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Research Article

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Bio-efficacy of Certain Insecticides Sequence on Cotton Sucking Pests and Pink Bollworm

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Abstract

The field trials were conducted for two consecutive years during *kharif*, 2018 and 2019 seasons in the Regional Agricultural Research Station, Warangal, Telangana, India. The susceptible hybrid RCH-2 was grown during both the years of study. Among the treatments, significant (25.4%) reduction of aphids was recorded in neem oil, clothianidin and flonicamid sequential spray. The sequence chlorpyriphos, flonicamid and clothianidin achieved superior efficacy against jassids with 32.3% reduction over control during the two seasons. The highest reduction (25.2%) of thrips was observed in neem oil, clothianidin, flonicamid sequential spray. The incidence of whitefly was low during the experimental period, however, the highest white fly reduction (15.0%) was observed in chlorpyriphos, flonicamid, clothianidin spray. The lowest number of PBW larvae per 10 green bolls was observed in profenophos, spinetoram, chlorpyriphos+cypermethrin sequential spray that reduces up to 61.9% incidence. The lowest number of (38.5) damaged locules per 100 fully opened bolls were observed in profenophos, spinetoram, chlorpyriphos+cypermethrin sequential spray. But, the highest seed cotton yield (1414 kg ha^{-1}) as well as benefit cost ratio (1.02) was recorded in chlorpyriphos, flonicamid, emamectin benzoate, clothianidin, indoxacarb+acetamiprid sequential spray. The study further revealed that, initial control of sucking pests menace especially jassid was crucial in deciding the cotton yield as compared to later stage pink bollworm menace. During both the years, it was noticed that during peak incidence of jassid, the treated plot with flonicamid against jassid in first instance had given highest seed cotton yield.

Keywords: Cotton, insecticides, pink bollworm, sucking pests

1. Introduction

Cotton is one of the most important textile fibers in the world, accounting for around 35% of the total world fiber use. At global level India is the largest cotton growing country with area of 12.5 m ha and production of 36 m bales (Anonymous, 2019) still the productivity is low (486 kg lint ha^{-1}) as compared to world's approximate average (764 kg lint ha^{-1}). Profitable cotton production will depend on successful and efficient insect pest management strategies which reduces the risk disastrous crop losses by pests (El-Basyouni, 2003). One major challenge faced by cotton farmers is the high pest incidence which occurs at virtually all stages of cotton growth, limiting its productivity and quality (Ismail, 2019). There are 1326 species of insect pests on cotton, though most cause little or no economic damage. Sucking pests have become relatively serious from seedling stage; their heavy infestation at times reduces the crop yield

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to a great extent. The estimated loss due to sucking pests is up to 21.20% (Dhawan et al., 1986). Among the sap feeder aphids *Aphis gossypii* (Glover), leafhoppers *Amrasca biguttula biguttula* (Ishida), thrips *Thrips tabaci* (Linn) and whitefly *Bemisia tabaci* are deadly pests. The major biotic constraint in attainment of desired productivity levels in Bt-cotton production is the sucking pests. More than 90% area is under Bt-cotton and is susceptible to sucking pests (Hoffs et al., 2004; Sharma and Pampapathy, 2006). Bt cotton succumb to yield loss due to the sap feeders (i.e. leafhoppers, aphids, thrips, whiteflies, mealy bugs, mirids and stainers) spread throughout the growing season, right from seedling emergence to harvest, as the biotic potential of sucking pests being high, they are a potential threat to Bt-cotton (Biradar and Venilla, 2008). In the recent past, Pink bollworm *Pectinophora gossypiella* (Saunders) has developed resistance to Bt technology and now it is considered as one of the most serious insect pests of cotton crop attacking on fruiting bodies which may result indirect losses of yield and indirectly damage the quality of fiber. In order for the cotton bollworms control program to be successful, it has to rely on the use of insecticides belonging to different groups in certain sequences, application time, and spraying interval (Abd El-Mageed et al., 2007). The losses in cotton due to sucking pets, bollworms and both together have been reported as 11.60%, 44.50%, and 52.10%, respectively (Dhawan and Sindu, 1986). Dilnur et al. (2019) reported that bollworms alone could cause yield losses of up to 85%. While, Chavan et al. (2010) reported 28.13% avoidable yield loss due to major sucking pests in cotton. Among the management practices used for insect pest of cotton, chemical control is the most popularized method among farmers. Highest share of pesticide consumption, amongst the crops grown in our country is received by cotton, consuming 36–50% of the total pesticides in the country (Devi, 2010; Bhardwaj and Sharma, 2013; Anonymous, 2016). Pesticides are the mainstay, used by the farmers to control pests. A wide range of insecticides have proved as effective weapons in reducing the pest population. However, negligence of the principles in the crop protection, indiscriminate and extensive use of synthetic pesticides led to problems like insecticidal resistance, pest resurgence, and destruction of natural enemies. Therefore, to overcome the above problems, the present evaluation of certain insecticides in sequence/rotation was undertaken either alone or in combination with some of the synthetic pyrethroids for effective management of both sucking pests and pink boll worm.

