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Influence of aphids *Aphis craccivora* on yield parameters of lucerne (*Medicago sativa* L.) and their management with different IPM components

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Abstract
Aphids *Aphis craccivora* significantly influenced per cent pod set, germination per cent, green forage yield, dry matter yield and seed yields. Aphids were responsible for reduction of 12.06 per cent seed yield and 13.14 per cent green forage yield. In the present experiment, among the different IPM components tested, insecticide imidacloprid @ 0.3 ml/L, acephate @ 1g/L and acetamiprid @ 1 g/L were superior over conventional insecticides used. Entomopathogenic fungi *Beauveria bassiana* @5g/L, *Verticilium lecanii*@5g/L, predator *Coccinella septumpunctata* @ 10/m^2 and *Neem* formulation (3,000 ppm) @ 2 ml/L were equally effective in managing aphid population. There was a strong positive correlation between aphid population and coccinellid predators (0.948). All the biological agents and *Neem* formulation were safe against natural enemies in comparison to insecticides. Among insecticides, field dosages of acephate, acetamiprid and imidacloprid were found safer to coccinellid predators compared to laboratory dosages.

Keywords: Aphids, IPM, Lucerne, Management, Predators

Alfalfa (*Medicago sativa* L.) or lucerne is the world's most important forage legume and a key component of many crop rotation systems (Osborn *et al*., 1997). Alfalfa is widely grown throughout the world as forage for cattle, and is most often harvested as hay, but can also be made into silage, grazed, or fed as green chop. Alfalfa has the highest feeding value of all common hay crops, being used less frequently as pasture. When grown on soils where it is well-adapted, alfalfa is the highest yielding forage plant. As a perennial crop, lucerne has a lifespan approaching 5 years, but in some areas of the world fields may remain productive for considerably longer (Summers, 1998). Such a long stand life affords ample time for the establishment and development of a diverse community structure by an abundance of organisms. In spite of system perturbations caused by frequent harvests and occasional pesticide applications, a lucerne field provides a temporal stability which is uncommon among field crops. While most of lucerne's inhabitants have little or no impact on it as a crop, a few are capable of causing extensive damage. Arthropods, plant pathogens, weeds, vertebrates, and plant parasitic nematodes can all cause significant yield and/or quality reductions and frequently contribute to shortening the productive life of the stand.

Alfalfa is considered an insectary due to the large number of insects it attracts. Over 1000 species of arthropods have been observed in Alfalfa fields. Of these fewer than 20 causes injury, and fewer still are serious pests. Some pests, such as alfalfa weevil, aphids, armyworms, and the potato leaf hopper, can reduce alfalfa yields dramatically, particularly with the second cutting when weather is warmest. Although only a few species infest alfalfa, they can cause substantial yield and quality losses if present in high numbers. An effective pest management programme can significantly reduce the losses caused by these pests (Summers *et al.,* 2007).

Aphids *Aphis craccivora* is a phloem feeding serious insect pest that damage lucerne crop throughout the world. They are gaining importance during summer months, in southern and western India. As it feeds on phloem, the leaves infested with aphids had lower concentration of crude protein and true *in vitro* digestible dry matter and decreased nutritive value of leaves and stems. Chemical controls are sometimes used to prevent them in popularly grown commercial varieties like Anand-2 and RL-88.

Different IPM components namely entomopathogens, predator, *Coccinella septumpunctata*, *Neem* formulation and insecticides were tested on aphids *Aphis craccivora* at recommended dosages in a randomized block design filed experiment replicated three times. Size of the exper-

-imental plot was 3x4 m and total of eleven treatments were used in this experiment (Table 1). All the treatments were imposed in 2014-15 and again in 2015-16 and later pooled analysis were made to know the efficacy of different treatments. Population of aphids was counted before the start of an experiment and the count after treatment was taken at 3, 7 and 14 days. Observation on seed yield (kg/ha), dry matter yield (t/ha) and green forage yield (t/ha) was recorded.

