洋葱移植機之研究

Development of Onion Transplanter

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摘　要

洋葱爲高屏地區特有之外銷園藝作物，其栽培面積約爲1200公頃，年產量42000餘公噸，價值達新臺幣二億餘元。洋葱栽培地區主要分佈在高屏地區，以林園、車城及恒春等地區爲主，以沙質壤土爲最佳，移植期爲九月底至十月底，畦形在林園地區爲65公分，在恒春爲130公分，移植時間爲九月底至十月，苗齡在三十天至四十天，三個月後即可採收，然後選別。爲配合本省洋葱栽培之特性，設計適合本省之小型洋葱移植機，以達成洋葱栽培一貫作業機械化。

研製完成之洋葱移植機共有四種機型，但依S-Diagram 之評價值曳引機承載盤爪式最佳如圖九所示，該機長2公尺、寬65公分、高1.3公尺，一次由一人雙手供苗，可移植二行，其行株距爲10公分×12公分，正常供苗速度爲 0.07m/s ，洋葱移植完畢後再行灌水。若要提高供苗速度，則必朝自動化供苗上著眼。

Abstract

The onion is one of the horticultural exporting crops in Taiwan. The planting area is almost 1200 hectares every year. The man-hours for onion transplanting, harvesting, and grading are 1310 per hectare (63% of the total production man-hours), and the labor cost per hectare is about NT$80,000 (55% of the total production cost). So, the mechanization of onion planting is very important to decrease the production cost and to solve the problem of a labor shortage in the rural community. In this study, we designed four models of onion transplanters to fit the planting method here.

According to the theoretic, soil-bin, field testing results, and the evaluation of S-diagram, the best model of all is the tractor-mounted disc-pocket model (if a farmer owned a small horse-power tractor, otherwise, the self-propelled disc-pocket model is a better choice). These are one man, twin-row, manual feeding types.

The normal spacing percentage of soil-bin testing speed at 0.07m/sec is 99%. The row distance and spacing is 10cm x 12cm and the furrow width is 65cm. We will try to develop the auto-feeding system to increase the effective field capacity.

1. INTRODUCTION

The onion is one of the horticultural exporting crops in south of Taiwan with a planting area of 1200 ha. per year.

The main area of onion cultivation is in Pingtung (Hengchung) and Kaohsiung (Linyuan) county. From September to October is the best transplanting period, with furrow width in Linyuan of 65cm (planting twin-row) and in Hengchung of 130cm (planting 5 to 6 rows). The best soil was sand silt. Transplanting onion seedling age was from 40 to 45 days.

The man-hours per ha. of onion planting, harvesting, and grading is 1310 (63% of total production man-hours), and the labor cost per ha. is NT$80,000 (55% of the total production cost). So, the mechanization of onion planting is very important to decrease the cost and to solve the problem of a labor shortage in the rural community.

In this study, we tried to design several models to fit the special planting work here. Last year, we finished the theoretic, soil-bin, and field test of the N25L-2 model onion transplanter (made in Japan), and made some improvements of its shortcoming. From the theoretic analysis, we found the best position of the feeding point. Then, we made two pocket type transplanting mechanisms (one-man one-row and one-man twin-row type). This year, we finished the manufacture of small, self-propelled, one-man, twin-row pocket type testing model. In order to simplify the construction, we developed another tractor-mounted, one-man, twin-row, disc-pocket type onion transplanter testing model. The evaluation of S-diagram shows that the best model of all is the tractor-mounted disc-pocket model (if a farmer owned a small tractor, otherwise, the self-propelled disc-pocket model is a better choice).

2. MATERIALS, INSTALLATIONS, METHODS, AND DESIGN FACTORS

2.1 Experiment Materials

The physical properties of Texas Early Grand 502 onion seedling at 45 days are as following (table 1).

Table 1: The physical properties of FM502 onion seedling at 45 days.

