UTILIZATION OF BIOPESTICIDES IN MANAGING THE COTTON PEST COMPLEX IN INDIA

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Abstract

Field trials were conducted with upland cotton (*Gossypium hirsutum* Var. Pusa 31) during the 1992, 1993 and 1994 crop seasons at the Indian Agricultural Research Institute, New Delhi, to evaluate the bioefficacy of neem products and Bt. formulations and their possible combinations with synthetic insecticides in a spray schedule for the management of cotton bollworms with the ultimate aim to reduce the load of synthetic insecticides and producing cost effective quality cotton. Observations were recorded on the incidence of bollworms viz., spotted (*Earias* spp.) , pink (*Pectinophora gossypiella*), American bollworm (*Heliothis armigera*) in green bolls and open bolls on loculi basis, quality of cotton, and total yield of seed cotton. The impact of insecticidal sprays was also noted on population build-up in whitefly, which was recorded on 30 leaves per plant basis after termination of all the rounds of spraying. Result shows that application of neem products or Bt. formulations alone or in combination with each other or with conventional synthetic insecticides failed to suppress bollworm complex in cotton under field conditions. However, neem or Bt in combination with at least one spray of synthetic pyrethroid in a 4-spray schedule proved effective in managing the bollworm complex and increasing quality of cotton produced. Our studies also showed satisfactory control of bollworm complex and cotton yield response by applying combinations of neem, Bt. and a 84% reduced rate of synthetic pyrethroid under field conditions. This management strategy will reduce the load of synthetic insecticides up to 75 percent and also safe to the environment with no resurgence problem of whitefly. The seed cotton yield in such a spray schedule was more (1910 kg/ha) as compared to spray schedules in vogue (1565 kg/ha, 1370 kg/ha). It shows that biopesticides (neem and Bt.) can replace conventional synthetic insecticides in a spray schedule and can effectively manage the bollworm complex in cotton without resurgence problem of whitefly, and will also minimize environmental exposure to toxic pesticides.

Introduction

The cotton production systems of the country illustrate well the ecological and environmental problems associated with intensive use of synthetic insecticides. In the 1960s and 1970s efforts began to change cotton insect control from a unilateral dependence on synthetic insecticides, primarily chlorinated hydrocarbons, organophosphorus and carbamate insecticides, to a system approach emphasizing diverse insect control tactics and ecological relationships. Integrated pest management remains the most promising approach in managing the cotton pest complex, but insecticides are still the primary control method used in most cotton production systems. Problems with insecticide resistance have developed repeatedly with each class of insecticide introduced for use in cotton production. Introduction of the synthetic pyrethroid insecticides in the late 1970s resulted in increase grower profits and return to the intensive insecticide use pattern of 1960s. As a result, insecticide resistance and outbreaks of secondary pests have increased during the past decade which usually sets the stage for the "disaster" phase, in which yields decline significantly and cotton production is no longer economical. Thus, development of specific strategies and tactics based on biopesticides (Bt and neem) as alternatives to synthetic insecticides have been identified and integrated into management of the bollworm complex viz., spotted bollworms, *Earias* spp.; pink bollworm , *Pectinophora gossypiella* and American bollworm *Heliothis armigera* in cotton systems for increased production efficiency, profits besides safety to the environment.

Materials and Methods

Field trials were conducted during the 1992, 1993 and 1994 crop seasons with 'Pusa 31' upland cotton (*Gossypium hirsutum*) and different commercial Bt formulations and neem products at the Indian Agricultural Research Institute, New Delhi, India. These biopesticides and botanicals were used alone as well as in different combinations with synthetic insecticides against the bollworm complex in a cotton system. The details of the treatments and dosages are given in Table 1. The experiments were laid out in 45 sqm in a randomized block design with three replicates. All the agronomic practices recommended for growing irrigated cotton in northern India were followed. The growth period starts with seed germination and extends to the appearance of the first square. At early stage of plant growth, cotton is attacked by sucking pests, mainly jassids, which can adversely affect the plant stand and yield of cotton, by sucking the cell sap. Therefore, regular monitoring of jassid populations was done and a protective spray of 0.04% dimethoate was applied as soon as the population exceeded the economic threshold level (1).

