Development of New Sugar Cane Harvesters in Japan

Part 1. Whole stalk harvester of medium size

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Sugar cane is grown on 38,000 ha of land in Japan (Japan Statistics 1978). All of the canes are harvested by hand, requiring 850–1,000 man-hour/ha annually. In most cases, canes are harvested by 3 to 5-membered crews. One or two male workers cut cane stalks at the ground level, and 15–20 cane stalks are piled on the rows. Two or three trashers remove tops and leaves from the cane stalks with trashing sickles. After the trashing, 15–20 clean stalks are bundled with straw rope, and the bundles of clean canes are carried out to farm roads by farmer carriers.

The sugar cane in Japan is grown on semi-circular raised beds, with 40–50 cm of width, in one row. Distance between each bed is 110–130 cm, and planting space in the row is 10 cm. Time required per 10 a (about 1/4 acre) by conventional harvesting work was 9–15 man-hours for cutting, 48–60 man-hours for trashing, 9–15 man-hours for bundling, and 8–10 man-hours for carrying, respectively. Intensity of working labor is highest for the cutting.

In recent several years, economic situation for sugar cane production has become more harsh. In 1974, selling price of cane was 15,000 yen/ton, though a certain amount of the production promotion subsidy was given to farmers. In case of an average harvest of 7 ton of canes/10 a, the gross income of a grower was 105,000 yen/10 a. On the other hand, the harvesting labor cost was 4,000 yen per day. Assuming that the harvesting capacity of a male worker is 0.7 ton per day, it is necessary to employ 10 workers for 10 a of field. Therefore, even if only the harvesting wage is taken as the running cost, the gain is only 65,000 yen. In addition to such a low gain, the harvesting of lodged canes, caused by typhoon, requires arduous works.

Thus, the low price and increased labor cost for harvesting have made the sugar cane production much less profitable in Japan. Mechanization of cane harvest is urgently needed as a key factor for the survival of sugar cane farming in Japan.

Mechanization of harvesting operation

According to a survey, 9 foreign-made large size harvesters had been introduced into Japan by February 1975. Results of their field operations showed the following problems: The first problem was not the technical one related to the cane stalks, but related to whether or not the field conditions permit their introduction. Large fields where large harvester can be used are located only in certain areas of Daito Island. Secondly, in place of hand trashing, cane leaves had to be burnt off, but this operation was very much affected by rain. On the other hand, under the dry condition, flying sparks of fire apt to cause another fire on other fields.

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The burning of leaves results in loss of organic matter to be applied to fields. Thirdly, the canes harvested by the imported harvesters were heavily contaminated by trash, amounting more than 30–40%, and which caused reduced rates of sugar extraction.

On the other hand, about 100 units of small size windrow type harvester, locally manufactured, have been introduced up to now. However, they don't work well with completely lodged canes, or they are not practical for fields with more than 100 ton/ha of cane yields.

In view of such a situation, a new sugar cane harvester of medium size was developed by the authors in the Institute of Agricultural Machinery. The characteristics of this harvester is that it is capable of doing various operations such as whole stalk harvesting, detrashing, and windrowing on the field.

Mechanical outline of the new harvester

Principal parts of the harvester are outlined in Fig. 1 and Table 1. This harvester is an extremely stable, compact whole stalk type harvester for single row of cane, designed basically to operate for unburned canes (green canes). It consists of a 40 PS water cooled diesel engine and other apparatus mounted on 4-wheel high-clearance tractor. The details are as follows:

1) Crop dividers

A pair of crop dividers, with a cross section of an equilateral triangle, are employed. Each divider can work independently. The rotating crop dividers lift the lodged canes to facilitate the cutting of canes at the basal portion of cane stalks and the feeding of cut canes into the throat of the machine. To give an effective raising of cane stalks, the crop dividers can move upwards and downwards by the operation of control levers, depending on the degree of lodging of canes. Each divider is fitted with a long shoe at its lower end, and which runs in close proximity to ground surface. Power to the crop dividers is supplied by the individual hydraulic motors which are controlled by a valve on the operation platform.

