Performance of Soybean Reapers in Japan

By TOMOHIKO ICHIKAWA

Laboratory of Harvesting and Threshing Machine, Institute of Agricultural Machinery
(Nissin, Omiya, Saitma, 330 Japan)

Area cropped to soybean in Japan, once accounted for more than 400,000 ha, had decreased from year to year since 1955, due to increased imports and subsequent lowering of relative price of soybean, and the area in 1977 was less than 80,000 ha. However, soybean was adopted as one of the priority crops in the new program named Reorganization of Paddy Field Utilization, which started in 1978 with an aim of improving the overall self-sufficiency of agricultural products in response to the changes in their demand, by balancing demand and supply of rice. As a result, the planted area of soybean increased to about 130,000 ha (60% increase of the previous year's area) in 1978 and in 1979.

Mechanical harvesting system for soybean is classified into two principal groups: harvesting by the use of combines, and by the combination of reaper-(drying)-thresher. In the former method, at present in Japan, conventional combines used for rice and wheat are employed for harvesting soybean only in a limited area. In the latter method, the use of relatively large machines is already in practice widely in the upland farming regions of Hokkaido. In addition, development of relatively small reaper and thresher adapted to soybean in the dry fields, which are converted from paddy fields in the implementation of the program of Reorganization of Paddy Field Utilization, is now underway, and some of them are already in practical use.

In this report, outline and performance of reapers which are used in the harvesting system by the combination of reaper-(drying)-thresher will be presented, with special reference to the bundle-making type reaper.

Outline of soybean reaper

Machines which are available on the market as soybean reapers and those now under test can be classified as follows: windrowing type soybean reapers such as bean cutter or modified bush cutter, etc., binding type soybean reapers which are partly modified rice binders, and bundle-making type reapers developed for special use for legume crops.

Among them, a type of reapers which shows most stable performance and is expected to be used widely is the bundle-making type. At present, about 10 different kinds of the bundle-making type reapers, ranging from 1-row soybean reaper walking type to 4-wheel tractor-mounted 2-row soybean reaper, are on the market. In areas with large farm blocks like upland farming region in Hokkaido, the tractor-mounted 2-row soybean reapers are already in practical use, and in other areas the 1-row soybean reapers are going to be used. These machines are mainly composed of cutting section, conveying section, and gathering section, each having different characteristics with different kinds of machines.

As the cutting section, i.e. cutting mechanism, reciprocating cutter or rotary cutter is used. The former is a blade with the same shape (pitch 50 mm) as used for rice binder or head feeding combine, but material and thickness of the blade are modified to increase durability. The latter has different types of cutting: cutting by a pair of circular saw cutter or of circular grindstone cutter, or by one rotating circular saw cutter or straight blade and ledger plate.

As the conveying section, which conveys reaped soybean to gathering bucket, a pair of

soft rubber belt or two steps of tined chain is used.

The gathering buckets are classified into manual operation type and automatic operation type based on the mechanism of opening and closing. The manual operation type permits to adjust freely the interval of opening and closing, but depending on the capacity of gathering bucket, there are two types: the one which accommodates soybean plants reaped from 7–10 m of row at the maximum and the other for about 15–20 m of row Automatic operation is made by the use of cam which works once for 3–4 m of row.

As an example of bundle-making type reapers. 1-row soybean reaper (walking type) —Model BH795, developed by the Institute of Agricultural Machinery (IAM) and now being

Plate 1. One-row soybean reaper—Model BH795

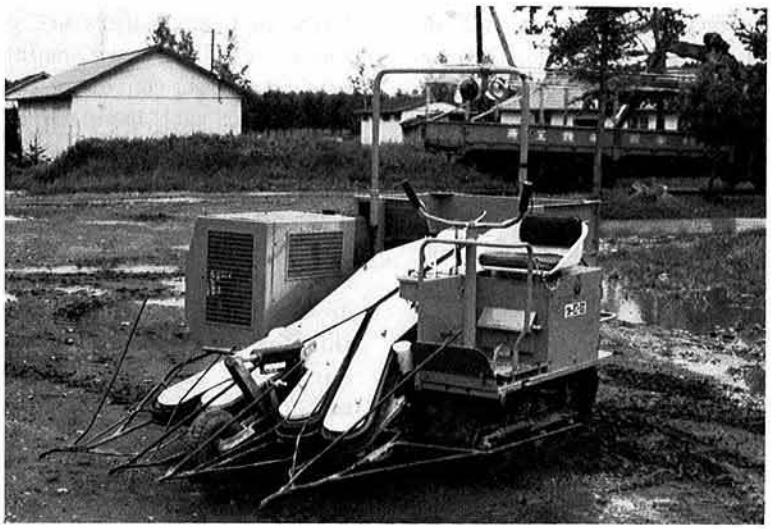

Plate 2. Two-row soybean reaper (self-propelled type) — Model Y2–S

Plate 3. Two-row soybean reaper (4-wheel tractor-mounted type)— Model M2–KB

tested in many places in Japan is shown in Plate 1. A self-propelled type (Model Y2-S) and mounted type (Model M2-KB) of 2-row soybean reaper, both in practical use in upland farming areas of Hokkaido are also shown in Plates 2 and 3, respectively. Major specifications of them are given in Table 1.