Cotton plants grow and bear reproductives in a definite sequence. Fruit formation begins with the appearance of first square (floral bud) on the first fruiting branch, and continues until the first boll opens. At this stage the growing shoot tips and reproductives become vulnerable first to the attack of spotted bollworm and then the pink bollworm. At this stage the American bollworm also

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appears but it is not as serious as the other two bollworms around Delhi. In order to evaluate the bioefficacy of different biopesticides and botanicals in different insecticidal schedules against bollworms, spraying was initiated at 50 per cent flowering, which coincides with peak square stage, 3-4 percent damage in fruiting bodies and less than l larva per plant. The crop was sprayed 4-5 times with high volume Knapsack sprayer at an interval of 15 days (3). The quantity of spray fluid was worked out at each stage of the crop growth by applying a known quantity of water on the control plot. As insects are able to differentiate between treated and untreated parts of their host plants, spraying was done with utmost care to cover the entire foliage. Care was also taken to avoid drift of insecticides. The spraying was terminated three weeks before picking.

Observations were recorded on the incidence of bollworms in green bolls and open bolls on randomly selected plants. Twenty green bolls, from each plot were dissected and percent damage was worked out on loculi basis. The incidence in open bolls was recorded on the basis of loculi damaged in all the open bolls of five randomly selected plants. Data were also recorded on quality and quantity of seed cotton based on two pickings. The percentage incidence of bollworms are subjected to angular transformation for statistical analysis.

Since whitefly has emerged as an important pest as it acts as a vector for virus causing leaf curl disease in cotton, studies were undertaken on population buildup of whitefly. The adult whitefly population was noted by visual observation on the lower side of three leaves from the top of each plant on ten randomly selected plants. These observations were recorded between 7 and 9 am., to avoid experimental error due to vertical movement of the pest.

Results and Discussion

Effect of different spray schedules against bollworms

The bioefficacy of different insecticidal treatments on the incidence of bollworms and quality of cotton produced during 1992, 1993 and 1994 are presented in Tables 2, 3 and 4, respectively. Tables 2 and 3 show that, during 1992 and 1993 there were significant differences among treatments in the incidence of bollworms in green and open bolls, and quality and quantity of cotton produced, however, in 1994 significant differences were observed in the incidence of bollworms in green bolls and total yield of seed cotton (Table 4).

Table 2 shows that spray schedules in which two sprays of neem alternated with two sprays of synthetic pyrethroids and one conventional synthetic insecticide (T5) or one spray of Bt formulation used in combination with two sprays of synthetic pyrethroids and two sprays of conventional synthetic insecticides (T7) were effective in reducing the incidence of bollworms in green bolls (12.7% ,14.8%) and open bolls (15.5%, 15.2%) and conversely increasing the yield (2476 kg/ha, 2428 kg/ha) and quality (7.7%, 7.5% stained cotton). These insecticidal schedules were statistically at par with T4 (2405 kg/ha total yield), in which three sprays of conventional synthetic insecticides were used in combination with two rounds of synthetic pyrethroids and is in vogue in northern India. Repeated application of neem alone (T1,T2) or Bt formulation (T6) and their use in spray schedule in combination with conventional synthetic insecticides (T3) did not prove effective in reducing the incidence of bollworms and increasing yield of seed cotton.

