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Validation of recommended doses of insecticides against sucking pests of BT cotton

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Abstract
Comparative efficacy of acetamiprid, imidacloprid and dimethoate at university recommended dose, double the recommended dose and dose used by the farmers was evaluated against sucking pests of Bt cotton. The results revealed that minimum population of sucking pests was observed in dose of acetamiprid used by farmers (6.0 g/10 L of water) and was followed by double the recommended dose of imidacloprid (4.5 ml/10 L of water) and higher dose of dimethoate used by farmers (30 ml/10 L of water). Maximum seed cotton yield (1816.81 kg/ha) was recorded in higher dose of acetamiprid used by farmers @ 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. Higher doses performed better than the recommended doses indicating possibility of resistance in sucking pests of Bt cotton.

Keywords: Acetamiprid, BT Cotton, dimethoate, imidacloprid, sucking pests, validation of doses

1. Introduction
Cotton is one of the most important cash crops in India and plays a dominant role in industrial and agricultural economy of the country [1]. Major losses in cotton production are due to its susceptibility to about 162 species of insect pests and number of diseases [2]. In post Bt era, the productivity levels are often low on account of ravages of sucking pests especially during early growth and boll formation stage. Among the sucking pests, leaf hoppers, *Amrasca biguttula biguttula* (Ishida); thrips, *Thrips tabaci* (Linn.); aphids, *Aphis gossypii* (Glover); and whiteflies, *Bemisia tabaci* (Genn.) are important. The abundance is evident from seedling stage and translates into losses to the tune of 21.20 to 22.86 per cent [3, 4, 5].
Heavy reliance and indiscriminate use of pesticides to control insect pests has led to the development of resistance to all classes of pesticides [6, 7]. Cotton growers still depend on synthetic insecticides to combat sucking pests, but the present cotton pest management with special reference to sucking pests was a concern due to insecticide resistance in sucking pests. Insecticide resistance rendered insecticides ineffective, necessitating repeated applications of insecticides or resorting to higher doses of insecticides, which in turn contributed to the development of resistance [7, 8]. Farmers use higher doses on account of perception that recommended doses are not working very well in fields. Hence, there is an inclination of the farmers towards the use of higher doses of pesticides than the recommended doses for the management of sucking pests in Bt cotton. Keeping this in view, the present study was carried out with three insecticides, which are recommended for the management of sucking pests of cotton for its efficacy and cost effectiveness.

2. Material and Methods
The multi-location trial was conducted at Cotton Research Unit, Akola, Regional Research Center, Amravati and Zonal Agriculture Research Station, Yeotmal during the year 2012-13. The experiment was laid out in randomized block design (RBD) replicated thrice with three insecticides *viz.,* acetamiprid, imidacloprid and dimethoate at university recommended dose, double the recommended dose and higher dose (farmers practice) along with untreated control (Table 1).

2.1 Effect of treatments on abundance of sucking pests
Observations on the population of sucking pests *i.e.* aphids, leaf hoppers, thrips and whiteflies were recorded on 3 leaves (top, middle and bottom) per plant on randomly selected five plants from each net plot at 7 and 14 days after each spray. The mean count of sucking pest per leaf is depicted in data.

2.2 Effect of treatments on abundance of predators
Observations on predators *i.e.* chrysopa larvae, lady bird beetles, syrphid larvae and spiders were also recorded at 7 and 14 days after each spray.

2.3 Effect of treatments on yield and ICBR
The picking wise yield of seed cotton was also recorded. The net plot yield was extrapolated to per hectare yield. The total cost of plant protection comprised of prevailing market price of insecticides per ha, labour and sprayer charges per ha. Net monetary return of a treatment 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 realization. Incremental cost benefit ratio (ICBR) was worked out as a ratio of net profit to the cost of plant protection, which exhibits the economic viability of the treatment.

2.4 Statistical Analysis
The data set from three locations *viz*., Akola, Amravati and Yeotmal was pooled for comparing the efficacy of treatments. Population count of sucking pests at 7 and 14 days after application of treatment was subjected to square root transformation before analyzing it in Randomised Block Design.

