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벼 直播栽培 類型에 따른 雜草發生 및 벼의 收量에 미치는 影響

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Weed Occurrence and Yield Loss due to Weeds in Different Direct-Seeded Rice Paddy Fields

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ABSTRACT

The pattern of rice cultivation in Korea is changing from hand transplanting and machine transplanting into direct-seeding for low input and cost-down practices. However, there are still some obstacles to establish the direct-seeding cultural practices because of poor seedling stand, lodging, and weed infestation.

In particular, there were much more and wide weed occurrence in direct-seeding rice as compared with the transplanted rice. Weed occurrence in terms of dry weight of weeds was highest in dry direct-seeded rice followed by sowing on puddled soil, sowing on submerged soil in order as compared with transplanting with infant rice seedling.

Echinochloa crus-galli was a common dominant weed with 35~44% distribution in any direct-seeding methods. The dominant weed species were *E. crus-galli*, *Cyperus difformis*, *C. serotinus*, and *Ludwigia prostrata* in dry-seeded rice. The dominant weed species in water-seeded rice were *E. crus-galli*, *Eleocharis kuroguwai*, *Scirpus juncoides*, and *Monochoria vaginalis*.

Yield loss of rice due to weeds at weedy condition was 96% in dry direct-seeded rice. In water-seeded rice, yield loss was 61%, whereas yield loss was 40% in machine transplanting with infant rice seedling.

Key words : Direct-seeded rice, weed occurrence, rice yield.

INTRODUCTION

The pattern of rice planting in Korea is changing from machine transplanting to direct-seeding. Recently, agricultural situation is facing the unfavorable socio-economic environment with rapidly decreasing rural population, poor labor quality, and high wages of rural society due to industrialization of social structure in Korea.

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In addition to those circumstance, free trade of agricultural products would be unavoidable under WTO system. Therefore, how to increase the international competitiveness and food supplies are important tasks to be solved as soon as possible.

The direct-seeding cultivation technology has been developed in Korea and direct-seeding culture covered 11.1% (117,495 ha) of rice cultivated area in Korea in 1995 and this cultivation will be expanded in the future. However, there are still some obstacles to apply the direct-seeding cultural practices due to unstable seedling stand, lodging, and weed infestation[2,5,6,8,9].

In particular, there are much more weed occurrence and its diversity in direct-seeded rice paddy fields as compared with the transplanted rice paddy fields because of longer duration of cultivation period. Furthermore, weeds may generally make canopy ahead of rice because soil has maintained under dry condition until rice seedling stage in dry direct-seeded rice. Both aquatic weeds and upland weeds including semi-aquatic weeds such as *Digitaria sanguinalis*, *Bidens tripartita*, and *Cardamine lyrata* occurred and suppressed rice growth and later reduced yield.[5,8,9,10] *E. crus-galli* was the most serious problem weed species in direct seeded rice because *E. crus-galli* emerged faster than rice under moisture stress[7,8,9].

Therefore, the objectives of the study were to identify the characteristics of weed occurrence and to estimate yield loss under weedy conditions in direct-seeded rice.

MATERIALS AND METHODS

This experiment was conducted in the experimental field at Chungnam Provincial Rural Development Administration from 1992 to 1994.

1. Weed survey in rice farming fields

Weed distribution was surveyed in lowland rice fields over 16 counties of Chungnam Province in order to identify weed community in 1992. Weed sampling was done 2 times with 50×50cm quadrat ($0.25m^2$) at 304 fields. Weed samples were classified and weighed after drying.

2. Weed occurrence and yield loss in direct-seeded rice

Two direct-seeding methods in comparison with machine transplanting were applied for examining the degree of weed infestation and estimating reduction of rice yield under weedy paddy conditions.

Direct-seeding on dry paddy (Dry seeding); Dry seed of rice was drill-seeded on dry paddy fields with 3~4cm soil depth by attachable drill-seeder. Dry condition was maintained up to 2~3 leaf stage of rice seedling and irrigation was started at 3 leaf stage.

Water-seeding; Two kinds of different seeding methods in flooding water were adopted, which were broadcasting on submerged soil by hand and drill-seeding on puddled soil by modified riding type of transplanter. But all results were expressed as a water-seeding by combining two methods because soil conditions were quite similar in terms of standing water on paddy.

