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EVALUATION OF SPRAY MODULES FOR BOLLWORMS MANAGEMENT IN HDPS COTTON

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ABSTRACT

The multilocation field experiment was conducted during *Kharif,* 2015 for evaluation of effective spray module for management of bollworms in HDPS cotton. The results revealed that minimum larval population of bollworm (0.09) was observed in treatment S2M2 followed by S2M3. Module 3 effectively managed larval population of bollworms whereas minimum green fruiting bodies damage (1.82%) was observed in treatment S2M2 followed by S2M1. Maximum damage of green fruiting bodies (12.97%) was noticed in S1M4. Minimum per cent open ball damage (1.82%) was observed in treatment S2M2 schedule whereas maximum open ball damage (26.84%) was recorded in S1M4 schedule. Per cent open boll damage and loculi damage was found significant however their interaction effect found no significant. Minimum loculi damage (0.45%) was observed in treatment S3M2 followed by S2M2. Maximum seed cotton yield (1915.14 kg/ha) was also recorded in S2M2 treatment whereas minimum in S1M4 treatment (790.12 kg/ha). Highest ICBR ratio (1:5.6) was also recorded in treatment S2M2 followed by S2M3 (1:4.9). Thus, application of M3 module *i.e.* flubendamide 480 SC @ 50ml/acre > chlorantraniliprole 18.5 SC @ 60 ml/acre > fenvalerate 20 EC @ 160 ml/acre was found superior in management of bollworms in high density planting system of cotton.

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INTRODUCTION

Cotton (*Gossypium* sp.) is mainly grown for its lint and seed but it also provides fibre, food, feed, fuel, shelter and has a wide variety of medicinal and industrial uses (Siwach and Sangwan, 2012). Though, India ranks first in the world in respect of area the average productivity in India is quite low (523 kg lint/ha) as compared to the world average of 760 Kg lint/ha (Anonymous, 2015).

Bt cotton increases the productivity to some extent and reduces pesticides use for management of bollworms. However, increased number of sprays for sucking pest management are also evident. The use of insecticide to managed the bollworm complex has dropped by 6,599 tonnes in 2003 to 222 tonnes in 2011, at the same time, the use of insecticide to manage sucking pests has more than doubled from 2,909 tonnes in 2003 to 6,372 tonnes in 2011 (Ramesh Babu and Meghwal, 2014). In 2009, scientists have reported higher survival of the pink bollworm on bollgard I cotton whereas in 2014 it was also reported on BG II cotton. Hence an alternative for increasing the cotton productivity through efficient management of bollworms is warranted.

The early maturity genotypes in soils that do not support excessive vegetative growth (Jost and Cothren, 2001) can make this system ideal for shallow to medium soils under rainfed conditions, where conventional late maturity hybrids experience terminal drought. Therefore, the high density planting system (HDPS) is now being conceived as an alternate production system. HDPS has a potential for improving the productivity and profitability, increasing input use efficiency, reducing input costs and minimizing the risks associated with the current cotton production system in India (Venugopalan *et al.,* 2013).

HDPS in cotton is more suitable to Indian conditions, being raised under rainfed conditions on 60 per cent area with low productivity. Rainfall is received in June and recedes in September in majority of the zone. Boll formation and retention gets negatively affected in long duration varieties and hybrids due to low soil moisture, especially in shallow soils thus, resulting in low yield. Major cotton producing countries like China, USA, Brazil, Uzbekistan and Australia continue to harvest high cotton yields through straight varieties adopting high plant population. (Venugopalan *et al.,* 2013). Some early maturing compact genotypes have been identified for HDPS but all these are non Bt and management of bollworm is must to get the desired productivity. Surulivelu (2004) reported that close spacing and dense canopy encourage the faster rate of multiplication of bollworms and other pests of cotton. An outbreak of *Helicoverpa armigera* was noticed in the initial fruiting phase in HDPS and two insecticide applications had to be given to control the pest (CICR, 2013). Nagrare *et al.* (2014) reported that in 2012 *H. armigera* was found to infest non Bt cotton, cultivated under HDPS with straight varieties crossing ETLs in many demonstration fields in Vidarbha region. Thus, there is an ardent need to manage the bollworm with effective IPM module. Therefore, the present study was planned to find out effective insecticidal module for the management of bollworms in HDPS cotton in rain fed condition of Vidarbha region.

