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Distribution, Habitats, Seed Germination and Ecological Characters of Wild Rice *Oryza perennis* and its Response to Herbicides

By the cooperative research work between Thailand and Japan, under the National Weed Science Research Institute (NWSRI) Project of Japan International Cooperation Agency (JICA)

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PREFACE

The National Weed Science Research Institute (hereinafter referred to as NWSRI) Project by the Japan International Cooperation Agency (hereinafter referred to as JICA) had started on April 18th, 1980, under the Record of Discussions between Thai and Japanese Government. The purposes of this Project were to supply machinery and equipments for research, to train Thai researchers in Japan and to conduct the cooperative research works by JICA experts and Thai counterparts for developing weed science research in a broad sense. The site of the Project is located at the Weed Science and Weed Control Branches, Botany and Weed Science Division (formerly, Weed Science Branch of Technical Division), Department of Agriculture, Ministry of Agriculture and Cooperatives, Royal Thai Government, at Bangkhen, Bangkok 10900.

The first author, Hiroshi HYAKUTAKE, was dispatched from Japan to Thailand on December 25th, 1980 as the long-term expert on weed control, and stayed there three years and three months until March 31st, 1984. During his term as the expert, he was assigned to conduct the cooperative research work on weedy wild rice with Thai counterparts since the invasion of weedy wild rice into paddy fields, especially in deepwater rice and direct seeding rice areas, have been offering serious problems to farmers in these areas. So far several Thai and Japanese researchers have investigated on geographical distribution and habitats of wild rice in Thailand mainly from the point of ecological-genetic studies. Our investigations were centered on the ecological characteristics of weedy wild rice in comparison with cultivated rice in order to obtain basic informations for the effective control of weedy wild rice.

We investigated geographical distribution, habitats, ecological characteristics of wild rice, Oryza perennis, and its differential response to herbicides in comparison with cultivated rice mainly from the standpoint of employing effective control measures. Although the researches we have conducted are not complete, rather we have come to know the many problems which must be the subject of future research. Further studies to elucidate these matters would need to be conducted on a much larger scale using field experiment.

We would be very happy if these results of research work would help and contribute to the effective control of weedy wild rice.

March 31st, 1984

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I. GENERAL INTRODUCTION

In Thailand, weedy type of wild rice has been infesting rice fields especially in deepwater rice and lowland rice areas, where rice cultivations are mainly practiced by direct broadcasting on dry soil. In these areas, farmers generally broadcast seed on dry soil after the first plowing in March or April (34) (45). With coming of rain, wild rice of which dormancy has been broken start to emerge at the same time with cultivated rice, offering serious competition from the beginning of their initial growth.

Thus, the infestations of wild rice reduce yield of cultivated rice by competing for light, nutrients and space, lower the grade of rice due to the presence of red grains (7) (9).

Another problem posed by wild rice is natural hybridization, through which wild rice absorbs, more or less, genes from cultivated rice (26), and disperses the seed for ensuring the continuity of the species (5). Therefore, weedy types of wild rice are considered to be hybrids between the wild and cultivated rice (25).

From the above-mentioned facts, the infestations of weedy types of wild rice into paddy field have been causing serious problems in the direct seeding rice areas of Thailand. There have been the worst cases at Ongkharak, Nakhon Nayok, where several farmers had to abondon rice culture due to the highly infestations of wild rice.

Our studies were focused mainly on the ecological aspects of weedy types of wild rice in relation to control since NWSRI Project is carrying out weed science in a broad sense.

The present studies were first undertaken to investigate distribution and habitats of wild rice in Thailand. Then, based on degrees of infestations of wild rice in paddy field, the seeds or seedlings of several different weedy types of wild rice were collected, and they were grown in the net house of NWSRI Project for further investigations on ecological aspects such as seed germination, emergence patterns, growing processes from germination to maturity. Effects of several herbicides and antidote for the control of wild rice were also examined to consider the feasibility of chemical control of wild rice.

II. DISTRIBUTION AND HABITATS OF WILD RICE IN THAILAND ------- IN RELATION TO CULTIVATION METHOD -------

Hiroshi HYAKUTAKE, Prasan VONGSAROJ, Chaiyot SUPATANAKUL and Siriporn ZUNGSONTIPORN

1. Introduction

Wild rice species as weed are causing great concerns in the direct seeding rice areas, especially in deepwater rice areas in Thailand. The areas are several Provinces of Central, Northern, and Southern Regions. In these areas, rice culture is being practised by direct broadcasting on dry soils after the first ploughing in March to April (45). With coming of rain, wild rice seeds which had shattered in previous crop start to germinate almost at the same time with cultivated rice, offering serious competition from the beginning of their initial growth. Thus, the infestation of weedy types of wild rice reduce the yield of cultivated rice, lower the grade of rice due to the presence of wild rice and cause hybridization (9).

Akihama and Watabe (1) investigated geographical distribution of wild rices, Oryza sativa f. spontanea and O. perennis in Thailand and concluded that the suitable area for rice cultivation might be judged from the distribution of the wild rices since the cultivated rice grows well in the areas. On the other hand, Oka and chang (30), Sano et al. (35), Morishima et al (25) and Morishima et al. (26) investigated the distribution of wild rice and hybrid swarms between wild and cultivated rice species, Oryza perennis and O. sativa in Thailand, referring to their evolutionary significance. These researches were conducted mainly from the point of evolutionary genetics.

Our present investigations were focused on finding geograhical distribution of weedy wild rice in Thailand and to find some relationships between rice cultivation method and degree of invasion of weedy types of wild rice into paddy field.

The taxonomy of wild rice species is confused and controversial because of their rich variations (25), (33). In this report, we followed the taxon designated by Morishima et al. (25), which classify the Asian form of O. perennis into perennial, intermediate, annual, and weedy types which might have been derived from hybrids between the wild and cultivated plants.

2. Methods

Distribution and habitats of wild rice were surveyed from October 1981 to December 1983. The investigations were chiefly made along the main road by which we travelled by car, in some occasions we stepped down into the lower parts of the field. At each site, records were taken on location, characteristics of wild rice, degree of infestation and main rice cultivation method.

For the site of Sing Buri (road mark 125), Saraburi (roadside) and Saraburi (army camp), wild rice were observed continuously for two years and the seeds were collected every year for further experiment, the results of which were shown in chapter V in this report.

Investigation trip was made as follows :

Northern Region :

Kamphaeng Phet, Sukhothai	Nov. 26, 1981
Phitsanulok	Aug. 10, 1982
Nakhon Sawan, Phitsanulok, Uttaradit, Phrae, Lampang, Chiang Mai, Tak	Jan 10~15, 1983

North-Eastern Region :

Nakhon Ratchasima, Buri Ram, Surin, Si Sa Ket, Mukdahan, Nakhon Phanom, Sakon Nakhon, Udon Thani, Ubon Ratchathani, Nong Khai, Khon Kaen — Aug. 30 ~ Sept. 3, 1982

Central Plain Region :

Chainat	June 17, Dec. 9, 1982
Nakhon Nayok	Oct. 29, Dec. 8, Dec. 15, 1981, June 3, 1982
Prachin Buri	Oct. 8, 1981, Dec. 17, 1982
Ayutthaya	Jan. 8, 1982, Jan. 7, July 5, Nov. 22, 1983
Saraburi	Oct. 7, Oct. 14, 1982, Oct. 13, Nov. 1, 1983
Sing Buri	Nov. 26, 1981, Dec. 23, 1982, July 12, Oct. 13, Nov. 23, Dec. 21, 1983.

Southern Region:

Chumpon, Nakhon Si Thammarat, Pattani, Phatthalung, Songkhla, Surat Thani — Jan. 18 ~ 20, 1982; March 1 ~ 3, 1983

3. Results and discussion

Geographical distribution of wild rice in Thailand were surveyed covering almost all the Provinces and the results were shown in figure II-1. Provinces of heavy distribution of weedy types of wild rice in paddy field were Nakhon Sawan, Phichit and Phitsanulok in Northern Region, Nokhon Nayok, Prachin Buri, Ayutthaya and Sing Buri in Central Plain Region, Nakhon Si-Thammarat and Songkhla in Southern Region. Provinces of moderate distribution were underlined in figure II-1, where wild rice does not cause serious problems. To survey more precisely, main rice cultivation method and habitats of wild rice were investigated, and the results were shown in table II-1. During our investigation trip, weedy types of wild rice were mostly found in direct-seeded rice field under dry condition, and were rarely found in transplanted rice field.

Infestation of weedy types of wild rice and rice cultivation method were closely related, indicating that a thorough preparations of land such as plowing, harrowing and puddling were indispensable work to prevent emergence of wild rice seeds or regenerative ability of rhizome. In transplanted rice field, these land preparations were practiced everywhere and the seeds of wild rice were rarely able to emerge as discussed in chapter IV, and they were unable to catch up with cultivated rice even if they were able to emerge.

Whereas in direct-seeding rice areas, at the beginning of the rainy season, the seeds of rice are generally broadcast on dry soil, where land preparation was not so thorough as in transplanted rice, and they emerge together with wild rice, allowing the competition from their intial growth stage. These differences in cultural practice in transplanted and direct-seeding fields are considered to be the main factor which permits invasion of weedy wild rice.

Heading date of weedy types of wild rice in Nakhon Nayok, Prachin Buri, Ayutthaya, Sing Buri, Nakhon Si Thammarat and Songkhla were earlier than those of cultivated rice growing in the same field. However, the heading time of the weedy types of wild rice are generally extended longer, thus offering overlapping period in heading with cultivated rice and in one instance causes natural hybridization as reported in (25) (26) (30) (31). Among the weedy types of wild rice, the one invated into deepwater rice field at road mark 125, Sing Buri was the most serious wild rice showing the characteristics of intermediate perennial-annual type reported by Sano et al. (35), and many ratoons were observed in paddy field during dry season. Regeneration from these ratoons were extremely rapid and far advanced than direct-seeded rice in terms of growth stage when the fields were rain-fed.

On the other hand, heading time of wild rices which were observed in roadside canal at Buri Ram, Sakhon Nakhon and Saraburi were extremely earlier than those of cultivated rice in adjacent fields, there existed no possibilities of natural hybridization and these wild rice were found to be annual types.

Unlike the weedy type of wild rice in Sing Buri, these wild rice growingin roadside canal seemed to possess of different characteristics, and the further research on life-cycle is required in comparison with a perennial type of wild rice.

Summary

Geographical distribution and habitats of wild rice in Thailand were investigated with special emphasis on cultivation method. Weedy types of wild rice were found to be invaded in the direct-seeding rice areas of *Phitsanulok, Phichit, Nakhon Sawan, Sing Buri, Ayutthaya, Nakhon Nayok,* Prachin Buri. Nakhon Si Thammarat and Songkhla Provinces.

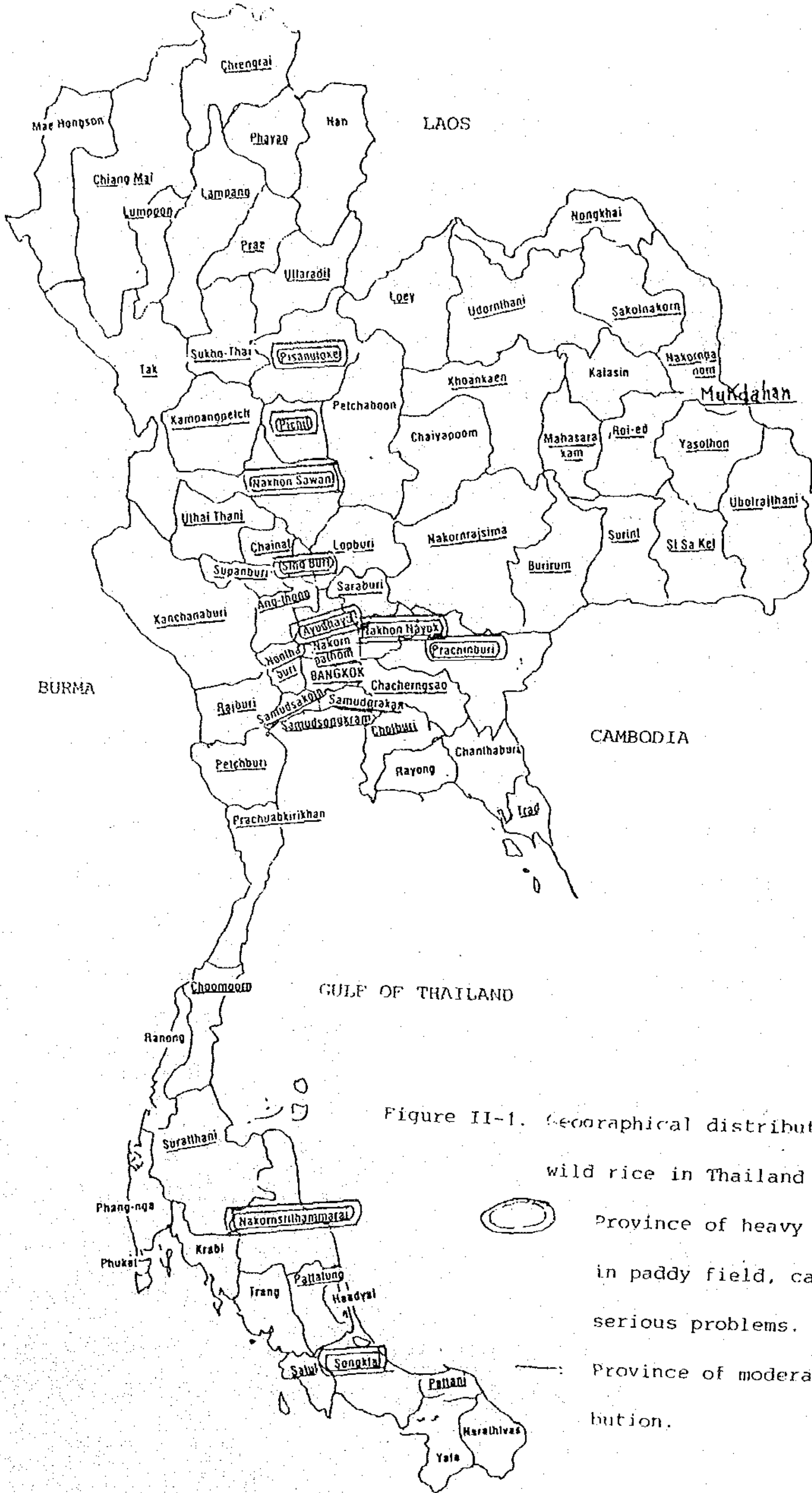

Figure II-1. Geographical distribution of wild rice in Thailand (1981~1984).

(oval): Province of heavy distribution in paddy field, causing serious problems.

——: Province of moderate distribution.

Table II-1 Main rice cultivation method and habitas of wild rice in Thailand (1981-1983)

Region	Province	*Main rice cultivation method	** Habitats
Northern	Kamphaeng Phet	1, 2B	2,4,5,6,7,8
	Chiang Rai	1, 2C	5
	Chiang Mai	1, 2C	5,4,8
	Tak	1, 2C	5
	Nakhon Sawan	1, 2B	2,5,7,8,9
	Payao	1, 2C	5,9
	Phrae	1, 2C	5
	Phichit	2B, 2A	1,5,6
	Phitsanulok	1, 2A, 2B, 2D, 2C	2,5,6,7,8
	Lampang	1, 2C	5
	Lamphun	1, 2C	5,2,8
	Sukhothai	1, 2B	2,5,7,8
	Uttaradit	1, 2C	5
	Uthai Thani	1, 2B	2,5,7,8
North-Eastern	Khon Kaen	1, 2B	5
	Nakhon Phanom	1, 2B	7,8
	Mukdahan	1, 2B	5,7,8
	Nakhon Ratchasima	1, 2B	5,8
	Buri Ram	1, 2B	5,8,9
	Maha Sarakham	1	8
	Yasothon	1, 2B	5
	Roi Et	1, 2B	5
	Loei	1, 2D	8
	Si Sa Ket	1	8
	Sakon Nakhon	1	7,8,5,9
	Surin	1, 2B	5
	Nong Khai	1, 2B	5
	Udon Thani	1, 2B	5
	Ubon Ratchathani	1, 2B	5

Region	Province	*Main rice cultivation method	** Habitats
Central Plain	Bangkok	1, 2D 2B	5,4
	Kanchanabri	1, 2B	5
	Chachoengsao	2D, 1, 2B	5,7,8
	Chai Nat	1, 2D, 2B	2,5,7,8
	Chon Buri	1, 2B	5
	Trat	1	8
	Nakhon Nayok	2A, 1	2,6,7,5,8
	Nakhon Pathom	1, 2B, 2D	5
	Pathum Thani	1, 2B, 2D	1,5,6
	Nonthaburi	1, 2D	5,7,8
	Prachin Buri	2A, 2B, 2C	1,5,6,7,8
	Prachuap Khiri Khan	1	8
	Ayutthaya	2A, 2B, 1	2,5,6,7,8
	Phetchaburi	1, 2B, 2D,2C	5,7,8
	Ratchaburi	1, 2B, 2A, 2C	1,2,5,7,8
	Lop Buri	2B, 2A, 1, 2C	1,2,5,7,8
	Samut Prakan	1	5
	Samut Sakhon	1, 2D, 2B	5
	Samut Songkhram	1, 2D, 2B	5
	Saraburi	1, 2B, 2D	4,5,7
	Sing Buri	2B, 2A, 1, 2D	2,5,6,7,8
	Suphan Buri	2D, 1, 2A, 2B	5
	Ang Thong	2B, 1, 2D	2,7,8,6
Southern	Chumphon	1, 2C	2,5,7,8
	Nakhon Si Thammarat	2B, 1	2,5,7,8
	Pattani	1, 2B, 2C	2,5
	Phatthalung	1, 2B, 2C	2,5,7,8
	Songkhla	2B, 1, 2A, 2C	2,5,7,8,9
	Satun	1	2
	Surat Thani	1, 2B, 2c	2,5,7,8

Note. * Main rice cultivation method

1. Transplanted
2. Direct seeding :
   A. under dry condition (Deepwater rice)
   B. under dry condition (Lowland rice)
   C. under dry condition (Upland rice)
   D. under wet condition (Pre-germinated direct-seeded rice)

** Habitats

1. Deepwater paddy field
2. Lowland paddy field
3. Upland rice field
4. Abondoned field
5. Roadside canal or ditch (with shallow water)
6. Roadside canal or ditch (with deep water)
7. Marsh
8. Swamp
9. Lake

III. NATURE OF SEED GERMINATION AND EFFECTS OF HIGH TEMPERATURE ON DORMANCY BREAKING IN WILD RICE (*Oryza perennis*)

Hiroshi HYAKUTAKE and Siriporn ZONGSONTIPORN

1. Introduction

Wild rice, both an annual and a perennial species, is a problem weed in the production of rice in the direct-seeding areas in Thailand. Control measures include deep ploughing, burning stumps and shifting from direct-seeding to transplanting method with combination of herbicide application. Among them, deep ploughing and shifting to transplanting method are satisfactory means for the control of wild rice (45).

Seeds of wild rice shatter readily at maturity and they have seed dormancy, enabling survival for extended periods under unfavorable conditions (9).

Several studies were conducted on the nature of seed dormancy of wild rice (24) (37) (32) and cultivated rice (18). The objective of this study was to determine proper conditions in the environment for breaking dormancy in wild rice collected from several Provinces in Thailand, in comparison with a cultivated rice.

2. Materials and methods

Mature wild rice were field harvested at the site of National Weed Science Research Institute Project in 1981, 1982, and 1983. Seeds were harvested randomly from individual plots by hand-shattering.

For high temperature treatment at 50°C, the seed samples were placed in the oven for respective periods and for temperature treatment at 20°C, 30°C and 40°C, the seeds samples were placed in the incubators.