Machine transplanting; Infant rice seedlings (8~10 day-old seedling) were transplanted by machine transplanter.

RESULTS AND DISCUSSION

1. Survey of weed distribution in farmer's direct-seeded rice fields

Weed distribution was quite different between direct-seeded rice paddy and transplanted rice paddy as shown in Table 1. The most dominant weed in association with cultural practices were *E. crus-galli* in dry- and water-seeding, *E. kuroguwai* in transplanted rice, and *Aneilema keisak* in hand transplanting, respectively.

Table 1. Survey of weed population as affected by cultural practices in 304 farmer's paddy fields in Chungnam Province in 1992.

Cultural practices	Dominance order				
	1st	2nd	3rd	4th	5th
Direct-seeding					
Dry-seeding	Ec	Ds	Cs	Lup	Cd
	(44)	(29)	(8)	(7)	(4)
Water-seeding	Ec	Ek	Mv	Cs	Sj
	(35)	(25)	(16)	(8)	(6)
Machine transplanting					
Infant seedling(8-10 day-old)	Ek	Ec	St	Mv	Cs
	(27)	(23)	(16)	(6)	(2)
Semiadult seedling(35 day-old)	Ek	Sp	Ec	Cs	Mv
	(45)	(20)	(16)	(9)	(3)
Hand transplanting(45 day-old)	Aj	Cs	Ek	Ec	Sp
	(36)	(24)	(18)	(14)	(6)

Parentheses indicate the ratio of distribution

Ec : *Echinochloa crus-galli*
Lup : *Ludwigia prostrata*
Ek : *Eleocharis kuroguwai*
Ds : *Digitaria sanguinalis*
Lup : *Lindernia procumbens*
Sj : *Scirpus juncoides*
Sp : *Sagittaria pygmaea*
St : *Sagittaria triforlia*
Cs : *Cyperus serotinus*
Mv : *Monochoria vaginalis*
Aj : *Aneilema japonica*
Cd : *Cyperus difformis*

According to the result of nationwide weed survey at the rice field of Korea in 1992, the most 10 dominant weed species were *E. kuroguwai* > *S. trifolia* > *E. crus-galli* > *M. vaginalis* > *Sagittaria pygmaea* > *C. serotinus* > *L. prostrata* > *Potamogeton distinctus* > *A. keisak* > *S. juncoides* in the order.[11] Like above result, *E. kurogwai*, *E. crus-galli*, *S. trifolia*, *M. vaginalis* and *C. serotinus* were dominant weeds at flooded conditions in this survey.

In direct-seeding culture, the most dominant weed species was *E. crus-galli* and its dominance values of dry-seeded and water-seeded rice were 44%, 35% respectively. However, weed species occurred in direct-seeded rice on dry paddy were differ from in water-seeded rice paddy except *E. crus-galli* and *C. serotinus*. In particular, second highest dominant species in dry direct-seeded rice was *Digitaria sanguinalis*, a upland weed. Weed distribution in water-seeded rice was similar with that in transplanted-rice because of the same condition in terms of flooding water condition of paddy.

Regarding occurrence of weed population in dry-seeded rice of farmer's field, *E. crus-galli* was the highest in weight and number of weeds (Table 2). On the other hand, Simpson's dominance index was low with 0.185. This result meaned that various weed species were evenly occurred.

Annual weeds such as *E. crus-galli*, *D. sanguinalis*, *L. prostrata* and *C. difformis* distributed much more than perennial weeds according to the life cycle of weeds. The distribution of grass weeds was high as well. Consequently, *E. crus-galli* was regarded as the most troublesome weed followed by *D. sanguinalis* in direct-seeded rice at all seeding methods.

2. Weed occurrence in direct-seeded rice

Available seeding time for direct-seeding cultivation is very restricted to the period of late April to middle of May because extremely late seeding causes poor yield and quality.

Table 2. Distribution of major weeds occurred in direct-seeded rice in farmer's fields.