Species	Leaves	Dia (mm)			Length (cm)	Weight (gm)	Center of gravity (cm)	Frictional Coefficiency		Section area of hundred Seedlings (cm^2)
		D1	D2	D3				iron	acrylic	
FM502	3.5	6.6	4.9	4.4	29.4	3.64	8.8	1.27	1.25	41.38

2.2 Theoretic Testing Installations

2.2 Theoretic Testing Installations

The onion transplanting mechanism theoretic testing installation is shown in Fig. 1. The diagram of power transmission shown in Fig. 2, includes engine, hydraulic pump, release valve, direction control valve, flow control valve, hydraulic motor, and onion transplanting mechanism.

There are five parts in the onion transplanting mechanism:

(1) Feeding mechanism.
(2) Transporting system.
(3) Opener.
(4) Press wheels.
(5) The frame.

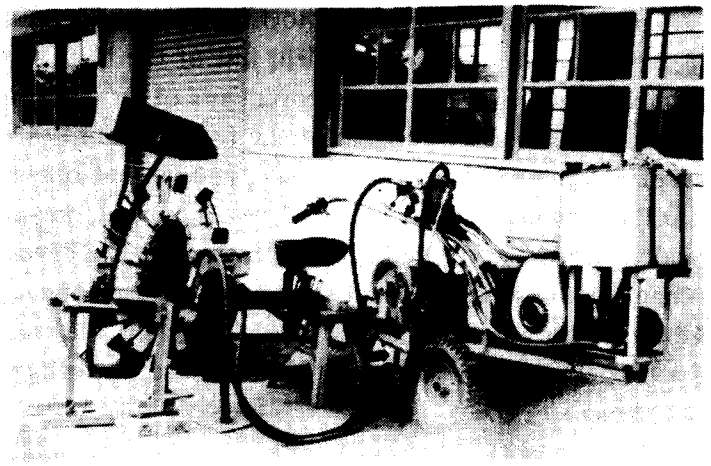


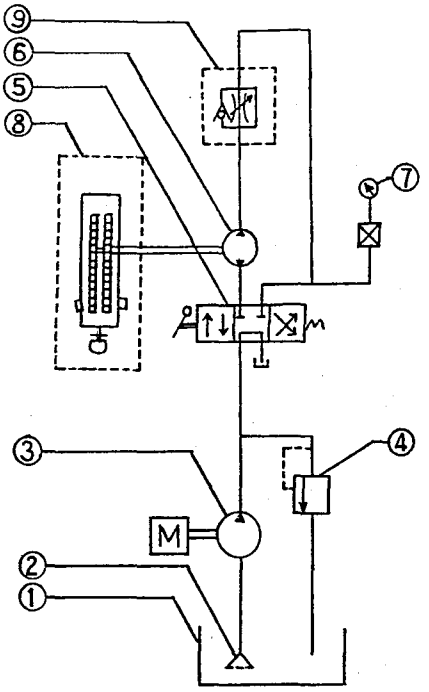
Fig. 1 The theoretical testing device for the pocket type onion transplanter.

2.3 Soil-Bin Testing Stand

We established a soil-bin testing stand with two tracks, 15 meters in length and 2.60 meters in width. The center of the soil-bin has a furrow width of 60 cm, ridge height of 20 cm, and ridge width of 30 cm on the top. Other testing instruments include digital tachometer, engine tune-up tester, soil hardness tester, soil moisture tester, and stop watch.

2.4 Factors about Onion Transplanter Design.

(1) The area of onion planting fields is small and fractional. So the best design for an onion transplanter is a small self-propelled or a small horse-power tractor-mounted one man twin-row type.



Theoretical testing stand for onion transplater driven by oil motor	
1. Tank	6. Motor
2. Filter	7. Pressure gage
3. Pump	8. Onion transplant unit
4. Relief valve	9. Flow control valve
5. Control valve	

Fig. 2 The power transmission diagram of the theoretical testing stand for an onion transplanter.

(2) This design of onion transplanter is used in upland fields., after planting it then feeds water into the furrow.

(3) There are three types of system for feeding seedlings, these are th manual, semi-auto, and automatic feeding systems. We chose the manual system as our feeding system for the sake of decreasing the manufacture cost, to meet the purchasing power of farmers, and because it can be finished in a short period of time.

