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MANAGEMENT OF LEAF CURL DISEASE OF SUNFLOWER UNDER FIELD CONDITIONS

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ABSTRACT

A field experiment on management of white fly transmitted leaf curl disease on sunflower crop was conducted for three years during *rabi* season at RARS, Nandyal. The experiment was planned with seven treatments (six insecticides and one untreated) in three replications for three years *i.e.*, *rabi* 2017-18, 2018-19 and 2019-20. The insecticides used were imidacloprid 17.8 SL, fipronil 5 SC, triazophos 40 EC, diafenthiuron 50 WP, flonicamid 50 WG and spiromesifen 24 SC. For six treatments (T_1 to T_6) seed treatment was done with imidacloprid 600 FS and for T_7 was maintained without seed treatment. Pooled analysis revealed that the treatment T_4:(Seed treatment with imidacloprid 600 FS@ 5ml/kg seed+ foliar spray with diafenthiuron 50 WP @1 g/lit at 30, 45 and 60 days after sowing) recorded the lesser leaf curl incidence of 23.72% and higher yield of 1591 kg/ha, which is followed by the treatment T_5: (Seed treatment with imidacloprid 600FS @ 5ml/kg seed + foliar spray with flonicamid 50 WG @ 0.25 g/lit at 30, 45 and 60 DAS) recorded the disease incidence of 24.29% with higher yield of 1457 kg/ha and both were *at par*. Both the treatments recorded B:C ratio of 1.79 and 1.80, respectively. Higher incidence of 41.9% and lower yield of 1268 kg/ha was recorded in untreated control. The results concluded that spraying of diafenthiuron and flonicamid was effective in reduction of disease with higher yields and high B:C ratio, followed by triazophos and spiromesifen.

Keywords: Insecticides, KBSH-44, Leaf curl, Sunflower, Whitefly.

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Sunflower is one of the important oil seed crops in India. It is cultivated in an area of 2.2 lakh ha with a production of 2.3 lakh tons and productivity of 1023 kg/ha in the year 2020-21 (Directorate of Economics and Statistics, 2021). In Andhra Pradesh, it is grown in an area of 10000 ha with a production of 10000 ton. having productivity of 934 kg/ha for the year 2019-20 (Directorate of Economics and Statistics, 2020). In recent years sunflower area is rapidly declining and among many reasons diseases are one of the major contributors for cropped area reduction. Among viral diseases, leaf curl is a serious disease reported in India apart from necrosis (Govindappa *et al*., 2011). This disease was reported first time on Sunbred-275 during *rabi*, 2009 at Main Agricultural Research Station, Raichur. It is caused by sunflower leaf curl virus which belongs to Begomo virus group and is infecting many crops. These are important pathogens causing serious food losses globally. The prominent symptoms of the disease observed were small size, malformed leaves, leaf and veinal thickening, enations and upward leaf curling. Emerging leaves exhibited yellow discolouration and severe reduction in leaf size. The infected plants were very much stunted when infected at early stages of crop and no ear head was erected. The disease significantly affects the plant height, head diameter, seed weight and oil percentage, etc. (Deepa *et al*., 2015). It is a whitefly (*Bemisia tabaci*) transmitted virus and the vector attacks numerous fiber (particularly cotton), food, vegetable and ornamental plants apart from sunflower because of its polyphagous nature. As the chemical management is highly effective and an important way to manage whiteflies, this experiment was planned with six insecticides for management of whitefly (vector), thereby examining reduction in disease incidence.

