Soybean Threshers in Japan and Development of a New Thresher

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At present, soybeans are grown widely in Japan, from Hokkaido to Kagoshima, on about 150,000 ha of land. Mechanical harvesting system and soybean reapers used in Japan were already reported in JARQ 14(4)[4]. Reaping is usually practiced for soybean plants with fairly high moisture contents, such as 18–25% for grains and pods, and 60–75% for stalks, in order to reduce shatter losses. The reaped plants are kept staying on the field for natural drying, until moisture content of grains and pods becomes 14–17%, and that of stalks lower than 20%, and then threshed.

In this report, the soybean threshers now being used in Japan, and the spiral-flow soybean thresher newly developed in the Institute of Agricultural Machinery will be presented.

Soybean threshers on the market

1) Kinds and structure

Soybean threshers now available on the market can be classified by feeding method into the intermittent feeding type and the continuous feeding type. By the difference in travelling method, they are classified into the stationary type, self-propelled type, tractor-mounted type, and the tractor-drawn type.

The intermittent feeding type (Plate 1) signifies that stalks and emptied pods in the threshing chamber are disposed intermittently by manual operation of stalk disposing plate. The structure is very simple, mainly consisted of a threshing unit, composed of threshing cylinder and concave, and a separating unit, which utilizes cleaning fan. The operation is made in the following sequence: feeded soybean plants are threshed in a state that the

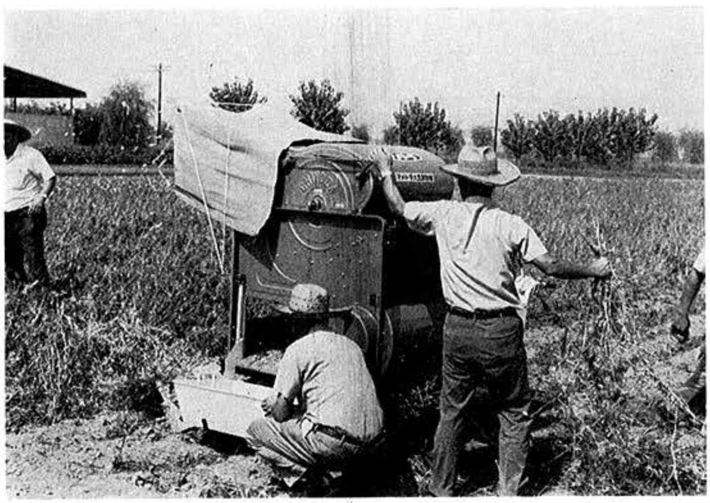

Plate 1. Soybean thresher (intermitted feeding type)

stalk disposing plate is kept shutting, and when all the threshed grains dropped down through the concave, the stalk disposing plate is opened to dispose stalks and emptied pods. This operation is repeated. This type has an advantage of easy handling and cheap price, but disadvantages that threshing capacity is low due to intermittent feeding, and some stalks and emptied pods tend to be mixed into threshed grains at the clean grain outlet, because only wind is used for the separation.

On the contrary, the continuous feeding type can feed soybean plants continuously, and stalks and emptied pods in the threshing chamber are disposed automatically. Although the structure of the threshing unit is not so much different from the former type, its separating unit is equipped with the separating mechanism composed of straw-rack, oscillating sieve, etc. and the winnowing mechanism by the use of cleaning fan. Some of the threshers of this type are equipped with 2 threshing cylinders, and beater to facilitate rapid disposal of stalks and emptied pods. This type threshers are more expensive than the former type, but characterized by higher threshing capacity and less mixing of stalks and emptied pods at the clean grain outlet.

Plate 2 shows an example of self-propelled soybean thresher of continuous feeding type, and Plate 3 shows a tractor-drawn soybean thresher of continuous feeding type, which is widely used in big farms in the upland farming region in Hokkaido. Examples of specification of soybean threshers now on the market are given in Table 1.

2) Performance of threshers

Threshing work of the intermittent feeding threshers is done by repeating shutting and opening of stalk disposing plate, as explained above. Therefore, grain feed rate and threshing performance vary with the length of time from the feeding to the opening of stalk disposing plate (crop dwell time in the threshing chamber). When the crop dwell time becomes longer the grain feed rate is decreased, but grain losses (free grains which are discharged with stalks and emptied pods through the stalk outlet) are reduced, because almost all of the threshed grains drop through the concave and are collected. On the contrary, when this time is short, the feeding becomes closer to the continuous one with an increased grain feed rate, but grain losses are also increased, because the ratio of the grains dropping through the concave is decreased.