(4) There are two methods of planting onions here in Taiwan. One is planting twin-row onion seedlings on a ridge, the row distance spacing of 10cm x 12cm and the furrow width of 65 cm. The other, with a furrow width twice that, plants 5 to 6 rows. We designed the testing model onion transplanter according to the former. Due to the 12 cm spacing, the speed of operation isn't easy to increase, unless the semi-auto or automatic feeding system is used.

(5) The design of the opening and pressing system is very important due to the row distance of only 10 cm. The opener we adopted here is a slipper type. The pressing system both in pocket and disc-pocket type is a center wheel with press wheels on both sides, exact timing of opening, covering, and pressing is very important to the transplanter.

2.5 Experiment Methods

2.5.1 Analysis of one-hand and two-hand Feeding Motions

The traditional way to feed the onion seedling in a small self-propelled twin-

row onion transplanter needed two operators. With the aid of micro-motion study and the principles of motion economy, we improved the original design. The process is as following:

(1) Complete the chart for using two-hand as in the old method.
(2) Analysis left hand and right hand motions with the micromotion study.
(3) Simplify the old method with the principles of motion economy and questioning attitude, then complete the improved chart.
(4) Develop new models according to the results of the motion and time analysis.

2.5.2 Choose the best Onion Transplanting Conditions

(1) In the theoretic test, we chose 9 points of feeding stand at three relative operating speeds to test the best position for feeding the seedlings.
(2) Test the normal planting percentage in the soil-bin stand to determine the best distance between the center press wheel and the axle of distributing plate.
(3) Test the best position of the opener.

3. EXPERIMENT RESULTS AND ANALYSIS

3.1 The Results and Analysis of one-hand and two-hand Feeding Motions

The old method of feeding onion seedlings to the twin-row type transplanter needed two operators. In the micromotion study, shown in Fig. 3, are the movements of the two-row two-handed chart. From this chart, we can find that the left operator's left hand and the right operator's right hand were all in holding condition, while the other hands were in the operating condition. So, we put two feeding-stands in the best position to eliminate this useless motion, then we developed a new model with one man using two-hand feeding to plant two rows of onions. This way we can save another operator.

From the improved method operation chart shown in Fig. 4, we show the movements of feeding the onion seedlings, with both hand simultaneously.

3.2 Results and Analysis of the best Position for Onion Seedlings Feeding

The test results of the one-man right-hand feeding in the theoretic testing stand are shown in Fig. 5. This test stand (was driven by the hydraulic motor attached to the axle of the press wheel, in the field relative operating speeds (0.08, 0.1, 0.12m/sec) and 9 testing points. The results showed that when the speed is 0.08m/sec the normal spacing percentage of all positions is 100%. When the speed raises the percentage is decreased. Thus we found that the best result was achieved when the clamping point and feeding stand were at the same height and 15 cm apart. The one-man two-hands feeding test results are shown in Fig. 6. We chose (15, 0) using both side feeding stands when the

