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Effect of Early Seeding on Seedling Establishment and Yield in Direct Dry Seeding Rice at Honam Plain Area of Korea

Sang Su Kim*†, Nam Hyun Back*, Min Gyu Choi*, Weon Young Choi*, Hong Kyu Park*, Bo Kyeong Kim*, Hyun Tak Shin*, and Soo Yeon Cho*.

ABSTRACT

To examine the seedling stand and growth as affected by early seeding dates of dry direct seeded rice in the Honam plain area of Korea, Dongjinbyeo was seeded at six seeding dates from early March to late April in rice fields of silty loam soil(Jeonbuk series) at the National Honam Agricultural Experiment Station (NHAES) for two years, 1996 and 1998.

Seedling stand decreased slightly, with an early seeding date, but it produced more than the optimum seedling number except for the seeding of 25 March in 1996. Days to emergence was significantly longer, as seeding date was earlier, and days to emergence by early seeding was shortened only by 8 days because the mean air temperature was lower in 1996 than average, while in 1998, the reduction effect was nine to twenty five days because the mean air temperature was higher than average. In early seeding, various weeds occurred at the emergence date of rice and dominant weeds were *Alopecurus aequailis, Ludwigia prostata* and *Rorippa islandica.* NH_4^+-N content in the soil at the 5th leaf stage and maximum tillering stage were lower, as the seeding date was earlier when nitrogen was split applied as basal and top dressed in 1996, while it was not significantly different among seeding dates when nitrogen was intensively applied as a top dressing in 1998. Tiller number at the maximum tillering stage and panicle number/m^2 were more, as seeding date was earlier in 1996, while it was not different in 1998. Filled grain rate and 1,000 grain weight was not different among the seeding dates. Milled rice yield was significantly decreased in the seeding before the middle of March, but in the seeding after late March, it was not varied when compared with the normal seeding date in 1996, while in 1998, there was no difference among seeding dates.

From the above results, in consideration of seedling stand, weed occurance, rice growth and milled rice yield, the critical optimum early seeding time in the southern plain area may lie in early April. But it was suggested that when soil moisture is proper for seeding practices, seeding amount is increased and nitrogen is applied after plumule emergence of rice, milled rice yield may not be reduced in the seeding of middle or late March, compared with the seeding in April.

Keywords : rice, dry seeding, seeding date, seedling stand, growth, yield.

Since direct seeding culture was propagated to farmers in 1993 in order to reduce the cost of rice production, the area for direct seeding of rice has come to one hundred and eleven thousand hectares, that is 10.5 percent of the rice cultivation area in 1997. Dry direct seeding area of rice covered fifty seven thousand hectares, fifty two percent of the direct seeded area. But in 1998, dry direct seeding area decreased up to sixteen thousand hectares due to frequent rainfalls around seeding time.

The direct seeding method of rice is distinguished as dry or wet direct seeding by flooding or non-flooding, respectively in paddy fields at seeding time. Wet direct seeding has some merits of avoiding the interference of weather or soil conditions at seeding time than dry direct seeding, while it also has disadvantages of frequent seedling rot caused by continuous low air temperature and burying of sown seed under the soil surface after seeding, and the resulting poor seedling stand and susceptibility to lodging. Therefore, recently, dry direct seeded area of rice gradually increased.

Dry direct seeding method is classified into ridged drill seeding and flat drill seedings. Ridged drill seeding favors in seedling stand and lodging resistance compared with flat drill seeding. But in order to conduct the dry direct seeding, there is a restriction of rainfall for seven to ten days before and after seeding to obtain a stable seedling stand. In Jeonbuk series, the silty loam soil, direct drill seeding can be conducted on condition of more than five no rainfall days before seeding time(Yoo, 1994). Since plumule elongation of rice is accelerated and days to emergence is shortened at higher temperatures 25℃ (Saito and Hosoda, 1963), the optimum date for dry direct seeding in the southern plain area may be from late April to the middle of May when the mean air

*National Honam Agricultural Experiment Station, RDA. Iksan 570-080, Korea. *† Corresponding author:(E-mail)kimss @nhaes.go.kr (Phone)+82-653-840-2172, Received 29 May, 1999.

temperature is about 13 or 14℃ (Park, 1993).

In the southern plain area of the Korean peninsula, there are wide areas of poorly-drained paddy fields. In addition it has two or three rainy days and nine to twenty three mm of precipitation per ten days from late April to the middle of May, which is supposed to be the optimum seeding date.

