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Management of Chilli Leaf Curl Disease Complex in Jharkhand, India

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A B S T R A C T

A field trial was conducted during Rabi, 2015-16 and Kharif, 2016 cropping seasons. An attempt was made to find out the cost effective management schedule to minimize the crop loss. Seven insecticides viz., Fipronil5% SC@800ml/ha, Indoxacarb 14.5% SC@400ml/ha, Acephate 75 SP@0.1%, Spinosad 45%SC@160ml/ha, Imidacloprid 17.8% SL@0.003%, Fenvalerate 20EC@500ml/ha and Carbofuran 3G@30Kg/ha were evaluated against vector activity to reduce the leaf curl disease incidence. The minimum disease incidence was recorded to the extent of (19.26 %) and (44.38 %) coupled with highest fruit yield of 87.78 q/ha and 65.94 q/ha in the treatment T7 having three times soil application of Carbofuran 3G @ 30 Kg/ha at an interval of ten days during both Rabi, 2015-16 and Kharif, 2016 cropping seasons, respectively. Maximum disease incidence was found in Kharif season. Minimum disease incidence was recorded during Rabi crop season in comparison to Kharif crop season. Infection by chili leaf curl disease complex adversely affected yield attributing characters during Kharif season as compared to Rabi season. Highest cost-benefit ratio of 1:13.80 and 1:11.60 was obtained by the application of Imidacloprid17.8 % @ 0.00 3 % during both Rabi and Kharif seasons, respectively.

Introduction

Chilli (*Capsicum annuum* L.) is considered as one of the most important vegetable and commercial spice crops grown throughout warm temperate, tropical and subtropical regions of the World. Chilli also called red pepper belongs to the genus *Capsicum* under the Solanaceae family. Besides traditional use of chilli as vegetables, spices, condiments, sauces and pickles it is also being used in pharmaceuticals, cosmetics and beverages (Tiwary *et al.,* 2005). In Jharkhand, it is grown mostly in the districts of Ranchi, Hazaribag, Palamu and Giridih etc. Although there is a scope to enhance the productivity of chilli, a number of limiting factors have been attributed to the productivity. The damage caused by insect pests and mite is of paramount importance. Chilli is known as suffer from as many as eighty three different diseases (Anonymous, 1966). Among these fungi, bacteria and viruses diseases which are the major limiting factors in successful crop production, aphids (*Myzuspersicae* Sulzer), white fly (*Bemisiatabaci* Glover) and thrips (*Scirtothrips dorsalis* Hood) are the major insects which besides sucking the sap of the plant parts, also act as vectors of virus diseases like mosaic and leaf curl due to which

the crop suffers heavy losses (Singh *et al.,* 1998). Venkatesh *et al.,* (1998) reported that chilli leaf curl complex was caused by chilli leaf curl geminivirus (CLCV) transmitted by *Bemisiatabaci* also by thrips (*Scirtothrips dorsalis*) and mites (*Polyphagotarsonemous latus*). Senanayake *et al.,* (2006) reported that a very high disease incidence (upto 100% plants during December 2004) in farmers' fields in Narwa and Tinwari villages at Jodhpur district Rajasthan was observed. Chilli leaf curl disease complex causes huge crop losses in Jharkhand state primarily due to attack of thrips, mites and white fly followed by invasion of chilli leaf curl virus. Keeping in view the importance and losses, there is need of special emphasis to know the effect of insecticides and seasons on vector activity to spread chilli leaf curl disease complex.

Materials and Methods

To test the efficacy of seven insecticides on incidence of chilli leaf curl disease complex and fruit yield, a field trial was conducted in the glasshouse compound of the Department of Plant Pathology, Birsa Agricultural University, Ranchi, Jharkhand. The trial was conducted during Rabi, 2015-2016 and Kharif, 2016 cropping seasons using the variety, Mirch-444. The field trial was conducted in Randomize Block Design (RBD). There were eight treatments with three replications, including control. The plot size was 3m x1.5 m with a spacing of 50 cm x 50 cm.