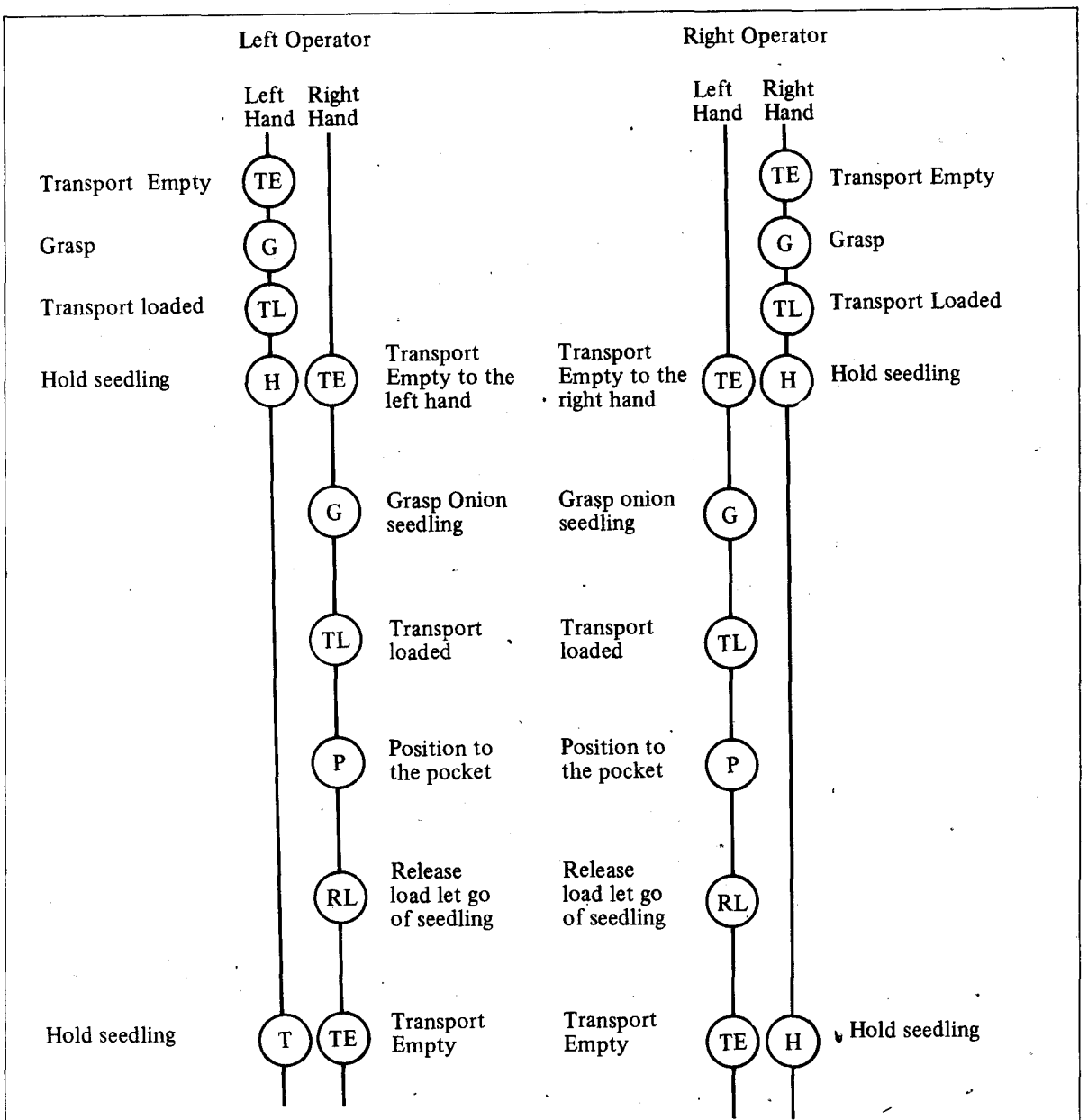
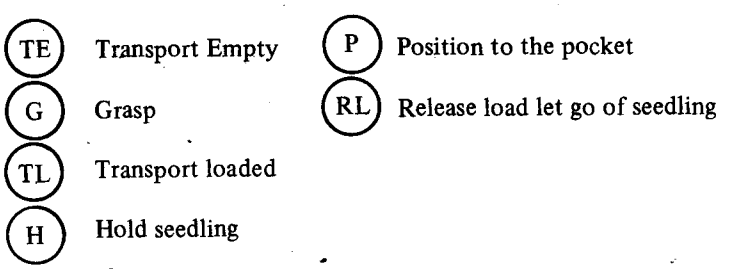


Fig. 3 Operation chart showed the movements of two men Two-Handed Chart (Old Method).