For the above reasons, many Korean farmers conduct dry direct seeding on or after the middle of March when it is favorable for plowing and leveling the paddy field. Therefore, the purpose of this study is to compare the seedling stand status and plant growth under early season dry direct seeded rice cultivation to clarify the threshold of early season direct seeding date, and to obtain some basic information on early season direct seeding in the southern plain area of Korea.

MATERALS AND METHODS

The experiment was conducted in Jeonbuk series, the silty loam soil in NHAES rice field for two years, 1996 and 1998, using Dongjinbyeo, a mid-late maturing rice variety, to compare the seedling stand and plant growth under early season dry direct seeding system.

There were 6 seeding times, at intervals of ten days, from March 5 to April 25 in 1996, and additional four times on March 18, March 31, April 20 and April 30 in 1998. Sixty kg of dry seeds were sown per ha. Nitrogen was split applied with 40 percent before seeding, 30 percent at the 5th leaf stage and 30 percent at the panicle formation stage in 1996, but in 1998, it was applied by the rates of 40, 30 and 30 percent at the 3rd leaf stage, 7th leaf stage and panicle formation stage respectively. The amount of nitrogen was 160kg/ha[1]. Phosphorus, of 90kg/ha[1] was applied before seeding, and 70 percent of total 110kg/ha in potassium was applied, before seeding and 30 percentage was applied at the panicle formation stage. Irrigation was conducted around the third leaf stage and two intermittent drainages were done from the critical threshold tillering stage to the panicle formation stage in order to reduce lodging of rice plants. To control weed occurrence, paraquat dichloride Lq. of 3 l /ha(one to four hundred ratio) was sprayed and pyrazosulfuron-ethyl+molinate of 30kg/ha was scattered at five days after irrigation. To examine the degree of weed incidence, weeds were collected at the first day of rice seedling emergence and their dry weight were weighed for quantitative comparison.

To measure the content of NH_4^+-N in the soil from the 5th leaf stage to heading stage, soil was sampled at six sites per experiment plot, and 17g of wet soil was mixed with 25ml of 10% KCl solution for one day, and analyzed with automatic nitrogen analyzer (Kuboda, 1975).

Weather conditions around seeding times in 1996 and 1998 are shown in Table 1. Mean air temperature was 0.4 to 3.9 degree lower compared with average temperature and minimum temperature was lower in 1996, whereas in 1998, mean air temperature was 0.9 to 4.9 degree higher than the average year air temperature. Precipitation in 1996 and 1998 were higher than the average year precipitation. Other management and measures were performed using

Table 1. Weather conditions before and after seeding date in Iksan in the years of the experiments.

Section		Year	March			April			May		
			1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Mean air temperature	(℃)	Aver.	4.2	5.2	7.5	9.7	11.1	14.4	15.2	16.1	18.5
		1996	2.7	4.0	6.8	5.8	7.3	14.0	13.6	16.5	18.6
		1998	6.8	6.3	7.3	12.0	14.6	19.3	18.3	17.2	20.2
Min. air temperature	(℃)	Aver.	-0.5	-0.2	2.5	3.5	4.9	8.2	9.5	11.4	13.6
		1996	-3.4	-1.3	3.1	0.9	0.5	7.9	8.3	10.3	13.3
		1998	1.2	0.8	2.3	8.5	10.3	14.8	13.5	13.6	14.7
Earth temperature*	(℃)	1996	6.5	7.8	9.4	10.7	12.2	15.7	11.8	17.3	19.4
		1998	8.0	8.7	10.0	12.2	14.8	18.0	19.2	18.2	20.8
Rainfal	(mm)	Aver.	18.2	5.0	8.7	12.5	22.7	19.3	12.0	33.8	16.4
		1996	39.0	36.5	44.5	2.5	20.0	22.5	29.5	0	5.5
		1998	0	26.5	2.5	106.0	26.5	28.5	20.5	64.0	0
Rainfall days	(day)	Aver.	3.0	2.8	2.6	1.0	2.4	2.4	2.2	3	2.4
		1996	2	5	4	1	2	2	2	0	2
		1998	0	1	1	5	3	2	6	3	0

*Earth temp. : measured at 10cm depth, Aver. : mean of 1991~1995

1st : the first 10 days of a month, 2nd : the second 10 days of a month, 3rd : the third 10 days of a month.

standard cultivation methods of NHAES and RDA procedures.

