移秧機 植付機構의 機構學的 分析

Kinematic Analysis of Planting Mechanism of Rice Transplanters

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적 요

줄모용 수도 이앙기에 있어서 식부 기구(植付機構)의 운동이 이앙작업 정도(精度)에 미치는 영향을 연구하기 위하여 3종의 줄모용 수도 이앙기를 대상으로 식부기구의 기구학적 분석을 위한 해석적 방법을 발전시켜 기구의 운동을 분석하고 기계와 모와 토양사이의 상호관계를 고찰하였다.

(1) 식부호가 모를 심고 지중에서 되돌아 나올때 식부호의 궤적이 이앙 작업정도에 미치는 영향은 식부 기구 B가 가장 적으며 C가 가장 크다.

(2) 식부 기구 A 및 B는 속도의 변화가 심하여 에너지 변동과 기계진동의 원인이 된다.

(3) 식부호가 지중에서 모와 접촉하며 되돌아 나올 때의 식부호의 속도를 그려보면 식부 기구 A가 B, C에 비하여 이앙작업 정도에 미치는 영향이 크다.

(4) 모를 절단할 때의 모 이송 로울러와 식부날과의 각도 및 식부호의 속도를 그려보면 식부 기구 A가 모에 손상을 줄 가능성이 가장 크다.

Introduction

Rice transplanting may be one of the most laborious operation in rice cropping. In addition, the labor requirement for this season is very critical because of the overlapping cropping functions such as barley and/or wheat harvesting. To reduce this peak labor requirement and minimize the timeliness effect of rice transplanting and the other associated croppings, the need for mechanizing the rice transplanting has been strongly recognized.

In Japan, various types of rice transplanters are the self-propelled machines which transplant the early seedlings with soil. In Korea, a hand-push-type rice transplanter was developed and is available now as a commercial unit. It transplants the early seedlings with soil, the seedlings being guided by serial belt to the planting hoe. In spite of tremendous improvement, it still possesses many undesirable points. An irregular planting depth, floating seedlings, and seedling damage during transplanting have been the major concern for further improvement. Transplanting accuracy of a machine depends upon the functional relationship among the planting machanisms, seedling, and soil conditions. The most desirable machine may be the one which functions properly in treating seedlings for prevailing soil conditions.

Therefore, it may be necessary to understand rigorously the whole picture pertinent to the transplanting system, or the functional relations among machines, seedlings, and soil conditions.

Unfortunately, no much work on the kinematic analysis has been done so far, so that one can understand better the transplanting system as a whole.

The objectives of this study were as follows;

(1) To analyze the planting mechanism of three different early-seedling-type rice transplanters available on the market.

(2) To investigate the effect of motions by these different planting mechanisms on planting

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accuracy.

Review of it Literature

Mechanization of rice transplantation may not be a new problem in the rice cropping countries. According to the literature[8], Japan has the longest history of developing rice transplanter in the world. The first patent for rice transplanter was obtained in 1898. But it was or five years ago that they put rice transplanter in practical use. It is estimated that in Japan about 200,000 rice transplanters are now used in farm villages. Rice transplanters on the market are classified into two types according to the kinds df the seedlings, or the seedlings with and without soil in their root zone. The former uses conventional seedlings which soil adhered to their roots is washed off. On the other hand, the latter uses seedlings with soil which are grown in seedling boxes and uses a set of special tools and facilities whiles while growing.

These rice-transplanters are classified into belt seedling type, serial belt seedling type, mat-type, pot-type according to the seedling growing.

Mechanical problems encountering with the commercial units of rice-transplanters were reported as follows;

(1) Floating seedlings or their sinking.
(2) Seedlings damaged by transplanting.
(3) Irregular planting depth.
(4) Indefinite number of seedling.
(5) Improvement of seedling belt and seedling feeding mechanism.
(6) Improvement of adaptability to condition of paddy fiels.
(7) Making weight of rice-transplanter lighter
(8) Improvement of adjusting mechanism to width of low dykes separating paddy fields and seedling interval.
(9) Simplification of handling.
(10) High price, etc.

The agronomic research of early seedlings with soil and rice cultivation in paddy fields for mechanizing rice-transplanting was performed by Kinebuchi[6]. He investigated the environmental adaptability of early seedlings, and the effect of the machine transplanting on the growth of rice plant and yield. He proposed that empty planting due to mechanical and the other faulses caused worse yields and too deep transplanting should be carefully avoided. By nation-wide experiments with TP-21 transplanting machine for seedling with soil, he concluded that no significant differences of yields and growth of rice plant with those of customary transplanting by hand were observed if increased the seedling density by 10% in the machine transplanting.

Yamazawa[18] investigated the effect of soil conditions of paddy field by varying tilling and harrowing pratices on the planting accuracy of the rice-transplanter for serial belt seedlings with soil which has planting hoes attached to rotating disk. He concluded that the slippage of the drive wheel, which alters greatly the linear displacement of planting hoe, cohesion between root portion of seedling and paddy soil were the significant factors for giving the unstability or on inclined standing of seedlings.

According to the literature[12] in which the performance of various commercial rice transplanters (included Yanmar FP 2A, Kanriu TE 2-1, and Mitsubishi PA 201) was observed by field test, planting depth causing floating seedlings was influenced by the ground conditions, which in turn affected the driving stability of the machine. The uprightness of seedling was also affected planting mechanism of the transplanters tested and soil conditions of paddy field.

Nanbu[8] investigated the limitations of the field capacity of the sugar beet transplanting machine with a geometrical solution and compared with high speed camera and actual field test analysis. They reached almost the same conclusion as indicated above.

There are many literatures (11. 12. 13. 14. 19) available for developing the rice transplanters, the review of which being avoided since they were no direct connection with this study.

In Korea, Institute of Agr. Eng. and Utilization[9] [10] manufactured a trial rice transplanter used for conventional seedlings, which was capable to transplant 4 rows by man power. It had so many problems in separating seedlings that it was not put in practical use.

Jun[11] studied the effect of various types of mechanical damage to conventional seedlings on growth of plant and yields. He also manufactured a trial hand-push-type transplanter applicable to conventional seedlings and investigated its performance by field test.

Han and his team[4] manufactured a trial hand-push-type transplanter for serial belt seedlings. Its planting hoe is actuated by the 4-bar linkage. He concluded that the machine gave the best performance of the existing hand-push-type transplanters and the most adaptable for Korean farmers. It is now available as a commercial unit.

Han and his team[5] compared by the field test with the performance of six models of rice transplanters (including Yanmar FP 2A and Mitsublishi PA 201) available on the market.