Germination tests were routinely performed at 30°C for 10 days in darkness with 4 replications of 20 seeds each. Oxygen uptake was determined at 30°C by the conventional Warburg method reported by Umbreit et al. (43).

3. Results and discusions

Effect of high temperature on dormancy breaking of wild rice seeds was shown in table III-1. Wild rice species No. 1 to 11 differed markedly in their characteristics of awning, panicle shattering and nodal color indicating an intermating and introgressive hybridization (15)(25), although they were collected in the same areas of Nakhon Nayok. All the seeds of wild rice were found to be dormant, and as the high temperature treatment prolonged, germination percentage was raised up to 82 per cent at the highest. Seeds of wild rice were generally in deep dormancy compared with a cultivated rice, which reached 100 in germination percentage in 6 days. Species No. 6,7 and 10 were observed to possess the traits of cultivated rice in awning, panicle shattering and nodal color, and as the result of these nature, germination percentage were condsidered to become much higher than other species.

Effect of the duration of heating on germination of wild rice which were collected from different locations was investigated and the results were shown in figure III-1. Seed of wild rice from Sing Buri showed the highest response to heating treatment, among five different seeds sources, but not to 100 per cent level within 8 days. Since the seeds of wild rice from Nakhon Nayok No. 1 and No. 11 showed 87 and 95 percent in germination without heating, the effect of the duration of heating was achieved a little, whereas the seeds from Prachin Buri and Nakhon Nayok responded poorly to heating treatment, partly due to a physiological state of the embryo and endosperm as reported by Takahashi (41). Factors governing sugar utilization by the embryo and the mobility of sugar from the endosperm to the embryo after heat treatment should be investigated to elucidate a mechanism of seed dormancy in wild rice.

Table III-3 shows the effect of various days of heating at 50°C on breaking dormancy of wild rice seeds collected at several Provinces. Wild rice seeds from Rajburi and Sing Buri could readily be broken their dormancy, whereas the seeds from Nakhqn Si Thammarat required longer period of heat treatment for germination, indicating a different nature of dormancy from other seeds. Wild rice seeds from Chianyai and Saraburi were shown to be medium in their degree of dormancy. The cultivated rice, Lep Mue Nahng 111 showed the highest germination, followed by the seeds from Rajburi, which was considered to have absorbed more genes from cultivated rice through natural hybridization. Although dormancy could be broken in all the seeds tested by heat treatment at 50°C, seeds from Nakhon Si Thammarat and Saraburi (roadside) required additional time of heat treatment for increasing germination.

Seed of wild rice shatters readily at maturity and it has seed dormancy, enabling survival for extended periods under unfavorable conditions (9). Seeds of three different types of wild rice, O. perennis, perennial-annual intermediate type, from deepwater paddy field in Sing Buri, O. perennis, annual type, from abonedoned field in Saraburi and O. perennis,annual type, from lowland paddy field in Nakhon Si Thammarat were used for the experiment on temperature versus storage conditions. Under the natural environmental conditions, shattered seeds of wild rice are considered to be remained under different soil moisture levels and temperatures. According to climatological data of Thailand (23), the mean maximum temperature of the period 1951~1980 at Don Muang meteorological station located close to the site of National Weed Science Research Institute Project was recorded 32.7°C. Based on this data, the temperature ranges were set for 20°C, 30°C, 40°C and 50°C for the experiment. For storage conditions, seeds were administered in a Petri dish for dry, seeds were wrapped up with moist filter paper and were kept in a Petri dish for moist and seeds were sunk in distilled water, replacing every other day, for submerged conditions, respectively. The results were shown in table III-4. Dry condition was found to be influential in breaking dormancy of wild rice seeds regardless of temperature range, whereas moist condition was unfavourable for it. Submerged condition under 20°C or 30°C in temperature for the seeds from Nakhon Si Thammarat proved to be effective but not under 40°C and 50°C in temperature. These results would suggest that in the natural environment seeds fall to the dry soil and then pass through high temperature possess higher rate of germination or emergence in the following season for the continuity of the species as well as an adaptation to habitat.

Table III-2 shows effect of dry heat treatment on oxygen uptake andgermination of Oryza perennis. There were little difference in oxygen uptake of seeds following heating up to 0,1,2 and 4 days. Heat treatment for 8 days stimulated oxygen uptake about 20% and it raised germination perecentage slightly. Since dry heat treatment in this test was less effective on breaking dormancy, it would be impossible to discuss oxygen uptake and germination percentage.

Time course of oxygen uptake of heated and non-heated wild rice seeds is shown in figure III-2. Heated seeds exhibited a tendency to consume more oxygen than non-heated ones especially harvested in previous year, indicating acceleration of subsequent germination. This evidence is shown in figure III-3. Effect of heat treatment on oxygen uptake was much higher in freshly harvested panicles when they were soaked for 72 hours. In this experiment, only the oxygen uptake was measured and it was accelerated by heat treatment, suggesting a possible general relationship between initial respiration rates and subsequent seedling growth as reported by Woodstock (50).

Summary

Effect of heat treatment on dormancy breaking of wild rice seeds was conducted. All the seeds of wild rice were found to be dormant and as heat treatment prolonged, germination percentage was raised. Wild rice seeds from Rajburi and Sing Buri could readily be broken their dormancy, whereas the seeds from Nakhon Si Thammarat required longer period of heat treatment for germination. Wild rice seeds from Chianyai and Saraburi were shown to be medium in their degree of dormancy and ones from Rajburi, which was considered to have absorbed genes from cultivated rice through natural hybridization, showed higher germination rate.

Dry condition was found to be influential in breaking dormancy of wild rice seeds regardless of temperature range, whereas moist condition was unfavourable for it. Submerged condition under 20°C or 30°C in temperature for certain seeds proved to be effective but not under 40°C and 50°C in temperature.

The oxygen uptake of dormant seeds was stimulated following heat treatment.

Table III-1 . Effect of high temperature on dormancy breaking of wild rice seeds (1981).

Species No.	Germination (%)			
	Without treatment	high temperature treatment at 50°C		
		1 day	3 days	6 days
1	0	4	25	45
2	0	19	32	39
3	0	0	15	34
4	0	9	10	42
5	0	0	2	2
6	0	25	55	82
7	1	27	65	79
8	0	2	15	40
9	0	0	3	12
10	0	5	38	77
11	0	7	18	39
Cultivated Var.	2	55	85	100

Note. Freshly harvested panicles were used for high temperature treatment and germination test was routinely performed at 30°C for 10 days.

species No.	Awn	Shattering	Nodal Color	Collected at
1.	awned	tight	red	Nakorn Nayok
2.	awned, long	tight?	red	Nakorn Nayok
3.	awned, red	tight	green	Prachin Buri
4.	awned	tight	green	Nakorn Nayok
5.	awned	shattering	green	Nakorn Nayok
6.	awned	tight	green	Nakorn Nayok
7.	awned, short	tight	green	Nakorn Nayok
8.	awnless	tight	red	Nakorn Nayok
9.	awnless	shattering	green	Nakorn Nayok
10.	awnless	shattering?	green	Nakorn Nayok
11.	awnless	shattering	green	Nakorn Nayok

Cultivated var. : Lep Mue Nahng 111.

Table III-2 . Effect of dry heat treatment on oxygen uptake and germination of Oryza perennis (1982).

Dry heat treatment (days)	Oxygen uptake (µl/g dry wt./hr.)	Germination percentage (%)	
		A	B
0	37.2 (100)	0	3
1	31.7 (85)	3	8
2	38.8 (104)	5	13
4	37.7 (101)	5	13
8	44.3 (119)	10	10

Note. 1. The seeds of wild rice were collected on October 14, 1982 and dry heat treatment was initiated under the temperature of 50°C in the oven on November 9, 1982, ending November 17, followed by germination test.

2. Germination test was conducted for A without soaking and for B with soking 24 hrs. prior to the start of the test.

Table III-3 . Percentage germination following heat treatment in wild and cultivated rice (1984).

Rice spp. collected at \ day	% germ. after various days of heating at 50°c.								Mean germination
	1	3	7	12	15	18	25	39	
Sing Buri	3	49	66	85	92	91	100	92	72
Saraburi (roadside)	0	29	11	26	44	49	90	86	42
Rajburi	0	17	75	97	97	100	100	100	73
Nakhon Si Thammarat	0	0	1	3	4	22	23	97	19
Chianyai	0	14	16	56	73	79	97	91	53
Lep Mue Nahng 111 (cultivated rice)	3	83	95	96	99	100	100	100	85

Note. Freshly harvested panicles were used for high temperature treatment and germination test was routinely performed at 30°C for 10 days.

Table III-4 Percentage germination following heating at various temperatures under dry, moist and submerged conditions for 2 to 42 days (1984).

Rice spp. collected at	Temperature / Days treated / Conditions	20°c							30°c							40°c							50°c						
		2	7	15	21	28	35	42	2	7	15	21	28	35	42	2	7	15	21	28	35	42	2	7	15	21	28	35	42
	D	0	30	67	42	33	70	60	0	73	65	80	45	39	60	0	20	25	75	0	65	90	0	90	90	88	80	0	100
Sing Buri	M	0	8	3	0	0	0	0	6	1	27	0	0	0	0	5	5	12	5	0	0	0	0	0	0	0	1	0	0
	S	55	55	22	83	10	0	0	0	41	0	0	0	0	0	0	16	33	12	5	0	0	0	0	0	0	0	0	0
	D	0	86	90	85	85	90	76	0	94	91	90	95	50	70	0	83	100	89	90	20	89	0	75	65	95	80	0	80
Saraburi	M	0	16	35	0	0	0	3	6	40	0	0	0	7	1	0	7	5	0	0	1	0	0	0	0	0	0	0	0
(roadside)	S	0	29	10	0	16	5	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Nakhon Si	D	0	100	85	90	89	84	85	0	95	90	94	80	55	35	0	97	70	95	85	100	85	0	100	67	74	40	0	35
Thammarat	M	0	46	4	0	0	0	0	31	36	8	1	0	0	0	7	14	21	0	0	3	4	0	0	0	0	0	0	0
	S	0	95	100	100	15	0	5	0	93	89	85	35	11	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0
Lep Mue Nahng	D	0	77	0	90	95	80	75	0	97	86	85	90	70	100	0	77	93	89	80	35	81	10	81	78	67	0	33	0
111	M	0	60	0	0	0	0	0	68	92	0	20	0	0	0	18	33	21	0	0	0	0	0	0	0	0	0	0	0
(cultivated rice)	S	0	90	75	80	80	50	65	0	73	45	20	25	11	0	0	0	0	0	0	0	0	0	43	0	0	0	0	0

Percentage germination (%)

Note. D,M and S stand for dry, moist and submerged conditions, respectively, under which the rice seeds were administered.

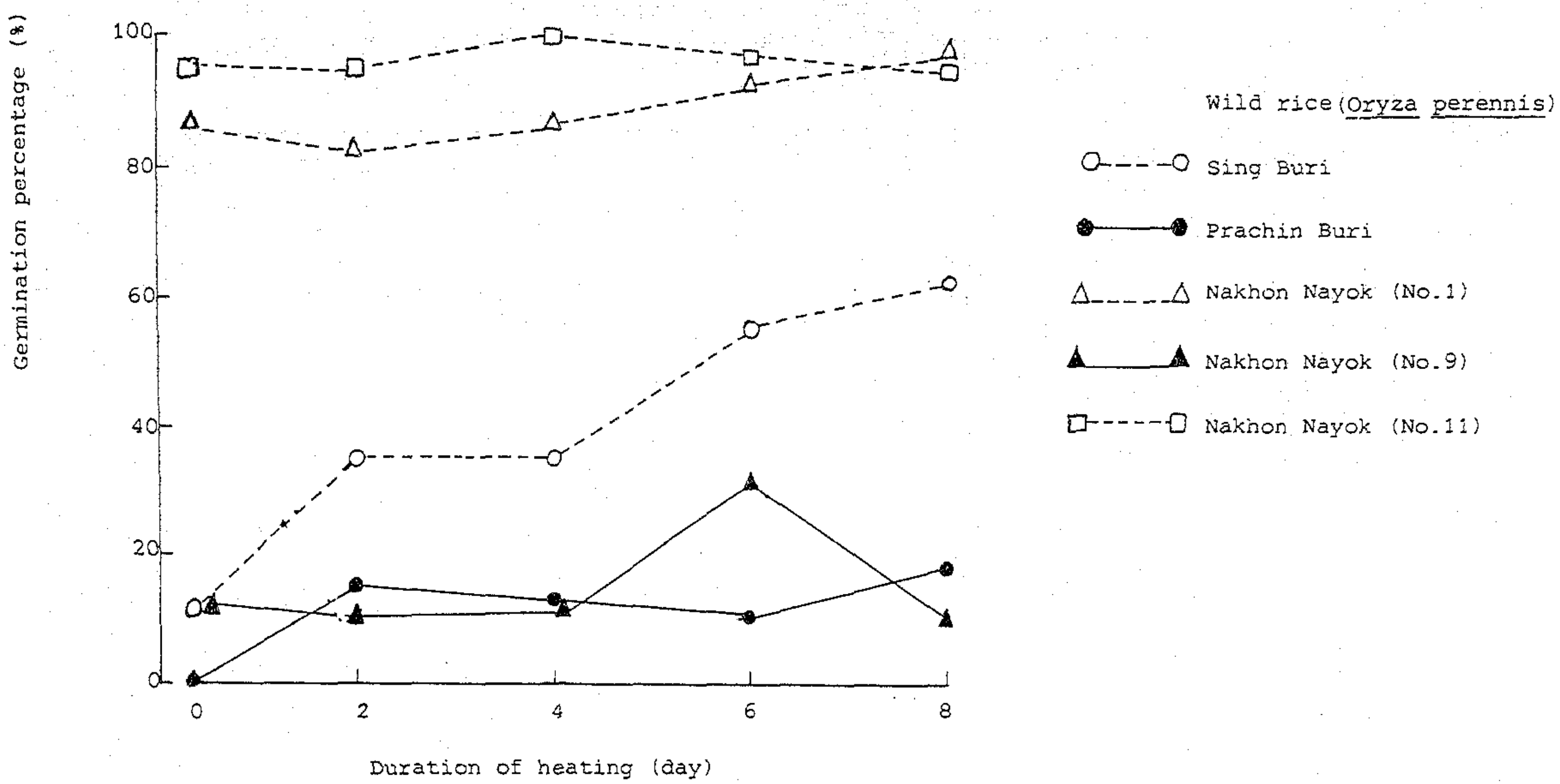

Fig. III-1 Effect of the duration of heating on germination of wild rice (1983).

Note. Seeds of wild rice were heated at 50°C in temperature.

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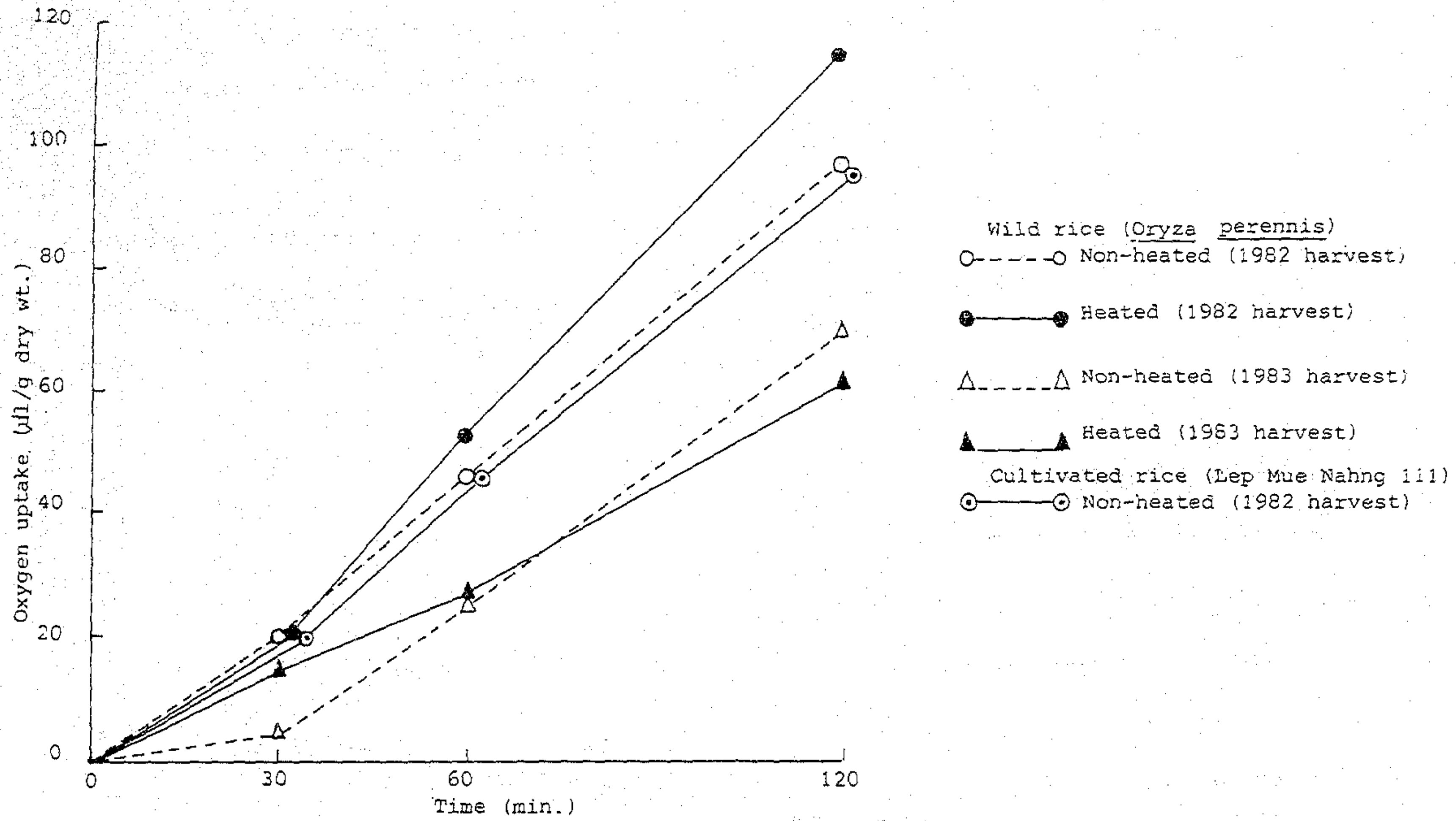

Fig. III-2 Effect of heat treatment on oxygen uptake by seeds of cultivated rice (Lep Mue Nahng 111) and wild rice (*Oryza perennis*) (1983).

Note : The seeds were soaked for 48 hours prior to the measurement of oxygen uptake.