Table 1. Infestation scale and response of insecticides on aphids *Aphis craccivora* (two years pooled data)

Treatment	Dosage	3 DAT	7 DAT	14 DAT
Acephate	1 g/L	45.66	32.00	25.33
Imidacloprid	0.30 ml/L	36.33	26.33	19.66
Acetamiprid	0.25 g/L	37.66	33.33	23.66
Quinolphos	2 ml/L	63.00	44.99	36.33
Dimethoate	1.5 ml/L	56.66	44.00	34.33
Beauveria bassiana	5ml/L	63.33	45.33	37.66
Verticilium lecanii	5ml/L	61.66	41.66	37.66
Neem formulation	2 ml/L	60.33	40.00	36.66
Coccinella septumpunctata	5/ mt^2	61.99	43.66	38.33
Water spray	-	73.66	63.33	53.33
Control	-	86.33	65.00	58.33
CV	-	4.80	7.50	6.8
CD (P<0.05)	-	4.9	4.46	3.55
SEm±	-	2.55	2.59	1.25

*DAT= Days after treatment

Pupae of the *C. sexmaculata* were collected in large numbers from lucerne field. Adults emerged on a single day were transferred to a separate glass jar to ensure the uniformity of age and these were used for testing the toxicity of insecticides. The desired concentration of each insecticide prepared by taking the known quantity of insecticides on w/v basis and dissolved in 1000 ml distilled water. Mortality was recorded at 4, 8, 12, 24, 48 and 72 h after spray. The average per cent mortality of adults was worked out for each treatment. The mortality data obtained were further corrected by using Abbott's formula as given below (Abbott, 1925).

$$\text{Corrected mortality percentage} = \frac{\text{Per cent mortality in treatment} - \text{per cent mortality in control}}{100 - \text{per cent mortality in control}}$$

Effect of different IPM components on pollinators under field conditions was assessed based on the pollinators' population at 3, 7 and 14 days after treatment.

The efficacy of different IPM components under field conditions during 2014-15 and 2015-16 was evaluated. Population of aphids was evenly distributed before the start of an experiment and the difference in the population was non-significant during both the seasons. However, all the treatments shown significant effect in reducing the aphid population (Table 1) on 3, 7 and 14 days after treatment (DAT). All the insecticides showed their significance within three days of treatment whereas; biological agents started showing their significance after 7 days of treatment. Among insecticides imidacloprid @ 0.3 ml/L was the most important treatment in reducing the aphid population followed by acephate @ 1 g/L and acetamiprid @ 0.25 g/L. All these three insecticides were superior to their older counterparts *i.e.*, quinolphos @ 2 ml/L and dimethoate 1.5 ml/L. Among alternate safe components *Beauveria bassiana* @5 ml/L, *Verticilium lecanii* @5 ml/L, *Coccinella septumpunctata* @ 5/ m^2

Table 2. Fodder and seed yield parameters in lucerne as influenced by IPM components

Treatment	Dosage	Green forage yield (t/ha)	Dry matter yield (t/ha)	Seed yield (kg/ha)
Acephate	1 g/L	46.20	12.00	191.20
Imidacloprid	0.30 ml/L	42.40	12.60	200.60
Acetamiprid	0.25 g/L	45.60	12.80	193.40
Quinolphos	2 ml/L	39.20	10.20	178.40
Dimethoate	1.5 ml/L	40.20	10.60	176.20
Beauveria bassiana	5ml/L	40.20	10.40	173.20
Verticilium lecanii	5ml/L	39.00	10.90	175.40
Neem formulation	2 ml/L	40.60	10.80	172.00
Coccinella septumpunctata	5/ mt^2	40.10	10.60	174.60
Water spray	-	34.20	9.20	153.20
Control	-	33.00	9.00	150.50
CV	-	8.20	7.20	8.40
CD (P<0.05)	-	5.40	1.20	6.80
SEm±	-	1.84	0.62	2.30

and *Neem* formulation @ 2 ml/L were at par with each other in reducing the aphid population (Table 1). Water spray alone was the most inferior treatment among all, however, it was proved effective over control. All the treatments recorded significantly higher green fodder and dry matter yields over control (Table 2). Higher seed yield (200.6 kg/ha) was recorded in imidacloprid followed by acetamiprid (193.4 kg/ha) and acephate (191.2 kg/ha).

Correlation studies (Table 3) proved that there was a strong relationship (0.948) between the aphids population and its natural predator *Coccinella septumpunctata,* which indicated predator needs aphid population for its survival. Both aphids and its predators were active when the weather is warm and their existence was negatively affected by minimum temperature and maximum relative humidity. A degree day model has been reported by Singh *et al*. (2017) for predicting the occurrence of aphids in lucerne. Rainfall was also negatively correlated with the population of aphids and its predator coccinellids (Table 3). Per cent mortality of predator *Coccinella septumpunctata* to different pesticides under laboratory conditions indicated that all the insecticides at the recommended dosages were detrimental to the predator *Coccinella septumpunctata* whereas, *Neem* formulation nimbicidine 0.03% @ 5 ml/L was moderately toxic. However, both the entomopathogens *Beauveria bassiana* and *Verticilium lecanii* @ 5 g/L were proved to be safe and not pathogenic to the predator *Coccinella septumpunctata* (Table 4). Rajagopal and Kareem (1983) observed higher toxicity of imidacloprid to *Coccinella eptumpunctata.* Safavi *et al*. (2002) reported that Vertalec, a commercial product of *Verticillium lecanii,* could be an effective agent against pea aphids. Further studies were recommended for its evaluation under natural conditions.

