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# Cultural Management to Control Weedy Rice in Paddy Field

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**ABSTRACT : To obtain a basic information on the development of effective control strategies for weedy rice in direct seeding rice cultivation, occurrence patterns of weedy rice as influenced by different cultural practices such as cultivation method, water management, seeding time, and tillage were investigated in field or pot experiments. High occurrence of weedy rice was observed in a continuous direct seeding paddy field as compared to machine transplanted one. Based on the percent of weedy rice panicle over three years trial, high ridged dry seeding was highest with 36.9%, followed by wet seeding with 30.9%, water seeding with 14.6% and machine transplanting rice with 0.8%, indicating 97.8% reduction in weedy rice occurrence by machine transplanting rice as compared with high ridged dry seeding. Germination of weedy rice was promoted to 83~94% when rice panicle was flooded from September 30 to October 10 for 6 days and 74-88% for 9 days on October 20. Weedy rice occurrence was also substantially reduced by delayed seeding on June 10 and intensive tillage. The results suggest that machine transplanting rice be more effective cultural practice than flooding treatment, delayed seeding and intensive tillage when weedy rice problem occurs in direct seeded paddy field.**

***Keywords* :** weedy rice, direct seeding, cultivation method, water management, seeding date, tillage.

Direct-seeded rice cultivation has been practiced in Korea since 1993 as a labor saving technology. The area of direct seeding cultivation in 1999 was only 70,741 ha which is 6.6% of the total rice cultivation area in Korea but government expects the area of direct seeding to increase further due to labor shortage and aged farmer in countryside. One of the key technologies for the success of direct seeding cultivation is development of an effective weed control technology, especially for a weedy rice.

In Korea, weedy rice has already considered as the second most troublesome weed next to *Echinochloa crus-galli* in direct seeded paddy field (Kim, 1997). So far, 0.5 to 35% of rice field in southern Korea has already infested with weedy rice and further expansion of its population is expected with increase in direct seeding rice cultivation.

Infestation of weedy rice in cultivated rice reduced not only rice grain yield but also grain quality (Smith, 1981; Kim *et al.*, 1998). Weedy rice density of 5 plants per reduced grain yield by 22% (Kwon *et al.*, 1991a). Weedy rice shows higher germination than cultivated rice even at low temperature (Son, 1995; Chung, 1998) and grain shatters more easily (Watanabe *et al.*, 1996; Park *et al.*, 1997).

Many scientists have worked on control of the weedy rice by herbicides but no effective herbicides have been reported yet (Diarra *et al.*, 1985; Kown *et al.*, 1991b; Son *et al.*, 1999) since there were no selective herbicides for weedy rice because of morphological and physiological similarity to cultivated rice. In recent, the use of transgenic rice has been suggested as another approach to alleviate a weedy rice problem (Braverman and Linscombe, 1994) but its application is still under consideration in Korea because of environmental safety. All these facts make weedy rice as a problem weed in paddy field. Although there are still no easy solutions, other control method like cultural practices to reduce the severity of the problem might be available.

The establishment of effective control strategies for weedy rice is one of the most important issues needed to solve for the further expansion of the direct seeded rice cultivation technology in Korea. The objective of this study was to investigate effective cultural practices which can employ for weedy rice control in direct seeded paddy field.

## MATERIALS AND METHODS

### Cultivation method

A field experiment was conducted at the National Yeongnam Agricultural Experiment Station (NYAES) from 1995 to 1997. The experiment soil was clay loam with pH 5.6 and 2.7% organic matter. Four rice cultivation methods, i.e. high ridged dry seeding, wet seeding, water seeding, and machine transplanting, were employed. The field was divided into 4 plots for each cultivation method. The plot, 27.8 m long and 7 m wide, was subdivided into two plots (27.8 m×3.5 m each); one for a purple rice and the other for a cultivated rice, 'Naepoongbyeo'. The purple rice plot for each cultivation method was included in order to differentiate cultivated

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rice and weedy rice easily in the purple rice plot during early growth stage. The position of cultivated rice and purple rice plots in each cultivation method was changed alternatively every year.

For the direct seeding method, 'Naepoongbyeo' and purple rices at 50 kg/ha were drill seeded with a row spacing of 25 cm in high ridged dry seeding and 30 cm in wet seeding. Dry seeds were used in dry seeding while pregerminated seed (1~2 mm long) were used for wet seeding. For water seeding, seed soaked in tap water for 24 hours was broadcasted at 50 kg/ha in 10cm water deep. Seeds were sown on May 5 for all direct seeding cultivation methods. For machine transplanted rice, 30 days old seedlings were transplanted on June 5 after grown in seedling tray in greenhouse.

