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A Research on None Covering of Top-soil for Rice Seedling Nursery for Sparse Machine Transplanted Rice

벼 소식재배를 위한 무복토 육묘 연구

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Abstract

To determine none top soil covering in rice seedling nursery method for the sparse machine transplanting, four different sowing methods were tested. Shoot and root length, fresh weight, leaf number and color using leaf color chart(LCC) and SPAD were collected as the data comparison of methods. The seedling height showed the highest growth according to the conventional (230g seed rate of pre-emerged seeds and top-soil covering) > high sowing density 1 (290g seed rate of pre-emerged seeds and top-soil covering) ≥ high sowing density 2(290g seed rate of pre-emerged seeds and none top-soil covering) > high sowing density 3(290g seed rate of iron-coated seeds and none top-soil covering). There was any statistical difference between groups in root length, leaf number, LCC, and SPAD values. Thus, a high sowing density of 290g for rice nursery seedling box was recommended to the sparse machine transplanting in rice cultivation with the none top-soil covering method, enabling convenient handling in transportation and machine transplanting work.

Key words : Rice nursery, Sparse transplanting, None topsoil covering, Seedling raising box, Dense sowing

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Ⅰ. Introduction

An average age of rural population in Korea has been increasing about 3% in every year and the number of rural population older than 60 was 58% in 2018 (Korean Statistical Information Service, 2018). Thus, high labor cost is understandable with the labor shortage(Lee, 2014). Accordingly, due to the increase of the production costs, the agriculture in Korea would be limited in achieving higher productivity. In addition, rice production costs in Korea should be decreased to the international price of rice to cope with the competition(Han and Lee, 2010). Therefore, the farming industry needs young people that can be engaged in agriculture, replacing aged farmers(Ma and Kim, 2018; Woo et al., 2018) or cultivation technologies to reduce rice production costs. Following the fourth industrial revolution, it becomes necessary to develop cultivation techniques as smart agriculture such as a drone, laser, robotics, etc., which is suitable for large farm management of rice production(Park et al., 2017). Thus, this experiment was conducted to reduce production costs and labor force at rice nursery and transplanting.
In 2016, the sparse transplanting was introduced to KNCAF in Korea, after the research in japan was finished. This method can reduce 75~86% of the required seedling, compared to conventional method(Park and Park, 2017; Sawamoto et al., 2019). In other words, the conventional method was inefficient, and new rice seedling nursery may be more efficient and convenient for machine transplanting.

Accordingly, the weight of the seedling box and the duration of the nursery stage are important for operation of more stable and convenient sparse transplanting. The process of the rice nursery preparation, including growing seedling, managing nursery, and transporting it to a field, is too heavy labor especially for old people, the old usually has been hired extra workers (Park et al., 2017). As the age of population for agriculture increase, the gap of productivity between the old/small farms and young/big farms will increase, farming will promote a rapid shift from old/small farms to young/large farms. Therefore, none top-soil covering seedling method that can be proceeded in a simple way will be conventionalized nationwide. This method reduces materials like seedling boxes and bed soil in rice nursery for machine transplanting. The labor costs will also be decreased regardless of farm size. This paper is showing the characteristics and advantages of the none top-soil covering the seedling box in rice nursery and aimed to determine a more convenient sparse transplanting method to be conventionalized.

Ⅱ. Materials and Method

1. Site description

Field experiments were conducted from 2019 in the Korea National College of Agriculture and

Fisheries(KNCAF, 35° 49′ N, 127° 3′ E), Jeonju-si, Jeollabuk-do in Korea. The experiment was conducted in southern west side of Korea, where an annual single or double rice cropping system is applied. The annual temperature was of 13℃ and precipitation rate was about 1,300mm. Temperature for the rice nursery season in May was listed in Fig. 1.

