31.56	-
	CD at 5%	-	101.16	57.45	91.45	-

Table 7: Incremental Cost Benefit Ratio (ICBR) of of protecting whitefly incidence in cotton using different insecticides on cotton (mean of 2016 & 2017)

Sr. No	Treatments	Dose (ml/ha) (1)	Cost of Chemical/ kg/l (₹) & (2)	Cost of Chemical/ha For 3 spray (₹) (3)	Cost application/ha For 3 spray (₹) (4)	Total Cost (₹) (5=3+4)	Total yield (q/ha) (6)	Net gain over control (q/ha) (7)	Realization (Rs/ha) (8)	Net Realization (₹/ha) (9=8-5)	ICBR (10=9/5)	NICBR
1	Diafenthiuron 30% + Pyriproxyfen 8% SE	600	1000	1800	1500	3300	11.27	2.31	11533.5	8233.5	1:2.50	1:1.50
2	Diafenthiuron 30% + Pyriproxyfen 8% SE	800	1000	2400	1500	3900	11.57	2.60	12995.0	9095.0	1:2.33	1:1.33
3	Diafenthiuron 30% + Pyriproxyfen 8% SE	1000	1000	3000	1500	4500	12.59	3.63	18125.5	13625.5	1:3.03	1:2.03
4	Diafenthiuron 30% + Pyriproxyfen 8% SE	1200	1000	3600	1500	5100	12.68	3.71	18570.0	13470.0	1:2.64	1:1.64
5	Std. Pyriproxyfen 10% EC	1000	1600	4800	1500	6300	11.13	2.16	10823.0	4523.0	1:0.72	1:-0.28
6	Std. Diafenthiuron 50% WP	600	910	1638	1500	3138	11.24	2.27	11348.5	8210.5	1:2.62	1:1.62
7	Untreated check	-	-	-	-	0	8.97	-	-	-	-	-

Standard spray volume = 500 lit of water/ha.; Market price of Cotton @ Rs. 50/Kg; Spraying Charges @ Rs. 500/ha

Conclusion

Effective management of whitefly could be achieved through application of Diafenthiuron 30%+ Pyriproxyfen 8% SE in cotton with appreciable economic advantage and also there shall not be any adverse effect on natural enemies..

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