TARC Notes

Biological and genetic nature of biotype populations of the brown planthopper, *Nilaparvata lugens*

The brown planthopper, *Nilaparvata lugens* (Stål) (Homoptera; Delphacidae), has become a serious threat to rice production throughout tropical and sub-tropical Asia with the spread of high-yielding rice varieties and of intensive cultural practices since about 1970[2]. It has recently been recognized that the brown planthopper exists as a complex of populations, which are commonly referred to as biotypes, having specific phenotypes with respect to their ability or inability to survive on and infest host varieties with specific genes for resistance. The existence of such host resistance-breaking biotypes has further complicated the control strategies of this rice pest by genetic manipulation in rice varieties[3].

Investigations were carried out on the biology and genetics of the three biotypes (biotypes 1, 2 and 3), which are being maintained as inbred populations on susceptible TN 1, as well as resistant Mudgo and ASD 7 varieties in the greenhouse of the International Rice Research Institute (IRRI). Four rice varieties were used as differential varieties: IR 24 and TN 1 susceptible to the three biotypes; IR 26 resistant to biotypes 1 and 3, but susceptible to biotype 2, and IR 40 resistant to biotypes 1 and 2, but susceptible to biotype 3. Four behavioral and physiological characters, namely host preference, honeydew excretion, nymphal development and fecundity, of the three biotypes and their inter-biotypic hybrids were compared to characterize their biological and genetic properties.

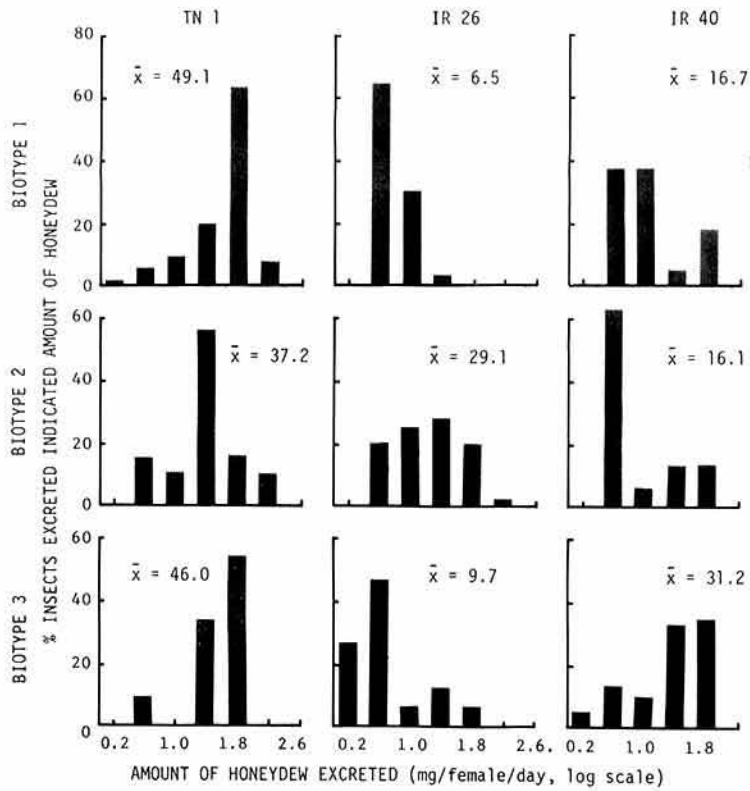

Fig. 1. Frequency distributions of honeydew excreted by female adults of the three biotypes on susceptible and resistant rice varieties

Honeydew excretion

Feeding activities of biotypes were measured by weighing honeydew collected in an air-tight parafilm envelope. A significant positive correlation was found between the average amount of honeydew excreted and the ability of each biotype to infest resistant varieties in spite of a wide range of individual variations within each biotype population (Fig. 1). The female adults of the three biotypes each excreted as much as 40–50 mg/day on TN 1. On IR 26 and IR 40, biotypes 2 and 3 females, respectively, excreted significantly more honeydew than did the others. All the hybrid progenies from the crosses between biotypes 1 and 2 and those between biotypes 1 and 3 excreted as little or less honeydew than did biotype 1 on IR 26 and IR 40, respectively (Fig. 2). The amount of honeydew excreted by the F_1 progenies from the crosses between biotypes 2 and 3 on IR 26 and IR 40 was also significantly smaller than that excreted by their respective upper parent on each respective variety (Fig. 2).

