Study on the Tractive Characteristics of the Seed Furrow Opener for No-till Planter

無耕耘 播種機用 溝切器의 牽引特性에 關한 硏究

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摘 要

動力耕耘機用 豆類의 無耕耘 播種機에 附着하여 使用하는 溝切器中에서 所要牽引力이 작고 溝切作業精度가 良好한 溝切器의 開發을 爲한 基礎資料를 얻기 爲하여 驅動式 土槽에 人工土壤을 채우고 圓板型 및 호우型 溝切器의 所要牽引力과 이에 影響을 미치는 因子들과의 關係를 究明코자 室內模型 確驗을 實施하여 다음과 같은 結果를 얻었다.

圓板型 溝切器에 對하여 直徑別로 組立角을 8°와 16°, 耕深을 3cm와 6cm로 變化시키면서 2.75cm/sec의 速度로 牽引力을 測定한 結果 圓板의 直徑이 約 28cm인 境遇에 牽引力이 最少로 나타났고, 直徑이 이보다 크거나 작은 때는 牽引力은 增加하는 傾向을 나타냈으며 比抵抗도 大體로 비슷한 傾向이었으나 圓板의 直徑이 約 30cm일 때 最少로 나타났다.

種子播種의 深度調節을 目的으로 作溝深(3cm 및 6cm)과 牽引力과의 關係를 調査하였던바, 耕深과 牽引力과의 關係는 거의 直線的인 變化를 나타냈으며 牽引力에 影響을 미치는 因子中에서 耕深의 影響이 가장 컸음을 알 수 있었다. 一般的으로 組立角 및 走行速度에 別 影響없이 耕深 3cm 및 6cm 共히 牽引力은 直徑 約 28cm에서, 比抵抗은 約 30cm에서 最少의 값을 나타내었다.

播種機의 作業性能과 關係가 깊은 走行速度 및 播巾의 調節을 目的으로 圓板의 組立角과 走行速度가 牽引力에 미치는 影響을 調査했던 바, 組立角과 走行速度가 增加함에 따라 모두 牽引力이 增加하는 傾向을 나타내었으나 牽引力에 미치는 影響은 走行速度가 더욱 크게 나타났다.

圓板型 溝切器와 호우型 溝切器를 比較하기 爲하여 쐐기角이 16°이고 리프트角이 20°인 호우型 溝切器와 條件이 비슷한 組立角 16°의 圓板型 溝切器의 牽引特性을 比較한 結果 直徑 30cm인 圓板型의 境遇는 比抵抗이 0.35~0.5kg/cm²인데 比해 호우型의 境遇는 0.71~1.02kg/cm²로 나타나 호우型의 牽引比抵抗이 平均 2倍程度 크게 나타났고 作溝狀態도 圓板型의 境遇보다 不良하였다

INTRODUCTION

For centuries the moldboard plow has been the basic tool of agriculture breaking and turning the soil as the first step in the series of operations collectively known as tillage. It is known that in the U.S.A. more than 250 billion tons of soil are estimated to be stirred or turned each year. To plow this soil once requires 500 million gallons of gasoline or diesel fule, costing over $ 100 million(10).

In recent years there has been increasing interest in minimum-tillage sytsems or no-tillage systems as a means of reducing row-crop production costs and improving soil conditions(29). Recently, in the U.S.A., on a large and growing

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area of farmland, the plow is being displaced by a system of farming that involves either no tillage or a greatly reduced amount of it(31).

In Korea, Pyeon et al. (24) conducted an experiment on soybean production using the method of no-tillage system. Kim et al. (11) conducted an expriment on the modification of the regular planter for no-tillage soybeans.

The objective of this study was to investigate the tractive characteristics of furrow opener which can be attached to the planter for no-tillage soybeans and so to obtain the data on how to reduce the draft and how to select suitable type of openers. For this study, two models of furrow opener, hoe and disc type, were tested on the artificial soil stuffed in the moving soil bin.