RESULTS AND DISCUSSIONS

Rainfall for 5 days before seeding, soil moisture content at seeding time and crushed clod rate

In dry direct seeding, soil moisture at seeding date may affect plumule emergence and seedling stand status. The soil moisture was determined first by the amount of rainfall before seeding, secondly by drainage condition of soil, duration of sunshine and air temperature(Yoo et al., 1997).

Minutely seeding work and good seedling establishment can be obtained in conditions in which over 60 percent of the crushed clods were smaller than 2cm in diameter. In the seeding of late March in 1996, rainfall of 33.5mm for 5 days before seeding caused excessive soil moisture and crushed clods decreased up to 48 percent so that seeding work was done inaccurately. But although, there was 9mm rainfall 2 days before seeding in case of seeding in the middle of March, soil was dry enough to increase crushed clods up to 84 percent and seeding work was done minutely. There were no obstacles in the other seeding times in 1996.

On one hand, in early March and April, there was rainfall so that seeding work could not be conducted owing to hydrophobic soil conditions, and in the middle of April, soil moisture content was a little higher than the optimum condition, causing the low crushed clod rate.

Days to emergence as affected by air temperature and cumulative air temperature.

Mean air temperature for ten days after seeding, accumulative temperature to emergence, effective accumulated temperature to emergence date, days to emergence and emergence date are shown in Table 3.

Mean air temperature for ten days after seeding greatly affects the seedling stand. In both 1996 and 1998, it was over thirteen degrees centigrade in the seeding after the middle of April. However, it was lower, below ten degrees centigrade before late March in 1996, that is the threshold temperature for germination. Accumulative temperature to emergence in the seeding of early March in 1996 was 501℃ but as the seeding date was delayed, it decreased, and it was 293℃ in the seeding of late April(normal seeding time), that is 200℃ lower than in early March. In 1998, it showed a similar trend as in 1996. Accumulative temperature was similar in the seeding of middle and late April, while it was sixty two to eighty two degrees centigrade lower in the seeding of middle and late March. This phenomenon was assumed to be caused by shorter days to emergence in 1998 than in 1996, owing to higher air temperature in 1998.

Effective accumulative temperature, sum of mean air temperature over ten degrees centigrade was lower as the seeding time was earlier. It was 293℃ at normal seeding time, while in the seeding of early March it was 225℃, that is about 70℃ lower than normal seeding time. These may be due to the fact that the plumule was able to germinate and elongate for the days over 10℃, even though the mean daily air temperature was below 10℃ at early seeding time, maximum daily air temperature was over 10℃. But in 1998, effective accumulative temperature to emergence was not varied among seeding times, and it was implied that air temperature to emergence was higher in 1998 than in 1996.

Days to emergence was longer with an earlier seeding time. Nineteen days were required in the seeding of April 25th in 1996, whereas it was sixty three days, that is forty four days longer, in the seeding of March 1st. From the above mentioned effects, emergence date was May 15 in the seeding of late April but it was May 7 in the seeding of early March. Therefore, reduced duration in the days to

Table 2. Amount of rainfall for 5 days before seeding, soil moisture content at seeding date and crushed clod rate.

Seeding time		Rain fall(mm)		Soil moisture(%)		Crushed clod(%)*	
		'96	'98	'96	'98	'96	'98
March	1st	0	-	20.0	-	97	-
March	2nd	9.0	8.5	23.3	23.7	84	79
March	3rd	33.5	0	35.7	30.5	48	58
April	1st	0	-	27.5	-	67	-
April	2nd	.0	22.0	22.5	31.4	87	51
April	3rd	0	0	23.7	26.5	80	63

*Crushed clod : small than ø 2cm

Table 3. Accumulated temperature, effective accumulated temperature, emergence days and emergence dates.

Seeding time	Year	Mean temp. for 10days after seeding (℃)	Accum. temp. (℃)	Effective accum. temp. (℃)	Days to emerence (days)	Emergence date
March 1st	'96	4.1	501	225	63	May 7
March 2nd	'96	5.1	487	252	55	May 9
	'98	6.2	422	351	36	April 23
March 3rd	'96	5.5	453	268	46	May 10
	'98	9.7	371	350	26	April 25
April 1st	'96	6.8	386	257	35	May 10
April 2nd	'96	10.1	332	272	26	May 11
	'98	18.9	344	344	26	May 8
April 3rd	'96	14.9	293	293	19	May 15
	'98	19.0	297	297	18	May 17

* Accum. : accumulated mean temperature from seeding to emergence

emergence date by earlier seeding was only eight days. But in 1998, the emergence date was shortened from nine to twenty four days by early seeding. The less effect of early seeding on the acceleration of emergence in 1996 than in 1998 may have resulted from the lower air temperature in early seeding of 1996 than of 1998 and plumule elongation was reduced in 1996.