Compiled data[5] of experiments conducted in the whole country in 1979 with 7 different models of intermittent feeding threshers showed that the upper limit of grain feed rate to reduce grain losses within 3% was

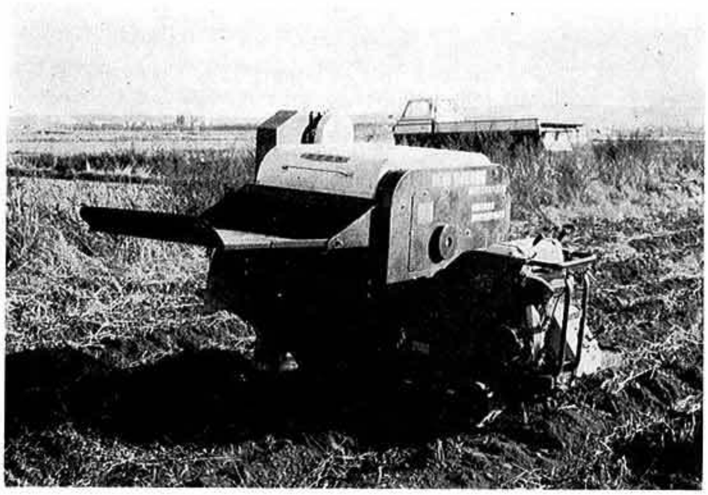

Plate 2. Soybean thresher (continuous feeding type, self-propelled)

Table 1. Examples of specification of soybean threshers

Machine		Plate 1	Plate 2	Plate 3
Type		Intermittent feeding type	Continuous feeding type	Continuous feeding type
Dimension (mm)				
Overall length		1330	2230	6000
Overall width		920	2865	2000
Overall height		1320	1530	2800
Weight (kg)		90	540	1350
Engine output (ps)		2	5	—
Threshing unit				Two-cylinder
Cylinder	Diameter (mm)	365	425	370
	Width (mm)	631	740	760
	Speed (rpm)	370	400	370–400
Concave		Perforated plate	Crimp mesh	Crimp mesh
Separating unit		Cleaning fan	Two-oscillating sieve Cleaning fan	Oscillating walker Oscillating sieve Cleaning fan
Remarks		Stationary type	Self-propelled type	Tractor-drawn type

150 kg/hr. In this case, percentage of damaged grains was less than 1%, and percentage of unthreshed grains was lower than 2%.

On the other hand, the continuous-feeding type has higher threshing capacity than the intermittent-feeding type, because it disposes stalks and emptied pods in the threshing chamber automatically. Grain feed rate is 400–500 kg/hr on an average, and about 1 ton/hr is possible with the thresher shown in Plate 3. The threshing performance is stable, being not much influenced by the feeding rate.

Compiled data[5], similar to that for intermittent feeding type, indicates that grain losses 3–4%, damaged grains less than 2%, and unthreshed grains lower than 1%. Need-

Plate 3. Soybean thresher (continuous feeding type, tractor-drawn)

Plate 4. The newly developed thresher (Model ST101) in operation

less to say, percent foreign matters found at clean grain outlet is also apparently less than that of the intermittent feeding type.

A newly developed spiral-flow soybean thresher

With the progress of the governments program of diversified use of paddy fields initiated in 1978, area cropped to soybean has increased year by year, with an increasing tendency of group cultivation. In regions, except Hokkaido where advanced mechanization of soybean cultivation is practiced, the introduction of reapers and threshers has come to be promoted with the target of the total labor within 300 hr/ha. However, the capacity of the above-mentioned threshers on the market is not always satisfactory in case of group cultivation which adopts joint use of machines. Thus, there is an increasing demand for a new thresher, relatively small, but with high threshing capacity and less grain losses.

In view of such a background, a research to develop a new thresher with the threshing and separating mechanism of spiral-flow type, which is completely different from the conventional types, was initiated in 1978 in the Institute of Agricultural Machinery. The thresher, thus developed, reached a stage for practical use, so that its outline will be presented.

1) Structure

The development of a new thresher was made, based on the concept to add threshing and separating functions to the screw auger which is originally used to transport materials in the direction of its axis. Accordingly, the main portion of this thresher is composed of two screw augers, one as a base for threshing unit and the other for separating unit.

As shown in Fig. 1, the threshing unit is composed of a threshing cylinder and a concave. The threshing cylinder (30 cm diameter and 140 cm length) has a spiral fin of 5 cm height with 15 cm pitch, and independent teeth to facilitate smooth revolving of feeded plants in the threshing chamber. The separating unit is composed of a screw auger (18 cm diameter with 18 cm pitch) and a concave below the screw auger. The mesh of the concave in the separating unit is smaller than that in the threshing unit.

