Development of Small Windrower Harvester for Sugar Cane

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Introduction

A great deal of labor has been required mostly in harvesting work to grow sugar canes in Okinawa and Kagoshima prefectures.

The demand for mechanization of the harvest has been increased yearly due to reduction of profitability with the augmentation in harvesting expenses under the urgent labor condition of late years since it has occupied 76 per cent of the whole working time; for example, ratoon crop of sugar cane which has been widely conducted in these areas.

Since 1966, five types of sugar cane harvesters made in Australia (two are chopper type and three are whole stalk type) have been introduced and the applicability under such background in these areas were investigated. These harvesters, however, have not always been applicable to the harvest in these areas due to the following reasons:

1) The size of the harvesters is too large for the field and the agricultural road in these areas.

2) They are too expensive for operation by the farmer at present.

3) It is difficult to apply them to sugar canes under heavily lodged condition due to typhoon and heavy rain.

4) Some problem in trafficiability of these harvesters under heavy clayey soil condition remains, since sugar cane harvesting in January to April comes in the rainy season.

5) It is extremely difficult to burn cane leaves before harvest because they are restricted by climatic, field and social conditions.

Consequently, a small harvester has been generally demanded under the existing circumstances. In order to meet the demand, a walking type of a small windrower harvester has begun to develop in 1967 at the Institute of Agricultural Machinery.

The prospect of putting it into practical application could be realized by several trials and improvements although several problems still remain.

The progress of development and basic mechanism of the harvester which have been developed recently are described in this article.

Progress of development of small windrower harvester

Model I had been developed in 1967, model II in 1968, model III in 1969, and model IV in 1970 and experiments were conducted on all of them. Brief specifications and the testing site of each experimental harvester are shown in Table 1.

Study and development of Models I to IV have been concentrated on how the lodged green cane could be picked up and discharged smoothly by the small machine. Besides, trafficability and handling have been also important factors of the study and development. The outlines of the trial progress are as follows:

Table 1. Brief specifications and test site of experimental harvesters

Harvester	Year	Brief specifications					
		Whole length (mm)	Whole width (mm)	Whole height (mm)	Whole weight (kg)	Engine	Test site
Model I	1967	2750	1420	1025	307	Air-cooled 4-stroke gasoline rated 4.0 ps. maximum 5.5 ps.	Okinoerabu Is. (Kagoshima Pref.)
Model II	1968	2750	1420	1100	381	Air-cooled 4-stroke gasoline rated 5.5 ps. maximum 7.5 ps.	Okinoerabu Is. (Kagoshima Pref.)
Model III	1969	2870	1476	1150	386	〃	Kagoshima-city (Kagoshima Pref.) Naha-city (Okinawa)
Model IV	1970	3100	1670	1200	450	〃	Kagoshima-city (Kagoshima Pref.) Naha-city (Okinawa) Kikai Is. (Kagoshima Pref.)

1) Experimental model I machine

The major part of this machine, whose cutting and conveying gears have been equipped with the partially remodeled walking tractor, is composed of running, cutting and conveying gears. It is not equipped with topping and bandling gears.

It was tested in 1967 using a variety of N: Co 310 (ratoon) which had not been heavily lodged and at a state with being stripped. But it was necessary to be remodeled due to several problems, such as (1) canes harvested were not smoothly discharged, (2) canes were not favorably cut, and (3) strength of the machine was partially insufficient.

2) Experimental model II machine

This machine was equipped with a larger engine (maximum output is 7.5 ps) and has been changed into a model which discharges canes holding the under part of them with a pair of roller chains fitted finger attachment to discharge them smoothly.

The speed of chains and base-cutter have been also changed. It was tested in Okinoerabu Island using ratoon crops under the condition that they have been completely stripped off the leaves manually, but a defect of the canes being choked up at the outlet could not be improved yet. It was found that the discharging mechanism should be drastically improved.

3) Experimental model III machine

The upper side-delivery mechanisms have been contrived in order to discharge canes smoothly by holding them tightly. That is, such a method has been applied that the canes which are cut by the base-cutter are conveyed and given constant stress by a pair of feed chains.

This machine is also characterized with the installation of side-delivery chains which are 160 mm higher than that of model II, and by being changed into a four-wheel type with a pair of auxiliary wheels fitted up front of the machine.

This machine was first tested in the city of Kagoshima and the operation could be smoothly conducted in case of the elect canes which are stripped off the leaves manually.

Subsequently, the remodeling and experiment for improving the discharging performance and the applicability to lodged canes have been repeated in Okinawa. As a result, canes could be smoothly discharged if the leaves fallen on the row were removed.

The performance also could be improved to the extent whereby it was applicable to the slightly lodged canes. But there still remained several problems in case of heavily

lodged canes. It was confirmed, however, that this machine shows high trafficability even under the wet clayey soil condition in these areas.

4) Experimental model IV machine

Model IV has been designed on the basis of the data and the experience gained from model III. In designing the machine, emphasis was laid on the point that the lodged canes are successfully picked up and smoothly discharged.

A relation of speed between the pick-up chain and the travelling speed, a relationship between length and height of side-delivery chains, the revolving direction of base-cutter, and the lower side-delivery mechanisms, etc., were reinvestigated, and at the same time trafficiability and handling were also taken into consideration.