MATERIALS AND METHODS

The experiment was laid out in FRBD with three replications. The cotton variety AKH-081 was sown at Akola, Amravati and Yeotmal locations on research station fields in *Kharif,* 2015 and regular agronomic practices were followed. Three different spacing's 45 x 10 cm, 60 x 10 cm and 60 x 15 cm along with four different insecticidal spray modules were evaluated in this study. The treatments details are as follows:

Main treatments (spacing)

S1 - 45 x 10 cm

S2 - 60 x 10 cm

S3 - 60 x 15 cm

Sub treatments (insecticidal modules)

M1 - Quinalphos 25 EC@ 400ml/ acre > Spinosad 45%SC @ 60 ml/acre > Fenvalerate 20 EC @ 200 ml/acre

M2 - Flubendamide 480 SC @ 40ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre > Fenvalerate 20 EC @ 200 ml/acre

M3 - Flubendamide 480 SC @ 40ml/acre > Spinosad 45%SC @ 60 ml/acre > Fenvalerate 20 EC @ 200 ml/acre

M4 - Control

Treatment combinations are

T1 - S1M1, T2 - S1M2, T3 - S1M3, T4 - S1M4, T5 - S2M1, T6 - S2M2, T7 - S2M3, T8 - S2M4, T9 - S3M1, T10 - S3M2, T11 - S3M3, T12 - S3M4.

First spray was initiated as soon as bollworms attended Economic Threshold Level and subsequent sprays were given in scheduled sequence as per the given in respective modules. The observations on green fruiting bodies damage was recorded regularly at 7 days after treatment spray on randomly selected 5 plants from each net plot on whole plant. In regards to larval population, the data was recorded at weekly interval on randomly selected five plants from each net plot on whole plant and was averaged. The observation on open boll damage and loculi damage by bollworms was recorded at the time of harvest. All the observations were statistically analysed in FRBD design as per Panse and Sukhatme (1985) with appropriate transformation. The picking wise yield of seed cotton was recorded and incremental cost benefit ratio (ICBR) for each treatment was also worked out for finding most economical module to managed bollworms in HDPS cotton.

RESULTS AND DISCUSSION

Effect on larval population of bollworm (pooled)

The pooled data recorded on larval population of bollworm was found significant over control. Minimum larval population of bollworm (0.09) was observed in treatment S2M2 *i.e.* in 60 x 10 cm spacing with application of Flubendamide 480 SC @ 40 ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre> Fenvalerate 20 EC @ 200 ml/acre followed by S2M3 (60 x 10 cm spacing with application of Flubendamide 480 SC @ 40 ml/acre > Spinosad 45 SC @ 60

Table 1: Effect of spacing, module and its interaction on larval population of bollworm

	Akola				Amravati				Yeotmal				Pooled			
	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN
M1	0.57(1.03)	0.34(0.92)	0.38(0.94)	0.43(0.96)	0.50 (1.00)	0.31 (0.90)	0.31 (0.90)	0.37 (0.93)	0.48(0.99)	0.31(0.90)	0.32(0.91)	0.37(0.93)	0.51 (0.72)	0.32 (0.57)	0.34 (0.57)	0.39 (0.62)
M2	0.37(0.93)	0.09(0.77)	0.22(0.85)	0.23(0.85)	0.29 (0.89)	0.10 (0.77)	0.17 (0.81)	0.19 (0.83)	0.34(0.92)	0.08(0.76)	0.17(0.81)	0.20(0.83)	0.33 (0.57)	0.09 (0.29)	0.19 (0.40)	0.20 (0.42)
M3	0.47(0.98)	0.22(0.85)	0.42(0.96)	0.37(0.93)	0.40 (0.95)	0.20 (0.84)	0.33 (0.91)	0.31 (0.90)	0.42(0.96)	0.18(0.82)	0.37(0.93)	0.32(0.90)	0.43 (0.64)	0.20 (0.44)	0.37 (0.61)	0.33 (0.56)
M4	1.27(1.33)	0.89(1.18)	0.89(1.22)	1.02(1.24)	1.19 (1.30)	0.76 (1.12)	0.81 (1.14)	0.92 (1.19)	1.26(1.32)	0.84(1.16)	0.91(1.19)	1.00(1.22)	1.24 (1.11)	0.83 (0.91)	0.90 (0.95)	0.99 (0.99)
MEAN	0.67(1.07)	0.39(0.93)	0.48(0.99)		0.59 (1.03)	0.34 (0.91)	0.41 (0.94)		0.63(1.05)	0.35(0.91)	0.44(0.96)		0.63 (0.76)	0.36 (0.55)	0.45 (0.63)	
	Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spa x Mod	Location
F test	SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS	NS
SE(m) +-	0.02	0.02	0.04		0.01	0.02	0.03		0.02	0.02	0.04		0.016	0.018	0.04	0.16
CD at 5%	0.06	0.07	-		0.04	0.05	-		0.05	0.06	-		0.045	0.052	-	-
CV %	7.27				8.13				6.53				14.88			

