

Development of Mulberry Shoot Reapers

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Traditional way of mulberry harvesting was plucking shootlets or cutting shoots for spring rearing, and picking leaves for summer and autumn rearings. However, since about 1958, a technique of shoot harvesting for all rearing seasons has developed as a labor-saving method, and as a result the shoot rearing system throughout seasons was established. At present, 95% of all sericultural farmers in Japan adopt this method.

However, as the shoot harvesting was practiced by using pruning shears or sickles, working time required for shoot harvesting accounted for 30% of the total working time for silkworm rearing. In response to the recent labor shortage, mechanization of shoot harvesting has been keenly desired.

In 1961, a mechanization study was initiated in the Sericultural Experiment Station, and a shoot reaper mounted on small 4-wheel tractor¹⁾ was developed in 1963 which served as a prototype for further improvement. Since then, the study has been continued by that experiment station, and makers of agricultural machines, etc., and, as a result, several types of shoot reaper have been developed. The main types are mulberry shoot reaper mounted on 4-wheel tractor, shoot reaper mounted on hand tractor, and shoot reaper mounted on small carrier.

Mulberry shoot reaper mounted on 4-wheel tractor

Starting from the prototype, i.e. shoot reaper mounted on 4-wheel tractor of 8-10 p.s.¹⁾ several models of shoot reaper mounted on 4-wheel tractor of about 20 p.s. were

developed in 1963-1967 by agricultural machine makers. An example is shown in Plate 1.

Main portion of this machine consists of cutter lift mechanism, drawing conveyor mechanism, cutting mechanism, and binding portion.

- (1) The cutter lift mechanism, composed of lift frame, wire winder, etc. adjusts the cutting height to the range from 40 to 150 cm above ground.
- (2) The drawing conveyor, consisted of a pair (double-layered) of cylindrical steel conveyor, carries mulberry shoots to the cutter.
- (3) The cutting mechanism, located at the rear of the drawing conveyor, cuts the shoots with reciprocating knife. Only the upper blade works with 10 cm of stroke to cut the shoots.
- (4) The binding portion follows the cutting mechanism and where the shoots are bound by hand into bundles.

This reaper is attached to the 4-wheel tractor at the right hand rear of the tractor, and



Plate 1. Mulberry shoot reaper mounted on 4-wheel tractor

operated by power through P.T.O. The reaper runs in a furrow and harvests the shoots of a half side of a ridge. Therefore, two strokes, going and returning, can finish the harvest of the shoots of a ridge. In a field with 2.5 m of furrow width (inter-ridge space), it works at the rate of 1 hr/10a, harvesting more than 90% of all shoots.

Although this type of reaper was introduced into farmer's mulberry fields, it remained only at the stage of experimental use, because (1) it is too big to usual farmer's fields with narrow furrows, (2) too costly and (3) two workers are required for the operation, and the operation and fitting are not easy.

Mulberry shoot reaper mounted on hand tractor

To meet the farmer's demand for smaller reaper adaptable to their small farms, a reaper mounted on hand tractor was developed in 1969 by the Sericultural Experiment Station²⁾. Although its main portion is similar to the one described above, its size and fitting mechanism are much improved. The structure and specification are shown in Fig. 1 and

Table 1, respectively. It consists of cutter lift mechanism, drawing conveyor mechanism, cutting mechanism, and binding table. This reaper is fitted at the right rear of hand tractor

- (1) The lift mechanism, composed of basic frame, auxiliary wheel, stand mast, and wire winder, is used for fitting the reaper to hand tractor and for lifting or lowering the cutter.
- (2) The drawing conveyor mechanism, consisted of divider, a pair of cylindrical steel conveyor, star wheel, etc., carries mulberry shoots to the cutter and lays cut shoots on the binding table.