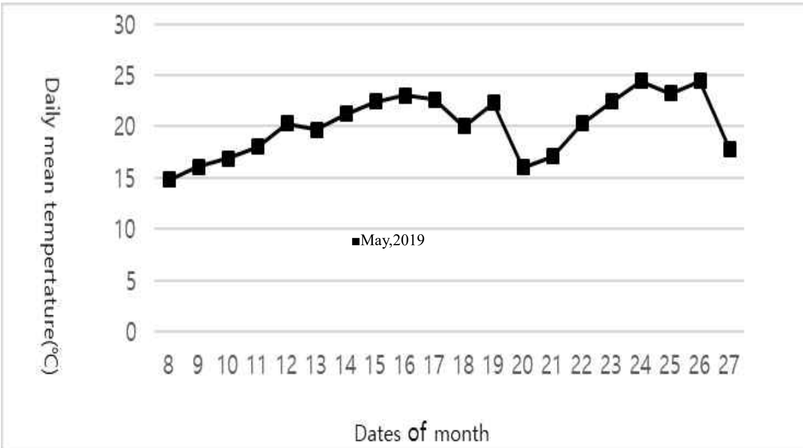

Fig. 1. Temperature of rice seedling nursery season on May 8 to 27, 2019

2. Experimental design

The experiment was conducted in the field site of the KNCAF. The experiment observed two factors of rice nursery management for none top-soil covering. One factor was different between seed sowing rates of a seedling box and the other groups that contained either of covering or noncovering top-soil. This experiment was a randomized block design with three replications. The size of each seedling box was 580mm x 250mm x 25 mm. Four rice nursery types in this experiment were described in Fig. 2.

The four types include one conventional method of covering top-soil as a control group and three types of dense sowing with different top-soil covering and seed treatment. In case of pre-emerged(1mm) seeds, the common seedling box of an infant rice seedling machine transplanting conventionally use 230g of seed per seedling box including top-soil covering. Unlike the conventional seedling box method as the A-1 in Fig.2, dense sowing(290g of seeds per box) in A-2 was covered with top-soil. In B-1 and B-2, dense sowing was proceeded, without covering top-soil. In addition, in B-2 group, the seed were iron-coated.

Fig. 2. Sowing methods of seedling nursery boxes

Note) A-1: Conventional(230g seed + top soil covering); A-2: High sowing density(290g seed + top soil covering); B-1: High sowing density(290g seed + None covering)); B-2: High sowing density(290g iron-coated seed + None covering)

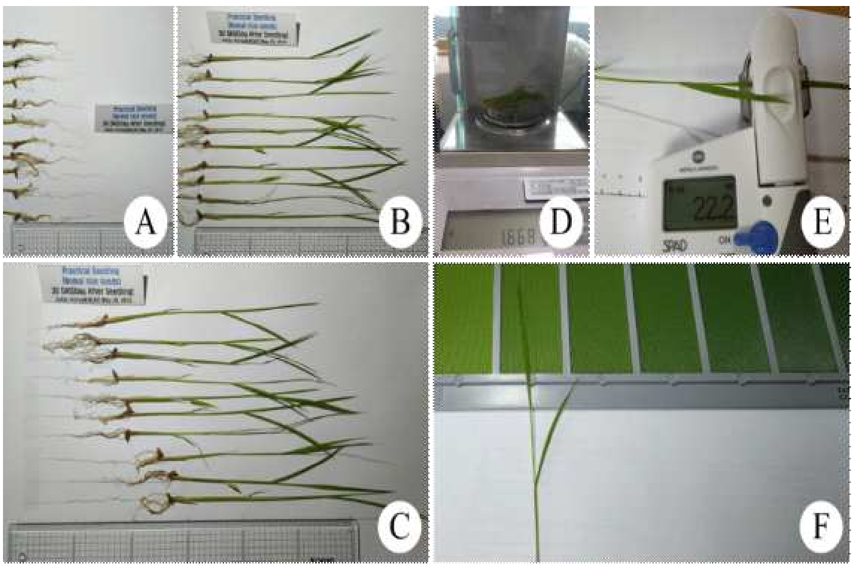

Fig. 3. The data collective methods and tools in the experiment

Note) A. Root length; B. Shoot length; C. Root + Shoot length; and number of leaf; D. Fresh weight of shoot and root; E. Leaf color value(SPAD); F. Leaf color chart(LCC)

3. Seed treatment

Japonica rice variety Shindongjin(Iksan 428) was used in all experiments. The Shindongjin is widely cultivated in the southern part of Korea(Kim et al., 2005). In 1998~1999, Rural Development Administration (RDA) in Korea has tested the variety of different regional adaptation trials to identify the characteristics of early growth, high yield, and high eating quality. The variety of Shindongjin used in experiments was harvested at the KNCAF in 2018 for the test of seeds. The iron-coated seed preparation followed by the manual of Park(2016).