Table 2: Effect of spacing, module and its interaction on per cent GFB damage

	Akola				Amravati				Yeotmal				Pooled			
	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN
M1	4.94 (2.22)	3.17 (1.77)	2.70 (1.63)	3.60 (1.87)	4.03 (2.01)	2.82 (1.66)	2.43 (1.54)	3.10 (1.74)	4.76(2.18)	3.17(1.76)	2.85(1.66)	3.59(1.89)	4.58 (2.14)	3.05 (1.73)	2.66 (1.61)	3.43 (1.83)
M2	2.65 (1.62)	2.10 (1.44)	1.88 (1.36)	2.21 (1.47)	2.47 (1.57)	1.55 (1.23)	1.50 (1.21)	1.84 (1.34)	2.52(1.58)	1.84(1.35)	2.09(1.43)	2.15(1.47)	2.55 (1.59)	1.83 (1.34)	1.82 (1.33)	2.07 (1.42)
M3	4.64 (2.15)	3.35 (1.83)	3.00 (1.73)	3.66 (1.90)	3.90 (1.97)	3.15 (1.77)	2.57 (1.60)	3.21 (1.78)	4.63(2.15)	3.52(1.87)	2.92(1.71)	3.69(1.92)	4.39 (2.09)	3.34 (1.82)	2.83 (1.68)	3.52 (1.86)
M4	12.63 (3.55)	10.07 (3.17)	10.76 (3.28)	11.15 (3.33)	13.23 (3.63)	9.83 (3.13)	9.94 (3.15)	11.00 (3.31)	13.08(3.61)	11.22(3.38)	10.93(3.33)	11.74(3.43)	12.97 (3.60)	10.45 (3.23)	10.63 (3.25)	11.35 (3.36)
MEAN	6.22 (2.39)	4.67 (2.05)	4.59 (2.00)		5.91 (2.29)	4.34 (1.95)	4.13 (1.88)		6.25(2.50)	4.94(2.22)	4.70(2.17)		6.12 (2.35)	4.67 (2.03)	4.48 (1.97)	
	Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spa x Mod	Location
F test	SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS	SIG
SE (m) +-	0.05	0.06	0.11		0.05	0.06	0.10		0.07	0.08	0.64		0.030	0.035	0.061	0.030
CD at 5%	0.18	0.18	-		0.15	0.17	-		0.19	0.22	-		0.091	0.105	-	0.091
CV %	8.37				8.48				10.60				9.12			

Figures in parenthesis are square root transformed values

Table 3: Effect of spacing, module and its interaction on per cent open boll damage

	Akola				Amravati				Yeotmal				Pooled			
	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN
M1	11.69(19.98)	6.37 (14.49)	4.07 (11.63)	7.38 (15.36)	7.40 (15.78)	3.65 (11.01)	3.75 (11.16)	4.93 (12.65)	10.07 (18.48)	4.48 (12.03)	4.55 (12.16)	6.37 (14.22)	9.72 (18.08)	4.83 (12.51)	4.13 (11.65)	6.23 (14.08)
M2	5.06 (12.81)	2.11 (8.34)	1.77 (7.63)	2.98 (9.59)	4.57 (12.23)	2.09 (8.31)	1.82 (7.76)	2.82 (9.43)	5.43 (13.27)	2.27 (8.65)	1.87 (7.86)	3.19 (9.93)	5.02 (12.77)	2.15 (8.44)	1.82 (7.74)	3.00 (9.65)
M3	9.55 (17.93)	4.38 (12.06)	3.30 (10.08)	5.74 (13.36)	6.05 (14.08)	4.09 (11.66)	2.45 (8.91)	4.20 (11.55)	8.10 (16.44)	5.47 (13.44)	3.70 (10.91)	5.76 (13.60)	7.90 (16.15)	4.65 (12.38)	3.15 (9.97)	5.23 (12.84)
M4	26.64 (31.04)	22.02 (27.96)	23.31 (28.85)	23.99 (29.28)	25 72 (30.34)	21 47 (27.58)	20.66 (27.00)	22.62 (28.31)	27.68 (31.62)	23.83 (29.17)	23.99 (29.26)	25.16 (30.02)	26.84 (31.10)	22.50(28.26)	22.65(28.37)	24.00 (29.24)
MEAN	13.24 (20.44)	8.72 (15.71)	8.11 (14.55)		10.93 (18.11)	7.83 (14.64)	7.17 (13.71)		12.82 (19.95)	9.01 (15.82)	8.53 (15.05)		12.37 (19.52)	8.53 (15.40)	7.94 (14.43)	
	Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spa x Mod	Location
F test	SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS	SIG
SE (m) +-	0.54	0.62	1.08		0.54	0.63	1.09		0.75	0.87	1.50		0.339	0.391	0.681	0.34
CD at 5%	1.58	1.82	-		1.60	1.84	-		2.20	2.55	-		1.021	1.179	-	1.02
CV %	11.04				12.18				15.37				13.21			