Table 3 shows that during 1993, the cotton crop was affected by biotic stress and incidence of bollworms was more and yield was less. During this year environmental stress also affected the crop, as there was continuous rains and cloudy weather during setting period of reproductives. In general, incidence of bollworms was more in green bolls and open bolls and percentage of stained seed cotton was also high, and as such yield declined in 1993 as compared to 1992 and 1994. Under stressed conditions also, insecticidal schedules in which two sprays of neem (T1) or Bt (T2) alternated with two sprays of synthetic pyrethroids and one spray of conventional synthetic insecticide were effective against bollworms, as minimum incidence, 18.2%, 15.0% in green bolls and 32.2%, 38.9% in open bolls, respectively, were recorded. These spray schedules were also effective in reducing stained seed cotton (21.9%,25.2%) and increasing yield of cotton produce (1076 kg/ha, 1039 kg/ha). None of the insecticidal treatments, in which repeated application of either neem or Bt was given (T4, T5, T6, T7, T9, T10) or when neem and Bt used in combination (T3) did not prove effective in suppressing incidence of bollworms and increasing yield of quality cotton, rather they were statistically at par with the untreated control. The present studies confirm the findings of previous years and are also in accordance with the findings of other workers (4, 8, 9, 11), who have also found that neem alone was less effective against bollworms, however, in combination with synthetic pyrethroids found to be effective.

During 1994 as a part of management strategy of bollworms, a reduced rate of synthetic pyrethroid was used in a spray schedule in combination with botanicals and biopesticides to observe effectiveness and practicability in our cotton system, which is inflicted with more insecticide related problems. Now cotton has reached a "disaster" phase in which outbreaks of secondary pest species become common, insecticide resistance developed and ultimately yield declined significantly and cotton production is no longer economical. Table 4 shows that during 1994, a maximum of one spray of synthetic pyrethroid was given in a four spray schedule and those schedules were effective in suppressing bollworms incidence and increasing quality yield. In insecticidal schedule T4, Alpha plus (1:1 mixture of Alphamethrin and chlorpyrifos) was applied as third spray at 750 g.a.i./ha in combination with one spray of neem and two sprays of Bt. In this schedule alphamethrin was used at reduced rate, i.e. 84 per cent less than the recommended dose and this treatment was significantly effective in reducing incidence of bollworms in green bolls (10.8%) and increasing maximum yield of seed cotton (1910 kg/ha). This insecticidal schedule (T4) was statistically at par with those spray schedules in which one spray of synthetic pyrethroids was given at recommended dose (T1, T2, T5, T6, T7). Insecticidal schedules T1 and T2 in which two rounds of half the dose of neem and Bt respectively were used at weekly interval followed by one spray of synthetic pyrethroid and again half dose of botanical and Bt at fort nightly interval, proved as effective as other spray schedules in managing the bollworm complex in the cotton system. A management strategy based on 84% reduced rate of synthetic pyrethroids in combination with botanicals and Bt proved effective in suppressing incidence of bollworms and increasing quality of cotton yield. The present finding is in accordance with the finding of Plato and Hood (6),who observed satisfactory control of *Heliothis* in cotton by applying combinations of Bactec Bt, Larvin and 90% reduced rate of Karate (cyhalothrin), a synthetic pyrethroid under field conditions. Schmutterer (10) also recommended use of neem alternativly or mixed with other products in order to increase efficacy.

Impact of spray schedules on whitefly population build-up.

The impact of insecticides of different spray schedules on population build-up of whitefly was recorded after termination of all the rounds of spraying targeted towards bollworms during 1992, 1993 and 1994. Whitefly populations were recorded after 1 day of last round of spraying and thereafter at regular weekly intervals up to 4-5 weeks. Results are presented in Tables 5, 6 and 7. In general, the whitefly population was minimum in 1992 throughout the period and significant variation in whitefly population among treatments was noted only in the third and fourth weeks after termination of spraying. During same period the whitefly population was significantly high in plots treated with all the rounds of synthetic insecticides, however, plots treated with biopesticides and botanicals showed comparatively low whitefly population and were at par with control (Table 5).

Table 6 shows population build-up of whitefly in 1993, which varied significantly among treatments at all the occasions except in the third week after termination of spraying. Significantly higher populations of whitefly were observed from those plots which were protected against bollworms with insecticidal schedules in which one or two rounds of synthetic pyrethroids were applied (T1, T2, T8). In insecticidal schedule T8, bifenthrin, a synthetic pyrethroid, was used which was responsible formaximum build-up in whitefly population, however, insecticidal schedules in which repeated application of either neem or Bt was given, there was no build-up in whitefly populations and were at par with the population found in the control.