2. Materials and Methods

The experiment was conducted at Regional Agricultural Research Station (18° 55′ and 79° 36°10′East), Warangal, Professor Jayashankar Telangana State Agricultural University, Telangana state, India to evaluate certain insecticidal sequence against sucking pests and pink bollworm in cotton under rainfed black cotton soils during two consecutive *Kharif* seasons (July–December 2018 and July–December, 2019). The experiment was laid out in a Randomized Block Design with seven treatments replicated thrice. The crop was sown with a variety RCH-2 on 06th July, 2018 and 3rd July, 2019 respectively, at a spacing of 90×60 cm^2 and all recommended agronomic practices were followed during the experimentation for proper crop management. The distance between two replications was 1.5m and it was 1.0 m between the treatments. In the present study, six insecticidal treatments and an untreated control (Table 1) were evaluated against sucking pests and pink bollworm.

Table 1: Details of treatments imposed in the study

Treatments	1st Spray @ 45 DAS	2nd Spray @ 60 DAS	3rd Spray @ 75 DAS	4th Spray @ 90 DAS	5th spray @ 105 DAS
T_1	Chlorpyriphos @ 2.5 ml l^{-1}	Flonicamid @ 0.3 g l^{-1}	Emamectin benzoate @ 0.5 g l^{-1}	Clothianidin @ 0.25 g l^{-1}	Indoxacarb +Acetamiprid @ 1 ml l^{-1}
T_2	Neem oil @ 5 ml l^{-1}	Clothianidin @ 0.25 g l^{-1}	Indoxacarb @ 1 ml l^{-1}	Flonicamid@ 0.3 g l^{-1}	Thiamethoxam +Lambda cyhalothrin @ 0.4 ml l^{-1}
T_3	Buprofezin @ 1.6 ml l^{-1}	Thiamethoxam @ 0.2 g l^{-1}	Spinosad @ 0.4 ml l^{-1}	Diafenthiuron @ 1.25 g l^{-1}	Chlorantraniliprole +Lambda cyhalothrin @ 0.5 ml l^{-1}
T_4	Acetamiprid @ 0.2 g l^{-1}	Diafenthiuron @ 1.25 g l^{-1}	Chlorantraniliprole @ 0.3 ml l^{-1}	Thiamethoxam @ 0.2 g l^{-1}	Pyriproxyfen +Fenpropathrin @ 1 ml l^{-1}
T_5	Profenophos @ 2 ml l^{-1}	Fipronil @ 2 ml l^{-1}	Spinetoram @ 0.9 ml l^{-1}	Acetamiprid @ 0.2 g l^{-1}	Chlorpyriphos +Cypermethrin @2 ml l^{-1}
T_6	Diafenthiuron @ 1.25 g l^{-1}	Acetamiprid@ 0.2 g l^{-1}	Quinolphos @ 2 ml l^{-1}	Fipronil @ 2 ml l^{-1}	Profenophos +Cypermethrin @ 2 ml l^{-1}
T_7	Control				