3. Results
3.1 Effect of insecticidal treatments on population of sucking pests at 7 DAT
Pooled data of three locations viz., Akola, Amravati and Yeotmal (Table 1) described in detail as below.

i) Aphids
Aphid population data revealed that all the treatments were significantly superior over untreated control. Minimum population of aphid (0.39 aphids/leaf) was recorded in imidacloprid 17.8 SL @ 9.00 ml/10 L water i.e. dose used by farmers of imidacloprid and statistically it was at par with acetamiprid 20 SP @ 6.0 g/10 L water (0.49 aphids/leaf). Dimethoate 30 EC @ 30 ml/10 L water ranked second in terms of efficacy against aphids. Among the different concentrations of all three insecticides higher concentration proved better followed by double the recommended dose. Maximum aphid population (4.30/leaf) was recorded in untreated control.

ii) Leaf hoppers
In case of leaf hoppers population, all the treatments were found significantly superior over untreated control. Similar efficacy trend of different insecticidal doses was observed as recorded in case of aphid population at 7 DAT with minimum leaf hoppers population in dose used by farmers i.e. higher doses of acetamiprid, dimethoate and imidacloprid. Untreated control recorded maximum leaf hoppers population i.e. 7.90 leaf hoppers/leaf (Table 1).

iii) Thrips
All the treatments showed significantly superior results over control. Maximum thrips population (4.30/leaf) was recorded in control treatment, whereas, minimum population of thrips was recorded in higher concentration of acetamiprid (6 g), dimethoate (30 ml) and imidacloprid (9 ml) used by farmers than the university recommended concentrations of the same insecticides. (Table 1).

iv) Whitefly
Pooled data regarding the whitefly population was statistically significant. Minimum whitefly population was recorded in higher concentration (dose used by farmers) of acetamiprid, dimethoate whereas, in case of imidacloprid higher concentration i.e. 9 ml/10 L was recorded at par results with double dose of imidacloprid (4.5 ml/10 L of water) than the university recommendation. Maximum whitefly population (12.74/leaf) was recorded in control treatment (Table 1).

3.2 Effect of insecticidal treatments on population of sucking pests at 14 DAT
i) Aphids
Data on effect of insecticidal treatments on population of aphids at 14 DAT revealed that all the treatments were found significantly superior over control. Minimum aphid population was recorded in dose used by farmers of acetamiprid (6 g), dimethoate (30 ml) and imidacloprid (9 ml) than lower concentrations of these insecticides. University recommended dose of above insecticides revealed lower efficacy against aphid population though, significantly superior over untreated control. Maximum aphid population (4.30/leaf) was recorded in untreated control. (Table 2).

ii) Leaf hoppers
All the treatments were significantly superior over untreated control. Maximum population of leaf hoppers (7.42/leaf) was recorded in untreated control, whereas, minimum leaf hoppers population was recorded in dose of acetamiprid, dimethoate and imidacloprid used by farmers, respectively, similar to the efficacy trend of different insecticidal doses at 7 DAT. (Table 2).

iii) Thrips
Data pertaining to thrips population recorded at 14 DAT showed that all the treatments were significantly superior over untreated control. Minimum population of thrips was recorded in the treatment of acetamiprid 6 g, dimethoate 30 ml and imidacloprid 9 ml than the university recommended concentrations of same insecticides whereas, maximum thrips population (4.30/leaf) was recorded in untreated control. (Table 2).

iv) Whitefly
All the treatments were significantly superior over untreated control in case of whitefly population. Maximum whitefly population i.e. 12.74/leaf was recorded in untreated control. Minimum population of whitefly population was recorded in higher concentration of acetamiprid, dimethoate used by the farmers whereas, in case of imidacloprid higher concentration i.e. 9 ml/10 L was recorded at par results with 4.5 ml/10 L concentration of same insecticide than university recommended concentration. (Table 2).

3.3 Effect of various insecticide doses on abundance of predators

All the concentrations of acetamiprid, dimethoate and imidacloprid did not showed any adverse effect on predators' population. There was no significant variation among the treatments even before and after application of insecticides. Insecticide interventions affect the predatory activity at 7 day after application than the 14 days recording minimum predator population in higher concentrations than the recommended concentrations, which ranged between 0.58 to 1.12 (7 DAT) and 0.63 to 0.89 (14 DAT) predators per plant respectively. Maximum predator activity was observed in untreated control.