In general, the whitefly population was maximum at all the dates of observation during 1994. At such a high natural population, the built-up in whitefly population was fast in plots protected with insecticidal schedules in which synthetic pyrethroid was incorporated in a spray schedule for the management of bollworms. The highest population (1085.3, 1248.3 per 30 leaves) was recorded in T5, in which bifenthrin was applied in combination with conventional synthetic insecticides for the control of bollworms. In this schedule, a high population of whitefly was noted at all times, whereas insecticidal schedules T8 and T9, in which Bt and neem respectively were repeatedly used, no build-up in whitefly population was observed, however, the population was at par with theuntreated control. The studies confirm our previous years work and findings of other workers (4,5) that synthetic insecticides and in particular synthetic pyrethroids are mainly responsible for build-up in whitefly populations. Neem products and Bt formulations are safe and do not induce build-up in whitefly populations, which is in confirmity with the findings of many workers (2,4,7).

Conclusion

On the basis of three years field trials, it is concluded that application of neem products or Bt formulations alone or in combination with each other or with conventional synthetic insecticides failed to check bollworms in cotton under field conditions. However, their combination with synthetic pyrethroid and conventional synthetic insecticides proved effective in managing bollworm complex and increasing good quality yield. Our studies also showed satisfactory control of bollworms and cotton yield response by applying combination of botanicals, Bt formulations, and a 84 per cent reduced rate of synthetic pyrethroid under field conditions. Such management study will reduce the load of synthetic insecticides up to 75 percent in the cotton system and is safe to the environment with no resurgence problem of whitefly.

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References

1. Ahmad, Z., M.R. Attique ,and A. Rashid, 1986. An estimate of loss of cotton yield in Pakistan attributed to the jassid, *Amrasca devastans* Dist. *Crop. Prot.* **5** : 105-108.

2. Deminik, S.J., and M. Mohansundaram, 1992. Susceptibility of *Bemisia tabaci* Genn. (Homoptera : Aleyrodiadae) to insecticides. *Pestology* **16**: 5-7.

3. Gupta, G.P., and R.A. Agarwal. 1985. Effect of insecticides for the control of bollworms in relation to phenological characters in cotton. *Pesticides*, **19** : 58-60.

4. Gupta, G.P., and Roshan Lal. 1995. Biopesticides as an alternative to synthetic insecticides in pest management system in cotton, pp 453-465. *In* S. Walia and B.S. Parmar (Eds), Pesticide Crop Production and Environment. Oxford and IBH, New Delhi.

5. Manickavasagam, S., and K. Gunathilagaraj. 1993. Evaluation of a new pyrethroid clocythrin for its bioefficacy and resurgence against sucking pests of cotton . *Pestology*, **17** : 17-20.

6. Plato, T.A., and E.M. Hood. 1991. Use of *Bacillus thuringiensis* chemical combinations against Heliothis spp. in cotton, pp. 93-95. *In* R. Milner and C. Chandler (eds.), Proc. Workshop on *Bacillus thuringiensis.* Canbera, Australia.

7. Prabhakar, N., N.C. Tuscano, and D.L. Coudriel. 1989. Susceptibility of immature and adult stages of the sweetpotato whitefly to selected insecticides. *J. Econ. Entomol.*, **82** :983-988.

8. Rao, N.V., A.S. Reddy, and P.S. Reddy. 1990. Relative efficacy of some new insecticides on insect pests of cotton. *Indian J. Plant Prot.* **18** : 53-58.

9. Samuthiravelu, and B.V. David. 1990. Bioefficacy of neem oil and deltamethrin against spotted bollworm, *Earias vitella* (Fab.) (Lepidoptera : Noctuidae) on cotton MCU5. *Madras Agric.J.* **77**. :294-298.

10 Schmutterer, H. 1990. Properties and potential of natural pesticides from the neem tree, *Azadirachta indica. Annual Rev. Entomol.*, **35** : 271-297.