Regarding observations for sucking pests, the observations were recorded on five randomly selected plants in each plot. The observations were recorded before and after each spray at 1 day after spray (DAS), 3 DAS, 5 DAS and 7 DAS. The observations on the actual count of sucking pests viz., aphids, jassids, thrips and whiteflies were recorded from top, middle and bottom three leaves from the selected plants. Regarding observations for pink bollworm, the observations were recorded before and after each spray at 10 day after spray (DAS), 20 DAS during both the seasons by following destructive sampling. To record incidence of bollworms in fully opened bolls at harvest time, 100 opened bolls per plot were plucked randomly and were collected in polyethylene bags and estimated locule damage. Cotton yield was recorded from each treatment and the data were presented as seed cotton yield in kg ha^{-1}. The observation on the number of sucking pests was subjected to square root transformation before statistical analysis. Data of both the years were pooled for statistical analysis as per the method given by Panse and Sukhatme (1967).

3. Results and Discussion

3.1. Efficacy of tested sequences of insecticides against aphids

The elucidated data in Table 2 show the variation between sequences of insecticidal spray against aphids. In general, all the tested sequences resulted in an appreciable reduction in aphid; as compared with control, but the highest reduction (25.4%) of aphid population was observed in neem oil, clothianidin and flonicamid sequential spray followed by buprofezin, thiamethoxam and diafenthiuron sequence (23%). The lowest reduction (4.6%) of aphid was observed both in chlorpyriphos, flonicamid and clothianidin sequence and acetamiprid, diafenthiuron and thiamethoxam sequential spray, respectively.

Table 2: Effect of different insecticidal sequence on the incidence of cotton aphid

Treat-ments	1st Spray @ 45 DAS	2nd Spray @ 60 DAS	3rd Spray @ 90 DAS	Pre Spray	1 DAS	3 DAS	5 DAS	7 DAS	% reduction over control
T_1	Chlorpyriphos	Flonicamid	Clothianidin	7.5 (2.91)	5.6 (2.56)	6.8 (2.80)	6.2 (2.75)	6.2 (2.68)	4.6
T_2	Neem oil	Clothianidin	Flonicamid	8.6 (3.10)	5.3 (2.51)	5.3 (2.50)	5.7 (2.50)	4.7 (2.38)	28.0
T_3	Buprofezin	Thiamethoxam	Diafenthiuron	9.7 (3.28)	5.8 (2.59)	6.8 (2.80)	5.8 (2.67)	5.0 (2.45)	23.0
T_4	Acetamiprid	Diafenthiuron	Thiamethoxam	7.8 (2.96)	5.2 (2.49)	6.3 (2.70)	6.2 (2.63)	6.2 (2.68)	4.6
T_5	Profenophos	Fipronil	Acetamiprid	9.3 (3.21)	4.9 (2.43)	5.8 (2.60)	5.3 (2.47)	5.4 (2.53)	16.9
T_6	Diafenthiuron	Acetamiprid	Fipronil	10.6 (3.39)	5.4 (2.52)	7.1 (2.85)	7.1 (2.88)	5.4 (2.52)	16.9
T_7	Control	Control	Control	10.8 (3.44)	6.8 (2.78)	7.8 (2.96)	7.6 (2.91)	6.5 (2.74)	
	SEm±			0.06	0.05	0.06	0.05	0.06	
	CD (p=0.05)			0.20	0.16	0.19	0.16	0.19	

Neem oil 1.0% showed 63% reduction of aphid on okra which was reported by Rao et al. (1991). However more than 70% reduction of aphid with treatment of imidacloprid @ 0.3 ml l^{-1}, followed by *V. lecanii* @ 5.0 g l^{-1}, B. bassiana @ 5.0 g l^{-1} and Azadirachtin 1500 ppm @ 4 ml l^{-1} with 50 to 70% reduction of aphid, *A. gossypii* was reported by Ghelani et al. (2006). The highest aphid mortality was obtained with flonicamid and imidacloprid in the laboratory experiment under controlled conditions (Samih et al., 2013). Similarly, Jyothsna et al. (2012) opined that in Gherkins, among all the chemicals, the reduction of *Aphis gossypii* population was more with thiacloprid at 120 g a.i. ha^{-1} (86.34%) followed by flubendiamide+thiacloprid at 48+48 g a.i. ha^{-1} (74.36%) and thiamethoxam at 31.25 g a.i. ha^{-1} (61.09%).

