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Effect of newer insecticide against whitefly (*Bemisia tabaci*) infesting soybean

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Abstract
Soybean (*Glycine max* L. Merrill), a significant global source of vegetable oil and protein, faces severe threats from insect pests, including the whitefly (*Bemesia tabaci*), which causes direct damage through sap-sucking and indirect harm by transmitting plant viruses and promoting sooty mold fungi. The present study evaluates the efficacy of twelve insecticides against whiteflies in soybean crops over two consecutive *Kharif* seasons (2021 and 2022) at the RARS Ujjain experimental station. The trials were conducted in a randomized block design with eleven insecticidal treatments, including Flubendiamide, Indoxicarb, Tetraniliprole, Spinosad, and a mixture of Betacyfluthrin + Imidacloprid, along with an untreated control. Two sprays were administered based on insect incidence. Observations on whitefly population were taken before and after the sprays at specified intervals. The results indicate that Betacyfluthrin + Imidacloprid and Thiamethoxam + Lambda Cyhalothrin were the most effective, significantly reducing the whitefly population compared to untreated controls. The study highlights the importance of using specific insecticides to manage pest populations while minimizing disruption to the natural ecosystem.

Keywords: Whitefly (*Bemisia tabaci*), Betacyfluthrin + imidacloprid, bioefficacy

Introduction
Soybean [*Glycine max* L. (Merrill)] is a legume crop belonging to sub family papilionaceae and family leguminaceae. It is one of the most important principal food plants since many years. Soybean is mainly grown for their seeds and second largest oil seed after groundnut and mustard. Various important names have been given to this crop as Miracle bean, Golden bean, Cow of the field, Meat of the field, Gold from soil and Pearl of the orient Cinderella crop (Padiwal *et al*, 2008) [11]. It is excellent source of protein (40-41%), fat (15-20%), carbohydrates (5-6%) and phospholipids (2%). Soybean is essentially rich in the amino acid, lysine (5%) which is deficient in most of the cereals. It is useful both as food, fodder and industrial crop and therefore it is called as 'Wonder crop' (Shrivastava *et al*, 2010) [14]. Soybean meal serves as a protein supplement in dietary regimens, as well as in the feed of cattle and fowl. Pattern of Soya protein is virtually equivalent to that of milk and egg (Bishnoi, 2005) [3]. Because of its high nutritional value, it is also known as the "nutritional powerhouse" and "King of the beans".

Soybean has now become the largest source of vegetable oil and protein in the world and its large scale cultivation has been concentrated in few countries such as Argentina, Brazil, Canada, China, India and USA which together produce about 96% of the world's 189 million tonnes annual soybean production. Major soybean growing states in India are Madhya Pradesh, Maharashtra, Rajasthan, Karnataka, Uttar Pradesh, Telangana and Gujarat. The global area of soybeans in 2021–22 is 130.47 million ha. and production is 372.85 million tonnes. It is estimated to increase to 133.79 million ha in area and 348.85 million tonnes in production by 2022–23 (Anonymous, 2022[a]) [1].

In India, the total area under soybean cultivation in 2022–23 is 12.07 million ha with a production and productivity of 13.98 million tonnes and 1158 kg ha^{-1}, respectively. Soybean cultivation is confined to Madhya Pradesh, Rajasthan, Karnataka, Maharashtra and Gujarat state of India; it is also grown in a small area of Himachal Pradesh, Punjab and Delhi (Anonymous, 2022[b]) [2].

