A Study On Manufacturing Rice Transplanter and Its Practical Use

水稻移秧機 製作과 그의 實用化에 關한 硏究

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要 旨

本硏究는 水稻移植期의 勞動力 Peak解消를 爲한 必要性에 副應하고, 또 이제까지 世界的으로 硏究된 거의 全部의 移植機가 幼苗用이고, 育苗機가 있어야 하고 또 복잡하므로, 모판에서 자란 自然狀態의 成苗用 移秧機를 考案製作할 目的으로 硏究 한 것이다. 먼저 機械移植에서 念慮되는 損傷 에 對하여 ① 加壓程度 ② 斷根의 길이 ③ 줄기의 휘임(bending)等에 對한 試驗을 하여 試作機 利用에 있어 支障의 有無를 檢討 하였다. 그리고 3次에 걸쳐 세 種類로 改造해 가며 移植試驗을 하였으나 좀더 完全한것을 製作, 硏究하고저 1969年에 實驗, 硏究한 것을 1971年에 再試驗, 硏究하여 그 結果를 報告한다. 그 結果는

1) 苗의 加壓程度는 4kg以下이면 生育에 큰 支障이 없다.
2) 斷根處理한 苗가 아니면 分離하기가 困難하므로 斷根하였는데 그 기리가 1.2cm程度이면 生育에 큰 支障이 없다.
3) 苗의 휘임(Bending)의 程度는 根附近에 있어 90度以內면 큰 支障이 없다.
4) 試作機의 要求條件은 草長은 20cm以下이고 뿌리는 서로 엉키지 않어야 하며 程度의 길이 6cm以下이며 土壤은 凹凸이 없고 水深은 2cm 程度가 適當하다.
5) 移秧作業 能率은 10a를 심는데 3.37*hr*가 所要되며 손으로 심는것에 비해 효과적이다.
6) 製作된 移植機는 實用化를 爲하여 動力傳達裝置, 全自動苗供給裝置의 硏究가 必要하다.

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Introduction

Rice cultivation is fundmental and main part of the agriculture in Korea. Thoughits technique is generally being developed the productivity of labour is comparatively low, mainly depending upon man and animal power. On one hand increase labour cost in the rural society and transfer of rural labour force into urban district demand the necessity oj agricultural mechanization.

Moreover, it is obvious thaj the problem of mechanization of rice transplanting should be solved immediately, considering the fatigue of labor and work efficiency. The development of rice transplanter, which is one of the most difficult tasks in farm mechanization, will have a good important effect on meeting the peak labour demands from July in Korea and will be a key point of establishing mechanized farming operation system. In Korea, the research activities for rice transplanter has started short time age and few research data are avaiilable. Here the author present a report upon the practical usefulness of manual rice transplanter through both fundamental experiments and field tests.

History

A study for rice planter has been conducted since many years ago, bu in America or Europe where rice is not main crop, much progress has not been made, The results studied at home or abroad so fax are as follows;

A) InKorea

According to the record, the study for rice transplanter was begun in 1967 witq making pincette-styled manual rice transplanter. Research activitics before 1967 tend to be a limited extent.

Before this was studies were made by those who are outsiders of this field, and it did not become a practical use.

B) Abroad

According to the literature, Japan has the longest history of developing rice transplanters in the world. The first patent for rice transplanter was obtained in 1898. But it was only four or five years ago that they put rice transplanter in practical use.

In Italy 2 TR-52 type pulled up by tractor was developed in 1952 and in 1963 Prierllt published a report on mechanization in rice transplanting.

In England in 1963 National Institute of Agr. Eng. manufactured pincette type manual rice transplanter, but it did not become popular use.

In Hungary Petrasevits pudlished research bulletin about mechanization of rice transplanting in 1963.

In Franc Casanova published CHINESE TRANSPLANTING MACHINE in 1963, which became a foundation of study on rice transplanter in France.

In Ukraine Lisevs' KYI published Overall mechanization of Rice Plantations in 1964.

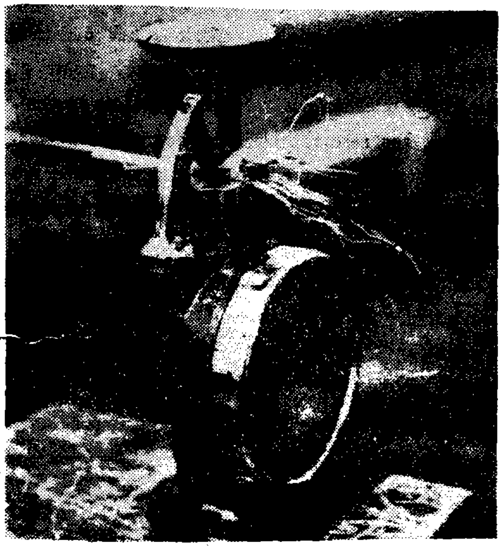


Fig. 1. pressing device

Fundamental Experiments

About the resistivity againist mechanical injury on rice seedlings.

A transplanter always touches the part of seeding near the growing point, which effects the growth and increase of rice stalks, in contrast with transplanting by human hands. The main factors which affect on injury on rice seedlings seen to be various according to the structure of transplanter, but among them are, pressure on seeding, root cutting for working, bending of rice seedling, folding of rice etc. The author tested to seek the limit of resistivity against the above mentioned mechanical injuries.

Ex.1 The Effect of the Degree of Pressing upon the Growth and Yield of Rice,

There are, in transplanting machines, many kinds of inserting mechanism, most of which are the types of picking rice seedling dirrectly and holding it between picking part it means pressing the rice seedlings between the metal part.

This experiment was performed to seek the limit of the pressure which effects the growth and setting root by applying different preasure at the 5mm above the root of rice seedling.

Material, and method.

1. Sample;Nong-Rim No.6

Sew it in the seed bed in the experimental farm at the College of Agriculture, Seoul National University and transplanted each of them at 15cmx 15cm. Specialized it according to the volume of manure and subdived them according to pressure with 3times, shown in table 1.

Table 1. Plan for this Experiment

N_1	8 : 6 : 6(N:P_2O_5:K_2O)
N_2	12 : 6 : 6(〃)
N_3	16 : 6 : 6(〃)
P_0	NO pressure.
P_1	Pressure 4kg
P_2	Pressure 2kg
P_3	Pressure 1kg

Pressing device; Grain hardness tester, P.A.T. No. 29119 (pressing part is 5mm in diameter.) was modified and used. (as shown in figl-1) Pressure was applied with this device for just 5 seconds at the point 5mm above the root of rice seeding.

