

Paraquat Resistance in *Solanum nigrum*, *Crassocephalum crepidioides*, *Amaranthus lividus* and *Conyza sumatrensis* in Malaysia.

K. Itoh (1), M. Azmi (2) and A. Ahmad (3)

(1) Tropical Agriculture Research Center, Tsukuba, 305, Japan

(2) Malaysian Agriculture Research and Development Institute, Kepala Batas, 13200 Seberang Perai, Malaysia

(3) Malaysian Agriculture Research and Development Institute, Tanah Rata, Cameron Highland, 39007 Pahang, Malaysia

Summary :

In sweet peas and potato fields in Tanah Rata, Cameron Highlands, Malaysia, paraquat dichloride at 1 kg a.i./ha were sprayed twice a year. In May and September 1990, paraquat resistant biotypes of *Solanum nigrum* L. (Solanaceae), *Crassocephalum crepidioides* (Benth.) S. Moore (Compositae), *Amaranthus lividus* Loisel. (Amaranthaceae) and *Conyza sumatrensis* (Retz). Walker (Syn. *Erigeron sumatrensis*, Retz, Compositae) were recorded as abundance in such fields. Leaf disk tests involving various concentrations of paraquat showed that the level of resistance in the resistant biotype of *C. crepidioides* was 100 times higher than that of its susceptible counterpart. Paraquat resistant biotypes of *C. sumatrensis* also distributed in Kota Bahru, Kelantan and *C. crepidioides* distributed in Tapah and Bidor, Perak, Malaysia.

Introduction

The repeated use of the same herbicide would be almost inevitable followed by the development of a resistant biotypes of weed. Ryan (10) reported the first case of resistance development in *Senecio vulgaris* grown in a nursery where atrazine and simazine had been used once or twice annually since 1958. Paraquat-resistance biotype of *Erigeron philadelphicus* L. was found 12 years ago by one of the authors in a mulberry field in Saitama Japan (12), also detected a paraquat-resistant biotype of *E. canadensis* L. (syn. *C. canadensis*) in vineyards in Osaka (8), followed by Hanioka (2,3) for *C. sumatrensis* (Retz.) Walker (syn. *E. sumatrensis*) and for *Youngia japonica* (L.) DC. in mulberry fields in Saitama. Presently in Japan, herbicide-resistance have been observed in a single field or levee of paddy field where paraquat had been applied 2 or 3 times annually during the preceding 15 - 20 years. The mode of paraquat action was also different between photosynthetic and nonphotosynthetic system, and also between intact plants and leaf disks or protoplasts (6). In Florida, USA, *Solanum americanum* (American black nightshade) was reported as paraquat resistant weed (1). Itoh *et al.* (7) reported that the level of resistance in the resistant biotypes of *Crassocephalum crepidioides* was 100 times higher than its susceptible ones.

This paper reported a continued study on paraquat resistant species in the sweet peas field in Cameron Highland, Malaysia.

Materials and methods

Experiment 1: A trail was conducted in a sweet peas field of MARDI experimental field in Cameron Highlands, Malaysia. The sweet pea was cultivated on early May, 1990. After harvesting the pea on mid August 1990, a mixture of paraquat dichloride (57.3% w/w) and diuron (24.7% w/w) was sprayed on 10th September 1990 at 1.0 kg a.i./ha. Randomized observation were made on 14th September 1990 in 1 m² quadrat with 6 replications to determined the survived, the half survived and the dead species of weeds. The weeds were identified

and counted according to species.

On 12th Sept. 1990, each five leaf discs from 4 species collected from Tanah Rata, Cameron Highland were also dipped into 4 ml paraquat (10^{-5} and 10^{-4} M). Phototoxicity and discoloration ratings of the discs were made 48 hours after treatment.

Experiment 2 : A trial was carried out in MARDI experimental field in Cameron Highlands near the field used in experiment 1 on 11th September, 1990. Four concentrations of paraquat dichloride (Gramoxon PP910, 25.3%), Glufosinate ammonium (Basta, 20.4%) (Gf), Glyphosate (Round Up, 41%) (Gs) and 2,4-D amine 720 (dimethyl amine, 60 %) (D) were applied in 2 m x 4 m plots with three replications. The paraquat dichloride concentration were 0.38 kg a.i./ha (P 0.5), 0.76 kg a.i./ha (P 1:recommended dosage), 1.52 kg a.i.(P 2)/ha and 3.04 kg a.i./ha(P 4), respectively. The concentration of Glufosinate ammonium,

Table 1 An average number of survived weeds 4 days after paraquat and diuron treatment on 14th September 1990 in Cameron Highlands, Malaysia.