3.2. Efficacy of tested sequences of insecticides against jassids

The exhibited data in Table 3 show the variation in% reduction between sequences of insecticidal spray against jassids. The sequence chlorpyriphos, flonicamid and clothianidin achieved superior efficacy against jassids with 32.3% reduction over control during the two seasons. While buprofezin, thiamethoxam and diafenthiuron sequential spray has proved to be next best in reducing jassid infestation (29.3%) and followed by acetamiprid, diafenthiuron and thiamethoxam sequence (26.3%). The lowest reduction (15.1%) was noticed in diafenthiuron, acetamiprid and fipronil sequential spray.

The present findings are in agreement with Ghelani et al. (2014) who reported that flonicamid caused significantly

Table 3: Effect of different insecticidal sequence on the incidence of cotton jassid

Treat-ments	1st Spray @ 45 DAS	2nd Spray @ 60 DAS	3rd Spray @ 90 DAS	Pre Spray	1 DAS	3 DAS	5 DAS	7 DAS	% reduction over control
T_1	Chlorpyriphos	Flonicamid	Clothianidin	9.5 (3.23)	5.0 (2.45)	5.7 (2.58)	4.4 (2.30)	6.7 (2.76)	32.3
T_2	Neem oil	Clothianidin	Flonicamid	9.0 (3.16)	5.6 (2.57)	5.1 (2.47)	4.9 (2.42)	7.5 (2.92)	25.2
T_3	Buprofezin	Thiamethoxam	Diafenthiuron	9.7 (3.27)	5.1 (2.46)	4.9 (2.42)	5.2 (2.48)	7.0 (2.82)	29.3
T_4	Acetamiprid	Diafenthiuron	Thiamethoxam	10.2 (3.33)	6.1 (2.65)	5.7 (2.57)	6.9 (2.79)	7.3 (2.87)	26.3
T_5	Profenophos	Fipronil	Acetamiprid	9.7 (3.26)	5.8 (2.60)	6.3 (2.69)	6.4 (2.7)	7.9 (2.97)	20.2
T_6	Diafenthiuron	Acetamiprid	Fipronil	9.7 (3.26)	6.9 (2.82)	6.6 (2.75)	7.5 (2.91)	8.4 (3.06)	15.1
T_7	Control	Control	Control	10.3 (3.36)	7.7 (2.93)	7.8 (2.96)	9.9 (3.29)	9.9 (3.30)	
	SEm±			0.08	0.03	0.06	0.08	0.08	
	CD (p=0.05)			NS	0.09	0.20	0.26	0.24	

maximum mortality of jassid (61.9%) and it was statistically at par with dinotefuran and imidacloprid. The percent reduction of leafhopper population was found higher with flonicamid @ 75 g a.i. ha^{-1} (Chandi et al., 2016). The higher effectiveness of thiamethoxam 25 WG @ 0.0125% is strongly supported by Saleem et al. (2001) and Srinivasan et al. (2004). Razaq et al. (2005) also reported diafenthiuron, acetamiprid, imidacloprid and thiamethoxam as more effective insecticides in reducing jassid population below ETL at 7th days post application. Kumar and Dhawan (2011) who reported that flonicamid 50WG were effective against cotton leafhopper.