Therbling Symbols:



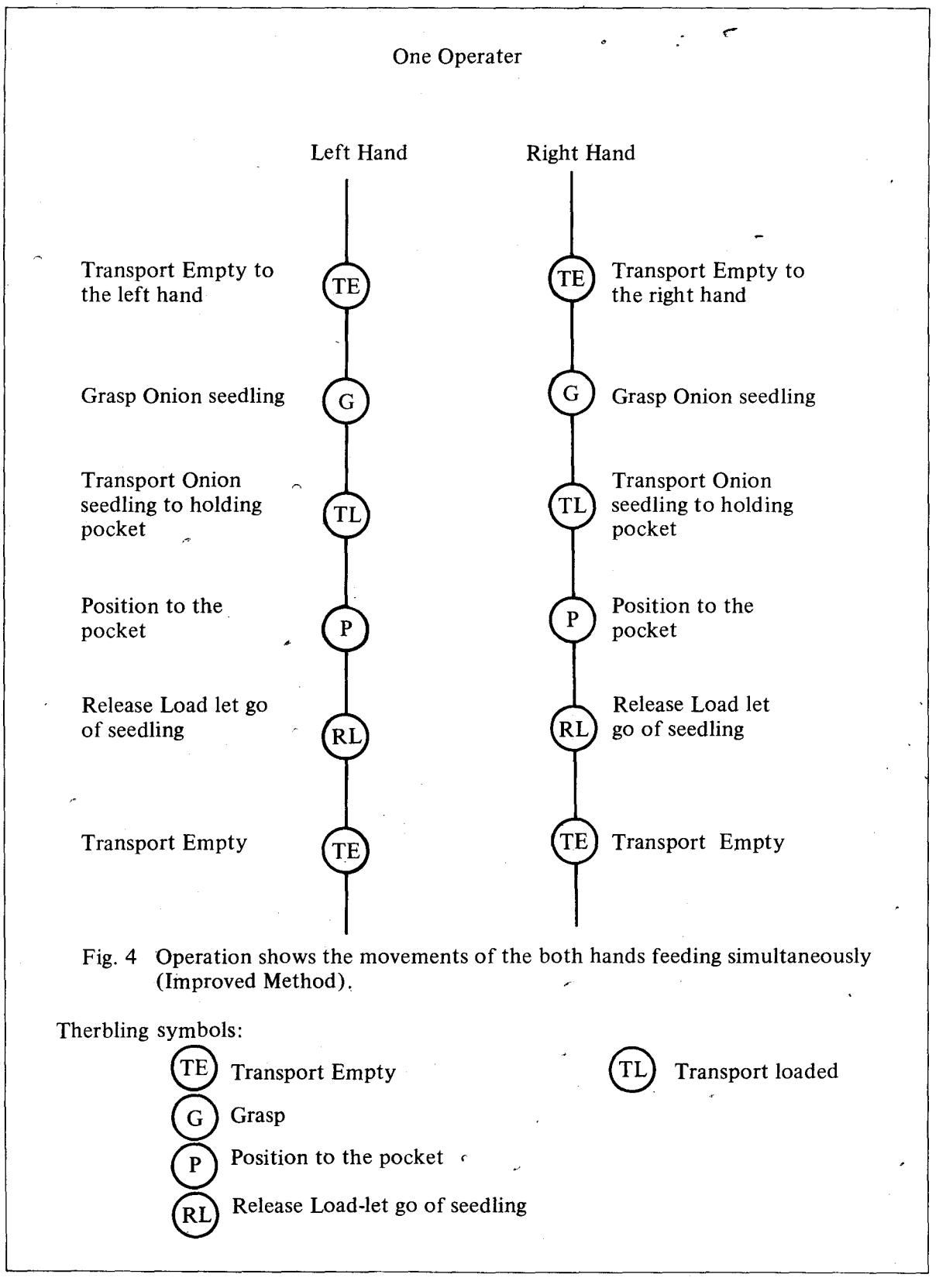


Fig. 4 Operation shows the movements of the both hands feeding simultaneously (Improved Method).

Therbling symbols:

TE Transport Empty

TL Transport loaded

G Grasp

P Position to the pocket

RL Release Load-let go of seedling

theoretic speed is within 0.08m/sec. At this speed the normal spacing percentage is acceptable.