REVIEW OF LITERATURE

Triplett, Jr. et al. (31) reported that in no-tillage system the seeds for a new crop are simply planted in soil that remains covered with the residues of the old crop. The control of weeds, which is a prime objective of tilling, is achieved mainly by the application of herbicides but partly by the fact that the old corp cuts as a mulch, stifling the growth of unwanted plants. And the main advantages of the new methods are that they reduce the labor cost of farming and be predicted that within a few years much of the crop land in the U.S. will be planted without a moldboard plow and in most conditions planting without tillage (but with herbicides) can save labor, energy, water, and soil.

The 1973 ASAE year book defines no-tillage planting as a procedure whereby a planting is made directly into an unprepared seedbed. It is also called chemical fallow. The advantages of no-tillage are listed as early planting of a following crop, reduced labor and machine cost, reduced danger of soil blowing, and soil and water conservation. Insect buildup is controlled by the application of chemicals (29). In Korea, Kim and Pyeon carried out a study on no-tillage system on soybean (11, 24).

Abernathy et al. (1) reported that furrow area tended to be least for openers with small vertical angles and the largest furrows were made by openers with medium vertical angles and large wedge angles, and the lift and drag forces acting on furrow openers increased with increasing vertical face angle and with increasing wedge angle. Kim et al. conducted an experiment on the comparison of hoe and disc-type furrow opener and concluded that continuous studies were needed on the diameter, disc angle and weight of seeder, and experiments using planters precisely manufactured were necessary. Many theses were reported on the characteristics of various parts of planters, but the study on the draft resistances of furrow openers of hoe and disc, and the comparison between them has not been carried out yet in Korea.

Many studies were reported on dynamic characteristics of artificial soils (2, 5, 6, 18, 21, 22, 23, 25). Research results from tillage implement experiments are affected by soil characte ristics as well as by implement design. Natural soils, both in the field and in the laboratory, have been found to vary widely in their mechanical characteristics. Major sources of variation have been those of moisture content, moisture distribution and tension hysteresis, and aggregation and aggregate-size distribution. To ascertain changes in implement performance with variation in implement design, it would be desirable to have a laboratory material with mechanical characteristics similar to natural soil, but with properties which could be maintined uniform over long periods of time and with repeated mechanical working.

The most important fact is that artifical soils simulate natural soils in tillage studies(25) but have the advantages in that the variances of physical properties are very small according to the change of temperature and humidity, and various types of soils are available by manufacuring them and the reproducibility is very good

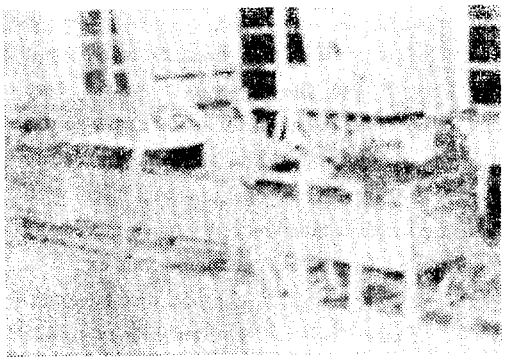


Fig. 1. The overall system for model furrowing studies.

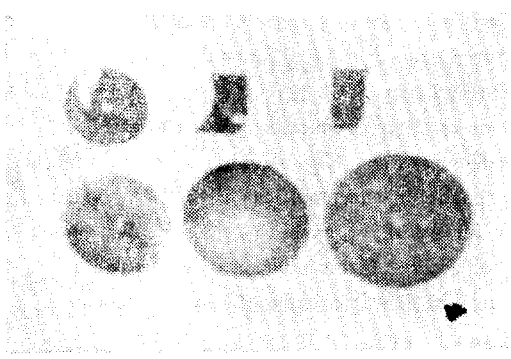


Fig. 2. The openers being tested.

and sufficient strength is obtained to simulate natural soil.

Artificial soils may be compounded using moistening agents such as ethylene glycol or oil, which do not evaporate rapidly and thus permit maintenence of given soil strength conditions over an extened period of time. Artificial soils compounded from clay, core sand and ethylene glycol have stength parameters similar to those of natural soils.

