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Observation of Gamma Irradiated Cotton Populations on Trend of Cotton Leafhopper Resistance Using Hopperburn Index

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ABSTRACT

The experiments were conducted during the 2000 and 2001 cotton growing seasons at Suwan Farm, Pakchong, Nakon Ratchasima to investigate the damage of gamma irradiated cotton populations caused by the cotton leafhopper *Amrasca bigutulla bigutulla* using hopperburn index. Preliminary observation on M_1 populations of cotton varieties, SR_2, R_1, AP_1 and AP_2, was administered in the year 2000. After which the M_2 seeds of SR_2, R_1, AP_1 and AP_2 from the first year were used in the second year test in RCB design with 4 replicates. The numbers of cotton jassid from 2 leaves, one from the top and the other from the middle portions of the canopy from 10 plants in 3 middle rows of each tested variety were recorded on Days 45, 60 and 75 after germination. Visual rating on leafhopper damage was employed and hopperburn index was calculated. It was found that on Day 45, M_2 populations of every tested line expressed moderate resistance to the leafhopper except R_1 susceptible as indicated by hopperburn indices. As the plants grew older to Days 60 and 75 the resistance reduced. The hopperburn indices were of negative correlation to the leafhopper whose amounts were high on Day 45 and decreased and rose again on Days 60 and 75, respectively. Scanning Electron Microscope (SEM) also showed AP_2 and R_1 with the greatest and lowest hair densities on Day 45 resulting in low and high hopperburn indices, respectively.

Key words: cotton, jassid, hopperburn, hopperburn index

INTRODUCTION

Cotton is one of the important commercial crops and is mainly cultivated as a fiber crop in about 60 countries of the world. Among these, USSR, USA, China, India, Brazil, Pakistan, Egypt, Mexico and Sudan account for 85% of the total production. India ranks first in respect of area and fourth in total production. In the Oriental region, it is predominantly grow in India and Pakistan. Small areas are placed under this crop in Thailand, Burma, Sri Lanka, Bangladesh Vietnam, Philippines and Indonesia. The yields are low because of serious pest problems. Among the reported pests, cotton jassid, *Amrasca bigutulla bigutulla* (Ishida) is one key pest.

The nymphs and adults of jassid suck the sap from leaves and cause phytotoxic symptoms known as hopperburn which results in complete desiccation of plants. Severe infestation leads to poor crop stand and stunted growth (Narayan and Singh, 1994). The leafhopper is essentially an early phase pest of cotton. However, in recent years, the insect occurs all through the cotton season and has become one of the limiting factors in economic productivity of the crop.

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There is an increasing public perception that cotton production may be dangerous to health and environmentally damaging through the demands it makes on pesticides. While conventional chemical insecticides will remain the main weapon in the small scale cotton producer's armoury as in Thailand in the jassid control for the foreseeable future, new technologies of alternative control method are being developed that may allow the substitution of at least some chemical applications. One of the alternative methods is the use of resistant cotton varieties. The development of cotton cultivars resistant to *Empoasca fascialis* in South Africa, during the first quarter of the 20th century, has been the most successful and outstanding achievement in managing this pest (Parnell *et al*., 1949). Growing resistant varieties has essentially eliminated the cotton leafhopper as a major pest in Tropical Africa. In Sudan, varieties of *Gossypium barbadense* resistant to *Empoasca lybica* were grown.

Induced mutation breeding which has been recognized as a valuable supplement to conventional breeding in crop improvement has been at least applied in grain legumes. In Kenya, Pathak (1991) obtained 2 aphid resistant mutants of cowpea from an M_2 population of susceptible seeds irradiated with 20 kr of gamma rays. Mutants for resistance to the brown planthopper were induced by gamma radiation in rice variety 1/1 and released as Atomita 1 and 2 in Indonesia (Mugiono *et al.,* 1984).

The objective of this study was to use gamma radiation in mutation induction of cotton and to observe M_2 populations of the irradiated varieties on trend of resistance against cotton leafhopper using hopperburn index.

MATERIALS AND METHODS

Four cotton varieties, SR_2, R_1, AP_1 and AP_2 were irradiated with gamma radiation from Cs-137 at 300 Gy. The irradiated seeds (M_1) and M_2 seeds were then planted at Suwan Farm, Pakchong, Nakon Ratchasima for damaging observation caused by cotton leafhopper in the growing seasons of 2000 and 2001, respectively.

2000 Field Test

M_1 seeds of each cotton entry were grown in unreplicated plots consisting of 5 rows of 80 meters in length, with spacing of 1 x 1 meter between rows and plants. Thinning to 1 plant per hole was conducted after 1 month of germination. Preliminary counts on populations of nymph and adult of jassid from 1 leaf per plant at the top portion were recorded on 20 randomly selected plants. Three consecutive counts at the ages of 45, 60 and 75 days after germination were made. The crop was partly rain fed and partly irrigated. M_2 seeds from M_1 populations of each tested variety were harvested for next growing season.