The basic mechanism and the principal dimensions of model IV are shown in Fig. 1 and Table 2. A screw type lower side-delivery mechanism, up and down movement dividers and direction controller to maintain a straight-line motion were newly fitted up.

The adaptability of this machine had been investigated from January to April in 1971 at three places — Kagoshima City, Okinawa and Kikai Island (Kagoshima Prefecture)— where a variety of N: Co 310 with 62–110 ton of yields per hectare was tested under the green cane, burnt cane and pre-topped

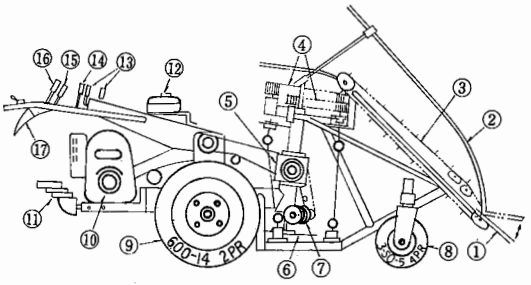

Fig. 1. Basic mechanisms of model IV harvester

1 Divider	10 Engine
2 Side-divider	11 Balance weight
3 Pick-up chain	12 Fuel-tank
4 Upper side-delivery chain	13 Transmission lever
5 Gear box	14 Divider-front wheel control lever
6 Base-cutter	15 P.T.O. clutch lever
7 Screw	16 Main clutch lever
8 Front wheel	17 Side clutch lever
9 Rear wheel (Driving wheel)	

cane conditions. An example of result of the test is shown in Table 3.

To pick-up the lodged cane, which had been a serious problem, was successfully conducted and discharging was also smoothly executed. Especially, screw type lower side-delivery mechanism, which was a new trial, was remarkably effective and it enabled one to solve almost perfectly the troubles about discharging of canes.

The tests in some areas have generally

Table 2. Principal dimensions of model IV harvester

Type of harvester	Whole stalk type	Front wheel	3.50–5 4 PR
Type of harvesting	Windrower type	Rear wheel	6.00–14 2 PR
Whole length	3100 mm	Diameter of base-cutter	520 mm
Whole width	1670 mm	Rotating speed of base-cutter	500 rpm (at engine 1800 rpm)
Whole height	1200 mm	Adjustable height of base-cutter	Max. 75 mm
Whole weight	450 kg (include: additional weight of 37 kg)	Transmission	Forward: 6 speed Reverse: 2 speed
Wheel base	1180 mm		4-stroke, air-cooled, gasoline
Tread	Front 860 mm, Rear 970 mm	Engine	Output 5.5 ps. (rated), 7.5 ps. (max.)

Table 3. Example of field test results of model IV harvester

Date: April 1971
Place: Kitai Island (Kagoshima Pref.)

Test field area Number of row×row length×raw spacing	5.28 are 6×80 m×1.1 m
Variety and method of cultivation	N : Co310, ratoon (first time)
Average length and diameter of cane stalks	Length: 183 cm Diameter: 20.5 mm (middle)
Estimated number of cane stalks and yields per 10 are	Number: 8908 Yield: 6173 kg
Cane conditions	Green cane (no burned) Percentage of lodged cane Angle of lodging 0°–30° 20% 〃 30°–60° 50% 〃 60°–30%
Traveling speed (average)	At low gear (1st): 0.24 m/sec At high gear (2nd) 0.44 m/sec
Slippage of rear wheels	6.6% (at gear 2nd)
Required time for havesting 10 are (estimated)	At low gear (1st): 90–120 min At high gear (2nd): 60–70 min
Accuracy of operation (weight percentage)	Harvested 95.8% Non-harvested 0.0% Damaged 4.2% High cut losses 0.0%

succeeded, and it could be concluded that they have approached to the practical use machine, but it was considered that it would be still necessary to improve the following points:

(1) To improve dividing and picking-up performance for lodged canes more than 90 tons per hectare.

(2) To prevent the twisting of dry leaves to rotating parts of the machine, which occurs when the machine is used at the trashy field.

Conclusion

Although it had been disappointed to harvest sugar canes in these areas, evidence has been given that it is possible to harvest them even by a small harvester with 7.5 ps.

However, there still remain several problems to be solved in order to use it as a practical machine because it is still in the experimental stage. But some of the problems could be solved by the cooperation in growing management. It is essential to prepare the conditions where the machine could be easily used, such as adjusting of row spacing and height of ridge to the machine, removal of leaves before harvesting, checking the canes so they will not be lodged or introducing the variety with excellent durability against lodging.

It could be expected that the small harvester would largely contribute to the harvest of sugar canes from the viewpoints of saving manpower and the retrenchment of harvesting expenditures since it would give play to mobility, which is a strong point of the machine, if these conditions would be prepared.

This machine is to be improved successively, about 10 machines are to be made within this year, and the test for extensive practical application is to be conducted in each area.

Acknowledgement

The authors greatefully acknowledge both Sugar Crop Development Fund in Tokyo for their continuous cooperation from the start of this development and Model Farm in Okinawa

for their long-term assistance, which has brought a rapid growth of this machine. Thanks are also due to Agricultural Experiment Station in Kagoshima Prefecture and Agricultural Experiment Station in Okinawa Prefecture for their assistance at the field trials.