Mem. Fac. Agr. Kagoshima Univ., 28, 135-141, 1992

Hand-Transmitted Vibration Reduction of a Tea-Plucking Machine

I Grasping Force of an Operator

Yoshiteru MIYABE, Koichi IWASAKI and Sumitaka KASHIWAGI
(*Laboratory of Agricultural Systems Engineering*)
Received for Publication September 10, 1991

Introduction

All through the tea production process, harvesting shares 60% but the harvesting period is limited from May to August. In former times hand-plucking or scissors-plucking were the main methods but after the latter half of 1960s with the appearance of a plucking machine possessing the plucking capacity 7 to 8 times as much as the manual one, the latter methods came into wide use very rapidly.

The tea production in Kyushu area is of a big amount and especially Kagoshima prefecture ranks second in Japan, sharing 15.2% production in 1990. And in accordance with the land condition or the inclination of fields, the portable type tea plucking machines to be carried by two operators with hands are widely used. As this portable type tea pluking machine is supported only by handle gripping, engine vibration-induced injury on the machine operator resembling Raynaud's phenomenon occurs. In this paper for the analysis of the affection of engine vibration on gripping fingers as well as finding an effective method applicable to the reduction of engine vibration, the grasping forces of each finger were measured using the grip strength dynamometer.

Experimental Appratus and Methods

1. Measuring apparatus

Tested portable type tea-plucking machine is shown in Fig. 1 and its specification is shown in

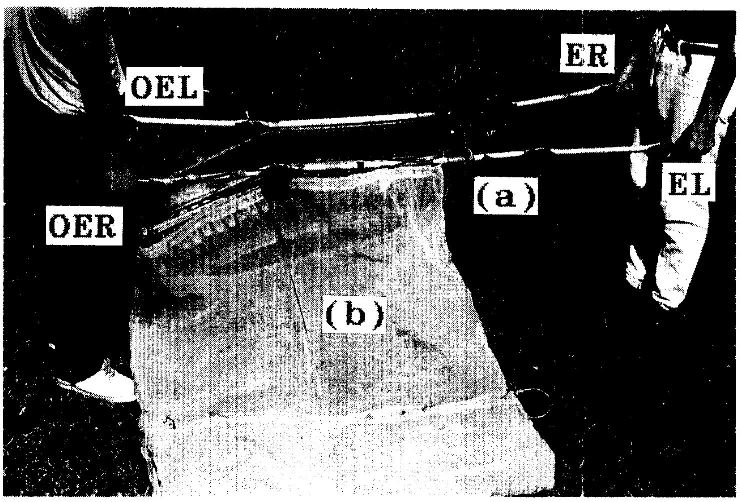
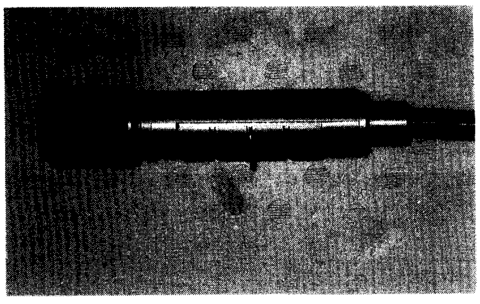


Fig. 1. Tested tea plucking machine.
(a) engine (b) tea leaves gathering bag

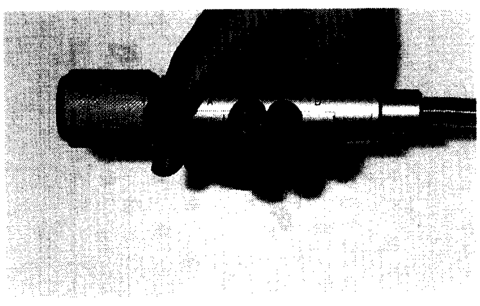
Table 1. Specification of the tested plucking machine