Germination test was performed to determine the seed vigor between the untreated control seeds and the iron-coated seeds. Two types of seeds were sown. 50 seeds of seeds on each petri dish were plated with moister paper tissue at 25 °C in a dark room. Germination was observed daily, according to the methods of the Association of Official Seed Analysis(AOSA, 1990). Germinated seeds with radicles or plumules longer than 2mm were counted daily for 3days after germination. The 50 seeds of each treatment were randomly selected and sown on the Petri dishes as mentioned in the AOSA method. Moister tissue was changed every day to enable it to be kept moisten condition. Rural Development Administration(RDA) has been tested the variety of Shindongjin at different regional adaptation trials that has characteristics of early growth and high yield being with high eating quality for 1998-1999 in Korea. The variety of Shindongjin used in experiments was harvested at the KNCAF in 2018 as the test of seeds.

4. Shoot and root growth and leaf color values

In the rice nursery stage using the seedling box for machine transplanting, major data collection must be compared between conventional method(T1) and treatments(T2~T4). The data was collected with the length of shoots and root, fresh weight of 20 seedlings, leaf number, and leaf color. The time of data collection was at 20 to 35 days after sowing(DAS) with every five days. Twenty seedlings were selected randomly from four different treatments of the seedling box. Each method was tested using the randomized block design. Fresh weight was measured using electronic balance as shown in Fig. 3-D. Leaf color was measured by using the leaf color chart(LCC, IRRI released) in Fig. 3-E and chlorophyll meter(SPAD 502 plus, Minolta, Japan) in Fig. 3-F. The test consisted of one treatment with three replications.

5. Statistical analysis

Analysis of variance(ANOVA) was performed using the Mystat statistical software. For the rice nursery experiment, two-way ANOVA was used to determine a significant difference between the shoot and root length and leaf color. The statistical significance was determined at the 5% level among treatments.

Ⅲ. Results and Discussion

1. Germination test

This experiment was conducted for the randomized block design of two types of seed germination tests with three replications. The G1 was the Shindongjin with untreated for control group and the G2 was the same variety of iron-coated seed. The result was a high rate in germination percentages (G1: 95%, G2: 98%) as shown in Table 1, respectively. This means that the seeds used in this experiment were certified as the test seeds of the experiment.

Table 1. Preliminary Germination test of test seeds

Treatments	Germination percentage(%)
G1(Conventional)	95a
G2(Iron-coated)	98a

*LSD 5%· ································2.87
[1)] In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

2. The growth and development of rice seedling

2.1. Shoot and root length

The shoot length was shown to be different between T1 and T2~T4, which were 2~3cm shorter than that of T1(Table 2-A) at the 20 DAS. Also, seedlings in 4 treatments grew at least 2.6cm(12.5cm, 25 DAS, T4), which is enough to transplanting elongation. While T1 and T2 grew more than 2.9cm during 25 to 30 DAS, T3 and T4 grew only 1.1cm during the same time of seedling growth. In addition, when from 30 to 35 DAS, T4 was shown only 0.8cm difference (13.6cm to 14.4cm) in growth. The reasons for the shoot length difference between T1(conventional seedling) and T2~T4 could be related with nutrients of the seedling box, depending on the amount of bed soil in the box. T2 was stiffer in terms of the seedling stem than that of T1 due to different sowing rates. Furthermore, T3 and T4 had less amount of bed soil because of none top-soil covering. This could be the reason why T3 and T4 showed slowly growth at the stage of 30 DAS to 35 DAS. Despite the differences in seedling growth, transplanting was possible in all cases of 30 DAS (Kanzunori et al., 2019).

As shown in Table 2 T1 showed better root growth compared to other treatments.

The root was available to absorb more nutrients in proportion to its surface area. If shoots were growing enough for transplanting, however, the only purpose of the root was a good formation of the root mats for the transplanting. As shown in Table 2-B, every root length was similar to each other. Finally, the investigation of the root length was not able to observe any constraints.