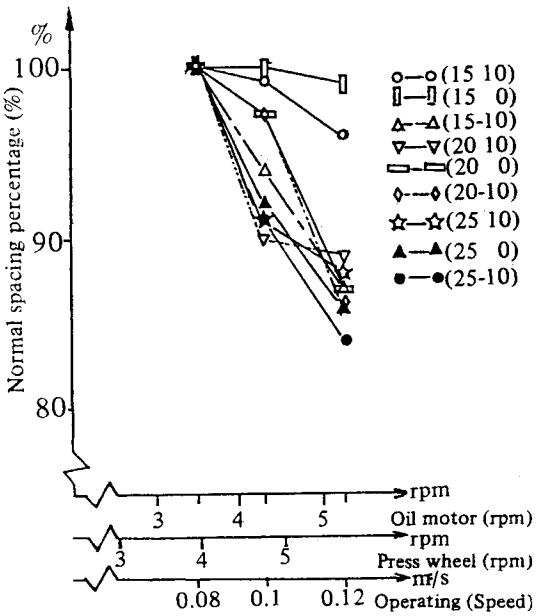


Fig. 5 The normal spacing percentage of 9 feeding points with right hand feeding at different operating speeds.

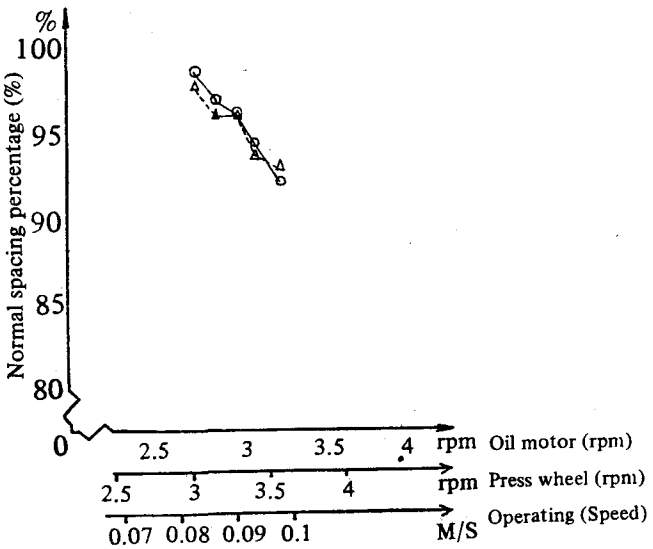


Fig. 6 The normal spacing percentage at the best feeding point with one-man two-handed feeding at different operating speeds.

△--△ Left hand feeding

o—o Right hand feeding

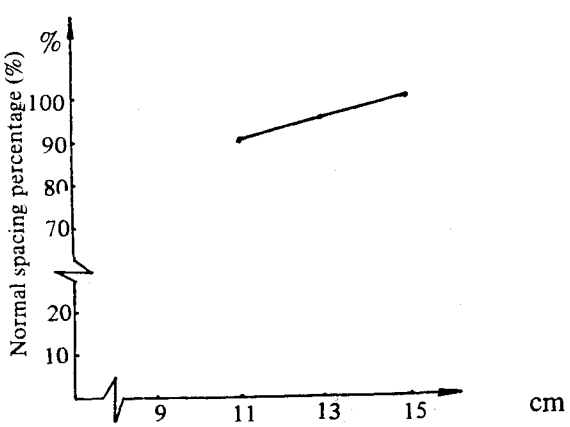


Fig. 7 Effect of variation in the distance between the axle of distributing plate and the axle of center press wheel.

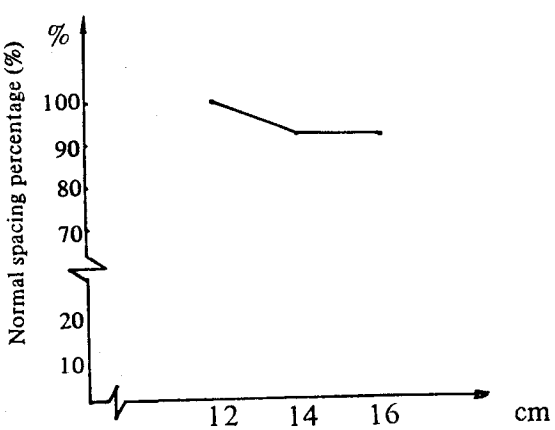


Fig. 8 Effect of variation in the distance between the axle of distributing plate and the opener end.