Twenty rice stalks were selected from each plot, and their growth rate, the yield and its component were measured and investigated.

Result and Discussion

1. Plant Height; Table 1-2 indicates that the growth of pressed seedling, as compared with the check, decreased regardless of the level of fertilizer.

Particularly, the P_1 (4kg) showed a remarkable contrast with the check. But as they grew, the difference became little, which meant the recovering form the pressed injury.

Table 2. Mean Value and its significant levei in Plant Height

Time of Investigation	(First Measurment)				(Second Measurment)				(Third Measurement.)			
Pressure	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total
P_0 (check)	33.1	33.2	34.6	100.9	44.7	50.6	65.0	150.3	62.4	68.9	73.2	204.5
P_1 (4kg pressure)	27.9	27.1	27.7	82.7	42.1	45.2	51.6	138.9	58.3	62.9	67.4	188.[illegible]
P_2 (2kg pressure)	31.2	31.9	31.8	94.9	44.1	50.0	52.3	146.4	60.9	66.3	69.2	196.4
P_3 (1kg pressure)	32.5	33.0	33.3	98.8	44.7	50.4	53.1	148.2	61.8	69.3	71.8	202.9
Total	124.7	125.2	127.4	377.3	175.6	196.2	212.0	583.8	243.4	207.4	281.6	792.4

L.S.D.(5%)	Once Inve.	Twice Inve.	Three Inve.
N_3—N_1	111	6.13	5.44
P_3—P_1	105	1.27	1.36
N_3P_3—N_1P_1	206	2.19	2.32

2. No. of tillering.

As shown in table 1-3, the perts of both p, and P_2 have much Difference with the check, but P_3 has no difference. As the seedling grow the injury was deviated.

Table 3. Mean value and its significant level in tillering.

Time of Investigation	(First Measurement)				(Second Measurement)				(Third Measurement)			
Pressre	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total
P_0 (check)	5.5	6.9	8.1	20.5	11.6	12.3	17.2	41.3	11.5	13.9	16.5	41.9
P_1 (4kg pressure)	5.4	5.7	6.7	17.8	10.1	9.7	15.4	35.2	10.3	12.5	15.3	38.1
P_2 (2kg 〃)	4.8	6.2	7.5	18.5	10.5	13.2	15.4	39.1	10.5	12.5	14.7	37.7
P_3 (1kg 〃)	5.4	6.8	7.7	19.9	11.3	12.7	15.9	39.9	10.9	14.3	15.8	41.0
Total	21.1	25.6	30.0	76.7	43.7	47.9	63.9	63.9	43.2	53.2	62.3	158.7

L.S.D. (%)	First Measurment	Second Measurment	Third Measarment.
N_3—N_1	3.23	5.32	4.74
P_3—P_1	0.61	1.67	0.92
N_1P_3—N_1P_1	1.05	2.89	1.58

3. Effects of Pressing on Yield anb its Components.

As shomn in Table 1-4, the differences in Yield between the check and pressed plots was insignificant. But the plot of 4kg pressure showed least yield, however, the yield comonents, number of spikelets, rate of fertility, etc, showed no differences.

Considering the results of this experiment, despite the little differences among the level of pressure, the plot of 4kg pressure showed retards growth during earing early state and least yield.

Application of pressure upon seedings should kept below 4kg level in order to assure satisfactory growth and yicld of rice.

Table 4. Effects of Pressing on the Yield and its Compo nents.

Item / Degree of pressure	(Culm Length) (cm)	(No. of Spikelets)	(No. of Grain per spiklets)	(Fer;ility)	Grain Yield/hill (gr)
P_0 (Check)	86.4	10.5	98.5	91.7	18.37
P_1 (4kg pressure)	85.6	9.6	96.9	93.5	16.63
P_2 (2kg 〃)	85.4	9.8	98.6	92.9	17.64
P_3 (1kg 〃)	87.0	9.9	99.4	93.0	17.96
L.S.D. (5%)	3.75	1.42	6.54	2.62	2.25

Ex. 2. Effect of Cutting Root on the Yield and Growth of Rice.

All the transplanters pick up a stalk ann set it into the ground by in setting device. Then the entangled root of rice seedlings cause the injury to the seedling and affects the depth of planting or floating of seedlings. Cutting some part of root may enable easy operation of the machine. This experiment was conducted in order to determine the allowable degree of root cutting which enable satisfactory growth of rice.

material and Method

$T_0=N_0$ cutting T_1=cutting the root at 6cm from the end of the root. T_2=cutting the root at 4cm from the end of the root, T_3=cutting the root at 2cm from the end of the root, T_4= cutting the root at 0.1cm from the end of the root.

Fig 2. shows the cutting equipment. The restsof the expeaimental procedures as Exp.1.

Result and discussion

After setting them into the paddy, rate of floating seedling was high and planted rice seedling were not good. Eight days after planting, lain seedlings of plot T_4 stood up like the check.

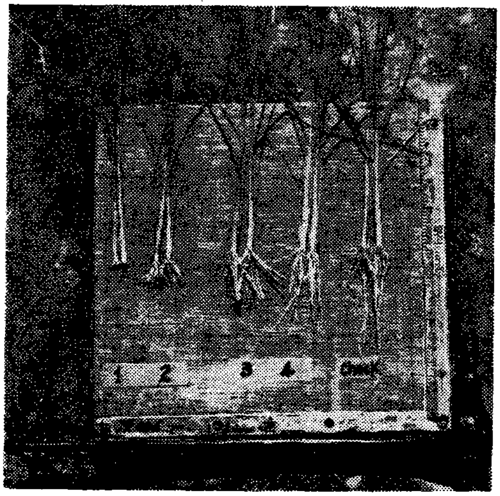


Fig 2. Cutting Equipment

1. Plant Height:As shown in table 2 there were little differences among different plots in plant height, having no connection with N-Level. As time goes by, the difference became less.