Weed species	Life cycle[1]	Classification[2]	Individuals No./m^2	Dry weight (g/m^2)	Simpson's dominance index
Echinochloa crus-galli	A	G	74	184.2	0.062
Digitaria sanguinalis	A	G	64	124.0	0.046
Ludwigia prostrata	A	B	22	28.4	0.005
Cyperus difformis	A	S	32	15.6	0.011
Cardamine lyrata	A	B	4	4.5	0.0001
Bidens tripartita	A	B	2	8.7	0.0001
Aeschynomene indica	A	B	2	9.2	0.001
Rorippa islandica	B	B	2	3.2	0.0001
Aneilema japonica	A	B	3	3.4	0.0001
Lindernia procumbens	A	B	8	0.9	0.0006
Cyperus serotinus	P	S	72	34.4	0.059
Scirpus juncoides	P	S	8	4.3	0.0006
Leersia japonica	P	G	3	9.3	0.0001
Simpson's dominance index					0.1849
Simpson's diversity index					0.8151

[1] A : Annual B : Biennial P : Perennial [2] B : Broaleaves G : Grasses S : Sedges

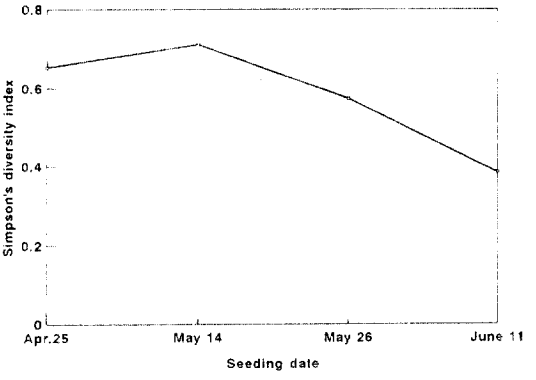

Fig. 1. Changes in Simpson's diversity indices according to the seeding date in direct seeded rice on dry paddy fields.

Fig. 1 shows changes in weed population as affected by seeding time in direct-seeded rice. Diversity index on May 10 was highest among 4 seeding times, indicating that occurrence of weed species was varied. Second highest diversity index was observed at the earliest seeding time. On the other hand, as seeding time was late, diversity index was drastically declined. This result indicated that weed species were occurred variously during the available seeding period as compared with late seeding time. Above phenomenon indicated that a few weeds were getting dominant with late seeding.

Table 3 shows that shift in weed community was observed during 3 years of field trials among the different rice cultivation systems. Dominant weeds in dry direct-seeded rice were *E. crus-galli* and *C. difformis*. During the first year of dry-seeded rice growing, weed species occurred were varied much. Five most dominant weeds were *C. difformis*, *E. crus-galli*, *Eragrostis multicaulis*, *C. sertoinus* and *Rorippa islandia* in discending order. Especially, weeds that became problem in dry direct-seeded rice were *E. multicaulis* and *R. islandica* as a upland weed. In the second year, *E. crus-galli* increased remarkably and occupied 60% of overall weeds occurred. *E. crus-galli* covered all the fields and almost dominant phenomenon was observed in the last year. It indicated that *E. crus-galli* increased more severely in dry direct-seeded rice paddy year by year. Thus, it is essential that *E. crus-galli* should be controlled for the direct-seeding cultivation. Meanwhile, there was no occurrence of *E. kuroguwai*, one of the widest

Table 3. Shift in weed communities at different cultural practices.

Cultural practices		Dominance order					Simpson's dominance index
		1st	2nd	3rd	4th	5th	
Dry-seeding	'92	Cd (31.2)	Ec (29.5)	Em (18.4)	Cs (10.4)	Ri (8.5)	0.292
	'93	Ec (60)	Cd (16)	Cs (12)	Sj (5)	Fm (3)	0.623
	'94	Ec (95)	Cd (1.5)	Fm (1.5)	Lp (0.8)	Cd (0.1)	0.942
Water-seeding	'92	Ek (25.6)	Sj (20.8)	Ec (18.4)	Mv (13.2)	St (8.7)	0.235
	'93	Ec (52)	Sj (15)	Ek (13)	Mv (10)	St (8)	0.342
	'94	Ec (35.8)	Cd (18.4)	Sj (9.8)	Cs (7.8)	Mv (4.8)	0.416
Machine transplanting with infant seedling (8-10 day-old)	'92	Sj (28.7)	Ek (25.4)	Ec (18.6)	Mv (14.4)	Cs (10.2)	0.211
	'93	Ec (32)	Sj (26)	Ek (22)	Cs (15)	Mv (2)	0.251
	'94	Sj (29.6)	Cs (26.4)	Ec (14.7)	Cd (11.5)	Ek (9.8)	0.232

Em : *Eragrostis multicaulis*
Cs : *Cyperus serotinus*
Ec : *Echinochloa crus-galli*
Cd : *Cyperus difformis*
Mv : *Monochoria vaginalis*
Ri : *Rorippa islandica*
Ds : *Digitaria sanguinalis*
Lup : *Ludwigia prostrata*
Lnp : *Lindernia procumbens*
Sj : *Scirpus juncoides*

weed species in flooded condition of Korea. In general, more abundant weeds occurred at the first year culture of direct-seeded rice.[5,10] But *E. crus-galli* might be dominant with successive direct-seeding cultivation year by year.