Institute of Agr. Eng[2]. in England manufactured a 4-row manual rice transplanter for conventional seedlings which had pincette type planting mechanism. In Italy, a tractor pulling type transplanter[14] was manufactured in 1952, but failed to introduce for practical use because of advantage of direct seeding.

Theoretical Development

I. Outline of transplanters used in this study.

Three rice transplanters were analyzed in this study. Types of the machines and their characteristics are summarized in Table 1.

Table 1. Types of rice transplanters analyzed

Identifying Notation	Brand & Type	Power Source	Number of rows	Country
A	Jung Ang	Hand-push-type	1	Korea
B	Yanmar FP 2A	Self-Propelled with engine	2	Japan
C	Mitsubishi PA-201 (Kanriu TE 2-1)	Self-Propelled with engine	2	Japan

The seedlings for which these transplanters use are grown for a shorter period than those which are transplanted by conventional manual method.

The seedlings suited for machine use are specially grown in nursery boxes (60cm in length, 30cm in width, and 3cm in depth) which are kept within a temperature-controlled space. The box is striped in 1cm interval in the lateral direction by the flexible plastics to make continuous grooves where seeds are planted.

It takes about 15 days before transplanting compared to about 45 days for seedlings used in conventional method.

The schematic drawings of the working parts of the rice transplanters used in this study are shown in Fig 1.

Fig 2 shows the plan views (left) and side views (right) of transplanting hoes for three machines.

The transplanting hoe for transplanters "A" and "B" is the main part for cutting, transporting and putting the seedling into soil and is extended from the connecting rod of the crank-rocker mechanism.

The hoe has a cutting edge at its end to provide a suitable working shape relative to seedlings and soil.

The basic difference between the transplanting hoe of machine "C" and those of machines "A" and "B" is that the former is attached to the rotating disk while the latter to the four-bar linkage. The disk possesses 7 transplanting hoes in its circumference and is there-fore 7 times as slow as the crank motion of the machines "A" and "B" in giving the same spacing of seedlings being transplanted. The other major machine

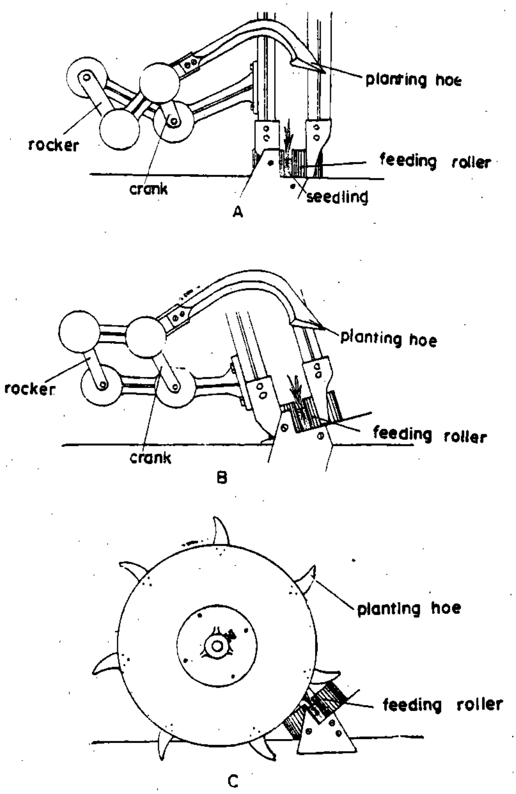

Fig 1. The schematic diagrams of transplanting mechanisms.

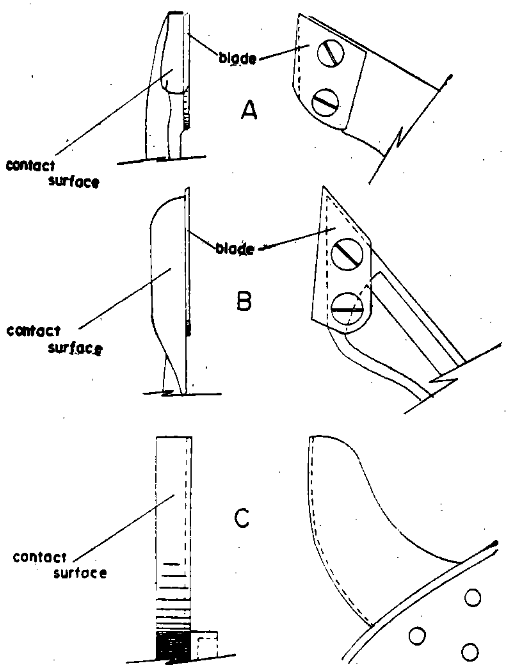

Fig 2. The details of transplanting hoe for each machine.

element common to those machines is the seedling conveying mechanism. The continuous conveyance of seedlings, from the box to the point where the transplanting hoe acts to the seedlings, is provided by rotating rollers between which the string-guided seedlings are forced to pass.

Power required to actuate the conveying and transplanting mechanisms comes from either traction wheel or self-propelled power source. Whichever the case is, there is a definite relation of rotational speeds between the traction wheel and input crank. The speed eduction can be obtained by gear train.

2. Displacements and velocities of the planting hoe of planting mec hanisms "A" and "B".

The planting hoe of mechanisms "A" and "B" is the part of connecting rod of four-bar mechanism.

As the machine move forward, the path traced by the planting hoe describes a coupler curve. To analyze the motion of the planting hoe relative

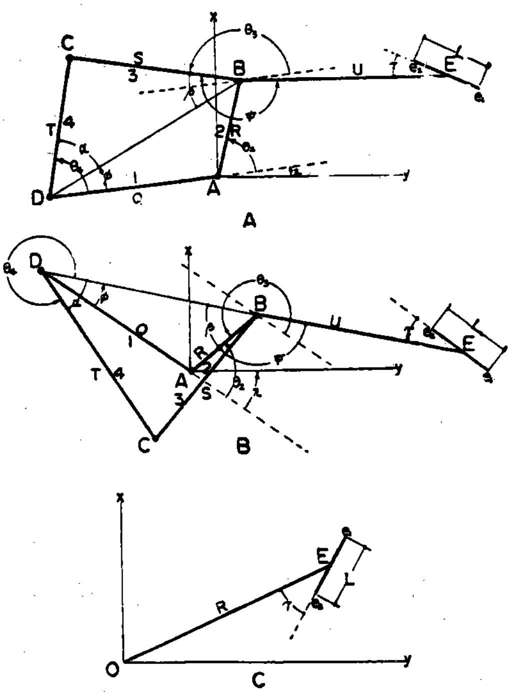

Fig 3. Mechanisms of there rice transplanters analyzed and notations used.

to both machine frame and ground, it was attempted to derive the general equations by which its di splacement and velocity could be given by the preselected forward motion of machines.

