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Incremental cost-benefit ratio of certain pesticides against *Aphis gossypii* (Glover) (Aphididae: Hemiptera) in cotton

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Abstract
Higher yield of seed cotton (1505.14 Kg/ha) was obtained from foliar application of thiamethoxam 25WG@ 0.125 Kg/ha followed by acetamiprid 20 SP @ 0.05 Kg/ha in which 1443.27kg/ha of yield was recorded. Based on two consecutive years data analysis, highest Incremental cost-benefit ratios (ICBRs) were computed in the plot treated with thiamethoxam 25WG@ 0.125 Kg/ha (12.97) and acetamiprid 20 SP @ 0.05 Kg/ha (1:12.92) in the year 2018 and but during the year 2019 highest ICBRs were computed in the plots sprayed with imidacloprid 17.8 SL @ 0.112 L/ha (1:15.98) and thiamethoxam 25WG@ 0.125 Kg/ha (12.97) respectively.

Keywords: cotton, *Aphis gossypii* (Glover) and ICBR

Introduction
Cotton is most important commercial crop known as "king of fibers" and world over commonly referred as "white gold" that belongs to family Malvaceae and the genus Gossypium. It plays a pivotal role in employment and strengthening economy of 76 countries across the world. Cotton directly impact on 60 million farmers of India and several millions of people which employing in processing, textile industry and trade. Cotton's fiber is used as an important raw material for textile industry that contributes nearly 4% of GDP of India. Cotton seed is used for cattle feed and to make cooking oil which contribute about 8% of the world's vegetable oil consumption (Annual report of textile, 2012-2013). Globally cotton is cultivated on 35.7 M hectares area and which produced 154 million bales and average productivity was 734Kg/ha. In India, cotton was cultivated on 12.71 million hectare area and the Production was 40 million bales with 535 Kg/ha productivity (Annual report of ICAR- AICRPC, 2018) [2]. The causes of low yield of cotton are highly complex in India. Several factors are responsible for low productivity and quality deterioration of cotton such as unfavorable environmental factors, indiscriminant use of various kinds of chemicals, fertilizers and pesticides, lack of knowledge of plant protection measures, lack of extension education and lack of coordination between farmers and agricultural institutes. But among them, most important factor is considered to be insect pests which cause significant loss to cotton crop. Globally cotton has quite broad pest spectrum and cotton is called as heaven of insect pests. A number of insect pests attack on cotton during its growth, development and till processing. Hargreaves, (1948) [6] reported 1326 insect pests harboured on cotton right from time of planting till processing of the crop worldwide.

Major losses in India in cotton production are due to its susceptibility to about 162 species of insect pests. In which few dozen are very serious, causing sufficient loss of cotton (Dhaliwal *et al.* 2004) [5]. *Aphis gossypii* damages cotton plants during both vegetative and reproductive stages. Infestation on vegetative stages turn leaves shriveled, whereas infestation on reproductive stages, especially at fruit opening stage causes fouls and reduces fiber quality. Severe attacks of *A. gossypii* may also reduce leaf area by 58% and shoot biomass 45%. Cotton plants which infested by cotton aphid are shorter and produce fewer vegetative branches than non infested plants (Slosser *et al.* 2001) [10]. The knowledge about infestation of pest during the cropping season and effects of pesticides upon pest and yield is crucial to find out economics and help in making better efficient strategies against pest. Therefore, keeping these points in view, the studies of economics of cotton aphid, *Aphis gossypii* Glover on cotton crop were determined during *kharif* 2018 and 2019.

Material and Methods

The experiment was conducted in Randomized Complete Block Design (RCBD) by sowing five cotton cultivars. Each one cultivar replicated three times in 5.4×4.2 m plot size with adopting plant to plant and row to row (60 cm x 60 cm) spacing to know the incidence of major sucking insect pest, cotton aphid. All the recommended agronomical practices except plant protection were followed for raising the cotton crop at Student Instructional Farm (SIF) of the Department of Agronomy, C. S. Azad University of Agriculture and Technology, Kanpur (Uttar Pradesh). The plot wise seed cotton yield was recorded and weighed separately after picking from every plot of each treatment. The average yield of seed cotton was extrapolated in form of kg/plot and kg/ha for each treatment then statistically analyzed. The total cost of plant protection was calculated as per the prevailing market price of insecticides per ha, labour and sprayer charges per ha. Net monetary return of a treatment was comprised of increase in yield as a function of treatment over control and prevailing market price of seed cotton. The net profit of treatment was worked out by deducting the total cost of plant protection from total monetary return (Nemade *et al.* (2017). Pesticides were purchased from pesticides local market of Kanpur and the cost of pesticides was obtained by multiplying total quantity (kg or litre) of respective pesticide required for per hectare application with the prevalent market price (Rs.) for per litter/kg of respective pesticide.

