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Vijaykumar N Ghante
Main Agricultural Research Station, UAS, Raichur, Karnataka, India

Arunkumar Hosamani
Main Agricultural Research Station, UAS, Raichur, Karnataka, India

Correspondence
Vijaykumar N Ghante
Main Agricultural Research Station, UAS, Raichur, Karnataka, India

Effect of wetting agent on the efficacy of diafenthiuron in controlling whiteflies in sunflower

Vijaykumar N Ghante and Arunkumar Hosamani

Abstract
The use of wetting agents enhances the insecticide efficiency and increases the persistence of insecticides. In this study, the effect of Wetting agent developed at the Main Agricultural Research Station, UAS, Raichur on the toxicity of Diafenthiuron 50 WP formulation was investigated under field conditions against the whitefly in Sunflower crop. Among the different treatment Wetting agent @ 1.50 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre was found to be optimum in reducing the whitefly populations which was on par with the treatments of Diafenthiuron 50% WP @ 1 g/ Litre tank mixed with wetting agent 2.0 ml/Litre and the commercial standard check Dhanuwet @ 2.0 ml/Litre along with Diafenthiuron 50% WP @ 1 g/ Litre. Significantly higher seed yield was recorded in the treatments of Wetting agent @ 5.0 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre and Wetting agent @ 2.0 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre. The next best treatment was Wetting agent @ 1.50 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre and Dhanuwit @ 2.0 ml/Litre along with Diafenthiuron 50% WP @ 1 g/ Litre. These results indicated that wetting agent increased efficiency of Diafenthiuron 50 WP commercial formulation and thereby yield of sunflower.

Keywords: Insecticides, pesticide application, whitefly, wetting agent, toxicity of insecticides

1. Introduction

Sunflower (*Helianthus annuus* L.) is an important oil seed crop of the family Asteraceae. Sunflower has shown distinct superiority over other oilseed crops owing to its wider adaptability to different agro-climatic conditions, highest oil production per unit area, short duration, high yield potential, ability to withstand drought, photoperiod insensitivity, lower seed rate, high seed multiplication ratio and high quality edible oil (Sindagi and Virupakshappa, 1986) [16]. Large scale cultivation of sunflower in India started only in 1972 with the introduction of high yielding open pollinated varieties from USSR and Canada. The development of early maturing variety Morden as well as the first sunflower hybrid, BSH-1 in 1980 provided the required fillip to expand sunflower cultivation in the country (Seetharam, 1984) [14]. Sunflower has attained a prime position in the oilseed economy of the country. Sunflower is largely confined to southern parts of the country comprising the states of erstwhile Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu. These four states contribute about 90 per cent of total acreage and 78 per cent of total production. In the recent past, the area has expanded under rabi and spring cultivation in Northern India and in rice fallows.

Profitable cultivation of sunflower is limited by the vulnerability of the released varieties and hybrids to multiple diseases and pests. Gulya and Masirevic (1991) [8] listed 80 pathogens causing diseases on sunflower. However, sunflower was free from diseases when introduced in India during early 1970s. Even during early 1980s it was not much affected by diseases. The popularity of the crop among farmers resulted in larger area under the crop and as a consequence many diseases caused by fungi and viruses have co-evolved with sunflower.

Whitefly has emerged as the new potential sucking insect pest of sunflower and also acting as the vector of leaf curl begomovirus in Northern Karnataka, India. This has attracted lot of attention of the entomologists and pathologists, as it affects the productivity of sunflower an important oilseed crop in the country (Katti, 2007) [10]. Sunflower leaf curl disease transmitted by whitefly was noticed for the first time in the country and the disease was recorded on sunflower hybrid ‘Sun breed - 275’ up to 40 per cent disease incidence in the fields of Main

Agricultural Research Station (MARS), University of Agricultural Sciences, Raichur, Northern Karnataka, during *Rabi* season of 2009 (Govindappa *et al*., 2011) [9]. The whitefly infestation has been noticed in an endemic form consecutively for the last three years in sunflower growing areas of Northern districts of Karnataka. The disease severity ranged from 10 - 58 per cent and correspondingly the increased population of *B. tabaci* (up to 200 per leaf) was observed with an average of 14.7 *B. tabaci* per leaf both in open pollinated varieties and hybrids. Further, the incidence of SuLCV was more in Koppal (11.16%) district fallowed by Raichur (7.41%) and Ballari (6.34%) district (Vindhyashree, 2014).Farmers are unable to control the whiteflies even with the repeated insecticidal sprays with conventional insecticides which resulted in pollution of natural resources and also development of resistance. Hence, there is need for evaluating the newer insecticides that may be effective against whitefly in sunflower.