11. Thangavel, P., T.R. Subramanium and S. Parameshwaran. 1975. Efficacy of certain insecticides against the incidence of bollworms *Pesticides*, **9**: 37-38.

Table 1. Details of Spray schedules and treatment

Treatment	Insecticide	Dose
1992		
T 1	Neem A 1	5 l/ha
T 2	Neem A 2	2.5 l/ha
T 3	Neemrich II 20% EC	5ml/l water
	Dipel (Bt) 8L	750 ml/ha
	Neemrich II 20%EC	5ml/l water
	Dipel (Bt) 8L	750 ml/ha
	Neemrich I 80% EC	10ml/l water
T4	Monocrotophos 36%WSC	500 g. ai/ha
	Deltamethrin 2.8% EC	12.5 g. ai/ha
	Quinalphos 20% EC	750 g. ai/ha
	Cypermethrin 25% EC	60 g. ai/ha
	Triazophos 40% EC	600 g. ai/ha
T5	Deltaphos 36% EC	250 g.ai/ha
	Neemrich II 20% EC	5 ml/l water
	Cypermethrin 25% EC	60 g. ai/ha
	Neemrich I 80% EC	10 ml l/water
	Triazophos 40% EC	600 g. ai/ha
T6	Biobit (Bt)	1000 g/ha
T7	Deltaphos 36% EC	250 g. ai/ha
	Endosulfan 35% EC	750 g. ai/ha
	Bifenthrim 10% EC	50 g. ai/ha
	Dipel (Bt) 8L	750 ml/ha
	Trebon 10% EC	100 g. ai/ha
T8	Control (No protection)	-
Dates of Spraying : Aug. 13, Aug. 28, Sept. 10, Sept. 25 and Oct.9		
1993		
T1	Deltaphos 36% EC	250 g. ai/ha
	RD- 9 Replin	5ml/l water
	Cypermetherin 25%EC	60 g. ai/ha
	Godrej Achook	5g/l water
	Triazophos 40% EC	600 g. ai/ha
T2	Deltaphos 36% EC	250 g. ai/ha
	Biobit	1000 g./ha
	Alpha plus 52.5% EC (Alphamethrin 2.5%+ Chlorpyrifos 50%)	750 g. ai/ha
	Dipel (Bt) 8L	750 ml/ha
	Trebon 10% EC 60 g. ai/ha	
T3	Nimbecidine	5 ml/l water
	Biobit (Bt)	1000 g/ha
	R-D 9 Repelin	5 ml/l water
	Dipel (Bt) 8L	750 ml/ha
	Godrej Achook	5 g/l water
T4	Nimbecidine	5ml/l water
T5	Dipel (Bt) 8L	750ml/ha
T6	Godrej Achook	5 g/l water
T7	Neem A2	2.5 l/ha
T8	R-D 9 Repelin	5 ml/l water
	Bifenthrin 10% EC	50 g. ai/ha
	Endosulfan 35% EC	750 g. ai/ja
	Alpha Plus 52.5% EC (Alphamethrin 2.5% EC+ Chlorpyrifos 50% EC)	750 g. ai/ha
	Godrej Achook	5 g./l water
T9	R-D 9 Repelin	5 ml/l water
T10	Biobit (Bt)	1000 g./ha
T11	Control (No Protection)	-
Dates of Spraying : Aug. 19, Sept. 7, Sept. 21, Oct. 6, Oct.21		
1994		
T1	Dipel (Bt) 8L	375 g./ha |
	Dipel (Bt) 8L	375 g./ha | weekly
	Cypermethrin 25% EC	60 g. ai/ha
	Dipel (Bt) 8L	375 g./ha
	Dipel (Bt) 8L	375 g./ha
T2	Godrej Achook	2.5g./l water |weekly
	Godrej Achook	2.5 g./l water |
	Cypermethrin 25% EC	60 g. ai/ha
	Godrej Achook	2.5 g./l water
	Godrej Achook	2.5 g./l water
T3	Nimbecidine	5 ml/l water
	Profenfos 50% EC	750 g. ai/ha