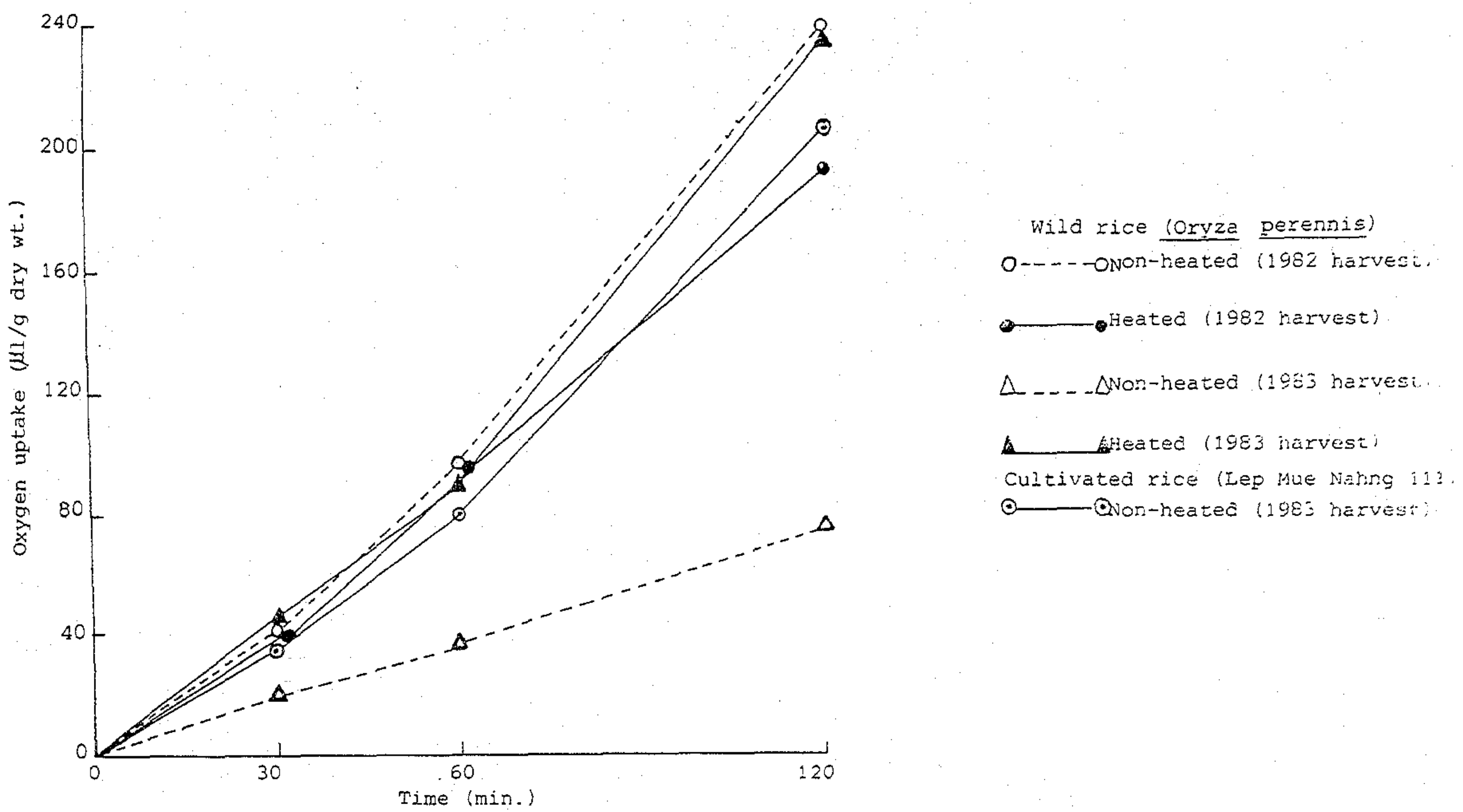

Fig. III-3 Effect of heat treatment on oxygen uptake by seeds of cultivated and wild rice (1983).

Note. The seeds were soaked for 72 hours prior to the measurement of oxygen uptake.

IV. EFFECT OF SEEDING DEPTH AND SOIL WATER REGIMES ON EMERGENCE OF WILD AND CULTIVATED RICE SEEDLING

Hiroshi HYAKUTAKE and Siriporn ZUNGSONTIPORN

1. Introduction

It has been reported that land preparation is very important for weed control, and two to three plowings before seeding reduce the number of weeds (45). Another experiment revealed that three ploughings were slightly more effective than two ploughings in reducing the number of wild rice plants (34). These results would suggest that seeds of wild rice ploughed into deep soil layer were unable to emerge, thus reduce the number of wild rice in paddy field.

The present study was undertaken to find some effect of varying sowing depths and water regimes on emergence of wild and cultivated rice.

2. Material and method

Experiment 1. (Table IV-1)

Seeds of wild and cultivated rice collected at Nakhon Nayok and partly at Prachin Buri were buried to the depth of 5 mm from soil surface in 1/10,000a pot. Water regimes were maintained for moist, saturated and submerged by watering lower than soil surface level, up to soil surface level and submerged to 1 cm, respectively. Number of emerged seedlings was counted 10 days after sowing.

Experiment 2 (Table IV-2 and Table IV-3)

Seeds of wild rice (O. perennis) and cultivated rice (Lep Mue Nahng 111, Indica type and Nihonbare, Japonica type) were buried to the depth of 1,3,5 and 7 cm from soil surface in 1/10,000a pot and soil water regimed were maintained for moist, saturated and submerged by the same method described in Experiment 1. Percent of emergence was traced 5,10 and 20 days after seeding. Unemerged rice seeds in submerged regime were recovered from soil and were placed in petri dish for germination test under aerobic condition.

Experiment 3 (Table IV-4)

Seeds of wild rice (O. perennis) and cultivated rice (Lep Mue Nahng 111, Indica type and Nihonbare, Japonica type) were buried to the depth of 1,4 and 7 cm from soil surface in 1/10,000a pot and soil water contents were maintaned at 25,50 and 100 % by weight basis. Percent of emergence was investigated 5,10 and 20 days after seeding.

Mesocotyl development of wild rice, cultivated rice and gramineous weeds were investigated by incubating the seeds of test plant in petri dish and in soil at 1,4 and 7 cm depth of sowing.

3. Result and discussion

Both wild and cultivated rice rarely emereged under submerged condition, and there was a tendency that moist condition was more favourable for emergence of rice species tested than saturated one (Table IV-1). Since the rate of emergence was generally low in this experiment, it would be rather difficult to make conclusion on the result obtained. However, it can be safely said that an aerobic condition would allow a higher rate of emergence of wild rice.

Table IV-2 shows the effects of seeding depths under different soil water regimes on emergence of rice seedlings. The emergence rate of O. perennis from deeper soil layer was comparatively lower than two types of cultivated rice, Lep Mue Nahng 111 (Indica type) and Nihonbare (Japonica type), under the moist and saturated soil water regimes. Under submerged condition, rate of emergence in O. perennis was zero throughtout 1,3,5 and 7 cm depth of seeding, whereas

Lep Mue Nahng 111 and Nihonbare were 4 and 25 percent at 1cm depth of seeding, respectively, and at 3,5 and 7 cm depth of seeding, no emergence was observed. The ability of emergence from deep layer in soil were on the whole in order of Nibonbare, Lep Mue Nahng 111 and O. perennis. O. perennis, however, possessed a potential germinating activity under aerobic condition as shown in table IV-3. When unemerged seeds were recovered from soil and were placed in petri dish under the temperature of 30°C, germination rate of O. perennis was extremely higher than Nihonbare and Lep Mue Nahng 111. These results indicated that seed of O. perennis was able to survive at least up to 7 cm depth in soil and able to emerge when submerged condition was changed to saturated or moist ones.

Effects of seeding depths under different soil water contents on emergence of rice seedlings was shown in table IV-4. At 50% in soil water content, percent of emergence of three rice species was comparatively high, whereas at 100% in soil water content, percent of emergence in three rice species were reduced greatly as seeding depth became deeper and no emergence were observed at 7 cm depth of seeding. On the other hand, at 25% in soil water content, percent of emergence was unexpectedly low in spite of more aerobic condition than 50% and 100% plots. The reason was not clear but it was conceivable that at deeper soil layer, soil water content was not uniform since a little amount of water was applied through soil surface.

Mesocotyl development of rice and gramineous weeds were investigated and the result was shown in table IV-5. Mesocotyl development may serve as index of seedling vigor during emergence (3). Gramineous weeds developed their mesocotyls much longer than rice species, and Lep Mue Nahng 111 generally developed the longest mesocotyl among rice species. The similar results were obtained in soil layer as shown in table IV-6. Mesocotyl was developed longer as a seeding depth increased and the degree of mesocotyl development was in order of Lep Mue Nahng, O. perennis and Nihonbare. Mesocotyle develpoment, however, did not elucidate a high ability of emergence from deep layer in soil since Nihonbare, whose development of mesocotyl was short, revealed a similar rate of emergence from deep soil layer. Further studies will be required on relation between development of mesocotyl and emergence rate from various soil depth.

Summary

The effects of seeding depths under different soil water regimes on emergence of rice seedlings were investigated. The emergence rate of O. perennis from deeper soil layer was comparatively lower than Lep Mue Nahng 111 (Indica type) and Nihonbare (Japonica type), under the moist and saturated soil water regimes.

The ability of emergence from deep layer in soil were on the whole in order of Nihonbare, Lep Mue Nahng 111 and O. perennis. Seed of O. perennis was able to survive at least up to 7 cm depth in soil and able to emerge when submerged condition was changed to saturated or moist states.

Mesocotyl development was investigated in connection with seeding depth and soil water content, and the result was in order of Lep Mue Nahng, O. perennis and Nihonbare.

Table IV-1. Effect of soil water regimes on emergence of wild and cultivated rice (1981).

Rice species No.	Emergence (%)		
	Moist	Saturated	Submerged to 1 cm
1	2	0	2
2	17	13	5
3	3	2	0
4	3	3	0
5	0	0	0
6	13	20	0
7	25	15	3
8	2	3	0
9	0	0	0
10	25	18	0
11	5	0	2
12	32	17	0

1) Seeds of wild and cultivated rice were buried to the depth of 5 mm from soil surface. Water regimes were maintained for moist, saturated and submerged by watering lower than soil surface level, up to soil surface level and submerged to 1 cm, respectively.

2) Rice species

No.	Awing	Panicle shattering	Nodal septum
1.	awned	low	pink
2.	long awned	moderate	pink
3.	awned	low	green
4.	awned	low	green
5.	awned	high	green
6.	awned	low	green
7.	short awned	low	green
8.	absent	low	pink
9.	absent	loose	green
10.	absent	moderate	green
11.	absent	loose	green

12. Cultivated rice (local variety from Nakhon Nayok)

3) All the seeds of rice species were collected at Nakhon Nayok except No. 3, which was collected at Prachin Buri.

Table IV-2. Effects of seeding depths under different soil water regimes on emergence of rice seedlings (1982).

Soil water regimes	Days after seeding / Seeding depth (cm) / Rice	Lep Mue Nahng 111 (Indica type) 5	10	20	*O. perennis* (wild rice) 5	10	20	Nihonbare (Japonica type) 5	10	20
Moist*	1	49	65	89	45	66	90	82	92	99
	3	47	81	100	16	68	86	25	80	94
	5	23	86	100	0	65	90	0	64	99
	7	0	46	77	0	4	47	0	0	60
Saturated**	1	37	49	72	25	70	81	69	89	96
	3	37	44	77	5	47	74	14	55	89
	5	5	68	88	2	31	72	0	15	87
	7	0	11	58	0	0	63	0	0	47
Submerged***	1	0	4	4	0	0	0	0	7	25
	3	0	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0	0
	7	0	0	0	0	0	0	0	0	0

Note: 1. Values indicate percent of emergence.

2. Soil moisture content. Average soil temperature.

	Soil moisture content	Average soil temperature (10.00 A.M.)	(15.00 P.M.)
*	38.8%	24.2 C° (10.00 A.M.)	-28.5 C° (15.00 P.M.)
**	40.5%	23.8	27.9
***	47.8%	21.8	26.7

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Table IV-3. Germination of digged-out seeds (1982).

Soil water regime	Seeding depth (cm) \ Rice	Lep Mue Nahng 111 (Indica type)	*O. perennis* (wild rice)	Nihonbare (Japonica type)
Submerged	1	0 %	18 %	0 %
	3	5	66	0
	5	4	57	13
	7	0	46	15

* Unemerged rice seeds were recovered from soil and were placed in petri dish under the temperature of 30°C.

Table IV-4. Effects of seeding depths under different soil water contents on emergence of rice seedlings (1983).

Soil water content	Rice / Days after seeding (day) / Seeding depth (cm)	Lep Mue Nahng 111 (Indica type)			*O. perennis* (wild rice)			Nihonbare (Japonica type)		
		5	10	20	5	10	20	5	10	20
25%	1	0	98	100	0	2	30	0	82	90
	4	0	6	77	0	0	28	0	0	53
	7	1	19	91	0	0	0	0	0	0
50%	1	96	98	98	44	88	88	88	95	95
	4	89	94	94	35	100	100	22	80	80
	7	68	100	100	2	72	79	0	35	43
100%	1	49	85	100	16	33	58	58	77	77
	4	6	30	30	2	2	7	3	7	17
	7	0	0	0	0	0	0	0	0	0

Note: Values indicate percent of emergence.

Table IV-5. Mesocotyl development of rice and gramineous weeds under dark condition (1982 & 1983).

Plant species	Length of mesocotyl (cm)	
	Experiment I(1982)	Experiment II(1983)
Lep Mue Nahng 111 (Indica type)	6.8	4.5
Nihonbare (Japonica type)	0.2	0.6
O. perennis	1.3	3.9
Echinochloa crusgalli	12.3	19.9
Ischaemum barbatum	10.5	10.6
Pennisetum pedicellaton	7.3	-

Note. In the experiment I and the experiment II, the seeds of the tested plants were incubated and grown for 7 days and 10 days, respectively under the temperature of 30 °C in darkress.

Table IV-6. Effect of seeding depths under different soil water contents on development of mesocotyl in rice seedlings (1983).

Soil water content	Seeding depth (cm) \ Rice	Lep Mue Nahng 111 (Indica type)	*O. perennis* (wild rice)	Nihonbare (Japonica type)
25%	1	4.1	3.7	1.2
	4	27.7	35.8	11.3
	7	-	-	-
50%	1	2.8	1.2	0.1
	4	22.2	17.8	0.8
	7	31.2	15.3	6.1
100%	1	2.4	2.6	1.2
	4	15.6	-	11.6
	7	-	-	-

Note : 1. Values indicate the length of mesocotyl in mm.

2. - shows no development.

V. COMPARATIVE STUDIES ON THE GROWING PROCESSES AND YIELDS IN WILD AND CULTIVATED RICE

Hiroshi HYAKUTAKE, Siriporn ZUNGSONTIPORN, Chaiyot SUPATANAKUL and Prasan VONGSAROJ

1. Introduction

Weedy type of wild rice seriously affects the yield and quality of the cultivated rice when they grow in the same field as reported in (7) (9) (39). During our investigations in farmers' field, some morphological and ecological differences between wild and cultivated rice were observed. Specifically, wild rice was distinct from cultivated rice in their characters such as plant length, number of tillering, heading date, culm length and panicle length.

Wirjahardja and Nurfilmarasa (46) reported that two species of wild rice O. sativa L. var. futua Prain and O. perennis Moench, serious weeds in rice fields in Indonesia, were very similar to the cultivated rice in their vegetative characteristics. Oka and Chang (29) found that the wild rice species were mostly sensitive to photoperiod.

This study was conducted to clarify the vegetative and reproductive characters of the wild rice with the view of gaining some clue as to the control of wild rice.

2. Materials and methods

During our investigation trip to farmers' field, seeds were collected from number of populations of wild Oryza species in Nakhon Nayok and Sing-Buri for the experiment in 1982. For the experiment in 1983, seeds were collected from six different locations as shown in table V-3. The cultivated variety Lep Mue Nahng 111 was used as comparison for the above-mentioned experiments.

Seeds of wild and cultivated rice were soaked in distilled water for 24 hours and then transferred to petri dish spread with filter paper and left for germination at room temperature. When the seedlings attained 1.0 leaf stage, they were transplanted to concrete pot of $0.5m^2$ in size, 9 hills (3 plants per hill) per $0.5m^2$ in planting density, square in planting pattern. The growing processes were traced by measuring plant length, number of tillers, plant age in leaf number. Plant type and growth vigours were also observed.

Since the maturation of panicles in wild rice were not uniform and they easily shatter, matured seeds were collected eveny day to obtain the exact yield. All the wild rice were harvested after the maturity period, and were investigated regarding various characters. All the experiments were conducted in a net house and were replicated 4 times.

The competition study was undertaken using concrete pot of $0.5m^2$ in size. Ungerminated seeds of O. perennis and Lep Mue Nahng 111 (cultivated rice, floating type) were mixed broadcast on the puddled soil with seeding density as shown in table V-6. After the seeds emerged, water depth was kept at 10 cm throughout the period of experiment. Both O. perennis and Lep Mue Nahng 111 had the nature of lodging, the plants were supported by rods to maintain a suitable growing condition.

3. Results and discussion

Growing processes and several characters at harvesting time (1982)

Nakhon Nayok No.1, No. 7. No. 8 and No. 11 are considered to be bybrids of wild and cultivated rice from their traits, and the growing processes were traced by measuring plant height, number of tillers and plant age in leaf number. The results are shown in table V-1. Lep Mue Nahng 111 elongated most 50 days after transplanting. Tillering capacity in Oryza perennis was extremely high at 30 and 50 days after transplanting, also showing prostrate growth habit, whereas Lep Mue Nahng and Nakhon Nayok No.1, No.7, No.8 and No.11 were erect types. There were little differences in plant age in leaf number among rice species tested.

Since the main habitat of O. perennis is in deepwater rice areas, where Lep Mue Nahng 111 is cultivated as recommended variety, these two rice species were compared in their characters at harvesting time (Table V-2).

O. perennis headed 12 days earlier than Lep Mue Nahng 111 and this difference was also observed in farmers' field. There were no differences in culm and panicle lengths, but the yield of Lep Mue Nahng 111 was much higher than that of O. perennis in spite of fewer number in panicle. This indicated that the number of spikelets per panicle in the latter was fewer than the former. Higher percentage of fruitful culms in O. perennis would show an essential character connected with the dispersal of seed and ensuring the continuity of the species as mentioned by Chatterjee (5).

Growing processes and several characters at harvesting time (1983)

Six different types of wild rice seeds were collected from paddy field or from abandoned field in each Province as shown in table V-3, and they were grown in 0.5m^2 concrete pots. Although their habitats were greatly differed, seeds collection were limited to deepwater paddy field, lowland paddy field and abandoned field to find some characters as weedy type of wild rice. Their growth habits ranged widely from erect, semi-erect to prostrate.

Only the wild rice from Sing Buri was found to propagate by seeds and rhizomes, whereas other types of wild rice had propagating habit by seeds (Table V-3).

Plant length was traced up to 50 days after transplanting and the results are show in Figure V-1, where weedy types of wild rice are divided into two groups accoring to plant height. Wild rice from deepwater paddy field except Nakhon Si Thammarat grew much higher than those from lowland paddy field indicating the adaptability to the habitat, although the experiment was conducted under the shallow water condition.

Number of tillers was traced up to 50 days after transplanting and the results are show in figure V-2. Wild rice from Saraburi (roadside) showed the highest tillering capacity, followed by the one from the adjacent Saraburi(armycamp). There exist a distinct tendency that weedy wild rice with short plant length has extremely higher tillering capacity than those with tall plant length.

Comparison of several characters in cultivated and wild rice at harvesting time was shown in table V-4. Heading date differed greatly, showing a tendency that wild rice from the North headed earlier than that from the South except the one from Chianyai. Culm length of wild rice collected at Saraburi (army camp) was the shortest among the plants tested but produced highest number of panicles/m^2. Although the wild rice investigated produced more panicles than a cultivated rice Lep Mue Nahng 111, the yields of wild rice were much lower than that of Lep Mue Nahng 111. Since early heading types from Saraburi were damaged by rodent at heading period, it was impossible to obtain the accurate yields. On the whole, grain-straw ratio of wild rice was much lower than that of Lep Mue Nahng 111.

Chang and Bardenas (3) reported that rice varieties differ in ratooning ability following initial harvest. Wild rice species collected at various Provinces were investigated their ratooning ability 30 days after harvest, and the result was shown in table V-5. Wild rice from Sing Buri showed a vigorous ratooning ability, followed by the one from Nakhon Si Thammarat under a uniform condition in water and nutrient supply.

The result indicated that under the favorable growing conditions such as water and nutrient supply, wild rice collected at Sing Buri, which was supposed to be a perennial-annual intermediate type, proved to propagate greatly.