During earlier years of its establishment in the country, soybean cultivars did not pose any serious stress on account of insect pests. Soybeans in India are subject to infestation by an average of 273 insect species, with defoliator and sap sucking insects being the primary factors impeding soybean output (Raju *et al.* 2013) [13]. Out of which 126 are defoliators, 14 insect pests attack seed, seedling and root of the plants, 10 feed on stem, 6 were known to infest flowers and 6 were recorded as stored pest. Singh *et al*., 1989 [16] has reported 41 insect pests attacking the plants at its different stages of growth in M.P. Singh and Singh, (1992) [15] reported that more than 150 insect pests cause damage to soybean in various regions of Madhya Pradesh, out of which about a dozen of insect pests cause serious crop damage to the crop from sowing to harvest. Among them leaf miner (*Aproaerema modicella*), stem fly (*Melanagromyza sojae*), girdle beetle (*Obereopsis brevis*), tobacco caterpillar (*Spodoptera litura*), semiloopers (*Chrysodeixis acuta, Thysanoplusia orichalcea*) and sucking insect pests as whitefly (*Bemisia tabaci*), Jassid (*Amra Ram Bigutulla bigutulla, Empoasca KERRI*) are important. Soybean plants are directly damaged by whiteflies due to sap sucking and toxin injection, and indirectly by virus transmission and excretion of honeydew, which serves as a substrate for the growth of sooty mold fungi (Hirose *et al*. 2015) [8]. Additionally, *B. tabaci* has been confirmed as a vector for about ten percent of all known plant pathogenic viruses (Fauquet *et al*. 2008) [6], and the yield losses resulted from direct and indirect damages on soybean plants can reach up to 300 kg hectare^{-1} (Fauquet *et al*. 2008) [6]. Knowing the onset of incidence of different major pests of soybean may help the cultivators to develop the efficient management strategies beforehand and might also save the crop from the adverse effect of some notorious pests of soybean, secondly this will reduce the indiscriminate use of insecticides in the soybean ecosystem. Complementarily, the presence of various natural enemies and beneficial insects will also be effected. Therefore, the newer insecticide compounds are more pest specific and prevents disturbance in the natural balance of the soybean ecosystem to an extent. Keeping these views and foregoing information in consideration following research of effect of newer insecticide on whitefly in soybean was carried out.

Materials and Methods

The field trail was carried out under field conditions at RARS, Ujjain during *Kharif* 2021 and 2022 seasons. The crop was sown in randomized block design with eleven treatments and an untreated control replicated thrice. The plot size was 4 m x 3 m. Treatments were Flubendiamide 39.35 SC, Indoxicarb 14.5 SC, Spinosad 45% SC, Tetraniliprole 18.18 SC, Novaluron 05.25% + indoxacarb 04.50% SC, Quinalphos 20 EC, Chlorantraniliprole 20 SC, Profenophos 50 EC, Emamectin benzoate 5 SG, Betacyfluthrin + Imidacloprid, Thiamethoxam + lambda Cyhalothrin and untreated control. During the period of study, two sprays were given at 35 and 55 days after germination were given based on occurrence of insect incidence.

Observations

For taking the data the population counts were recorded on three leaves (one from upper, middle and lower leaves) of each plant from randomly selected ten plants. The pest count were made one day before the spray and after the 1, 3, 5 and 10 days of spray.