2001 Field Test

M_2 seeds of four tested varieties, SR_2, R_1, AP_1 and AP_2 from 2000 year experiment were planted for further resistant observation against the cotton leafhopper. RCB was a designed experiment with 4 replications. Rows of 20 meter long were 1 meter apart with plants spaced at 1 meter within the rows, seven rows for each variety. Four weeks after germination, plants were thinned to one plant per hole. The crop was partly rain fed and partly irrigated as in 2000 Test. M_3 seeds of selected M_2 plants of each tested variety were harvested and bulked.

Seasonal abundance

Sampling for jassid began approximately 6 weeks after germination for 3 consecutive times at 2 weeks interval. Nymphs and adults of jassid were counted from 10 plants that were randomly selected along diagonals from the 5 middle rows of each tested variety in each block. The numbers were recorded from two leaves per plant, one from the top and the other from the middle portions of the canopy of the selected plants. Scanning Electron Microscope (SEM) was administered to show the appearance of hair density.

Assessment of hopperburn damage

Hopperburn injury was assessed according to ICCC (Indian Central Cotton Committee,1960) and based on resultant symptoms of infestation. Visual rating of hopperburn injury on each variety was recorded on Days 45, 60 and 75 after germination and the mean injury indices were calculated. The hopperburn grades consist of:

- Grade 1: Undamaged leaves
- Grade 2: Few leaves on lower position of the plant curling, crinkling and slight yellowing
- Grade 3: Crinkling and curling all over, yellowing, bronzing and browning leaves in the middle and lower positions.
- Grade 4: Extreme curling, yellowing, bronzing and browning, drying of leaves and defoliation, stunted growth.

A jassid resistance index (hopperburn index) was calculated as proposed by Nageswara Rao (1973). Grouping of injury index into categories of resistance is as follows:

Grade index	Category
0.1 – 1.0	Resistant
1.1 – 2.0	Moderately resistant
2.1 – 3.0	Susceptible
3.1 – 4.0	Highly susceptible

RESULTS AND DISCUSSION

2000 Field Test

The stability in agronomic performances, yields as well as insect resistance could hardly be encountered in the M_1 plant population grown from the irradiated seeds (M_1 seeds) according to Lamseejan (1993). She stated that most mutation which was the change in recessive genes, would only be noticed in M_2 when the number of cells began to relate with type and ratio of mutant in M_2. Therefore, the results of the first year test were discarded and M_2 seeds from M_1 plants of each tested variety were harvested and bulked for furtherly tested in 2001.

2001 Field Test

Table 1 presents the average numbers of cotton leafhopper and hopperburn indices of each tested variety at 45, 60 and 75 days after germination. Among these varieties, there were statistical differences in the average numbers of cotton leafhopper between SR_2 population and the rest on Day 45, while on Day 75, the significant difference from the others was found in AP_2 population. As for the times (days after germination), it was noticed the significant differences in the average numbers of jassid among populations of all tested varieties on each recorded day except those plants of AP_2

Table 1 Average numbers of cotton jassid / 2 leaves and hopperburn indices of 4 tested varieties on Days 45, 60 and 75 after germination.

Variety	Ave. nos. of jassid / 2 leaves Days after germination			Hopperburn grades Days after germination		
	45	60	75	45	60	75
AP_1	4.5 aC	2.1 aA	3.7 bB	2.0	2.25	2.75
AP_2	4.5 aB	2.1 aA	2.5 aAB	1.5	2.50	2.25
SR_2	5.1 bC	2.2 bB	3.4 bB	2.0	2.75	2.50
R_1	4.2 aC	2.3 bB	3.1 bB	2.5	2.50	2.75

Means followed by the same letters in the horizontal (A) and vertical (a) rows are not significantly different at 5% levels of DMRT.

population on Days 60 and 75 which were slightly significantly different from each other.

It can be seen that the amounts of cotton leafhopper on populations of every tested varieties were at the highest on Day 45 after which the numbers reduced on Day 60 and rose again on Day 75 (Table 1). The numbers of leafhoper showed negative correlation to the hopperburn indices of population of most tested varieties which were in the ranges of 1.5-2.0 indicating moderately resistant to the cotton leafhopper on Day 45 except R_1 susceptible. On Days 60 and 75, all indices of population of each variety which were in the ranges of 2.25-2.75 indicated susceptibility of the tested varieties to the jassid according to Nageswara Rao (1973). The results presented the populations of tested varieties to express trend of moderate resistance to the cotton jassid when they were young and became more susceptible to the insects as they grew older.