Different pesticide mixture's performances as well as physical properties of them are modified by the addition of agricultural adjuvant into the pesticide tank. The addition of these substances (Adjuvant) into the pesticides is practiced before their applications (Stevens, 1993) [17] and these were intended to operate as wetting agents, spreaders (Fred *et al.,* 1996) [6] stickers, emulsifiers, dispersing agents, drift-control agents (Cai *et al.,* 1997) [3] foam sup- pressers and penetrates. Efficacy of some agricultural pesticides is increased by adjuvants (Sharma and Pampapathy, 2006) [15] and environmental fate is modified as well. The Present study was conducted to evaluate the efficacy of Diafenthiuron 50 WP against whitefly alone and along with the agricultural adjuvant under field conditions.

2. Materials and Methods

A synthetic polymer based Wetting agent was formulated at the Main Agricultural research station and evaluated for its efficacy in enhancing the performance of insecticides against whitefly in Sunflower under field codition. The field experiment was laid at Main Agricultural Research Station, UAS, Raichur in randomized block design during Rabi season of 2017 and 2018 to evaluate the effect of Wetting agent on the efficacy of Diafenthiuron in controlling Whiteflies in Sunflower at various doses, comprising nine treatments and three replications. Wetting agent was evaluated as tank mix at 5 concentrations along with Diafenthiuron 50 WP for its ability to increase the efficiency of Diafenthiuron to control the whiteflies on Sunflower crop (hybrid KBSH 44). Two sprays were taken up at 50 DAS and 70 DAS. Observations on whitefly were made on six leaves comprising of two leaves each from top, middle and bottom portion of five randomly selected plants from each plot. Population of whiteflies was recorded at one day before treatment and one, three, five, seven and ten days after treatment. The mean population of whitefly was worked out and subjected to statistical analysis. Dhanuvit from Dhanuka Agritech Limited, Gurgaon, Haryana was used as standard check for comparison

3. Results and Discussion

Population reduction of the whitefly nymphs and adults fed on treated sunflower leaves with various treatments of insecticide formulations and insecticide formulations/adjuvant mixtures (in tank) at various dosages under field conditions during 2017-18, 2018-19 rabi season and pooled data are shown in Table 1-3.

Table 1: Effect of wetting agent on the toxicity of Diafenthiuron 50 WP formulation against whiteflies in sunflower during 2017-18 rabi season

Treatments	Mean no. of whiteflies/6 leaves/plant after first spray				Mean no. of whiteflies/6 leaves/plant after second spray				Yield (kg/ha)
	1 DBS	1 DAS	3 DAS	7 DAS	1 DBS	1 DAS	3 DAS	7 DAS	
T1 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 0.50 ml/litre	32.30 (5.73)	11.70 (3.49)	9.39 (3.14)	6.41 (2.63)	27.64 (5.30)	10.75 (3.35)	8.79 (3.05)	5.45 (2.44)	1131.49
T2 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 1.00 ml/litre	35.10 (5.97)	10.91 (3.38)	9.14 (3.10)	6.16 (2.58)	24.61 (5.01)	9.96 (3.23)	8.52 (3.00)	5.20 (2.39)	1186.00
T3 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 1.50 ml/litre	33.70 (5.85)	8.23 (2.95)	5.57 (2.46)	2.59 (1.76)	27.61 (5.30)	7.28 (2.79)	4.78 (2.30)	1.63 (1.46)	1200.00
T4 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 2.00 ml/litre	31.75 (5.68)	8.11 (2.93)	5.39 (2.43)	2.41 (1.71)	25.66 (5.11)	7.11 (2.76)	4.36 (2.20)	1.45 (1.40)	1202.55
T5 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 5.00 ml/litre	35.20 (5.97)	7.36 (2.80)	4.02 (2.13)	1.04 (1.24)	27.11 (5.25)	6.41 (2.63)	3.18 (1.92)	0.56 (1.03)	1207.41
T6 : Wetting agent @ 2.00 ml/litre	33.00 (5.79)	29.16 (5.45)	28.44 (5.38)	27.62 (5.30)	26.91 (5.24)	33.41 (5.82)	32.44 (5.74)	31.06 (5.62)	684.07
T7 : Diafenthiuron 50 WP @ 1 gm/Litre	32.60 (5.75)	11.19 (3.42)	9.81 (3.21)	6.83 (2.71)	26.51 (5.20)	10.24 (3.28)	9.21 (3.12)	5.87 (2.52)	1128.16
T8: Diafenthiuron 50 WP @ 1 gm/Litre + Dhanu-wit @ 2.0 ml/Litre	31.33 (5.64)	8.32 (2.97)	5.81 (2.51)	2.83 (1.82)	25.31 (5.08)	7.37 (2.81)	4.92 (2.33)	1.87 (1.54)	1197.00
T9: Control	33.75 (5.85)	30.24 (5.54)	28.29 (5.37)	28.05 (5.34)	26.93 (5.24)	34.30 (5.90)	33.08 (5.79)	31.84 (5.69)	683.21
SEm ±	0.84	0.03	0.05	0.06	0.55	0.02	0.04	0.08	2.34
CD	NS	0.09	0.13	0.17	NS	0.06	0.13	0.22	7.12
CV	14.65	8.97	12.83	11.64	12.68	10.51	11.26	12.14	9.18

