showed significant effect to reduce the lesion size by over 50% in comparison with the control. The treatment of 0.01 mM SA showed a maximum reduction of 58.8%.

Tests with 0.01 mM SA indicated that the proper interval between induction treatment of SA and the challenge inoculation was 12—4 d. When the SA-pretreated seedlings were inoculated 2 d later, the blast severity of SA-pretreated seedlings reduced by 59.8% in comparison with the controll. The induced resistance was observed to be last until 15 d after SA treatment, when the SA-treated seedlings still showed 24.3% of the disease reduction.

The effects of treatment in twice with 0.01 mM SA at an interval of 2 or 5 d on resistance induction were also tested. It demonstrated that the booster treatment increased the effect of SA on the resistance induction by 35—47% and elongated the lasting period of the induced resistance compared with single SA treatment. In addition, treatment in twice at an interval of 5 d were more effective than that at an interval of 2 d.

When the lower leaves 1 and 2 were sprayed with 0.01 mM SA before challenge inoculation, systemic acquired resistance on the upper unsprayed leaves 3 and 4 was observed.

No inhibitory effect of SA on spore germination and mycelium growth of *P. oryzae* was detected on culture in vitro even at 0.5 mM SA concentration. Therefore, the reduction of disease severity in SA-pretreated seedlings was suggested as SA-induced resistance of rice seedlings to blast.

Relationship of egg parasitoids of rice planthoppers between rice and non-rice habitats

YU Xiaoping, Zhejiang Acad Agri Sci, Hangzhou 310021, *China;Heong KL, IRRI, Philippines; HU Cui, Zhejiang Agric Univ, Hangzhou* 310029, *China*

Egg parasitoids, *Anagrus* spp. and *Oligosita* spp. have been found to be important biological agents in suppressing rice planthoppers in Asian countries. However, most of these studies have been confined to conditions within rice fields. In this study, field surveys were made to study the floral and faunal diversity in various habitats surrounding rice fields. The rice and grass (*Echinochloa* spp.) plants were infested with 2 gravid females of brown planthopper *Toya* spp. or *T. pusanus* per tiller respectively for two days. The oviposited plants were : 1) Rice plants bearing BPH eggs, 2) grass plants bearing BPH eggs, 3) grass plants bearing *Toya* spp eggs, and 4) grass plants bearing *T. pusanus* eggs. Above plants were placed in the rice field, the grassy area adjacent to rice fields and the grassy area away from rice fields, respectively. Potted plants with host eggs were brought back after a 2-day exposure, and placed in the emergence cages. To facilitate parasitoid collection, the cages were covered with black cloth jackets with their tops fitted with glass vials. The egg parasitoids were collected daily, by replacing vials, and then stored in 75% alcohol for identifying and counting. Additionally, the various grasses were collected from uncultivated areas. About 100 tillers per grass species were hand-pulled and kept separately in plastic bags. All the grass species were placed in mylar cages for parasitoid emergence. The egg parasitoids while emerged from grasses were collected daily and kept in 75% alcohol for sorting and counting. By using BPH eggs as traps, 4 species of egg parasitoids. *A. flaveolus*, *A. optabilis* , Oligosita naias and *O. aesopi* were collected in various habitats. In grassy areas

Table 1. The proportion[a] of egg parasitoids trapped by hopper egs in various habitats

Habitat	Host eggs	No[b]	*A. flaveolus*	*A. optablis*	*O. naias*	*O. aesopi*
Grassy	BPH	128	14.06	53.13	26.56	6.25
away	*Tova*	3	66.66	0	33.33	0
rice fields	*Tagosodes*	117	100	0	0	0
Grassy area	BPH	72	69.44	22.22	2.78	5.56
neighboring	*Toya*	126	96.03	0	2.38	1.58
rice fields	*Tagosodes*	58	89.66	3.45	6.90	0
	BPH	153	15.03	26.14	42.48	16.34
Rice fields	*Toya*	88	85.23	0	11.36	3.41
	Tagosodes	5	100	0	0	0

[a]proportion $= \frac{\text{Number of each egg parasitoid}}{\text{Number of total egg parasitoid}} \times 100\%$. [b]Total number of egg parasitoids from 3 potted plants. Density were 300—500 eggs per potted plant (20 tillers per pot)

Table 2. The abundance (No. per 100 plant stems) of parasitoid associated with hopper on various vegetation

Parasotoid	No. of parasitoids per plant stems											
	Tot	*Fimb*	*Lept*	*Pasp*	*Sacc*	*DigA*	*EchA*	*EchB*	*Brac*	*Cyna*	*Cype*	*DigB*
Anagrus spp.	—	—	—	—	6	7	10	—	2	—	—	25
Oligosita spp.	1	5	—	—	1	1	2	1	—	3	—	14
Goatocerus spp.	—	—	8	4	5	18	5	—	3	1	—	44
Mymar spp.	2	4	1	—	—	2	—	—	11	1	3	24
Tetrastichus spp.	—	16	2	3	1	15	20	—	—	—	—	57
Trichogramma spp.	—	—	46	5	—	3	—	15	3	8	3	83
Encyrtidae	—	—	—	—	1	—	—	—	—	—	5	6
Panstenon spp.	—	—	3	—	—	—	—	—	—	—	—	3
Total	3	25	60	12	14	46	37	16	19	12	11	256

