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MANAGEMENT OF GHERKIN IN SYSTEM B FOR INSECT PESTS & DISEASES WITH REDUCED RELIANCE ON PESTICIDES

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Management of gherkin in System B for insect pests and diseases with reduced reliance on pesticides

J. R. Burleigh and V. Vingnanakulasingam

Introduction

Gherkins were introduced to System B farming systems by private companies and have provided farmers with a crop option to increase income through access to export markets. Farmers contract with the companies Sun Frost or Aitken-Spence which provide seed, fertilizer and pesticides for insect and disease management. Gherkins are delivered to company facilities in System B where they are sold and prepared for export.

Farmers follow recommendations given by the contractor for all cultural practices, including pest management. Sun Frost recommends to farmers and commonly supplies them with several of the following pesticides for insect and disease control: carbofuran, methamidophos, endosulfan, carbaryl and chlorpryophos are provided for insect management (cucumber beetle, loopers, thrips, aphids, mites, and leafminer). Thiram, mancozeb, benomyl and chlorothalonil are provided for diseases (damping-off fungi, downy mildew and powdery mildew). Payment for chemical inputs is deducted from sale of the crop to the company; and it is our understanding that farmers are required to accept these inputs when they contract with Sun Frost. Farmers, therefore, have a proprietary interest in the pesticides and use them without attention to pest and disease intensity.

Sun Frost and Aitken-Spence operate on the principle that cucumber beetles, thrips, mites, aphids, damping-off fungi and downy mildew (among others) occur during both growing seasons and reduce gherkin yields so they advocate prophylatic use of pesticides. Nevertheless, their recommendations are hampered by insufficient knowledge regarding relationships between pest and disease intensity and crop damage. Their policy fosters use of the same pesticides during Maha and Yala even though weather (principally rainfall) differs among seasons. Logic suggests that seasonal differences in rainfall and temperature will lead to differences in pest and disease incidence and severity. If that assumption is correct then some pesticides will be used that are unnecessary because the target insect or disease is absent or present in insufficient intensity to warrant treatment.

The study described here was designed to: 1) determine the relative incidence and severity of gherkin insect pests and diseases, and 2) determine if reduced pesticide use will increase the risk of crop loss to insects and disease. Implied in the objectives is the formation of a pest/disease management strategy that focuses on the most severe pests and fosters the judicious use of pesticides.

Materials and Methods

RARC trial

The gherkin cultivar Calypso was planted on March 13, 1994 in plots 4 x 4 m. Plant spacing was standard 1 x 0.2 m with four beds per plot, 20 hills per bed and one plant per bed. Plots were arranged in a 6 x 6 latin square with six treatments and six repetitions. Treatment 1 was the conventional pesticide treatment recommended by Sun Frost. Treatment 2 was 75% of the conventional. Tréatment 3, 50% of conventional. Treatment 4, 25% of conventional. Treatment 5, nil and treatment 6 as recommended by the research team (see Table 1). On the day of seeding 25, 8 and 3 kg ha $^{-1}$ of triple super phosphate, murate of potash and urea, respectively, were applied to each plot. A top dressing of 12 and 8 kg ha $^{-1}$ of murate of potash and urea, respectively, was applied at two-week intervals (four occasions) during the growing season. A standard trellis system was constructed for each plot. The system consisted of sturdy wood sticks spaced 1.8 m apart within beds. Three horizontal rows of coir rope were attached with the lowest row 15 cm from the ground. Rows two and three were 95 cm and 175 cm from the ground. At each plant, coir was wound around the horizontal rows to form a vertical trellis on which the gherkin grew. Plots were irrigated each five days by gravity flow (12 occasions). From April 15 to May 31 market-size gherkin fruit 5 cm in length was picked daily from each plot and fresh weight recorded. Only fruit from the center two beds in each plot was used to calculate yield.

Beginning two weeks after emergence and continuing at weekly intervals insect and disease incidence and severity were noted on 10 leaves from 24 columns of plants in each plot. We refer to columns of leaves rather than to individual plants as the vine nature of gherkin growth and the method of trellising promote intertwining of plants. After five weeks it becomes difficult therefore, to identify a leaf as coming

from a specific plant. Incidence refers to the number of plant columns in a plot where at least one insect or disease lesion was observed (maximum 24 per plot). Severity values for cucumber beetle (*Aulacophora foveicollis*), armyworm (*Spodoptera* sp.), looper (suspect *Trichoplusia* sp.), whitefly (*Bemisia tabaci*), mites (species unknown- probably *Hemitarsonemus latus*), thrips (*Frankliniella schultzei* and *Scirtothrips dorsalis*) and aphids (*Aphis gossypii*) were the number of insects observed on 240 leaves per plot. Severity values for leafminer (*Liriomyza* sp.) , downy mildew (*Pseudoperonospora* sp.) and powdery mildew (*Erysiphe* sp.) were estimated on a scale of 0 to 9, where 0 = no infection, 1 = 1 - 3% tissue showing symptom, 2 = 4 - 6%, 3 = 7-12%, 4 = 13 - 25%, 5 = 26 - 50%, 6 = 51 - 75%, 7 = 76 - 87%, 8 = 88 - 94% and 9 = 95 - 100% (Chakraborty ,1990). Virus severity was recorded by using the scale of Joshi and Dubey (1973) where 0 = no symptoms, 1 = 25% of leaves in a plant column show symptoms, 2 = 50% of leaves show symptoms, 3 = 75% of leaves show symptoms and 4 = 100% of leaves show symptoms.

Area under the insect and disease progress curves was calculated from incidence and severity values according to the method of Shaner and Finney (1977) where AUDPC $= \sum((X_i + X_{i+1})/2) \times (T_{i+1} - T_i)$. X_i is incidence or severity at time T_i and X_{i+1} is incidence or severity at time T_{i+1}. AUDPC values were normalized day $^{-1}$ plant $^{-1}$ for incidence but day $^{-1}$ leaf $^{-1}$ for severity. Values from the RARC trial and on-farm trials are, therefore, comparable.