Seedling stand number and rate

Poor seedling stand may result in low yield and bad grain quality, while overseedling stand was known to induce the occurrence of sheath blight disease and lodging accompanied with the reduction of filled grain rate and rice yield(Kim et al., 1992; Lee et al., 1993).

It was reported that 120~150 plants/m^2 was required to obtain 450 panicles/m^2 under dry direct seeding of rice(Moritani, 1962). The optimum seeding amount was 60kg/ha and the optimum seedling stand was 90 to 150 plants/m^2(Lee et al., 1993; Uemura et al., 1973)

Seedling stand and plant growth at maximum tillering stage were shown in Table 4. Seedling stand number showed a tendency to decrease as the seeding date was earlier except for the seeding of late March, but even in the seeding of early March in 1996, an optimum seedling stand was obtained with 110 plants/m^2 in spite of the lower temperature in 1996 than average. But in the seeding of late March, seedling stand was low, that is 83 plants/m^2, and it was due to the rainfall before seeding caused a excessive hydrophonic soil condition and reduced the crushed clod rate.

Seedling stand rate is usually 55 to 75 percent in dry direct seeding(Yamane et al., 1969). As seeding time was earlier, seedling stand rate tended to decrease, but seedling stand rate in early March reached up to 55 percent. But that in the seeding of late March in 1996 decreased up to 42 percent, and was lows, up to 51 percent in 1998, while those of the other seeding dates were over 55 percent.

From the above results, it may be concluded that

Table 4. Seedling stand number per ㎡ and seedling stand rate under different seeding dates.

Seeding time	Seedling stand number per ㎡			Seedling stand rate		
	'96	'98	Mean	'96	'98	Mean
March 1st	110	-	110	55	-	55
March 2nd	137	102	120	69	51	60
March 3rd	83	112	98	42	56	49
April 1st	143	-	143	72	-	72
April 2nd	147	140	144	74	70	72
April 3rd	153	132	143	77	66	72

a hydrophonic soil condition causes a lowering of seedling stand rate and the seeding amount should be increased to obtain an optimum seedling stand.

Changes of NH_4^+-N in soil under different seeding dates according to the growth stage of rice.

In dry direct seeding, in which plowing and leveling of soil are conducted under dry soil conditions, the applied fertilizer is lost faster than in transplanting culture or wet direct seeding culture. Therefore, dry direct seeding requires a 50% higher level of fertilizer, and split application is done at the rate of 40, 30 and 30 percent at basal, 5th leaf stage and panicle formation stage, respectively(Lee, 1995).

In 1996, NH_4^+-N content in soil decreased to panicle formation stage, irrespective of seeding dates, but it increased a little at the heading stage. From the 5th leaf stage to maximum tillering stage, NH_4^+-N content in the soil was lower as the seeding date was earlier, while there was no difference among seeding dates after the panicle formation stage.

The phenomenon of lower content of NH_4^+-N in soil under earlier seeding date from the 5th leaf stage to the maximum tillering stage was explained by the fact that as the seeding date was earlier, days to emergence was delayed, and because applied nitrogen was quick acting manure, so that the loss of nitrogen increased.

On one hand, in 1998, there was no difference in NH_4^+-N content in soil among seeding dates as nitrogen was applied only as a top dressing.

Plant growth at maximum tillering stage.

Table 5 shows the variation of plant growth related traits at maximum tillering stage. Plant height was not different among various seeding dates in 1996, while in 1998, it was 13㎝ shorter in the seeding of the middle and late March than in that of April. These were inferred that under early seeding dates, emergence date was 23 to 24 days earlier and rice plants did not elongate well during the low temperature duration, but in the seeding after late April, rice plants elongated better than at the early seeding dates due to a slightly higher temperature.