Competition between cultivated rice (Lep Mue Nahng 111) and wild rice (O. perennis) was investigated as shown in table V-6. The conditions of the competition studies were not appropriate since the two species of rice propagated to innumerable density. Under the same seeding density, the yield of Lep Mue Nahng was extremely lowered due to a great decrease in number of panicles/m^2. Leitao et al. (21) reported a similar result that root development and tillering of cultivated rice (IAC-435) were markedly affected by competition with red rice. In this study, as the size of pot was rather small, both cultivated rice and wild rice were unable to exhibit their natural characteristics. Further studies in field condition are required to elucidate a yield decrease through competition between cultivated and wild rice.

Summary

Six different types of wild rice seeds were collected from paddy field or from abandoned field and they were grown in a net house. Their

growth habits ranged widely from erect, semi-erect to prostrate. Only the wild rice from Sing Buri was found to propagate by seeds and rhyzomes, whereas other types of wild rice had a propagating habit by seeds. Wild rice from deepwater paddy field grew much higher than those from lowland paddy field indicating the adaptability to the habitat. Wild rice from Saraburi (roadside) showed the highest tillering capacity, and a distinct tendency was observed that weedy wild rice with short plant length has extremely higher tillering capacity than those with tall plant length. Heading date differed greatly showing a tendency that wild rice from the North headed earlier than from the South. Yields of wild rice were much lower than that of Lep Mue Nahnq 111. Wild rice from Sing Buri, a perennial-annual intermediate type, showed a vigorous ratooning ability.

Table V-1. Growing processes of cultivated and wild rice (1982).

Characters / Days after transplanting (day) / Rice spp.	Plant height (cm)				Number of tillers/m^2				Plant age in leaf number		
	10	20	30	50	10	20	30	50	10	20	30
Nakhon Nayok No. 1	38	68	109	149	54	113	357	327	3.8	6.3	9.5
Nakhon Nayok No. 7	38	68	105	145	55	153	422	399	4.2	6.7	9.9
Nakhon Nayok No. 8	37	68	109	168	55	152	478	442	4.1	6.7	9.8
Nakhon Nayok No. 11	38	71	108	156	58	183	548	480	4.4	7.1	10.2
Oryza perennis	30	58	94	153	57	165	596	608	3.8	6.4	9.7
Lep Mue Nahng 111 (floating rice) cultivated rice	36	71	118	187	54	136	382	372	4.2	6.9	10.1

Note : The cultivated and wild rice were grown in a square pot of 0.5 m^2 in size.

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Table V-2 . Comparison of several characters between cultivated and wild rice at harvesting time.(1982).

Characters \ Rice spp.	Lep Mue Nahng 111 (floating rice) cultivated rice	*Oryza perennis* (wild rice)
Heading date	Nov. 9, 1982	Oct. 28, 1982
Date of maturity	Dec. 5, 1982	Nov. 12-27, 1982
Culm length (cm)	254	256
Panicle length (cm)	25.8	25.2
Number of panicles/m^2	122	306
Weight of unhulled rice (g/m^2)	460	246
Weight of straw (g/m^2)	3,548	3,742
Grain-straw ratio (%)	13.0	6.6
Percentage of fruitful culms (%)	32.8	50.3

Note : The cultivated and wild rice seedlings of 1.0 leaf-stage were transplanted on June 14, 1982 in a square pot of 0.5 m^2 in size.

Table V-3 Weedy type of wild rices investigated (1983).

Item / Seed sources (Province)	Species and type	*Habitat	Growth habit	Propagating habit
Sing Buri	O. perennis perennial-annual intermediate type	(1),4,5,6,7	Prostrate	By seeds and rhizome
Saraburi (roadside)	O. perennis annual type	(3),4,6	Prostrate	By seeds
Saraburi (army camp)	O. perennis annual type	(3),4	Prostrate	By seeds
Ratchaburi	O. perennis annual type	(1),2,4,6,7	Erect	By seeds
Nakhon Si Thammarat	O. perennis annual type	(2),4,6,7	Erect	By seeds
Chianyai District	O. perennis annual type	(2),4,6,7	Semi-erect	By seeds
Lep Mue Nahng 111 (cultivated rice)	O. sativa L. annual type	Indica type cultivated rice	Erect	By seeds

*Habitat 1. Deepwater paddy field, 2. Lowland paddy field, 3. Abondoned field, 4. Roadside canal or ditch (with shallow water), 5. Roadside canal or ditch (with deepwater), 6. Marsh, 7. Lake.

O: indicates the location where the seeds of wild rice were collected.

Table V-4 Comparison of several characters in cultivated and wild rices at harvesting time (1983).

Characters / Rice spp. collected at	Heading date	Culm length (cm)	Panicle length (cm)	Number of panicles/m^2	Weight of unhulled rice (g/m^2)	Weight of straw (g/m^2)	Grain-straw ratio (%)	Percentage of fruitful culms (%)
Sing Buri	Nov.7, 1983	219	31.2	175	220	2283	9.6	59.7
Saraburi (roadside)	Sept.30 1983	115	15.8	224	25*	674*	3.7*	22.2
Saraburi (army camp)	Oct.3, 1983	90	21.7	319	30*	636*	4.7*	49.0
Ratchaburi	Nov.15, 1983	147	31.1	106	154	2527	6.1	39.6
Nakhon Si Thammarat	Nov.28, 1983	150	30.9	213	315	2532	12.4	44.1
Chianyai	Oct.30, 1983	99	19.1	201	131	554	23.6	74.4
Lep Mue Nahng 111 (cultivated rice)	Nov.10, 1983	159	26.1	72	350	886	39.5	63.7

Transplanting date : July 6, 1983, rice seedling of 1.0 leaf-stage. * Damaged by rodent.

Table 7-5 Differences in ratooning ability between cultivated and wild rice (1984).

Rice spp. collected at	Number of ratoons/$0.5m^2$ (30 days after harvest)
Sing Buri	207
Saraburi (roadside)	0
Saraburi (army camp)	1
Ratchaburi	16
Nakhon Si Thammarat	35
Chianyai	0
Lep Mue Nahng 111 (cultivated rice)	0

Note: The cultivated and wild rice seedlings of 1.0 leaf-stage were transplanted on July 6, 1983 in a square pot of $0.5m^2$ in size. Water and nutrient supply were uniform for all the rice species.

Table V-6 . Competition between cultivated rice (Lep Mue Nahng 111) and wild rice (*Oryza perennis*) (1982).

Basis of competition, number of seeds/m^2 \ Characters		Culm length (cm)	Panicle length (cm)	Number of panicles/m^2	Weight of unhulled rice (g/m^2)	Weight of straw (g/m^2)
Lep Mue Nahng 111	200	271	26.3	64	214	2376
Oryza perennis	0	-	-	-	-	-
Lep Mue Nahng 111	200	277	26.6	78	260	2614
Oryza perennis	25	258	26.8	25	37	252
Lep Mue Nahng 111	200	258	26.2	75	244	2480
Oryza perennis	50	223	28.5	73	36	418
Lep Mue Nahng 111	200	247	23.8	95	322	2260
Oryza perennis	100	237	30.0	85	29	750
Lep Mue Nahng 111	200	273	24.3	39	130	1170
Oryza perennis	200	270	29.0	135	26	982

Note. Seeds of cultivated and wild rice were sown mix-broadcast in a square concrete pot of 0.5 m^2 in size.

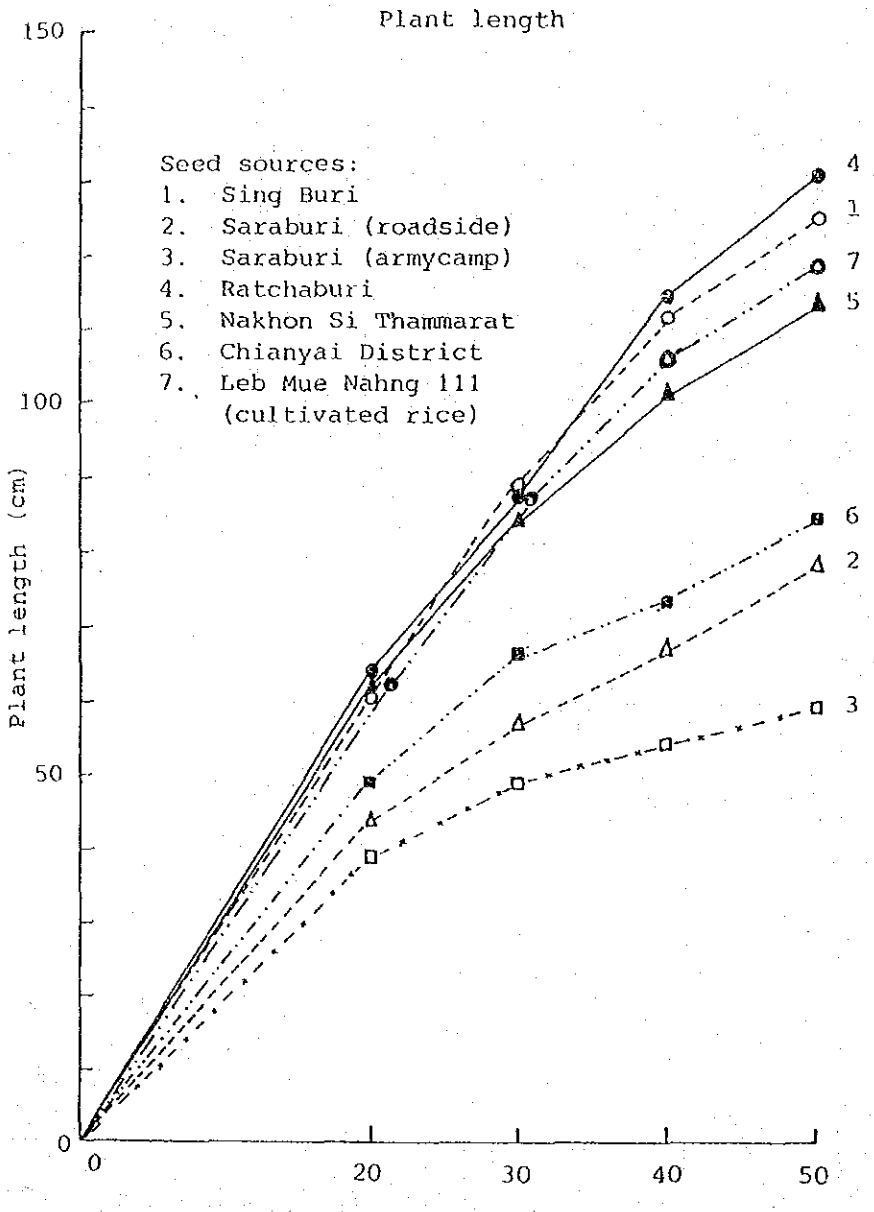

Fig. V-1 Growing processes of wild and cultivated rices.

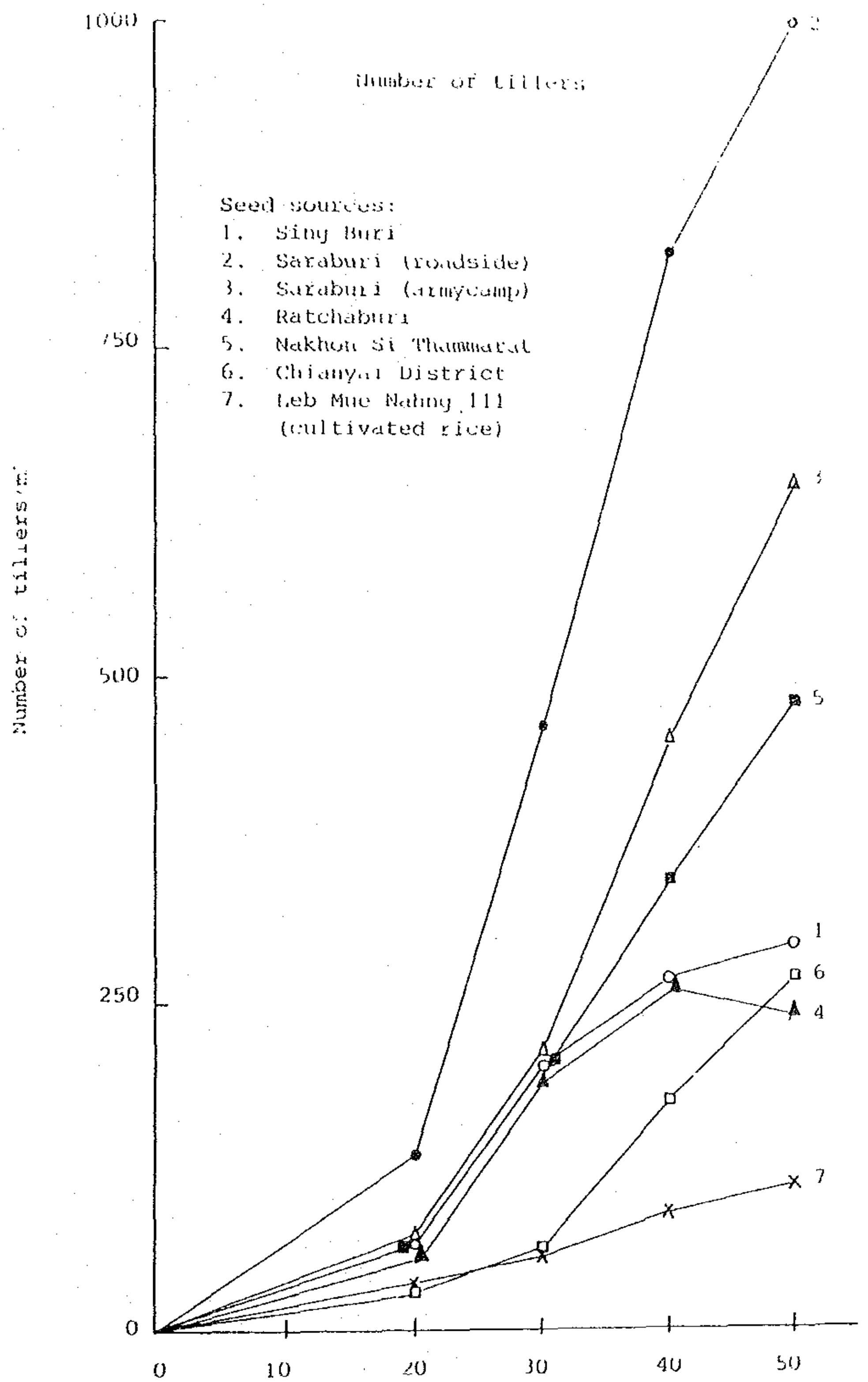

Fig.V-2 Growing processes of wild and cultivated rices.

VI. REGENERATIVE ABILITY OF STEM SEGMENTS IN COMPARISON WITH SEEDLING IN WILD RICE

Siriporn ZUNGSONTIPORN and Hiroshi HYAKUTAKE

1. Introduction

During our field investigation on wild rice at deepwater rice field in Sing Buri on June 17,1982, we found a weedy type of wild rice apparently regenerated from stem segments, growing under dry field condition. One month after when irrigation water was introduced, wild rice regenerated from stem segments produced many tillerings, exceeding seed-propagating wild rice in growth. These observations had suggested the regeneration from stem segments, if they were able to remain intact, was dominant over propagation by seeds.

The present study was conducted to elucidate the difference of these two modes of propagation.

2. Material and method

Seeds and stem segments were taken from O. perennis, intermediate perennial-annual type, collected in Sing Buri. Stem segments about 4 cm long, having a node were cut off from wild rice at maturity stage and 5 segments were planted into a pot of $0.5m^2$ in size and were thinned out to 3 regments per pot.

For growing from seedling, 3-leaf stage plants were transplanted into the same size of pot and were thinned out to 3 plants per pot after they took root.

Growth was traced by counting number of tillers every 10 days after transplanting.

3. Result and discussion

Plant type grown from stem segments was completely different from the one grown from seedling ; wild rice grown from stem segments showed prostrate type, whereas one from seedling developed to an erect type plant, and this features never changed throughout growth period.

Increase in number of tillers from seedling was higher than that from stem segments up to 60 days after transplanting, and after this period the increase was levelled off (Fig.VI-1). Number of tillers in wild rice from stem segments were continuously increased, having more tiller buds developed from nodes which parts were touched either in water or on wet soil because of prostrate type. One node produced more than 1 tiller and when some portions of node were cut off, a remaing node rapidly developed new tillers.

The yield from stem segments was lower than that from seedling, this is due to a coutinuous vegetative growth on the part of plant from stem segments. From this mode of growth, propagation potentialities of stem segments was considered to be higher than those of seedling.

Summary

Wild rice grown from stem segments showed a prostrate type, whereas one from seedling developed to an erect type plant. Number of tillers in wild rice from stem segments were continuously increased, having more tiller buds developed from nodes. Propagation potentialities of stem segments was considered to be higher than those of seedling.

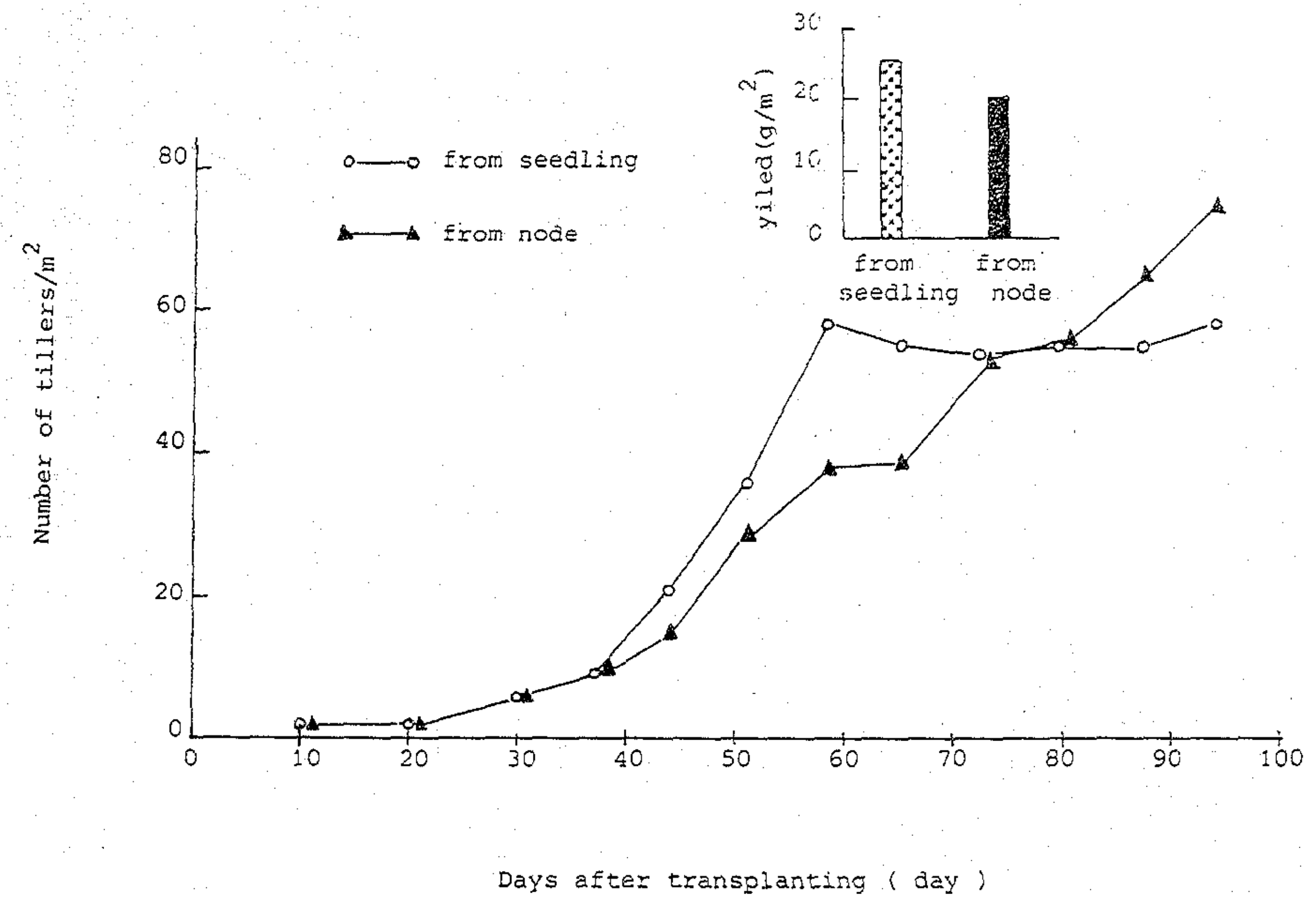

Fig. VI-1 Regenerative ability of stem segments in comparison with seedling in wild rice (O. *perennis*).