ml/acre > Fenvalerate 20 EC @ 200 ml/acre). However, maximum larval population of bollworm (1.24) was recorded in S1M4 which consisted 45 x 10 cm spacing without any insecticidal application. Interaction effect of spacing and module and locations were found non significant. Similar trend was observed at all three locations indicating Module 2 which include Flubendamide 480 SC @ 40 ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre> Fenvalerate 20 EC @ 200 ml/acre effectively managed larval population of bollworms in HDPS cotton. (Table 1).

Effect on green fruiting bodies (GFB) damage (pooled)

The pooled data recorded on GFB damage by bollworm revealed that minimum green fruiting bodies damage (1.82 %) was observed in treatment S3M2 i.e. in 60x15 cm spacing with application of Flubendamide 480 SC @ 40 ml/acre > Spinosad 45% SC @ 60 ml/acre > Fenvalerate 20 EC @ 200 ml/acre and it was at par with Flubendamide 480 SC @ 40 ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre> Fenvalerate 20 EC @ 200 ml/acre. Intraction effect of spacing x module were found non significant whereas location effect was found significant. Maximum damage of green fruiting bodies (12.97 %) was noticed in S1M4 i.e. control treatment having 45 x 10 cm spacing. The data recorded at Akola, Amravati and Yevatmal location also revealed similar trend indicating Module 2 (Flubendamide 480 SC @ 40 ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre> Fenvalerate 20 EC @ 200 ml/acre) effectively managed larval population of bollworms in HDPS cotton irrespective of spacing's. (Table 2).

Effect on open boll damage (pooled)

Pooled per cent open boll damage was found significant but their interaction effect were non significant. Minimum open boll damage (1.82 %) was observed in treatment S3M2 i.e. in 60 x 15 cm spacing with application of Flubendamide 480 SC @ 40 ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre> Fenvalerate 20 EC @ 200 ml/acre and it was on par with S2M2 which recorded 2.15 per cent open boll damage whereas maximum open boll damage (26.84 %) was recorded in closer spacing *i.e.* S1M4 treatment (45 x 10 cm spacing with untreated plot). Similar trend was observed at all three locations indicating Module 2 which include Flubendamide 480 SC @ 40 ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre> Fenvalerate 20 EC @ 200 ml/acre effectively managed larval population of bollworms in HDPS cotton irrespective of spacing. Location effect were found significant (Table 3).

Effect on loculi damage (pooled)

The pooled data recorded on per cent loculi damaged by bollworm revealed that minimum loculi damage was found in was observed in treatment S3M2 i.e. in 60x15 cm spacing with application of Flubendamide 480 SC @ 40 ml/acre > Spinosad 45% SC @ 60 ml/acre > Fenvalerate 20 EC @ 200 ml/acre and it was at par with the treatment S2M2 which comprises Flubendamide 480 SC @ 40 ml/acre > Chlorantraniliprole 18.5 SC @ 60 ml/acre> Fenvalerate 20 EC @ 200 ml/acre. The data recorded at Akola, Amravati and Yeotmal location also showed similar type of results indicating superiority of Module 2 over the other modules. Interaction effect of spacing x module were found non significant whereas location effect was found significant. (Table 4).