Table 2: Effect of wetting agent on the toxicity of Diafenthiuron 50 WP formulation against whiteflies in sunflower during 2018-19 rabi season

Treatments	Mean no. of whiteflies/6 leaves/plant after first spray				Mean no. of whiteflies/6 leaves/plant after second spray				Yield (kg/ha)
	1 DBS	1 DAS	3 DAS	7 DAS	1 DBS	1 DAS	3 DAS	7 DAS	
T1 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 0.50 ml/litre	41.22 (6.46)	11.30 (3.44)	8.90 (3.07)	6.89 (2.72)	29.94 (5.52)	9.43 (3.15)	6.95 (2.73)	4.80 (2.30)	931.94
T2 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 1.00 ml/litre	40.38 (6.39)	10.49 (3.32)	8.65 (3.02)	6.64 (2.67)	30.28 (5.55)	8.64 (3.02)	6.70 (2.68)	4.55 (2.25)	983.14
T3 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 1.50 ml/litre	38.00 (6.20)	7.81 (2.88)	5.08 (2.36)	3.07 (1.89)	31.84 (5.69)	5.96 (2.54)	3.13 (1.91)	1.01 (1.23)	995.62
T4 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 2.00 ml/litre	38.81 (6.27)	7.67 (2.86)	4.92 (2.33)	2.91 (1.85)	30.27 (5.55)	5.84 (2.52)	2.95 (1.86)	0.92 (1.19)	998.17
T5 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 5.00 ml/litre	37.83 (6.19)	6.24 (2.60)	3.62 (2.03)	1.82 (1.52)	31.72 (5.68)	5.09 (2.36)	1.72 (1.49)	0.43 (0.96)	1004.25
T6 : Wetting agent @ 2.00 ml/litre	40.62 (6.41)	39.24 (6.30)	36.78 (6.11)	34.77 (5.94)	30.52 (5.57)	32.85 (5.77)	34.19 (5.89)	32.04 (5.70)	478.72
T7 : Diafenthiuron 50 WP @ 1 gm/Litre	38.67 (6.26)	10.77 (3.36)	9.32 (3.13)	7.31 (2.79)	32.45 (5.74)	8.92 (3.07)	7.37 (2.81)	5.22 (2.39)	930.04
T8: Diafenthiuron 50 WP @ 1 gm/Litre + Dhanu-wit @ 2.0 ml/Litre	37.68 (6.18)	8.37 (2.98)	5.52 (2.45)	3.51 (2.00)	29.58 (5.48)	6.07 (2.56)	3.37 (1.97)	1.25 (1.32)	993.74
T9: Control	39.85 (6.35)	39.78 (6.35)	37.21 (6.14)	35.20 (5.97)	32.74 (5.77)	32.50 (5.74)	34.78 (5.94)	32.63 (5.76)	478.40
SEm +	0.78	0.05	0.04	0.06	1.04	0.05	0.03	0.05	2.51
CD	NS	0.15	0.13	0.18	NS	0.13	0.09	0.16	7.53
CV	12.47	11.36	10.12	13.24	14.81	9.46	9.82	10.43	11.46

