EFFECTIVE WEED CONTROL TECHNOLOGY FOR DRY SEEDED RICE IN KOREA

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Summary. Newly developed direct seeding method, high-ridged dry seeding of rice, was evaluated on yield performance with stability, weed ecology, and effective weed control method. This new direct seeding method resulted in as much grain yield and stability as the conventional mechanical transplanting method through good seed germinability and uniform seedling growth. Several herbicide recommendations were summarized. Basically, two (or three) herbicide applications were needed, one (or two) at the period of upland soil condition and another one at the period of permanent flooding condition.

INTRODUCTION

Recent international and local socio-economic situation made a significant change in agricultural research activity in Korea: better grain quality in varietal improvement program and low production cost in cultivation technology development program to meet international market competition. Currently, more than 90% of rice area is transplanted by mechanical transplanter (58% for aged seedling, 30-35 days old and 33% for infant seedling, 8-10 days old) while remaining areas are mostly manually transplanted (12). Labor hour requirement of rice crop was 540 hrs/ha for Korea (5), 480 hrs/ha for Japan (5), and 25 hrs/ha for USA (14).

Since 1987 the Yeongnam Crop Experiment Station has intensively studied on developing new technology of direct seeding method in rice crop and thus released a new technology, high-ridged dry seeding method. The success of this technology was almost relied on the successful control of weeds. The paper discusses mainly effective weed control measures.

METHODS

Tractor attachable rice drill seeder can be manipulated either high ridged seeding or flat seeding. One way passing of this seeder produce 6 seeding rows making about 50 cm canal in the center and the digged soils in this canal are used as seed covering material to both sides. Land was not plowed until seeding date to minimize the harmful effect of excessive rainfall. Only one or two rotavations is needed for seeding. Basal fertilizer was manually broadcasted just before rotavation. One hundred sixty kg/ha of nitrogen was applied in 5 splits with the rate of 30% for basally, 20% for 3 leaf stage, 20% for 7 leaf stage, 20% for panicle initiation stage, and 10% for flowering stage, respectively while phosphorus (90 kg/ha) and potassium (110 kg/ha) were all applied as basally. After one or two rotavations, well cleaned intact seeds were sown at the rate of 50 kg/ha and followed by one canal irrigation which is essential in this technology. For the first 30-40 days until rice leaf reaches 4-5 leaves the field maintained upland condition and thereafter maintained flooded condition as normal paddy rice field.

Herbicide research and weed ecology were mostly concentrated on the first 30-40 days (upland soil condition period). The herbicides used during the experimental period were mostly marketable herbicides for transplanted rice in Korea. Herbicides were basically tested in three stages: *stage 1*, for pre-emergence both in rice and weed; *stage 2*, for pre- and post-emergence (pre-emergence of rice and post-emergence of weed); and *stage 3*, for post-emergence both in rice and weed. Crop protection and other cultural practices were followed by the standard

methodology for rice crop in Yeongnam Crop Experiment Station (15) while those for data collection was followed by Rural Development Administration (13).

RESULTS AND DISCUSSION

Advantages of High Ridged Seeding Technology

Since 1987 the author published several research papers related on high ridged dry seeding: for seeding method (2, 3, 11), for seeding time (8, 10), for seeding rate (4), for water management (6), for weed control (7, 9), for yield potential and stability (2), and for economic analysis (3), respectively. A series of this research resulted in several advantages of this technology. One canal irrigation just after seeding provided quite a stable environment for seed germination and thus resulted in better seed germination, seedling growth, lodging tolerance, herbicidal efficacy and minimized the harmful effect of barley straw, stubble and other crop residues in double cropping, excess soil moisture damage, and herbicidal phytotoxicity.

The productivity of this technology for 6 years was 4.52 t/ha in polished rice which was 98% of transplanted rice while coefficient of variation of this yield was 8.5% for new technology and 6.4% for transplanted rice, respectively (Table 1).

Table 1. Comparison of the yield productivity between mechanical transplanting and high-ridged dry drill seeding (polished rice, t/ha)

Year	Mechanical transplanting (A)	High-ridged dry drill seeding (B)	Index (B/A)
1987-1992	4.60	4.52	98
CV%	6.4	8.5	-

Effective Weed Control Method

Weed ecology. Among the rice cultivation methods dry seeding method resulted in the greatest weed growth and thus weed control is of prime importance in success of the new technology. During experimental period (1987-92) yield loss due to weed growth was 70-100% for dry seeding, 40-60% for water seeding, 30-35% for mechanical transplanting of infant seedling (8-10 days old), 25-30% for mechanical transplanting of aged seedling (30-35 days old), and 10-20% for manual transplanting, respectively. More than two fold of weed was harvested at dry seeding than at manual transplanting.

Shift of cultivation method from transplanting to dry seeding resulted in change of not only total weed biomass but also floristic composition. Recently the occurrence of *E. crus-galli* has rapidly increased.

This was not an important weed in 1980 weed survey. Recently, herbicides were predominantly developed as a mixtures with sulfonyl ureas which have relatively poor efficacy to grasses. And also, labor shortage and high labor wage resulted in a tendency to reduce tillage operation and

poor water management. These all might be contributed to increase of *Echinochloa* species. One other possible contribution is the possibility of the development of herbicide resistant strain.