AUDPC values were subjected to analysis of variance (ANOVA) and Fisher's Least Significant Difference (LSD) test to determine treatment effects.

On-farm trials

Treatments T1, T3 and T6 (as described above) were installed on eight farm fields during late Maha and Yala 1994. All farmers planted the cultivar Calypso. Treatments were repeated three times in a completely randomized design with unequal area per treatment to ease farmer management of the trial. Farmers were instructed to treat plots T1 as they would normally. Plots T3 then were treated with 50% of the dose applied to plots T1. Plots T6 were treated as recommended by the researchers. Farmers kept a daily record of tasks performed, pesticides applied and gherkin weight. Insect and disease observations were recorded weekly by the research team. Incidence was the presence of at least one insect or lesion observed

on 10 leaves from each of 10 plants; whereas, insect severity (with the exception of leafminer) was the number observed on 10 leaves of 10 plants per plot. Downy mildew, powdery mildew, cucumber mosaic virus and leafminer severities were noted by use of scales described above. Incidence and severity values were used to calculate areas under progress curves for insect and disease development as described for the RARC trial. As in the RARC trial, AUDPC values were analyzed by ANOVA and Fisher's LSD to test for treatment effects. Analyses were conducted on data from each farm individually.

Results

RARC - trial

Treatment T1 was treated once with thiram and on three occasions each with ridomil MZ (metalaxyl 8% a.i. - mancozeb 64%) and chlorothalonil for a total of 11.14 kg ha $^{-1}$ active ingredient (see Table 1). Treatments T2, T3 and T4 received the same number of applications of each fungicide but total doses were 8.5, 5.93, and 3.31 kg ha $^{-1}$, respectively. Treatment T5 received one application each of thiram and ridomil MZ for a total of 0.74 kg ha $^{-1}$. Treatment T6 was given the same number of treatments with thiram and ridomil MZ as T1 but only two treatments with chlorothalonil for a total of 10.92 kg ha $^{-1}$. Two applications of methamidophos and one of chlorpyrifos were made on T1, T2, T3 and T4 for a total insecticide dose of 0.8, 0.67, 0.54 and 0.41 kg ha $^{-1}$ active ingredient, respectively. Treatment T5 received one application of methamidophos (0.29 kg ha $^{-1}$). Treatment T6 received two treatments of methamidophos (0.58 kg ha $^{-1}$).

Significant treatment effects occurred only for downy mildew and leafminer severities (see Fig. 1). There were no treatment effects for incidences and severities of cucumber mosaic virus, cucumber beetle, armyworm, loopers, and aphids. There was significantly more downy mildew in T5 than in T1, T2, T3 and T4. Downy mildew severities in plots T5 and T6 were not different. In contrast, there was significantly less leafminer severity in T5 than in all other treatments. Approximately 30% of the plants in T5 were killed by a combination of insects and diseases. That is in sharp contrast to less than 8% killed in all other treatments. Consequently, yield from T5 was significantly less than yields from other

treatments. There were no differences in yield among treatments T1, T2, T3, T4 and T6.

On-farm trials

During Maha farmers made from five to eight fungicide treatments and from two to five insecticide treatments (see Table 2). Total number of treatments ranged from seven to thirteen. Farmers treated more frequently in Yala than in Maha. In Yala the number of fungicide and insecticide treatments ranged from four to 13 and from six to 12, respectively. Total numbers of pesticide treatments in Yala were 10 to 22. Farmers chose from an array of six fungicides and eight insecticides. The quantity of pesticide applied varied widely among farmers. Mr. Ranatunga in Maha applied a total of 5.33 kg active ingredient ha $^{-1}$; whereas, Ms Bisomeneke applied 15.36 kg ha $^{-1}$. The least amount of pesticide applied in Yala was 37 kg ha $^{-1}$ by Mr. Kularathna Banda; whereas, the greatest amount was 669 kg ha $^{-1}$ applied by Mr. Ariyarathna.

Treatment effects during Maha were noted only for leafminer and downy mildew severities and then only on three and two farms, respectively (see Fig. 2). As in the RARC trial, leafminer severity was greater in treatments T1 and T3 than in T6 on the farms of Mr. Wilbert, Mr. Somarathna and Mr. Ranathunga. Downy mildew severity was least when Mr. Somarathna treated with 3.17 kg ha $^{-1}$ of fungicide. Oddly, downy mildew severities were similar where he applied 0.4 kg ha $^{-1}$ (T6) and 6.34 (T1). Mr. Ranathunga applied 3.41 kg ha $^{-1}$ of fungicide to T1 and 1.70 to T3 and downy mildew severity was not different among those two treatments. Where he made one application at 0.36 kg ha $^{-1}$ (T6) downy mildew severity was significantly greater.

Downy mildew and leafminer were the dominant pests during Maha (see Table 3). AUDPC values for incidence and severity clearly show that downy mildew infected a greater number of plants than all other pests noted and was more severe than other pests.

Significant treatment effects on gherkin yield in late Maha were noted on farms of Mr. Wilbert, Mr. Somarathna and Mr. Ranathunga (see Fig. 3). There were no treatment effects on the other five farms. Only on the farm of Mr. Ranathunga did yield loss appear to be related to downy mildew infection. There, five fungicide

treatments (3.41 kg ha $^{-1}$) was associated with greater yield than plots treated five times but with only 1.7 kg ha $^{-1}$. And yield from plots treated with 1.7 kg ha $^{-1}$ was the same as yield from plots treated with 0.36 kg ha $^{-1}$. Ten treatments in contrast to four on the farm of Mr. Ranasinghe Banda, 13 in contrast to four on the farm of Ms Bisomeneke, 10 in contrast to five on the farm of Mr. Wimalarathna, 10 in contrast to five on the farm of Mr. Ariyarathna and nine in contrast to four on the farm of Mr. Kularathna Banda did not improve gherkin yield.