Table 5. Mean Value and Significant level in Plant Hight

Time of Investigation Pressure	(First Measurement)				(Second Measurement)				(Thired Measarment)			
	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total
T_0 (check)	32.9	33.5	33.1	99.5	45.1	49.6	54.5	149.2	60.6	67.8	72.0	200.4
T_1 (6cm)	33.0	34.2	35.3	102.5	42.7	42.7	55.7	144.1	59.8	68.4	72.7	200.9
T_2 (4cm)	33.3	34.9	33.6	101.8	42.0	50.8	54.7	147.5	58.4	67.9	72.7	199.0
T_3 (2cm)	33.2	35.0	34.7	102.9	42.4	50.1	65.1	147.6	59.3	68.5	73.5	201.3
T_4 (0.1cm)	32.3	31.6	32.3	96.2	43.0	48.3	53.0	144.3	59.9	66.4	70.3	196.6
Total	64.7	169.0	502.9	215.2	215.2	241.5	273.5	729.7	298.0	339.0	361.2	978.2

L.S.D. (5%)	First Measurement	SecondMeasurement	Third Measurement
N_2—N_1	2.46	4.31	4.95
T_2—T_1	0.80	1.23	1.05
N_1T_2—N_1T_1	1.49	2.18	1.81

2. Number of tillering. As shown in ɟable 2-2, there was no significant difference except the plot T_4, having no cornnection wiɿh N-level. As the time goesby, the difference became less

Tablə 6. mean value and its significant Ievel intillering

Time of Investigation	First Measurement				Second Measurement				Third Measurment			
	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total
T_0 (check)	5.2	6.5	7.6	19.3	11.5	11.6	16.0	39.3	10.5	13.3	15.6	39.4
T_1 (6cm)	4.3	5.8	8.1	18.2	9.5	11.9	16.5	37.9	9.6	12.4	16.2	38.4
T_2 (4cm)	4.4	7.0	7.7	19.1	9.4	13.1	15.5	38.0	9.3	13.6	15.0	36.6
T_3 (2cm)	4.5	6.9	7.3	18.7	10.9	11.5	16.5	38.9	9.7	13.6	15.0	36.6
T_4 (0.1cm)	4.0	5.3	7.1	16.4	9.0	11.2	14.6	34.8	9.3	12.3	15.0	36.6
Total	22.4	31.5	37.8	91.7	50.3	59.5	79.1	188.9	48.6	64.6	78.5	191.7

L.S.D.(5%)	First Measure ment	SecondMeasurement	Third Measurement
N_2—N_1	2.95	3.76	4.08
T_1—T	0.40	0.78	0.68
N_1T_1—N_1T_1	0.69	1.36	1.18

3. Yield and Yield Components

As shown in Table 2—3, no differences were shown among treatments. The plot of T_4 (0.1cm cutting) showed least yield but number of spikelets, number of grain per ear and rate of fertility showed no difference.

Through this experiment, it is found that root cutting treatment does not affect yield.

Table 7. Effects of root cutting on the yield and its components.

Item Degree cutting	Culm length (cm)	No. of spikelets	No. of Grain per ear	Fertility %	Grain Yield/hill (g)
T_0 (check)	86.9	10.0	101.1	94.2	17.81
T_1 (6cm)	85.1	9.0	103.5	91.7	17.22
T_2 (4cm)	83.0	8.9	98.1	91.4	16.77
T_3 (2cm)	83.4	9.1	100.8	90.0	16.86
T_4 (1cm)	84.3	8.8	100.2	92.2	16.51
L.S.D. (5%)	3.56	0.83	7.11	2.61	1.66

Ex 3. Influence of bending seedling upon the yield and growth of rice.

When we seperate every seedling fɿom the cluster, the entanglement of rice root and seperating speed cause bending of seedling. The experiment was performed to investigate the effect of bending root and growth of rice.

Material and Method

Nong Rim No. 6 was selected as the tes variety. Three levels of fertilizers were setup first. And 3 different levels of bending seedlings were set up as follows;

B_0=without bending B_1=90° bending

B_2=180° bending

Result and Discussion.

1. Height and Tillering.

As shown in table 3—2, there was difference among B_1, B_2, and the check during the early days. As times goes by, the difference become less.

Table. 8. Mean value and its significant level in Plant Height.

Time Inve. / Degree of bending	First Measurement				Secon Measurement				Third Measurement			
	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total
B_0	33.1	33.2	34.6	100.9	44.7	50.6	55.0	150.3	62.7	69 0	73.3	205.0
B_1	31.8	32.2	34.3	98.3	45.3	49.8	55.2	150.3	61.7	67.1	71.6	200.4
B_2	29.7	31.9	33.7	95.3	43.5	50.1	57.3	150.9	58.3	67.8	73.1	199.2
Total	95.6	97.3	102.6	294.5	133.5	150.5	167.5	451.5	182.7	203.9	218.0	604.6

L.S.D. (5%)	1st,M	2nd M.	3rd M.
N_2—N_1	1.47	6.36	6.62
B_2—B_1	1.21	2.35	1.83
N_1B_2—N_1B_1	2.15	4.07	3.17

Table 9. Mean value and its significant level in tillering.

Time of Inve. / Degree of Bending	First Measurement				Second Measwrement				Third Measurement			
	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total	N_1	N_2	N_3	Total
B_0	5.5	6.9	8.1	20.5	11.8	12.2	17.2	41.2	11.5	13.9	16.5	41.9
B_1	4.6	5.1	6.5	16.2	10.3	9.5	14.9	34.7	11.3	11.3	15.1	37.7
B_2	4.2	7.1	7.3	18.5	8.7	13.6	16.3	39.8	8.8	14.7	15.3	38.8
Total	4.3	19.0	21.9	55.2	30.8	35.5	48.4	147.7	31.6	39.9	46.9	118.4

L.S.D. (5%)	1st M.	2nd M.	3rd M.
N_2—N_1	2.45	4.79	4.38
B_2—B_1	0.74	2.26	1.49
N_1B_2—N_1B_1	1.28	3.92	2.58

2. Yield and its components

Table 10. shows that there were no signficant differences among plots in the culm lengch, the number of spikelets and number of grains per ear. Considering the 180° bending plot showed least yield, 180ט bending is not good for yield. Though 90° bending have not bad effect on grain yield, jt is perferable that bending should be avoided as possible.

Table 10. Effect of bending on the yield and its components.

Item / Degree of Bending	Culm length (cm)	No. of spikelets	No. of Grains per ear	Fertility %	Grain Yield/hill (gr)
Check b_0 t_0	86.4	10.5	98.5	91.7	18.37
90—B_1T_1	88.5	10.5	102.8	93.2	20.30
80—B_2T_2	86.7	9.5	107.0	92.1	18.00
L.S.D. (5%)	9.29	5.23	16.79	12.29	4.28

Ex. 4. Effect of folding point on growth and yield of rice.

The method of planting, seedling are various according to type of transplanter. When planting seedlings with transplanter, it is often the case that seedlinigs were put: nto soil with folded state according to soil condition and working conditon. This experiments was performed to investigate the growth when planting seedlings with folding stalk at 5mm above roots and when folded at the roots.