MATERIALS AND METHODS

The experiment was carried out at Regional Agricultural Research Station farm, Nandyal (15°27'N and 78°28'E) of Andhra Pradesh for a period of three seasons from *rabi*, 2017-18 to 2019-20 under All India Coordinated Research Project on Sunflower scheme. The soil of the experimental field was black, with pH 8.3 and EC 0.26 dS/m. Seeds of susceptible check (KBSH-44) were obtained from IIOR, Hyderabad. The experiment was laid out in Randomized Block Design with seven different treatments in three replications. Plot size was maintained as 4.2 x 3 m^2 (60 plants per plot), spacing of 60x30 cm and fertilizer schedule of 75-90-30 NPK kg/ha was followed. Three irrigations were given at different stages i.e., star bud stage, flowering and seed setting in the crop period. All agronomic practices were followed as per package of practices. The foliar application of insecticides was done as per

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schedule at 30, 45 and 60 days after sowing.

Germination percentage was calculated for each treatment. Data on leaf curl incidence was recorded at monthly interval starting from sowing date and final data was taken into consideration. Leaf curl incidence was calculated by using the following formula:

$$\text{Disease incidence} = \frac{\text{No. of plants infected with leaf curl}}{\text{Total number of plants}} \times 100$$

Seed yield, cost of cultivation and benefit cost ratio were calculated for each treatment.

RESULTS AND DISCUSSION

The results indicated that during 2017-18, germination percentage recorded was more than 90% in all the treatments and it was found that there was no significant difference among the treatments. The results are elucidated in Table 1. Among the imposed treatments, less leaf curl incidence of 10.74% was observed in the treatment T_4(seed treatment with imidacloprid 600FS @ 5ml/kg seed + foliar spray with diafenthiuron 50%WP@ 1 ml/lit at 30, 45 and 60 days after sowing) with a disease reduction of 78.62% over control, followed by the treatment T_5(seed treatment with imidacloprid 600FS @ 5ml/kg seed + foliar spray with flonicamid 50WG @0.25g/l at 30, 45 and 60 DAS) recorded disease incidence of 13.3% and both were *at par*. Higher leaf curl incidence of 32.2% was recorded in untreated plot and it was *at par* with the treatment T_1(seed treatment with imidacloprid 600FS @ 5ml/kg seed and foliar spray with imidacloprid 17.8SL@ 0.5ml/l at 30, 45 and 60 DAS) and T_2 (seed treatment with imidacloprid 600FS@ 5ml/kg seed + foliar spray with fipronil 5SC @ 2 ml/lit at 30, 45 and 60 DAS) which recorded disease incidence of 27.6% and 26.8% , respectively. Less leaf curl incidence of 15.95% and 24.41% were observed in the treatments such as T_3(seed treatment with imidacloprid 600FS @ 5ml/kg seed + foliar spray with triazophos 40EC @ 2 ml/lit at 30, 45 and 60 DAS) and T_6 (Seed treatment with imidacloprid 600FS @ 5ml/kg seed + foliar spray with spiromesifen 24SC @ 0.4 ml/l at 30, 45 and 60 DAS), respectively and they were *at par* with T_4 and T_5 treatments. Higher yield of 1716 kg/ha was recorded in the treatment T_4, followed by T_5 which recorded seed yield of 1701 kg/ha and the treatment T_3 recorded that of 1622 kg/ha; however, all these treatments were *at par* with each other and significantly differed with untreated plot. Less yield of 1302 kg/ha was observed in untreated plot among all the treatments and it was non-significant with treatments T_1 and T_2.

During 2018-19 also, similar trend was observed *i.e.*, the treatment T_4 recorded the lowest leaf curl incidence of 29.72% followed by the treatment T_5 (31.6%) and both the treatments were *at par* with T_6 and T_3 which recorded disease incidence of 37.52% and 38.65%, respectively (Table 1). More disease incidence of 48.35% was observed in T_7 (untreated plot) and the incidence was non-significant with treatments T_1 and T_2. The treatments T_1 and T_2 recorded more incidence of 42.76% and 42.22%, respectively. Non significant differences were observed in germination percentage among the seven imposed treatments. Regarding yield, all the treatments showed higher seed yield over that of untreated plot. However, significant differences were found between untreated plot and T_4 treatment.