Recommended doses of fertilizers N: P: K and FYM were applied@100:60:50 kg/ha and 200q/ha, respectively. Nurseries were treated with Carbofuran 3G @ 5gm/m^2 including control. Thirty five days old seedlings were transplanted. Three sprays were given at an interval of ten days. Carbofuran 3G @ 2gm/plant was applied three times at an interval of 10 days. The details of treatments were as follows: T_1-Fipronil 5% SC @800 ml/ha, T_2-Indoxacarb 14.5 SC@ 400ml/ha, T_3-Acephate 75 SP @ 0.1 %, T_4-Spinosad 45%SC @ 160ml/ha, T_5-Imidacloprid 17.8%SL @ 0.003%, T_6-Fenvalerate 20 EC @ 500ml/ha, T_7-Soil application with Carbofuran3G @ 30Kg/ha, T_8-Control.

Results and Discussion

Chilli is grown during both Rabi and Kharif seasons in Jharkhand state. Like other crops chilli is also attacked by a number of diseases. Among these, chilli leaf curl disease complex is most prevalent. Seven insecticides namely Fipronil, Indoxacarb, Acephate, Spinosad, Imidacloprid, Fenvalerate and soil application of Carbofuran were evaluated for their effects on vector activities, disease incidence and yield attributing characters during Rabi, 2015-16 and Kharif, 2016 cropping seasons. Minimum disease incidence (19.26 percent) was observed intreatment T_7 (three times soil application of Carbofuran 3G) which was statistically superior to all other treatments. This treatment T_7 was followed by T_5 (Imidacloprid) (20.53 percent), T_4 (Spinosad) (20.91 percent) and T_3 (Acephate) (23.46 percent). Maximum green fruit yield (87.78 q/ha) was recorded in T_7 (three times soil application of Carbofuran 3G). This treatment (T_7) also recorded maximum increase in yield over control (45.01 percent) followed byT_5three sprays of Imidacloprid 17.5 % SL @ 0.003% (42.14 percent) and T_4 (38.42 percent).The maximum disease reduction over control was observed in T_7 (38.43 percent) followed by T_5 (34.15 percent) and T_4 (32.94 %) (Table 1 and Fig. 1). Highest cost-benefit ratio (1:13.80) was recorded by three sprayings with Imidacloprid 17.5% SL @ 0.003 percent (T_5) which was followed by T_4 (Spinosad 45% SC@ 160 ml/ha) (1:9.47), T_6 (Fenvalerate 20 EC@ 500 ml/ha) (1:7.43), T_3 (Acephate 75 SP@ 0.1 %)(1:6.16), T_1 (Fipronil 5% SC @ 800 ml/ha) (1: 3.22) and T_7 (Carbofuran 3G @ 30 Kg/ha) (1:1.96).

Table.1 Effect of insecticides on leaf curl disease incidence and green fruit yield of chilli

Rabi, 2015-16 cropping season

Treatments	Dose	Disease incidence (%)	Disease reduction over control (%)	Yield (q/ha)	Increase yield over control (%)
T_1 - Fipronil 5% SC	800 ml/ha	25.74(30.39)	17.45	76.83	28.65
T_2 - Indoxacarb 14.5% SC	400 ml/ha	30.24(33.29)	3.25	72.60	21.57
T_3 - Acephate 75 SP	0.1%	23.46(28.95)	24.75	82.29	37.79
T_4 - Spinosad 45% SC	160 ml/ha	20.91(27.20)	32.94	82.67	38.42
T_5 - Imidacloprid 17.8% SL	0.003%	20.53(26.84)	34.15	84.89	42.14
T_6 - Fenvalerate 20 EC	500 ml/ha	26.98(31.10)	13.48	74.89	25.41
T_7 - Soil application of Carbofuran 3G	30 Kg/ha	19.26(25.95)	38.23	87.78	45.01
T_8 - Control		31.18(34.32)	-	59.72	-
S.Em ±		1.535		0.238	
C.D. at 5%		4.700		0.728	
C.V. %		8.933		11.76	