In tillage studies, the outdoor experiments were usually carried out, but they troublesome. Instead of them, recently, indoor experiments are widely carried out using soil bins(5, 13, 16 17). Indoor experiments on tillage studies have much advantages compared with outdoor experiments. Field testing of soil-machine systems is difficult, time consuming, and costly. Controlling soil conditions for field-testing purposes is almost impossible. These difficultics suggest the use of models in a laboratory where soil conditions could be controlled. Controll of test conditions, economics, and convenience are factors which make a model tillage laboratory desirable. The comparatively low cost of such a laboratory makes it posisble for more research installations to

Table 1. Specifications of the experimental apparatus.

Experimental apparatus	Dimensions	Remarks
disc opener (angle,°)	8, 16	DA is simpler form for disc angle in
〃 (cm)	φ20, 25, 30, 35	the following figures.
hoe opener (lift angle,°)	20, 40	
〃 (wedge angle,°)	16	
〃 (cm)	12L×3.4W×14H	
soil bin (cm)	480L×45W×30D	
speed of soil bin (cm/sec)	2.75, 5.63	S-1, S-2 are simpler forms for 2.75cm
roller (cm,kg)	φ27×40W, 60	/sec, 5.63cm/sec in the following fi-
scarifier (no. of tines)	9	gures.
strike-off blade (cm)	40W×15H	D-3, D-6 are simpler forms for depth
capacity of load cell (kg)	200	3cm, 6cm in the following figures.
electric motor (p.s.)	2	

Table 2. Measuring instruments.

Items	Dynamic strain amplifier	Rapicorder	Soil hardness tester
manufacturer	Kyowa Electronic Instrument Co.	Kyowa Electronic Instrument Co.	Kiya Seisakusho Ltd.
model	DPM-5E	RMV-33N	Yamanaka
channel	6		
dimensions(mm)	386×307×150	325×210×494	φ30×200L

Table 3. Physical properties of artificial soil.

Sieve analysis		Properties				
Sand(%)	Bentonite(%)	Oil content(%) (SAE 10w)	Wet unit weight (g/cm^3)	Cohesion (kg/cm^2)	Angle of internal friction(deg.)	Absolute soil hardness (kg/cm^3)
48.10	39.35	12.55	1.51	0.10	30	5.27

perform research on soil machine systems. The laboratories could be small enough to be enclosed in a controlled environment and large enough or performing valid tillage and traction research. But, in Korea, no study has been done on soil bin and artificial soil yet.

EQUIPMENT AND METHODOLOGY

1. Experimental apparatus, measuring instrument and artificial soil

The equipment used for this study was a moving soil bin in which the artificialsoil was stuffed.

The overall system is shown in Fig. 1 and the openers being tested in Fig. 2.

Specifications of the experimental apparatus and measuring instrument are shown in Table 1 and 2.

Physical properties of artificial soil are shown in Table 3.

The gradation curve for the mixture of sand and bentonite is shown in Fig.3.

2. Mothodology

To measure the oil content, a soxhlet apparatus was used to extract oil from the artifical soil (7). The bin carriage were accelerated to the desired speed and moved past a fixed bar at a uniform speed by an electric motor. After the

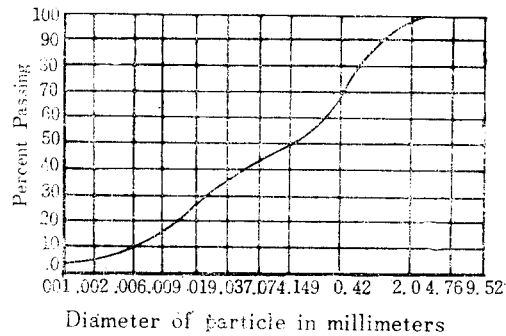


Fig. 3. The gradation curve for the mixture of sand and bentonite.

bin passed the tool bar, the drive motor was turned off andthe bin decelerated to a stop. Furrowing tool was attached to a mounting frame equipped with vertical and horizontal screws for close adjus-tment of tool position.

The uniformity of soil hardness in the soil bin

was maintained by the method that the entire experiment was repeated after tilling the soil once by scarifier followed with the strike-off blade and then with roller passes of 4 times, and ending with measurement of soil hardness at 8 locations in the bin by Yamanaka-type soil hardness tester.

Each of the two types of furrow openers was operated at two kinds of speeds in one type of artificial soil. Drafts on the openers were recorded by oscillographic equipment connected to a force transducer.