Tiller number decreased as the seeding date was earlier, except for the seeding of late March in 1996 and it was higher in 1998 than in 1996, which was caused by the split application of nitrogen only as top dresser in 1998 instead of the division of nitrogen as a basal fertilizer and top dressing at the rate of 40 and 30 percent, respectively in 1996. Effective tiller rate was, more or less, lower in the seeding of March than in April in 1996, while in 1998, it was not different among seeding dates. This result is thought to be that in 1996, 40 percent of the nitrogen was applied as a basal fertilizer and the applied nitrogen was exhausted at the time around panicle formation differentiation stage.

Weed amount at emergence date of rice under the different seeding dates

Dry direct seeding favors more various weed plants and has a longer competition period with weeds requiring more intensive weed control than the transplanting culture.

Weed amounts at the emergence date of rice is shown in Table 6. Weed amounts were more in earlier seeding in March, but it was not different in the seeding in April, and it was not measured in the seeding of late April. On the one hand, weed species were various and occurred more in order of *Alopecurus aequalis, Ludwigia prostrata, Rorippa islandica, Cardamine flexuosa* and *Stellaria alsine,* while barnyard grass could not be measured because it was too early to emerge and elongate.

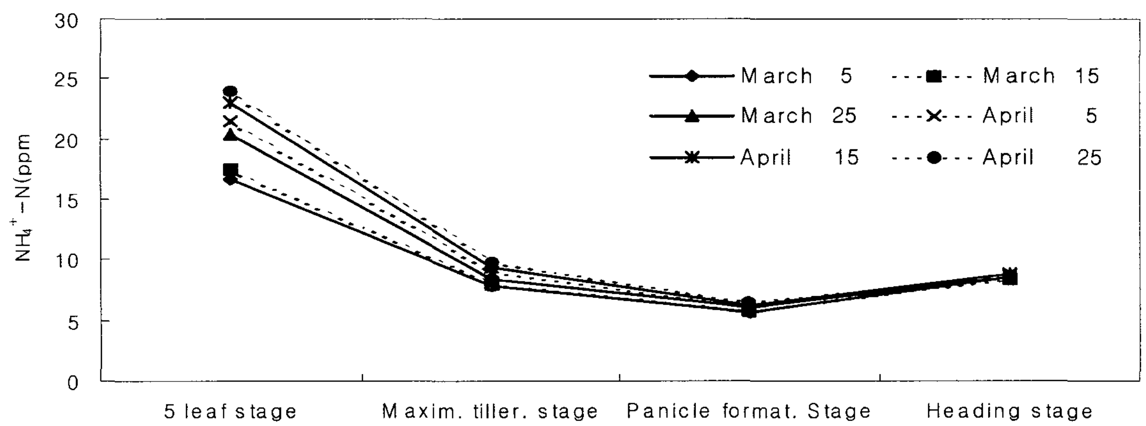

Fig. 1 Change of NH_4^+-N in soil at different growth stage as affected by seeding date in 1996.

Table 5. Tiller number, plant height at maximum tillering stage and effective tiller rate under different seeding dates.

Seeding time		Plant height(cm)		Tiller number per m²		Effective tiller rate	
		'96	'98	'96	'98	'96	'98
March	1st	44	-	470	-	66	-
	2nd	43	40	487	687	67	54
	3rd	44	40	357	727	86	54
April	1st	44	-	483	-	70	-
	2nd	44	50	497	620	69	53
	3rd	44	53	512	583	69	54

Table 6. Changes of weed amounts at emergence date as affected by seeding dates.

Section	*Alopecurus aequalis* Sobal	*Ludwigia prostrata* Roxb	*Rorippa islandica* Borbas	*Cardamine flexuosa* With	*Stellaria alsine* Grimm	Total
	------	------	------ D.W, g/m²	------	------	
March 1st	21.5	10.1	9.3	7.0	0.5	48.4
March 2nd	10.8	1.3	9.6	1.4	0.3	14.3
March 3rd	3.0	0.5	0	0.2	0.1	3.6
April 1st	1.0	0	0	0	0	1.0
April 2nd	0.7	0	0	0	0	0.7

Table 7. Yield and yield components under different seeding dates.