The equation for the coupler curve given by Beyer[1] may not be convenient for the analysis of planting hoe. The reason is that the coordinate used to derive the Beyer's equation gives no relation between the coupler and angular displacement of input link. Therefore, Martin's method[7] for analyzing the position of a stationary four-bar mechanism was adopted in this study as the basis for formulating the moving 4-bar mechanism.

(1) Positions of the 4-bar linkage.

Refer to Fig. 3, Let Q, R, S, and T denote the lengths of links 1, 2, 3, and 4, respectively. Link 2 is the driver whose motion can be prescribed by the angular displacement θ_2 in reference to machine frame and the angular velocity ω_2. The angular displacements of link 2(θ_2), link 3(θ_3), and link 4(θ_4) to the reference frame as shown in Fig. 3, and their time derivatives are considered positive when rotating in the counterclockwise direction.

It can be seen that the sums of the horizontal and vertical components of R,S, and T are given by

$$Q=R\cos\theta_2+S\cos\theta_3-T\cos\theta_4 \quad (1)$$

$$R\sin\theta_2+S\sin\theta_3=T\sin\theta_4 \quad (2)$$

where θ_3 and θ_4 are to be given by the known lengths of links and the input angle θ_2.

Two triangles $\triangle$ABD and $\triangle$BCD are formed by connecting points B and D, and applied the laws of sines and cosines to those triangles.

Applying the law of cosines to the triangle $\triangle$ABD,

$$BD=\sqrt{R^2+Q^2-2\times R\times Q\times\cos(180^\circ-\theta_2)} \quad (3)$$

and using the law of sines of the triangle ABD,

$$\phi=\sin^{-1}\frac{R\times\sin(180^\circ-\theta_2)}{BD} \quad (4)$$

It may be noted that BD and ϕ are the function of θ_2 only.

By following the similar method on the triangle $\triangle$BCD,

$$\beta=\cos^{-1}\left(\frac{S^2+BD^2-T^2}{2\times S\times BD}\right) \quad (5)$$

$$\alpha=\sin^{-1}\left(\frac{S\times\sin\beta}{T}\right) \quad (6)$$

The geometric difference of the mechanisms between the machines "A" and "B" is observed in θ_3 and θ_4 as:

For planting mechanism "A",

$$\theta_3=180^\circ+\beta+\phi \quad (7)$$

$$\theta_4=360^\circ-(\alpha-\phi) \quad (8)$$

For planting mechanism "B",

$$\theta_3=180^\circ-(\beta-\phi) \quad (9)$$

$$\theta_4=\alpha+\phi \quad (10)$$

(2) Linear displacement and velocity of the point E relative to the machine frame.

Consider point E on link 3, the center of planting hoe. The position can be described by two position vectors U and R for a given θ_2 as the reference point is selected at A.

Components of the linear displacement of point E in X-and Y-directions relative to the machine frame are:

$$Ex=R\cos(\theta_2+\lambda)+U\cos(\theta_3+\phi+\lambda) \quad (11)$$

$$Ey=R\sin(\theta_2+\lambda)\times U\cos(\theta_3+\phi+\lambda) \quad (12)$$

where λ and ϕ are fixed for a machine and independent upon the position of θ_2.

The derivatives of equations (1) and (2) with respect to time yield the following equations:

$$-R\omega_2\sin\theta_2-S\omega_3\sin\theta_3+T\omega_4\sin\theta_4=0 \quad (13)$$

$$R\omega_2\cos\theta_2+S\omega_3\cos\theta_3-T\omega\cos\theta_4=0 \quad (14)$$

where ω_2, ω_3 and ω_4 are the angular velocities of link 2, 3, and 4, respectively.

To solve Eqs. (13) and (14) for ω_3 and ω_4 Cramer,s rule is used. The resulting equations for ω_3 and ω_4 are:

$$\omega_3=\frac{R}{S}\omega_2\frac{\sin(\theta_2-\theta_4)}{\sin(\theta_4-\theta_3)} \quad (15)$$

$$\omega_4=\frac{R}{S}\omega_2\frac{\sin(\theta_2-\theta_3)}{\sin(\theta_4-\theta_3)} \quad (16)$$

(3) Velocity of the point E relative to the machine frame.

Differentiating Eqs. (11) and (12) with respect to time gives the velocity components in X-and Y—directions or $(V_E)x$ and $(V_E)y$ as:

$$(V_E)x=\frac{dEx}{dt}=-R\omega_2\sin(\theta_2+\lambda)$$

$$-U\omega_3\sin(\theta_3+\psi+\lambda) \quad (17)$$

$$(V_E)y=\frac{dEy}{dt}=R\omega_2\cos(\theta_2+\lambda)$$
$$+U\omega_3\cos(\theta_3+\phi+\lambda) \quad (18)$$

(4) Linear displacement of the point E relative to the ground.

When the machine moves on the ground at the constant forward velocity V, the machine frame moves as much as X during a period of t

$$X=V\times t \quad (19)$$

Since angular velocity of the input link is given by

$$\omega_2=\frac{\theta_2}{t} \quad (20)$$

where θ_2 is measured from $t=0$.

By eliminating t from Eqs. (19) and (20)

$$X=V\times\frac{\theta_2}{\omega_2} \quad (21)$$

Therefore, the linear displacements of the point E in X-and Y directions in reference to ground are:

$$E'x=Ex+X=R\cos(\theta_2+\lambda)+U\cos(\theta_3+\psi+\lambda)+V_E\frac{\theta_2}{\omega_2} \quad (22)$$

$$E'y=Ey \quad (23)$$

(5) Linear displacement of two extreme points of cutting edge relative to the ground.

The cutting edge of the planting hoe has the length L. Two extreme points of the cutting edge were termed as the inner and outer edge points and denoted by e_1 and e_2, respectively, as shown in Fig.3. From the geometric relation, the linear displacements of points e_1 and e_2 relative to ground derived as:

For the outer edge point e_1,

$$(e_1')x=E'x+\frac{L}{2}\cos(\theta_3+\psi+\lambda+\gamma) \quad (24)$$

$$(e_1')y=Ey+\frac{L}{2}\sin(\theta_3+\psi+\lambda+\gamma) \quad (25)$$

where $(e_1')x$ is the linear displacement of outer edge point in X-direction,

$(e_1')y$ is the linear displacement of outer edge point in Y-direction,

and γ is fixed for a machine and independent upon the position of θ_2.