Note. Stem segments about 4 cm long, having a node were cut off from wild rice at maturity stage and planted in pots.

VII. EFFECT OF HERBICIDES AND ANTIDOTE FOR THE CONTROL OF WILD RICE

Hiroshi HYAKUTAKE and Siriporn ZUNGSONTIPORN

1. Introduction

With infestations of wild rice in direct-sowing rice areas in Thailand, control methods are being earnestly sought by weed scientists and farmers concerned. Chemical weed control is on the increase because of the high cost of labour (20), and chemical control of wild rice would be more meanningful in case some highly selective herbicides are to be found. Since the conditions in direct-sowing field are such that both wild and cultivated species of rice start to germinate almost at the same time and grow with the same pace, a herbicide should be equipped with the nature of high selectivity (14) between the two species.

Moreover, it would be difficult to expect good control of rice unless a herbicide is applied within the early seedling growth stage of wild rice. Chemical control of wild rice were investigated world-wide (33)(47)(48)(38)(49) and, molinate and benthiocarb herbicides proved to be selective (33)(47)(38).

The present studies were conducted to find a selective herbicide between wild and cultivated rice.

2. Material and method

Ungerminated rice seeds were placed in a 9 cm petri-dish containing designated CNP solution for pre-emergence treatment. and CNP solution was treated to greenned rice seedlings of approximately 5 mm in length in pertri-dish for post-emergence treatment (Table VII-1).

Propanil was applied at 1,2 and 3-leaf stage of cultivated and wild rice which were grown in pots, 10 cm in diameter filled with Bangkhen clay soil, and were subsequently grown in glasshouse (Table VII-2).

For the experiment of susceptibility of wild and cultivated rice, benthiocarb (S-(4-chlorobengyl)-N,N-diethylthiocarbamate, CNP (2,4,6-trichlorophenyl-4´- nitrophenyl ether), pyrazolate (4-(2,4-dichlorobenzoyl)-1,3-dimethyl-5-pyrazolyl- p - toluenesulfonate and molinate (S-ethly-N,N-hexamethylene thiolcarbamate) as pre-emergènce herbicide and propanil (3´, 4´- dichloropropionanilide) as post-emergence herbicide, were used, respectively. For the study of antidote, seeds of cultivated rice were soaked in NA (naphtalic anhydride) 2% solution for 16 hrs. prior to sowing (Table VII-3).

For the study of calcium peroxide (® Calper) and naphthalic anhydride (NA) as antidotes,seed was dressed with these material at 0.5% w/w to protect cultivated rice against damage from the herbicide (Fig. VII-2).

3. Result and discussion

CNP petri-dish test indicated that there existed some varietal differences in response to this herbicide as post-emergence treatment. Among the recommended Thai rice varieties, RD-21 and RD-25 showed a higher tolerances, whereas RD-9 was susceptible as the same degree with wild rice, with post-emergence treatment(Table VII-1). No inhibition of the germination was observed. CNP was reported to be highly selective with pre-emergence treatment on rice and baruyardgrass (13), however, the selectivity between cultivated and wild rice was low with pre-emergence treatment. Difference in resistance against post-emergence treatment of CNP in cultivated rice and wild rice was probably due to the difference in surfaces of coleoptiles, although SEM study was required (12).

The applications of propanil at three different growth stages were not effective against wild rice. Two types of wild rice showed tolerance at almost same degree with culltivated varieties (Table VII-2). It was reported (22) that rice species having genomes relating to A,B,C and D have the activity of propanil-hydrolyzing enzyme and were supposed to be tolerant to propanil. This analysis in combination with bioassay test is required to determine a tolerance to propanil.

Benthiocarb strongly inhibited the growth of both wild and cultivated rice at lower concentration and completely inhibited germination of O. perennis. When protected with 2% NA (naphtalic anhydride), Lep Mue Nahng 111 (Indica type) showed tolerance against benthiocarb, whereas protective effect of NA in Nihonbare (Japonica type) was not observed. CNP was distinctly effective against O. perennis in soil test, but not against other wild rice species collected at Nakhon Nayok.. In this experiment, pyrazolate, molinate and propanil were not effective for control of wild rice (Table VII-3). Indica was more sensitive to benthiocarb than the other varieties (16), and mechanism of differences in tolerance should be investigated for safety utilization of this herbicide.

Influence of CaO_2 or NA seed coating (0.5%w/w) on benthiocarb toxicity to cultivated and wild rice was investigated and the result is shown in figure VII-1. CaO_2 seed coating stimulated the initial growth of Nihonbare and Lep Mue Nahng, but it did not work as antidote. NA seed coating (0.5%w/w) was effective against benthiocarb in Lep Mue Nahng but not in Nihonbare. This varietal difference in efficacy was observed in previous test shown in Table VII-3. It would be quite meaningful to find highly effective antidotes to dust the seed before planing as pointed out by Hoffmann (10).

Summary

Effect of CNP, propanil, benthiocarb, pyrazolate, molinate and antidote on wild and cultivated rice were investigated with petri-dish and soil tests. Cultivated varieties RD-21 and RD-25 showed a higher tolerance to post-emergence treatment of CNP, whereas RD-9 was susceptible as the same degree with wild rice. The selectivity between cultivated and wild rice was low with pre-emergence treatment of CNP, whereas in soil test, CNP was distinctively effective against O. perennis. Post-emergence treatment of propanil was not effective against wild rice at 1,2 and 3-leaf stage. Benthiocarb was very effective against O. perennis, and when protected with 2% NA, Lep Mue Nahng 111 showed tolerance against benthiocarb. In this experiment, pyrazolate, molinate and propanil were not effective against wild rice. CaO_2 seed coating stimulated the initial growth of cultivated rice, but not effective as antidote.

Table VII-1 Effect of CNP on germination and early seedling growth of cultivated and wild species of rice (1981).

Cultivated rice var. or wild rice	Shoot dry wt. (% of control)			
	CNP (M)	Pre-emergence treatment	CNP (M)	Post-emergence treatment
Leuang Pra-tew 123	10^{-6}	105	10^{-6}	94
	10^{-5}	95	10^{-5}	77
	$5x10^{-5}$	82	10^{-4}	73
Khao Pahk Maw 148	10^{-6}	99	10^{-6}	92
	10^{-5}	83	10^{-5}	84
	$5x10^{-5}$	72	10^{-4}	59
RD 7	10^{-6}	95	10^{-6}	96
	10^{-5}	84	10^{-5}	93
	$5x10^{-5}$	86	10^{-4}	83
RD 9	10^{-6}	95	10^{-6}	129
	10^{-5}	87	10^{-5}	64
	$5x10^{-5}$	80	10^{-4}	40
RD 21	10^{-6}	102	10^{-6}	105
	10^{-5}	87	10^{-5}	110
	$5x10^{-5}$	85	10^{-4}	101
RD 23	10^{-6}	79	10^{-6}	87
	10^{-5}	60	10^{-5}	87
	$5x10^{-5}$	56	10^{-4}	60
RD 25	10^{-6}	85	10^{-6}	134
	10^{-5}	81	10^{-5}	109
	$5x10^{-5}$	69	10^{-4}	108
Nihonbare	10^{-6}	107	10^{-6}	121
	10^{-5}	92	10^{-5}	107
	$5x10^{-5}$	92	10^{-4}	91
Wild rice (from Prachin Buri)	10^{-6}	100	10^{-6}	85
	10^{-5}	79	10^{-5}	56
	$5x10^{-5}$	68	10^{-4}	46

1. Pre-emergence treatment : Ungerminated rice seeds were placed in a 9 cm petri-dish containing designated CNP solution.
2. Post-emergence treatment: CNP was treated to greenned rice seedlings of approximately 5 mm in length in petri-dish.

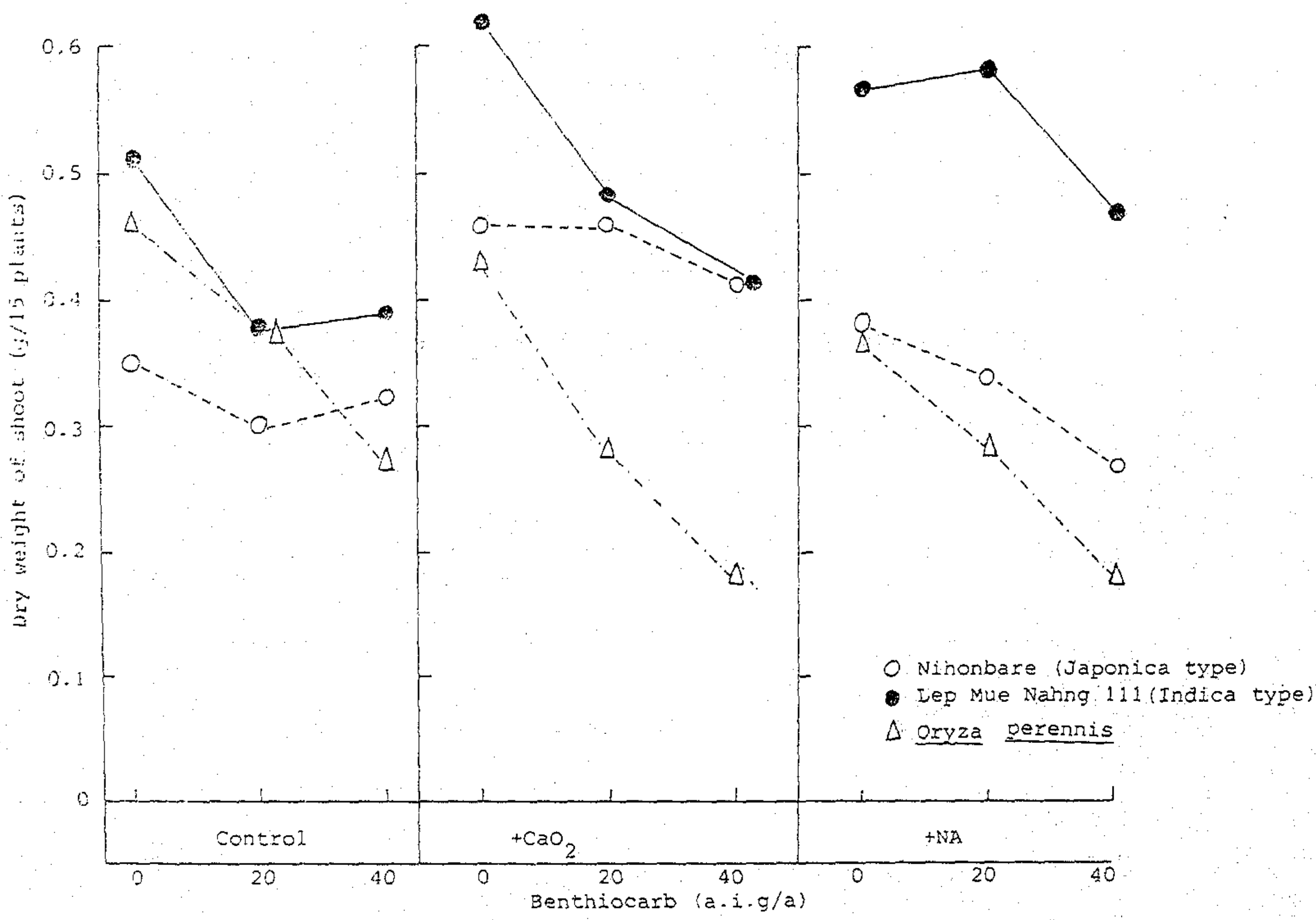

Fig. VII-1 Influence of CaO_2 or naphthalic anhydride seed treatments (0.5%w/w) on benthiocarb toxicity to cultivated and wild rice (1983)

Table VII-2. Effect of propanil on the initial growth of cultivated and wild rice (1981).

Plant	Propanil (a.i.g/a)	Shoot dry wt. (% of control) applied at		
		1-leaf stage	2-leaf stage	3-leaf stage
Leruang Pra-tew 123	20	82	106	111
	40	85	93	70
	60	73	88	62
* Lep Mue Nahng 111	20	101	95	101
	40	91	63	98
	60	83	57	93
* Ta-pow-gaew 161	20	119	108	86
	40	88	96	84
	60	82	87	72
Nihonbare	20	81	93	76
	40	83	90	69
	60	82	93	71
O. perennis	20	84	84	118
	40	88	81	108
	60	82	73	102
Wild rice (from Prachin Buri)	20	95	84	122
	40	92	78	105
	60	85	74	86
Echinochloa crus-galli	20	35	4	66
	40	26	3	65
	60	4	2	64

Note. Indica type : Leuang Pra-tew 123, Leb Mue Nahng 111.
Ta-pow-gaew
Japonica type : Nihonbare
* : Floating rice

Table VII-3. Susceptibility of wild and cultivated rice to herbicides and antidote (1981).

Rice		Shoot dry wt. (% of control)									
		A		B		C	D	E	F	G	H
NA		O	NA	O	NA	O	O	O	O	O	O
Herbicides (a.i. g/a)											
Benthiocarb	10	53	84	44	63	37	-	55	61	98	0
	20	36	70	37	40	32	-	43	48	23	0
	30	12	69	36	0	21	-	44	35	0	0
CNP	15	99	78	68	73	57	-	83	95	91	30
	30	66	72	59	56	31	-	46	79	76	21
	45	55	70	56	40	24	-	43	56	69	14
Pyrazolate	15	102	95	82	89	74	-	90	111	107	59
	30	90	86	78	87	65	-	79	111	98	41
	45	84	59	72	33	50	-	71	94	78	38
Molinate	20	82	-	79	-	68	74	77	77	66	-
	30	75	-	72	-	48	65	76	50	18	-
	45	61	-	57	-	37	49	51	60	11	-
Propanil	20	95	-	111	-	105	114	138	94	95	-
	40	82	-	100	-	100	105	117	91	89	-
	60	82	-	103	-	93	92	98	87	102	-

1. Rice A. Leb Mue Nahng 111 } cultivated rice
   B. Nihonbare

	awning	panicle shattering	nodal septam	
C.	awned	low	pink	collected at Nakhon Nayok
D.	awned	low	green	
E.	awned	low	green	
F.	awned	low	green	
G.	absent	loose	green	

   H. *O. perennis*

2. Benthiocarb, CNP, pyrazolate, molinate : preemergence treatment; propanil : 2-leaf stage treatment.
3. Seeds of cultivated rice were soaked in NA 2% solution for 16 hrs. prior to sowing.
4. Shoot dry wt. (per 30 plants) in control and NA treatment : Leb Mue Nahng 111 0.40 g(100), 0.38 g (95); Nihonbare 0.54 g (100), 0.37 g (69)
5. - : No experiment.

VIII. DIFFERENTIAL RESPONSES OF SELECTED THAI RICE VARIETIES AND SOME GRAMINEOUS WEEDS TO HERBICIDES.

Patcharin WANICANANTAKUL, Hiroshi HYAKUTAKE and Orasa WONGKASEM

1. Introduction

Weed control is one of the important problems in rice culture. The competition between rice and weeds reduces yield of rice and lowers its quality. Muzik (27) stated that as new dwarf-type rice varieties which possess a high yield potential are being bred, the need for weed control becomes more critical.

In Thailand, chemical weed control has been increasing in paddy fields due to the shortage and higher cost of labours. However, the phytotoxicity of herbicides in rice occurs frequently with different patterns in different regions, where approximately forty recommended rice varieties plus several local rice varieties are being cultivated now.

Different rice varieties are considered to posses different physiological and biochemical properties which might be manifested in their responses to herbicides (44). Therefore, it is necessary to investigate the response of the representative rice varieties to the various types of herbicides for the effective utilization of chemicals in farmer's field.

The present studies were conducted to obtain basic data on this point together with the control of gramineous weeds in paddy field.

2. Materials and methods

Ten recommended rice varieties in Thailand (Indica type): RD-7, RD-9, RD-21, RD-23, RD-25 (hybrid varieties), Khao Ta Hang 17, Nahng Mon S-4, Khao Dawk Mali 105, Nahng prayah 132, and Leuang Pra-tew 123 (local varieties)

Japanese rice variety (Japonica type): Nihonbare, and three gramineous weeds in paddy field: Oryza perennis (perennial type), Ischaemum rugosum Salisb, and Echinochloa crus-galli (L.) Beauv. were selected, and fifteen seeds of each rice variety and weeds were sown at the depth of 0.5～1 cm in plastic pots, 30cmx30cm size, containing Bangkhen clay soil, sieved through a 3-mm screen.

Oxadiazon (5-tert-butyl-3(2,4-dichloro-5-isopropoxyphenyl)-1,3,4-oxadiazolin-2-one), butachlor (2-chloro-2,6-diethyl-N- (buthoxymethyl) acetanilide), and molinate (S-ethylhexahydro-1H-azepine-1-carbothioate) were applied at the rate of 0.1, 0.5, 1.0, 2.0 and 4.0 a.i.Kg/ha, whereas CNP (2,4,6-trichlorophenyl-4'- nitrophenylether), benthiocarb (S-(4-chloro-benzyl)-N,N- diethylthio-carbamate) were applied at the rate of 0.5, 1.0, 2.0, 4.0 and 8.0 a.i.Kg/ha as pre-emergence herbicides one day after seeding. Propanil (3,4-dichloropropionanilide) and 2,4-D(2,4-dichlorophenoxyacetic acid) were treated at the rate of 0.5 1.0, 2.0, 4.0 and 8.0 a.i.Kg/ha as post-emergence herbicides at 2.5 to 3.5 leaf stage of rice and weeds. One day prior to the pre-emergence treatment of herbicides, water level in the pot was kept up to the soil surface, and when rice and weeds attained 2～3cm in height, the water level was raised to 2～3cm above the soil surface accordingly. Propanil and 2.4-D were treated under the submerged condition of 2～3cm.

The experiment was carried out under the greenhouse condition, where the daily temperature and relative humidity were recorded 20～37°c and 42-105%, respectively, The experiment was conducted by randomized block design with three replications. The phytotoxicities of herbicides were investigated 3,5,7,10 and 12 days after treatment, and all the plants were harvested 14 days after treatment to determine the dry weight of shoot.

3. Results and discussion

Oxadiazon :

Application of oxadiazon at the rate of 1.0 a.i.Kg/ha caused "browning" in the leaves, but this symptom was recovered to control level after 7 to 10 days. As the rate of application increased, the phytotoxicity increased accordingly. RD-7 was the most susceptible variety to oxadiazon, whereas RD-9, RD-21, Khao Dawk Mali 105, and Nihonbare were moderately tolerant. The dry weight of shoot were markedly reduced by increasing rate of application (Fig. VIII-I, Table VIII-I &.VIII-8).

CNP :

CNP applied at 4.0 or 8.0 a.i.Kg/ha had some effects on the initial growth stage, causing spotted brown color in the leaves but the symptom soon disappeared and no detrimental effects were found in the rice varieties tested. The rice plants recovering from phytotoxicity might be due to the in activation of herbicide(19). The dry weight of shoots was not much affected in selected rice varieties, but RD-21, Khao Dawk Mali 105 and Nihonbare showed moderately tolerance to CNP (Fig. VIII-2, Table VIII-2, &.VIII-8).