In water-seeded rice, 3 major dominant weeds were *E. kuroguwai*, *S. juncoides* and *E. crus-galli* throughout 3 years. There were no big changes in weed community for 3 years, but *E. crus-galli* was a dominant weed in the last year as well as that in dry direct-seeded rice.

Weed distribution in transplanted rice was quite similar with water-seeded rice. There were a little changes in weed community in transplanted rice throughout 3 years and major weeds occurred were *S. juncoides, E. kuroguwai, E. crus-galli* and *C. serotinus*. According to these results, *E. crus-galli* was the most troublesome weed at all seeding method in direct-seeded rice. On the other hand, upland weeds such as *E. multicaulis* and *R. islandica*, which were not occurred in flooded condition may make weed control more difficult.

Changes in dominance of weed community in association with the continuous rice growing at different cultural practices were observed (Fig. 2). In dry direct-seeded rice, Simpson's dominance index was increased to 0.942 with the successive cultivation due to dominance of *E. crus-galli*. This result implies that occurrence of weed species was varied in the first year of cultivation, but it was dominant by a few weed species in the last year. Simpson's dominance index was slightly increased in water-seeded rice, but its value was generally low.

In transplanted rice, there was no trend in changes of weed community for 3 year and so

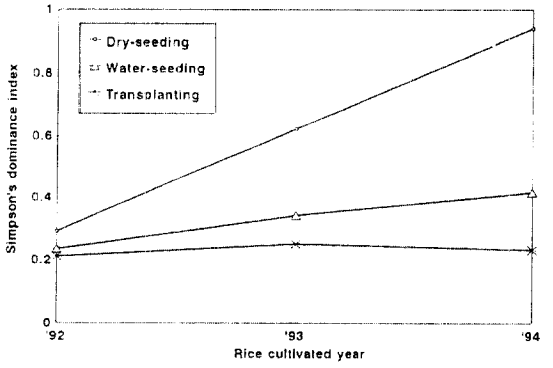

Fig. 2. Changes in weed flora in association with the successive rice cultivation at different practices.

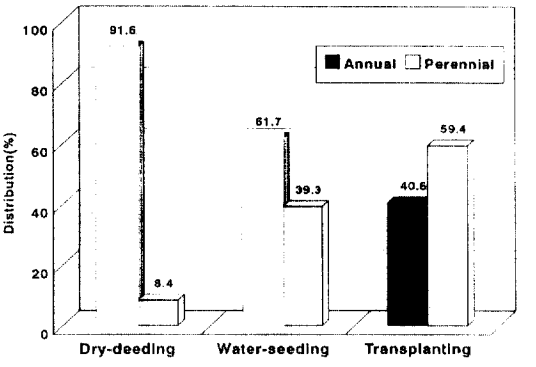

Fig. 3. Distribution of weeds at different practices of rice cultivation based on life cycle.

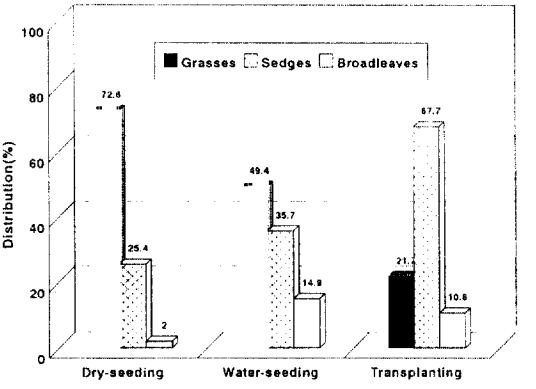

Fig. 4. Distribution of weeds at different practices of rice cultivation based on the morphological characteristics.

Simpson's dominance indicies were quite low with 0.2 more or less.