Table 1. Brief specifications

Type	Cutting-Trashing-Windrowing, Single row green cane harvester.
Weight	3,810 kg.
Dimention	Total length, 5,720 mm. Total width, 2,210 mm. Total height, 2,690 mm.
Power unit	40 PS/2200 rpm, 4 cycle water cooled diesel.
Transmission	Mechanical, 24 steps, forward.
Cluch	Dry type dual cluch.
Brakes	Hand brake, mechanical. Foot brake, hydraulic. Actuate, oli immersed disc type.
Steering	Front wheel, orbitrol power steering.
Wheels	Front wheel, 7-20-4 ply. Rear. 12.4/11-28 4 ply.
Wheel track	Front, 1,580 mm. Rear, 1,500 mm.
Wheel base	1,980 mm.
Ground clearance	355 mm.
Basecutter	Twin cutter with spiral lifter and slip cluch. Cutting height, −50.8 to +500 mm.
Crop divider	Angle of inclination, 65 deg. Trigonal pyramid type. Drive, hydraulic motor, OMP-270.
Detrasher	Contra rotating chain type. Chain dia., 6 mm short link chain.
Side delivery device	Deflector, 3 rotating vertical axial roller type, roller dia., 300 mm. Delivery roller, 3 rotating horizontal axial roller type, dia., 200 mm., roller length, 600 mm.

2) Basecutter

It cuts cane stalks at the ground level. It consists of two disks with vertical feed cylinder which moves in opposite direction, and each disk is bolted 10 blades. The function of vertical feed cylinder is to lift the cane stalks from the upper surface of basecutter to the top dead point of the cylinder, and feed to the horizontal feed rollers.

3) Feed rollers

The horizontal feed rollers consist of an upper roller and a bottom roller. The bottom roller rotates around the fixed axis at side plate of the harvester, and the upper roller rotates around the axis which moves up and down vertically according to the flow quantities of the cut cane stalks, and these rollers provide a

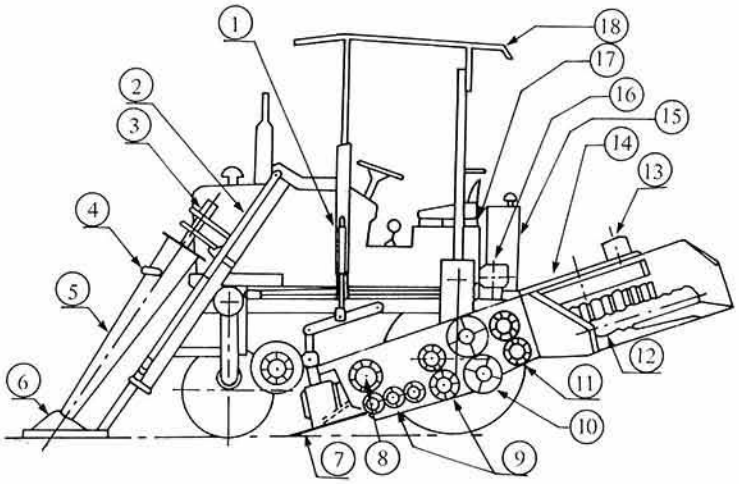

Fig. 1. Sectional view of the harvester

1 Cutting height control cylinder.
2 Crop dividercontrol cylinder.
3 Hydraulic motor.
4 Cane push bar.
5 Crop divider.
6 Floating shoe.
7 Base-cutter with vertical feed. cylinder.
8 Top horizontal feed roller.
9 Horizontal feed roller.
10 Trashing chain wheel.
11 Draw out roller.
12 Side delivery roller.
13 Hydraulic motor for deflector.
14 Side delivery apparatus.
15 Hydraulic tank.
16 Power take off.
17 High-clearance tractor.
18 Safety frame.

positive grip to the cane stalks at all times. The function of the feed rollers is to feed the cane stalks to the detrashing apparatus.