Labour wages (Rs./ha): Two labourers were considered sufficient for spraying in a day over one hectare crop @ prevailing local market rate of Rs. 350 or 400.00/day/labour.

Sprayer hiring charges (Rs./ha): The rent charge of power sprayer was considered as Rs.100.00 per hectare for respective treatments.

Total cost of plant protection/ treatment (Rs./ha): Cost of insecticide, Labourer wages and sprayer hiring charges were summed up to work out the cost of respective treatment.

Additional yield (Q/ha): This was obtained by subtracting the values of control yield from total seed cotton yield of a respective treatment.

Additional income (Rs./ha): It was calculated by multiplying the additional yield over the untreated control with prevailing minimum support price of seed cotton.

Net return (Rs./ha): This was calculated separately by subtracting the cost of treatment from additional income of respective treatment.

Incremental Cost-Benefit Ratio: Incremental cost benefit ratio (ICBR) was worked out as a ratio of net profit to the cost of plant protection of treatment which exhibits the economic viability of the treatment. This was calculated separately for each treatment as per following formulae suggested by Ojha (2017) [7].

$$\text{Incremental Cost Benefit Ratio} = \frac{\text{Net Profit}}{\text{Total cost of Plant Protection or Treatment}}$$

Results and Discussions

Impacts of different pesticides on seed cotton yield and theirs ICBRs in two consecutive years, 2018 and 2019

According to the mean seed cotton yield of both years, it was found that all the pesticides were found best over control in rising seed cotton yield. The highest seed cotton yield 1505.14 Kg per ha was obtained in thiamethoxam 25 WG @ 0.125 Kg/ha treated plots whereas lowest yield 617.28 Kg/ha was recorded in control followed next higher yield obtained in acetamiprid 20 SP @ 0.05 Kg/ha (1443.27 Kg), imidacloprid 17.8 SL @ 0.112 L/ha (1440.85 Kg/ha), fipronil 5 SC @ 1.5 L/ha (1352.36 Kg per ha), dimethoate 30 EC @ 0.833 L/ha (1313.20 Kg per ha), chloropyrifos 20 EC @ 1.25 L/ha (1251.54Kg per ha), Beauveria bassiana 1% @ 5 Kg/ha (1000.88 Kg per ha), azardiractin 300 PPM @ 2.5 L/ha (994.34Kg per ha), and Garlic Extract 5% @ 25 L/ha (937.39Kg perha) respectively treated plots. Based on two consecutive years findings, highest incremental cost benefit ratio (12.97), (12.92) and (9.53) were found by thiamethoxam 25 WG @ 0.125 Kg/ha, acetamiprid 20 SP @ 0.05 Kg/ha and imidacloprid 17.8 SL @ 0.112 L/ha treated plots respectively whereas (1:66), (1:61) and (1:1.05) ICBRs respectively were computed by spraying of Beauveria bassiana 1% @ 5 Kg/ha, azardiractin 300 PPM @ 2.5 L/ha and Garlic Extract 5% @ 25 L/ha during 2018. But during kharif season 2019, highest ICBRs (1:15.98), (1:14.86) and (14:21) were calculated in imidacloprid 17.8 SL @.112 L/ha, thiamethoxam 25 WG @ 0.125 Kg/ha and acetamiprid 20 SP @ 0.05 Kg/ha treated plots however lowest ICBRs (1:2.17), (2.03) and (1:1.68) were calculated in Beauveria bassiana 1% @ 5 Kg/ha, azardiractin 300 PPM @ 2.5 L/ha and Garlic Extract 5% @ 25 L/ha treated plots respectively. The present findings corroborates with *Patil et al.* (2009) [8] who reported significantly highest seed cotton yield of 27.23 q/ha (2007) and 27.50 q/ha (2008) was harvested with higher dosage of fipronil 5% SC @ 800 g/ha respectively proving them to be on par with acetamiprid 20 SP, Udikeri *et al.* (2009) who reported that sgnificantly highest seed cotton yield of 20.32q/ha (2006) and 28.22 q/ha (2007) was harvested with higher dosage of SYN 13623 a combiproduct of thiomethoxam 141 SC+lcyhalothrin 106 SC @ 300ml/ha and proving them to be on par with acetamiprid 20 SP, a standard check, Bharpoda *et al.* (2014) who reported highest seed cotton yield (30.81 q/ha) was harvested from crop treated with imidacloprid followed by thiamethoxam (26.01 q/ha), acetamiprid (25.68 q/ha) and fipronil (23.44 q/ha). The highest Insecticidal Cost Benefit Ratio (1:16.54) was registered in imidacloprid followed by acetamiprid (1:11.06), thiamethoxam (1:7.05) and fipronil (1:5.93), Patil *et al.* (2016) [9] who found that acetamiprid 20 SP @ 0.004 per cent highest seed cotton yield was obtained and it was equal with thiamethoxam 25 WG @ 0.01 per cent and imidacloprid 17.8 SL @ 0.008 per cent. Thereby, treatment of acetamiprid 20 SP @ 0.004 per cent recorded highest ICBR (1: 18.50) indicating most economically viable treatment followed by acetamiprid 20 SP @ 0.002 per cent (1:16.67), imidacloprid 17.8 SL @ 0.004 per cent (1:12.86) and 0.008 per cent (1:12.35) and Nemade et al. (2017) who revealed in the results that maximum seed cotton yield (1816.81 Kg/ha) was recorded in higher dose of acetamiprid used byfarmers @ 6 g/10 L of water and it was at par with imidacloprid @ 9 ml/ 10 L of water (1661.00 Kg/ha) and imidacloprid @ 4.5 ml/ 10 L of water, double the recommended dose (1453.00 Kg/ha). However, maximum ICBR (1:13.7) was obtained in acetamiprid @ 6 g/10 L of water (higher dose used by farmers) and was followed by acetamiprid @ 3 g/10 L of water (double the recommended dose) with ICBR of 1:9.8. The present finding is in contradiction with findings of *Zanwar et al*. (2012) [12] reported that the significantly highest seed cotton yield (14.35 q/ha) was recorded in fipronil 40 per cent + imidacloprid 40 per cent at the rate of 100 ml/ha, followed by fipronil 5 per cent SC (12.58-q/ha) and imidacloprid 200 SL (11.84 q/ha).