Benthiocarb :

The phytotoxicity of benthiocarb varied markedly among rice varieties. The application of 0.5 a.i.Kg/ha seemed to stimulate the initial growth of rice, whereas higher rate of application inhibited the growth. Benthiocarb at 2.0 a.i.Kg/ha significantly reduced the dry weight of RD-23, causing the initial growth of rice to decumbent form and dark-greening of the leaves, and also inhibiting the shoot elongation. RD-21, RD-25 and Nahng Mon S-4 showed tolerance to benthiocarb to some extent, whereas RD-23 and Khao Dawk Mali 105 were shown to be susceptible. Nihonbare was more tolerant than the other selected rice varieties(Fig. VIII-3, Table VIII-3 &. VIII-8).Takematsu et. al. (42) reported Japanese rice varieties (Japonica Type) were more tolerant to benthiocarb than Indica rice varieties (Indica type).

Molinate :

Molinate at 0.5~4.0 a.i.Kg/ha inhibited shoot growth of rice varieties. Wirjahardja and Susilo (48) reported that molinate at 2.0 a.i.Kg/ha was not safe to IR rice varieties, even if they were protected by NA. In our experiment, only Nihonbare showed tolerance to Molinate. RD-23 and Khao Dawk Mali 105 were moderately susceptible to this herbicide (Fig. VIII-4, Table VIII-4 &. VIII-8)

Butachlor :

All the rice varieties treated with butachlor did not show any injury symptom at the initial growth stage except for the inhibition of elongation of rice shoots. Butachlor at 1.0~2.0 a.i.kg/ha reduced the dry weight of shoots approximately 20~50% of the control. In this study, Nahng Mon S-4 and Nihonbare were tolerant to butachlor whereas RD-7 moderately susceptible (Fig. VIII-5, Table VIII-5 &. VIII-8).

Propanil :

Propanil seemed to act mainly as contact herbicide. At higher application rates of 4.0~8.0 a.i.kg/ha, the burning type of injury appeared on the leaves within a few hours after application. Hofstra and Switzer (11) reported that the first phytotoxic action of propanil was on cell and chloroplast membranes, and the secondary one, possibly, on the energy transfer mechanism in plant. Application of propanil at 1.0~4.0 a.i.kg/ha had no effect on dry weight of shoot in rice varieties. Nihonbare was found to be the most tolerant variety in this experiment. Among Indica type, local varieties seemed to be more tolerant than hybrid varieties (Fig. VIII-6, Table VIII-6 &. VIII-8).

2,4-D :

The application of 2,4-D at 1.0~2.0 a.i.kg/ha caused phytotoxicity to rice varieties. The yellowish, discolored leaves with abnormal elongation in the lowest internode were observed at 7~10 days after treatment. The effect was more pronounced with RD-7 and Khao Dawk Mali 105, while the other rice varieties were moderate(Fig. VIII-7, Table VIII-7 &. VIII-8).Sundaru et. al. (40) reported that IR-36, Indica variety, was more susceptible to 2,4-D than Hawara Batu, Japonica variety, at low temperature. The weight of shoots were not much affected at 1.0~2.0 a.i.Kg/ha, whereas application of 4.0-8.0 a.i.Kg/ha strongly suppressed the elongation of rice plants.

Oxadiazon, CNP, benthiocarb, butachlor and propanil at recommended rate in rice culture were effective for the control of Ischaemum rugosum and Echinochloa crusgalli, however molinate was unable to control Ischaemum rugosum.

In this experiment, no herbicides were found to inhibit the growth of Oryza perennis. Only benthiocarb and molinate applied at 2.0 a.i.Kg/ha were able to reduce the growth of Oryza perennis about 70% (Fig. VIII-3 & VIII-4, Table VIII-3. VIII-4 and VIII-8).

This experiment is considered to enable to select the suitable rice variety for the efficient utilization of herbicide in rice culture.

Summary

The selected Thai rice varieties (Indica type) plus a Japapnese rice variety (Japonica type) and three gramineous weeds were tested with seven herbicides; oxadiazon, CNP, benthiocarb, molinate, butachlor, propanil and 2,4-D. Each rice variety responded differently to different herbicides. Among the rice varieties tested, Japonica type (Nihonbare) was more tolerant to the herbicides tested than Indica type. Among the selected Thai rice varieties, the difference in response to herbicides between hybrid and local variety was slight. Selected rice varieties responded extremely different degree, ranging, from susceptible to the tolerant degree. RD-21, RD-25 and Nahng Mon S-4 were

relatively tolerant to the herbicides tested than the other rice varieties. *Ischaemum rugosum* Salisb and *Echinochloa crus-galli* (L.) Beauv, were susceptible to the herbicides except 2,4-D, whereas *Oryza perennis* was moderately tolerant to the herbicides tested.

Table VIII-I Dry weight (g/15 plants) of shoot as affected by oxadiazon:

Rice Varieties or Weeds \ Oxadiazon	0 kg a.i./ha	0.1 kg a.i./ha	0.5 kg a.i./ha	1 kg a.i./ha	2 kg a.i./ha	4 kg a.i./ha
RD 7	.5312 ± .0088 (100)	.4274 ± .0055 (80.41)	.2963 ± .0129 (55.86)	.2208 ± .0276 (41.6)	.1169 ± .0227 (22.01)	.0990 ± .0332 (18.64)
RD 9	.4213 ± .0055 (100)	.4155 ± .0219 (98.69)	.3143 ± .0195 (74.65)	.2701 ± .0099 (64.15)	.2007 ± .0186 (49.5)	.1466 ± .0084 (34.82)
RD 21	.5261 ± .0362 (100)	.6971 ± .0127 (118.07)	.3521 ± .0121 (66.93)	.3029 ± .0128 (57.58)	.2322 ± .0128 (44.14)	.1474 ± .0145 (28.02)
RD 23	.5008 ± .0212 (100)	.4906 ± .0165 (98.12)	.3482 ± .0319 (69.64)	.2279 ± .0466 (45.58)	.1857 ± .0132 (37.14)	.0924 ± .0167 (18.46)
RD 25	.3996 ± .0087 (100)	.3698 ± .0140 (92.68)	.2601 ± .0252 (65.18)	.2281 ± .0241 (57.08)	.1984 ± .0140 (49.72)	.1192 ± .0093 (29.87)
Khao-ta-hang 17	.6035 ± .0159 (100)	.6158 ± .0620 (102.10)	.4255 ± .0184 (70.5)	.2713 ± .0128 (44.95)	.2243 ± .0351 (37.16)	.1011 ± .0127 (16.75)
Nahng-mon S-4	.6668 ± .0241 (100)	.6696 ± .0109 (100.54)	.4056 ± .0342 (60.82)	.3742 ± .0148 (56.11)	.2636 ± .0302 (39.53)	.1062 ± .0082 (15.92)
Khao-dawk-mali 105	.4567 ± .0707 (100)	.4791 ± .0666 (104.90)	.3843 ± .0155 (84.14)	.2680 ± .0254 (58.68)	.2473 ± .0471 (54.14)	.0687 ± .0112 (15.04)
Nahng-pra-yah 132	.3416 ± .0240 (100)	.3812 ± .0141 (111.59)	.2600 ± .0321 (75.11)	.2330 ± .0102 (68.20)	.1685 ± .0112 (49.32)	.0793 ± .0143 (23.21)
Leuang-pra-tew 123	.5932 ± .0564 (100)	.5448 ± .0791 (91.84)	.4004 ± .0108 (67.49)	.3008 ± .0134 (50.71)	.2435 ± .0289 (41.04)	.1101 ± .0290 (18.56)
Nihonbare	.3512 ± .0429 (100)	.3554 ± .0255 (101.195)	.2699 ± .0583 (76.85)	.2146 ± .0458 (61.10)	.2140 ± .0221 (60.93)	.0705 ± .0142 (20.07)
I. rugosum	.1210 ± .0073 (100)	.0132 ± 0 (10.82)	0	0	0	0
E. crus-galli	.0496 ± .0099 (100)	.0165 ± 0 (33.26)	0	0	0	0
O. perennis	0	0	0	0	0	0

Note.-: No experiment.

Dry weight of shoot was taken 14 days after the treatment.

Values in parenthis indicate % of control in each rice varieties or weeds.

Table VIII-2 Dry weight (g/15 plants) of shoot as affected by CNP.

Rice \ CNP Varieties or Weeds	0 kg a.i./ha	0.5 kg a.i./ha	1.0 kg a.i./ha	2.0 kg a.i./ha	4.0 kg a.i./ha	8.0 kg a.i./ha
RD 7	.2470 ± .0121 (100)	.2495 ± .0188 (101.01)	.2364 ± .0213 (95.71)	.2037 ± .0364 (82.42)	.1918 ± .0231 (77.65)	.1763 ± .0229 (71.38)
RD 9	.2412 ± .0294 (100)	.2393 ± .0277 (99.21)	.2094 ± .0112 (86.82)	.1989 ± .0450 (82.46)	.1605 ± .0090 (66.54)	.1712 ± .0128 (70.97)
RD 21	.2751 ± .0248 (100)	.2706 ± .0211 (98.36)	.2436 ± .0067 (88.54)	.2312 ± .0165 (84.04)	.2236 ± .0196 (81.27)	.2202 ± .0086 (80.04)
RD 23	.2861 ± .0080 (100)	.2496 ± .0229 (87.24)	.2786 ± .0155 (97.38)	.2234 ± .0071 (78.08)	.2255 ± .0257 (78.82)	.2478 ± .0162 (86.61)
RD 25	.2384 ± .0235 (100)	.1974 ± .0034 (82.80)	.2311 ± .0038 (96.94)	.1892 ± .0264 (79.36)	.2091 ± .0218 (87.71)	.1609 ± .0036 (67.49)
Khao-ta-hang 17	.3772 ± .0044 (100)	.3378 ± .0165 (89.55)	.2847 ± .0090 (75.48)	.2641 ± .0544 (70.02)	.2715 ± .0440 (71.98)	.2712 ± .0169 (71.90)
Nahng-mon S-4	.4038 ± .0049 (100)	.3284 ± .0233 (81.33)	.3494 ± .0147 (86.53)	.2930 ± .0265 (72.56)	.2914 ± .0322 (72.16)	.2455 ± .0146 (60.80)
Khao-dawk-mali 105	.2936 ± .0149 (100)	.2685 ± .0221 (91.45)	.2505 ± .0223 (85.32)	.2362 ± .0252 (80.45)	.2203 ± .0496 (75.03)	.1924 ± .0080 (65.53)
Nahng-pra-yah 132	.2666 ± .0198 (100)	.2433 ± .0221 (91.26)	.2336 ± .0148 (87.62)	.2217 ± .0269 (83.15)	.2230 ± .0560 (83.65)	.2049 ± .0072 (76.85)
Leuang-pra-tew 123	.3249 ± .0158 (100)	.2976 ± .0075 (91.60)	.3067 ± .0112 (94.49)	.2714 ± .0124 (83.53)	.2972 ± .0528 (91.87)	.2373 ± .0113 (73.04)
Nihonbare	.2128 ± .0187 (100)	.2102 ± .0143 (98.78)	.2025 ± .0148 (95.16)	.2010 ± .0145 (94.45)	.1885 ± .0359 (88.58)	.1785 ± .0036 (83.88)
I. rugosum	.1203 ± .0035 (100)	.0328 ± .0082 (27.27)	.0169 ± .0045 (14.05)	0	0	0
E. crusgalli	.0551 ± .0062 (100)	.0350 ± .0206 (63.52)	.0144 ± .0076 (26.13)	.0030 ± .0024 (5.44)	0	0
O. perennis	.1614 ± .0100 (100)	.1243 ± .0329 (77.01)	.0896 ± .0121 (55.51)	.1809 ± .0226 (50.12)	.0798 ± .0249 (49.44)	.0608 ± .0091 (37.67)

Note.--: No experiment.

Dry weight of shoot was taken 14 days after the treatment.

Values in parenthis indicate % of control in each rice varieties or weeds.

Table VIII-3 Dry weight (g/15 plants) of shoot as affected by benthiocarb.

Rice Varieties or Weed / Benthiocarb	0 kg a.i./ha	0.5 kg a.i./ha	1 kg a.i./ha	2 kg a.i./ha	4 kg a.i./ha	8 kg a.i./ha
RD 7	.2539 ± .0457 (100)	.2690 ± .0265 (105.94)	.2430 ± .0208 (95.70)	.2116 ± .0225 (83.33)	.0749 ± .0342 (29.49)	.0630 ± .0235 (24.81)
RD 9	.2295 ± .0121 (100)	.2711 ± .0249 (118.12)	.2028 ± .0026 (88.36)	.1752 ± .0233 (76.33)	.0654 ± .0354 (28.49)	.0436 ± .0218 (18.99)
RD 21	.2892 ± .0212 (100)	.3167 ± .0371 (109.50)	.2655 ± .0186 (91.80)	.2505 ± .0355 (86.6)	.0923 ± .0483 (31.91)	.0838 ± .0239 (28.97)
RD 23	.2751 ± .0399 (100)	.2835 ± .0405 (103.05)	.1773 ± .0142 (64.44)	.1654 ± .0347 (60.12)	.0735 ± .0464 (26.71)	.0587 ± .0108 (21.33)
RD 25	.2365 ± .0115 (100)	.2742 ± .0233 (115.94)	.2333 ± .0187 (98.64)	.2122 ± .0222 (89.72)	.0944 ± .0473 (39.91)	.0933 ± .0270 (39.45)
Khao-ta-hang 17	.3505 ± .0280 (100)	.3382 ± .0312 (96.49)	.3050 ± .0065 (87.01)	.3019 ± .0352 (86.61)	.1990 ± .0370 (56.77)	.1676 ± .0671 (47.18)
Nahng-mon S-4	.3678 ± .0358 (100)	.4078 ± .0282 (110.87)	.4081 ± .0039 (110.95)	.3604 ± .0101 (97.99)	.2460 ± .0640 (66.88)	.1706 ± .0701 (46.38)
Khao-dawk-mali 105	.2111 ± .0213 (100)	.2296 ± .0964 (108.76)	.1816 ± .0527 (86.02)	.1554 ± .1065 (73.61)	.0975 ± .0124 (46.18)	-
Nahng-pra-yah 132	.1975 ± .0327 (100)	.2162 ± .0712 (109.46)	.1754 ± .0182 (88.81)	.1816 ± .0383 (91.94)	.0975 ± .0223 (49.36)	.0244 ± .0184 (12.35)
Leuang-pra-tew 123	.2790 ± .0240 (100)	.2760 ± .0425 (98.92)	.2673 ± .0077 (95.81)	.2332 ± .0213 (83.58)	.1771 ± .0659 (63.48)	.0621 ± .0168 (22.25)
Nihonbare	.2171 ± .0126 (100)	.2454 ± .0390 (113.03)	.2045 ± .0149 (94.19)	.2004 ± .0377 (92.30)	.1006 ± .0349 (46.33)	.0276 ± .0188 (12.71)
I. rugosum	.1290 ± .0479 (100)	.0137 ± .0028 (10.62)	0	0	0	
E. crusgalli	.1041 ± .0244 (100)	.0244 ± .0122 (23.43)	.0056 ± .0036 (5.37)	0	0	
O. perennis	.1972 ± .0293 (100)	.1976 ± .0444 (100.20)	.1292 ± .0411 (65.51)	.0519 ± .0259 (26.31)	.0443 ± .0349 (22.46)	.0030 ± 0 (1.52)

No'e. -: No experiment.

Dry weight of shoot was taken 14 days after the treatment.

Values in parenthis indicate % of control in each rice varieties or [illegible].

Table VIII-4 Dry weight (g/15 plants) of shoot as affected by molinate.

Rice Varieties or Weeds \ Molinate	0 kg a.i./ha	0.1 kg a.i./ha	0.5 kg a.i./ha	1 kg a.i./ha	2 kg a.i./ha	4 kg a.i./ha
RD 7	.3833 ± .0540 (100)	.3392 ± .0372 (88.49)	.2995 ± .0428 (78.13)	.2692 ± .0524 (70.23)	.0731 ± .0153 (19.07)	.0151 ± .0027 (3.94)
RD 9	.1177 ± .0026 (100)	.1032 ± .0169 (92.39)	.0948 ± .0070 (80.54)	.0862 ± .0316 (73.24)	.0237 ± .0097 (20.14)	.0060 ± .0021 (5.10)
RD 21	.3614 ± .0043 (100)	.3507 ± .0221 (97.04)	.3330 ± .0248 (92.14)	.2877 ± .0537 (79.61)	.0453 ± .0079 (12.53)	.0148 ± .0014 (4.10)
RD 23	.3907 ± .0509 (100)	.3387 ± .0350 (86.69)	.2747 ± .0233 (70.31)	.1287 ± .0107 (32.94)	.1267 ± .0609 (32.43)	.0138 ± .0002 (0.04)
RD 25	.2523 ± .0310 (100)	.2302 ± .0197 (94.81)	.2282 ± .0127 (90.45)	.2004 ± .0600 (79.42)	.0664 ± .0123 (26.32)	.0057 ± .0029 (2.26)
Khao-ta-hang 17	.3936 ± .0208 (100)	.3569 ± .0408 (90.68)	.3541 ± .0355 (89.96)	.2552 ± .0765 (64.84)	.0170 ± .0096 (4.32)	.0069 ± .0031 (1.75)
Nahng-mon S-4	.5063 ± .0350 (100)	.3932 ± .0431 (77.66)	.3988 ± .0119 (78.77)	.2644 ± .0756 (52.22)	.0214 ± .0068 (4.23)	.0124 ± .0025 (2.45)
Khao-dawk-mali 105	.3604 ± .0500 (100)	.3120 ± .0348 (86.57)	.2716 ± .0600 (75.36)	.1314 ± .0701 (36.46)	.0237 ± .0029 (6.58)	.0101 ± .0041 (2.80)
Nahng-pra-yah 132	.2702 ± .0071 (100)	.2383 ± .0236 (88.19)	.2335 ± .0468 (86.42)	.1988 ± .0388 (73.58)	.0490 ± .0418 (18.13)	.0078 ± .0032 (2.89)
Leuang-pra-tew 123	.3756 ± .0242 (100)	.3574 ± .0157 (95.15)	.3268 ± .0053 (87.01)	.2908 ± .0232 (77.42)	.1247 ± .0353 (32.20)	.0058 ± .0010 (1.62)
Nihonbare	.2419 ± .0187 (100)	.2238 ± .0099 (92.51)	.2154 ± .0157 (89.04)	.2078 ± .0036 (85.90)	.1972 ± .0098 (81.52)	.0686 ± .0034 (28.35)
I. rugosum	.1234 ± .0132 (100)	.1035 ± .0116 (83.87)	.1004 ± .0145 (81.36)	.1021 ± .0115 (82.74)	.0751 ± .0062 (60.86)	.0164 ± .0037 (13.29)
E. crus-galli	.1027 ± .0124 (100)	.0602 ± .0070 (58.62)	.0565 ± .0141 (55.01)	.0232 ± .0009 (22.59)	.0136 ± .0007 (13.24)	.0054 ± .0009 (5.26)
O. perennis	.1397 ± .0053 (100)	.1254 ± .0225 (89.76)	.0996 ± .0053 (77.30)	.0819 ± .0128 (58.63)	.0285 ± .0040 (20.40)	.0080 ± .0006 (0.43)

Note.-: No experiment.

Dry weight of shoot was taken 14 days after the treatment.

Values in parenthis indicate % of control in each rice varieties or weeds.

Table VIII-5 Dry weight (g/15 plants) of shoot as affected by butachlor.