Seeding time	Year	Heading date	No, of panicle per m²	Ripened grain rate	1,000 grain weight (g)	Milled rice yied (kg/10a)	Lodging (0~9)
March 1st	'96	Aug.14	311	96	25.5	495	0
March 2nd	'96	Aug.14	324	97	25.6	500	0
	'98	Aug.10	373	93	23.8	517	3
March 3rd	'96	Aug.15	308	95	25.6	516	0
	'98	Aug.11	390	92	24.0	532	3
April 1st	'96	Aug.15	337	96	25.5	527	0
April 2nd	'96	Aug.15	345	96	25.6	538	0
	'98	Aug.15	390	97	25.0	524	1
April 3rd	'96	Aug.16	354	95	25.7	539	0
	'98	Aug.18	377	96	24.8	533	1
LSD(5%)	'96	-	-	-	-	25	-
	'98	-	-	-	-	37	-

Yield and yield components under the different seeding dates

Yield and yield components are shown in Table 7. Heading date was shortened by one to two days in 1996, but in 1998 it was three to 8 days shorter for early seeding compared with normal seeding of late April. The reason is that in spite of early seeding, emergence date was shortened by only three to eight days and the seeded variety, Dongjinbyeo, a medium late maturing and photosensitive rice. In 1998, heading date was three to eight days shorter in early seeding than in normal seeding owing to higher mean air temperature in 1998 than in 1996.

Panicle number/m^2 decreased as the seeding date was earlier except for the seeding of late March in 1996 but in 1998, there was no difference among seeding dates by the intensive application of nitrogen as a top dressing. On the other hand, panicle number/m^2 was higher in 1998 than in 1996 irrespective of seeding date. Filled grain rate and 1,000 grain weight were not different among seeding dates in 1996, but in the seeding of late March in 1998, they were decreased since lodging occurred..

Milled rice yield was not varied among seeding dates after late March in 1996, while in the seeding before the middle of March, it was significantly decreased. In 1998, to some extent, milled rice yield decreased in the seeding of the middle of March, compared with normal seeding, but there was no significant difference among the different seeding dates.

Considering the results shown above, early March is the threshold date for early dry seeding of rice in the Honam plain area.

REFERENCES

Jun, B. T. 1993. The status and problems of direct seeded rice culture on dry paddy field in Korea. '93 Seminar on Direct Seeded Rice. HCES, RDA I : 37-57.

Kim, S. C., D. Y. Hwang, S. T. Park, B. T. Jun and S. K. Lee. 1992. Optimum seeding rate of dry-seeded rice at Yeongnam area. Res. rept. RDA(R) 34(1) : 39-48.

Kuboda, S. 1975. Soil nutrient analysis method. Japan Soil Anal. Soc. Yanghyundang: p.184-195*

Lee, C. W., Y. D. Yun, Y. J. Oh and S. Y. Cho. 1993. Seeding emergence and mescotyl elogation as affected by temperature and seeding depth in direct-seeded rice on dry soil. KJCS 37(6) : 534-540.

Lee, S. Y. 1995. Direct seeding cultivation of rice in Korea. '95 Korea Japan Seminar on Direct Seeded Rice : 34-50.

Lee, S. Y., S. S. Kim, I. B. Im, S. J. Seok and C. H. Kim. 1993. The current status, problem and future research project of direct seeded cultivation in flooded paddy field in Korea. '93 Seminar on Direct Seeded Rice : 58-76.

Miishi, A. 1982. The process of establishment on the rice direct seeding method on dry soil(paddy). Agri. Tech. 37(7) : 294-303.*

Moritani, Y. 1962. Reseaches and problems on rice direct seeding on dry soil in Tohoku area. Agri. Tech. 17(1) : 16-19.*

Park S. H. 1993. A current status of direct seeding in lowland rice and its future strategy. '93 Seminar on Direct Seeded Rice. HCES, RDA : 1-27.*

Saito, T. and K. Hosoda. 1963. Estimation of emergence date on the rice direct seeding on dry soil. Agri & Hort. 38(12) : 113-116.*

Uemura, Y., M. Himeda, H. Chisaka and N. Kuramoto. 1973. Present status and technical problems on rice direct seeding culture. Agri. & Hort. 48(9) : 1183-1187.*

Yamane, K., H.Koshii. Otani R. and T. Nomura. 1969. Rice(direct) broadcast seeding on dry soil. Agri. Tech. 24(8) : 367-369.*

Yoo, C. H., C. H. Yang, K. B, Lee, B. W. Shin, S. K. Kim, J. D. So and G. S. Rhee. 1994. Effect of drainage methods on machine work ability and rice growth for dry seeding in paddy field. J. Korean SOC. Soil SCI. FERT. 27(3) : 117-12.

(* : translated from Japanese or Korean by present author)