Results and Discussion

The efficacy of twelve insecticides along with untreated control was studied against whitefly on soybean during *kharif* seasons of 2021 and 2022 and the results obtained from the studies are presented in table no.1 and table no. 2. Cumulative mean efficacy of insecticides against whitefly population during *Kharif,* 2021 shows that the across the entire period from 1 DBS to 10 DAS, the mean whitefly counts per three leaves for each treatment varied. Highest pest count was observed by Emamectin benzoate 5 SG at 5.86 whitefly/3 leaves followed by Quinalphos 20 EC, and Profenophos 50 EC with a mean count of 5.58 and 5.51 whitefly/3 larvae, respectively. Flubendiamide 39.35 SC had a mean count of 4.68 whitefly/3 leaves followed by Spinosad 45% SC with a mean count of 4.01 whitefly/3 leaves indicating moderate effectiveness. Indoxicarb 14.5 SC, Tetraniliprole 18.18 SC, Novaluron 05.25% + Indoxacarb 04.50% SC, and Chlorantraniliprole 20 SC had mean counts around 5.67 to 5.69 whitefly/3 leaves. Betacyfluthrin + Imidacloprid recorded the lowest pest count of 3.69 whitefly/3 leaves followed by Thiamethoxam + Lambda Cyhalothrin at 3.82 whitefly/3 leaves. The untreated control plot had a markedly higher mean count of 8.40, highlighting the necessity and effectiveness of the insecticide treatments in controlling whitefly populations. Cumulative mean efficacy of insecticides against whitefly population during *Kharif,* 2022 shows that the across the entire period from 1 DBS to 10 DAS, the mean whitefly counts per three leaves for each treatment varied. Highest pest count was observed by Tetraniliprole 18.18 SC at 5.84 whitefly/3 leaves followed by Emamectin benzoate 5 SG (5.77 whitefly/3 larvae), Indoxicarb 14.5 SC (5.72 whitefly/3 larvae) and Quinalphos 20 EC (5.70 whitefly/3 leaves). Treatment application of Chlorantraniliprole 20 SC, Novaluron 05.25% + Indoxacarb 04.50% SC and Profenophos 50 EC recorded a pest count of 5.62, 5.49 and 5.47 whitefly per 3 leaves, respectively. Treatment application of Thiamethoxam + Lambda Cyhalothrin recorded least population of 3.81 whitefly per 3 leaves followed by Betacyfluthrin + Imidacloprid (3.91 whitefly/3 leaves), Spinosad 45% SC (4.23 whitefly/3 leaves) and Flubendiamide 39.35 SC (5.11 whitefly/3 leaves). Almost similar result was obtained by kalyan and ameta (2016) [9] who recorded that the significant maximum reduction in the whitefly, *Bemisia tabaci* Gennadius population was recorded in case of thiamethoxam 25 WG at 3 and 5 DAS during 2012 and 2013, respectively. It was followed by imidacloprid 200 SL. The findings of present investigation are in close agreement with the findings of Dahiphale *et al*. (2007) [5] who reported that thiamethoxam 25 WG and carbosulfan DS were found most effective against jassid and whitefly. Kumar *et al.* (2013) [10] also reported that application of thiamethoxam and imidacloprid was superior in suppressing the population of whiteflies. Ghosal and Chatterjee (2013) [7] reported that thiamethoxam, imidacloprid, diafenthiuron and acetamiprid were found most effective insecticides for the whitefly control. Observed that the acetamiprid 20 SP @ 0.004% proved the most effective treatment in controlling whitefly under field conditions on soybean followed by thiamethoxam 25 WG @ 0.008% and imidacloprid 17.8 SL @ 0.005%.

Table 1: Bio-efficacy of some newer insecticide against whiteflies infesting soybean during Kharif, 2021