Eighteen number of weed species were found throughout 3 years successive culture in dry direct -seeding rice paddy (Table 4). However, there were 12 and 10 weed species in water-seeded and transplanted rice paddy, respectively.

Individuals of weed species occurred in dry direct-seeded rice were more abundant than in 2 other cultural practices. Especially, dry weight of weeds in dry direct-seeded rice and water-seeded rice was almost 5 times and 3 times higher than in transplanted rice. This result suggested that weed control was the most serious problem to be solved quickly for successful direct-seeding cultivation.

There were much more annual weeds than perennial weeds in direct-seeded rice. Annual weeds were 91.6% in dry direct-seeded rice and 61.7% in water-seeded rice (Fig. 3). Unlike in direct-seeded rice, perennial weeds covered 59.4% compared to annual weeds in transplanted rice.

Based on morphological characteristics of weeds, grasses was 72.6% in dry-seeded rice and 49.4% in water-seeded rice and sedges covered 67.7% in transplanted rice (Fig. 4).

Above results indicated that annual weeds or

Table 4. Comparison of major weed occurrence in accordance with cultural practices for 3 years.

Cultrual practices	No. of weed species	Individuals (no./m^2)	Dry weight (g/m^2)	Index
Direct-seeding				
Dry-seeding	18	724	1073.6	492
Water-seeding	12	348	723.3	332
Machine transplanting (Infant seedling)	10	274	218.1	100

grasses were more troublesome than perennial and other weeds in direct-seeded rice, particularly in dry direct-seeded rice. Similarity of weed community among the different cultural practices was quite different (Table 5). Similarity showed around 31% between dry-seeded rice and water-seeded rice. But coefficient of similarity was very low with 0.183 between dry direct-seeded rice and transplanted rice. It was confirmed that distribution of weed flora in dry direct-seeded rice was quite different compared to the other cultural practices.

3. Yield loss of direct-seeded rice under weedy condition

Yield loss as affected by weed competition showed significant difference among the cultural practices (Table 6). The highest yield loss, 96% was recorded in dry direct-seeded rice. Yield loss was 60.7% and 40.3% in water-seeded rice and transplanted rice, respectively. That suggests that efficacy of weed control is greatly important to reduce rice yield due to weeds in direct-seeded rice.

Table 5. Similarity of weed distribution among the different cultural practices.

Cultural practices	Water-seeding	Machine transplanting
Dry-seeding	0.312	0.183
Water-seeding		0.487

Table 6. Rice yield loss due to weed competition at different cultural practices for 2 years.

Cultural practices	Rice yield loss (%)		
	'93	'94	Mean
Direct-seeding			
Dry-seeding	91.5	100	95.8
Water-seeding	68.4	53.8	60.7
Machine transplanting	46.5	34.0	40.3

摘 要

벼 직파재배시 가장 문제가 되고 있는 잡초 방제법을 확립하고자 농가답 잡초분포조사, 벼 직파재배 유형에 따르는 잡초발생 및 건답직파재배에서 파종기 이동에 따른 우점초종, 무제초시 재배유형별 수량감소 정도 등을 어린모 기계이앙재배와 비교분석하였다.

1. 벼 직파재배 농가답의 주요 우점잡초는 피, 바랭이, 너도방동산이, 여뀌바늘 등으로 피는 44%로서 가장 많이 발생되었으나 Simpson 우점지수는 0.185로서 낮아 여러 초종이 다양하게 분포된 결과를 보였다.
2. 건답직파에서는 피 > 알방동산이 > 너도방동산이 > 여뀌바늘, 담수직파답에서는 피 > 올방개 > 올챙이고랭이 > 물달개비 순으로 우점되어 벼 직파재배시에는 피가 공통적으로 우점초종이었다.
3. 벼 재배유형별 건물중으로 나타낸 잡초발생량은 건답직파답에서 1,074g/m^{2}로 가장 많이 발생되었으며, 담수직파답에서는 723g/m^{2}으로 어린모이앙답의 218g/m^2 보다 각각 3.3~5배 정도 더 많았다.
4. 무제초시 잡초발생에 따른 벼의 수량감소는 건답직파답에서 96%로 거의 수확량이 전무한 상태였으며 담수직파답에서는 61%, 그리고 어린모이앙답에서는 40% 감수되었다.

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