Table 1. Details of Spray schedules and treatment, continued

	Endosulfan 35% EC	750 g. ai/ha
	Nethrin	5 ml/l water
T4	Dipel (Bt) 8L	750 ml/ha
	Nethrin	5 ml/l water
	Alpha Plus 52.5% EC (Alphamethrin 2.5% + Chlorpyrifos 50%)	750 ml/ha
	Biobit (Bt)	1000 g./ha
T5	Monocrotophos 36% WSC	500 g. ai/ha
	Bifenthrin 10% EC	50 g. ai/ha
	Endosulfan 35% EC	750 g. ai/ha
	Imidacloprid 20% EC	150 g. ai/ha
T6	Profenfos 50% EC	750 g. ai/ha
	Biobit (Bt)	1000 g./ha
	Deltaphos 36% EC	250 g. ai/ha
	Nimbecidine	5 ml/l water
T7	Profenfos 50% EC	750 g. ai/ha
	Cypermethrin 25% EC	60 g. ai/ha
	Endosulfan 35% EC	750 g. a i/ha
	Trebon 10% EC	60 g. ai/ha
T8	Dipel (Bt) 8L	750 ml /ha
T9	Godrej Achook	5 g./l water
T10	Control (No Protection)	-

Date of Spraying Aug. 19, Sept. 4, Sept. 25 and Oct. 12.

Table 2 - Effect of different treatments against bollworms and yield of seed cotton, 1992.

Treatment	Incidence in loculi		Stained seed cotton	Yield of seed cotton
	Green boll (%)	Open boll (%)	(%)	(Kg/ha)
T1	27.9 (31.9)	37.1 (37.3)	20.6 (26.7)	1492
T2	26.0 (30.5)	34.4 (35.7)	18.8 (25.6)	1723
T3	25.8 (30.5)	34.3 (35.7)	18.4 (25.4)	1516
T4	9.7 (17.8)	16.9 (24.3)	7.5 (15.9)	2405
T5	12.7 (20.8)	15.5 (23.0)	7.7 (16.0)	2476
T6	26.9 (31.2)	30.7 (33.6)	17.9 (24.9)	1864
T7	14.8 (22.6)	15.2 (22.8)	7.5 (15.8)	2428
T8	37.8 (37.9)	44.4 (42.0)	26.9 (31.2)	896
S Em ±	2.1	2.8	1.6	64
CD (P=0.05)	6.3	8.5	4.8	194
CD (P=0.01)	8.8	11.8	6.7	269

Table 3 - Effect of different treatments against bollworms and yield of seed cotton, 1993.

Treatment	Incidence in loculi		Stained seed cotton	Yield of seed cotton
	Green boll (%)	Open boll (%)	(%)	(Kg/ha)
T1	18.2 (25.3)	32.2 (34.5)	21.9 (27.8)	1076
T2	15.0 (22.4)	38.9 (38.4)	25.2	1039 (29.9)
T3	26.1 (30.7)	52.6 (46.6)	32.9 (35.0)	387
T4	47.5 (43.1)	57.1 (49.3)	36.1 (36.9)	431
T5	56.0 (46.8)	62.5 (52.3)	33.9 (35.5)	390
T6	51.3 (45.8)	61.5 (50.4)	39.5 (38.9)	422
T7	56.3 (49.1)	55.2 (48.0)	34.4 (35.9)	309
T8	36.6 (37.2)	43.0 (40.9)	24.2 (29.5)	678
T9	55.1 (48.0)	65.7 (54.2)	39.5 (38.7)	381
T10	44.7 (41.9)	41.5 (40.1)	27.8 (31.7)	322
T11	50.0 (44.8)	57.7 (49.5)	38.1 (38.0)	222
S Em ±	4.6	3.4	2.7	91
CD (P=0.05)	9.7	7.2	5.6	190
CD (P=0.01)	13.2	9.7	7.6	259

Table 4 - Effect of different treatments against bollworms and yield of seedcotton, 1994.