3.3 Results and Analysis of the best Opening and Pressing System.

The distance between the axle center of the distributing plate, and both the center

press wheel and the opener, affected the performance of the onion transplanter. So, we did the testing of the self-propelled one-man, twin-row, pocket type onion transplanter in the soil-bin.

The testing conditions are engine speed 700rpm (operating speed 0.063 m/sec), the distance between axle of distributing plate and the end of the opener is 12 cm. The testing results are shown in Fig. 7. We can find from the curve that the best position is 15 cm to the axle of distributing plate. In this position, we changed the position of slipper type opener and made the same test in the soil-bin. The results are shown in Fig. 8. The best distance between axle center of distributing plate to the end of the opener is 12 cm.

3.4 The S-Diagram Evalution of Different Types of Onion Transplanters

We developed four models of one-man, twin-row, manual feeding type onion transplanters:

(1) Self-propelled disc-pocket model (Fig. 10).

(2) Tractor-mounted disc-pocket model (Fig. 11).

(3) Self-propelled pocket model (Fig. 12).

(4) Tractor-mounted pocket model (Fig. 13).

The S-diagram evalution of these four models is shown in Fig. 9. This diagram shows the relationships between economical (Y-axis) and technical (X-axis) values, $R = \sqrt{xy} = 0.1, 0.2, \ldots 0.9, 1$ is equal-value line. In this diagram, TIII is the tractor mounted model (if a farmer owned a small horse-power tractor) which shows the best quality value. However, if the farmer has no small tractor, then the self-propelled disc-pocket model is the best choice.

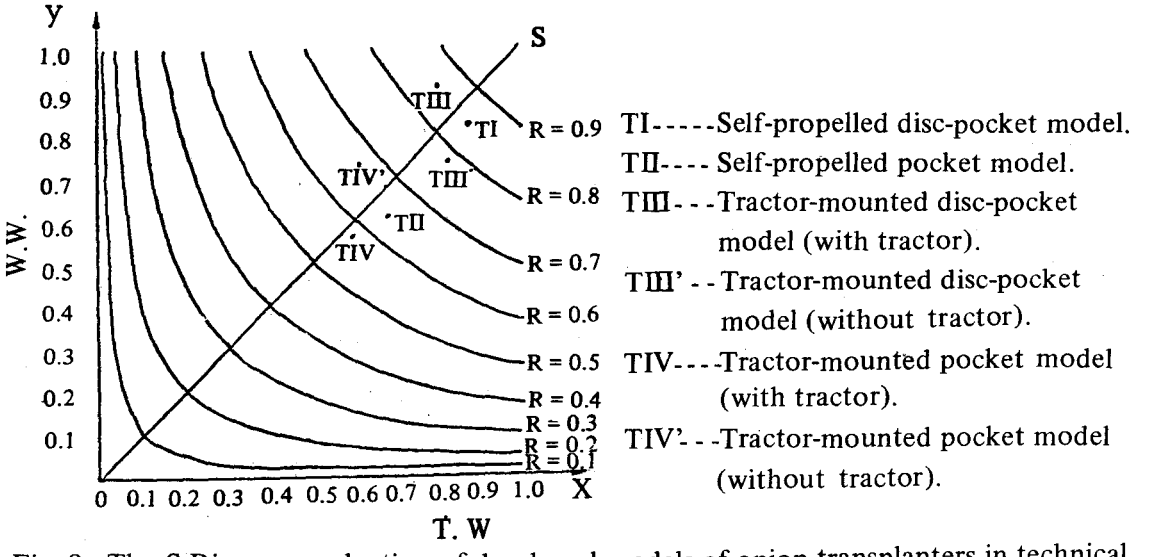


Fig. 9 The S-Diagram evaluation of developed models of onion transplanters in technical and economical values.

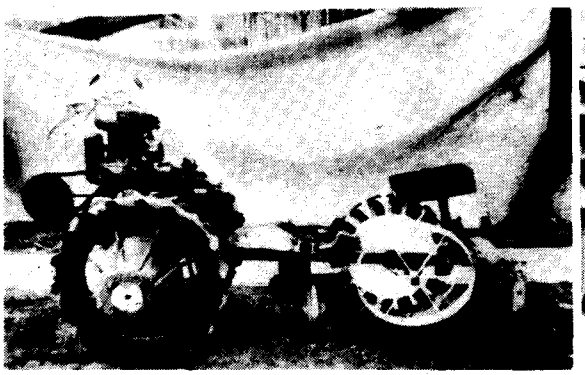


Fig. 10 Self-propelled disc-pocket model onion transplanter.