For the inner edge point e_2.

$$(e_2')x=E'x-\frac{L}{2}\cos(\theta_3+\psi+\lambda+\gamma) \quad (26)$$

$$(e_2')y=Ey-\frac{L}{2}\sin(\theta_3+\psi+\lambda+\gamma) \quad (27)$$

where $(e_2')y$ is the linear displacement of inner edge point in X-direction,

$(e_2')y$ is the linear displacement of inner edge point in Y-direction.

(6) Velocity of the point E relative to the ground.

Differentiating Eqs. (22) and (23) with respect to time gives the velocity components in X-and Y-directions in reference to ground as:

$$(V'_E)x=\frac{dE'x}{dt}=\frac{d}{dt}\left(Ex+Vx\frac{\theta_2}{2}\right)$$
$$=(V_E)x+V \quad (28)$$

$$(V'_E)y=\frac{dEy}{dt}=(V_E)y \quad (29)$$

where $(V'_E)x$ is the linear displacement of the point E in X-directione

$(V'_E)y$ is the linear displacement of the point E in Y-direction.

3. Displacements and velocities of the planting hoe of planting mechanism "C".

Refer to Fig.3. Let R represent the length between the center of contacting surface of planitng hoe and the axis of the rotating disk.

(1) Linear displacement of the point E relative to the machine frame.

Consider point E, the center of contacting surface of planting hoe. The positon can be described by a position vector R for a given θ as the reference point is selected at point A.

Components of the linear displacement of point E in X-and Y-directions relative to the machine frame or Ex and Ey are given by:

$$Ex=R\cos\theta \quad (30)$$

$$Ey=R\sin\theta \quad (31)$$

where θ is the angular displacement of the rotating disk.

(2) Velocity of the point E relative to the machine frame.

Differentiating Eqs. (30) and (31) with respect to time gives velocity components in X-and Y-directions as:

$$(V_E)x=\frac{dEx}{dt}=-R\omega\sin\theta \quad (32)$$

$$(V_E)y=\frac{dEy}{dt}=R\,\omega\cos\theta \qquad (33)$$

where ω is the angular velocity of the rotating disk.

(3) Linear displacement of the point E relative to the ground.

By following the similar method and the same notations as done on the mechanisms "A" and "B," the linear displacements of the point E relative to theground are:

$$E'x=Ex+X=R\cos\theta+Vx\frac{\theta}{\omega} \qquad (34)$$

$$E'y=Ey \qquad (35)$$

(4) Linear displacements of two extreme points of the planting hoe relative to the ground.

For the outer point e_1,

$$(e_1')x=E'x+\frac{L}{2}\cos(\theta+\gamma) \qquad (36)$$

$$(e_1')y=Ey+\frac{L}{2}\sin(\theta+\gamma) \qquad (37)$$

For the inner point e_2,

$$(e_2')x=E'x-\frac{L}{2}\cos(\theta+\gamma) \qquad (38)$$

$$(e_2')y=Ey-\frac{L}{2}\sin(\theta+\gamma) \qquad (39)$$

(5) Velocity of the point E relative to the ground.

By differentiating Eqs. (34) and (35) with respect to time,

$$(V'_E)x=\frac{dE'x}{dt}=\frac{d}{dt}\left(Ex+Vx\frac{\theta}{\omega}\right)$$

$$=(V_E)x+V \qquad (40)$$

$$(V'_E)y=\frac{dEy}{dt}=(V_E)y \qquad (41)$$

Analysis of Mechanism

Analysis of displacements and velocities of various points, which were considered important to understand the motion of the rice transplanters "A", "B" and "C" was performed by the computer programs. The equations derived in the previous chapter were conveniently applied for calculating various kinematic values for different position of links, using 5-degree intervals of crank angle for the input link, link 2. Table 2 shows the dimenions of linkages which were actually measured from three machines. The forward velocity of each machine relative to the ground was assumed as 60 centimeters per second and the corresponding constant angular speeds of input links are slso indicated. The results of analysis for these machine parameters and for 72 different positions are shown in Table A-2-1 through Table A-4-2.

Table 2. Machine parameters used for analysis of mehcanisms.

Quantity	Description	Unit	Machine A	Machine B	Machine C
Q	length of link 1	cm	10	5.5	—
R	length of input link (crank or rotor)	〃	4	3	17.5
S	length of link 3	〃	8	5	—
T	length of link 4	〃	8	4	—
U	length from point B to E of transplanting hoe	〃	17.5	15.5	—
L	length of cutting edge of transplanting hoe	〃	3	3	3
ϕ	angle between link 2 and points B and E	degree	137°18′	182°	—
γ	angle between cutting edge and the line connecting points B and E	〃	−14°30′	−14°30′	45°
λ	angle between link 1 and ground level	〃	−30°	20°	—
V	forward velocity of machine	cm/sec	60	60	60
ω	angular velocity of input link	rad/sec	−36	−36	−5

Results and Discussion

Figs.4. through 6 show the path traced by the center point of the transplanting hoe relative to the machine frame. The trace of point E of the machine "C" forms a circle whose radius is the radial distance from the center of the rotational shaft to the point E. Instead, the couplers for the machines "A" and "B" are vary complex curves. The significant differences between the couplers of both may be seen in their lower portion where the planting hoe and seedlings are contact with the ground soil.

The paths traced by the hoe center as the machine moves forward are shown in Figs 7 through 9. Fig 10 shows in detail the moving pattern of the hoe-edge within the ground soil.

These paths are very important to study planting phenomena and the stability of seedlings after

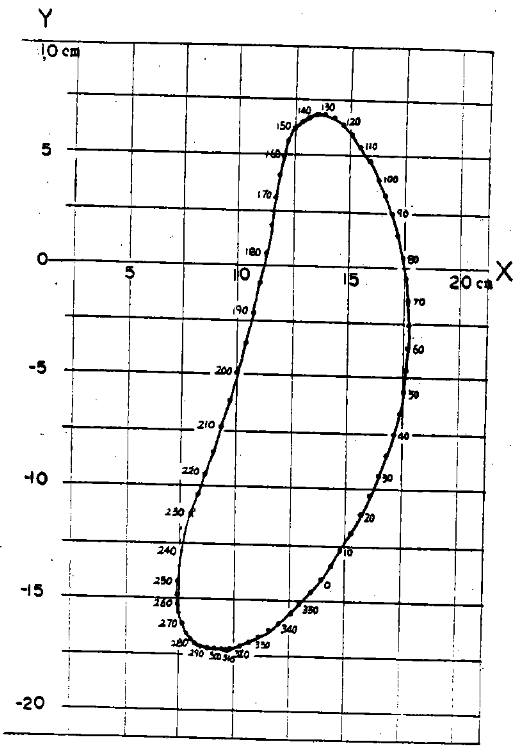

Fig 4. **Coupler curve of hoe-center of mechanism "A" relative to the machine frame.**