A 100 kg N/ha as urea was applied for high ridged dry seeding. Fifty percent of nitrogen was applied as preplant incorporation, 30% at the 5th leaf stage and 20% at panicle formation stage. On the other hand, 110 kg N/ha was used for other three cultivation methods. Phosphorus at 70 kg/ha was applied basally and potassium at 80kg/ha was applied as 80% basal and 20% at panicle formation stage, regardless of cultivation methods. All plots were flooded after seedling emergence and they remained flooded until rice matured at fall.

For general weed control, all plots were treated with pendimethalin/propanil at 0.75 kg/0.75 kg ai $ha^{-1}$ after rice emergence with a spray volume 1,000 L $ha^{-1}$ and pyrazosulfuron/molinate at 21 g/1.5 kg ai $ha^{-1}$ 25 days after seeding (DAS). Weeds not controlled by herbicide treatment were removed by hand.

Weedy rice occurrence was expressed in the ratio of the weedy rice panicle to cultivated rice and weedy rice panicles instead of weedy rice density because differentiation of weedy rice and cultivated rice plants was difficult at early seedling stage. Panicle numbers of cultivated rice and weedy rice per for high ridged dry seeding, wet seeding and machine transplanting methods were recorded after panicle heading. For water seeding method, panicle number of 50×50 cm were recorded and then converted into number of panicle/$m^2$.

### Water management

Four weedy rices collected from Chongdo, Yongdong, Maejeon and Dalsung places were grown in the seedling tray in greenhouse. Thirty-day-old seedling was transplanted by hand on June 5, 1998 at the NYAES experimental field. After panicle heading (Aug. 22 for Majeon, Dalsung; Aug. 24 for Chungdo, Yongdong weedy rices), panicles were tagged with a label and collected at 10 days intervals from September 30 to October 20. The freshly collected rice panicles were placed on the soil surface in the pot (50 cm×40 cm×10 cm) filled with 10 kg clay loam soil. The pot was placed in an open area to stimulate a natural condition and maintained the 3 cm water deep for 3 to 12 days. Germination percentage was recorded at 20 days after treatment. Seeds are considered germinated when radicle was emerged about 2 mm long. Treatment was replicated three times.

### Seeding date

'Naepoongbyeo' was sown in flat dry seeding at 50 kg/ha on April 25, May 10, May 25, and June 10, 1997. Size of individual subplot was 20 m by 5 m. Weedy rice density before seeding while panicle ratio of weedy rice to cultivated rice after heading was determined by placing four 1 $m^2$ quadrats at random in each plot.

### Tillage method

A field experiment was conducted at NYAES from 1992 to 1994. The whole plots consisted of three tillage regimes: rotary, fall plowing with rotary, and spring plowing with rotary. Size of individual subplots was 27 m by 8 m. 'Hwanambyeo' was sown in high ridged dry seeding. Field was plowed to 20 cm depth around November 15~20 for fall plowing and March 10~20 for spring plowing. All the fields were rotavated before seeding. Weedy rice occurrence was expressed in panicle ratio of weedy rice to cultivated rice after panicle heading.

### Statistical analyses

Treated mean was calculated and analyzed using Least Signifiant Differences (LSD).

## RESULTS AND DISCUSSION

### Cultivation method

Weedy rice occurrence patterns in four rice cultivation methods were significantly different. In high ridged dry seed-

**Table 1.** Panicle ratio of weedy rice as influenced by rice cultivation methods.

| Cultivation method | Panicle of weedy rice (%) | | |
|---|---|---|---|
| | 1995† | 1996 | 1997 |
| High ridged dry seeding | 0.1 | 10.5 | 36.9 |
| Wet seeding | 0.1 | 9.7 | 30.9 |
| Water seeding | 0.2 | 6.4 | 14.6 |
| Machine transplanting | 0.1 | 0.0 | 0.8 |
| LSD (0.05) | ns‡ | 5.1 | 7.2 |

†density of weedy rice occurrence.
‡not significant.

ing, even though weedy rice occurrence was as low as 0.1% at the first year but it increased rapidly from the second year (Table 1). Similar trend of weedy rice occurrence was observed in wet and water seeding methods. Based on the percent of weedy rice panicle after three year trial, high ridged dry seeding was highest with 36.9%, followed by wet seeding with 30.9%, and water seeding with 14.6%. On the other hand, in machine transplanting rice, weedy rice did not occur at the second year trial and the percent of weedy rice panicle at the third year was as low as 0.8%, indicating 97.8% reduction in weedy rice occurrence in machine transplanting rice as compared with high ridged dry seeding. This result suggests that change of cultural practice to machine transplanting be effective in reducing weedy rice occurrence when a weedy rice problem occurs in direct seeded paddy field. Chung *et al* (1998) also found that weedy rice occurrence was reduced as high as 99% by changing cultivation method from flat dry seeding to machine transplanting.