Sample Variety: Zin Hueng

S_0:Planting seelding with check (Straigth)

S_1:Folding stalks at 5mm above the roots.

S_2:Planting seeldings with folded root at 5mm below the end of stalk

Other test procedures were the same as except having only one level of fertilizers.

Result & Discussion

1, Growth

The seedlings with folding root were set normally, but with folding stalks were set slowly and grew only by tillering.

2. Plant Height and No. of tillering. The hight of S_1 was shorter than S_2 at the first measurement, but no difference in hight was found at the second cmeasurement. There were differences in S_1 and S_2 comparing with the checks. Tillering in S_1 were less than S_2 in both 1st and 2nd measurement. As the conclusion The effect of folding seedling on growth is bad in case of folding stalk of seedling and little ià case of folding root.

Table. 11. Mean value and its significant level in plant height and tillering.

Item	Plant Height		Fillering	
Time of Investigation Degree of double	1st measurement	2nd measurment	1st measurment	2nd Measurment
S_0	41.0	60.1	3.6	9.9
S_1	34.9	54.6	2.4	6.7
S_2	39.0	59.3	3.3	8.2
L.S.D. (%)	3.26	7.48	0.64	2.62

Ex I. Experiment on trialproduction of transplanter

This experiment was performed to produce manual rice transplanter most adaptable to soil condition and seedlings.

1. Material and Method

Trial rice transplanter was produced at the workshop in the college of Agriculture, Seoul National University.

Materials used were 3/4 pipe, 18tems of iron goods and 4 tems of wood. Equipments used were welded and other machine tools.

2. Result and Discussion

1) Structure of Transplanter, is shown in table 12. Fig 3. Fig 4. Fig 5.

2) Machanism

Table 12. Dimensions of Transplanter

Item			Transplanter No.1. Transplanter	(No.2)	(No.3)
(Man power or power)			(Man power)	(〃)	(〃)
(Transplanter)	(Wheel)	Rim	Dia 9 mm pipe	Dia 9 mm steel bar	〃
		Spoke	Dia 8 mm steel bar	〃	〃
		Hub	Dia 13 mm	〃	〃
			20cm×50cm×4cm=2cm	—	—
	(Length)		174cm	182cm	182cm
	(Height)		72cm	84cm	84cm
	(Width)		60cm	60cm	71cm
	(weight)		25.7kg	26.3kg	28.8kg
(Planting density)	(Raw Space)		30cm	30cm	30cm
	(Planting Space)		15cm	13, 15, 17cm	15, 15, 17cm
	(No. of Seedling per hill)		3, 4, 5	3, 4, 5	4
(Part of conveying seedling)			4 point saw (Type)	Belt	Belt
(Planting Method)			Fork)Type)	Treadin (Type)	Fork (Type)
(Supply Method)			(Washed root)	〃	〃

Fig 3.

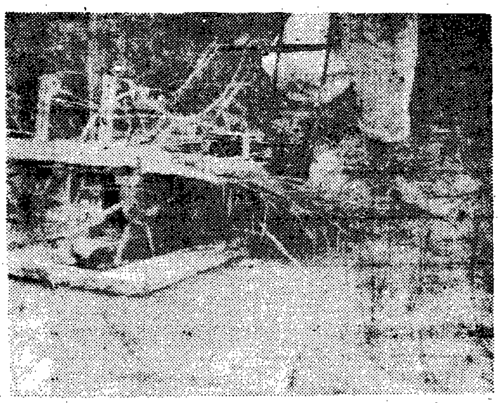


Fig 4.

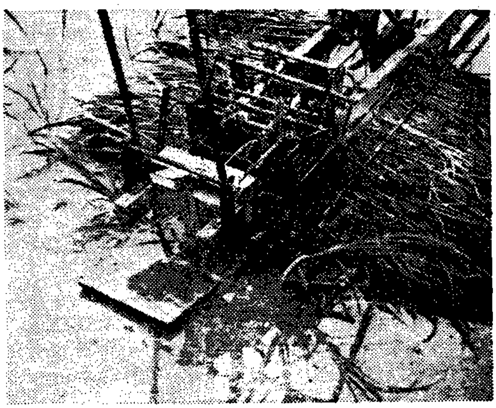


Fig 5.

Mechanisms of trial transplanters are tabulated as shown on Table 5—2

Table 13. Mechanism

Steel wheel — power-transmission chain — main shafi — spur gear

connecting rod
- →slider crank mechanism→4point asw
- →ratchet -pawl mechanism→Belt pulley
- →tangential cam with roller follower → slider crank mechanism
- →positive-motion cam with primary aod seondary follower → sliding block linkage
- →tangential cam with roller follower → quadric crank mechanism

3) Principles of planting

(1) No.1. Transplanter

Seedlings are placed upward with their root down on the belt which is operated by rachet-pawl mechanism T_3. First seperater connecting to push rcd pushes definit number of seedings toward Pincette Type-Secoend seperator Second seperator transfer seeldings to rammer. Fork type Rammer which is operated up and down presses down the roots of seeldings to plant them.