Table.2 Cost-Benefit ratio of insecticides

Rabi, 2015-16 cropping season

Treatments	Dose	Yield (q/ha)	Additional yield over control (q/ha)	Value of additional yield @ Rs1000/q	Cost of insecticidal application (Rs)	Net Return/ha (Rs)	Cost - benefit ratio
T_1 – Fipronil 5% SC	800 ml/ha	76.83	17.11	17110	4050	13060	1: 3.22
T_2 - Indoxacarb 14.5% SC	400 ml/ha	72.60	12.88	12880	5910	6970	1: 1.17
T_3 - Acephate 75 SP	0.1%	82.29	22.57	22570	3150	19420	1: 6.16
T_4 - Spinosad 45% SC	160 ml/ha	82.67	22.95	22950	2190	20760	1: 9.47
T_5 - Imidacloprid 17.8% SL	0.003%	84.89	25.17	25170	1700	23470	1: 13.80
T_6 - Fenvalerate 20 EC	500 ml/ha	74.89	15.17	15170	1800	13370	1: 7.43
T_7 – Soil application of Carbofuran 3G	30 Kg/ha	87.78	28.06	28060	9450	18610	1: 1.96
T_8 - Control		59.72	-	-	-	-	-
S.Em±		0.29					
C.D. at 5%		0.79					
C.V. %		11.76					

Rate of insecticides: Kg^{-1}or L^{-1}

Fipronil- Rs1125 /,Indoxacarb- Rs 3800/-, Acephate - Rs 750/-, Spinosad –Rs2416.67/-, Imidacloprid- Rs 1167/-, Fenvalerate- Rs 300/-, Carbofuran- Rs 90/-Labour cost - Rs 225/-, Rate of fruit-Rs 1000/-per quintal -, No. of applications -3.

Table.3 Effect of insecticides on yield attributing characters of chilli

Rabi, 2015-16 cropping season

Treatments	Dose	Mean Plant height (cm)	Mean no. of branches /plant (No.)	Mean no. of fruits/plant (No.)	Mean length/fruit (cm)	Mean breadth /fruit (cm)	Mean fruit weight/ Plant (gm)
T_{1-} Fipronil 5% SC	800ml/ha	50.67	26.94	31.37	19.39	2.67	74.67
T_{2-} Indoxacarb 14.5 %SC	400ml/ha	45.54	22.87	26.66	18.79	2.58	71.12
T_{3-} Acephate 75 SP	0.1%	51.13	28.00	33.37	19.94	2.68	75.00
T_{4-} Spinosad 45%SC	160ml/ha	54.26	28.06	35.82	20.87	2.71	80.52
T_{5-} Imidacloprid 17.8%SL	0.003%	55.58	28.89	35.98	20.94	2.74	82.20
T_{6-} Fenvalerate 20 EC	500ml/ha	46.00	26.30	27.40	19.19	2.65	74.62
T_{7-} Soil application of Carbofuran 3G	30kg/ha	60.26	31.24	39.69	23.26	3.29	104.64
T_{8-} Control		44.25	22.35	25.40	17.52	2.27	66.04
S.Em±		3.25	1.71	3.05	0.95	0.14	7.01
C.D. at 5%		9.96	5.42	9.34	2.91	0.43	NS
C.V. %		11.05	11.04	16.53	8.22	8.92	15.42

**Figures in parentheses are arcsine transformed values.

Table.4 Effect of insecticides on leaf curl disease incidence and green fruit yield of chilli

Kharif, 2016 cropping season

Treatments	Dose	Disease incidence (%)	Disease reduction over control (%)	Yield (q/ha)	Increase yield over control (%)
T_1 - Fipronil 5% SC	800 ml/ha	50.87 (46.43)**	18.55	53.72	30.65
T_2 - Indoxacarb 14.5% SC	400 ml/ha	54.37 (47.52)	12.94	44.38	7.93
T_3 - Acephate 75 SP	0.1%	50.48 (45.49)	19.17	55.40	34.73
T_4 - Spinosad 45% SC	160 ml/ha	50.58 (45.32)	19.01	56.45	37.29
T_5 - Imidacloprid 17.8% SL	0.003%	46.61 (43.02)	25.37	58.89	43.22
T_6 - Fenvalerate 20 EC	500 ml/ha	53.78 (47.12)	13.89	51.40	25.00
T_7 - Soil application of Carbofuran 3G	30 Kg/ha	44.38 (41.70)	28.94	65.94	60.36
T_8 - Control		62.45 (52.12)		41.12	
S.Em ±		1.73	-	0.22	-
C.D. at 5%		5.32		0.65	
C.V. %		6.52		15.25	