Rice Varieties or Weeds / Butachlor	0 kg a.i./ha	0.1 kg a.i./ha	0.5 kg a.i./ha	1 kg a.i./ha	2 kg a.i./ha	4 kg a.i./ha
RD 7	.2071 ± .0024 (100)	.1385 ± .0051 (66.88)	.1244 ± .0144 (60.07)	.1157 ± .0177 (55.87)	.1049 ± .0106 (50.65)	.0623 ± .0334 (30.08)
RD 9	.1855 ± .0041 (100)	.1817 ± .0116 (97.95)	.1769 ± .0185 (95.36)	.1489 ± .0108 (80.27)	.1232 ± .0179 (66.42)	.0789 ± .0449 (42.53)
RD 21	.2513 ± .0218 (100)	.2366 ± .0132 (94.15)	.2145 ± .0177 (85.36)	.1831 ± .0102 (72.68)	.1072 ± .0163 (42.66)	.0360 ± .0162 (14.33)
RD 23	.2213 ± .0134 (100)	.2161 ± .0322 (97.65)	.2087 ± .0374 (94.30)	.1854 ± .0070 (83.77)	.1126 ± .0042 (50.88)	.0601 ± .0237 (27.15)
RD 25	.1813 ± .0177 (100)	.1822 ± .0189 (99.36)	.1764 ± .0196 (93.30)	.1521 ± .0362 (83.89)	.1137 ± .0029 (62.71)	.0760 ± .0178 (41.92)
Khao-ta-hang 17	.2966 ± .0193 (100)	.2817 ± .0016 (94.98)	.2605 ± .0447 (87.83)	.2366 ± .0210 (79.77)	.1817 ± .0066 (61.26)	.0498 ± .0187 (16.79)
Nahng-mon S-4	.3132 ± .0312 (100)	.2950 ± .0703 (94.19)	.2799 ± .0233 (89.37)	.2588 ± .0178 (80.10)	.2136 ± .0090 (68.20)	.0394 ± .0174 (12.5)
Khao-dawk-mali 105	.2489 ± .0042 (100)	.2203 ± .0173 (88.51)	.1965 ± .0027 (78.96)	.1699 ± .0243 (68.26)	.1266 ± .0032 (50.86)	.0430 ± .0726 (17.27)
Nahng-pra-yah 132	.2227 ± .0230 (100)	.1786 ± .0458 (80.20)	.1460 ± .0125 (65.56)	.1311 ± .0241 (58.87)	.1218 ± .0079 (54.69)	.0493 ± .0433 (22.30)
Leuang-pra-tew 123	.2732 ± .0047 (100)	.2074 ± .0208 (75.92)	.1674 ± .0312 (61.27)	.2108 ± .0213 (77.16)	.1286 ± .0586 (47.07)	.0453 ± .0245 (16.56)
Nihonbare	.1648 ± .0037 (100)	.1600 ± .0318 (97.07)	.1573 ± .0070 (95.45)	.1350 ± .0332 (81.92)	.1264 ± .0218 (76.70)	.0660 ± .0105 (40.05)
I. rugosum	.1053 ± .0046 (100)	.0085 ± .0036 (8.07)	0	0	0	0
E. crusgalli	.1146 ± .0387 (100)	.0069 ± .0022 (6.02)	0	0	0	0
O. perennis	.1845 ± .0295 (100)	.1536 ± .0878 (83.25)	.1425 ± .0972 (77.24)	.1267 ± .0561 (68.67)	.1008 ± .0511 (54.63)	.0850 ± .0231 (46.07)

Note.-: No experiment.

Dry weight of shoot was taken 14 days after the treatment.

Values in parenthis indicate % of control in each rice varieties or weeds.

Table VIII-6 Dry weight (g/15 plants) of shoot as affected by propanil.

Rice Varieties or Weeds / Propanil	0 kg a.i./ha	0.5 kg a.i./ha	1 kg a.i./ha	2 kg a.i./ha	4 kg a.i./ha	8 kg a.i./ha
RD 7	.5070 ± .0302 (100)	.5097 ± .0261 (100.53)	.5082 ± .0257 (100.24)	.4611 ± .0321 (96.95)	.3642 ± .0235 (71.83)	.3462 ± .0152 (68.28)
RD 9	.4428 ± .0114 (100)	.4556 ± .0173 (102.89)	.4500 ± .0436 (101.63)	.4256 ± .0125 (96.12)	.4062 ± .0258 (91.73)	.3416 ± .0133 (77.15)
RD 21	.5424 ± .0072 (100)	.5212 ± .0276 (96.07)	.5018 ± .0212 (92.50)	.4822 ± .0147 (88.88)	.4492 ± .0200 (82.80)	.4315 ± .0129 (79.54)
RD 23	.5696 ± .0328 (100)	.5572 ± .0046 (97.82)	.4957 ± .0527 (87.03)	.4539 ± .0241 (79.69)	.4415 ± .0323 (77.51)	.4692 ± .0280 (82.37)
RD 25	.4872 ± .0094 (100)	.4845 ± .0105 (99.45)	.4922 ± .0117 (101.03)	.4512 ± .0229 (92.61)	.4184 ± .0274 (85.88)	.3752 ± .0391 (77.01)
Khao-to-hang 17	.5700 ± .0339 (100)	.6203 ± .0119 (105.82)	.6292 ± .0147 (110.39)	.5340 ± .0248 (93.68)	.4817 ± .0129 (84.51)	.4396 ± .0422 (77.12)
Nahng-mon S-4	.6380 ± .0273 (100)	.6478 ± .0219 (101.54)	.5561 ± .0817 (87.16)	.5254 ± .0229 (86.41)	.5166 ± .0369 (80.97)	.4707 ± .0074 (73.78)
Khao-dawk-mali 105	.4635 ± .0684 (100)	.4457 ± .0134 (96.16)	.4473 ± .0079 (96.50)	.4050 ± .0249 (87.38)	.3939 ± .0023 (84.98)	.3784 ± .0079 (81.64)
Nahng-pra-yah 132	.4273 ± .0097 (100)	.4380 ± .0258 (102.50)	.3705 ± .0165 (86.71)	.3764 ± .0247 (88.09)	.3666 ± .0208 (85.79)	.3187 ± .0275 (74.58)
Leuang-pra-tew 123	.6067 ± .0082 (100)	.6340 ± .0456 (104.50)	.6321 ± .0131 (104.19)	.5445 ± .0126 (89.75)	.5281 ± .0343 (87.04)	.4314 ± .0293 (71.11)
Nihonbare	.3722 ± .0232 (100)	.3985 ± .0240 (107.07)	.3932 ± .0181 (105.64)	.3883 ± .0244 (104.33)	.3645 ± .0141 (97.93)	.2527 ± .0149 (67.89)
I. rugosum	.3999 ± .0335 (100)	.1590 ± .0183 (39.76)	.1844 ± .0026 (46.11)	0	0	0
E. crusgalli	.3990 ± .0264 (100)	.1960 ± .0073 (49.12)	.2088 ± .0162 (52.33)	.0050 ± .0 (12.53)	0	0
O. perennis	.4997 ± .0207 (100)	.4636 ± .0156 (92.78)	.4762 ± .0074 (95.30)	.4887 ± .0296 (97.80)	.4233 ± .0056 (84.71)	.3040 ± .0378 (60.84)

Note.-: No experiment.

Dry weight of shoot was taken 14 days after the treatment.

Values in parenthis indicate % of control in each rice varieties or weeds.

Table VIII-7 Dry weight (g 15 plants) of shoot as affected by 2,4-D.

Rice Varieties or Weeds \ 2,4-D	0 kg a.i./ha	0.5 kg a.i./ha	1 kg a.i./ha	2 kg a.i./ha	4 kg a.i./ha	8 kg a.i./ha
RD 7	.4571 ± .0191 (100)	.4347 ± .0176 (95.10)	.4654 ± .0373 (101.82)	.4077 ± .0218 (89.19)	.2992 ± .0437 (65.46)	.2883 ± .0191 (63.07
RD 9	.4510 ± .0209 (100)	.4698 ± .0326 (104.17)	.4585 ± .0163 (101.66)	.4298 ± .0769 (95.30)	.2721 ± .0094 (60.33)	.2636 ± .0094 (58.45)
RD 21	.4643 ± .0238 (100)	.5039 ± .0114 (108.53)	.4917 ± .0579 (105.90)	.5464 ± .0251 (117.68)	.3879 ± .0365 (83.55)	.3356 ± .0130 (72.[illegible])
RD 23	.4937 ± .0176 (100)	.5071 ± .0433 (102.71)	.5000 ± .0059 (101.28)	.5403 ± .0118 (109.44)	.4869 ± .0123 (98.62)	.3727 ± .0464 (75.49.
RD 25	.5224 ± .0332 (100)	.5424 ± .0143 (103.83)	.5471 ± .0398 (104.73)	.5478 ± .0353 (104.86)	.4580 ± .0456 (87.67)	.4207 ± .0160 (80.53)
Khao-ta-hang 17	.5578 ± .0464 (100)	.5524 ± .0632 (99.03)	.5130 ± .0211 (91.97)	.5196 ± .0476 (93.15)	.5072 ± .0564 (90.93)	.4534 ± .0128 (81.28.
Nahng-mon S-4	.5321 ± .0137 (100)	.4783 ± .0209 (89.89)	.4764 ± .0715 (89.53)	.5043 ± .0171 (94.77)	.4356 ± .0172 (81.86)	.4082 ± .0095 (76.72)
Khao-dawk-mali 105	.4378 ± .0076 (100)	.4328 ± .0424 (98.86)	.3938 ± .0082 (89.95)	.3724 ± .0243 (85.06)	.2678 ± .0353 (61.17)	.1955 ± .0055 (44.66)
Nahng-pra-yah 132	.5187 ± .0194 (100)	.4894 ± .0260 (94.35)	.4589 ± .0040 (88.47)	.5425 ± .0029 (104.59)	.4040 ± .0203 (77.89)	.3634 ± .0315 (70.0[illegible]
Leuang-pra-tew 123	.4130 ± .0175 (100)	.5253 ± .1115 (127.19)	.4910 ± .0368 (118.89)	.4813 ± .0295 (116.54)	.3983 ± .0240 (96.44)	.3956 ± .0465 (95.79
Nihonbare	.4350 ± .0115 (100)	.4640 ± .0126 (106.67)	.4043 ± .0234 (92.94)	.3768 ± .0451 (86.62)	.3053 ± .0313 (70.18)	.2433 ± .0460 (55.93)
I. rugosum	.3447 ± .0252 (100)	.3945 ± .0352 (114.45)	.3475 ± .0267 (100.81)	.2387 ± .0106 (69.25)	.2077 ± .0124 (60.25)	.2066 ± .0166 (59.9[illegible]
E. crusgalli	.2767 ± .0117 (100)	.2636 ± .0344 (95.27)	.2918 ± .0210 (105.46)	.2894 ± .0430 (104.59)	.2688 ± .0122 (97.14)	.1248 ± .0101 (45.10
O. perennis	.2471 ± .0176 (100)	.2159 ± .0092 (87.37)	.2268 ± .0198 (91.78)	.2333 ± .0190 (94.41)	.7732 ± .0199 (70.09)	.1571 ± .0279 (63.57.

Note.-: No experiment.

Dry weight of shoot was taken 14 days after the treatment.

Values in parenthis indicate % of control in each rice varieties or weeds.

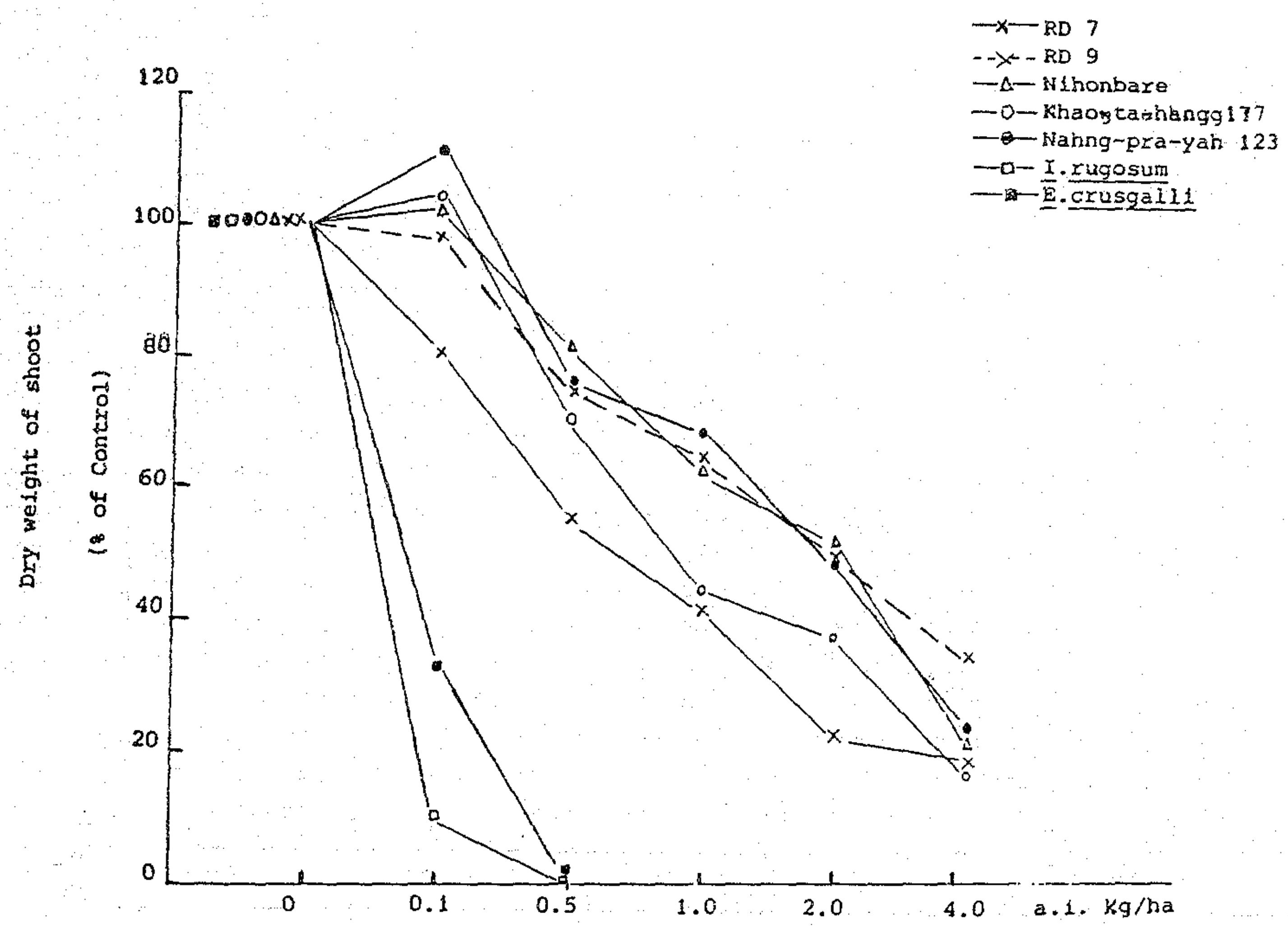

Fig.VIII-I Effects of oxadiazon on the initial growth of selected rice varieties and gramineous weeds.

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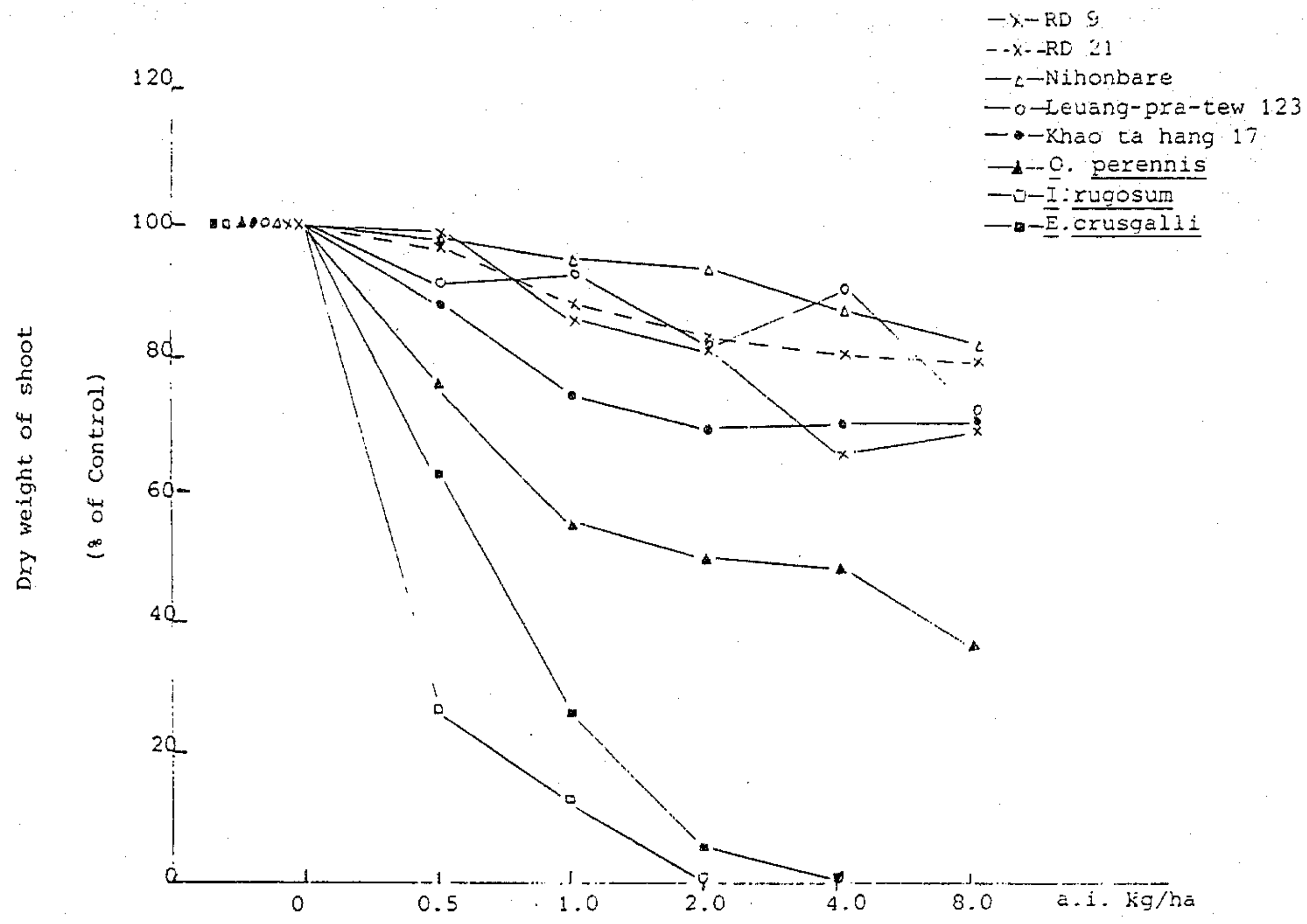

Fig.VIII-2 Effects of CNP on the initial growth of selected rice varieties and gramineous weeds.