Table 3: Effect of wetting agent on the toxicity of Diafenthiuron 50 WP formulation against whiteflies in sunflower (Pooled data for 2017-18 and 2018-19 rabi season)

Treatments	Mean no. of whiteflies/6 leaves/plant after first spray				Mean no. of whiteflies/6 leaves/plant after second spray				Yield (kg/ha)
	1 DBS	1 DAS	3 DAS	7 DAS	1 DBS	1 DAS	3 DAS	7 DAS	
T1 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 0.50 ml/litre	41.22 (6.46)	11.30 (3.44)	8.90 (3.07)	6.89 (2.72)	29.94 (5.52)	9.43 (3.15)	6.95 (2.73)	4.80 (2.30)	931.94
T2 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 1.00 ml/litre	40.38 (6.39)	10.49 (3.32)	8.65 (3.02)	6.64 (2.67)	30.28 (5.55)	8.64 (3.02)	6.70 (2.68)	4.55 (2.25)	983.14
T3 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 1.50 ml/litre	38.00 (6.20)	7.81 (2.88)	5.08 (2.36)	3.07 (1.89)	31.84 (5.69)	5.96 (2.54)	3.13 (1.91)	1.01 (1.23)	995.62
T4 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 2.00 ml/litre	38.81 (6.27)	7.67 (2.86)	4.92 (2.33)	2.91 (1.85)	30.27 (5.55)	5.84 (2.52)	2.95 (1.86)	0.92 (1.19)	998.17
T5 : Diafenthiuron 50 WP @ 1 gm/Litre + Wetting agent @ 5.00 ml/litre	37.83 (6.19)	6.24 (2.60)	3.62 (2.03)	1.82 (1.52)	31.72 (5.68)	5.09 (2.36)	1.72 (1.49)	0.43 (0.96)	1004.25
T6 : Wetting agent @ 2.00 ml/litre	40.62 (6.41)	39.24 (6.30)	36.78 (6.11)	34.77 (5.94)	30.52 (5.57)	32.85 (5.77)	34.19 (5.89)	32.04 (5.70)	478.72
T7 : Diafenthiuron 50 WP @ 1 gm/Litre	38.67 (6.26)	10.77 (3.36)	9.32 (3.13)	7.31 (2.79)	32.45 (5.74)	8.92 (3.07)	7.37 (2.81)	5.22 (2.39)	930.04
T8: Diafenthiuron 50 WP @ 1 gm/Litre + Dhanu-wit @ 2.0 ml/Litre	37.68 (6.18)	8.37 (2.98)	5.52 (2.45)	3.51 (2.00)	29.58 (5.48)	6.07 (2.56)	3.37 (1.97)	1.25 (1.32)	993.74
T9: Control	39.85 (6.35)	39.78 (6.35)	37.21 (6.14)	35.20 (5.97)	32.74 (5.77)	32.50 (5.74)	34.78 (5.94)	32.63 (5.76)	478.40
SEm +	0.78	0.05	0.04	0.06	1.04	0.05	0.03	0.05	2.51
CD	NS	0.15	0.13	0.18	NS	0.13	0.09	0.16	7.53
CV	12.47	11.36	10.12	13.24	14.81	9.46	9.82	10.43	11.46

During 2017-18, Whitefly population ranged from 31.33 to 35.20 per six leaves at one day before first spray and it was statistically non-significant among the treatments. One day after first spray, Among various doses of wetting agent tested as tank mix, Wetting agent @ 5.0 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre recorded significantly least whitefly population (7.36 whiteflies/6 leaves/Plant) followed by Wetting agent @ 2.0 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre (8.11 whiteflies/6 leaves/Plant), Wetting agent @ 1.50 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre (8.23 whiteflies/6 leaves/Plant) and standard check, Dhanuwet @ 2.0 ml/Litre along with Diafenthiuron 50% WP @ 1 g/ Litre (8.32 whiteflies/6 leaves/Plant). The treatment of Diafenthiuron 50% WP @ 1 g/ Litre alone without tank mix of wetting agent recorded a population of 11.19 whiteflies/six leaves/Plant at 1 DAS and was inferior to Diafenthiuron 50% WP @ 1 g/ Litre tank mixed with wetting agent @ 1.50 ml and 2.0 ml/Litre. Untreated control recorded 30.24 whiteflies per six leaves/plant and the treatment of Wetting agent @ 2.00 ml/Litre alone is as good as untreated control. At 3 DAS and 7 DAS also the trend of whitefly population reduction was quite similar to 1 DAS. Similar observations on population reductions were recorded during second spray.