Treatments			Whiteflies/ 3 leaves										
				1st Spray					2nd Spray				
S. No.	Details of treatments (Insecticides)	(Dose ml/ha)	1 DBS	1 DAS	3 DAS	5 DAS	10 DAS	1 DBS	1 DAS	3 DAS	5 DAS	10 DAS	Mean
1	Flubendiamide 39.35 SC	100 ml	4.48	4.35	4.17	3.91	4.21	5.85	5.82	4.83	4.65	4.55	4.68
			(2.23)	(2.2)	(2.16)	(2.1)	(2.17)	(2.52)	(2.51)	(2.31)	(2.27)	(2.25)	(2.28)
2	Indoxicarb 14.5 SC	200 ml	5.42	5.30	5.14	5.14	5.31	6.73	6.68	6.05	5.60	5.37	5.67
			(2.43)	(2.41)	(2.37)	(2.37)	(2.41)	(2.69)	(2.68)	(2.56)	(2.47)	(2.42)	(2.48)
4	Tetraniliprole 18.18 SC	250 ml	5.16	5.08	4.91	4.91	5.24	6.99	6.86	6.25	5.81	5.64	5.69
			(2.38)	(2.36)	(2.33)	(2.33)	(2.4)	(2.74)	(2.71)	(2.6)	(2.51)	(2.48)	(2.49)
5	Novaluron 05.25% + indoxacarb 04.50% SC	825 ml	5.19	5.22	5.00	4.78	5.14	6.81	6.74	5.94	5.93	5.86	5.66
			(2.38)	(2.39)	(2.35)	(2.3)	(2.37)	(2.7)	(2.69)	(2.54)	(2.54)	(2.52)	(2.48)
7	Chlorantraniliprole 20 SC	100 ml	5.27	5.28	4.94	4.84	5.17	6.83	6.69	6.22	6.22	5.95	5.74
			(2.4)	(2.4)	(2.33)	(2.31)	(2.38)	(2.71)	(2.68)	(2.59)	(2.59)	(2.54)	(2.5)
3	Spinosad 45% SC	200 ml	4.97	4.91	3.64	3.20	2.70	4.91	4.91	4.68	3.23	2.96	4.01
			(2.34)	(2.33)	(2.03)	(1.92)	(1.79)	(2.33)	(2.33)	(2.28)	(1.93)	(1.86)	(2.12)
9	Emamectin benzoate 5 SG	100 g	5.74	5.41	5.18	4.89	5.13	6.94	6.88	6.25	6.19	5.98	5.86
			(2.5)	(2.43)	(2.38)	(2.32)	(2.37)	(2.73)	(2.72)	(2.6)	(2.59)	(2.55)	(2.52)
6	Quinalphos 20 EC	1500 ml	5.92	5.55	4.80	4.48	5.11	7.04	6.80	6.03	5.10	4.93	5.58
			(2.53)	(2.46)	(2.3)	(2.23)	(2.37)	(2.75)	(2.7)	(2.55)	(2.37)	(2.33)	(2.47)
8	Profenophos 50 EC	1250 ml	5.59	5.39	4.57	4.13	4.65	7.22	6.81	6.39	5.21	5.14	5.51
			(2.47)	(2.43)	(2.25)	(2.15)	(2.27)	(2.78)	(2.7)	(2.63)	(2.39)	(2.37)	(2.45)
10	Betacyfluthrin + Imidacloprid	350 ml	5.47	5.10	3.98	2.55	2.08	4.54	4.52	4.30	3.00	2.69	3.82
			(2.44)	(2.37)	(2.12)	(1.75)	(1.61)	(2.24)	(2.24)	(2.19)	(1.87)	(1.79)	(2.08)
11	Thiamethoxam + lambda Cyhalothrin	125 ml	5.17	4.70	3.83	2.67	2.04	4.37	4.34	4.32	2.79	2.65	3.69
			(2.38)	(2.28)	(2.08)	(1.78)	(1.59)	(2.21)	(2.2)	(2.19)	(1.81)	(1.77)	(2.05)
12	Untreated (control)		4.87	5.18	5.57	7.07	7.81	10.12	10.16	10.48	10.60	12.12	8.40
			(2.32)	(2.38)	(2.46)	(2.75)	(2.88)	(3.26)	(3.26)	(3.31)	(3.33)	(3.55)	(2.98)
Sem (±)			0.076	0.070	0.056	0.055	0.042	0.032	0.029	0.034	0.033	0.030	0.027
CD (5%)			0.219	0.200	0.161	0.158	0.121	0.091	0.084	0.099	0.096	0.085	0.078

Table 2: Bio-efficacy of some newer insecticide against whiteflies infesting soybean during Kharif, 2022