Table 1. Examples of specifications of soybean reaper

Model	BH 795	Y2-S	M2-KB
Type	Walking type	Self-propelled type	4-wheel tractor mounted type
Cutting row	1-row	2-row	2-row
Dimension (mm)			
Overall length	2,000	3,250	2,200
Overall width	1,480	1,760	2,850
Overall height	1,080	1,770	940
Weight (kg)	155	850	500
Engine output (PS)	2.5	11.0	—
Cutter	Reciprocating cutter	Rotary cutter	Rotary cutter
Conveyor belt	Soft rubber belt	Soft rubber belt	Soft rubber belt
Gathering bucket	Manual	Automatic	Automatic
Standard working speed (m/s)	0.8	1.1	1.0-1.5

Operation accuracy

It is desirable to minimize grain losses in harvesting. The grain losses are defined as the sum of (1) shattering loss, (2) pod loss, (3) stubble loss, and (4) lodging loss (Fig. 1). The shattering loss (grain shattering) is caused by the pod dehiscence induced by vibration and impact given to plants during harvesting operation. The pod loss is caused by pod shattering occurring due to same reason as above, and expressed in terms of grain loss. The stubble loss corresponds to grains left on stubbles, and the lodging loss corresponds to grains on lodged plants which escaped from reaping due to insufficient picking-up by dividers. As the grain losses differ not much among the bundle-making type reapers now in practical use, that of BH795 will be given below:

As shown in Fig. 2,[1] the shattering loss is greatly influenced by moisture contents of pods. It occurs less at higher moisture contents, and it is only about 2% at the moisture contents higher than 20%. Diurnal change in pod moisture content is generally 30-40% in early morning, followed by gradual decrease to about 15% at 1-2 o'clock p.m. and again increase after 4-5 o'clock in the evening. Therefore, the proper time for reaping is before 10-11 o'clock a.m. and after 4-5 o'clock p.m.

The pod loss showed a trend to increase to some extent at low moisture contents of pods, but not so apparent as the case of shattering loss, showing almost less than 1% (Fig. 2).

The stubble loss is influenced by the lowest podding height and cutting height, so that it hardly occurs with the cutting height close to soil surface, but it occurs at the rate of 0.5-1.0% with the cutting height of 3-4 cm as in the case of BH 795, when the lowest podding height is about 5 cm (Fig. 3).[1] On the other hand, the lodging loss occurs with some kinds of reapers, depending on trafficability, structure of divider, and width of cutter, but it hardly occurs with the usual stable reaping operations.

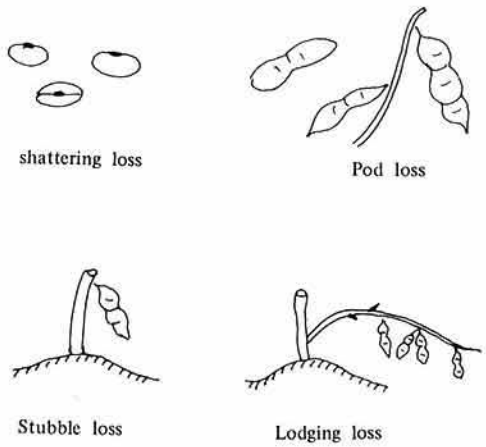

Fig. 1. Definition of grain losses

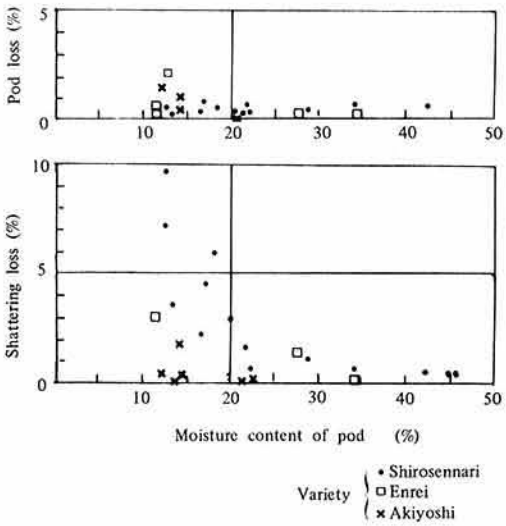

Fig. 2. Relation between moisture contents of pods and shattering loss, or pod loss — Model BH795

Characteristics of cutter

Reciprocating cutter and rotary cutter are used for soybean reapers, and it is difficult to infer which is most suitable because each one has merits and demerits. As shown in Fig. 4, the former requires less power for cutting,[2] but it needs about 3-4 cm of cutting height in view of durability, because it bites soil particles when used in soil or close to soil surface. Therefore it causes some stubble loss when podding height is low. On the contrary,