RESULTS AND DISCUSSION

1. Relationship between the diameter of discs and draft

To find out the diameter of disc that required least draft in the case of disc type, the draft was measured according to the various sizes of diameters. As shown in Fig. 4, there were analogous tendencies regardless of working depths and disc angles, and the diameter of disc which required the least draft was about 28cm.

2. Relationship between the working depths and draft

As shown in Fig. 5, the variations of draft according to the various working depths showed almost linear changes irrespective of working speeds and disc angles within the scope on this experiment. In the case of plow, Song(30) reported that the draft resistance was increasecd with increased depth of plowing and the specific draft resistances were decreased with depth to a certain poiat above which depths they were increased.

As shown in Fig. 4, there were general tendencies at both working depths, 3cm and 6cm, that total draft showed the minimum with the disc diameter of about 28cm; and specific draft showed it with the disc diameter of about 30cm regardless of disc angle and working speed, as shown in Fig. 7.

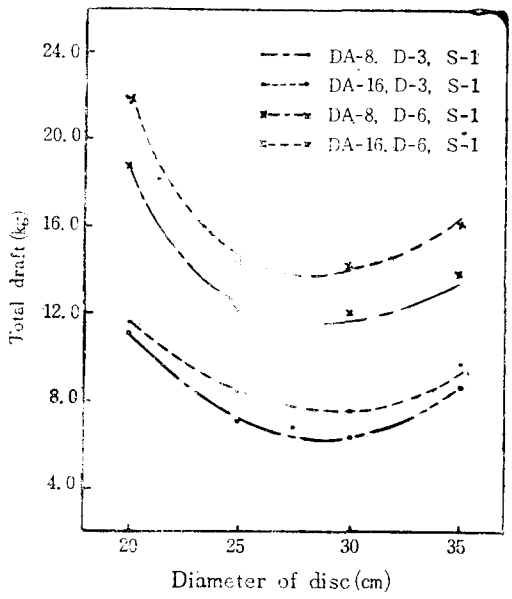


Fig. 4. Relationship between the total draft and the diameter of disc.

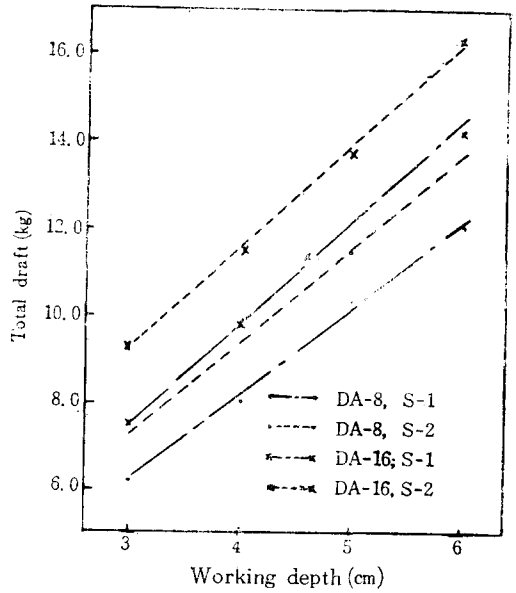


Fig. 5. Relationship between the total draft and working depth at the diameter of disc, 30cm.

It was thought to be desirable that the furrowing be controlled by the adjustment of disc angles and disc diameters rather than by working depths with the end in view of reducing the draft requirements of the planter because the variations of working depths affect the draft requirements in higher degree than other factors under the same condition of experiment.

3. Relationship among the draft, disc angle, and working speed

As shown in Fig. 6, there were general tendencies that the draft increased with increasing disc angle and with increasing working speed.

Shibano(27) reported that the ridging resistance increased when the wedge angle was larger on every conditions. In general, increased forward speed increases the draft with most tillage implements, mainly because of the more rapid acceleration of any soil that is moved appreciably. Soil acceleration increases draft for at least two reasons-first, because accleration forces increase the normal loads on soil engaging surfaces, thereby increasing the frictional resistance, and second, because of the kinetic energy imparted to thesoil (10, 19, 28, 29).

