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Research Article

STUDIES ON DIFFERENT INSECTICIDES AGAINST APHID (*APHIS CRACCIVORA*) IN FENUGREEK

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Abstract: A field experiment was conducted at Instructional Farm, College of Agriculture, Junagadh Agricultural University, Junagadh during *Rabi*, 2019-20. The results revealed that out of ten treatments, flonicamid 50 WG, imidacloprid 17.8 SL and clothianidin 50 WDG were found highly effective for the control of aphid population. The maximum seed yield was obtained in plots treated with flonicamid 50 WG followed by imidacloprid 17.8 SL and clothianidin 50 WDG. The maximum ICBR was registered in imidacloprid 17.8 SL followed by dimethoate 30 EC and thiamethoxam 25 WG.

Keywords: *Insecticides, Aphid, Fenugreek*

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Introduction

Fenugreek, *Trigonella foenumgraecum* L. is leguminous crop belonging to the sub family Papilionaceae under the family Fabaceae. Fenugreek has been used both as a food or food additive as well as in medicines. In the Indian subcontinent, it is a common ingredient of innumerable recipes and is used as an herb as well as a spice. Dried leaves, either whole or ground, are called kasuri methi. Fenugreek is a rich source of minerals, protein as well as vitamin A and C. The major producers of fenugreek are India, Morocco, Spain, Turkey, China and Pakistan. In our country, it is mainly grown in, Uttar Pradesh, Madhya Pradesh, Gujarat and Rajasthan.

Rajasthan, which accounts about 75 to 85% of the total production. While in Gujarat, it is mainly grown in Banaskantha, Dahod, Patan and Mehsana districts and sporadically in Saurashtra region. In Gujarat, it is cultivated in about 14,963 hectares with total production of 28,923 Metric tonnes [1]. There are various factors responsible for reducing the crop yield [2]. Among the biotic and abiotic stresses, insect pests are considered as the most important factor. Among the all-infesting insect pests, aphid, *A. craccivora* is the major insect pest of fenugreek.

Among the above listed insect pests, aphid, *A. craccivora* is the major insect pest of fenugreek. It is a cosmopolitan, polyphagous species widely distributed in different habitats worldwide. This pest has a broad range of hosts and has been reported feeding on most of the pulse's crops.

It causes damage directly by physical contamination with their honeydew or indirectly by transmit viruses. Both nymphs and adults of aphid infest the crop either in colonies or individually by piercing their sharp needle like stylets into cells of plant for sucking the cell sap, resulting in curling of leaves or appearance of discoloured spots on the foliage. As aphids become more abundant at juvenile stage, the plant gradually wilts and leaves become yellowish to brownish resulting in to death of the plant. Higher population of aphid cause stunted growth and reduction in seed yield. Aphid attacks almost all parts of plant *i.e*., leaves, branches, stems, terminal shoots, flower, pods *etc*. Moreover, aphid excreted honeydew like sweet sugary substance that served as a medium to grow black fungus that interferes the photosynthesis process of the plants [3].

The importance of the fenugreek crop and the seriousness of the *A. craccivora*, it become necessary to have comprehensive information on different aspects of pest management. Hence, study was carried out on chemical management of aphid, *A. craccivora*, particularly under Junagadh condition.