3.3. Efficacy of tested sequences of insecticides against thrips

To know the effect of different insecticide sequences on thrips and percent reduction was calculated and presented in Table 4. Among the sequence of insecticides, the highest reduction

Table 4: Effect of different insecticidal sequence on the incidence of Cotton thrips

Treat-ments	1st Spray @ 45 DAS	2nd Spray @ 60 DAS	3rd Spray @ 90 DAS	Pre Spray	1 DAS	3 DAS	5 DAS	7 DAS	% reduction over control
T_1	Chlorpyriphos	Flonicamid	Clothianidin	12.9 (3.72)	11.5 (3.54)	12.6 (3.68)	11.6 (3.54)	10.4 (2.78)	19.4
T_2	Neem oil	Clothianidin	Flonicamid	12.3 (3.65)	12.5 (3.68)	13.0 (3.73)	11.1 (3.48)	9.6 (2.68)	25.6
T_3	Buprofezin	Thiamethoxam	Diafenthiuron	13.1 (3.75)	12.2 (3.63)	11.8 (3.58)	11.2 (3.50)	11.2 (2.89)	13.2
T_4	Acetamiprid	Diafenthiuron	Thiamethoxam	13.5 (3.79)	10.7 (3.41)	11.2 (3.49)	10.4 (3.38)	11.4 (2.93)	11.6
T_5	Profenophos	Fipronil	Acetamiprid	12.5 (3.67)	10.3 (3.35)	12.6 (3.69)	10.8 (3.43)	10.6 (2.81)	17.8
T_6	Diafenthiuron	Acetamiprid	Fipronil	12.5 (3.67)	11.5 (3.54)	14.7 (3.96)	12.1 (3.62)	10.2 (2.77)	20.9
T_7	Control	Control	Control	12.5 (3.66)	11.7 (3.56)	14.2 (3.90)	10.3 (3.36)	12.9 (3.72)	
	SEm±			0.14	0.05	0.07	0.06	0.12	
	CD (p=0.05)			NS	0.17	0.22	NS	NS	

(25.2%) of thrips was observed in neem oil, clothianidin, flonicamid sequential spray followed by diafenthiuron, acetamiprid and fipronil sequential spray (20.9%) and chlorpyriphos, flonicamid, clothianidin sequential spray (19.4%). The least percent reduction (11.6%) was noticed in acetamiprid, diafenthiuron and thiamethoxam sequential spray.

The present results are comparable with Ghelani et al. (2014) who reported that among the insecticidal treatments, application of flonicamid 0.02%, imidacloprid 0.005% and dinotefuran 0.008% resulted in effective control of thrips on Bt-cotton.

3.4. Efficacy of tested sequences of insecticides against whitefly

The data on reduction of whitefly incidence as a result of insecticidal sequence spray was presented in Table 5. The incidence of whitefly was low during the experimental period, however, among the sequence of insecticides the highest white fly reduction (15.0%) was observed in chlorpyriphos, flonicamid, clothianidin followed by acetamiprid, diafenthiuron and thiamethoxam sequential spray (10.0%) and diafenthiuron, acetamiprid and fipronil sequential spray (10.0%), respectively.

Table 5: Effect of different insecticidal sequence on the incidence of cotton whitefly

Treat-ments	1st Spray @ 45 DAS	2nd Spray @ 60 DAS	3rd Spray @ 90 DAS	Pre Spray	1 DAS	3 DAS	5 DAS	7 DAS	% reduction over control
T_1	Chlorpyriphos	Flonicamid	Clothianidin	1.3 (1.52)	1.4 (1.55)	2.0 (1.71)	2.3 (1.81)	1.7 (1.65)	15.0
T_2	Neem oil	Clothianidin	Flonicamid	1.4 (1.55)	1.4 (1.54)	1.9 (1.69)	2.2 (1.77)	1.9 (1.69)	5.0
T_3	Buprofezin	Thiamethoxam	Diafenthiuron	1.4 (1.56)	1.4 (1.56)	1.7 (1.65)	2.4 (1.84)	1.9 (1.70)	5.0
T_4	Acetamiprid	Diafenthiuron	Thiamethoxam	1.5 (1.59)	1.8 (1.68)	2.0 (1.71)	2.7 (1.91)	1.8 (1.68)	10.0
T_5	Profenophos	Fipronil	Acetamiprid	1.3 (1.52)	1.8 (1.69)	2.3 (1.82)	2.6 (1.88)	1.9 (1.71)	5.0
T_6	Diafenthiuron	Acetamiprid	Fipronil	1.5 (1.60)	1.9 (1.70)	1.9 (1.70)	2.2 (1.79)	1.8 (1.68)	10.0
T_7	Control	Control	Control	1.8 (1.65)	1.8 (1.68)	2.4 (1.84)	2.4 (1.84)	2.0 (1.71)	
	SEm±			0.06	0.08	0.04	0.08	0.04	
	CD (p=0.05)			NS	NS	0.13	NS	NS	