3.4 Yield

Higher seed cotton yield (1816.81 kg/ha) was recorded in dose used by farmers of acetamiprid 6.0 g/10 L of water and it was at par with imidacloprid 9 ml/10 L, recording 1661.07 kg/ha seed cotton yield. Next efficacious treatment was imidacloprid 4.5 ml/10 L, dimethoate 30 ml/10 L of water and acetamiprid 3.0 g/10 L of water with yield level of 1453.38, 1441.52 and 1427.19 kg/ha, respectively. However, it was observed that seed cotton yield obtained in farmer's dose (highest dose) treatments was on par with double the recommended dose treatments of respective insecticides. The lowest yield was observed in control treatment (792.267 kg/ha). (Table 3).

3.5 Net profit and ICBR

Highest monetary returns i.e. Rs. 37,236/ha was recorded in treatment with acetamiprid dose used by the farmers @ 6.0 g/10 L of water. The next best treatment was imidacloprid 9 ml/10 L of water (dose used by the farmers) which recorded net profit of Rs. 30,712/ ha followed by imidacloprid 4.5 ml/10 L of water, double the recommended dose (Rs. 23,260/ ha), acetamiprid 3.0 g/10 L of water, double the recommended dose (Rs. 22,464 per ha) and dimethoate 30 ml/10 L of water, dose used by the farmers (Rs. 22,321 per ha). In terms of incremental cost benefit ratio, higher concentrations of acetamiprid (6.0 g (dose used by the farmers) and 3.0 g /10 L of water, double the recommended dose) registered highest ICBR *i.e.*1: 13.7 and 1:9.8, respectively. The second best treatment in terms of ICBR was imidacloprid dose used by the farmers @ 9 ml/10 L of water which registered high ICBR of 1: 9.7, whereas, dimethoate higher dose used by the farmers (30 ml/10 L of water) registered ICBR of 1: 7.4. (Table 3).

Table 1: Effect of various insecticide doses on population abundance of sucking pests at 7 days after treatment application (Pooled)

Tr. No.	Treatments	Pooled data of three (AKL, AMT & YTM) locations				
		Aphids/leaf	Leaf hoppers/ leaf	Thrips/leaf	Whiteflies/leaf	Predators/plant
T_1	Acetamiprid 20 SP @ 1.5 g/10 L water	2.24 (1.36)	2.99 (1.72)	1.79 (1.18)	3.40 (1.83)	0.87 (0.84)
T_2	Acetamiprid 20 SP @ 3.0 g/10 L water	0.72 (0.83)	1.72 (1.26)	1.24 (0.93)	2.11 (1.40)	0.77 (0.77)
T_3	Acetamiprid 20 SP @ 6.0 g/10 L water	0.49 (0.66)	1.09 (0.98)	0.98 (0.77)	1.70 (1.26)	0.58 (0.66)
T_4	Dimethoate 30 EC @ 10.0 ml/10 L water	2.47 (1.45)	3.73 (1.93)	1.99 (1.26)	3.82 (1.94)	0.86 (0.85)
T_5	Dimethoate 30 EC @ 20.0 ml/10 L water	1.39 (1.12)	2.91 (1.69)	1.66 (1.08)	3.17 (1.76)	0.76 (0.80)
T_6	Dimethoate 30 EC @ 30.0 ml/10 L water	0.95 (0.93)	2.22 (1.46)	1.31 (0.98)	2.67 (1.62)	0.82 (0.79)
T_7	Imidacloprid 17.8 SL @ 2.25 ml/10 L water	2.03 (1.32)	3.33 (1.82)	1.75 (1.14)	3.75 (1.93)	0.93 (0.88)
T_8	Imidacloprid 17.8 SL @ 4.5 ml/10 L water	0.77 (0.86)	2.17 (1.43)	1.31 (0.94)	2.71 (1.60)	0.82 (0.80)
T_9	Imidacloprid 17.8 SL @ 9.0 ml/10 L water	0.39 (0.58)	1.22 (1.02)	0.93 (0.74)	2.19 (1.39)	0.70 (0.74)
T_{10}	Control	4.30 (2.04)	7.90 (2.79)	4.68 (1.90)	12.74 (3.50)	1.12 (0.99)
'F' test		**Sig.**	**Sig.**	**Sig.**	**Sig.**	**Sig.**
SE (m)±		0.041	0.044	0.043	0.076	0.023
CD at 5%		0.122	0.132	0.127	0.225	0.071
CV %		11.09	8.27	11.72	12.51	8.84

AKL: Cotton Research Unit, Akola, AMT: Regional Research Center, Amravati, YTM: Zonal Agriculture Research Station, Yeotmal, DAT: Days after treatment. Figures in parentheses are square root transformed values.