Table 1. Brief specification of mulberry shoot reaper mounted on hand tractor

Whole length	2600 mm
Whole width	1500 mm
Whole height	2450 mm
Whole weight	180 kg
Cutting height range	350-1300 mm
Cutter speed	0.80 m/sec
Inside conveyor speed	0.47 m/sec
Outside conveyor speed	0.22 m/sec
Stalk speed	0.3 m/sec
Tractor power	4-5 p.s

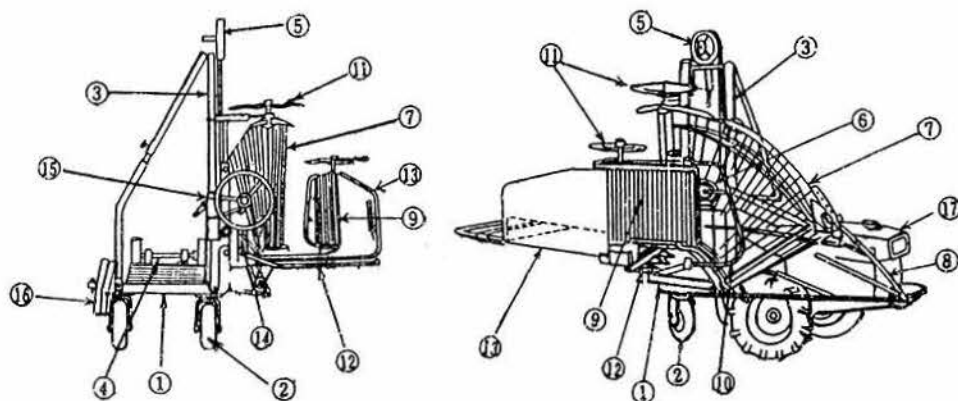


Fig. 1. Basic structure of mulberry shoot reaper mounted on hand tractor

1 Base frame	7 Inside conveyor	13 Binding table
2 Auxiliary wheel	9 Outside conveyor	14 Lift frame
3 Lift mast	10 Outside conveyor	15 Lift winding handle
4 Drive shaft	11 Divider	16 Balance weight
5 Tension pulley	12 Star wheel	17 Hand tractor
6 Idle pulley	12 Reciprocal cutter	

- (3) The cutting mechanism is made of reciprocating knife of 40 cm, with its upper blade moving at 8 cm of stroke.
- (4) The binding table in rear of the cutting portion is a L-shaped table, on which cut shoots are bound by hand into bundles of about 15 kg.

Harvesting by this reaper is done as follows:

- (1) Cutting height is adjusted as required (30–120 cm).
- (2) Running on the furrow, the reaper harvests shoots on the left hand half of a ridge.
- (3) When the cut shoots on the binding table reached to about 15 kg, let the reaper stop running to bind them into a bundle by hand, and the shoot bundle is placed on the furrow.
- (4) When the harvesting of shoots from the left half of a ridge is finished, the reaper is turned to harvest remaining shoots on another side of the ridge.
- (5) At the end of the harvesting work, shoot bundles are carried to the rearing house by cart or truck.

Harvesting with this reaper can be done by one worker. The performance is shown in Table 2. The working efficiency is about 2 hr/10a, i.e. about 4 times that of manual harvesting, with more than 95% of the total shoots harvested.

This reaper has been popularly used, and the following problems had been pointed out: damage of steel conveyor, difficulty of cutting large shoots, etc. However, these defects are all ameliorated later.

Mulberry shoot reaper mounted on small carrier

In 1974 a new type of reaper, shown in Plate 2, was developed by a maker of agricultural machines. It employs fingered rubber belt and fingered chain as the drawing conveyor, and rotary knife as the cutter. It is mounted on the small vehicle, which is cheaper than hand tractor and specially designed for the reaper.



Plate 2. Mulberry shoot reaper mounted on small carrier

Table 2. Work efficiency of mulberry shoot reaper mounted on hand tractor

Test season	Length of harvested shoots cm	Cutting height cm	Time required per 10 a		
			Reaping min	Binding min	Total min
Spring rearing season	120–130	60	37	77	114
Summer rearing season	190–200	80	37	53	90
Late autumn rearing season	170–180	120	39	56	95

Planting density : inter-ridge space=2.5 m, inter-plant space in a ridge=0.5 m
Ridge length : 50 m

Operation and working efficiency are almost similar to those of the reaper mounted on hand tractor, but with less troubles in practice. Therefore, this type of reaper is now spreading among sericultural farmers.

References

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(Received for publication, October 1, 1980)