After three years consecutive dry seeding of rice the floristic composition was drastically changed. The most important weed species was *Echinochloa* species having dominance of 47.2% followed by *Digitaria adscendens* (9.6%), *Aeschynomene indica* (7.5%), *Leptochloa chinensis* (6.7%), etc. One interesting thing was the occurrence of weedy rice.
The occurrence of weedy rice might possibly be originated from shattered grain in previous year, outcross among cultivated cultivars, and/or outcross between cultivated rice cultivar and red rice. Strictly speaking, the term of weedy rice imply the collective term of a descendant between cultivated rice and wild rice (1). Author, however, included the above three categories as weedy rice.

Chemical control. Even though there is an increasing awareness of the importance of the integrated weed management concept herbicide is working on key factor on this concept particularly in dry seeding method.It can be said that herbicide recommendations are well established in irrigated rice field and thus it was focused mainly on first 30-40 days of upland period.

Table 2. Herbicidal efficacy of several soil applied herbicides as affected by irrigation regime

Herbicide (a.i. g/ha)	Water solubility (ppm)	Flushing[a]		Canal irrigation	
		Phytotoxicity (1-9)	Herbicidal efficiacy (%)	Phytotoxicity (1-9)	Herbicidal efficacy (%)
. butachlor (1800)	240	1.2	83	1	60
. thiobencarb (2800)	30	1.0	85	1	45
. chlomethoxyfen/ butachlor (2700)	0.3/240	1.0	86	1	60
. pyrazolate/ butachlor (2850)	0.05/240	1.0	85	1	55
. pyrazoxyfen/ butachlor (2850)	0.9/240	1.0	86	1	60
. butachlor/ bensulfuron-methyl (801)	240/8	2.0	95	1	65
. mefenacet/ bensulfuron-methyl (789)	8/8	1.5	94	1	50
. thiobencarb/ bensulfuron-methyl (1539)	30/8	1.5	94	1	60
. molinate/ pyrazosulfuron-ethyl (1521)	800/221	1.5	96	1	85
. thiobencarb/ pyrazosulfuron-ethyl (1521)	30/221	1.5	95	1	76

[a] Flushing: 3-6 hours flooding.

Several granular herbicides currently use in transplanted rice were screened the herbicidal performance and phytotoxicity as pre-emergence application. Most of herbicides performed better at flushing of water (3-6 hours flooding just after herbicide application) than canal

irrigation (Table 2). Among herbicides the mixture of molinate/pyrazosulfuron-ethyl had the greatest herbicidal efficacy in both water regimes. Effective herbicide recommendations for new direct seeding technology were summarized in Table 3 based on 5 years research.

Among those, just before the rice emergence about 12-15 DAS application of herbicide mixtures of pre-emergence soil-treatment herbicides and post-emergence foliar application herbicide were particularly effective throughout the experimental period.These were propanil mixtures : propanil+butachlor, propanil+pendimethalin, and propanil+thiobencarb. The maximum safety and good herbicidal efficacy can be achieved by application of these herbicides at just before rice emergence but weeds are almost complete their emergence. *Echinochloa* species were usually emerged faster than rice by 4-6 days. As mentioned early one additional herbicide application was needed just after permanent irrigation about 40 days after seeding. Therefore, basically two (sometimes three) herbicide applications are needed for this new technology, one (or two) application for dry period and another one for flooding period. Non-selective contact herbicides of paraquat, glyphosate, or glufosinate ammonium are sometimes applied either single application before seeding or tank mix application with butachlor, pendimethalin or thiobencarb for controlling the developed weeds such as *Alopecurus aequalis*.

Table 3. Effective herbicides for controlling weeds in dry seeded rice

Application time	Herbicide (formulation)	Dosage (kg a.i./ha)	Phytotoxicity (1-9)	Efficacy (%)	Test year
0-5 DAS* (phase 1)	. pendimethalin (32.7EC)	1.60	1	75-93	1990-93
	. pyrazosulfuron-ethyl/ butachlor (0.07/2.5G)	0.77	1	70-92	1991-93
	. pyrazosulfuron-ethyl/ thiobencarb (0.07/5G)	1.52	1	73-95	1991-93
	. pyrazosulfuron-ethyl/ molinate (0.07/5G)	1.52	1	70-92	1991-93
	. mefenacet/bensulfuron-methyl/dymron (3.5/0.13/1.5G)	1.54	1	73-93	1991-93
	. pyrazosulfuron-ethyl/ quinclorac (0.07/1G)	0.32	1	90-95	1991-93
	. bensulfuron-methyl/ quinclorac (0.17/1G)	0.35	1	88-92	1991-93
12-15 DAS (phase 2)	. propanil + butachlor (35 + 33 EC)	1.4+1.3	1	92-98	1989-93
	. propanil + pendimethalin (35 + 31.7 EC)	1.4+1.3	1	95-98	1990-93
30-35 DAS (phase 3)	. quinclorac/bentazon (10/40 WP)	1.5	1	90-98	1989-93

* DAS; days after seeding.

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