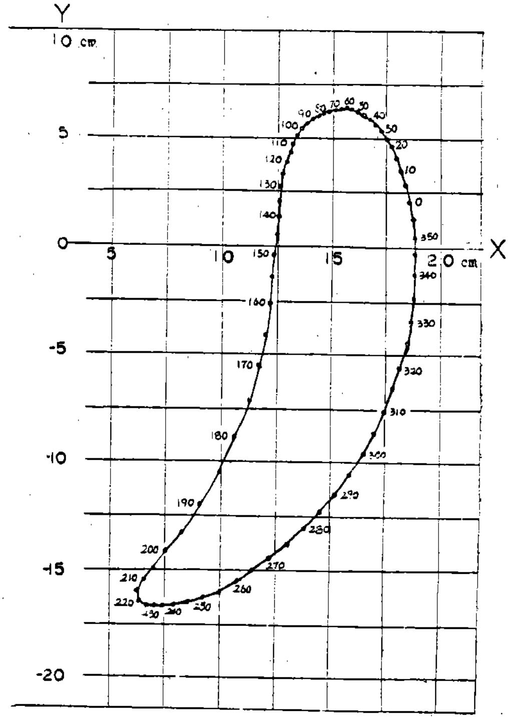

Fig 5. Coupler curve of hoe-center of mechanism "B" relative to the machine frame.

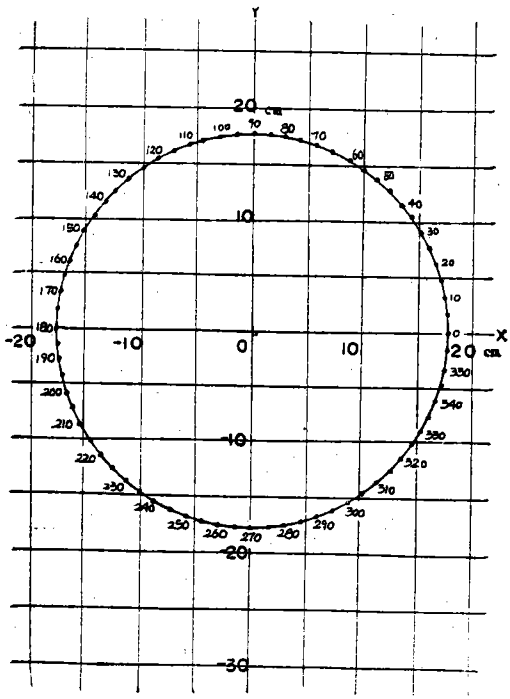

Fig 6. Coupler curve of hoe-center of mechanism "C" relative to the machine frame.

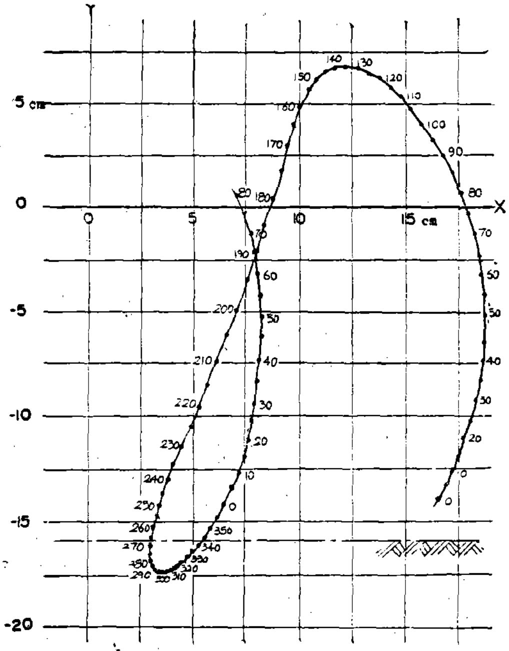

Fig 7. Path traced by hoe-center of machine "A" relative to ground.

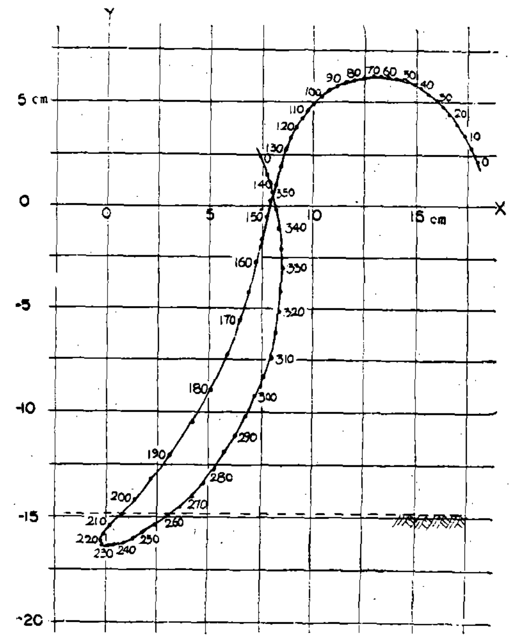

Fig 8. Path traced by hoe-center of mach ine "B" relative to ground.

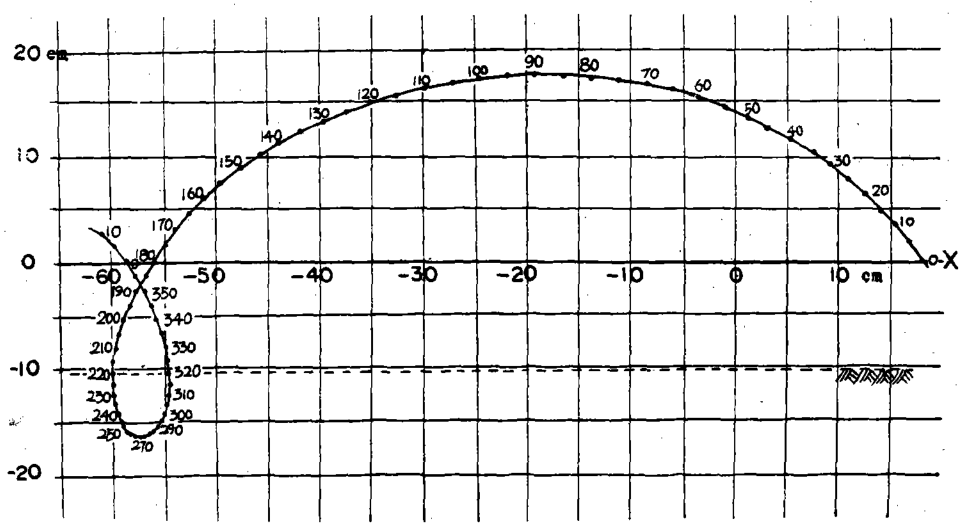

Fig 9. Path traced by hoe-center of machine "C" relative to ground.

planted by the machines. The path traced by the hoe center of the machine "C" is a cycloid, forming a symetric loop at its lower portion. On the other hand, the paths formed by the machines "A" and "B" show inclined, irregular loops.