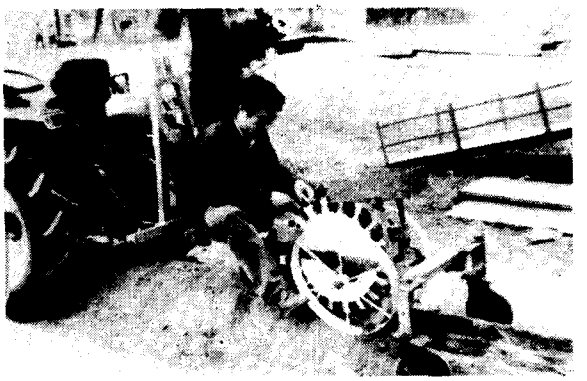


Fig. 11 Tractor-mounted twin-row disc-pocket model onion transplanter.

Fig. 12 Self-propelled pocket model onion transplanter.

Fig. 13 Tractor-mounted twin-row pocket model onion transplanter.

3.5 The Manufacture of the one-man twin-row Onion Transplanter

This self-propelled onion transplanter consists of: (1) power and its transmission system, (2) running and steering system, and (3) transplanting and pressing system. The following gives specifications.

(1) Power and Its Transmission System

We adapted a small two-stroke gasoline engine with a 4.3ps Maximum horse-power at 2428rpm, and a rating horse-power 3ps/1845 rpm. The power-take-off shaft is located in the side of the crankcase. We mounted a sprocket pulley set to reduce the engine speed by a 14:1 reducing ratio and with a tension pulley as a clutch to drive the transmission axle. This allows an operation speed of between 0.06m/sec and 0.16m/sec (Fig. 14).

Fig. 14 Developed self-propelled one-man twin-row pocket model onion transplanter.

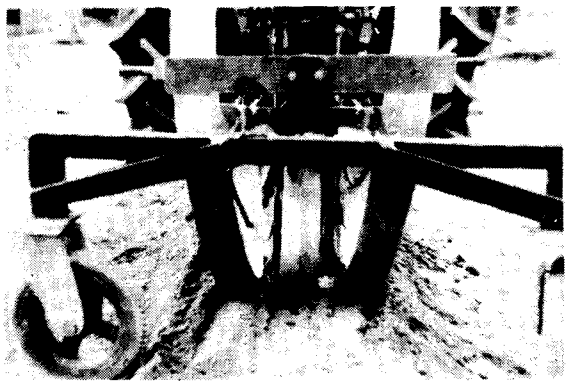


Fig. 15 The idle wheels hanging while the press wheels travel along the top of the ridge.

(2) Running and Steering System

The drive wheels are tires of 850x300 mm. We set another two idle wheels in the rear part of the transplanting unit. This device made the test machine easy to operate both on the road and in the field (see Fig. 15). The steering system is driven by side clutchs.

(3) Transplanting and Pressing System

This part consists of a pair of disc plates, with 20 equal spacing pockets on the rim, feeding stands, seedling storage box, the openers, center and side pressing wheels. The operator grasps the seedlings from left and right feeding stands then places them on the "r" type pockets. Press wheels drive the disc to transplant the onion seedlings on the top of ridge.

4. DISCUSSIONS AND SUGGESTIONS

(1) The S-diagram shows that the small tractor mounted, disc-pocket model onion transplanter is the best choice. In the future, we can combine the fertilizing, furrowing, and transplanting at the same time to establish a minimum cultivating system.

(2) The speed of the manual feeding type transplanter is not easy to increase. So, the semi-auto and auto feeding systems are the better models to develop in the future.

(3) The disc type clamping or holding system will be adapted to agree with the semi-auto and auto feeding system.

5. REFERENCES

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