Table 1: Incremental cost benefit ratio (economics) of various treatments in 2018

Treatments & doses	Cotton yield (Kg/ha)	Increased in yield over control (Kg/ha)	Cost of Ts for three sprays (Kg or L/ha)	Labour charge for three spray (Rs/ha)	Total cost of plant protection/ Treatment (Rs/ha)	Cost of increased yield (Rs/ha)	Net Profit (Rs)	ICBR (Cost: Benefit Ratio)
Acetamiprid 20 SP @ 0.05 Kg/ha	1460.91	836.28	195	2100	2595	36127.10	33532.1	12.92
Azardiractin 300 PPM @ 2.5 Liter/ha	973.54	348.91	3375	2100	5775	15073.13	9298.13	1.61
Beauveria bassiana 1% @ 5 Kg/ha	1000.88	376.25	3750	2100	6150	16243.2	10224.71	1.66
Chloropyrifos 20 EC @ 1.125 L/ha	1275.72	651.09	1181	2100	3581	28127.10	24546.1	6.85
Dimethoate 30 EC @.833 Liter/ha	1311.73	687.10	1375	2100	3775	29682.65	25907.65	6.86
Fipronil 5 SC @ 1.5 L/ha	1264.84	640.21	4050	2100	6450	27657.25	21207.25	3.29
Garlic Extract 5% @ 25 L/ha	916.23	291.60	3750	2100	6150	12596.94	6446.94	1.05
Imidacloprid 17.8 SL @.112 L/ha	1301.59	676.96	378	2100	2778	29244.56	26466.56	9.53
Thiamethoxam 25 WG @ 0.125 Kg/ha	1507.93	883.3	330	2100	2730	38145.6	35415.4	12.97
Control	624.63	0	0	0	0	0	0	0

1. Labour charges for one spray/ha @ Rs. 350/ labour /day, two labour required for each treatment
2. Sprayer pump hiring charge/ha @ Rs. 100 for each treatment
3. Sale value (Minimum support price) of seed cotton @ Rs. 4320/qtl in 2018

Table 2: Incremental cost benefit ratio (seed cotton yield and economics) of various treatments in 2019