Leafminer severity during Yala 1994 was affected by insecticide treatments (see Fig. 4). Generally, severity decreased with reduced insecticide-use frequency and dose. In contrast, thrip incidence and severity increased with increased insecticide-use frequency and dose (see Fig. 5). There were no treatment effects for infestations of cucumber beetle, aphid, looper, armyworm, mites, whitefly, powdery mildew, cucumber mosaic virus and root knot nematode. No downy mildew was observed in Yala.

Leafminer was the dominant pest in Yala (see Table 3). White fly, cucumber mosaic virus, aphids and thrips followed in importance based on AUDPC values for incidence and severity.

Treatment effects on yield in Yala were noted on the farms of Mr Ranasinghe Banda, Mr. B. M. Wimalarathna, Mr. B. G. Ariyarathna and Mr. Kularathna Banda. Treatment T6 yielded significantly less than T1 on the farms of Mr. Ranasinghe Banda and Mr. Kularathna Banda (see Fig. 6). In both cases treatment T6 received about 33% of the insecticide dose given to T1. Mr. Ariyarathna treated T6 with 188.94 kg ha $^{-1}$ insecticide, T3 with 150.37 and T1 with 212.61. Treatment T3 received the least amount among treatments and gave significantly less yield than T1 and T6. Yield from treatment T6 on the farm of Mr. Wimalarathna was not significantly different from T1 yield even though T1 received 32.59 kg ha $^{-1}$ insecticide and T6 received 7.47. Treatment T3 received 9.47 and yield was significantly different from T1. Interestingly, treatment T6 on Mr. Wimalarathna's farm received 35.9 kg ha -1 fungicide and T3 received 13.11.

On-farm gherkin yields were consistently 3 to 15 times higher in Yala than in Maha and we believe that difference is associated, in part, with the absence of downy mildew in Yala. Yield from Mr. Kularathna Banda's farm seemed exceptionally

high in Yala. Yet Mr. K's yields in Maha also were higher than with any other cooperator.

Discussion

Six fungicide treatments at RARC were not sufficient to prevent infection by downy mildew in late Maha, yet those treatments improved yield 40% (difference in yield of T1 and T5) by reducing AUDPC 43%. Similarily, on the farm of Mr Ranathunga a 40% reduction in downy mildew AUDPC improved yield by 51%; whereas, on the farm of Mr. Somarathna a 26% reduction in downy mildew intensity improved yield by 55%. Clearly, downy mildew reduces gherkin yield in System B. We believe that measureable losses would have occurred on other farms if treatments had been successful. Farmers made up to eight fungicide treatments for downy mildew during Maha but with the exceptions of treatment effects on the farms of Mr Ranathunga and Mr. Somarathna no differences in disease intensity were noted. Yields generally were less than 1000 kg ha $^{-1}$. Again, the farm of Mr. Ranathunga appears as an exception. Yield from T1 was about 3500 kg ha $^{-1}$. Yields from the farm of Mr. Kularathna Banda were about 4000 kg ha $^{-1}$ on T1, T3 and T6 and there were no significant differences among treatments. Also, there were no treatment effects on AUDPC values for downy mildew severity but values were two to three times greater than values noted from the farm of Mr. Ranathunga. It appears that the farming methods of Mr. Kularathna Banda promote good gherkin yield in spite of infection by downy mildew.

Downy mildew infection was not observed during Yala yet farmers made from four to 13 fungicide treatments and most of those were with chlorothalonil and mancozeb, materials used to control downy mildew. Those treatments were, therefore, unjustified and could be eliminated without placing the crop at risk.

Insecticide treatments did not affect intensities of cucumber beetle, aphids, mites, white flies and loopers. Treatments did appear to aggravate leafminer and thrip intensities, however. Farmers applied one or more of the insecticides metasystox, monocrotophos, carbaryl, methomyl, methamidophos, chlorpyrifos, sulfur and endosulfan and that combination was associated with increased leafminer and thrip intensities. Insecticides may harm leafminer predators rather then leafminers and thrips may have developed resistance to one or more of the commonly used

insecticides. Regardless of the mechanism, use of insecticides is creating, not solving, insect pest problems in gherkin.

Surely, if gherkin continues to be promoted in System B careful pest monitoring will be necessary to recommend appropriate biocides only when needed to avoid use of materials when target pests and diseases are absent. Companies sponsoring gherkin production in System B operate as if all possible pests and diseases are present each season and therefore provide cooperators with an array of biocides, all of which are used. That policy requires adjustment according to our data. The judicious application of biocides for management of downy mildew is needed, but our data also suggest that only in Maha is treatment justified. The massive application of insecticides should stop while answers are found to critical questions of pesticide resistance among thrip populations and role of pesticides on leafminer predators.

It might be profitable to study the cultural methods employed by Mr. Kularathna Banda. Exceptional yields in both Maha and Yala suggest that he uses some practices that would be worth emulating. Interestingly, he made the fewest number of pesticide treatments and applied the least dosage among our grower - cooperators. Downy mildew intensity on his farm was not markedly different from intensities on other farms.

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2. Joshi, R. D. and L. N. Dubey. 1973. Assessment of losses due to cucumber mosaic virus on chili (*Capsicum annuum* L.). Science and Culture 39: 521-522.

3. Shaner, G. and R. E. Finney. 1977. The effect of nitrogen fertilization on the expression of slow mildewing resistance in Knox wheat. Phytopathology 67: 1051-1056.

Recommendations

1. Refrain from using insecticides until their impact on thrip and leafminer populations is carefully assessed.

2. Refrain from using fungicides for downy mildew control during Yala unless warranted by disease intensity.

3. During Maha increase frequency of fungicide treatments for downy mildew but reduce dosage per treatment. Assess the downy mildew population for the presence of fungicide resistance.

4. Inaugurate an insect and disease monitoring program to evaluate pest development and make recommendations for pesticide use based on pest intensity.