During the year 2019-20, data (Table 1) indicated that all the treatments were non significant with each other in terms of germination percentage. The treatment T_5 recorded lesser disease incidence of 27.99% followed by the treatment T_4 which recorded 30.67%. The treatment T_5 was at par with T_2 and T_6. Like previous two years results, untreated plot recorded more disease incidence of 45.13% and the two treatments T_1 and T_2 were significant with untreated plot. Higher seed yield of 1433 kg/ha was recorded in T_4 treatment, followed by the treatment T_5, which recorded 1415 kg/ha and both the treatments significantly differed for yield with that of untreated treatment.

Relatively higher yields were observed in the year 2017-18 when compared to the remaining two years, it might be due to less disease incidence observed in the same year. Less yields were reported in the year 2019-20 compared to two years, because one irrigation during seed setting stage was not given because of inadequacy of water in canal.

Pooled analysis results indicated that, all the treatments except T_1 and T_2 reduced the disease incidence significantly over control. Among the imposed seven treatments, the treatment T_4 recorded less leaf curl incidence of 23.71% and recorded higher yield of 1591 kg/ha, followed by the treatment T_5 (24.29%) with seed yield of 1563 kg/ha. Other two treatments also performed good in reduction of leaf curl incidence i.e., T_3 and T_6 which recorded disease incidence of 29.86% and 32.00% with seed yield of 1470 kg/ha and 1457 kg/ha, respectively. Higher leaf curl incidence of 41.9% and lower yield of 1268 kg/ha was observed in untreated plot. These results indicated that insecticides in most of the treatments reduced leaf curl incidence, by suppressing the whitefly (vector) population and among them diafenthiuron was found most effective. The results are in accordance with Raichur location where treatment T_5 (foliar spray with flonicamid@0.25g/lt of water) was observed with least leaf curl incidence of 4.54% and necrosis of 4.21% with higher seed yield of 1607 kg/ha followed by T_4 (diafenthiuron@1g/litre of

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Table 1. Germination percentage, leaf curl incidence and seed yield in virus disease management trials

Treatment	2017-18			2018-19			2019-20		
	Germination (%)	incidence (%)	Seed yield (kg/ha)	Germination (%)	incidence (%)	Seed yield (kg/ha)	Germination (%)	incidence (%)	Seed yield (kg/ha)
T : Seed treatment with imidacloprid 600FS @ 5ml/kg seed and foliar spray with imidacloprid 17.8SL @ 0.5ml/l at 30, 45 and 60 DAS.	92.46 (77.92)	27.6 (31.69)	1437	92.16 (73.94)	42.76 (40.86)	1367	90.56 (72.14)	43.93 (41.50)	1211
T : S.t with imidacloprid 600FS @ 5ml/kg seed + foliar spray with fipronil 5SC @ 2 ml/lit at 30, 45 and 60 DAS.	91.43 (78.55)	26.8 (31.16)	1478	91.25 (73.17)	42.44 (40.67)	1385	91.00 (72.58)	39.66 (39.05)	1273
T : S.t with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with triazophos 40EC @ 2 ml/lit at 30, 45 and 60 DAS.	92.76 (75.33)	15.95 (23.55)	1622	88.33 (70.17)	38.65 (38.46)	1500	93.86 (75.69)	34.99 (36.28)	1289
T : S.t with imidacloprid 600FS @ 5ml/kg seed+ foliar spray with diafenthiuron 50 wp@1 g/lit at30,45and 60 DAS.	94.43 (76.62)	10.74 (19.06)	1716	89.16 (71.05)	29.72 (33.05)	1624	93.60 (75.38)	30.67 (33.65)	1433
T :S.t with imidacloprid 600FS @ 5ml/kg seed + foliar spray with flonicamide 50WG (Ulala)@0.25g/l at 30, 45 and 60 DAS.	90.53 (75.33)	13.3 (21.41)	1701	87.58 (69.68)	31.60 (34.20)	1572	92.53 (74.18)	27.99 (31.96)	1415
T :S.t with imidacloprid 600FS @ 5ml/ kg seed + foliar spray with spiromesifen 24SC (Oberon)@ 0.4 ml/l at 30,45and60 DAS.	93.60 (75.69)	24.41 (29.62)	1535	88.5 (70.51)	37.52 (37.75)	1490	93.91 (75.75)	34.58 (36.04)	1347
T_7: Control (untreated plot)	93.43 (75.59)	32.2 (34.59)	1332	90.16 (72.09)	48.35 (44.08)	1300	92.83 (74.51)	45.13 (42.18)	1173
Sem±	NS	1.5	75.4	2.25	1.77	88.21	1.38	2.75	78.54
CD at 5%	NS	4.45	232.4	6.93	5.28	262	4.26	8.48	241
CV (%)	5.8	13.62	8.45	5.43	11.23	12.07	3.17	12.71	10.43