** Figures in parentheses are arcsine transformed value

Table.5 Cost -Benefit ratio of insecticides

Kharif, 2016 cropping season

Treatments	Dose	Yield (q/ha)	Additional yield over control (q/ha)	Value of additional yield @ Rs1000/q	Cost of insecticides application (Rs)	Net return (Rs)	cost – benefit ratio
T_{1}- Fipronil 5% SC	800ml/ha	53.72	12.60	12600	4050	11730	1: 2.10
T_{2}- Indoxacarb 14.5% SC	400ml/ha	44.38	3.26	3260	5910	6300	1: 0.30
T_{3}- Acephate 75 SP	0.10%	55.4	14.28	14280	3150	13360	1: 3.50
T_{4}- Spinosad 45% SC	160ml/ha	56.45	15.33	15330	2190	14530	1: 6.00
T_{5}- Imidacloprid 17.8%SL	0.003%	58.89	17.77	17770	1700	15840	1: 11.60
T_{6}- Fenvalerate 20 EC	500ml/ha	51.40	10.28	10280	1800	12800	1: 4.70
T_{7}- Soil application of Carbofuran 3G	30 kg/ha	65.94	24.28	24280	9450	10120	1: 1.60
T_{8} - Control	-	41.12	-	-	-	-	-
S.E.m ±	-	0.22	-	-	-	-	-
C.D. at 5%	-	0.65	-	-	-	-	-
C.V. %	-	15.25	-	-	-	-	-

Rate of insecticides: Kg^{-1} / L^{-1}
Fipronil- Rs1125 /,Indoxacarb- Rs 3800/-, Acephate - Rs 750/-,
Spinosad -Rs 2416.67/-, Imidacloprid- Rs 1167/-, Fenvalerate- Rs 300/-,
Carbofuran- Rs 90/-,Labour cost-Rs 225/-, Rate of fruit- Rs 1000/-per quintal,
No. of applications -3.

Table.6 Effect of insecticides on yield attributing characters of chilli

Kharif, 2016 cropping season

Treatments	Dose	Mean Plant height (cm)	Mean no. of branches/ plant (No.)	Mean no. of fruits/plant (No.)	Mean length/ fruit (cm)	Mean breadth/ fruit (cm)	Mean fruit Weight/ plant (gm)
T_{1}- Fipronil 5% SC	800ml/ha	28.52	2.90	3.39	3.54	0.46	30.48
T_{2}- Indoxacarb 14.5% SC	400ml/ha	26.42	2.70	2.79	3.14	0.40	30.48
T_{3}- Acephate 75 SP	0.10%	29.05	3.06	3.45	3.63	0.52	32.46
T_{4}- Spinosad 45%SC	160ml/ha	30.58	3.27	3.74	3.79	0.54	32.59
T_{5}- Imidacloprid 17.8%SL	0.003%	31.76	4.05	4.01	4.43	0.56	37.42
T_{6}- Fenvalerate 20 EC	500ml/ha	27.65	2.80	3.25	3.20	0.43	30.78
T_{7}- Soil application of Carbfuran 3G	30 kg/ha	32.97	4.50	4.29	4.65	0.63	39.95
T_{8}- Control		24.03	2.59	2.29	3.05	0.36	28.67
S.Em±		1.74	0.31	0.35	0.31	0.03	1.93
C.D. at 5%		5.33	0.96	1.07	0.95	0.10	5.91
C.V.%		10.44	16.72	17.93	14.71	13.50	10.12

Fig.1 Effect of insecticides on chilli leaf curl disease incidence and fruit yield