It is particularly noted that the retracting paths, for which the hoe-center motion is incorporated with seedlings, are quite variable for three mac-

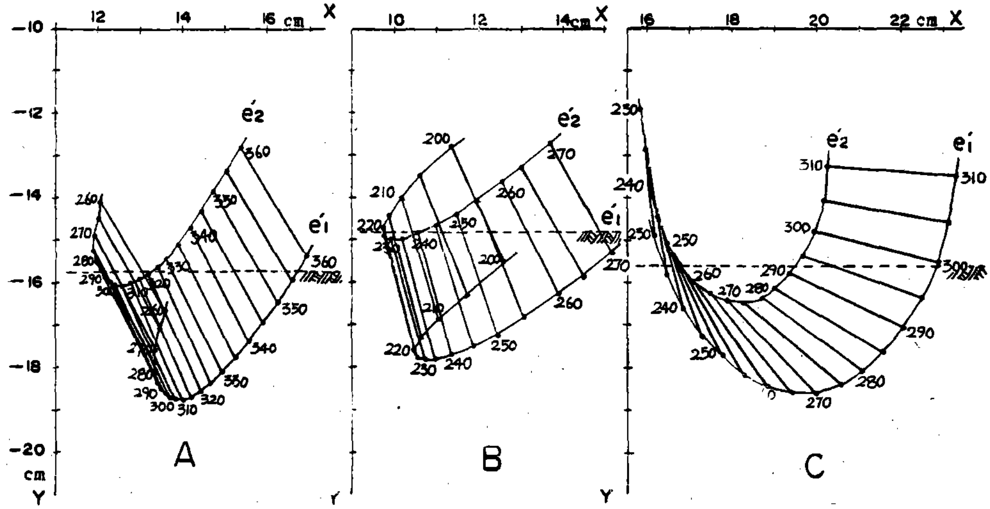

Fig 10. Moving rattern of the hoe-edge within the ground soil.

hines. As the basis for comparing the characteristics of the retracting path of the loop, the amounts of total displacement components in X- and Y-direction was considered. The machine "C" has the greatest displacement with about 2.95 cm in X-direction and 5.61cm in Y-direction. The machine "B" has the least with 0.16cm in X-direction and 0.23cm in Y-direction.

In this point of view, the best path traced by the hoe-center could be obtained from the mechanism of the machine "B" which has the least retracting movement within the soil. By the same reason, the machine "C" is apparently the worst case.

The paths of the hoe-center could be changed with the inclination of machine frame relative to the shaft axis of traction wheel. This instability generally occurs due to the variation of soil condition and to the difficulty to maintain the machine frame or float always in horizontal plane in the actual field operation. The chance that seedling is pushed out of the ground level should be greater under the condition that the hoe at its retracting stroke moves longer distance toward the opposite direction of machine movement.

Generally speaking, the frictional force between the seedling and the hoe edge is much less than the adhesion between the seedling and the plastic soil. However, onnce the hoe-edge is covered with the plastic soil, the contact force between the seedling and the hoe-edge may become greater and approach the adhesive condition between them. This condition shall accelerate the chance that seedling is pushed out.

The relative positions of seedlings to the planting hoe-edge at the moment of cutting and the subsequent movement are shown in Fig. 11. To avoid any cutting damage to seedling, it may be desirable for the seedling and cutting hoe-edge to be parallel. However, for all the machines the hoe-edge at cutting meets the seedling at a certain angle. A correction should be made by adjusting or redesigning the orientation of the feeding roller so that the seedling and the hoe-edge should be as nearly parallel as possible.

Under this non-parallel feeding condition, it is quite obvious that the cutting damage could be much greater as the planting-hoe velocity becomes higher. As indicated earlier, the hoe-edge for the machines "A" and "B" has not only a sharp cutting blade but also movement with a higher velocity. Therefore, a greater seedling damage can be expected from the machines "A" and "B"

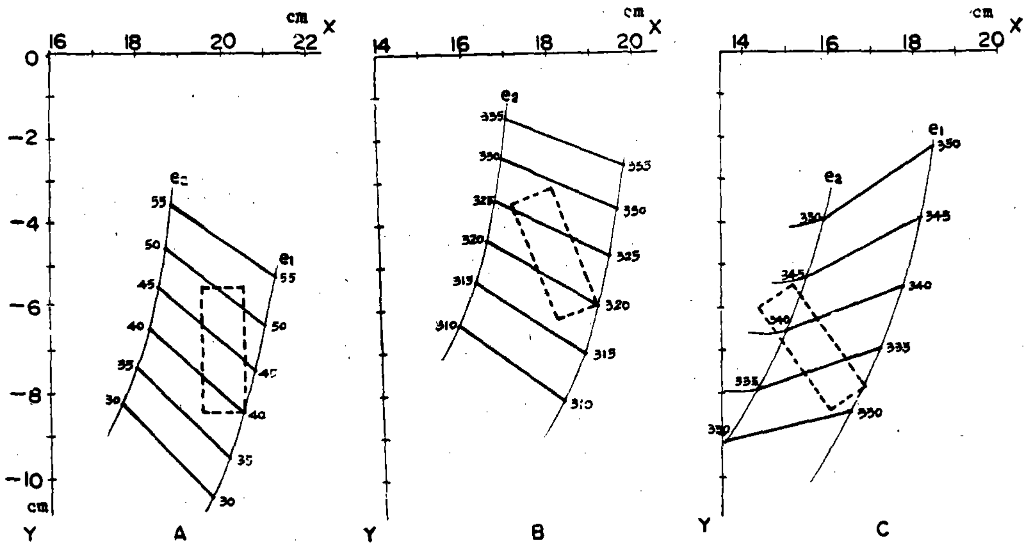

Fig 11. The Orientation of seedling relative to the hoe-edge movement.