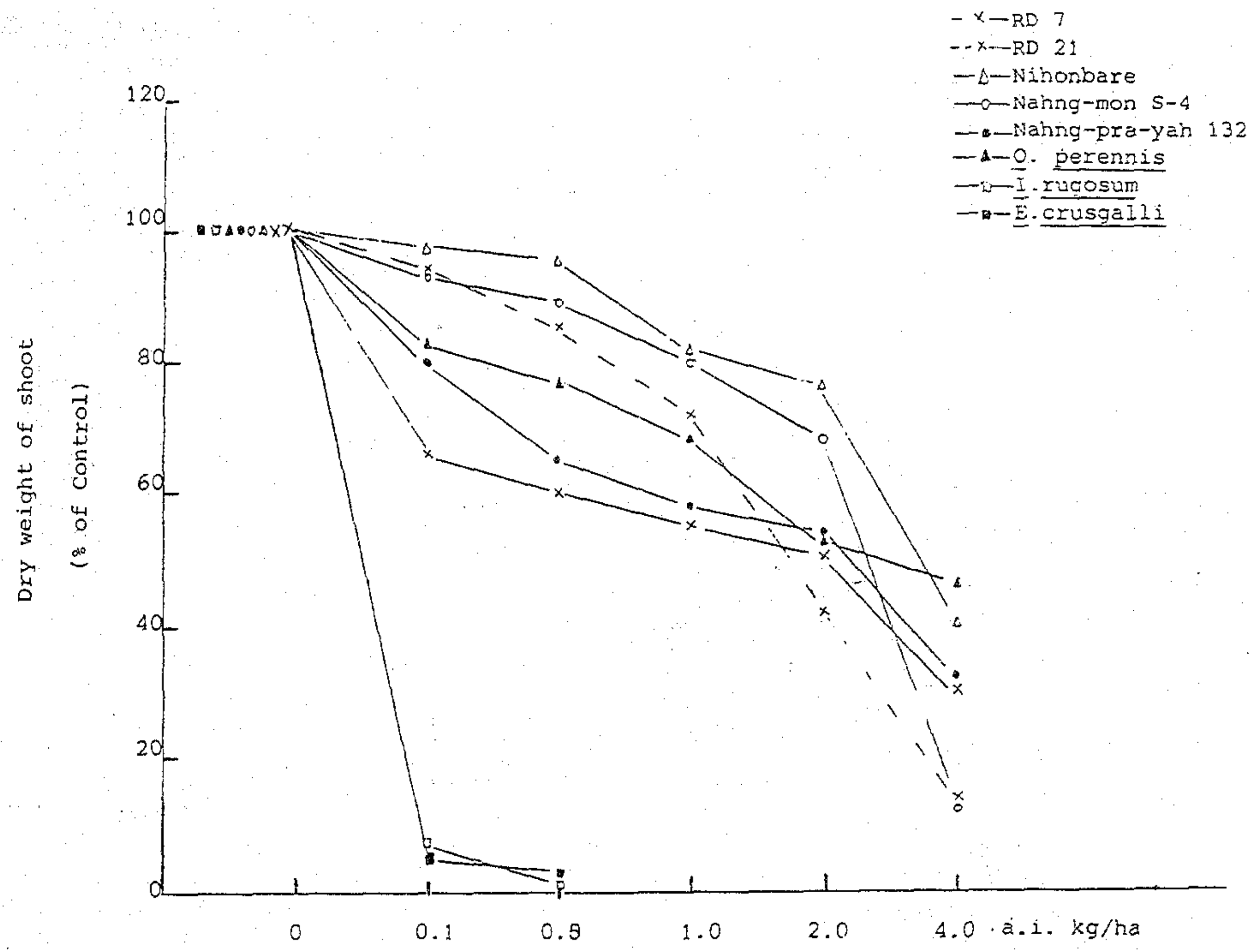

Fig.VIII-5 Effects of butachlor on the initial growth of selected rice varieties and gramineous weeds.

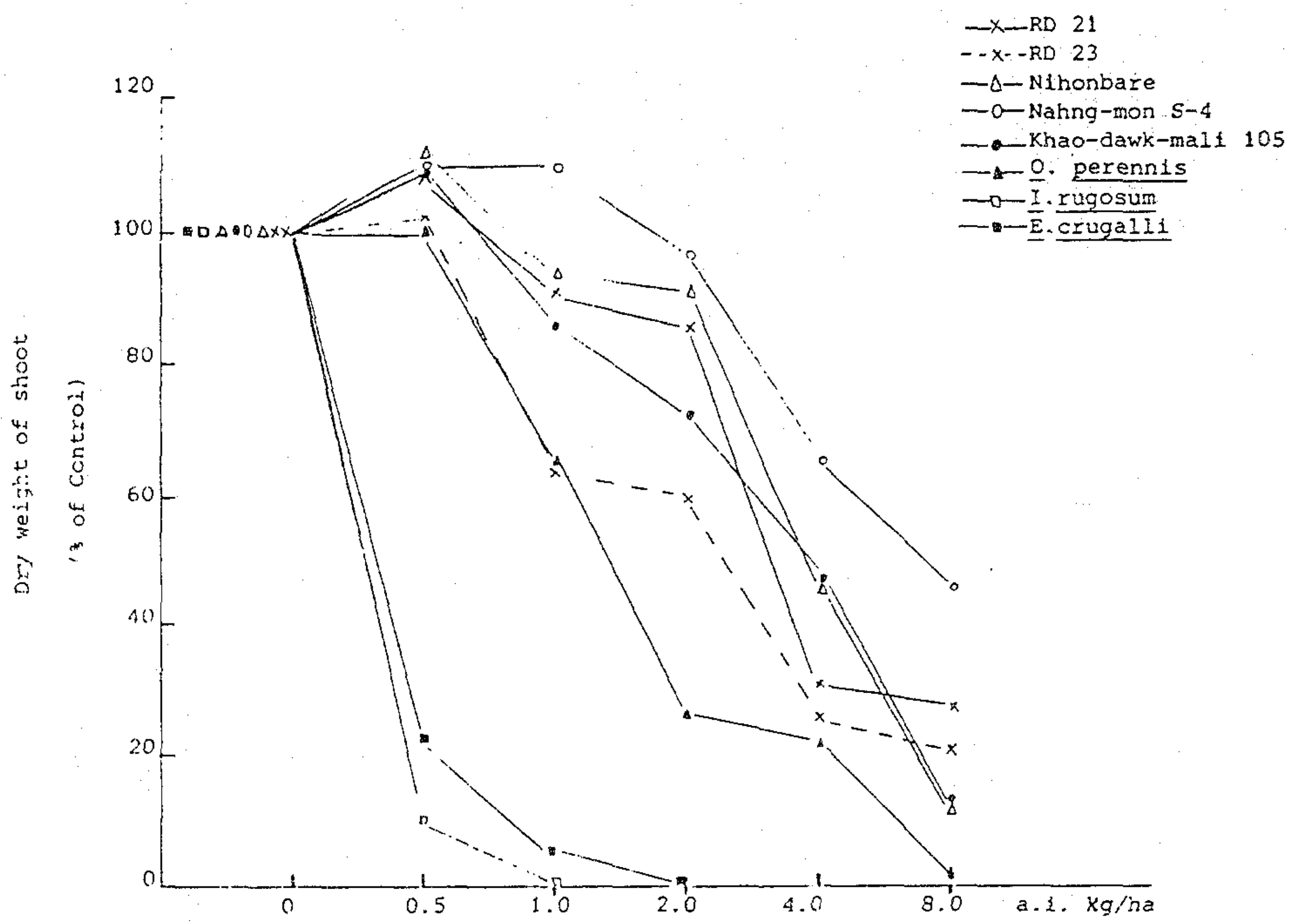

Fig.VIII-3 Effects of benthiocarb on the initial growth of selected rice varieties and gramineous weeds.

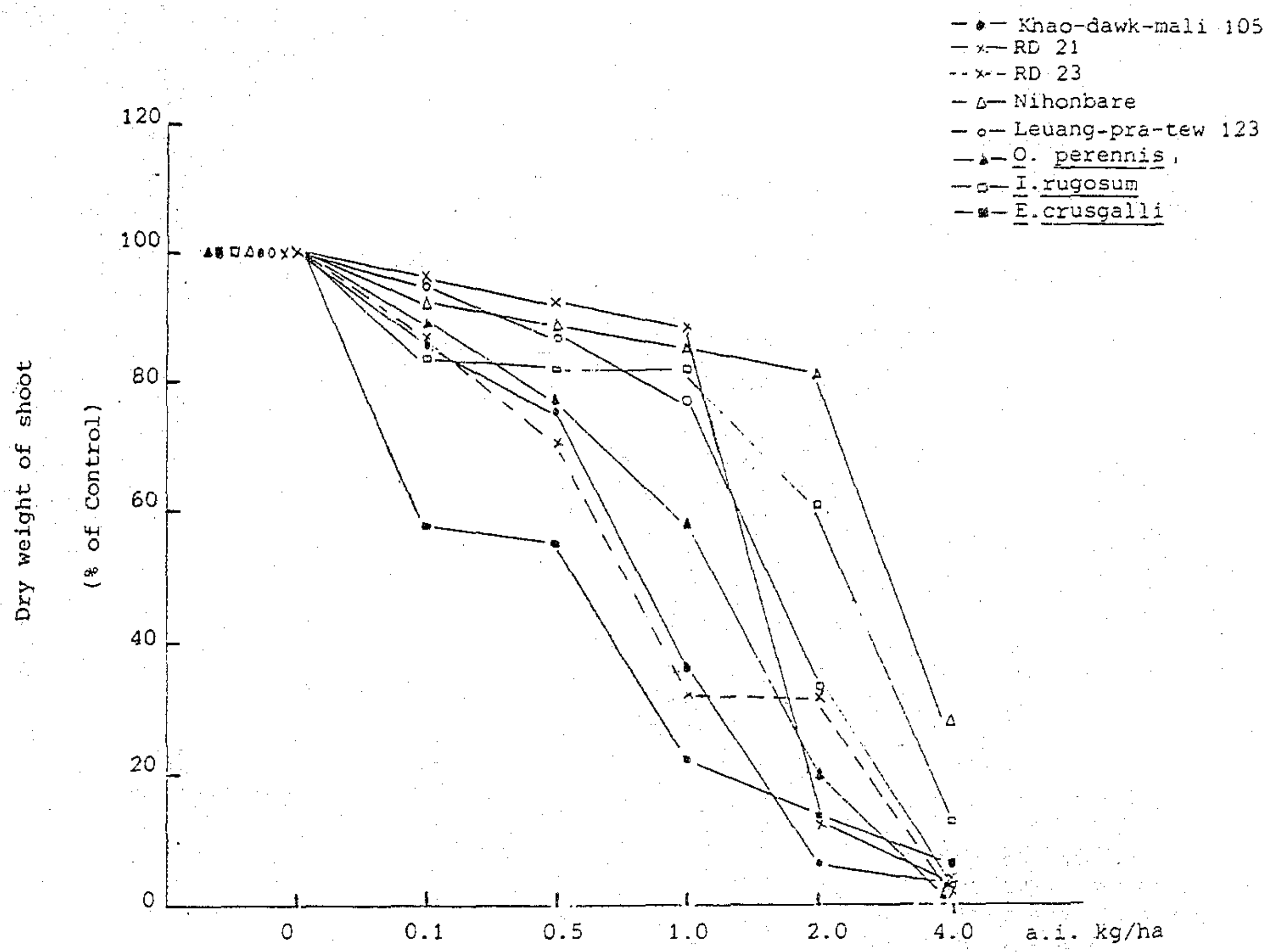

Fig.VIII-4 Effects of molinate on the initial growth of selected rice varieties and gramineous weeds. 76

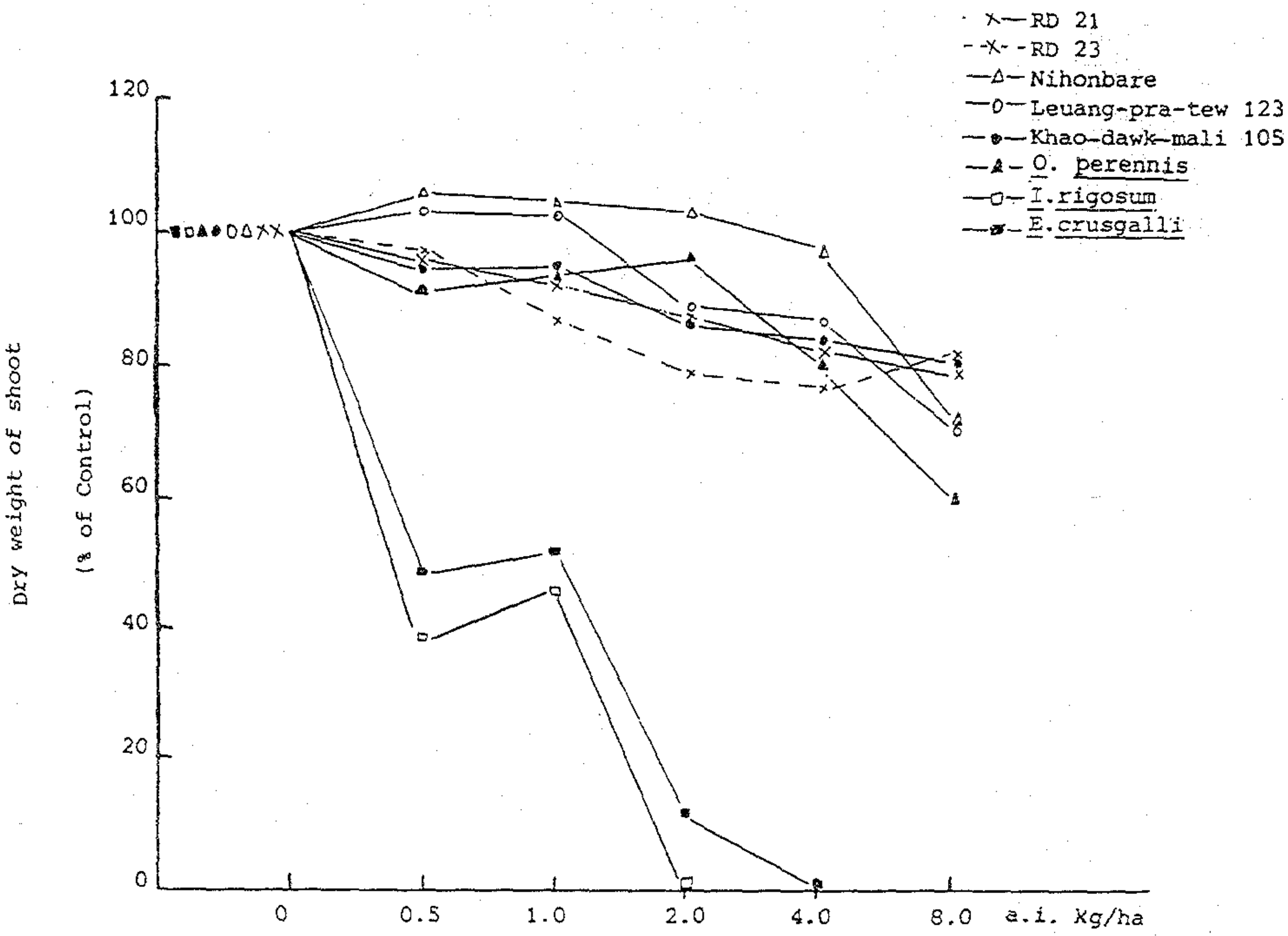

Fig.VIII-6 Effects of propanil on the initial growth of selected rice varieties and gramineous weeds.

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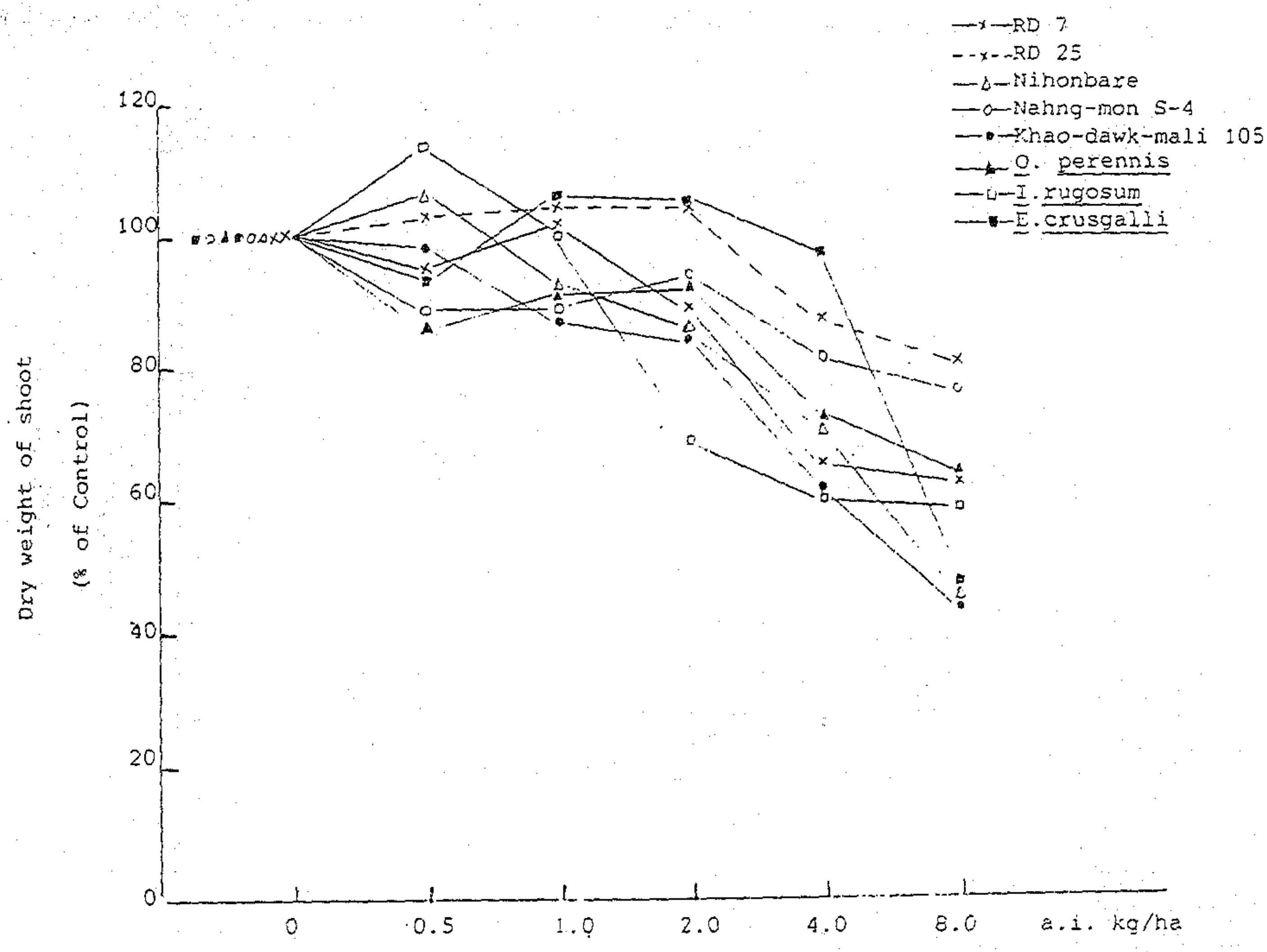

Fig.VIII-7 Effects of 2,4-D on the initial growth of selected rice varieties and gramineous weeds.

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Table VIII-8 . Differential responses of selected rice varieties and gramineous weeds to herbicides (1982).

Herbicides \ Varieties	RD7	RD9	RD21	RD23	RD25	Khao ta hang17	Nahng mon S-4	Khao dawk mali 105	Nahng pra yah 132	Leung pra tew 123	Nihon bare	*O. perennis*	*I. rugosum*	*E. crus-galli*
Oxadiazon	◕	◔	◔	◑	◑	◑	◑	◔	◑	◑	◔	—	●	●
CNP	◑	◑	◔	◑	◑	◑	◑	◔	◑	◑	◔	◑	●	●
Benthiocarb	◔	◕	○	●	◔	◔	○	●	◑	◔	○	◕	●	●
Molinate	◑	◑	◑	◕	◑	◑	◑	◕	◑	◔	○	◕	◑	◑
Butachlor	◕	◑	◑	◑	◑	◔	○	◔	◑	◔	○	◔	●	●
Propanil	◑	◑	◔	◑	◑	◔	◔	◑	◑	◔	○	◔	●	●
2,4-D	◕	◔	◔	◔	◔	◑	◔	◕	◑	◑	◑	◔	◔	◔

Note : ● = Susceptible ◕ = Moderately susceptible ◑ =Moderate

◔ = Moderately tolerant ○ = Tolerant