Table 2. Leaf curl incidence (%) and seed yield (kg/ha) under various treatments

Treatment	Germination (%)	Leaf curl incidence (%)	Seed yield (kg/ha)
T_1: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed and foliar spray with Imidacloprid17.8SL @ 0.5ml/l at 30, 45 and 60 DAS.	91.72 (73.31)	38.09 (38.13)	1338
T_2: ST with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with Fipronil 5SC @ 2 ml/lit at 30, 45 and 60 DAS.	90.23 (71.82)	36.3 (37.07)	1379
T_3: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with triazophos 40EC @ 2 ml/lit at 30, 45 and 60 DAS.	91.65 (73.76)	29.86 (33.14)	1470
T_4: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed+ foliar spray with diafenthiuron50 wp @1 g/lit at30,45and 60 DAS.	92.39 (74.39)	23.71 (29.15)	1591
T_5: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with Flonicamide 50WG @0.25g/l at 30, 45 and 60 DAS.	90.21 (72.08)	24.29 (29.54)	1563
T_6: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with Spiromesifen 24SC @ 0.4 ml/l at 30,45and60 DAS.	92.00 (73.99)	32.00 (34.47)	1457
T_7: Control (untreated plot)	92.14 (74.11)	41.9 (40.36)	1268
Sem±	1.11	1.69	76.37
CD at 5%	3.41	5.19	235
CV (%)	2.58	8.48	9.17

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water) which recorded leaf curl incidence of 7.06% and necrosis of 6.34% with yield of 1538 kg/ha compared to control, which recorded more leaf curl incidence and necrosis of 16.6 and 9.09, respectively with low yield of 944 kg/ha (Annual report, sunflower 2019-20).

Deepa *et al*. (2014) conducted an experiment on management of leaf curl incidence of sunflower with insecticides, leaf extracts and bioagents and the results concluded that seed treatment with imidacloprid @ 5 g/kg along with two sprays of imidacloprid @ 0.5 ml/l or triazophos @ 1.5 ml/l were effective in controlling the leaf curl incidence and vector population with increased yield. In the present experiment also, disease reduction was found with insecticides but results of foliar spray with imidacloprid and fipronil were *at par* with untreated plot. According to Rajasekhar *et al*. (2018), who tested 8 insecticides against whiteflies of cotton under normal and high density planting system, found that diafenthiuron 50% WP @ 1.25 g/litre was effective in reducing whitefly population followed by flonicamid 50%WG@ 0.3 g/litre and acephate 75 SP@ 1.5 g/litre, but promising results were not obtained with imidacloprid 17.8% SL and fipronil 5% SC. Similar results were found in the present experiment. The

Table 3. Economics of various treatments (Pooled analysis)