Rabi, 2015-16 cropping season

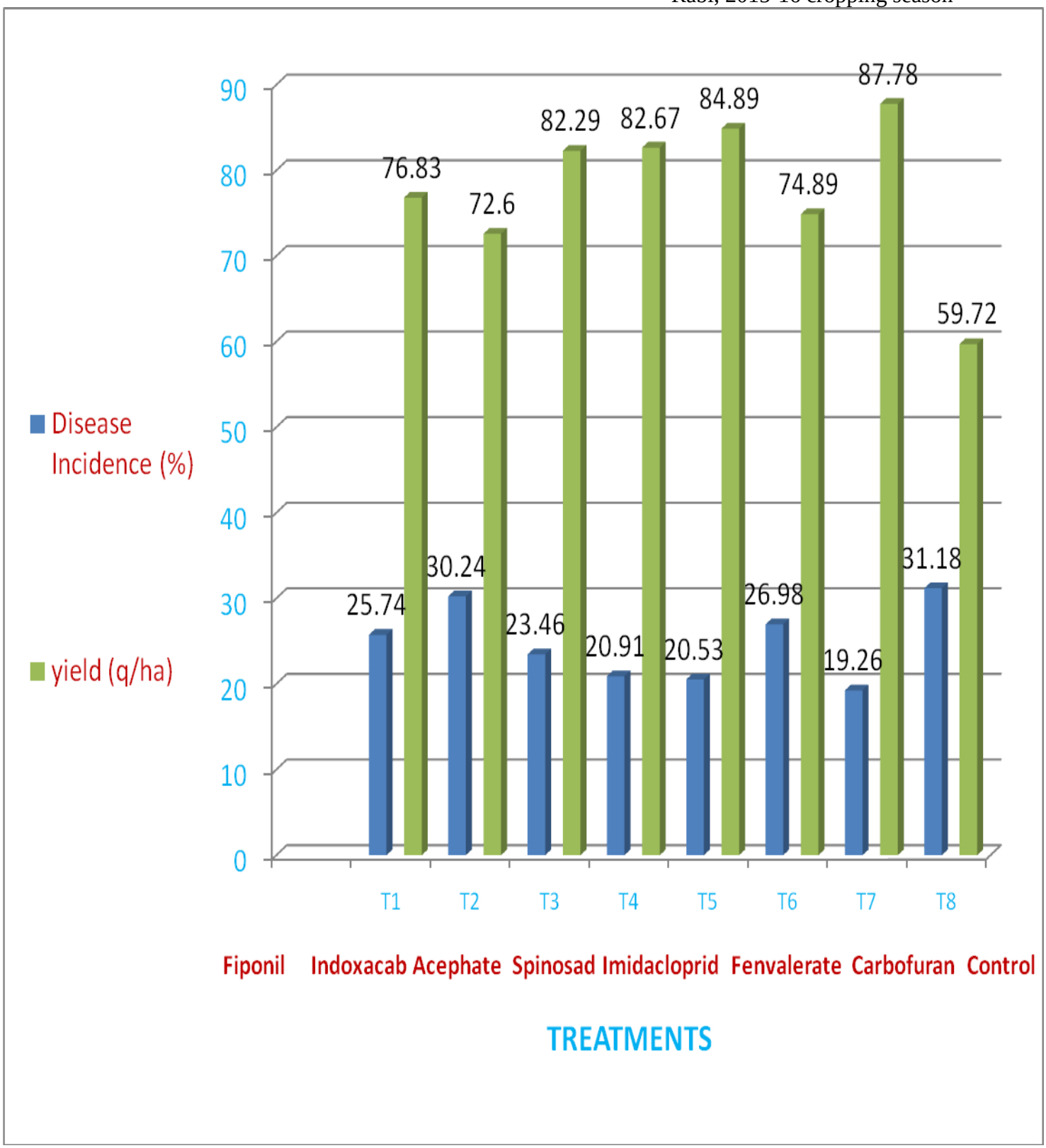
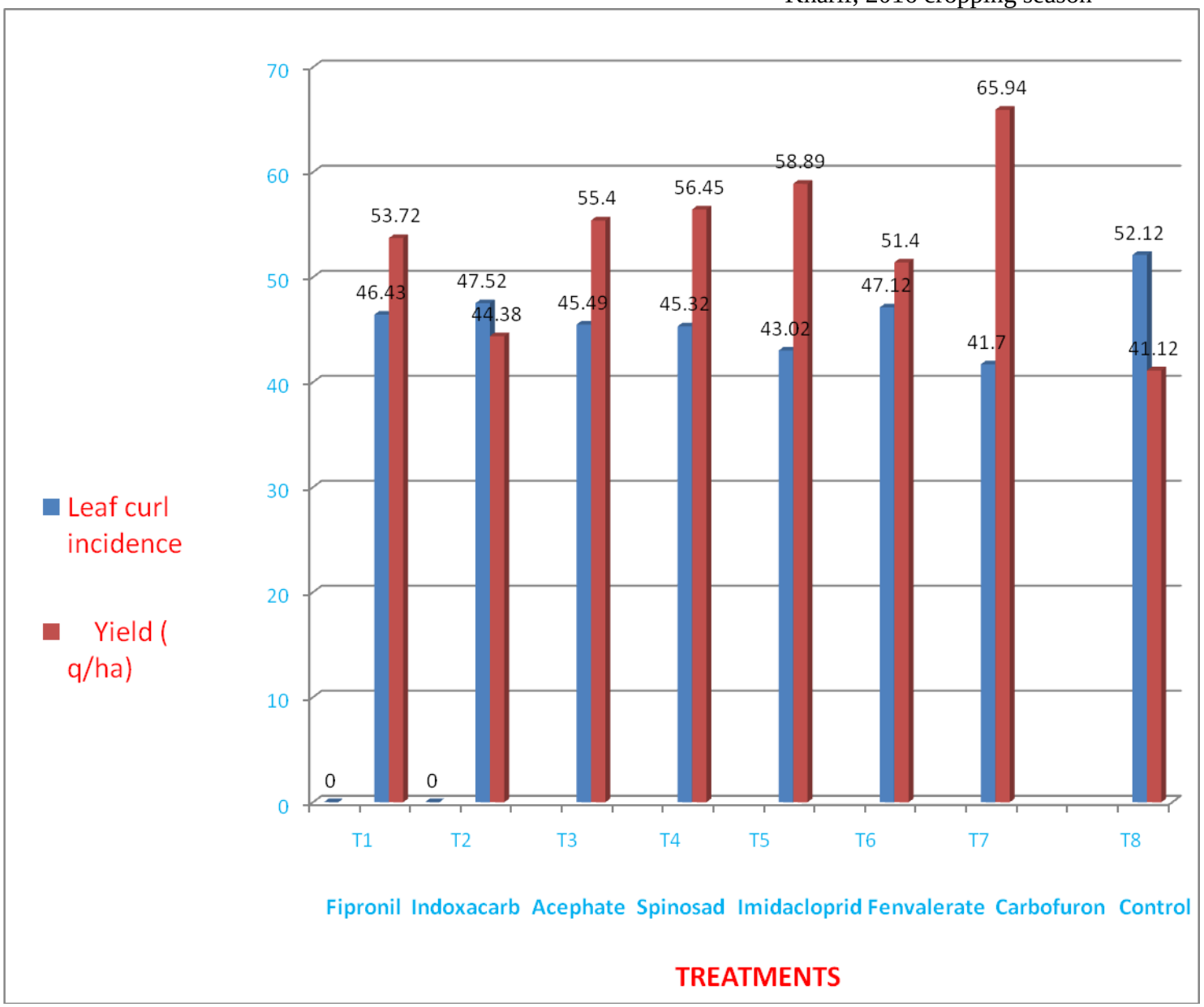