Nymphal development

Nymphal development of the three biotypes reared on seedlings of differential varieties was compared. On susceptible TN 1 seedlings, nymphs of the three biotypes emerged to adults within 12–14 days, and their growth was well synchronized. On IR 26 and IR 40, biotype 3 nymphs showed the best growth among the biotypes. Nymphs of biotypes 1 and 2 suffered much higher mortality from IR 26 and IR 40, particularly from IR 26, than did those of biotypes 3, and emerged to smaller adults on them. Their nymphal duration varied greatly ranging from 14 to 28 days. Therefore biotypes 1 and 3 were satisfactorily differentiated by their nymphal development on IR 40, although differences between biotypes 1 and 2 were not so appreciable

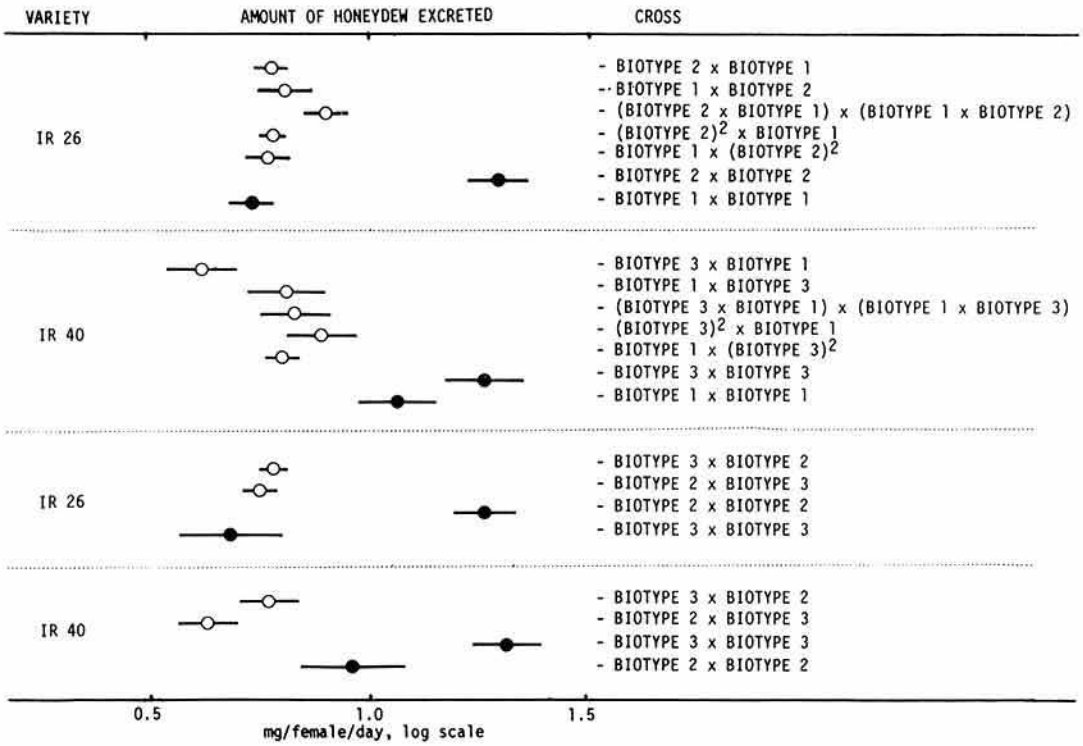

Fig. 2. Amount of honeydew excreted by biotypes 1, 2 and 3, and their hybrid progenies on IR 26 and IR 40 (mean ± S.E.).