5. Inaugurate a regional plan to destroy gherkin plant debris.

Table 1. Number of treatments and doses of fungicides and insecticides applied to six treatments of the gherkin cultivar Calypso during late Maha 1994 at the Regional Agricultural Research Station, Aralaganwila, Sri Lanka.

	Fungicides								Insecticides			
	Thiram		Metalaxyl		Mancozeb		Chlorothalonil		Methamidophos		Chlorpyrifos	
Treatment	Number of Treatments	kg ai ha^{-1}	Number of Treatments	kg ai ha^{-1}	Number of Treatments	kg ai ha^{-1}	Number of Treatments	kg ai ha^{-1}	Number of Treatments	L ai ha^{-1}	Number of Treatments	L ai ha^{-1}
T1	1	0.39	3	1.12	3	8.97	3	0.66	2	0.58	1	0.22
T2	1	0.39	3	0.84	3	6.79	3	0.48	2	0.51	1	0.16
T3	1	0.39	3	0.58	3	4.63	3	0.33	2	0.43	1	0.11
T4	1	0.39	3	0.30	3	2.47	3	0.15	2	0.36	1	0.05
T5	1	0.39	1	0.04	1	0.31	0	0.00	1	0.29	0	0.00
T6	1	0.39	3	1.12	3	8.97	2	0.44	2	0.58	0	0.00

Table 2. Pesticide dose and number of treatments made on the gherkin variety Calypso by eight farmers on three famer-managed treatments; farmer standard (T1), one-half farmer standard (T3), and as recommended by farmer and researcher (T6), during late Maha and Yala seasons 1994 in System B, Sri Lanka.

		Maha				Yala			
		Fungicides [a]		Insecticides [b]		Fungicides		Insecticides	
Farmer	Treatment	Number of Treatments	kg ai/ha	Number of Treatments	L ai/ha	Number of Treatments	kg ai/ha	Number of Treatments	L ai/ha
J. A. Wilbert	T1	8	8.34	4	2.72	10	12.15	12	25.31
do	T3	8	4.17	4	1.36	10	8.32	12	18.93
do	T6	4	2.33	2	0.68	3	3.74	7	8.74
W. M. Ranasinghe Banda	T1	6	5.59	4	4.48	7	51.67	9	29.49
do	T3	6	2.79	4	2.24	7	36.91	9	18.45
do	T6	2	0.76	2	1.92	3	15.09	2	3.87
Bisomeneke	T1	6	6.84	7	8.52	6	45.77	5	27.51
do	T3	6	3.42	7	4.26	6	41.16	5	23.75
do	T6	2	0.76	2	1.92	5	42.25	2	15.14
A. G. Somarathna	T1	7	6.34	4	2.28	11	26.62	9	13.45
do	T3	7	3.17	4	1.14	11	17.44	9	8.02
do	T6	1	0.40	1	0.48	3	5.02	1	0.85
B. M. Wimalarathna	T1	5	3.34	5	4.68	8	73.88	8	32.59
do	T3	5	1.67	5	2.34	7	13.11	8	9.47
do	T6	3	1.13	2	1.92	5	35.90	3	7.47
B. G. Ariyarathna	T1	7	6.41	3	4.32	10	405.82	12	212.61
do	T3	7	3.20	3	2.16	10	326.19	12	150.37
do	T6	3	1.13	2	1.92	9	479.80	9	188.94
H. M. Kularathna Banda	T1	6	5.14	3	2.12	4	20.64	6	16.40
do	T3	6	2.57	3	1.06	4	15.17	6	12.53
do	T6	2	0.73	2	0.68	2	6.09	3	5.52
Ranatunga	T1	5	3.41	2	1.92	13	30.92	9	15.91
do	T3	5	1.70	2	0.90	13	24.46	7	10.43
do	T6	1	0.36	0	0.00	7	17.90	4	7.07

[a] Fungicides used
Daconil - ai 75% Chlorothalonil
Pomarsol Forte - ai 80% Thiram
Mancozeb - ai 80% Mancozeb
Captan - ai 50% Captan
Benlate - ai 50% Benomyl
Ridomil MZ- ai 8% Metalaxyl +64% Mancozeb

[b] Insecticides used
Tamaron - ai 25% Metasystox
Monocrotophos - ai 60% Monocrotophos
Sevin - ai 85% Carbaryl
Lannate - ai 18% Methomyl
Methamidophos - ai 60% Methamidophos
Lorsban - ai 20% Chlorpyrifos
Kumulus - ai 80 % Sulfur
Thiodan - ai 30% Endosulfan

Table 3. Mean area under insect and disease progress curves normalized day $^{-1}$ plant $^{-1}$ across treatments T1 (farmer conventional), T3 (50% farmer conventional) and T6 (as recommended by researchers) for incidence, but normalized day $^{-1}$ leaf $^{-1}$ for severity of pests and diseases on gherkin during Maha and Yala seasons 1994 from eight farms in System B, Sri Lanka.

Season	Cucumber Beetle	Leaf Miner	Aphid	Looper	Spodoptera sp.	Mites	White Fly	Thrips	Downy Mildew	Powdery Mildew	CMV	Root Knot Nematode
						INCIDENCE						
Maha	<0.01	0.57	<0.01	0.06	0.08	0.00	0.00	0.00	0.92	0.00	<0.01	0.00
Yala	<0.01	0.91	0.10	<0.01	0.04	0.03	0.20	0.08	0.00	0.01	0.10	0.00
						SEVERITY						
Maha	<0.01	0.10	<0.01	0.02	0.04	0.00	0.00	0.00	3.95	0.00	0.00	0.00
Yala	<0.01	0.85	0.04	<0.01	0.01	0.10	0.05	0.08	0.00	0.01	0.03	<0.01