Treatment	Incidence in loculi Green boll (%)	Open boll (%)	Stained seed cotton (%)	Yield of seed cotton (Kg/ha)
T1	27.1 (30.0)	46.2 (42.7)	12.1 (19.9)	1438
T2	26.2 (30.5)	47.1 (43.2)	11.5 (19.5)	1391
T3	31.4 (33.9)	41.2 (39.8)	11.8 (19.9)	1819
T4	10.8 (19.1)	41.1 (39.8)	8.6 (16.8)	1910
T5	20.0 (26.3)	26.3 (30.7)	11.3 (19.6)	1565
T6	28.1 (30.7)	47.0 (43.3)	11.8 (19.1)	1177
T7	9.1 (16.5)	39.7 (39.0)	5.8 (13.1)	1370
T8	24.5 (28.9)	39.6 (38.8)	10.4 (18.3)	1127
T9	26.4 (30.4)	49.4 (44.4)	20.2 (24.1)	639
T10	38.9 (38.3)	50.7 (45.4)	21.6 (26.3)	365
S Em	7.1	NS	NS	249
CD (P=0.05)	14.8	-	-	524
CD (P=0.01)	-	-	717	

Table 5: Mean whitefly population 1992 (adult/30 leaves)

Treatment	1d	1wk	2wk	3wk	4wk
T1	20.3	22.0	26.6	10.3	4.7
T2	11.0	15.3	18.3	8.6	1.7
T3	8.6	14.6	19.0	11.6	8.7
T4	26.3	44.6	44.0	37.3	12.0
T5	16.6	27.3	22.0	22.6	1.7
T6	15.6	31.0	21.3	21.6	1.7
T7	34.0	24.6	29.0	18.0	3.0
T8	11.0	12.0	10.3	9.0	2.0
S Em	NS	NS	NS	4.2 2.5	
CD (P=0.05)		-	-	-12.7 5.4	
CD (P=0.01)		-	17.2	-	

Table 6: Mean whitefly population 1993 (adult/30 leaves)

Treament-	1d	1wk	2wk	3wk	4wk	5wk
T1	123.3	277.3	212.3	173.3	23.3	12.3
T2	52.0	137.0	104.3	95.5	18.3	12.7
T3	20.7	76.3	38.3	52.7	22.3	15.3
T4	75.0	65.0	74.3	42.3	12.3	13.3
T5	31.0	66.3	49.7	48.7	11.3	9.7
T6	30.3	61.3	23.3	29.3	8.3	16.7
T7	27.3	66.3	54.0	67.3	9.7	14.0
T8	141.3	321.0	113.3	107.7	28.3	15.7
T9	34.3	95.7	54.0	57.0	6.3	9.0
T10	21.7	28.3	22.7	20.0	13.3	12.7
T11	23.0	30.3	39.0	26.7	8.7	9.3
S Em±	9.2	10.0	15.0	NS	13.5	3.4
CD(P=0.05)	19.3	20.9	31.3	-	28.2	7.1
CD(P=0.01)	26.3	28.5	42.7	-	38.5	9.6

Table 7: Mean whitefly population 1994 (adult/30 leaves)

Treat-ment	1d	1wk	2wk	3wk	4wk	5wk
T1	568.0	543.7	779.7	414.7	363.0	49.3
T2	529.7	554.3	876.7	478.0	548.7	107.3
T3	489.0	538.7	657.3	317.3	168.0	28.3
T4	508.0	899.3	995.0	655.3	444.3	142.3
T5	538.7	1085.3	1248.3	774.3	411.0	98.3
T6	627.7	873.3	987.0	704.3	632.3	157.7
T7	469.0	585.3	718.3	345.7	219.3	62.7
T8	669.0	425.3	557.3	243.0	138.3	46.7
T9	326.7	598.7	626.7	281.3	128.6	29.3
T10	348.7	449.3	577.3	266.3	165.3	38.0
S Em ±	NS	124.9	117.5	98.0	84.9	29.8
CD(P=0.05)	-	262.5	246.9	206.0	178.3	62.7
CD(P=0.01)	-	359.2	337.9	281.9	244.0	85.8