In this thresher, soybean plants introduced through the feeding inlet are threshed during their spiral movement in the threshing chamber. The majority of stalks and emptied pods are carried along the direction of axis and

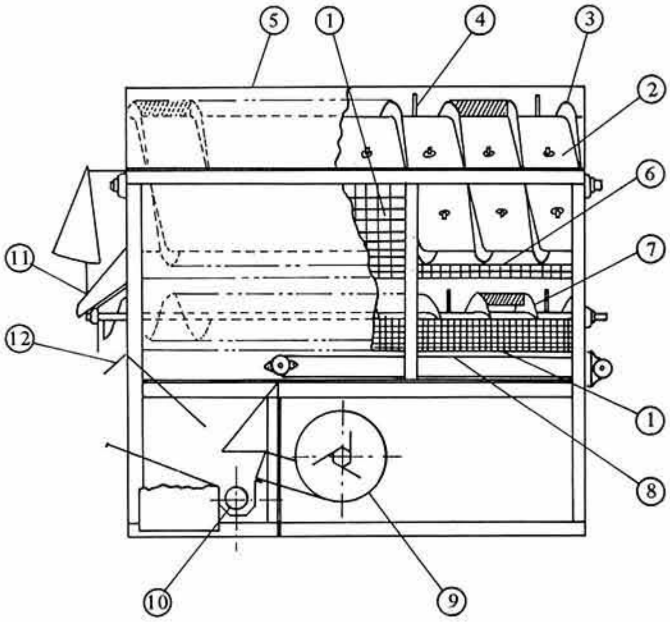

Fig. 1. Sectional view of the newly developed thresher (ST101)

① Concave ② Threshing cylinder ③ Spiral fin
④ Tooth ⑤ Cylinder chamber ⑥ Feeding inlet
⑦ Separating auger ⑧ Rubber belt ⑨ Cleaning fan
⑩ Clean-grain auger (to bucket conveyor) ⑪ Stalk outlet (I)
⑫ Stalk outlet (II)

disposed through the stalk outlet. Grains fall down to the separating unit together with small stalks and pods. In the separating unit, the stalks and pods are carried to the stalk outlet similarly as in the threshing chamber, while only grains fall down through the concave. Finally, the grains are carried to the winnowing unit by rubber belt, winnowed by the wind of cleaning fan, and carried to the clean grain outlet by bucket conveyor.

The threshing mechanism of spiral-flow type was already employed for rotary combines in U.S.A.[1,7], and many experimental results were reported. However, in all of them materials are transported by spiral vanes fixed to the cylinder cover. Contrary to that, the new thresher devised by us uses the spiral fin attached to the cylinder for threshing and carrying, so that it can work without trouble for materials with high moisture content and long stalks. Furthermore, as it has no oscillating mechanism in the separating unit, its structure is very simple, and oscillation and noise are extremely scanty. This new thresher in operation is shown in Plate 4.

2) Threshing performance

In the course of the designing, a large number of basic experiments were carried out on the threshing and separating performance as related to various factors such as cylinder speed, length of cylinder, pitch of spiral fin, mesh of concave, etc.[2,3]. All the results will be reported elsewhere in detail, but an example of threshing performance in relation to grain feed rate is shown here.

At the condition of 400 rpm of threshing cylinder speed and 100 rpm of screw auger speed in the separating unit, the threshing performance at the varying grain feed rates from 100 to 700 kg/hr was as shown in Fig. 2. With the increase of feed rate, percentage

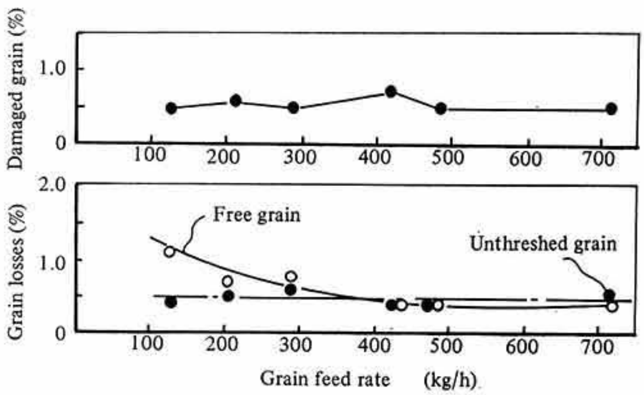

Fig. 2. Performance of the new soybean thresher (ST101)
Variety: Tachisuzunari
Moisture content: Grain 11.4%
Pod 13.2%
Stalk 14.0%

of free grains at the stalk outlet decreased, but no big change occurred at the feed rates higher than 400 kg/hr, showing a stable performance. On the other hand, unthreshed grains at the stalk outlet was about 0.5%, irrespective of feed rate. Accordingly the grain losses (free grains + unthreshed grains) were less than 1% at the feed rate of 500–700 kg/hr, a target feed rate of this thresher. This performance was apparently superior in rate of work and operation accuracy to that of conventional soybean threshers. Percentage of damaged grains was also lower than 1%, in spite of fairly low moisture content of grains; 11.4%. It was proved that the percent damaged grains in rotary combines of U.S.A. was apparently lower than in conventional combines[6,8]. It seems that the similarity exists in the newly developed thresher with axial-flow type, which is a different mechanism from that of the rotary combines.

The new thresher was introduced into 6 model areas for group soybean cropping in the whole country in 1981, with a good result. It is scheduled that the new thresher will appear on the market starting from 1982.

Future research direction

It is intended to continue basic studies to get higher grain feed rate and also to initiate a research to develop soybean combine with the new spiral-flow mechanism. Furthermore, the possibility of using this mechanism to other crops like wheat, barley or rice will be searched, with an aim of establishing universality for crops.

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