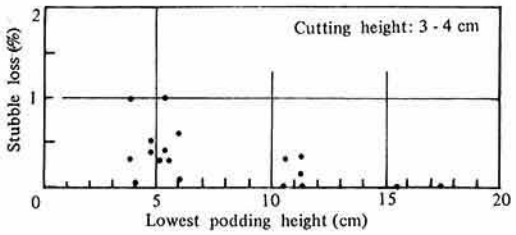

Fig. 3. Relation between the lowest podding height and stubble loss—Model BH795

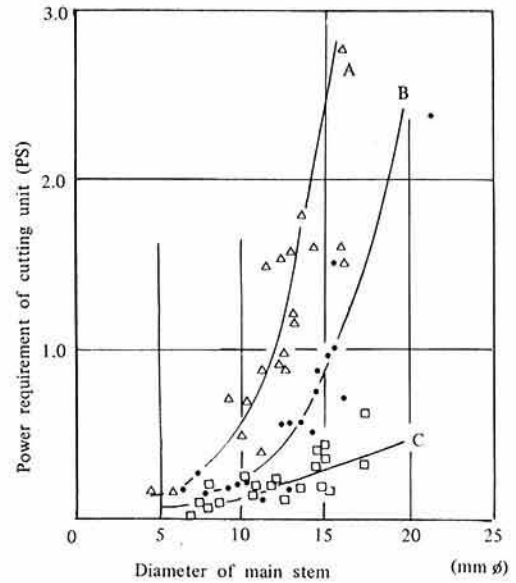

Fig. 4. Comparison of power requirement of various cutting units

A: Rotary cutter (a pair of circular grindstone cutter)
Diameter : 205 mm
Speed of revolution : 900 rpm, 1080 rpm

B: Rotary cutter (a pair of circular saw cutter)
Diameter : 254 mm
Speed of revolution : 900 rpm, 1080 rpm

C: Reciprocating cutter
Pitch : 50 mm
Cutting speed : 0.8 m/s

the latter (a pair of circular saw cutter and circular grindstone cutter) causes no serious trouble when it cuts soybean stems in soil and gives no stubble loss even when the podding height is close to soil surface, but it needs higher engine output due to higher power requirement for cutting than the former.

Main stems of soybean, more than 13 mm in diameter, give a considerable load to each of cutters, causing durability problems. However, as the majority of stems have about 10 mm in diameter, there will be no need to replace cutter for the harvest on 3-5 ha fields.

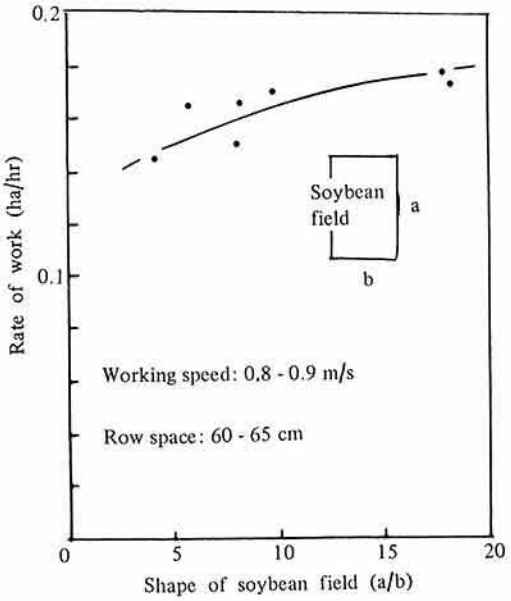

Fig. 5. Relation between shape of soybean field and rate of work of 1-row soybean reaper — Model BH795

Rate of work

As the bundle-making type soybean reapers take a roundabout reaping method due to the position of gathering bucket, rate of work is greatly influenced by shape of fields when working speed and row space are similar.

In Fig. 5, the rate of work of BH795 reaper is shown in relation to shape of fields. When the ratio of length of long side to short side of soybean field is more than 10, the rate of work is 0.16–0.18 ha/hr. However, as the ratio is 3–5 in usual soybean fields, converted from paddy fields, the rate of work may be about 0.15 ha/hr, although it may become higher than that when row space is wider 70–75 cm.

The rate of work of 2-row reapers, which have working speed of 1.0–1.5 m/s, is as high as 0.3–0.4 ha/hr, because they are used in

large fields in upland farming areas of Hokkaido.

Crop management desirable for mechanical harvesting

For the mechanization of harvesting soybean, it is, of course, necessary to improve performance of machines mentioned above, but it is also important as well to adopt cultural techniques suitable for the mechanization, such as suitable plant conditions and planting patterns. Cultural conditions desirable for the use of current reapers are summarized from many research results as follows:

Field conditions:

1) Inter-row space : 60–70 cm
2) Row height : <15 cm
3) Less weeds and less stones

Plant conditions:

1) Plant height : >50 cm
2) Diameter of main stem : <10 mm
3) The lowest podding height : >10 cm
4) Less spreading of branches, and no lodging.

References

1) Ichikawa, T. et al. : Developments of soybean reaper. *Tech. report IAM*, **54**(4), 65–81 (1979) [In Japanese].
2) Ichikawa, T. et al. : Studies on power requirement for cutting of soybean stem. *Tech. report IAM*, **54**(4), 83–101 (1979) [In Japanese].

(Received for publication October 1, 1980)