Effective control of whiteflies was recorded with application of flonicamid 0.02% on Bt-cotton (Ghelani et al., 2014). The Present findings regarding efficacy of flonicamid 50 WG, diafenthiuron 50 WP and fipronil 5 SC, is comparable with that of Rohini et al. (2011), Ghelani (2014), Gaurkhede (2015), who recorded lowest population of whiteflies

3.5. Efficacy of tested sequences of insecticides against pink bollworm

The revealed data in Table 6 show the variation in % reduction between sequences of insecticidal spray against pink bollworm. The lowest number of PBW larvae per 10 green bolls was observed in profenophos, spinetoram, chlorpyriphos+cypermethrin sequential spray reduces up to 61.9% incidence followed by buprofezin, spinosad, chlorantraniliprole+lambda cyhalothrin sequential spray (61.1%) during both the years of study. Regarding locule damage, the lowest number of (38.5) damaged locules per 100 fully opened bolls was observed in profenophos, spinetoram, chlorpyriphos+cypermethrin sequential spray followed by diafenthiuron, quinolphos and profenophos +cypermethrin (38.8) sequential spray.

According to Patil et al. (2009) both thiodicarb 70 SP (750 g a.i ha l^{-1}) as well as profenophos 50 EC (500 g a.i ha l^{-1}) effectively controlled PBW by registering significantly lower% locule damage of 8.88 and 9.50. Thiamethoxam 25% WDG (40 g ha^{-1}) was the most effective insecticide followed by chlorantraniliprole 20% SC and spinetoram 12% SC for the control of PBW (Sabry et al., 2014). Beta-Cyfluthrin (24.11%), spinosad (25.33%) and indoxacarb (26.43%) were promising for control of PBW (Gopalswamy et al., 2000). Parmar and Patel (2016) opined that Profenophos 50 EC 10 ml, cypermethrin 25 EC 4 ml, alpha cypermethrin 10 EC 10 ml, spinosad 45 SC 3 ml, emamectin benzoate 5 SG 3 g, deltamethrin 1%+triazophos 35 EC 10 ml, chlorpyriphos 16%+alpha cypermethrin 1% EC 10 ml, fenpropethrin 30 EC 10 ml, chlorpyriphos 50%+cypermethrin 5% EC 10 ml in 10 lit of water) alone and with integration can be effective for control of PBW.

Table 6: Effect of different insecticidal sequence on the incidence of pink bollworm

Treat-ments	1st Spray @ 45 DAS	2nd Spray @ 60 DAS	3rd Spray @ 90 DAS	Pre Spray	10 DAS	20 DAS	% reduction over control	Locule damage per 100 fully opened bolls
T_1	Chlorpyriphos	Emamectin benzoate	Indoxacarb +Acetamiprid	7.3 (2.85)	13.8 (3.80)	25.5 (5.13)	39.3	43.7 (41.38)
T_2	Neem oil	Indoxacarb	Thiamethoxam +Lambda cyhalothrin	5.3 (2.48)	10.8 (3.42)	23.0 (4.89)	45.2	41.3 (39.9)
T_3	Buprofezin	Spinosad	Chlorantraniliprole +Lambda cyhalothrin	5.0 (2.44)	9.3 (3.21)	16.3 (4.15)	61.1	40.1 (39.3)
T_4	Acetamiprid	Chlorantra-niliprole	Pyriproxyfen +Fenpropathrin	4.4 (2.33)	12.9 (3.72)	20.7 (4.65)	50.8	39.4 (38.86)
T_5	Profenophos	Spinetoram	Chlorpyriphos +Cypermethrin	5.0 (2.45)	6.6 (2.75)	16.0 (4.11)	61.9	38.5 (38.3)
T_6	Diafenthiuron	Quinolphos	Profenophos +Cypermethrin	4.2 (2.27)	12.5 (3.67)	22.8 (4.88)	45.6	38.8 (37.3)
T_7	Control	Control	Control	11.8 (3.57)	18.9 (4.46)	42.0 (6.55)		46.1 (42.7)
	SEm±			0.17	0.21	0.19		0.99
	C.D (p=0.05)			0.52	0.66	0.59		3.10