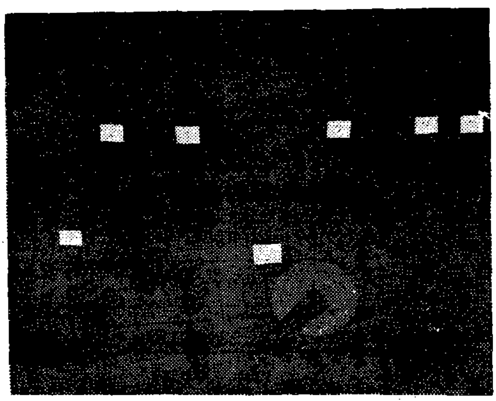


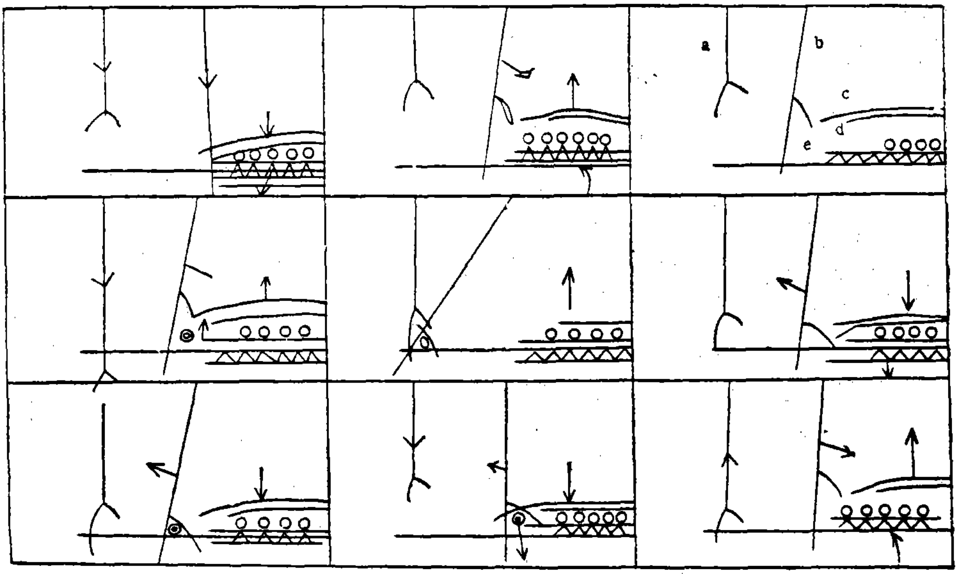
Fig. 6.

S_1, S_2; First Seperator

S_3, S_4; Second 〃

T_1 ; Rammer

T_2, T_3 ; Part of Transplanter



a; Rammer
b; Second separator
c; Supplementary separator
d; Supplementary separator
e; Part of transfer
f; Supplementay separator

Fig 7. planting process of No.3 transplanter

The plan of the most excellent No.3. Transplanter among three of them is as follows.

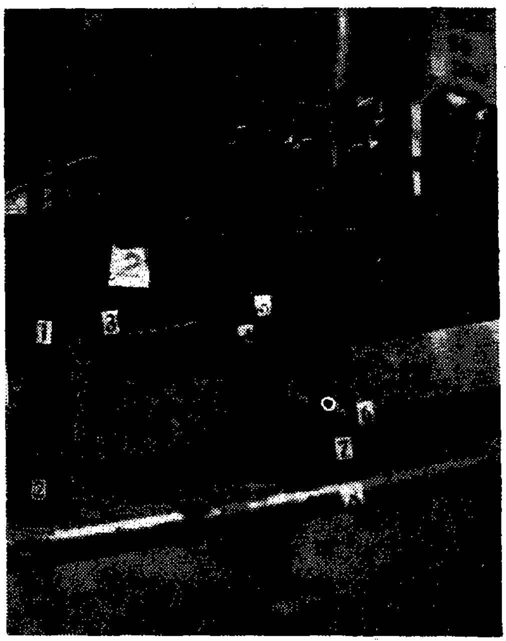


Fig 8. Seperator Rammer

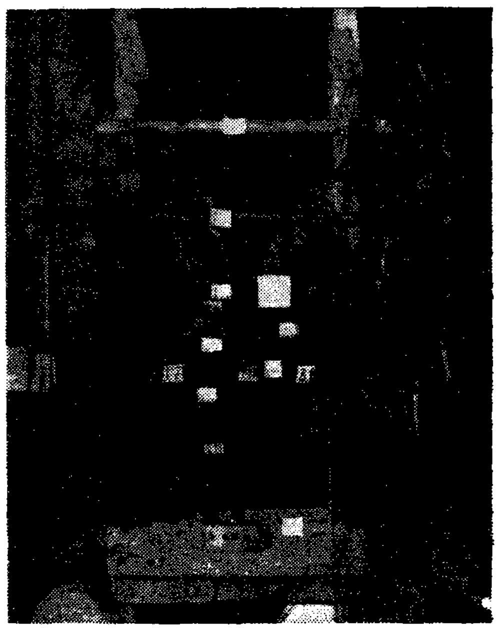


Fig 9. Transmission

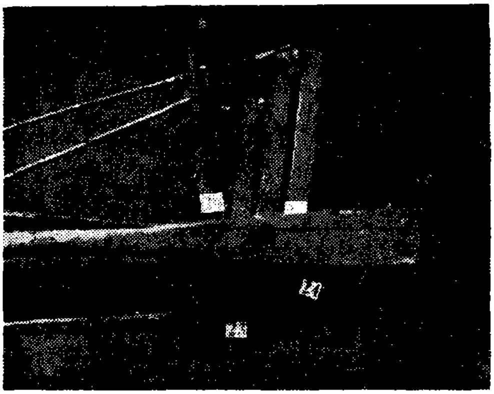


Fig 10. Transfer

Exp. Ⅱ Worlding Efficiency Test of Transplanter.

woking Efficiency of transplanter is changed by soil condition, cultivating condition, skill of operater and seedition. This test was performed to s?k for planting efficiency of transplanter.

Material and Method

1) place; The Farn at the College of Agriculture, S.N.U.
2) field; area 10a
3) seedling; 1) lenth; 13cm 23cm
   2) No. of stalks, 1 ea

Result and Discussion

1) Time Required

Fig 1. Shows theoretical fficiency of planting.

Fig 2 Shows the relation between planting space and Plantingspeed. Generally planting speed is higher in case of wide space than narrow in planting. Sunning speed is 0.24m/sec on an average in plang space 15cm. Then it takes 1.8 hours per 10a to plant seedlings.

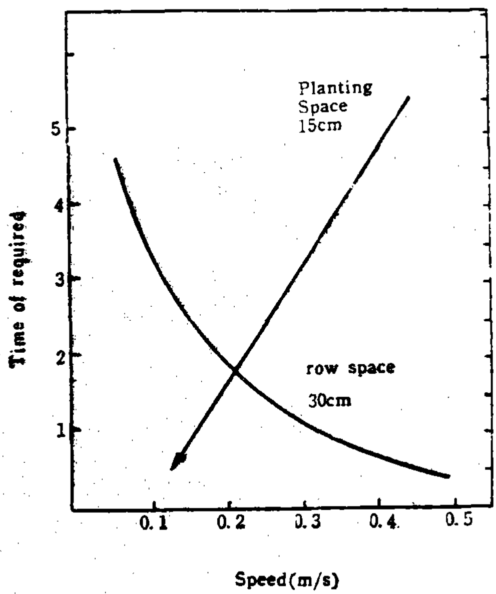


Fig 11. (Theoretical Efficiency of Planting)

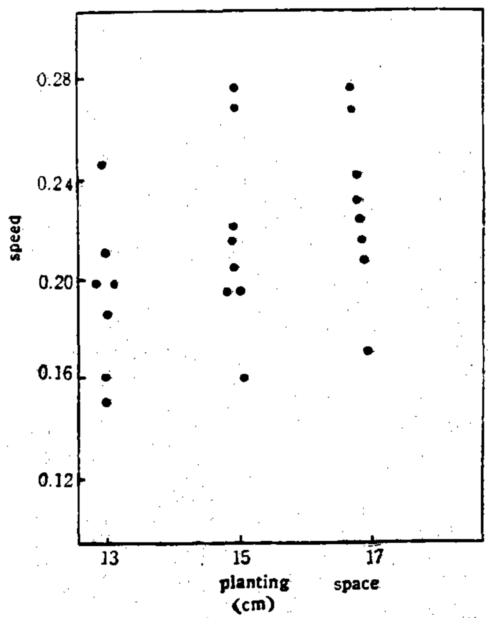


Fig 12. (Relation between planting Space and Planting speed)

2) Time of Supplyings Seedlings.