Treatment	Seed yield (Kg/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	B:C ratio
T_1: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed and foliar spray with Imidacloprid17.8SL @ 0.5ml/l at 30, 45 and 60 DAS.	1338	29236	48168	1.65
T_2: ST with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with Fipronil 5SC @ 2 ml/lit at 30, 45 and 60 DAS.	1379	31650	49644	1.57
T_3: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with triazophos 40EC @ 2 ml/lit at 30, 45 and 60 DAS.	1470	29830	52920	1.77
T_4: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed+ foliar spray with diafenthiuron50 WP @1 g/lit at30,45and 60 DAS.	1591	32000	57276	1.79
T_5: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with Flonicamide 50WG @0.25g/l at 30, 45 and 60 DAS.	1563	31180	56268	1.8
T_6: Seed treatment with Imidacloprid 600FS @ 5ml/kg seed + foliar spray with Spiromesifen 24SC @ 0.4 ml/l at 30,45and 60 DAS.	1457	34950	52452	1.5
T_7: Control (untreated plot)	1268	27000	45648	1.69

insecticides such as flonicamid 50%WG, thiamethoxam 25% WG, diafenthiuron 50% WP were found effective against sucking pests including whiteflies in cotton (Jagadish Baraskar and Paradkar, 2020). Kumar *et al*. (2018) reported that the insecticides such as imidacloprid, acetameprid, nitenpyram, thiamethoxam and diafenthiuron gave significant results against aphids, whiteflies and other insect pests in tomato and diafenthiuron in potato (Swati *et al*., 2017). Diafenthiuron acts selectively on group of insects and mites by inhibiting or enhancing biochemical sites such as respiration and also inhibiting mitochondrial ATPase action. Balikai (2020) found that spiromesifen 24SC @ 150, 120 and 90 g a.i /ha was effective on management of sucking pests in tomato when compared to acephate and dicofol.

Seed treatment was done with imidacloprid 600FS @5g/kg of seed in all the treatments to suppress the sucking pest population in initial days of sowing. The effect of seed treatment was in conformity with Singh *et al*. (2002), who suggested that seed treatment with imidacloprid (Gaucho 70WS) @5g/kg of seed reduced whitefly (vector population) incidence compared to untreated plot and reduced leaf curl incidence in cotton. Similar results were reported by Chandel *et al*. (2010).

In the present experiment, yield levels varied among different treatments based on disease incidence and it depends on the stage of the plant at which leaf curl virus infection takes place. Deepa *et al*. (2015) concluded that variation in seed yield losses depended on the stage of virus attack *i.e*. when leaf curl incidence appeared. At 30 days old plants seed yield losses were 79.25% and when incidence appeared at 45, 60, 75 and 90 DAS the percentage of yield losses recorded were 67.22%, 59.16%, 35.78% and 7.14%, respectively. Hence, seed yield depends on the stage of plant at which virus attacks.

Similarly, the highest B:C ratio was recorded in the treatment T_5 as 1.8 followed by T_4 with 1.79 and all other treatments recorded less B:C ratio when compared to control. Though the pesticide triazophos was able to reduce leaf curl incidence and higher yield than control, we will not use it because triazophos was banned after 2020 as per Gazette notification No.3591(E).

Evaluation of various molecules of insecticides against the whitefly (vector) transmitted leaf curl disease of sunflower revealed that even though the seed treatment was common in all the treatments, the spraying of insecticide diversified the results. Foliar spray with diafenthiuron 50WP @ 1 g/l at 30, 45 and 60 DAS exhibited less disease incidence (9.25%) whereas, foliar spray with flonicamid 50WG @ 0.25 g/l at 30, 45 and 60 DAS resulted in good seed yield; but economics was good in foliar spray with fipronil 5SC. Rational use of these insecticides plays a significant role in management of *Bemisia tabaci* and consequently leaf curl incidence.

Based on the above data, it was concluded that two chemicals (diafenthiuron and flonicamid) will be effective at recommended concentration for management of vector and hence leaf curl incidence.

Authors' contribution

Conceptualization of research work and designing of experiments(KV, SN, KP, DLK); Execution of field/ lab experiments and data collection(KV, SN, KP, DLK): Data analysis and interpretation(KV, SN, KP, DLK); Preparation of manuscript(KV, SN, KP, DLK).

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