Table 2: Effect of various insecticide doses on population abundance of sucking pests at 14 days after treatment application (Pooled)

Tr. No.	Treatments	Pooled data of three (AKL, AMT & YTM) locations				
		Aphids/leaf	Leaf hoppers/ leaf	Thrips/leaf	Whiteflies/leaf	Predators/plant
T_1	Acetamiprid 20 SP @ 1.5 g/10 L water	1.47 (1.06)	1.95 (1.38)	0.60 (0.74)	4.66 (2.12)	0.76 (0.81)
T_2	Acetamiprid 20 SP @ 3.0 g/10 L water	0.31 (0.55)	0.82 (0.88)	0.41 (0.59)	3.42 (1.68)	0.63 (0.69)
T_3	Acetamiprid 20 SP @ 6.0 g/10 L water	0.17 (0.38)	0.50 (0.67)	0.33 (0.49)	2.99 (1.58)	0.66 (0.67)
T_4	Dimethoate 30 EC @ 10.0 ml/10 L water	1.67 (1.13)	2.23 (1.48)	0.68 (0.79)	4.92 (2.17)	0.69 (0.74)
T_5	Dimethoate 30 EC @ 20.0 ml/10 L water	0.70 (0.79)	1.29 (1.12)	0.50 (0.68)	3.77 (1.88)	0.72 (0.77)
T_6	Dimethoate 30 EC @ 30.0 ml/10 L water	0.50 (0.69)	1.16 (1.06)	0.43 (0.62)	3.66 (1.80)	0.81 (0.81)
T_7	Imidacloprid 17.8 SL @ 2.25 ml/10 L water	1.46 (1.07)	1.99 (1.40)	0.61 (0.75)	4.84 (2.16)	0.75 (0.76)
T_8	Imidacloprid 17.8 SL @ 4.5 ml/10 L water	0.29 (0.53)	0.98 (0.97)	0.41 (0.59)	3.84 (1.79)	0.67 (0.72)
T_9	Imidacloprid 17.8 SL @ 9.0 ml/10 L water	0.16 (0.38)	0.63 (0.73)	0.38 (0.55)	3.39 (1.66)	0.70 (0.72)
T_{10}	Control	3.97 (1.92)	7.42 (2.70)	2.01 (1.32)	16.81 (4.01)	0.89 (0.90)
'F' test		Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±		0.037	0.052	0.036	0.070	0.027
CD at 5%		0.109	0.153	0.106	0.209	0.079
CV %		13.02	12.47	15.07	10.14	10.62

AKL: Cotton Research Unit, Akola, AMT: Regional Research Center, Amravati, YTM: Zonal Agriculture Research Station, Yeotmal, DAT : Days after treatment. Figures in parentheses are square root transformed values.

Table 3: Effect of various insecticide doses on seed cotton yield, Net profit and ICBR (Pooled)

Tr. No.	Treatments	Yield (Kg/ha)	Increase in yield over control (Kg/ha)	Cost of Increased yield (Rs.)	Plant protection application cost (Rs/ha)	Net Profit (Rs/ha)	ICBR
T_1	Acetamiprid 20SP @ 1.5 g/10 L water	1178.47	386.21	15062	2090	12973	1 : 6.2
T_2	Acetamiprid 20SP @ 3.0 g/10 L water	1427.19	634.92	24762	2298	22464	1 : 9.8
T_3	Acetamiprid 20SP @ 6.0 g/10 L water	1816.81	1024.54	39957	2721	37236	1 : 13.7
T_4	Dimethoate 30 EC @ 10.0 ml/10 L water	955.07	162.80	6349	2250	4099	1 : 1.8
T_5	Dimethoate 30 EC @ 20.0 ml/10 L water	1194.68	402.41	15694	2625	13069	1 : 5.0
T_6	Dimethoate 30 EC @ 30.0 ml/10 L water	1441.52	649.25	25321	3000	22321	1 : 7.4
T_7	Imidacloprid 17.8 SL @ 2.25 ml/10 L water	1191.38	399.11	15565	2199	13366	1 : 6.1
T_8	Imidacloprid 17.8 SL @ 4.5 ml/10 L water	1453.38	661.11	25783	2523	23260	1 : 9.2
T_9	Imidacloprid 17.8 SL @ 9.0 ml/10 L water	1661.07	868.80	33883	3171	30712	1 : 9.7
T_{10}	Untreated control	792.27	-	-	-	-	-
	'F' test	**Sig.**					
	SE (m)±	76.62					
	CD at 5%	227.66					
	CV %	10.05					