Time of supply=Time of washing root of seedling Time of carrying seedling+Time of loading seedlingon transplanter.

Relationship between tillering and control of hill is shown in table 14. According to table 14. the more number of seedling per hill and the number of tillering are, more time of supply is required. Time of supply is 1.7 hours on an average in case of 3 seedlings per hill.

Table 14. Relation between tillering and control of hill.

(No. of tillering control of hill)	Tillering (Tillering)	1	2	mean
3	1.74hr	2.40hr	2.98hr	2.25 L.S.D.
4	1.97	2.32	3.32	2.54 5%0.26
5	2.64	3.12	3.74	3.19 1%0.40
Mean	2.12	2.49	3.35	

L.S.D. 5% 0.42
1% 0.48

3) Turning Time

Table 15. shows percentage of turning time to total planting time in field area of 10a

As shown in the table, 88% required 15minutes of less: it is reasonable to say turning time is less than 15 minutes.

Table 15. (Turning Time)

Turning Time	5—10 (min)	10—15 (〃)	15—20 (〃)	20—25 (〃)	25(〃)
%	39	49	6	3	3

4) Time Required of Hindrance and adjustment of the planter

As rate of missing hills is high in case of hindrance of machine, the machine should be stopped and adjusted. Time required by hindrance and adjustment is less than 15 minutes as shown in Table 16.

Table 16. Time Required by Hindrance and Adjustment of planter.

(Time Requ. by Hindrance, Adjustment.	0	5 (min.)	5—10 (〃)	10—15 (〃)
%	9	22	37	19

(Time Requ. of Hindrance, control)	15—20 (min.)	20—25 (〃)	25 (〃)
%	5	7	1

5) Time Required in paddy Field.

Fig 3. shows time required in paddy field.

The actual time required in paddy field is 3.34 hours on the average which is 2 hours more than theoretical time at planting space 15 cm, raw space 30cm and planting speed 0.24 m/sec.

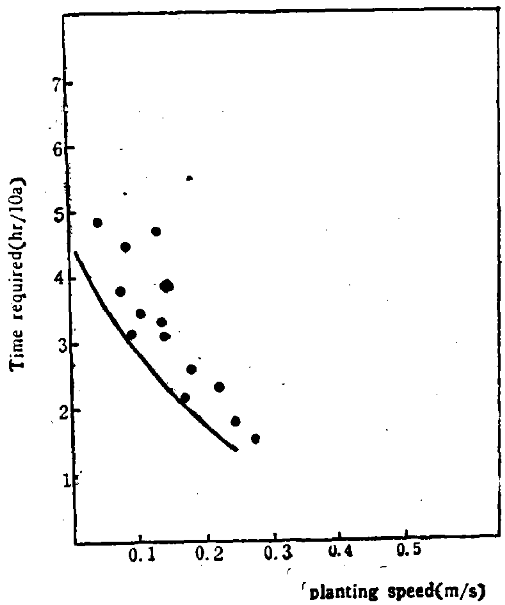


Fig 13. Time Required in paddy field.

Exp Ⅱ. Experiment of planting accuracy of transplanter.

The performance of a transplanter may be vaired according to soil condition, cropping condition and condition of seedling. This test was run in order to investigate planting performance of the transplanter. Field condition and cropping condition were sepearted or readjusted according to item of Exp Ⅰ. Planting accuracy was measured 3 times by 60 rounds, and Procedures of the test was Same as in Case of Exp. Ⅱ.

Result and Discussion

1) Raw Space

When the transplantor turned around the variation of raw space was great, but mechnical variation of raw was little.

Table 17. shows the percentage of variation of raw space 30cm. Raw space was inclined to be less than 30cm. As raw space 30+1 cm was 76%, more Number of seedlings than expected was needed. Therefore the worker should take utmost care of transplanter at work.

Seedlings planted were not vertical but lanting and readjustment of transplanter was necessary in deep water.

Table 17. Variation of Raw Space.

Raw Space (cm)	28(−)	28—29	29—30	30—31	31—32	32(+)
%	9	11	53	23	2	2

2) Planting Space

The wheel of transplanter was made in consideration of slip and velocity in design. Variation of planting space is shown in table 18.

Tabie 18. Variation of planting Space.

Planting Space	12—13	13—14	14—15	15—16	16—17	17+
%	2.2	6.1	42.4	40.9	6.3	2.1

As shown in table 18. the effect of variation of the planting space on the number of seedlings required seems to be little. Since the spaces are fairly uniform and the rate of wider spaces and that of narrower spaces are similar.

3) Ratio of Missing Hills by Structure

A. Relation between plant height and ratio of missing hills.

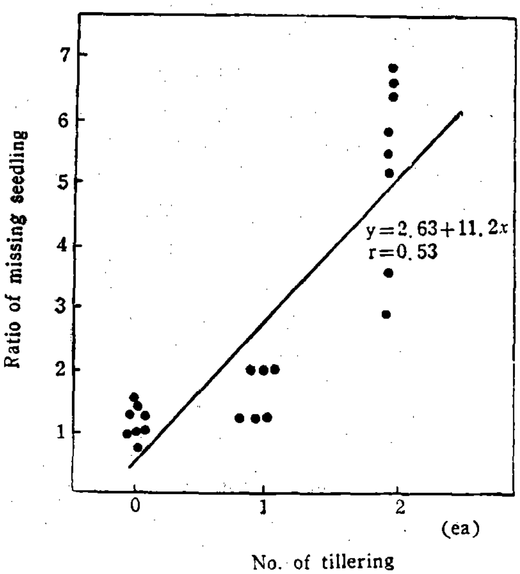


Fig 14. Relation between plant height and ratio of missing hills

As shown in Fig 14. ratio of missing hills was increased in proportion to plant height.