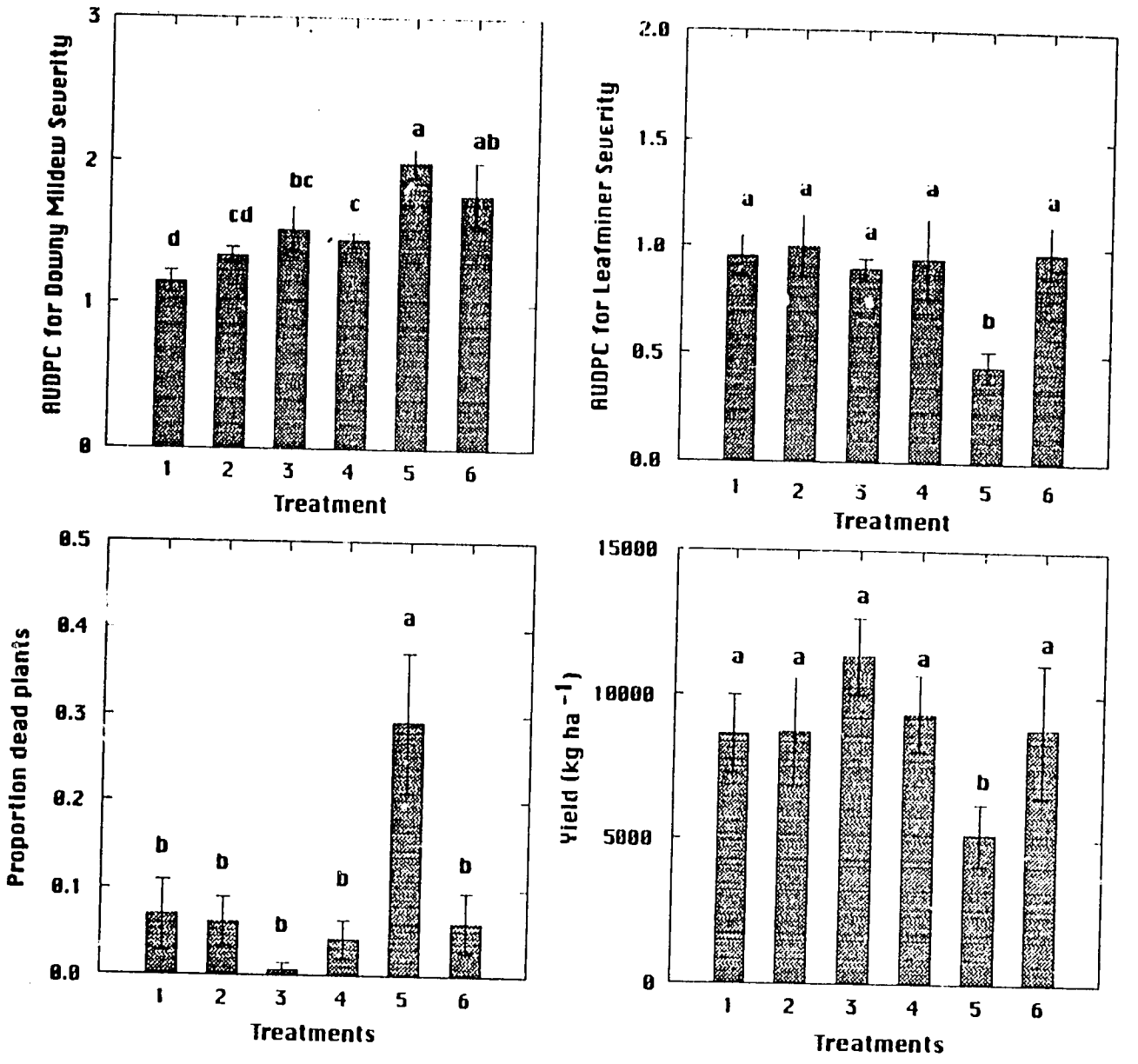

Fig. 1 Area under the progress curves for downy mildew and leafminer severities, proportion dead plants and yield of gherkin from the RARC trial during late Maha 1994, System B, Sri Lanka.