Material and Methods

The seed of fenugreek variety "GM-2" was sown during Rabi-2019-20 in the plot measuring 3.0 m X 1.8 mkeeping. There were ten treatments including control, replicated four times. The field experiment was conducted in simple randomized block design (RBD). All the insecticides were applied as foliar spray with the help of high volume knapsack sprayer fitted with hollow cone nozzle.The sprayer was washed thoroughly prior to the application of subsequent treatments. The application of respective insecticides (Acetamiprid 0.008%, Imidacloprid 0.005%, Thiamethoxam 0.01%, Diafenthiuron 0.05%, Flonicamid 0.015%, Acephate 0.02%, Clothianidin 0.025%, Acephate + Imidacloprid 0.05% and dimethoate 0.03%) was sprayed after substantial aphid population was build up. The required quantity of insecticide was mixed in small quantity of water in a beaker and then added to the bucket containing required volume of water. The necessary care was taken to prevent the drift of pesticide to reach the adjacent plots. The observation on pest population was recorded from five randomly selected plants from the net area of each plot before spraying. Subsequently, the observation was recorded at 1, 3, 5, 7 and 9 days after spraying. The analysis of variance was worked out by using standard statistical procedures as described by Panse and Sukhatme (1985) [4]. Standard error of mean (S.E.m ±), critical difference (C.D.) at 5% probability and coefficient of variance (C.V. %) were also worked out for the interpretation of the results. The yield was converted on hectare basis. The percentage increase in yield over control was calculated by using following formula.

Yield increased (Percent) = 100 × [(T - C) / C]

Here,

T = Yield from treated plants (kg/ha)

C = Yield from untreated plants (kg/ha)

Table-1 *Bio-efficacy of various chemical treatments on aphid, A. craccivora infesting fenugreek after first spray*

SN	Treatment	Conc. (%)	Population of aphid as per aphid index (A.I.)						
			Before spray	1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	Pooled over period
T_1	Acetamiprid 20 SP	0.008%	1.68(2.84)	1.56(2.44)	1.55(2.42)	1.44(2.07)	1.39(1.93)	1.46(2.13)	1.48(2.19)
T_2	Imidacloprid 17.8 SL	0.005%	1.67(2.78)	1.39(1.93)	1.28(1.64)	1.16(1.34)	1.12(1.24)	1.22(1.49)	1.23(1.52)
T_3	Thiamethoxam 25 WG	0.01%	1.68(2.83)	1.46(2.14)	1.37(1.88)	1.26(1.59)	1.22(1.49)	1.30(1.68)	1.32(1.75)
T_4	Difenthiuron 50 WP	0.05%	1.70(2.88)	1.64(2.68)	1.59(2.53)	1.53(2.33)	1.51(2.29)	1.55(2.39)	1.56(2.44)
T_5	Flonicamid 50 WG	0.015%	1.69(2.84)	1.30(1.69)	1.14(1.30)	1.00(1.00)	0.97(0.94)	1.11(1.24)	1.10(1.22)
T_6	Acephate 75 SP	0.02%	1.70(2.88)	1.69(2.84)	1.67(2.80)	1.64(2.69)	1.63(2.64)	1.66(2.74)	1.66(2.74)
T_7	Clothianidin 50 WDG	0.025%	1.68(2.84)	1.41(1.99)	1.32(1.74)	1.18(1.39)	1.14(1.29)	1.24(1.53)	1.26(1.58)
T_8	Acephate 50% + Imidacloprid 1.8 % 51 SP	0.05%	1.70(2.89)	1.67(2.80)	1.64(2.69)	1.61(2.58)	1.59(2.53)	1.62(2.63)	1.63(2.65)
T_9	Dimethoate 30 EC	0.03%	1.65(2.74)	1.52(2.30)	1.48(2.19)	1.37(1.89)	1.33(1.77)	1.41(1.98)	1.42(2.02)
T_{10}	Control (Water spray)	-	1.68(2.83)	1.70(2.88)	1.68(2.84)	1.67(2.79)	1.70(2.89)	1.69(2.85)	1.69(2.85)
S.Em.±		T	0.0689	0.0640	0.0690	0.0641	0.0639	0.0632	0.027
		P	-	-	-	-	-	-	0.021
		T x P	-	-	-	-	-	-	0.065
C.D. at 5%		T	NS	0.1857	0.2002	0.1860	0.1854	0.1834	0.076
		P	-	-	-	-	-	-	-
		T x P	-	-	-	-	-	-	NS
C.V. %			8.18	8.35	9.37	9.25	9.41	8.87	9.04

Note: Figures in parentheses are retransformed values of √x+0.5 , DAS = Days After spray

Table-2 *Bio-efficacy of various chemical treatments on aphid, A. craccivora infesting fenugreek after second spray*