Fig.2 Effect of insecticides on leaf curl disease incidence and fruit yield of chilli Kharif, 2016 cropping season



The treatment T_5 (Imidacloprid) also recorded highest net return/ha of Rs. 23,479/- followed by three foliar sprays of Spinosad (T_4) which recorded net return/ha of Rs. 20,760/-. Lowest cost-benefit ratio (1:1.17) was recorded in (T_2) (Indoxacarb 14.5 % SC@ 400 ml/ha) (Table 2).

Observations recorded on the effect of insecticides on yield attributing characters have been presented in Table 3. During Rabi,2015-16 cropping season maximum mean plant height (60.26cm), mean no. of branches/plant (31.24), mean no. of fruits/plant (36.69), mean length/fruit (23.26cm), mean breadth/fruit (3.29cm), mean weight/plant (104.64gm) were recorded in T_7 (three times soil application of Carbofuran 3G @ 30 Kg/ha) which was statistically significant in comparison to

control. Mean weight/plant (104.64 gm) was also recorded maximum in treatment T_7 (three times soil application of Carbofuran 3G @ 30 Kg/ha) which was followed by T_5 (three sprays of Imidacloprid 17.8% SL @ 0.003%) (82.20 gm) and T_4 (three sprays with Spinosad 45% SC @ 160ml/ha) 80.52 gm but it was statistically non-significant. All these characters were found to be statistically significant except mean weight/plant which was statistically non-significant.

During Kharif 2016 cropping season, all the treatments reduced the disease incidence significantly in comparison to control. Minimum disease incidence (44.38 percent) was recorded by the treatment T_7 (soil application of Carbofuran 3G @ 30 Kg/ha) coupled with highest fruit yield of 65.94 q/ha. The treatment T_7 was statistically at par with treatment T_5 (three sprays of Imidacloprid 17.8% SL @ 0.003%) which recorded disease incidence of 46.61 % and fruit yield of 58.89 q/ha. Highest disease incidence (62.45 percent) and lowest yield of 41.12 q/ha was recorded in control. The treatment T_7 recorded maximum disease reduction overcontrol (28.94 percent) which was statistically superior to all other treatments followed by T5 (25.37 percent).