Machine	
Type	M-5
Length	1800 mm
Height	350 mm
Width	450 mm
Frame material	Aluminum pipe
pipe size	Diameter 22 mm (outer) 19 mm (inner)
Engine spec.	KT-18, Air-cooled 2 cycle, 1.0–1.5 PS/3600 rpm, Displacement 35 cc
Total weight	18 kgf
Cutter-bar	
Type	Drum type of straight cutting edge-connection
Radius of curvature	1100 mm
Width	870 mm
Tea gathering	Forced-feeding method gathering
capacity	20 kgf

Table 1 and the size in detail was reported in the previous paper[1]. For the purpose of measuring the grasping forces of each finger, the grip strength dynamometer shown in Fig. 2 is attached on the respective four handle grips (engine side right and left grips, opposite to engine side right and left grips). This grip strength dynamometer is designed to measure grasping forces of the four fingers (from the 2nd to the 5th finger) independently by making each finger put on to the corresponding load cells (A-D). The grasping state is shown in Fig. 2(b).



(a)



(b)

Fig. 2. Grip strength dynamometer.

2. Measuring method

The tea plucking machine was supported by two operators (whose physique is shown in Table 2.) gripping four handle grips on which the grip strength dynamometers were attached and the measured stresses of the respective fingers were amplified and recorded on oscillograph. The grasping force data were obtained 20 sec after the conditions of the engine and the operator became stable. The grips on the engine side were named EL and ER, those on the opposite side OEL and OER.

Table 2. Physique of operators

Items		operator A	operator B
Age		23	24
Sex		Male	Male
Stature		175.0 cm	164.3 cm
Weight		65.0 kgf	55.2 kgf
Grasping power	Left	55.0 kgf	51.0 kgf
	Right	63.2 kgf	53.0 kgf

3. Measuring conditon

Measuring test condition is determined so as to ascertain the influence of the magnitude of total grasping force and as well as the influence of the load on to the tea gathering bag. This means that the operator is forced, in the process of the tea plucking work, to take various location and the grasping force should vary according to the posture of the operator. Moreover, in an actual working, the plucked tea leaves are gathered into the bag mounted on the tea plucking machine, and as the work proceeds the load on the bag increases, there has to be a huge influence of the bag weight to the grasping force.

All through the measurements engine speed was kept 3600 rpm (the rating rotational speed). The grasping force was changed into two ways: the tightly grasped one and the loosely grasped one, and accordingly the load on to the gathering bag was changed from 0 kgf to 10 kgf at intervals of 2 kgf.

Results and Discussions

1. Influence of grasping magnitude

The measured grasping forces in the cases of tight and loose grips are shown in Fig. 3(a)-(b). As shown in these figures, there were not so big differences according to the difference of handle grip position, the average grasping forces of each finger are shown in Table 3.

(1) Tight grip

As to operator A, the maximum grasping force was on the 3rd finger and the magnitude was 4.0–5.0 kgf. The second was on the 4th finger and the grasping force was 3.1–3.3 kgf, and the next was on the 2nd finger with the grasping force 2.1–3.5 kgf. The last was on the 5th finger and the grasping force was 2.2–2.5 kgf.

As to operator B, the maximum grasping force was on the 3rd finger and the magnitude was 3.6–3.9 kgf. The second was on the 4th finger and the grasping force was 3.4–3.6 kgf. The rest were evenly on the 2nd and the 5th finger and the grasping forces were 2.0–2.5 kgf and 2.1–2.8