SN	Treatment	Conc. (%)	Population of aphid as per aphid index (A.I.)					
			1 DAS	3 DAS	5 DAS	7 DAS	9 DAS	Pooled over period
T_1	Acetamiprid 20 SP	0.008%	1.45(2.11)	1.40(1.96)	1.29(1.67)	1.24(1.53)	1.33(1.78)	1.34(1.81)
T_2	Imidacloprid 17.8 SL	0.005%	1.20(1.44)	1.13(1.27)	0.99(0.99)	0.94(0.89)	1.07(1.14)	1.07(1.14)
T_3	Thiamethoxam 25 WG	0.01%	1.30(1.69)	1.24(1.53)	1.13(1.28)	1.09(1.18)	1.19(1.42)	1.19(1.41)
T_4	Difenthiuron 50 WP	0.05%	1.58(2.49)	1.55(2.39)	1.51(2.29)	1.48(2.19)	1.49(2.23)	1.52(2.32)
T_5	Flonicamid 50 WG	0.015%	1.09(1.19)	0.99(0.99)	0.86(0.75)	0.80(0.64)	0.97(0.95)	0.94(0.89)
T_6	Acephate 75 SP	0.02%	1.63(2.64)	1.61(2.60)	1.60(2.55)	1.58(2.50)	1.56(2.45)	1.60(2.55)
T_7	Clothianidin 50 WDG	0.025%	1.24(1.54)	1.16(1.34)	1.02(1.04)	0.95(0.89)	1.12(1.24)	1.10(1.20)
T_8	Acephate 50% + Imidacloprid 1.8 % 51 SP	0.05%	1.61(2.60)	1.58(2.49)	1.56(2.44)	1.53(2.35)	1.51(2.29)	1.56(2.43)
T_9	Dimethoate 30 EC	0.03%	1.39(1.94)	1.33(1.78)	1.26(1.59)	1.22(1.50)	1.28(1.65)	1.30(1.69)
T_{10}	Control (Water spray)	-	1.65(2.74)	1.64(2.69)	1.64(2.69)	1.61(2.59)	1.59(2.54)	1.63(2.65)
S.Em.±		T	0.0604	0.0670	0.0603	0.0578	0.0569	0.026
		P	-	-	-	-	-	0.019
		T x P	-	-	-	-	-	0.061
C.D. at 5%		T	0.1753	0.1944	0.1750	0.1677	0.1651	0.071
		P	-	-	-	-	-	-
		T x P	-	-	-	-	-	NS
C.V. %			8.55	9.83	9.37	9.30	8.67	9.15

Figures in parentheses are retransformed values of √x+0.5, DAS = Days After Spray

Economic of all the treatments was worked out by considering the price of products, cost of insecticides and labour charges. Incremental cost benefit ratio (ICBR) was worked out to compare the economics of different insecticidal treatments.

Results and Discussion

First spray

1 DAS

Among the different nine insecticides, flonicamid 50 WG 0.015% was recorded the lowest (1.69 A.I./plant) population of aphid to the rest of the treatments. However, it was at par with imidacloprid 17.8 SL 0.005% (1.93 A.I./plant), clothianidin 50 WDG 0.025% (1.99 A.I./plant) and thiamethoxam 25 WG 0.01% (2.14 A.I./plant).

3 DAS

The lowest population of aphid (1.30 A.I./plant) was noticed in plots receiving treatment, flonicamid 50 WG. However, it was at par with imidacloprid 17.8 SL (1.64 A.I./plant) and clothianidin 50 WDG (1.74 A.I./plant).

5 DAS

The treatment of flonicamid 50 WG maintain its significant superiority (1.00 A.I./plant) and also found at par with imidacloprid 17.8 SL (1.34 A.I./plant) and clothianidin 50 WDG (1.39 A.I./plant).

7 DAS

Among the different insecticides, flonicamid 50 WG was proved to be most effective as it recorded the lowest (0.94 A.I./plant) population of aphid to the rest of the treatments.