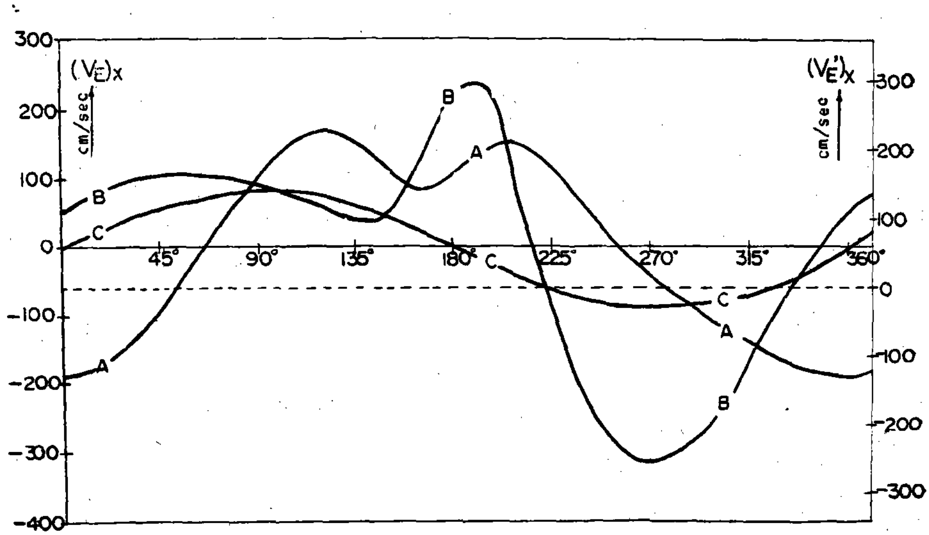

Fig 12. Linear velocities in X-direction of hoe-center relative to the machine frame (left ordinate) and ground (right ordinate).

than the machine "C". It is particularly true for the machine "A", for the hoe-edge cuts the seedling almost at the right angle. The machine "C" may cause little seedling damage because its hoe has a better orientation relative to seedling with a very slow motion. Since disturbance of an aggregate of soil particles in the root-zone, due to the improper cutting angle relative to seedling, may possibly increase the planting inaccuracy, a new design for correcting the orientation of feeding roller is thought very important.

Thə velocity components of the hoe-center, the point E, relative to both the machine frame and the ground were analyzed separately for its

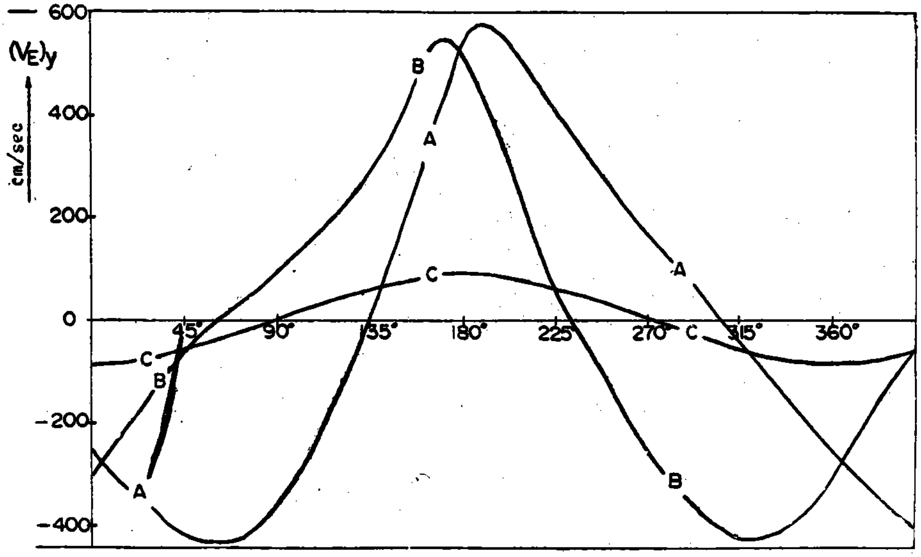

Fig. 13. Linear velocities in Y-direction of hoe-center relative to the machine frame and ground.

various locations in a cycle and plotted as shown in Figs 12 and 13. The left ordinates in these figures represent the velocities relative to the machine frame and the right ordinates the ones relative to the ground. For convenience of comparisons, velocities for these different machines were plotted on the same sheet.

The velocity components of the hoe-center of the machine "C" vary according to sine curve, while those of the machines "A" and "B" make irregular curves. Curves for the machines "A" and "B" show how great the velocities of the hoe-centers for each machines varies during their motions. To generalize the statement, the resultant velocities were plotted as shown in Fig. 14. The resultant linear velocity of the hoe-center of the machine "C" gives a constant value irrespective of the rotor positions. The resultant velocities of the hoe-center E of the machines "A" and "B" vary a great deal for a cycle of motion. For the condition of giving the same forward speed, the machine "A" has 6. 7 times greater maximum resultant velocity than the machine "C", aod the machine "B" does 6.5 times greater.

There are three points which may be important to discuss in connection with velocity analysis.

First of all, it is natural to expect a greater energy fluctuations or machine vibration as the velocity variaion become greater. The machine "C" may be easier to control and much more stable than the machines "A" and "B" because the former has better rotating balance with less velocity variation. In the actual field operation, it has been stated that the machine "C" is much easier to operate compare to the others, the part of which may come from its less velocity fluctuation.

Secondarily, consider the velocity of seedling. The more the velocity of planting hoe within the ground soil is, the more kinetic energy of seedling is absorbed to it. If the plastic soil reaction could not be strong enough to stop the decelerating seedling within the ground soil, there would be a great chance that the seedling may stand inclined or with an irregular depth and that seedling can be pushed out of the soil surface to cause the floated seedling. This situation could occur more easily when soil is too plastic and the

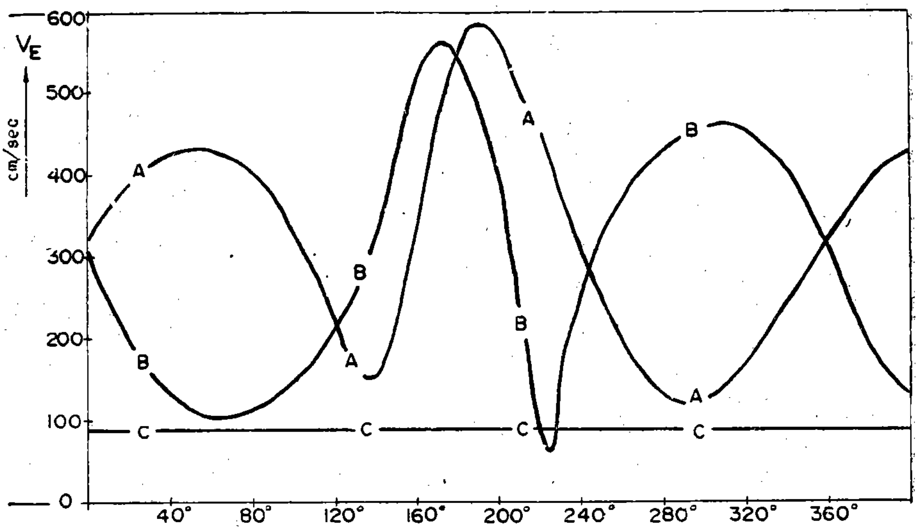

Fig 14. Resultant velocities of hoe-center relative to the machine frame.

velocity component in y-direction is relatively large in the retracting process.