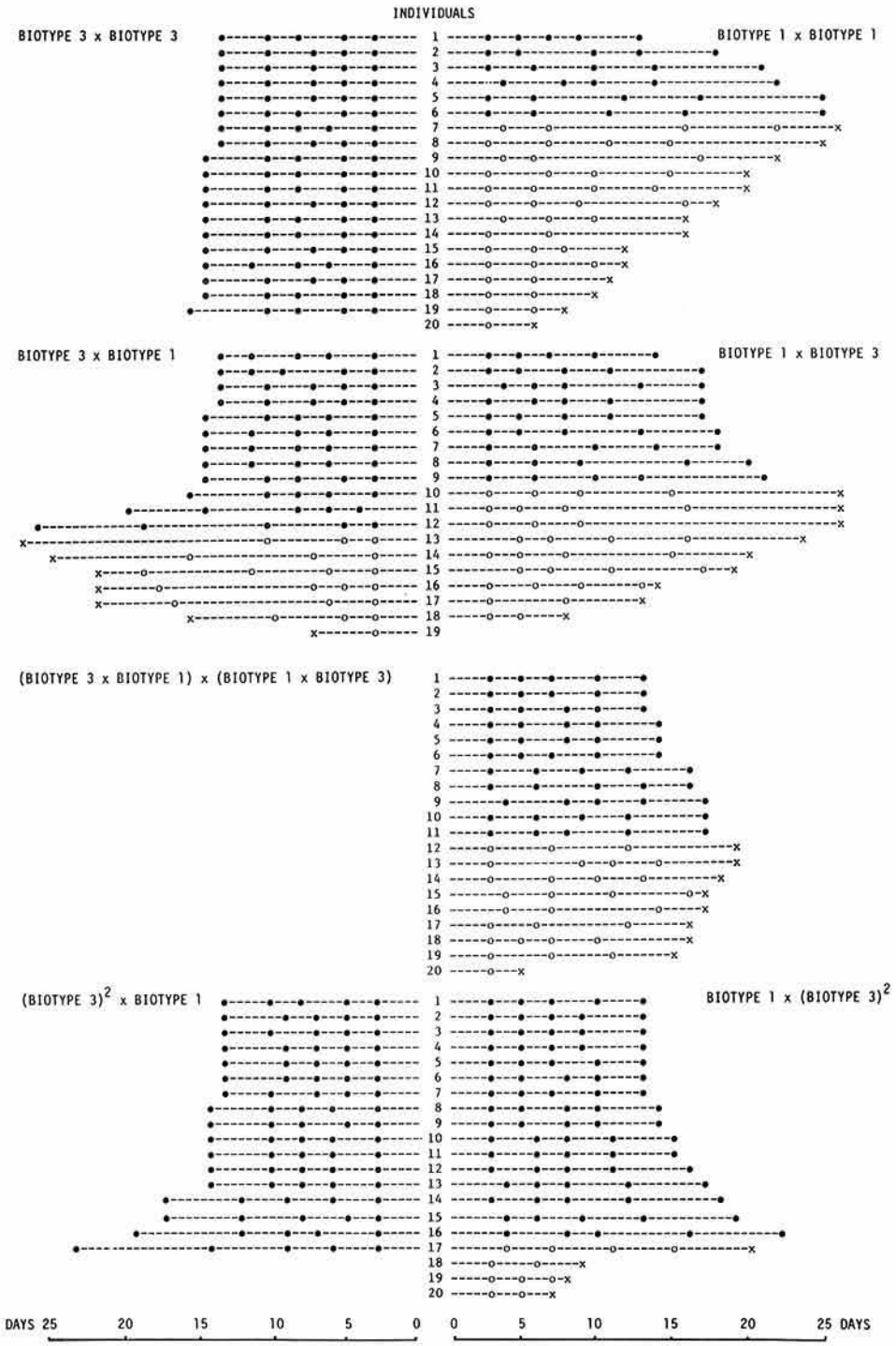

Fig. 3. Individual records of nymphal development of biotypes 1 and 3 and their hybrid progenies on IR 40. --●--● Emerged to adults, --○--× Not completed nymphal stages and died.

in this respect. The F_1 and F_2 progenies from the crosses between biotypes 1 and 3 showed a development intermediate between that of their parents. The progenies obtained by backcrossing the F_1's to biotype 3 reacted more similarly to biotype 3 as compared with the F_1 progenies (Fig. 3). Nymphs of the hybrids between biotypes 2 and 3 grew better than those of biotype 1 on IR 26 and IR 40.