3.6. *Efficacy of tested sequences of insecticides on yield*

The highest seed cotton yield (1414 kg ha^{-1}) as well as benefit cost ratio (1.02) was recorded in chlorpyriphos, flonicamid, emamectin benzoate, clothianidin, indoxacarb+acetamiprid sequential spray (Table 7). It was understood that the initial control of sucking pests menace especially jassid was crucial in deciding the cotton yield as compared to later stage pink bollworm menace. During both the years of study, it was noticed that during peak incidence of jassid, the treated plot which has received flonicamid against jassid in first instance has given highest seed cotton yield.

The results are in concurrence with those of Chandi et al. (2016) who reported high seed cotton yield from flonicamid 50 WG in cotton.

Table 7: Effect of different insecticidal sequence on the kapas yield and economics of cotton crop

Treat-ments	1st Spray @ 45 DAS	2nd Spray @ 60 DAS	3rd Spray @ 75 DAS	4th Spray @ 90 DAS	5th spray @ 105 DAS
T_1	*Chlorpyriphos (438)	Flonicamid (1375)	Emamectin benzoate (1625)	Clothianidin (1950)	Indoxacarb +Acetamiprid (1900)
T_2	Neem oil (1163)	Clothianidin (1950)	Indoxacarb (1800)	Flonicamid (1375)	Thiamethoxam+Lambda cyhalothrin (575)
T_3	Buprofezin (840)	Thiamethoxam (420)	Spinosad (3635)	Diafenthiuron (1938)	Triazophos+Deltamethrin (680)
T_4	Acetamiprid (300)	Diafenthiuron (1938)	Chlorantraniliprole (2400)	Thiamethoxam (420)	Pyriproxyfen +Fenpropathrin (2130)
T_5	Profenophos (850)	Fipronil (1200)	Spinetoram (4875)	Acetamiprid (300)	Chlorpyriphos +Cypermethrin (700)
T_6	Triazophos (650)	Acetamiprid (300)	Quinolphos (450)	Fipronil (1200)	Profenophos +Cypermethrin (800)
T_7	-	-	-	-	-

Table 7: Continue...

Treat-ments	5th spray @ 105 DAS	Yield (kg ha-1)	Cost of total insecticides (₹ ha-1)	cost of total sprayings (₹ ha-1)	Total cost of culti vation (₹ ha-1)	Gross Returns (₹ ha-1)
T_1	1414	7288	7500	73038	77063	1.05
T_2	1184	6863	7500	72613	64528	0.89
T_3	1271	7513	7500	73263	69270	0.94
T_4	1177	7188	7500	72938	64147	0.88
T_5	1061	7550	7500	73,300	60277	0.82
T_6	999	3400	7500	69150	54446	0.79
T_7	857	-	-	58,250	46707	0.80

The figures in parenthesis indicates the price of insecticides ha-1; MSP (minimum support price) for cotton ₹ 5,450 100 kg^{-1}; Monthly average 1US$= INR 70.77 and INR 71.20 respectively during December, 2018 and 2019

4. Conclusion

The insecticidal sequence consisting of flonicamid in first instance was found to be the most effective with maximum per cent reduction of jassid as well as realized the highest seed Cotton yield during the both years of study as compared to other treatments. Further, it was understood that the initial control of sucking pests menace especially jassid was crucial in deciding the Cotton yield as compared to later stage pink bollworm menace.

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