13

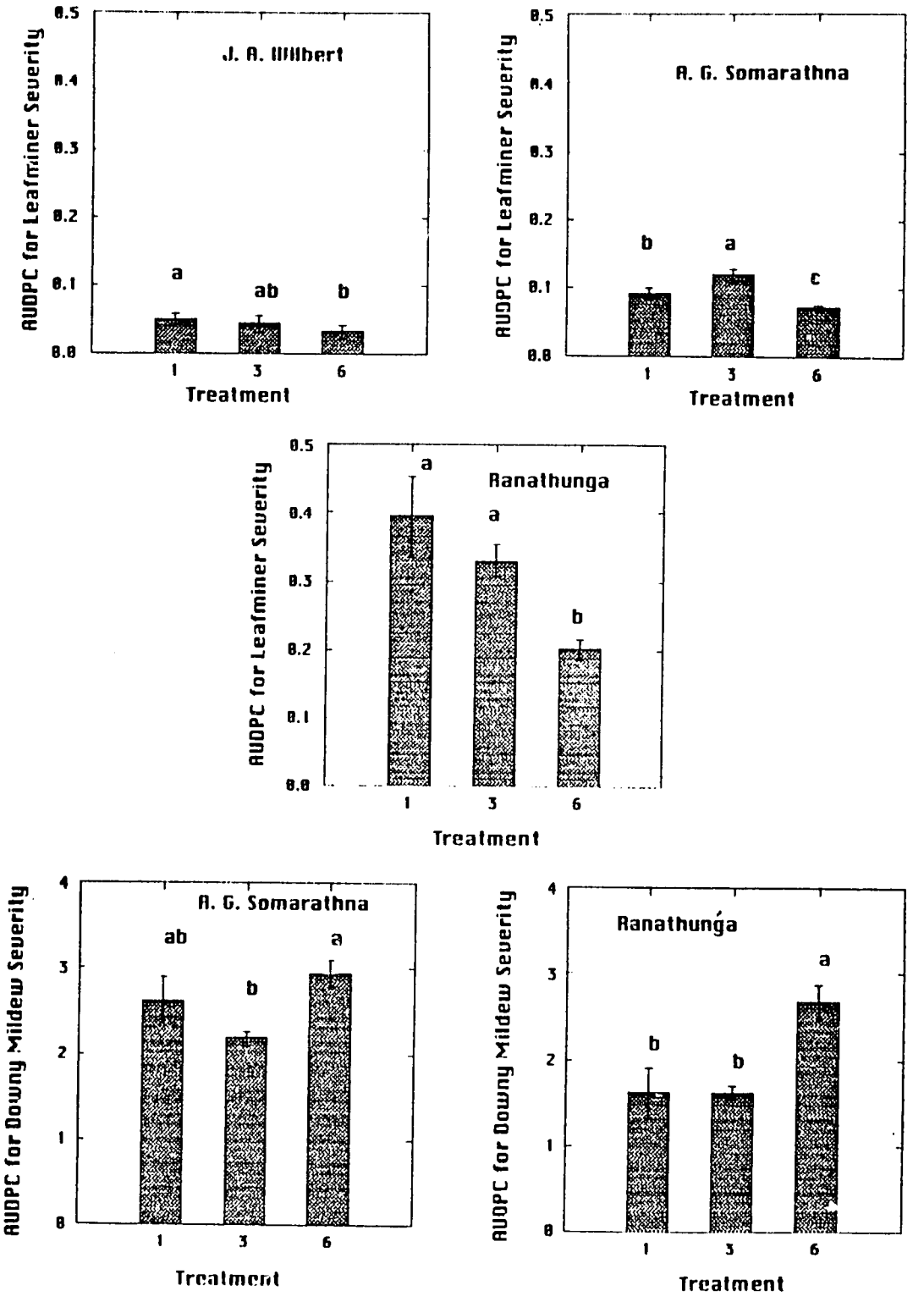

Fig. 2. Area under the progress curves for leafminer severity and downy mildew severity in late Maha, 1994 on farms in System B, Sri Lanka where significant treatment effects occurred.

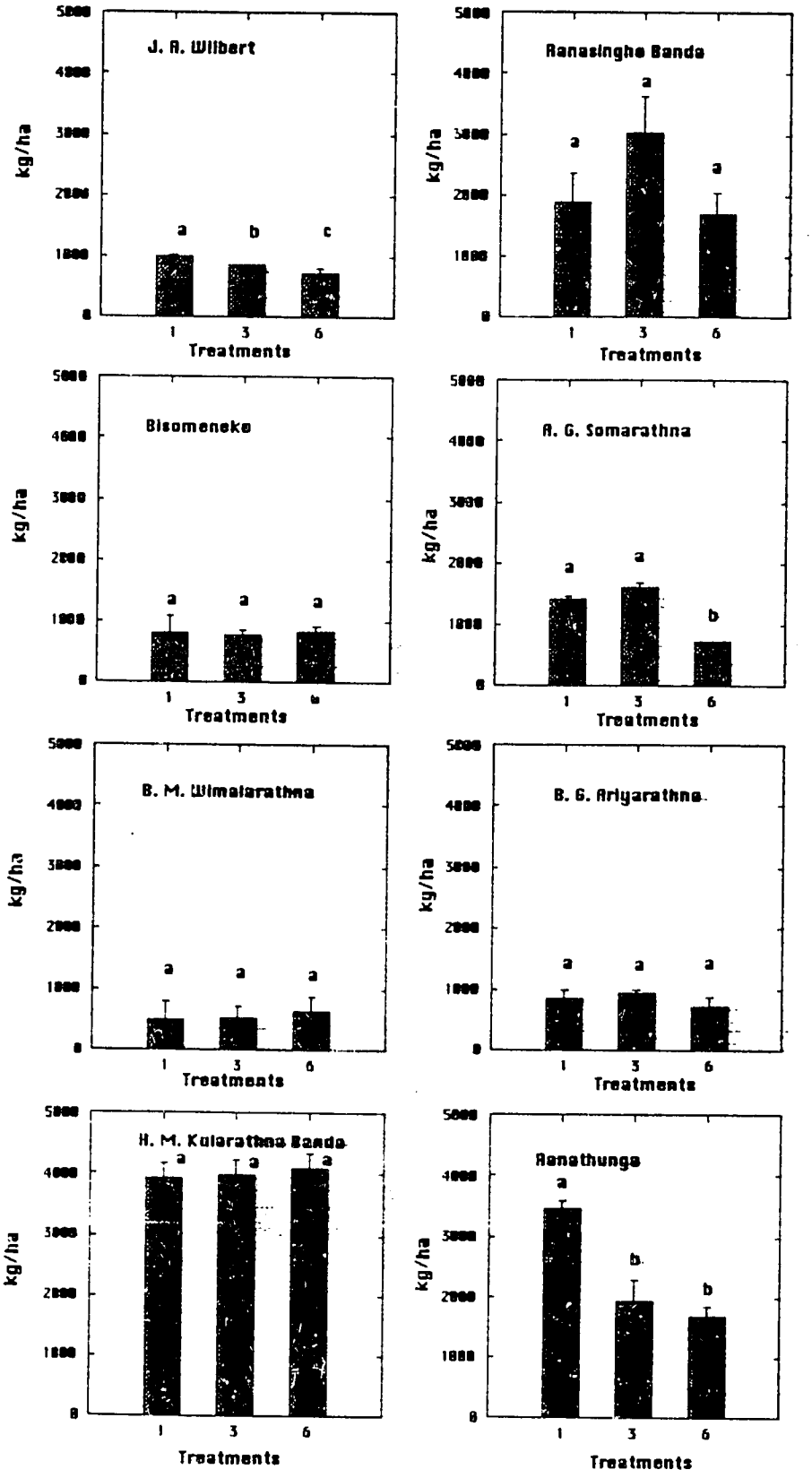

Fig. 3. Gherkin yield from three pesticide treatments on eight farms during late Maha 1994 in System B, Sri Lanka.