As shown in Fig. 6, in the case of optimum disc diameter of 30cm, the rates of increased draft by the variations of disc angles and working speeds were compared to find out by which the draft is affected more. In the condition of working depth, 3cm and working speed, 2.75 cm/sec, the drafts were about 6.2kg and 7.7kg in the case of disc angle, 8° and 16° respectively, showing little differences; but 7.2kg and 9.3kg in the case of disc angle 8° and 16°, respectively, at the working speed of 5.63cm/sec and same working depth as above; which show that draft is affected more by working speed than by disc angle. It was thou-ght to be desirable that the working speed of planters be reduced a little than that of ordinary tillage implements from the standpoint of draft requirement and precision planting.

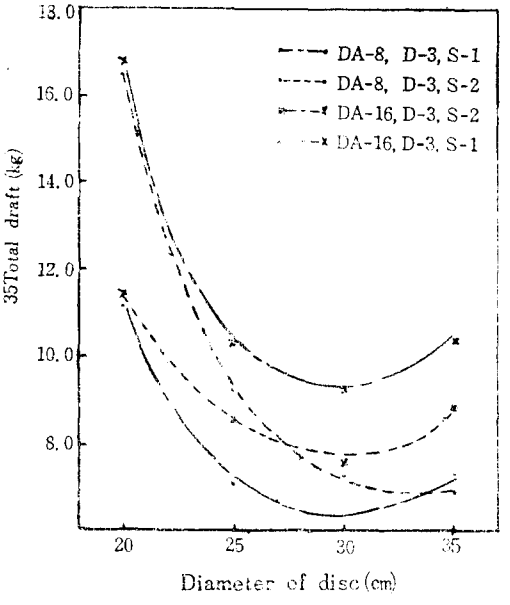


Fig. 6. Relationship among the total draft, disc angle, and working speed.

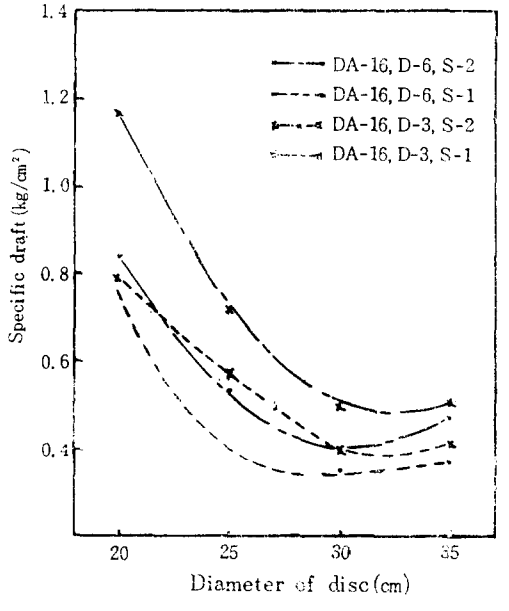


Fig. 7. Specific draft of disc-type furrow opener.

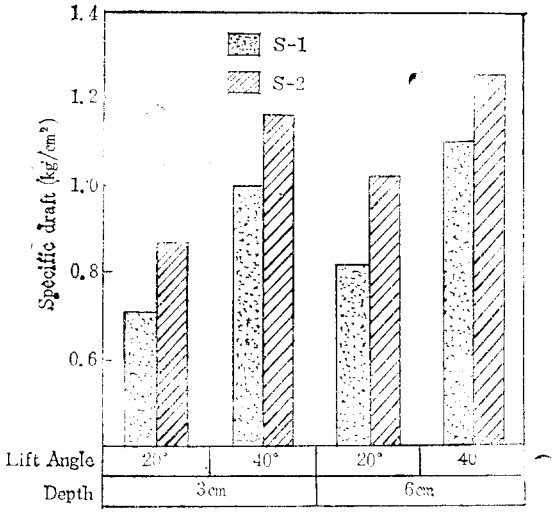


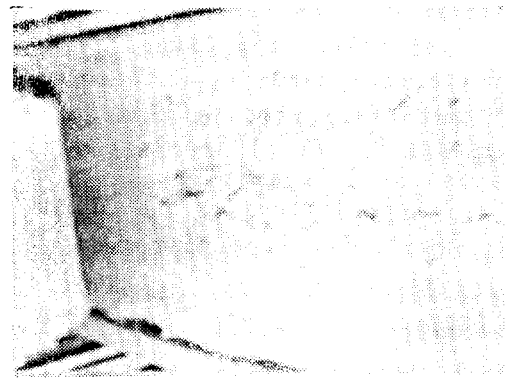
Fig. 8. Specific draft of hoe-type furrow opener.