9 DAS

The treatment of flonicamid 50 WG was proved to be most effective as it recorded the lowest (1.24 A.I./plant) population of aphid to the rest of the treatments. The pooled data (pooled over period) of first spray presented in [Table-1] indicates that all the treatments had significantly reduced the aphid population. Among them the insecticide, flonicamid 50 WG (1.22 A.I./plant) were found superior to the rest of the treatments. The next best treatments was imidacloprid 17.8 SL (1.52 A.I./plant), which was at par with clothianidin 50 WDG (1.58 A.I./plant). The treatment was next in order thiamethoxam 25 WG (1.75 A.I./plant). Further, dimethoate 30 EC (2.02 A.I./plant) and acetamiprid 20 SP (2.19 A.I./plant) treatments were found at par with each other and less effective. Rest of the treatments *viz*., difenthiuron 50 WP (2.44 A.I./plant), acephate 50% + imidacloprid 1.8 % 51 SP (2.65 A.I./plant) and acephate 75 SP (2.74 A.I./plant) were found least effective and recorded highest aphid population.

Based on results of pooled over period, damage due to aphid was effectively managed by chemical treatments like flonicamid 50 WG, imidacloprid 17.8 SL, clothianidin 50 WDG and thiamethoxam 25 WG was found effective than the other treatments.

Table-3 *Effect of various chemical treatments on fenugreek seed yield*

Sr. No.	Treatments	Seed yield (kg/ha)	Yield Increase over control	Percent increase in yield over control (%)
T_1	Acetamiprid 20 SP	1310	247	23.35
T_2	Imidacloprid 17.8 SL	1531	468	44.12
T_3	Thiamethoxam 25 WG	1432	369	34.80
T_4	Difenthiuron 50 WP	1185	122	11.48
T_5	Flonicamid 50 WG	1607	544	51.26
T_6	Acephate 75 SP	1082	19	1.82
T_7	Clothianidin 50 WDG	1523	460	43.35
T_8	Acephate 50% + Imidacloprid 1.8 % 51 SP	1125	62	5.88
T_9	Dimethoate 30 EC	1399	336	34.65
T_{10}	Control	1063	0.00	0.00
S. Em. ±		53.57	-	-
C.D. at 5%		155.35	-	-
C. V. (%)		8.07	-	-

1.Treatment mean with letter(s) in common are not significant at 5 % level of significance within a column
2. Yield increased over control = Yield of treatment – Yield of control , 3. Per cent yield increased over control = [(Yield of treatment – Yield of control) / Yield of control] X 100

Table-4 *Economics of various chemical treatments combinations evaluated against aphid, A. craccivora on fenugreek*

Treatments	No. of Sprays	Quantity of insecticides for two sprays (gm or ml/ha	Cost of insecticide for two spray (Lit. or kg)	Cost of labour for two spray (ha)	Total cost of plant protection for two sprays (ha)	Yield (kg/ha)	Yield increase over control (kg/ha)	Gross realization (₹/ha)	Net realization (₹/ha)	ICBR
1	2	3	4	5	6	7	8	9	10	11
Acetamiprid 20 SP	2	110	350	900	1250	1310	247	14,820	13,570	01:11.9
Imidacloprid 17.8 SL	2	76	650	900	1550	1531	468	28,080	26,530	01:18.1
Thiamethoxam 25 WG	2	110	550	900	1450	1432	369	22,140	20,690	01:15.2
Difenthiuron 50 WP	2	270	1670	900	2570	1185	122	7,320	4,750	01:02.9
Flonicamid 50 WG	2	80	1440	900	2340	1607	544	32,640	30,300	01:14.0
Acephate 75 SP	2	270	450	900	1350	1082	19	1,140	-210	01:00.8
Clothianidin 50 WDG	2	80	2400	900	3300	1523	460	27,600	24,300	01:08.3
Acephate 50% + Imidacloprid 1.8 % 51 SP	2	405	655	900	1555	1125	62	3,720	2,165	01:02.4
Dimethoate 30 EC	2	270	245	900	1145	1399	336	20,160	19,015	01:17.6
Control	2	-	-	-	-	1063	-	-	-	-

