Self-Propelled Tea-Plucking Machines

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It has been the most important problem in tea cultivation to save plucking labor, which constitutes more than half of the total labor cost and labor hours, by mechanizing the plucking operation.

In an early date, about 60 years ago, the traditional hand-plucking began to move to the shears-plucking when the area of tea gardens expanded to plain land, aiming at a greater production, with the hedge planting method in place of age-old, inefficient bush plantings. However, it was in 1961 that the small size power plucker[1] was developed and began to be used. From that time, being supported by prosperous tea industry, tea gardens have been expanded rapidly with newly reclaimed large scale tea gardens. On the other hand, tea processing machines have become increasingly large with a marked increase of capacity, which requires enough supply of a large amount of materials.

Reflecting such a situation, there has been a great progress in plucking machines: port-

Table 1. Specification of self-propelled plucking machine designed by the author

	Items		Standard
1.	Engine horse-power		12 ps
2.	Body	length	4. 00 m
		width	2. 40 m
		height	2. 61 m
3.	Cutter		
		Type	Arc-shaped, reciprocating type
		Radius of curvature	1. 00 m
		Width	1. 20 m
4.	Mechanism for collecting plucked shoots		Combination of suction and blowing

Table 2. Specification of self-propelled plucking machine of Matsumoto type

	Items		Standard
1.	Engine horse-power		5 ps
2.	Body	length	2. 51 m
		width	2. 43 m
		height	2. 57 m
3.	Cutter		
		Type	Cylinder type
		Radius of curvature	1. 10 m
		Width	0. 90 m
4.	Mechanism for collecting plucked shoots		By suction (into net-bags)

able power pluckers were developed, and furthermore self-propelled plucking machines came into practical use.

In this paper, researches done with self-propelled plucking machines will be described together with some information of performance and characteristics of some of the machines now in use.

Plucking mechanism

A reciprocating type of cutter which gives less fragmentation of leaves was selected. Repeated experiments have shown that the combination of pitch of knife: 25–30 mm, length of knife: 30 mm, cutting angle: 10°, and cutting pitch: 20–30 mm gave the best result with regard to quality of plucked shoots and an evenness of plant surface after plucking.

Mechanism of collecting plucked shoots

A combination of suction and blowing, by which plucked shoots are sucked up and then blown out by a fun, was studied. A suction nozzle of 80 mm of width with a tip curved outwards with a radius of curvature of 25 mm was found most effective. With this nozzle, the minimum air flow capable of sucking leaves was 8–12 m/sec[2], and a distance of 50–60 mm between the suction nozzle and plucking surface gave a good result[2].

Modelling of self-propelled plucking machine

A plucking unit thus designed was attached to the upper and lower links connecting to three-point hitch (oil pressure) of a tractor. A pair of suction nozzles, each for a half of the cutting width, was placed at 50 mm above the cutting blade. By using two units of turbofun, plucked leaves are sucked into a suction cylinder through suction nozzles, and the leaves, which fall down on the metal-net belt equipped inside the cylinder, are blown into net bags by the use of the exhaust of the funs. As the cutters are adjusted by hand to come right onto the plucking surface, two operators are needed (Plate 1).

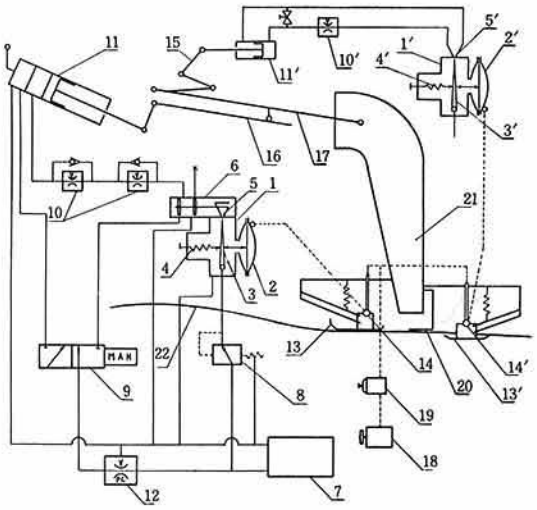
Plate 1. Plucking machine developed in the National Research Institute of Tea

Specification of the machine is given in Table 1. Working efficiency is about 13–17 a/hr, with satisfactory performance giving as high as 70% of normal shoot and even plucked surfaces[2,3].

Automatic adjustment of cutter

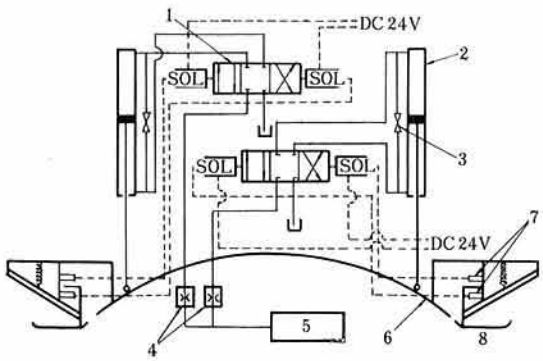
An automatic adjustment of cutter as shown in Fig. 1 was designed by utilizing automatic controller of hydraulic jet pipe system which works by receiving pneumatic signals generated in response to a relative distance between cutters and plucking surface. Accuracy of plucking was improved remarkably by this device. Either shallow plucking or deep plucking can easily be done with very short shoots, plucking of which is difficult by hand control method or with uneven plucking surface a good accuracy can be obtained[2,4].