B. Relation between Seedlings per Hill and Ratio of Missing hills.

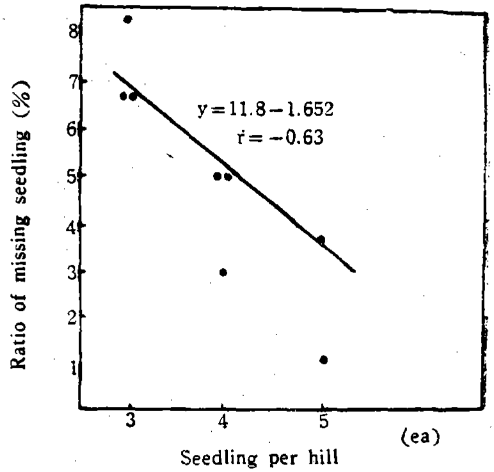


Fig 15. Seedling Per Hill

As shown in Fig 10—2, ratio of missing hills was decreased as number of seedling per hill was increased.

C. Relation between tillering and ratio of missing hills

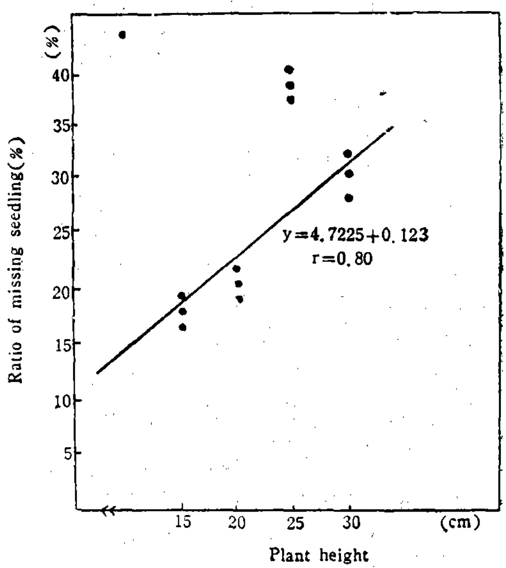


Fig 16. Relation between tillering and ratio of missing hills

As shown in Fig 16. degree of tillering greatl effects ratio of missing hills, especially in case of more than 2 tillerings mean ratio of missing hills is 28.2%. Therefore it took many hours to fill up the missing hills and work efficiency was decreased. Increase of number tillering not only makes the accuracy of seperating seedlings decline but also is the cause of injury on seedlings. Therefore, tillering seems to have most important effect upon ratio of missing hills.

Ratio of floated seedlings

A. Relation between depth of water and ratio of floating seedlings

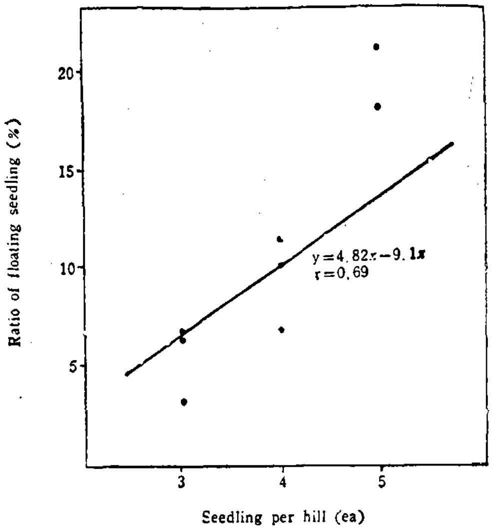


Fig 17. Relation between depth of water and ratio of floated seedlings

As shown in Fig 17. there was a great difference in ratio of floated seedlings when depth of water is more than 2cm. Therefore, planting is not accurate.

B. Relation Between Seedlings per Hill and Ratio of Floated Seedlings.

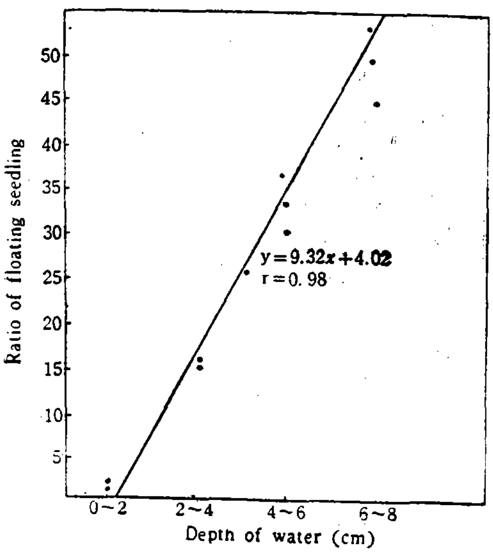


Fig 18. Relation between Seedling per Hill and Ratio of Floated Seedlings.

C. Relation between Tillering and Ratio of Floated Seedlings

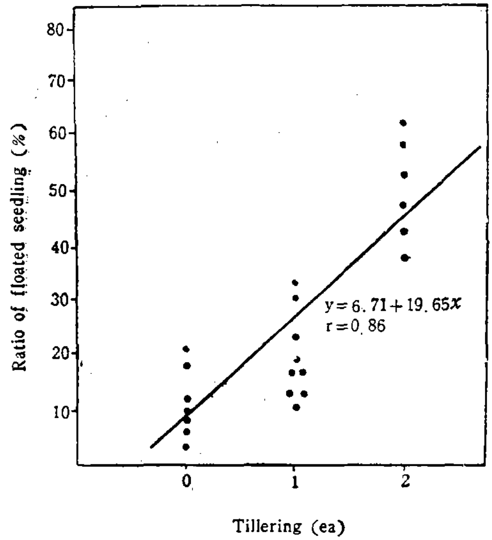


Fig 19. Relation between tillering and Ratio of floated Seedling

Tillering shows remarkable effect upon floated seedlings.