Weeds	Average number of plants / m ²		
	Completely survived	Half survived	Died
<i>Amaranthus lividus</i>	3.3	11.7	4.3
<i>Crassocephalum crepidioides</i>	0.8	0	0.3
<i>Solanum nigrum</i>	0.7	0	0.3
<i>Conyza sumatrensis</i>	0.3	0	0.7
<i>Mazus pumilas</i>	0	4.7	2.2
<i>Oxalis corymbosa</i>	0	3.8	5.2
<i>Drymaria cordata</i>	0	1.3	2.5
<i>Eleusine indica</i>	0	1.0	0.3
<i>Ageratum conyzoides</i>	0	1.0	5.3
<i>Plantago major*</i>	0	0.8	1.0
<i>Polygonum sp.</i>	0	0.7	2.0
<i>Galinsoga ciliata**</i>	0	0.7	2.7
<i>Rumex conglomeratus</i>	0	0.2	0
<i>Cyperus cyperoides</i>	0	0	0.7
<i>Cardamine flexuosa</i>	0	0	14.0

* : *P. major* or *P. asiatica*, ** : *G. ciliata* or *G. parviflora*

Table 2 Survivorship of leaf disks in the four species into 10^{-5} M paraquat solution

	<i>C. crepidioides</i>	<i>A. lividus</i>	<i>C. sumatrensis</i>	<i>S. nigrum</i>
No. of plant	51	19	5	8
No. of survived	36	6	2	1
% of resistant	70.6	31.6	40.0	12.5

Glyphosate and 2,4 - D amine were 0.255 l a.i./ha, 2.46 l a.i./ha and 1.02 l a.i./ha respectively. A check plot (2 m x 4 m) with three replications was not sprayed with herbicides. Observation was made on 10th October 1990 in 50 cm x 50 cm quadrats for P 0.5, Gf, D and check plots, and 2 m x 4 m areas for P 1, P 2, P 4 and Gs. A number of survived weeds was recorded according to species.

Results and discussion

Table 1 showed an average number of weeds survived 4 days after paraquat treatment in the field. It was appeared that *Amaranthus lividus*, *Solanum nigrum*, *Conyza sumatrensis* and *Crassocephalum crepidioides* were resistant to paraquat treatment. Susceptible biotypes were also observed at those 4 species. Some of *A. lividus* also showed a tolerance to paraquat. The other tolerance species were *Mazus pumilas*, *Oxalis corymbosa*, *Drymaria cordata*, *Eleusine indica*, *Ageratum coizoides*, *Galinsoga ciliata* and *Rumex conglomeratus*. It was also found that *Cyperus cyperoides* and *Cardamine flexuosa* were completely killed. There was no significant effect of the herbicides on weeds. This fact suggested that the field was having a rainfall just after the herbicides treatment.

Itoh *et al.* (7) reported that *C. crepidioides*, *A. lividus* *C. sumatrensis* were resistant to paraquat and no plants of *C. sumatrensis* was died during paraquat treatment. However, the result of the experiment showed that there was another species resistant to paraquat, that was *S. nigrum*. Some plants of *C. sumatrensis* and *S. nigrum* was also found killed due to paraquat treatment. A result of leaf disk tests which dipped into 10^{-5} M paraquat solution was shown in Table 2. The result suggested that paraquat resistant and susceptible biotypes occurred in the four species.

A number of survived weeds 1 month after herbicides treatment were shown in Table 3. *A. lividus*, *C. crepidioides* and *S. nigrum* were found resistant to paraquat, while the other resistant biotype, *C. sumatrensis* was not found in the field. It appeared that *A. lividus* and *C. crepidioides* could survived even at 4 times of recommended dosage as paraquat treatment. All weeds were completely killed after Glyphosate treatment, but the effect of Glufosinate and 2,4 - D amine treatments were insignificant. It is because only half of the recommended dosage was used during the treatment and sticker was not applied with the chemical. There was also an effect of rain 4 hours after treatment. A tolerance weeds for 2,4 - D amine were *A. lividus*, *O. corymbosa*, *E. indica*, *Poa annua*, *A. conizoides*, *P. major*, *Polygonum* sp., *G. ciliata*, *C. flexuosa* and *Stellaria* sp. Another weeds such as *M. pumilas*, *Panicum repence*, *Sonchus aspen* and *C. cyperoides* were completely died.