4) Detrasher

The cut canes are then transferred to the detrashing apparatus which has two detrashing drums rotating contrariwise each other. The detrashing drum consists of a rotor and short link chains, one end of which is fixed to outside of the rotor and the other end is left free. When cane stalks pass through between upper and lower drums, the cane tops and leaves are removed by striking action of the chains. The removed trashes are discharged to fields together with dirt, stone and other foreign matters.

5) Side delivery apparatus

After detrashing, the canes are transferred to the side delivery apparatus. This apparatus consists of a deflector and three horizontal conveyer rollers. The deflector acts to change the moving direction of canes to an angle of 30 degree against the moving direction of the harvestor. The conveyor has the wavelike flight on the circumferential surface melted with constant pitches, and each rollers rotates in the same direction with the hydraulic motors. When cane stalks are transferred onto the roller, they are carried and windrowed on the field.

6) Bundling and carrying

After being disharged on the field, the canes are bundled with straw rope by hand and are carried to farm roads by farm carriers.

Performance of the new harvester

During recent few years, field tests of this new harvester were carried out more than twenty times under various conditions of fields in Okinawa. The results are summarized as follows:

Under the condition of about 70 ton/ha of cane yield or with a few lodged canes, satis-

Table 2. Some performances of the harvester

	Okinwa Experiment Station field	Kume Sugar Co. field	Ryukyu Univ. field
Variety	Nco: 310	Nco: 310	Nco: 310
Mean stalk length (cm)	254	184	153
Yields (ton/10 a)	10.5	5.0	4.1
Lodged cane stalk* (%)	60	30	5
Travelling speed of harvester (m/s)	0.125	0.320	0.457
Normal cane stalk (%)	56.1	82.0	90.5
Partially broken cane stalk (%)	36.3	12.0	5.2
Partially crushed cane stalk (%)	7.6	6.0	4.3
Total	100.0	100.0	100.0

* Lodged cane: stalks inclined with angle less than 30 degree against ground level.

Plate 1. Rear view of the newly developed harvester

factory results were obtained. Even when yields were more than 100 ton/ha, this harvester worked well. But, in the fields where large number of canes were lodged or entangled each other, it happened that the canes were partly crushed or broken into 2—3 pieces per stalk (Table 2). The occurrence of the broken or crushed stalks was not avoided under that condition. The lodging is caused not only by cultural methods, but also by typhoon which some times causes drastic lodging. The lodged stalks show complicated shapes like "L" or "S", etc.

Regarding the detrashing efficiency, separation of trash from stalk was sufficient. For example, in the field test in 1977, amount of trash (cane tops, leaves) remained unseparated was only 0.2–2.0% to the clean cane stalks: similar to the value shown by the conventional hand trashing. But, the quantity of trash ejected from between two chain drums onto the field was very little, while large quantity

of trash was ejected from the side delivery conveyor together with clean cane stalks. Therefore, if we desire to get cane stalks completely separated from trashes, hand separation is necessary before bundling.

Trafficability test conducted immediately after 50 mm rainfall in the field of heavy clay soil, called "Jargal" in Okinawa, showed a sufficient result.

Harvesting capacity

Harvesting capacity of this harvester is as high as 30 to 40 times that of the conventional harvesting, but when the time required for manual operations such as bundling and carrying is taken into account, it is 3 to 5 times that of the conventional harvesting.

Assuming that a capacity of harvester is 0.5 ha/day and workable days during a year is 55 days, 2,700,000 yen per year or 10,000 yen per 1 ares will be saved by the use of this harvester.

This newly developed harvester has been introduced to Okinawa, and at present 5 of it are in practical use. Plate 1 shows the practical operation at the Okinawa Agricultural Experiment Station in 1978.

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