Table 2. The differences of shoot length, root length, leaf number and fresh weight during 20DAS to 35DAS by seeds dense and topsoil covering

Treatments	Shoot length(cm)			
	20DAS	25DAS	30DAS	35DAS
T1	12.9a	15.9a	20.17a	21.2a
T2	10.9b	13.5ab	16.4b	17.3ab
T3	10.7c	14.2b	15.5c	17.0b
T4	9.9b	12.5ab	13.6bc	14.4b
*LSD(5%)	0.42	1.72	1.20	1.92

1) In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Note) T1: Conventional(230g seed + top soil covering); T2: High sowing density(290g seed + top soil covering); T3: High sowing density(290g seed + None covering); T4: High sowing density(290g iron-coated seed + None covering)

Treatments	Root length(cm)			
	20DAS	25DAS	30DAS	35DAS
T1	7.5a	9.3a	10.9a	11.3a
T2	8.0a	9.2a	9.8a	10.1a
T3	8.7a	10.4a	10.6a	11.3a
T4	7.4a	9.7a	9.3a	10.2a
*LSD(5%)	1.25	0.99	1.13	1.02

1) In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Treatments	Leaf number			
	20DAS	25DAS	30DAS	35DAS
T1	3.0	3.1b	3.7a	3.9a
T2	3.0	3.1ab	3.5a	3.7a
T3	3.0	3.1a	3.5a	3.7a
T4	3.0	3.3ab	3.6a	3.8a
*LSD(5%)		0.10	0.20	0.21

1) In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Treatments	Fresh weight(g/20Seedlings)			
	20DAS	25DAS	30DAS	35DAS
T1	1.832	3.328	4.037	5.165
T2	2.316	3.247	4.117	4.712
T3	2.244	3.401	4.311	4.854
T4	2.007	3.839	4.388	4.587
*LSD(5%)	0.32			

1) In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

2.2. Fresh weight of seedlings

There was any significant difference at the 5% level by DMRT among treatments as shown in Table 2-4. With the comparison of each 5 days of fresh weight, a remarkable difference was found. T1 has obtained a stable weight at 20 DAS to 35 DAS. On the other hand, T2 and T3 showed similar fresh weight with T1 at 20 DAS to 30 DAS. But between 30 DAS and 35 DAS, T2 and T3 showed greater decrease in fresh weight than that of T1. Meanwhile, T4 was shown much lower in weight. In another word, seedlings that used in T2~T4 were competed against nutrients because of limited soil amount. It seems to be matured seedling(over 30 DAS) is disadvantageous to obtained a plant weight and nutrient for raising seedling. Therefore, T2~T4 was recommended for transplanting at 25 DAS to 35 DAS.

2.3. Leaf number and leaf color

Leaf color experiment was conducted with the leaf color chart(LCC) and SPAD-502 chlorophyll meter to measure the chlorophyll content of the rice leaf for recommending the amount of nitrogen that was needed by the rice plant for optimum growth(Muhammad, 2019). Also, the leaf chart was indirectly used to verify chlorophyll contents(Table 4.).

Table 3. The comparison of leaf color among treatments

Treat-ments	Leaf color	
	SPAD Value	Leaf color chart
T1	24.8a	3.3a
T2	27.0a	3.4a
T3	26.9a	3.4a
T4	28.1a	3.5a
*LSD 5%	3.43	0.62

[1)] In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

At the 25 DAS, leaf numbers of T1 were unevenly out, but the others were more stable in growth than that of T1(Table 2-3). Total leaf numbers at the 30 DAS to 35 DAS were shown a normal growth of the leaf numbers as similar to that of the conventional(T1). In India, 21 DAS seedling's mean Leaf color chart(LCC) and SPAD values were varied from 3.19–5.31 and 27.36–39.26, respectively(Maiti et al., 2004). While LCC was within the average range in every experiment, only T2 and T4 were within the range of SPAD. According to a recent study, SPAD values below 25 would be result in poor physiological development due to insufficient nitrogen supply and later may affect the yield productivity(Kharim et al., 2019). Thus, new methods of rice nursery system were shown within an acceptable level.

IV. Conclusion

Recently, sparse transplanting was recommended to increase rice yield as well as decrease labor costs. Simultaneously, a new method was highly required to decrease labor input in the early rice growing stage. Thus, we suggested none top-soil covering and dense sowing methods(T3 and T4). This experiment was demonstrated that a moderate increase in planting density with removing top-soil was maintained with root length, fresh weight, leaf number, and leaf color but showed only a slight decrease in shoot length compared to that of the conventional top-soil covering of the seedling box. The decrease of shoot length rate, however, was below the level of influence to transplanting operation. Therefore, dense sowing with none top-soil covering seedling box might be advantageous in rice cropping, reducing labor cost and producing high efficiency of transplanting operation being with high yield and grain quality as well.

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