Table 4: Effect of spacing, module and its interaction on per cent loculi damage

	Akola				Amravati				Yeotmal				Pooled			
	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN	S1	S2	S3	MEAN
M1	2.60 (1.60)	1.47 (1.20)	1.03 (1.02)	1.70 (1.10)	1.77 (1.33)	0.88 (0.94)	0.91 (0.95)	1.19 (1.07)	2.33 (1.52)	1.08 (1.03)	1.14 (1.05)	1.52 (1.20)	2.23 (1.48)	1.14 (1.05)	1.03 (1.01)	1.47 (1.18)
M2	1.16 (1.05)	0.53 (0.73)	0.45 (0.67)	0.71 (0.81)	1.11 (1.04)	0.50 (0.71)	0.44 (0.66)	0.68 (0.80)	1.35 (1.14)	0.55 (0.74)	0.47 (0.68)	0.79 (0.86)	1.21 (1.08)	0.53 (0.73)	0.45 (0.67)	0.73 (0.82)
M3	1.79 (1.33)	1.10 (1.05)	0.70 (0.82)	1.20 (1.07)	1.46 (1.19)	0.98 (0.99)	0.59 (0.76)	1.01 (0.98)	2.66 (1.59)	1.35 (1.16)	0.92 (0.94)	1.64 (1.23)	1.97 (1.37)	1.14 (1.06)	0.74 (0.84)	1.28 (1.09)
M4	5.75 (2.40)	4.88 (2.20)	4.92 (2.22)	5.18 (2.27)	6.16 (2.47)	5.16 (2.27)	4.91 (2.21)	5.41 (2.32)	6.75 (2.58)	5.72 (2.39)	5.56 (2.35)	6.01 (2.44)	6.22 (2.48)	5.25 (2.29)	5.13 (2.26)	5.53 (2.34)
MEAN	2.83 (1.59)	2.00 (1.29)	1.76 (1.18)		2.62 (1.51)	1.88 (1.22)	1.71 (1.15)		3.27 (1.71)	2.18 (1.33)	2.02 (1.26)		2.91 (1.60)	2.02 (1.28)	1.84 (1.20)	
	Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spacing x Module		Spacing	Module	Spa x Mod	Location
F test	SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS		SIG	SIG	NS	SIG
SE (m)+-	0.04	0.05	0.09		0.04	0.02	0.04		0.07	0.08	0.13		0.02	0.02	0.04	0.03
CD at 5%	0.13	0.15	-		0.12	0.07	-		0.20	0.23	-		0.06	0.07	-	0.08
CV %	11.70				11.14				16.28				7.27			

Figures in parenthesis are square root transformed values

Table 5: Effect of spacing, module and its interaction on yield, net profit and ICBR

Sr.No.	Treatment Details	Pooled (Akola, Amravati and Yeotmal) Yield (Kg/ha)	Increased yield	Plant prot. Cost (Rs/ha)	Net profit (Rs/ha)	ICBR
T1	S1M1	1228.48	438.36	5686	12299.63	1: 2.1
T2	S1M2	1407.49	617.37	6434	18590.97	1: 2.9
T3	S1M3	1359.47	569.35	6680	16368.58	1: 2.5
T4	S1M4	790.12	-	-	-	-
T5	S2M1	1682.35	822.87	5686	27894.86	1: 4.8
T6	S2M2	1915.14	1055.66	6434	36335.91	1: 5.6
T7	S2M3	1829.08	969.6	6680	32608.15	1: 4.9
T8	S2M4	859.48	-	-	-	-
T9	S3M1	1595.43	637.28	5686	20391.95	1: 3.5
T10	S3M2	1840.99	882.84	6434	29333.20	1: 4.5
T11	S3M3	1669.38	73.95	6680	22131.48	1: 3.3
T12	S3M4	958.15	-	-	-	-

Standard spray volume - 500 lit of water/ha.Labour charges for spraying - 5 labour per ha @ Rs 180 per day for spraying. 3 Knapsack spray pump rent - @ Rs 25/day = 75 Rs/haAv. Market price of Cotton - @ Rs 4100 per quintal (MSP 2015-16)Quinolphos 20 SP @ Rs. 370/LiterSpinosad 45 SC @ Rs. 1123/75 mlChlorantraniliprole 18.5 SC @ Rs. 800/60 mlFlubendamide 5 SC @ Rs. 682/50 ml Fenvalerate 20 EC @ Rs. 295/500 ml

Effect on Seed Cotton Yield and ICBR (Pooled)