During 2018-19, also the performance of the treatment Wetting agent @ 1.50 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre (7.81 whiteflies/6 leaves/Plant) was found to be optimum in reducing the whitefly populations which was on par with the treatments of Diafenthiuron 50% WP @ 1 g/ Litre tank mixed with wetting agent 2.0 ml/Litre (7.67 whiteflies/6 leaves/Plant) and the commercial standard check

Dhanuwet @ 2.0 ml/Litre along with Diafenthiuron 50% WP @ 1 g/ Litre (8.37 whiteflies/6 leaves/Plant) at 1 DAS.

During 2017-18, Significantly higher seed yield of 1207.41 and 1202.55 kg/ha was recorded in Wetting agent @ 5.0 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre and Wetting agent @ 2.0 ml/Litre + Diafenthiuron 50% WP @ 1g/ Litre respectively. The next best treatment was Wetting agent @ 1.50 ml/Litre + Diafenthiuron 50% WP @ 1 g/ Litre (1200 kg/ha) and Dhanuwit @ 2.0 ml/Litre along with Diafenthiuron 50% WP @ 1 g/ Litre (1197 kg/ha). These were followed by rest of the treatments. The untreated control recorded lower yield (683.21 kg/ha). The trend was almost same during 2018-19 season also.

From the results of two years research under field condition, it is revealed that, in general, the mixing of wetting agent with Diafenthiuron 50 WP commercial formulations increased insecticidal efficiency and lengthened the residual toxic effect against whiteflies. These results are in good agreement with several investigators. Brady *et al.* (1980) [2] mentioned that Nu-film and Triton X-100 increased the persistence of chlorpyrifos. In addition, Wills and McWhorter (1982) [19] stated that adjuvants can be used to increase the bioactivity of pesticides. Osipow (1964) [12] indicated that the decrease in surface tension caused an increase in wetting and spreading characteristics. The enhancement of insecticides efficiency caused by adding adjuvants may be attributed to their effects of increasing atomization and droplet sizes of insecticide, retention of insecticides on the treated surfaces, spreading and coverage of insecticide solutions, uptake and translocation of insecticides, and the effect of decreasing the surface tension between insecticide and treated surface (Chow *et al*., 1989) [4]. Our findings are confirmatory with those John C. Palumbo (2002), who stated that efficacy of insecticides increases when mixed with adjuvants against whitefly nymphs. Our results showed good efficacy of insecticides when mixed with the adjuvant, which is confirmatory with those of Liu T-X (Liu and Stansly, 1995) [11], who reported that adjuvants (surfactants and mineral oils) has insecticidal activity and also increase insecticidal potency when mix with insecticides against whitefly nymphs. Gaskin *et al.* (2010) [10] reported that adjuvant increased the toxicity of spirotetramet when mixed with it. The use of adjuvants increases the insecticides efficiency and enhances their persistency (Abdelgaleil *et al.*, 2015) [4]. Adjuvants enhance the insecticidal efficacy and inadvertently the non-target effects of the active ingredient of pesticides. Spray adjuvants as a mixture of insecticides are successfully used to manage insect in the field (Christopher *et al.*, 2016) [5]. The waxy body of many insect-pests makes it difficult for most spray solutions to penetrate in their body surface. Adjuvants can overcome this barrier and increase the efficacy of insecticides. The insect-pest can be successfully controlled by the addition of adjuvants in insecticides (Gaskin *et al.*, 2010) [10]. Xue Dong Chen and John (Xue Dong Chen and John, 2010) [20] reported that the toxicity of spirotetramat against *Ceriodaphnia dubia* significantly increased by the addition of adjuvant. Our results are similar with all the studies.

In summary, the results of this study indicated that the use of wetting agent developed at the Main Agricultural Research station, strongly enhanced the efficiency and persistence of cyhalothrin and chlorpyrifos commercial formulations and, consequently, the number of insecticide application in the season and the rate of application of insecticides can be decreased. This will reduce the environmental pollution and overcome the pests' resistance problem.

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