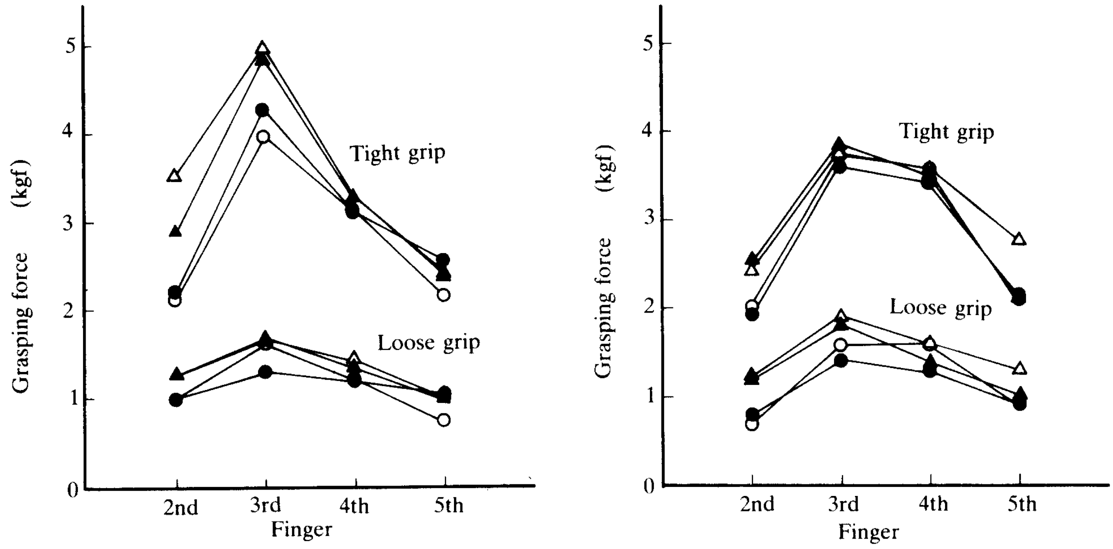


Fig. 3. Measured grasping forces on each finger at tight and loose grip.
(○: EL, ●: ER, △: OEL, ▲: OER)

Table 3. Grasping force of each finger at tight and loose grip in average (kgf)

	Finger	2nd	3rd	4th	5th	Total
Operator A	Tight grip	2.7 (21%)	4.5 (35%)	3.2 (25%)	2.4 (19%)	12.8
	Loose grip	1.2 (23%)	1.6 (32%)	1.3 (26%)	1.0 (19%)	5.1
Operator B	Tight grip	2.3 (19%)	3.8 (32%)	3.5 (30%)	2.3 (19%)	11.9
	Loose grip	1.0 (19%)	1.7 (33%)	1.5 (29%)	1.0 (19%)	5.2

kgf, respectively.