Fecundity

The three biotypes were also clearly differentiated from each other on the basis of their reproductive potentials on differential varieties. On susceptible IR 24, the three biotypes achieved the highest reproductivity. However, only biotypes 2 and 3 reproduced as well on IR 26 and IR 40, respectively, as on IR 24. Reproductiveness of biotypes 1 and 3 on IR 26, and that of biotypes 1 and 2 on IR 40, was negligible. The F_1, F_2 and backcross progenies from the crosses between biotypes 1 and 2 had no ability to reproduce on IR 26. The F_1's from the reciprocal crosses between biotypes 1 and 3 showed very low fecundity, if any, on IR 40. However, when they were backcrossed to biotype 3, their progenies acquired as high a fecundity as that of biotype 3 on IR 40. The females of F_1's from the crosses between biotypes 2 and 3 survived well and became gravid on IR 26 and IR 40.

The present experiments demonstrated that the three biotypes were most clearly distinguished from each other on the basis of their averaged abilities to feed and reproduce on differential varieties. Particularly, their differential feeding abilities on resistant varieties seemed to be a crucial factor responsible for their different performance on those varieties[5]. In addition, biotype 3 differed significantly from the others, particularly from biotype 1, in its host preference response as well as in nymphal development on resistant varieties.

Breeding experiments indicated that the biological characteristics of biotypes 2 and 3 were generally inherited in a recessive or intermediate manner when these biotypes were hybridized with biotype 1, as summarized in Table 1. These results seems to be in agreement with the previous finding of IRRI (1978)[4], but not with those of Cheng and Chang (1979)[1] who suggested that biotype 2 is recessive against biotype 1, and that biotype 3 is dominant over biotype 1. However, no evidence was obtained to support IRRI's finding (IRRI, 1978) that biotype 3 was dominant over biotype 2. Also, from the evidence that no definite segregation was apparent in the F_2 or backcross progenies (Table 1), it seems possible to posturate that physiological traits of biotypes 2 and 3 associated with host resistance-breaking ability are controlled by polygenic or quantitative

Table 1. Behavioral and physiological reactions of the F_1, F_2 and backcross(BC) progenies from inter-biotypic crossings on resistant varieties

Characteristics[1]	Biotypes 1×2			Biotypes 1×3			Biotypes 2×3
	F_1	F_2	BC	F_1	F_2	BC	F_1
Host preference	*	*	*	1	1	1	1
Honeydew excretion	1	1	1	1	1	1	1
Nymphal development	1	*	*	1-3	1-3	3>1	2/3
Fecundity	1	1	1	1	3>1	3>1	2/3

[1] 1 = Reaction similar to biotype 1.
1-3 = Reaction intermediate between that of biotypes 1 and 3.
3>1 = Reaction more similar to that of biotype 3 than of biotype 1.
2/3 = Reaction similar to biotypes 2 or 3 depending on host varieties.
* = Not tested because of no significant parental differences.

inheritance.

It has been assumed that the natural brown planthopper populations generally include small proportions of 'pre-existing' biotypic variants. Consequently, when resistant varieties are intensively planted, a population of planthoppers builds up that can infest them. Thus the non-virulent population may shift to a new virulent biotype[3]. It seems, however, more reasonable to assume that the host resistance-breaking biotypes devolp by accumulation and recombination of various effective minor genes through the elimination of off-types, inbreeding among individuals selected, and reproductive competition among diffferent genotypes under the continuous selection pressure from wide-range cultivation of particular resistant varieties.

These studies were conducted at IRRI from October 18, 1976 to December 25, 1979 as part of a collaborative research project on the rice brown planthopper between TARC and IRRI.

1) Cheng, C. H. & Chang, W. L.: Brown planthopper: threat to rice production in Asia, IRRI, Philippines, 251–271 (1979).
2) Dyck, V. A. & Thomas, B.: Brown planthopper: threat to rice production in Asia, IRRI, Philippines, 3–17 (1979).
3) IRRI: The International Rice Research Institute, *Annual Report for 1975*, IRRI, Philippines, 479pp (1976).
4) IRRI: The International Rice Research Institute, Annual Report for 1977, IRRI, Philippines, 548pp (1978).
5) Sogawa, K & Pathak, M. D.: *Appl. Ent. Zool.* **5**, 145–158 (1970).

Kazushige SOGAWA* *Tropical Agriculture Research Center, Japan*

(Received for publication August 22, 1980)

* Present address: Hokuriku National Agricultural Experiment Station
(Inada, Joetsu, Niigata, 943-01 Japan)