Market price of fenugreek seeds: 60 ₹/kg, labour cost: 450 ₹/ha (Two spray) 900 ₹/ha

Second spray

1 DAS

The aphid population recorded at 24 hours after second spray, clearly indicated that it was significantly decreased in all the treated plots over untreated check. Among the tested different insecticides, flonicamid 50 WG found significantly superior (1.19 A.I./plant) to the rest of the treatments. However, it was at par with imidacloprid 17.8 SL (1.44 A.I./plant) and clothianidin 50 WDG (1.54 A.I./plant).

3 DAS

The lowest population of aphid (0.99 A.I./plant) was noticed in plots receiving treatment, flonicamid 50 WG. However, it was at par with imidacloprid 17.8 SL (1.27 A.I./plant) and clothianidin 50 WDG (1.34 A.I./plant).

5 DAS

The flonicamid 50 WG was found significant superior (0.75 A.I./plant) and It was statistically at par with imidacloprid 17.8 SL (0.99 A.I./plant) and clothianidin 50 WDG (1.04 A.I./plant).

7 DAS

The lowest (0.64 A.I./plant) population of aphid was recorded in flonicamid 50 WG (0.64 A.I./plant) than the rest of the treatments.

9 DAS

The flonicamid 50 WG was proved to be most effective as it recorded the lowest (0.95 A.I./plant) population of aphid to the rest of the treatments, it was also found at par with imidacloprid 17.8 SL (1.14 A.I./plant) and clothianidin 50 WDG (1.24 A.I./plant).

The pooled data (pooled over period) of second spray presented in [Table-2] indicates that all the treatments had significantly reduced the aphid population. Among them the insecticide, flonicamid 50 WG (0.89 A.I./plant) were found superior to the rest of the treatments. The next best treatments were imidacloprid 17.8 SL (1.14 A.I./plant), which was at par with clothianidin 50 WDG (1.20 A.I./plant). The treatment was next in order thiamethoxam 25 WG (1.41 A.I./plant). Further, dimethoate 30 EC (1.69 A.I./plant) and acetamiprid 20 SP (1.81 A.I./plant) treatments were found at par with each other and less effective. Rest of the treatments *viz*., difenthiuron 50 WP (2.32 A.I./plant), acephate 50% + imidacloprid 1.8 % 51 SP (2.43 A.I./plant) and acephate 75 SP (2.55 A.I./plant) were found least effective and recorded highest aphid population. Based on results of pooled over period, damage due to aphid was effectively managed by chemical treatments like flonicamid 50 WG, imidacloprid 17.8 SL, clothianidin 50 WDG and thiamethoxam 25 WG was found effective than the other treatments.

The obtained result from chemical treatments were close conformity with the earlier workers as Sarvaiya and Patel (2018) [5] revealed that the treatment flonicamid 0.015% proved to be most effective in suppressing the aphid population followed by thiamethoxam 0.01% and imidacloprid 0.014%. The efficacy in % reduction of aphid over control clearly indicated that imidacloprid 17.5 SL @ 50 g a.i./ha (56.62%) and dimethoate 30 EC @ 300 g a.i./ha (55.60%) were superior than the rest of chemicals [6]. Treatment imidacloprid 0.005 per cent (0.19 aphid index/plant) was found to be most effective followed by thiamethoxam 0.01 per cent (0.33 aphid index/plant) [7]. The maximum reduction in aphid population (77.64%) was recorded in imidacloprid 0.005 percent treatment which was at par with thiamethoxam 0.005 percent which resulted in 74.16 percent reduction [8]. These are directly or indirectly correlated with present studies.