D. Relation between Plant Height and Ratio of Floated Seedlings.

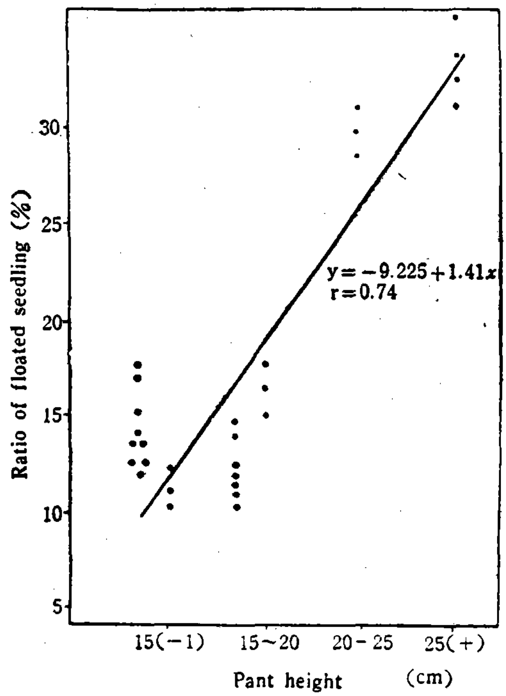


Fig 20. Relation between Plant Height and Ratio of floated seedling.

E. Relation between Soil Condition and Ratio of floated Seedling.

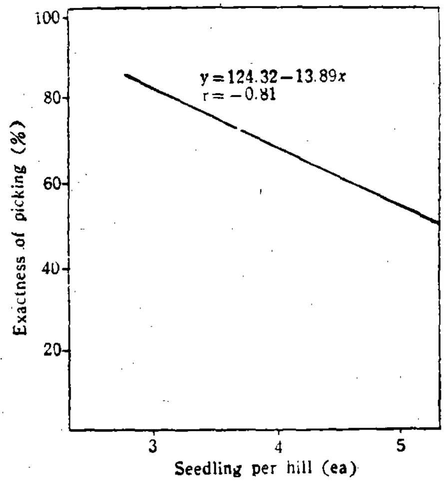


Fig 21. Relation between Soil Condition and Ratio of floated seeding.

4) Relation between Seedling per Hill and Exactness of Picking.

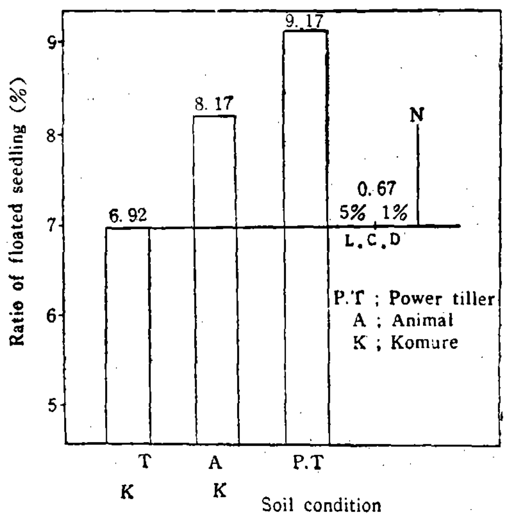


Fig 22. Relation between seedling per hill and Exactness of picking

Ex. Ⅳ Field Test

This test was performed in order to investigate whether the trial rice-transplanter may be useful or not by comparing the early stage growth of seedlings planted by transplanter with those planted by hands.

Method Materi... and

1) Test field
   a) Area 5a (54m×9m)
   b) Weight of Fertilizers N=4kg, p=3kg, K=3kg
   c) Depth of water 2cm+1cm

20 Paddy Rice
   a) Variety Tin Hueng
   b) Plant Height of seedlings; 14,7cm (Average)
   c) No. of Tillering; 0,2 (Average)
   d) Length of Root; 4.3cm 〃

3) Working Condition
   a) No. of Raw 2
   b) Raw Space×planting Space; 30cm×15cm
   c) Man Required; 5 (I for transplanter 4 for hand planting)

Result and Discussion

1) Appearance of transplanted seedling

Appearance of seedlings transplanted by transplanter was worse than that by hand as shown in Fig. 23. But seedlings transplanted by transplanter stood up erect equally to those by hands in 8days, as shown in Fig 24. Roots of seedlings were set into soil by then.

Fig 23. Appearance right after transplanting

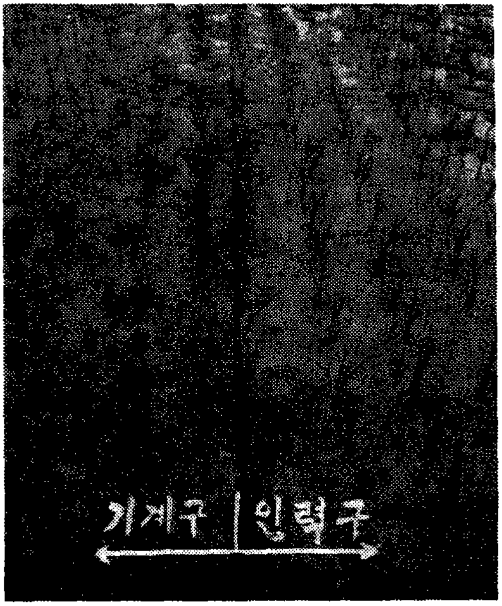


Fig 24. Appearanc 8 days after transplanting

2) Growth in early days.

Classification	Plant Height		tillering	
	Aug. 5 (first)	Aug. 20 (second)	Aug.5	Aug. 20
by Hand	47.1	66.5	3.6	14.2NS
by Trans-planter	47.9NS	67.4NS	8.2	13.9

The differences are insignificant.

3) Appearance of heading date

There was no difference in heading date of the plants planted by transplanter comparing those by hands.

Fig 25. Appearance at heading date

Results

Obtained results are as follows.

1) Recovery from mechanical injury on rice Seedlings are easily made.

when; pressure less than 2kg, the degree of bending less than 90 and the length of cutting root less than 2cm.

It is more advantageous to handle the root of seedling.

2) work efficiency in field is 5% lower than theoroctical work efficiency.

3) Time for supplying seedling is 52% of total time required for transplanting and it is main cause of declining the work efficiency.

4) Force for pushing transplanter is small. (18.5kg)

5) It is more advantageous to transplant seedlings, when the depth of water is less than 2cm, the plant height less tha 20cm and no tillering.

6) It takes 3.37 hours per 10a to transplant rice seedlings.

7) There are some differences in planting accuracy but none in growth of early days between planting by transplanter and by hands.

Summary

A rice transplanter autheticated by the basic experiments was applied in a field test.

The results obtained were folloasws.

1. The necessary conditions for this rice transplanter are no tillering, shorter seedlings of less than 20 cm, level soil surface and water depth of less than 2 cm.
2. In order to assure the practical use of the rice transplanter in field work, the power trans mission and [illegible] should be studied and modified.

3) Field performance of the rice transplanting work is 337 hrs. per 10 a under the necesary conditions and it is satisfactory as a trial transplanter.

4) Accuracy of work of this transplanter is as good as that of the hand-planting under the given conditions.

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