C. crepidioides was found in a starfruit area in Tapah and in a citrus area in Bidor, Perak. *C. sumatrensis* was also found in a starfruit field in Tapah and in a garden of village house near Kota Bahru, Kelantan. It suggested that the resistant biotypes might be widely distributed. No experiment have been conducted, but we observed a resistant biotype in *A. conizoides* at a estate of clove tree fields, after 2 - 3 weeks paraquat spray by the farmer in Penang, Malaysia in Nov. 1991. A tea estate located in Puncak, West Java around 100 km from Jakarta, Indonesia. *C. sumatrensis*, *C. crepidioides* and *A. lividus* were predominant in Oct. 1991. These weeds were known paraquat resistant biotypes or not. It is considered that if a more comprehensive survey is achieved, more species with biotypes resistant to paraquat may be found. Future studies on the widely screening of resistant weeds in the tropic are needed.

Table 3 An average number of survived weeds 1 month after herbicides treatment (/m²)

Weeds	P 0.5	P1	P2	P4	Gf	Gs	D	Check
<i>Amaranthus lividus</i>	12.4	0.6	1.0	0.4	9.3	0	5.3	12.0
<i>Crassocephalum crepidioides</i>	5.4	0.2	0.1	0.1	1.3	0	0	4.0
<i>Solanum nigrum</i>	1.3	0	0.04	0	0	0	0	0
<i>Conyza sumatrensis</i>	0	0	0	0	0	0	0	0
<i>Mazus pumilas</i>	0	0	0	0	0	0	0	1.3
<i>Oxalis corymbosa</i>	0	0	0	0	0	0	1.3	9.3
<i>Eleusine indica</i>	0	0	0	0	0	0	1.3	0
<i>Poa annua</i>	0	0	0	0	0	0	5.3	1.3
<i>Ageratum conizoides</i>	0	0	0	0	0	0	1.3	0
<i>Plantago major</i>	0	0	0	0	1.3	0	4.0	2.7
<i>Panicum repence</i>	0	0	0	0	0	0	0	2.7
<i>Polygonum sp.</i>	0	0	0	0	6.7	0	2.7	2.7
<i>Sonchus aspen</i>	0	0	0	0	0	0	0	1.3
<i>Galinsoga ciliata</i>	10.7	0	0	0	2.7	0	2.7	2.7
<i>Rumex conglomeratus</i>	1.4	0.1	0	0	4.0	0	0	1.3
<i>Cyperus cryperoides</i>	0	0	0	0	0	0	0	1.3
<i>Cardamine flexuosa</i>	0	0	0	0	0	0	2.7	1.3
<i>Stellaria sp.</i>	1.3	0	0	0	1.3	0	5.3	1.3

P0.5 : Paraquat at 0.38 kg a.i./ha ; P1 : Paraquat at 0.76 kg a.i./ha;

P2 : Paraquat at 1.52 kg a.i./ha ; P4 : Paraquat at 3.04 kg a.i./ha;

Gf : Glufosinate at 0.255 l a.i./ha ; Gs : Glyphosate at 2.46 l a.i./ha;

D : 2.4 - D amine at 1.02 l a.i./ha

Evidently, the appearance of first resistant plant to paraquat in Japan occurred since 1980 (12). It has been reported that paraquat resistant in *E. philadelphicus* which originated in Japan (5) and *C. bonariensis* which originated in Egypt (11) are conferred by a single dominant gene. Islama and Powlers (4) data obtained from regeneration populations indicated that paraquat resistant in *Hordeum glaucum* (barley grass) is controlled by a single nuclear gene with incomplete dominance, it is imagined that these 4 species may be controlled by a single gene. Future studies on the inheritance and competitive ability of two biotype are required to determine their genetic characteristics (6).

In a field infested with resistant biotypes of *S. nigrum*, *C. crepidioides*, *A. lividus* and *C. sumatrensis*, it is recommended that other herbicides should be applied or a change in control method introduced to overcome the weed menace.

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