Yield

The highest seed yield (1607 kg/ha) was recorded in the treatment of flonicamid 50 WG [Table-3]. However, it was at par with imidacloprid 17.8 SL (1531 kg/ha) and clothianidin 50 WDG (1523 kg/ha). The next best treatment was thiamethoxam 25 WG (1432 kg/ha), which was at par with dimethoate 30 EC (1399 kg/ha) and acetamiprid 20 SP (1310 kg/ha). The treatments of difenthiuron 50 WP, acephate 50% + imidacloprid 1.8 % 51 SP and acephate 75 SP recorded lower *i.e*., 1185, 1125 and 1082 kg/ha seed yield.

Percent increase in yield over control

The maximum percent increase yield over control [Table-3] was found in application of flonicamid 50 WG (51.26%) followed by imidacloprid 17.8 SL (44.12%) and clothianidin 50 WDG (43.35%). The treatment found next in order in respect of the per cent increase in yield over control were thiamethoxam 25 WG (34.80%), dimethoate 30 EC (31.65%) and acetamiprid 20 SP (23.25%).

Even though the yield increase over control was very low in the treatments *viz*.,difenthiuron 50 WP, acephate 50% + imidacloprid 1.8 % 51 SP and acephate 75 SP as they increase the yield in range of 1.82 to 11.48 percent.

Economics

The details of net realization calculated for different chemical treatments are presented in [Table-4]. The maximum (₹ 30,300/ha) net realization was found in the treatment of flonicamid 50 WG followed by imidacloprid 17.8 SL 26,530/ha), clothianidin 50 WDG (₹ 24,300 /ha), thiamethoxam 25 WG (₹ 20,690/ha), dimethoate 30 EC (₹ 19,015/ha) and acetamiprid 20 SP (₹ 13,570/ha). While, the minimum realization was obtained from the difenthiuron 50 WP (₹ 4,750/ha) followed by acephate 50% + imidacloprid 1.8 % 51 SP (₹ 2,165/ha) and acephate 75 SP (₹ -210/ha). The details of Incremental Cost Benefit Ratio (ICBR) calculated for different treatments are presented in [Table-4]. The maximum (1: 18.12) ICBR was registered in imidacloprid 17.8 SL followed by dimethoate 30 EC (1: 17.61), thiamethoxam 25 WG (1: 15.17), flonicamid 50 WG (1: 13.95), acetamiprid 20 SP (1: 11.86) and clothianidin 50 WDG (1: 8.30). While, the lowest ICBR was recorded in the plot treated with difenthiuron 50 WP (1: 2.85) followed by acephate 50% + imidacloprid 1.8 % 51 SP (1: 2.39) and acephate 75 SP (1: 0.84). From the above obtained results, it can be concluded that the treatments *viz*., imidacloprid 17.8 SL, dimethoate 30 EC, thiamethoxam 25 WG, flonicamid 50 WG and acetamiprid 20 SP were economical as compared to the other treatments.

Conclusion

It can be concluded that the treatments of imidacloprid, dimethoate, thiamethoxam and flonicamid were found superior than rest of the chemical treatments and these treatments can be recommended for effective and economical control of *A. craccivora* infesting fenugreek. From the overall results of the present investigation, it can be concluded that the aphid was firstly appeared in 1st week of January and attained peak level during last week of January then, decreasing and disappeared with maturity of crop from 4th week of February. Bright sunshine hours (BSS) observed positive significant correlation [0.382*] with aphid population. Among tested seven bio-rational treatments, azadirachtin 10000 ppm found most effective.

The maximum seed yield and ICBR was recorded in the treatment of azadirachtin 10000 ppm (1512 kg/ha & 1: 15.43). Among the tested nine chemical treatments, flonicamid 50 WG found most effective and also recorded the maximum seed yield (1607 kg/ha). The treatment imidacloprid 17.8 SL recorded the maximum ICBR (1: 18.12)

Application of research: Study showed maximum seed yield and ICBR was recorded in the treatment of azadirachtin.

Research Category: Agricultural Entomology

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Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Instructional Farm, College of Agriculture, Junagadh

Cultivar / Variety / Breed name: Fenugreek, *Trigonella foenumgraecum* L.

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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