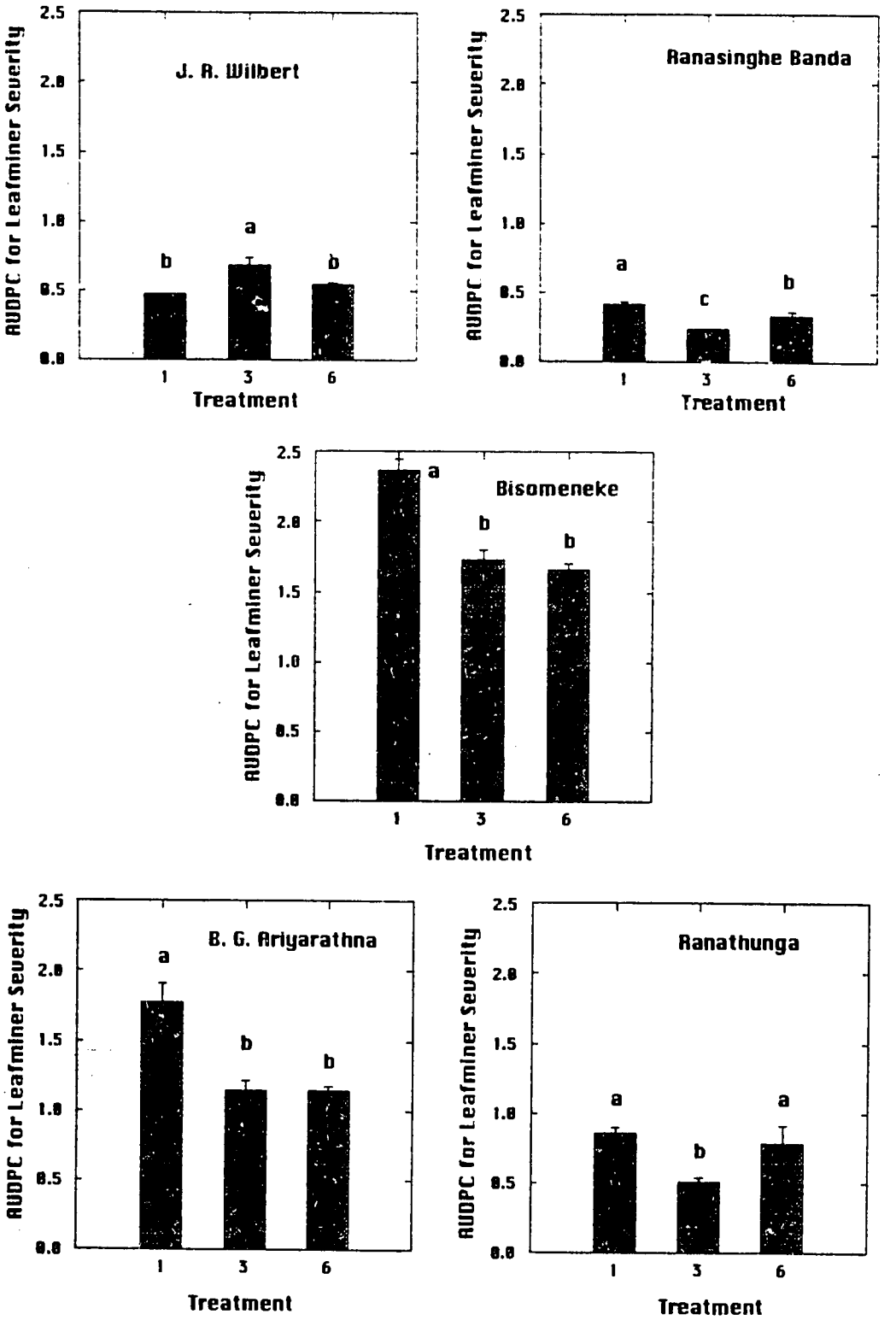

Fig. 4. Area under the progress curves for leafminer severity in Yala, 1994 on farms in System B, Sri Lanka where significant treatment effects occurred.