- Standard spray volume - 500 L of water/ha.
- Labour charges for spraying - 5 labour per ha @ Rs 120 per day for spraying.
- 3 Knapsack spray pump rent - @ Rs 25/day = 75 Rs/ha
- Av. Market price of Cotton - @ Rs 3900 per quintal (MSP 2012-13)
- Acetamiprid 20SP @ Rs. 940/kg , Dimethoate 30 EC @ Rs. 250/L, Imidacloprid 17.8 SL @ Rs. 960/L

4. Discussion

The present findings are in line with the reported bio efficacy of acetamiprid (Pride 20 SP), at the rate of 100, 150 and 200 g/ha, to be as good as the recommended dosages of oxydemeton methyl at 750 ml/ha, triazophos at 1500 ml/ha and ethion at 2000 ml/ha, in controlling cotton whitefly and leaf hoppers with higher efficacy associated with higher dose of acetamiprid [9]. The reports on the bioefficacy of the nicotineoides molecules *viz*., imidacloprid, thiamethoxam and acetamiprid in spray and seed dressing formulation against sucking pests of cotton crops has been well proved [10, 11]. Imidacloprid 17.8 SL @ 100 g ai/ha was significantly superior in checking the population of cotton whitefly [12]. Lowest population of thrips in acetamiprid 20 SP (100 mg/ha) against standard insecticidal check, triazophos 40 EC (1500 ml/ha) and untreated check [13]. Superiority of acetamiprid 20 SP @ 0.003% against aphids on cotton was also documented [14]. All the new chemistry insecticides were found statistically equally toxic against whitefly, 24 hours after application of insecticides. Imidacloprid proved to be less effective 48 hours after treatment. Population of whitefly was statistically equal to plots that did not receive insecticide [15]. In the present investigation, application of higher dose of acetamiprid @ 6.0 g /10 L of water and dimethoate @ 30 ml/10 L of water and double the recommended dose of imidacloprid *i.e.* 4.5 ml/10 L of water were found more effective in terms of management of sucking pests on Bt cotton translating in higher yield and monetary returns. Higher doses perform better than the university recommended doses which indicates the possibility of resistance in sucking pests of Bt cotton against the tested insecticides at recommended doses. A field trial to revalidate existing recommendation of insecticides against sucking pest of cotton at Cotton Research Station, Nanded revealed that higher doses of flonicamid (75 gai/ha) translated into lowest population of jassids (2.44 / 3 leaves), thrips (5.41 / 3 leaves) and whiteflies (4.01 /3 leaves) and the highest seed cotton yield 8.77 q/ha recorded supporting the present findings [16]. On similar lines, at Cotton Research Station, Srivilliputtur (Tamilnadu), higher doses of Flonicamid 50 WG @ 100 g a.i./ha, Diafenthiuron 50 WP@300 g a.i./ha, Fipronil 5 SC @ 87.5 g a.i./ha and Buprofezin 25 SC @250 g a.i./ha were found to be highly effective in terms of lower population of leaf hoppers, whitefly and thrips along with higher yield [17] supporting the present findings though the insecticides used are different. Thus, further studies on resistance development against sucking pests of Bt cotton is needed for confirmation.

5. Conclusion

Minimum population of sucking pests was observed in dose of acetamiprid used by farmers and was followed by double the recommended dose of imidacloprid and higher dose of dimethoate used by the farmers. Also, the maximum seed cotton yield was recorded in higher dose of acetamiprid used by the farmers and was at par with imidacloprid, clearly indicating higher efficacy of these doses over the recommended doses. Cost effectiveness data in terms of maximum ICBR in acetamiprid dose used by the farmers @ 6 g/10 L of water confirms the above findings. In nut shell, irrespective of insecticides under evaluation, higher doses performed better than the recommended doses indicating possibility of resistance in sucking pests of Bt cotton against these insecticides at recommended doses and need to confirm the data at various location to revalidate the doses of insecticides used for the management of sucking pests in Bt cotton.

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