4. Comparison between hoe and disc-type openers

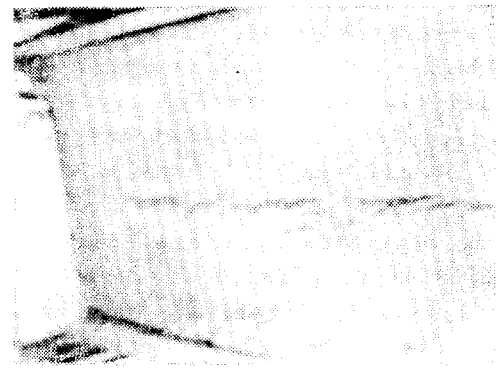
For the purpose of comparing the darft of these two types of opener, the specific drafts of hoe type openers were compared with those of disc type openers with the disc angle of 16.° As shown in Fig. 7 and Fig. 8, the specific draft of disc type opener with the diameter of 30cm was 0.35~0.5kg/cm², while 0.71~1.02kg/cm² in the case of hoe type with the lift angle of 20° which is 2 times as much as that of disc type in average value.

The movement of soil during furrowing operations were compared between the two types. With the bin level, or at zero slope, the artificial soil was furrowed, and there remained equal banks on both sides of the furrow opened by both types. But the degree of crack of removed artificial soil to both banks of furrow was greater in the case of hoe type than of disc type (Fig. 9).

Choking of artificial soil between the two discs was beside the question during the experiment, but it was thought the scrapers would be necessary to be attached between them in actual furrowing operatoin in the field.



A) Furrow opened by disc type.



B) Furrow opened by hoe type

Fig. 9. The furrows opened by the two types of opener.

The degree of artificial soil adhesion on the opener was greater in the case of hoe type than of disc type, and soil adhesion is not desirable because it causes the increase of friction between soil and metal face of opener.

So, considering the conservation of moisture content, draft requirement and soil adhesion, it was thought that furrow opener of disc type would be more suitable furrow opener of planter than that of hoe type.

Summary

This study was carried out to obtain basic date for the type selection of furrow openers for the no-tillage soybean planter trailed by the two-wheel tractor from the standpoint of minimum draft and good performance of furrowing. For this study, two models of furrow opener, hoe and disc type, were tested on the artificial soil stuffed in the moving soil bin. The results obtained were as follows.

In the case of disc furrow opener, the drafts were measured according to various diameters of discs under the condition of disc angle 8° and 16°, working depth 3cm and 6cm, working speed 2.75cm/sec. Minimum draft appeared when the diameter of disc was about 28cm and the drafts increased as the diameter of discs became larger or smaller than this diameter. Specific draft showed aimost same tendencies as above but showed the minimum when the diameter was about 30cm.

For the purpose of controlling the seeding depth, the relationships between draft andworking depths, 3cm and 6cm, were tested. The variations of draft concerning the various working depths showed linear changes and were affected in higher degree by depths than other factors.

There were general tendencies at both working depths, 3cm and 6cm, that total draft showed the minimum with the disc diameter of about 28cm and specific draft showed it with the disc diameter about 30cm regardless of disc angle and working speed.

For the purpose of controlling the working width and speed, the relationships among drafts, disc angle and working speed were investigated and there were general dendencies that the draft increased as the angle and speed were increased and the draft was affected more by speed than by angle.

To compare the hoe-type with disc-type opener, the specific drafts of hoe openers were compared with those of disc opener of 16° angle and 30cm diameter. The specific draft of disc-type opener with the diameter of 30cm was 0.35~0.5 kg/cm^2, while 0.71~1.02kg/cm^2 in the case of hoe type with the lift angle of 20° which is 2 times as much as that of disc type in average value. And the furrows opened by disc openers were cleaner than those opened by hoe openers.

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