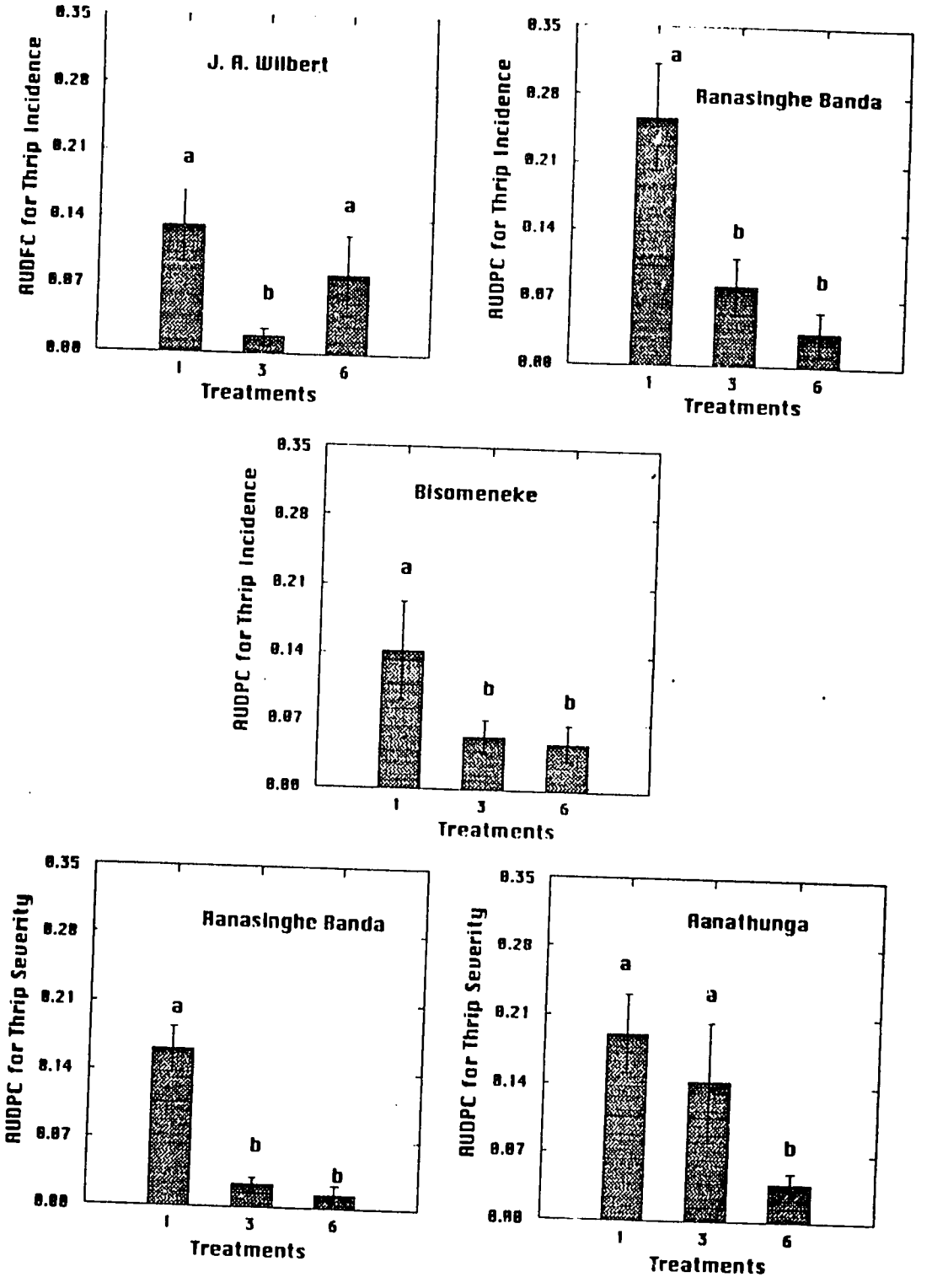

Fig. 5. Area under progress curves for thrip incidence and thrip severity during Yala 1994 in System B, Sri Lanka.

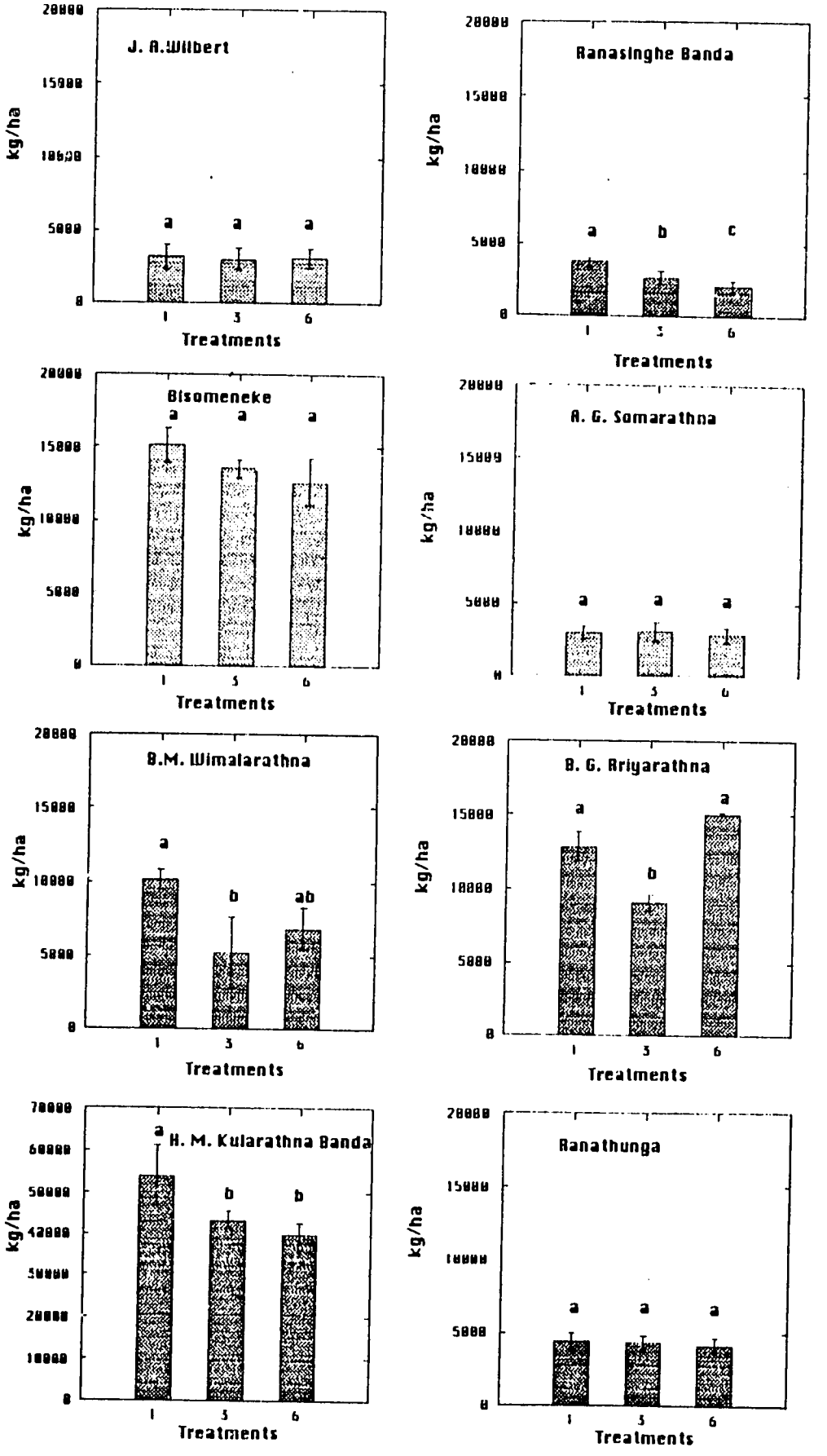

Fig. 6. Gherkin yield from eight farms in System B, Sri Lanka during Yala, 1994.