The pooled data of three location recorded on seed cotton yield revealed that treatment S2M2 (60 x 10 cm spacing with application of flubendamide 480 SC @ 40 ml/acre > chlorantraniliprole 18.5 SC @ 60 mL/acre> fenvalerate 20 EC @ 200 ml/acre) was recorded maximum seed cotton yield (1915.14 kg/ha) and it was at par with S3M2 (1840.99 Kg/ha) and S2M3 (1829.08 Kg/ha). Minimum seed cotton yield was recorded in S1M4 (790.12 kg/ha) which consist of 45 x 10 cm spacing with no insecticidal application at all. The above results clearly indicated that spraying of flubendamide 480 SC @ 40 ml/acre followed by chlorantraniliprole 18.5 SC @ 60 ml/acre followed by fenvalerate 20 EC @ 200 ml/acre was found superior in getting higher seed cotton yield with spacing 60 x 10 cm in HDPS cotton system (Table 5). Pooled results recorded highest ICBR ratio (1:5.6) in the treatment 60 x 10 cm spacing with application of flubendamide 480 SC @ 40 ml/acre followed by chlorantraniliprole 18.5 SC @ 60 ml/acre followed by fenvalerate 20 EC @ 200 ml/acre i.e. S2M2 module followed by S2M3 module (1:4.9). Second maximum ICBR (1:4.8) was recorded in treatment S2M1 and S3M2 (1:4.5). Lowest (1:2.1) was recorded in treatment S1M1 i.e. quinalphos 25 EC@ 400ml/ acre followed by spinosad 45%SC @ 60 ml/acre followed by fenvalerate 20 EC @ 200 ml/acre (Table 5).

The results of the present investigation substantially supported by the findings of Paslawar *et al.* (2013) who reported that AKH-081 an early and dwarf variety at narrow spacing of 45 x 10 cm showed highest plant height, higher LAI, highest seed cotton (3218 Kgha-1), lint and biological yield with highest gross monetary (Rs. 125502) and net monetary returns (Rs. 86258) with cost benefit ratio of 3.18. However, square dropping and incidence of bollworm complex was more in narrow spacing. Venugopalan *et al.* (2013) tested several compact varieties and among them AKH-081, NH 615, Suraj, Anjali KC3 (*G. hirsutum*) and AKA7, JK5 and HD123 (*G. arboreum*) planted at 60 x 10 cm, 45 x 15 cm and 45 x 10 cm under rainfed conditions. Further they stated that, by increasing the plant population from 50,000 plants/ha to 1.5 to 2.0 lakh plants/ha, it is possible to realize 1800-2000 kg/ha seed cotton/ ha with the above varieties on marginal soils under rainfed conditions with minimum inputs which is more than twice the average yield of Vidarbha. Ganvir *et al.* (2013) reported that the spacing 60 x 10 cm produced significantly higher seed cotton yield, gross monetary returns and net monetary returns than spacing 60 x 30 cm and it was at par with 60 x 15 cm but benefit cost ratio was higher in 60 x 15 cm of AKH 081. These results are in conformity with present findings. Ahuja *et al.* (2013) evaluated *G. arboreum* genotypes for HDPS in Northern India and on the basis of two years data reported that there was in general higher yield for 67.5 x 20 cm spacing with an increase in yield range of 3 to 8 q/ha (10.1 to 27.8% increase) over normal spacing of 67.5 x 30 cm except for CISA-310 (67.5 x 10 cm, 32.2%). Besides these, several workers reported efficacy of individual insecticides which are used in modules as schedule spray. Gadhiya *et al.* (2014) found chlorantraniliprole (0.006%) and spinosad (0.018%) were effective and statistically at par with each other in protecting the crop from the infestation of *Spodoptera litura* (Fab.) and *Helicoverpa armigera* (Hubner). Jat and Ameta (2013) observed spinosad 45% SC at 200 ml/ha with 74.67 per cent mean reduction in *H. armigera*. Patil *et al.* (2014) reported that ten days after first spraying, the incidence of *C. acuta* per sq. m. row was found lowest in Chlorantraniliprole (0.05) and it was significantly at par with Spinosad (0.27). Hardke *et al.* (2014) evaluated effcacy of selected insecticides (chlorantraniliprole, fubendiamide, lambda-cyhalothrin, novaluron and spinetoram) against fall armyworm, *Spodoptera frugiperda* in transgenic Bt (Bollgard II) and non-Bt (conventional) cotton and reported that significantly higher fall armyworm mortality was observed on chlorantraniliprole, flubendiamide, and spinetoram sprayed Bollgard II leaves compared to mortality on novaluron sprayed Bollgard II leaves ($p < 0.05$). These findings are in line with the present findings though some crop and pests are different.

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