The difference in occurrence of weedy rice according to cultivation methods can be explained by different cultivation environments associated. In high ridged dry seeding and wet seeding methods, a field remains dry condition for 15 to 25 days after seeding until rice seedling grows upto the 4th to 5th leaf stages. Under such conditions, most weedy rice on the soil surface emerged faster than the cultivated rice since weedy rice seed in the soil had already absorbed enough moisture for germination. This could have led to high weedy rice occurrence in both high ridged dry seeding and wet seeding methods.

On the other hand, with water seeding method, the field was subjected to flooding from seeding time to seedling emergence. When soil is submerged, gas exchange, especially for oxygen between soil and air is impaired (Ponnamperma, 1973). This might have suppressed the weedy rice germination and thereby lowered weedy rice occurrence as compared with high ridged dry seeding and wet seeding methods. Similarly, in transplanting rice, a combination of late transplanting and water flooding further suppressed weedy rice occurrence. In the transplanting plot, occurrence of 10 weedy rice plants per $m^2$ was observed before seedling transplanting (data not shown). Choi *et al.* (1995) also found higher weed and weedy rice occurrence in dry seeded paddy field as compared with that in water seeding and transplanting.

### Water management

Germination of four weedy rices was enhanced by water flooding but it was different depending on time and duration of water flooding. Germination of weedy rice was highest at September 30 treatment and then it gradually decreased thereafter regardless of flooding durations as flooding time delayed. When panicles of Chungdo, Youngdong and Majeon weedy rices were subjected to flooding treatment on September 30 for 3 days, germination percentage was ranged from 73 to 84% but germination was significantly increased to 93~95% for 6 days flooding (Fig. 1). Exposure of rice panicles longer than 9 to 12 days flooding did not increase germination further as compared with 6 days flooding. Similar germination trend was observed on October 10 treatment although it was not statistically significant in flooding durations. On the other hand, when flooding treatment was made longer than 9 days on October 20, germination percentage of weedy rice significantly increased except for Yongdong weedy rice wherein germination was significantly enhanced even after 6 days flooding. This result indicates that flooding rice fields immediately after rice harvest for 6 days between September 30 and October 10 and for 9 days on October 20 can promote germination of shattered weedy rice grains before or during combine harvest and thereby reduce weedy rice population subsequent cropping year, killing emerged seedling by frost temperature during overwintering in the temperate country like Korea. Low percentage of germination in October 20 flooding treatment was probably due to low temperature for seed germination.

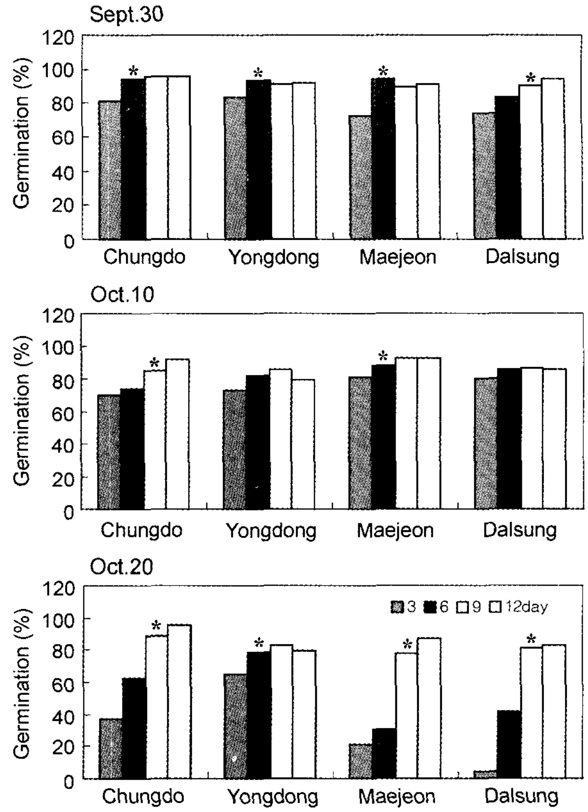


**Fig. 1.** Germination percentage of weedy rices as influenced by flooding time and duration. *significant at LSD (0.05).