Fig 15 shows the velocities of the hoe-center for each machine when plotted the velocity component in y-direction as the ordinate and the x-component as the abscissa. The velocities below the x-axis indicate the motion in which the hoe goes downwards. The second quadrant indicates the velocities of the hoe-center for its motion being retracted and still pushing the seedling in the backward direction of machine movement.

Theorecticaly, at the positive y-axis the hoe-edge is separated out from the seedlings to resume the forward motion.

The indication is that there exists a large resultant velocity having a backward velocity while the hoe-center goes upward, especially in the machines "A" and "B", which could cause the seedling pushing out of the soil surface. The machine "A" may have this possibility much more than the machines "B" and "C".

Finally, the high velocity is undesirable at the moment when the hoe-edge cuts the seedling root-zone. It was estmated that the resultant velocity of machines "A" and "B" at the instant

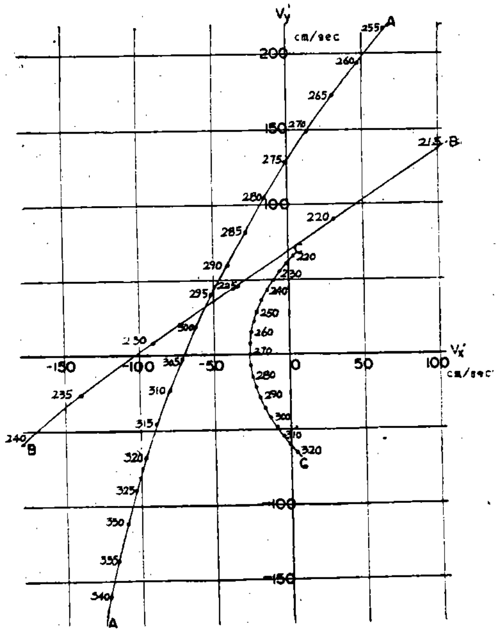

Fig 15. Resultant velocities of hoe-center for three machines while the hoe is in retraction process from the ground soil.

of cutting were about 430cm/sec and were about five times higher than the corresponding velocity of the machine "C". This fact indicates that a proper orientation of the seedling relative to the hoe-edge is more important in the machines "A" and "B" than the machine "C" to avoid any possible damage to the seedlings.

Summary and Conclusion.

Kinematic analysis of the planting mechanisms for three existing rice transplanetrs was performed to study the characteristics of their motion and the functional relations among machines, seedling and ground soil.

The equations that could be used for determining the paths and velocities were developed. These equations were applied to computing the motion for different locations of the planting hoe.

The results of this study can be summarized as follows:

(1) As the machine moves forward, the path traced by the hoe-center of the machine "C" is a cycloid, forming a symmetric loop at its lower portion. On the other hand, the paths formed by machines "A" and "B" Show inclined irregular loops.

(2) The best path traced by the hoe-center could be obtained from the mechanism "B" and the worst for the mechanism "C", the basis of this conclusion being the least effect of retracting movement of the planting hoe on the seedling.

(3) For all three machines the hoe-edge at the moment of cutting meets the seedling at a certain angle. A correction for adjusting the orientation of the feeding roller is necessary to avoid the cutting damage to seedling and also to maintain the aggregate of soil in the seedling root-zone. The roller orientation for machine "A" is the worst.

(4) The machines "A" and "B" have a greater energy fluctuation and therefore are expected to have more machine vibration than the machine "C".

(5) There exists a large resultant velocity having a backward velocity component while the hoe-center goes upwards, especially in the machines "A" and "B" which could cause the seedling pushing out of the ground soil. The machine "A" may have this possibility much more than the machines "B" and "C".

(6) It is estimated that the resultant velocities of the machines "A" and "B" at the instant of cutting are about five times higher than the corresponding velocity of the machine "C". This fact indicates that a proper orientation of the seedling relative to the hoe-edge is more important in the machines "A" and "B" than the machine "C" to avoid any possible damage to seedling.

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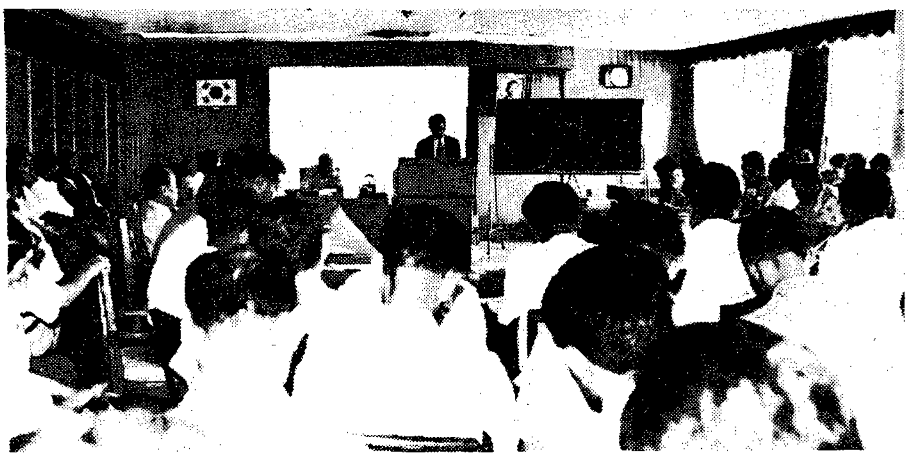
會 告

1) 會 費

每年 莫重한 事業을 推進하면서도 恒常 會費 納付가 遲延되고 있어 學會 運營에 支障이 많습니다. 會員諸賢께서는 이 點을 널리 惠諒하시어 早速한 時日內에 71年度 未納 會費를 自進 納付하여 주시기 바라며 아울러 72年度會費도 納付 하여 주시기 바랍니다.



當 學會에서는 지난 8月 12日 三祐 콘설탄트 門脇 達을 招請하여 耕地整理 事業에 對한 講演會를 갖었음. (農振公 狀況室)