Treatments & doses	Cotton yield (Kg/ha)	Increased in yield over control ((Kg/ha)	Cost of Ts for three sprays (Kg or L/ha)	Labour charge for three spray (Rs/ha	Total cost of plant protection/ Treatment (Rs/ha))	Cost of increased yield (Rs/ha)	Net Profit (Rs)	ICBR (Cost: Benefit Ratio)
Acetamiprid 20 SP @ 0.05 Kg/ha	1425.63	812.31	210	2400	2910	44271.22	41361.2	14.21
Azardiractin 300 PPM @ 2.5 Liter/ha	1015.13	401.82	3750	2400	6750	21899.31	14699.3	2.17
Beauveria bassiana 1% @ 5 Kg/ha	1000.88	387.57	4125	2400	6825	21122.34	13922.3	2.03
Chloropyrifos 20 EC @ 1.125 Liter/ha	1227.36	614.05	1350	2400	4050	33465.74	29584.5	7.62
Dimethoate 30 EC @.833 Liter/ ha	1314.66	701.35	1500	2400	4200	38223.68	34023.7	8.10
Fipronil 5 SC @ 1.5 Liter/ ha	1439.88	826.57	4275	2400	6975	45048.19	37848.2	5.26
Garlic Extract 5% @ 25 Liter/ha	958.554	345.24	4312.5	2400	7012.5	18815.46	11803.0	1.68
Imidacloprid 17.8 SL @.112 Liter/ha	1580.10	966.78	403.2	2400	3103.2	52689.72	49586.5	15.98
Thiamethoxam 25 WG @ 0.125 Kg/ha	1503.52	890.21	360	2400	3060	48516.52	45456.5	14.86
Control	613.31	0	0	0	0	0	0	0

1. Labour charges for one spray/ha @ Rs. 400/ labour /day, 2 labour for each treatment
2. Spray pump charge/ha @ Rs. 100 /day/pump for each treatment
3. Minimum support price of seed cotton @ Rs. 5450/qtl

Conclusion

Impact of different pesticides on rising seed cotton yield in two consecutive years 2018 and 2019

According to data of seed cotton yield for the both years showed that all the pesticides were observed superior in increasing seed cotton yield over control. Seed cotton yield in different treatments for both the years ranging from 617.28 to 1505.14 kg per ha. The significantly highest seed cotton yield 1505.14 kg ha^{-1} was obtained in thiamethoxam 25 WG @ 0.125 Kg/ha treated plot. The next best treatments in rising seed cotton yield were acetamiprid 20 SP @ 0.05 Kg/ha (1443.27 kg per ha), imidacloprid 17.8 SL @.112 Liter/ha (1440.85 kg per ha), fipronil 5 SC @ 1.5 L/ha (1352.36 kg per ha), dimethoate 30 EC @ 0.833 L/ha (1313.20 kg per ha), chloropyrifos 20 EC @ 1.25 L/ha (1251.54 kg per ha), azardiractin 300 PPM @ 2.5 L/ha (994.34 kg per ha), *Beauveria bassiana* 1% @ 5 Kg/ha (1000.88 kg per ha) and Garlic Extract 5% @ 25 L/ha (937.39 kg per ha). However, the lowest seed cotton yield (617.28 kg per ha) was recorded in untreated control.

Impact of incremental cost benefit ratio (ICBR) of certain pesticides against aphid, *Aphis gossypii* Glover in cotton cv. RS 2013 in 2018 and 2019

The highest incremental cost benefit ratio (1:12.97) was computed from the plot sprayed with thiamethoxam 25 WG @ 0.125 Kg/ha followed by acetamiprid 20 SP @ 0.05 Kg/ha (1:12.92), imidacloprid 17.8 SL @ 0.112 Liter/ha (1:9.53), dimethoate 30 EC @ 0.833 L/ ha (1:6.86), chloropyrifos 20 EC @ 1.25 L/ha (1:6.85), fipronil 5 SC @ 1.5 L/ ha (1:3.29), *Beauveria bassiana* 1% @ 5 Kg/ha (1:1.66), azardiractin 300 PPM @ 2.5 L/ha (1:61) and Garlic Extract 5% @ 25 L/ha (1:1.05) respectively in first spray schedule of 2018. In second spray schedule 2019, the highest incremental cost benefit ratio (1:15.98) was obtained by imidacloprid 17.8 SL @.112 Liter/ha, afterward next highest ICBR of pesticides were achieved by thiamethoxam 25 WG @ 0.125 Kg/ha(1:14.86), acetamiprid 20 SP @ 0.05 Kg/ha (1:14.21), dimethoate 30 EC @ 0.833 L/ ha (1:8.10), chloropyrifos 20 EC @ 1.25 L/ha (1:7.62), fipronil 5 SC @ 1.5 L/ ha (1:5.26), azardiractin 300 PPM @ 2.5 L/ha (1:2.17), *Beauveria bassiana* 1% @ 5 Kg/ha (1:2.03) and Garlic Extract 5% @ 25 L/ha (1:1.68) respectively.

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