Effect of different IPM components on pollinators under field conditions (Table 5) indicated that pollinators were not seen within three days after insecticides spray and they returned to foraging only after fourteen days after spray. This might be due to insecticides either might have killed the pollinators or they might have repelled the bees from foraging. Whereas in case of neem sprayed plots and also in other biological control treated plots it didn't made any difference in the bee activity even after three days of spraying, which indicated that all the biological control agents were safe to the bees. Systemic insectic-

Table 3. Correlation coefficient between weather parameters with coccinellids and aphids

Attributes	Coccinellids	Aphids	Max. temp (^{0}C)	Min. temp (^{0}C)	Max. RH (%)	Min.RH (%)	Rainfall
Coccinellids	-	0.948**	0.302	-0.575**	-0.642**	-0.546*	-0.508*
Aphids	0.948**	-	0.282	-0.569**	-0.616**	-0.527*	-0.479*

*(P≤0.05); ** (P≤0.01)

Table 4. Per cent mortality of predator *Coccinella septumpunctata* to different pesticides under laboratory conditions

Pesticides	Dosage	Percent mortality after treatment at					
		4 hours	8 hours	12 hours	24 hours	48 hours	72 hours
Acephate	1 g/L	63.33 (53.07)*	73.33 (59.00)	80.00 (63.93)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Imidacloprid	0.3 ml/L	56.67 (48.85)	56.67 (48.85)	60.00 (50.85)	73.33 (59.00)	80.00 (63.93)	100.00 (90.00)
Acetamiprid	1 g/L	63.33 (53.07)	63.33 (53.07)	73.33 (59.00)	80.00 (63.93)	100.00 (90.00)	100.00 (90.00)
Quinolphos	2 ml/L	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Dimethoate	1.7ml/L	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
Nimbicidine 0.03%	5ml/L	56.67 (48.85)	56.67 (48.85)	60.00 (50.85)	60.00 (50.85)	63.33 (53.07)	63.33 (53.07)
Beauveria bassiana	5 g/L	0.00	0.00	0.00	0.00	0.00	0.00
Verticilium lecanii	5 g/L	0.00	0.00	0.00	0.00	0.00	0.00
Water spray	-	0.00	0.00	0.00	0.00	0.00	0.00
SEm±		3.30	2.98	2.94	1.38	1.77	2.02
CD (P<0.01)		11.72	10.10	09.95	5.78	7.42	8.21

*Figures in parenthesis are arcsine transformed values

Table 5. Effect of different IPM components on pollinators under field conditions

Treatment	Pre count of pollinators	Post count of pollinators after 3 DAT	Post count of pollinators after 7 DAT	Post count of pollinators after 14 DAT
Acephate	6.66	0.00	1.33	7.00
Imidacloprid	6.00	0.00	1.66	7.33
Acetamiprid	6.66	0.00	0.99	7.66
Quinolphos	6.66	0.00	1.33	7.00
Dimethoate	7.00	0.00	1.66	7.00
Beauveria bassiana	6.33	7.33	7.00	7.33
Verticilium lecanii	6.66	7.00	7.00	7.66
Neem formulation	6.33	7.66	6.66	7.00
Coccinella septumpunctata	6.66	7.66	6.66	7.33
Water spray	6.66	7.00	6.66	7.66
Control	6.33	7.66	7.00	7.33
CV	8.40	8.10	8.30	8.10
CD (P<0.05)	NS	0.52	0.92	NS
SEm±	1.30	1.64	2.98	1.40

DAT= Days after treatment

-ides, such as neonicotinoids were more toxic and persistent than the majority of organophosphorus insecticides (Bayo and Goka, 2016). Safety of entomopathogens to honey bees was reported by Vandenburgi (1990). However, Sihag (1988) reported that both protective application of pesticides and use of bee pollination were essential for maximum crop yields.

It was concluded that even though insecticides were the most effective treatment for the management of aphids, they had detrimental effects on the population of predators *Coccinella septumpunctata* and pollinators. Use of other safe alternative methods like *Neem* formulations, entomopathogenic fungi *Beauveria bassiana* and *Verticilium lecanii* and releasing of predator *Coccinella septumpunctata* played a promising role in IPM of aphids. Insecticides could be avoided during the blooming and when the predator population was highest and might be used only after outweighing the benefits of insecticides spraying.

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