Treatments			Whiteflies										
				1st Spray					2nd Spray				Mean
S. No.	Details of treatments (Insecticides)	(Dose ml/ha)	1 DBS	1 DAS	3 DAS	5 DAS	10 DAS	1 DBS	1 DAS	3 DAS	5 DAS	10 DAS	
1	Flubendiamide 39.35 SC	100 ml	4.72	5.12	4.97	4.34	4.57	5.80	5.86	5.45	5.33	4.97	5.11
			(2.28)	(2.37)	(2.34)	(2.2)	(2.25)	(2.51)	(2.52)	(2.44)	(2.41)	(2.34)	(2.37)
2	Indoxicarb 14.5 SC	200 ml	5.48	5.45	5.22	5.07	5.24	6.37	6.28	6.10	5.82	6.12	5.72
			(2.45)	(2.44)	(2.39)	(2.36)	(2.4)	(2.62)	(2.6)	(2.57)	(2.51)	(2.57)	(2.49)
4	Tetraniliprole 18.18 SC	250 ml	5.47	5.40	5.38	5.07	5.18	6.81	6.63	6.37	6.15	5.94	5.84
			(2.44)	(2.43)	(2.43)	(2.36)	(2.38)	(2.7)	(2.67)	(2.62)	(2.58)	(2.54)	(2.52)
5	Novaluron 05.25% + indoxacarb 04.50% SC	825 ml	4.95	4.90	4.86	4.79	5.08	6.39	6.33	5.84	5.90	5.87	5.49
			(2.33)	(2.32)	(2.32)	(2.3)	(2.36)	(2.63)	(2.61)	(2.52)	(2.53)	(2.52)	(2.45)
7	Chlorantraniliprole 20 SC	100 ml	4.93	4.94	4.88	4.76	5.18	6.35	6.36	6.22	6.29	6.29	5.62
			(2.33)	(2.33)	(2.32)	(2.29)	(2.38)	(2.62)	(2.62)	(2.59)	(2.61)	(2.61)	(2.47)
3	Spinosad 45% SC	200 ml	5.16	5.02	4.41	3.62	2.97	5.04	5.00	4.65	3.47	2.99	4.23
			(2.38)	(2.35)	(2.22)	(2.03)	(1.86)	(2.35)	(2.34)	(2.27)	(1.99)	(1.87)	(2.18)
9	Emamectin benzoate 5 SG	100 g	5.24	5.23	5.16	5.24	5.29	6.34	6.58	6.32	6.29	5.98	5.77
			(2.4)	(2.39)	(2.38)	(2.4)	(2.41)	(2.62)	(2.66)	(2.61)	(2.61)	(2.55)	(2.5)
6	Quinalphos 20 EC	1500 ml	5.79	5.66	5.50	5.04	5.19	6.71	6.44	6.03	5.54	5.08	5.70
			(2.51)	(2.48)	(2.45)	(2.35)	(2.39)	(2.69)	(2.63)	(2.56)	(2.46)	(2.36)	(2.49)
8	Profenophos 50 EC	1250 ml	5.80	5.67	5.67	4.75	4.93	6.16	6.09	5.70	5.07	4.84	5.47
			(2.51)	(2.48)	(2.48)	(2.29)	(2.33)	(2.58)	(2.57)	(2.49)	(2.36)	(2.31)	(2.44)
10	Betacyfluthrin + Imidacloprid	350 ml	5.48	5.35	3.98	3.00	2.18	4.44	4.38	4.16	3.59	2.54	3.91
			(2.45)	(2.42)	(2.12)	(1.87)	(1.64)	(2.22)	(2.21)	(2.16)	(2.02)	(1.74)	(2.1)
11	Thiamethoxam + lambda Cyhalothrin	125 ml	5.26	5.18	3.64	3.14	2.08	4.30	4.29	4.18	3.45	2.58	3.81
			(2.4)	(2.38)	(2.03)	(1.91)	(1.61)	(2.19)	(2.19)	(2.16)	(1.99)	(1.75)	(2.08)
12	Untreated (control)		5.09	5.22	6.27	7.53	9.87	11.92	12.46	12.90	13.49	14.37	9.91
			(2.37)	(2.39)	(2.6)	(2.83)	(3.22)	(3.52)	(3.6)	(3.66)	(3.74)	(3.86)	(3.23)
Sem (±)			0.050	0.044	0.038	0.048	0.038	0.037	0.032	0.036	0.045	0.053	0.020
CD (5%)			0.143	0.126	0.109	0.137	0.110	0.106	0.092	0.104	0.130	0.151	0.056

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