An on-off system with a simple mechanism[2,5] was also examined. This is the method using micro-switch and electromagnetic valve as shown in Fig. 2. Result of the performance test with this device was almost similar to the above system. With 5 mm of spacing of the micro-switch it gives



1 : Controller (vertical adjustment) ; 1′ : Controller (horizontal adjustment) 2. 2′ : Diaphragm ; 3. 3′ : Jet pipe ; 4. 4′ : Regulating spring ; 5. 5′ : Divider of oil pressure ; 6 : Supporting piston ; 7 : Hydraulic pump ; 8 : Pressure ; control valve ; 9 : Change-over valve ; 10. 10′ : Governor valve (check valves were added at 10) ; 11. 11′ : Operating piston ; 12 : Discharge valve ; 13. 13′ : Detector (13 : vertical 13′ : horizontal) ; 14. 14′ : Wind nozzle : 15 : Link mechanism ; 16 : Supporting stand ; 17 : Upper link ; 18 : Rotary blower ; 19 : Pressure-reducing valve ; 20 : Cutter ; 21 : Suction pipe ; 22 : Plucking surface

Fig. 1. Diagramatic illustration of automatic cutter adjustment unit with hydraulic jet pipe system



1 : Directional controlling valve ; 2 : Operation cylinder ; 3 : Short-circuit valve ; 4 : Governor valve ; 5 : Hydraulic unit ; 6 : Cutter ; 7 : Micro-switch ; 8 : Detector

Fig. 2. Diagram of micro-switch system for cutter adjustment

a sufficient accuracy of plucking[2].

By the use of such automatic adjustment devices, it was made possible to handle the self-propelled plucking machine by one operator.

Several types of self-propelled plucking machine

1) Tea Garden Tractor—65

This is a tractor of general use for tea garden management, to which plucking unit is attached. It was developed by the Tea Experiment Station of Kagoshima Prefecture. The tractor can be used for tea gardens with 1.8 m of row width. The cutter is arc-shaped (with a radius of curvature of 1.0 m) with a plucking width of 1.72 m, and is of reciprocating type. Plucking can be done up to 0.5–1.0 m of plant height. Plucked leaves are collected into two leaf-tanks of 1.3 m^3 volume by suction (Plate 2).

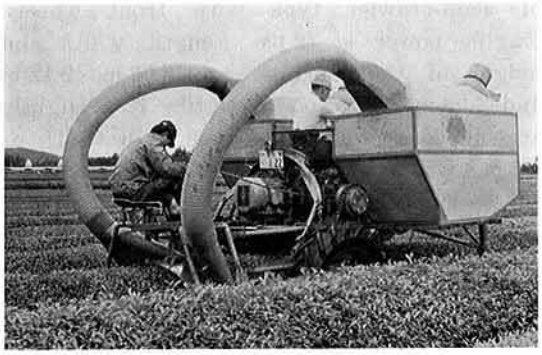


Plate 2. Tea Garden Tractor-65

Run by two operators, the best result is obtained at an advanced speed, 0.3 m/sec, with an efficiency of 15 a/hr.

2) Self-propelled plucking machine of Matsumoto type

This is a small-sized crawler type, developed for increasing economy and reducing soil compaction at the space between hedges. It is a half-row type: pluckingg of one row is made by two strokes (Table 2 and Plate 3). Run by two operators, an efficiency is

Plate 3. Plucking machine of Matsumoto type

Plate 4. Plucking machine of Kirishima type

10 a/hr. Because of its high efficiency in spite of relatively small size and easiness of handling, this machine is now used mainly in southern Kyushu.

3) Kirishima type

This was developed by Tea Experiment Branch Station of the Agricultural Experiment Station of Miyazaki Prefecture. It is of semi-crawler type with front wheels. Engine power is 12 ps. Length, width and height of the machine are 3.92 m, 2.12 m and 2.93 m respectively. Cutter is a slightly arc-shaped reciprocating type with width of 1.5 m. One stroke completes the plucking of one row. Plucked shoots are sucked up and blown into bags by air flow (a combination type of suction and blowing), as given in Plate 4.

Run by two operators, it works at a rate of 9–13 a/hr. This machine is already widely used by producers.

All these types of machines are based on 1.8 m of row width as a standard. They are applicable to plant height up to about 0.8 m, and 100 m of row length as a standard. Several other types of machines are now in the course of development, and it is expected that relatively small-sized machines with an engine power less than 10 ps will be popularized in future.

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