The increase in yield over control was highest in T7 (60.36 percent) followed by T5 (43.22 percent) (Table 4 and Fig. 2). Highest cost-benefit ratio of 1:11.60 was obtained when three sprays of Imidacloprid 17.8 % @0.003% was applied at an interval of ten days. This T_5 treatment also recorded net return/ha of Rs 15,840/- which was statistically superior to all other treatments followed by T4 (Spinosad 45 % SC @ 160 ml/ha) (1:6.00) recorded cost - benefit ratio of 1:6.00 and net return of Rs. 14,530/- per ha. Lowest cost benefit ratio (1:0.30) was recorded by three sprays of Indoxacarb 14.5% SC @ 400 ml/ha (T2) (Table 5). Maximum mean plant height (32.97 cm), mean number of branches per plant (4.50), mean number of fruits per plant (4.29), mean fruit length (4.65 cm), mean fruit breadth (0.63 cm) and mean fruit weight (39.95 g) were recorded by T7 (soil application of Carbofuran 3G @30 Kg/ha) followed by three sprays of Imidacloprid 17.8 % SL @ 0.003 % (T 5). These phenotypic characters were statistically significant (Table 6). Similar results were found by the earlier workers. Effectiveness of insecticidal sprays to lower disease development was on record (Nagaraju *et al.*, 1997; Salam, 2005; Borah, 1995; Chakraborti, 2000). Application of insecticides significantly improved the dry chilli yield than untreated control (No spray). Ahmad and Prasad (2010) indicated that insecticide use can reduce thrips and borer populations on chilli plants by over 95%, which leads to a doubling of yield in comparison to untreated plants. Rao *et al.,* (1984) evaluated eighteen insecticides for the control of pest complex of chilli, acephate was recommended as the most effective compounds against the chilli pest complex as a whole.

Patnaik *et al.,* (1985) found that fenvalerate resulted in the lowest damage index, with lowest incidence of *S. dorsalis* and highest fruit yield, followed by dimethoate. Hosmani (1993) mentioned that organic insecticides like, Fenvalerate (0.02%) has been found effective in controlling Chilli thrips, when sprayed 4-6 rounds at 15 days interval, commencing from three weeks after transplanting. The curative action showed by Carbofuran could be due to its growth promoting properties (Venugopal and Litsinger, 1980). It is also possible that Carbofuran or its metabolites may have acted as antiviral compound that inhibit the multiplication of the virus within the host as caused by dodecyle benzene sulphonate on tobacco mosaic virus in *Phaseolus vulgaris* (Watanabe *et al.,* 1982). The present

investigation revealed that three times soil application of Carbofuran 3G@ 30 Kg/ha was found to be best treatment for checking the vector activity of chili leaf curl disease complex resulting minimum disease incidence (19.26 and 44.38 percent) coupled with highest fruit yield of 87.78q/ha and 65.94 q/ha during Rabi 2015-16 and Kharif crop seasons, respectively than other treatments. This may be due to better protected nursery as well as the transplanted seedlings in the main field because of its systemic nature. The next affective treatment was Imidachloprid 17.8 % @ 0.003% which recorded disease incidence of 20.53 and 46.61percent and fruit yield of 84.89 q/ha and 58.89 q/ha followed by Spinosad 45 % SC @ 160 ml/ha (20.91 and 50.58 percent), Acephate 75 SC @ 0.1% (23.46 and 50.48 percent) disease incidence. The more or less similar findings were also reported earlier by other workers. Imidachloprid was the best for managing leaf curl disease in chilli and the correct dosage and the concentration are 500 - 750 ml/l and 1.0 ml/l, respectively (Anon. 1995).The investigation revealed that Imidacloprid at 0.003% concentration level was found to be best treatment for checking the vector of leaf curl disease incidence and reduced maximum percent disease than the other treatments (Pandey *et al.*, 2010). Vanisree *et al.*, (2013) reported that the insecticides Spinosad 0.015% proved most effective against *S. dorsalis* followed by Diafenthiuron 0.045%, Pymetrozine 0.02% and Fipronil 0.01%.

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