Fimb = *Fimbristylis miliacea*; *Lept* = *Leptochloa chinensis*; *Pasp* = *Paspalum* sp.; *Sacc* = *Saccharum spontaneum*; *DigA* = *Digitaria ciliaris*; *EchA* = *Echinochloa*; *EchB* = *E. glabrescens*; *Brac* = *Brachiaria sp*; *Cyna* = *Cynadon dactylon*; *Cype* = *Cyperus difformis*; *DigB* = *D. setigera*.

away from rice fields, 53.13% of egg parasitoids trapped was *A. optablis*, while *A. flaveolus*, *O. naias* and *O. aesopi* accounted for 14.06%, 26.56% and 6.25%, respectively. However, in grassy areas adjacent to rice fields, a higher proportion (69.44%) of *A. flaveolus* was trapped. In the rice field, parasitization was evenly distributed although *O. naias* was dominant (Table 1). When *Toya* spp. egg traps were used, a number of *A. flaveolus* and some *O. naias* were trapped in rice fields and grassy areas nearby rice fields. Only a few egg parasitoids were trapped from the grassy area away from rice fields. *Toya* spp. eggs failed to trap *A. optablis* and *O. aesopi* in all three habitats. *T. pusanus* eggs trapped many *A. flaveolus* in non-rice habitats, but only a few in rice fields. The results showed that *A. flaveolus* was the dominant egg parasitoid species attacking delphacids in rice and non-rice habitats.

The abundance of egg parasitoids related to hoppers was recorded by collecting 11 species of grasses and sedges for parositiod emergence (Table 2). *Genatoceurs* spp. seemed to be more abundant than *Anagrus* spp. and *Oligosita* spp. on many grasses. More *Anagrus* spp. were collected on the grasses *E. colona*, *E. glabrescens* and *Digitaria ciliaris*, while *Oligosita* spp. tended to be higher on

Leptochloa chinensis. Other parasitoids, especially *Trichogramma* spp. and *Tetrastichus* spp. were abundant on the grasses, *Echinochloa* spp., *Leptochloa chinensis* and *D. ciliaris*.

The results indicated that *A. flaveolus*, *A. optabilis*, *O. aesopi* and *O. naias* are important egg parasitiods of rice hoppers that exist in both rice and surrounding non-rice habitats. The abundant vegetation dominated by grameneous grasses in rice ecosystems may serve as a reservoir for egg parasitoids of rice planthoppers.

Combined pollution of Cd and Zn in soil-rice systems and its indexes

ZHOU Qixing and WANG Fengping, Dept of Environmental Sciences, Zhejiang Agri Univ, Hangzhou 310029, *China*

Due to the mining , smelting, sewage irrigation, agricultural runoff, and development of rural enterprises, combined pollution of Cd and Zn in soil-rice systems has frequently occurred. This problem was studied by using the pot-culture imitative method combined with chemical analysis and mathematical models. Tested soil was brunisolic paddy soil and the tested concentrations of Cd and Zn were selected as follows:

Cd (mg/kg) 0.0 0.5 1.0 1.5 2.0 3.0
Zn (mg/kg) 0.0 100 200 400

The results showed that the Cd-Zn combined pollution was more complicated than the single-factor pollution of Cd or Zn in soil-rice system: Influences of the Cd-Zn combined pollution on biological yield of rice, accumulation and distribution on Cd and Zn in tissues of rice were not only dependent on the concentration of Cd and Zn added into the tested paddy soil, but also related to their ratio. Under the condition of the Cd-Zn combined pollution, interrelationship between biological yield (Y) of rice and exponential logarithmic values of Zn/Cd ratios (Xv) of brown rice can be expressed by the following equation,

$Y = 33.78 + 2.17 \ln Xv$ ($r = 0.7708$, $n = 15$),

where significance level < 0.001. However, under the condition of single-factor pollution, the corresponding interrelationship can be expressed as follows:

$Y = 33.19 + 1.62 \ln Xv$ ($r = 0.5435$, $n = 8$),

where significance level is equal to 0.10. The linear relationships between Y and Xv were not significant,

According to the above conclusion, a mathematical model for weighting combined pollution of Cd and Zn in soil systems was deduced as follows: $Pd = f[(X_{Cd} + k_1 X_{Zn})/(k_2 Y)]$.

The corresponding simplified formula is as follows: $Ic = (X_{Cd} + X_{Zn} - 20.0)/Y$ ($X_{Zn} < 20.0$ mg/kg) or $Ic = X_{Cd}/Y$ ($X_{Zn} < 20.0$ mg/kg), where Ic is an index of combined pollution, Y is the yield of rice , X_{Cd} is the concentration of Cd in brown rice and X_{Zn} is the concentration of Zn in brown rice.

In many countries, the food hygienically standards for Cd is 0.2 mg/kg and for Zn is 30.0 mg/kg respectively. The calculation according to the food hygienical standards and by applying the above formula and the results from the pot-culture experiment showed that the maximum allowable concentrations of Cd and Zn in the paddy soil were equal to 1.0 and 400 mg/kg, which was consistent with the conclusion based on 10% of the height yield of rice regarded as the deceased yield due to the Cd-Zn combined pollution. In this sense, it is a scientific rationalization proposal that the environmental quality guidelines for Cd and Zn in the paddy soil under the conditions of Cd-Zn