SEM was employed to provide the appearance of hair density on lower leaf surfaces of the four varieties on Day 45. AP_2 population with the greatest pubescence of them all gave the lowest hopperburn index of 1.5 indicating moderately resistant while R_1 with the least hairiness expressed the highest one of 2.5 implying susceptible (Figure 1). The results agreed with Bhat *et al.* (1982) whose view was that the hairiness of the lower surface of the leaf imparted a high degree of resistance but not

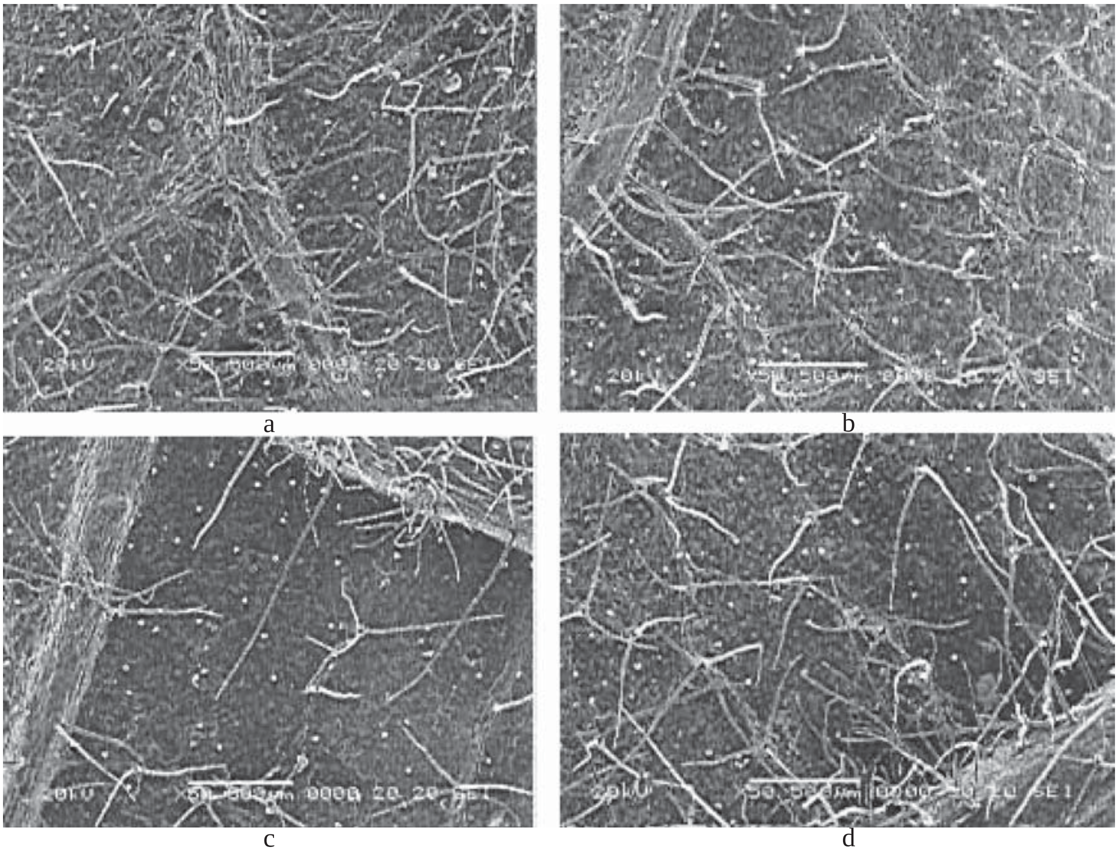

Figure 1 The lower leaf surfaces of tested varieties on Day 45 after germination.

a) AP_2 c) R_1

b) AP_1 d) SR_2

complete resistance. It was also noticed that the lower leaf surfaces of the young plants of tested varieties were governed with dense longer and more erect hairs than those of the old ones. Such hair might provide viable and heritable resistance against the cotton leafhopper. Leaf hairiness has been reported to be the only recognizable morphological attribute which is closely linked with resistance to the leafhopper (Agarwal *et al*., 1978). It appears that hairiness on the undersurface of leaves is the most important morphological character positively related in leafhopper resistance (Singh *et al*., 1972; Uthamasamy, 1985). However, presence of hairs does not always confer resistance and some glabrous genotypes also show resistance.

At this stage, the populations of tested varieties grown from M_2 seeds, the conclusion on whether such lines could be considered resistant or susceptible to the cotton jassid has not yet been definite. The further tests on resistant screening in the advanced generations until approaching stable stages (no more change from the radiation) have to be conducted. This is only the beginning but the results offer the trend to work on. It is known that morphological and biochemical mechanisms against the leafhopper operate in *Gossypium* spp. such as hairiness of leaves, toughness of leaf vien, thickness of leaf lamina, length of hair and angle of insertion are reported to be associated with resistance (Uthamasamy, 1985). Non-nutritional and anti-nutritional leaf factors also play a significant role in confering resistance. Since none of such characters has not yet been investigated, screening of mechanisms as non-preference, antibiosis and tolerance as well as genetics and the causes of resistance should be furtherly investigated by growing seeds of each selected plant in the next study.

CONCLUSION

M_2 seeds of 4 irradiated varieties, SR_2, R_1, AP_1 and AP_2, grown into the cotton plants are still in unstable stage. Changes due to gamma radiation might be expected to continue. The moderate resistance and susceptibility indicated by hopperburn indices of most populations of tested varieties at Day 45 and, Days 60 and 75, respectively, to the cotton leafhopper might furtherly developed. Continuous investigation on individual plant of M_3 populations of all tested varieties in terms of resistance development, causes of resistance including the resistant mechanism must, therefore, be undertaken.

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