Similar weedy rice control effect by water management was observed by Smith (1981). Son (1995) also reported that most of freshly harvested weedy rice had germinability in laboratory condition and 83% of weedy rice was viable even after overwintering. Therefore, shattered weedy rice on the soil surface should be controlled to prevent seed of weedy rice from infesting rice field in succeeding years. This practice can be employed by sowing an early-maturing rice cultivar in paddy field infested with weedy rice which, in return, harvests early.

## Seeding date

Weedy rice occurrence was significantly reduced as seeding date was delayed from April 25 to June 10. Seedling number of emerged weedy rice before seeding was increased as seeding date delayed but the reverse was true after seed sowing (Table 2). Weedy rice of 13 plants per $m^2$ occurred at April 25 seeding but no occurrence was observed at June 10 seeding. This indicates that delayed seeding is effective in reducing weedy rice population. This difference in emergence among seeding dates was due to environmental influences. The higher occurrence of weedy rice at April 25 seeding than that at June 10 seeding was largely due to cool temperatures in April (Fig. 2). However, at the time of June, a rice field is generally moist due to frequent rain, and soil and air temperature increase which are favorable

**Table 2.** Occurrence of weedy rice and days to rice seedling emergence as influenced by seeding date.

| Seeding date | Weedy rice ($plant/m^2$) | Panicle of weedy rice (%) | Days to rice seedling emergence (day) |
|---|---|---|---|
| | Before seeding | After heading | |
| April 25 | 0 | 13 | 17 |
| May 10 | 1 | 7 | 13 |
| May 25 | 3 | 6 | 12 |
| June 10 | 9 | 0 | 10 |
| LSD (0.05) | 4.0 | 3.6 | - |

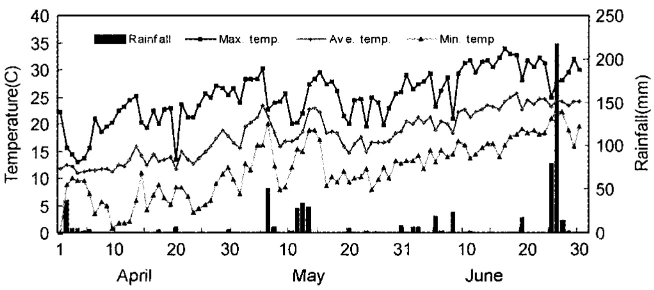


**Fig. 2.** Air temperature and rainfall during seedling emergence period in 1997.

for germination and emergence of weedy rice. As a result, significant numbers of weedy rices are emerged and the emerged seedlings are removed during seedbed preparation and thereby subsequent emergence of weedy rice was low at June 10 seeding. This result is supported by the days required from seeding to emergence of rice which was shortened rate of emergence at later seeding. Kim (1993) also observed similar trend of weed rice occurrence from February 10 to June 10 seeding in dry seeded paddy field. Forcella *et al.* (1993) reported that late seedbed preparation killed most emerged seedlings and greatly diminished foxtail populations.

## Tillage method

Tillage reduced weedy rice to some extent but the degree was different according to tillage methods. In 1992, weedy rice occurrence was similar in three tillage methods but it was significantly low in fall and spring plow with rotary tillage from 1993. In 1994, panicle ratio of weedy rice was reduced by 49% and 67% in fall and spring plow with rotary tillage, respectively, as compared to rotary tillage but it was similar in fall and spring plow with rotary tillage (Table 3). The fewer weedy rice panicles in spring and fall plow plus rotary tillages as compared with only rotary tillage were probably due to lower weedy rice occurrence caused by deep burial of weedy rice seeds and intensive land preparation. Many weedy rice seeds buried in the deep soil were less favorable for germination and establishment. However, with rotary tillage, most shattered seeds remained at or near the soil surface where environment is more favorable for germination and establishment in spring. The result indicates that weedy rice could be controlled by through land preparation although its effect is not pronounced. Greater faxtail infestation in continued use of reduced tillage system than fall chisel plowing plus spring disc and fall board plowing plus spring disc was reported by Spandl *et al.* (1998)

In conclusion, all the cultural practices were effective to some extent in suppressing weedy rice occurrence in direct rice seeding but machine transplanting method was most effective in reducing weedy rice occurrence.

**Table 3.** Panicle ratio of weedy rice as influenced by tillage methods.

| Tillage method | Panicle of weedy rice (%) | | |
|---|---|---|---|
| | 1992 | 1993 | 1994 |
| Fall plow+Rotary tillage | 1 | 8 | 23 |
| Spring plow+Rotary tillage | 0 | 6 | 15 |
| Rotary tillage† | 1 | 25 | 45 |
| LSD (0.05) | ns | 7.3 | 14.1 |

†just before seeding.

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