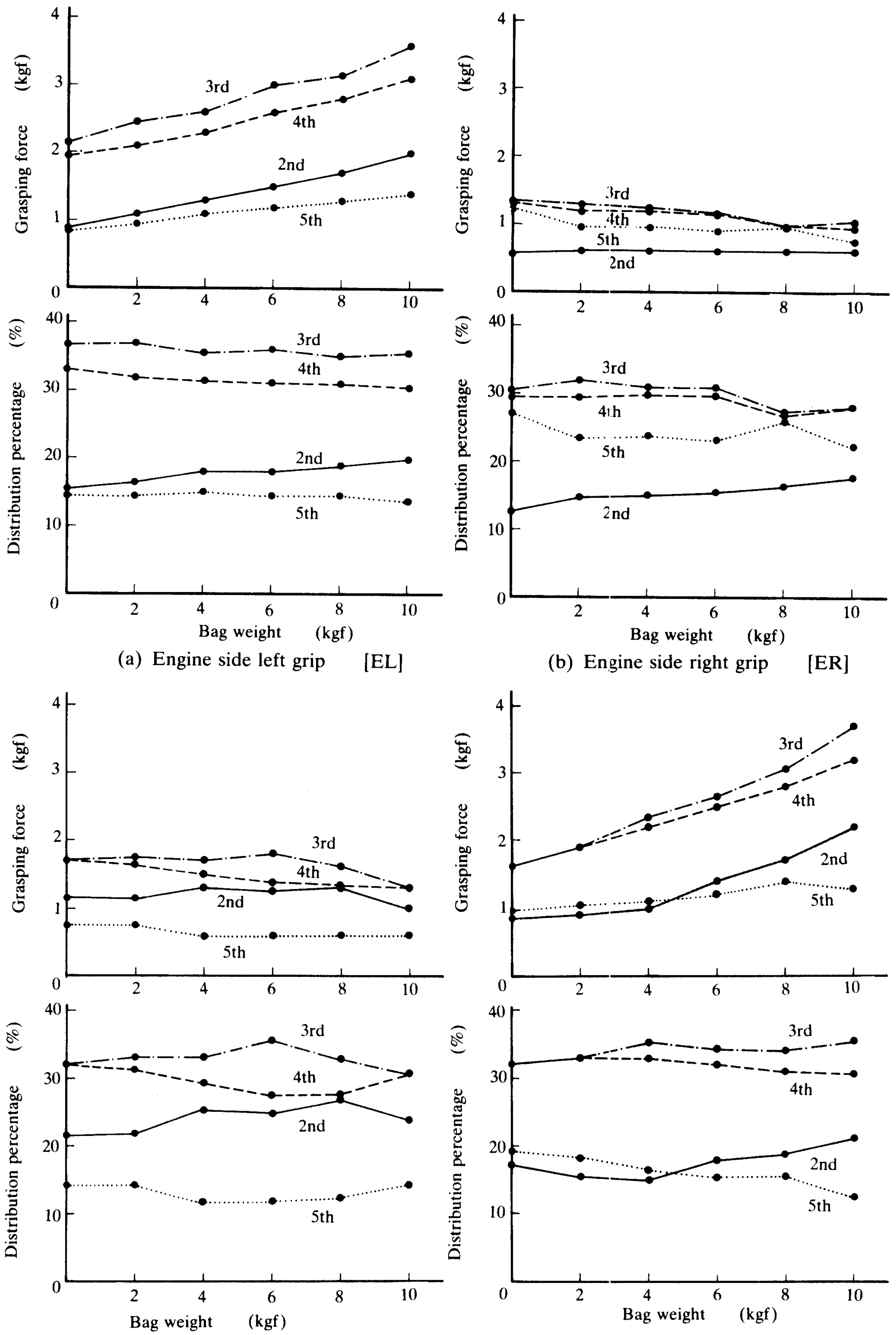
Comparing operators A and B, the grasping force of operator B on 3rd finger was relatively smaller than that of operator A but on the 4th finger it was relatively larger than that of operator A. These trends depend on the fact that the grasping-force distribution-characteristics were different between operator A and B, but totally the grasping forces were distributed mainly on the 3rd and the 4th fingers.

(2) Loose grip

In the case of loose grip, as the total grasping forces were not so large and the sequence level was relatively smaller than the deviation of the data. The grasping forces on each finger were as follows.

As to operator A, the grasping force was on the 2nd finger 1.0–1.3 kgf, on the 3rd finger 1.4–1.9 kgf, on the 4th finger 1.3–1.6 kgf and on the 5th finger 0.7–1.1 kgf. The sequence in average value was the 3rd, the 4th, the 2nd and the 5th finger.

As to operator B, the grasping force was on the 2nd finger 0.7–1.3 kgf, on the 3rd finger 1.4–1.9 kgf, on the 4th finger 1.3–1.6 kgf and on the 5th finger 0.9–1.3 kgf. The sequence in average value was the 3rd finger, the 4th finger. The 2nd finger and the 5th finger showed nearly the same value.



(a) Engine side left grip [EL]

(b) Engine side right grip [ER]

(c) Opposite to engine side left grip [OEL]

(d) Opposite to engine side right grip [OER]

Fig. 4. Measured grasping force and distribution percentage of each finger against total grasping force.

Just like in the case of tight grip the grasping forces were mainly on the 3rd and the 4th fingers.

(3) Influence of tight and loose grip

The increasing ratios of grasping forces at tight grip against those at loose grip were as follows:

	2nd	3rd	4th	5th
operator A	2.36	2.84	2.43	2.46
operator B	2.27	2.23	2.42	2.22

Comparing increases of the grasping forces on each finger, the 3rd finger of operator A showed a little higher value but generally the grasping forces uniformly increased with the increase of total grasping forces.

2. Influence of the weight of the tea-leaves gathering-bag

The influences of the weight of the gathering bag on to the grasping forces on each finger are shown in Fig. 4(a)-(b).

(1) On the left grip of engine side [EL]

As shown in Fig. 4(a), when the weight of the gathering bag increased, each grasping forces increased linearly. The sequence of the grasping force was the 3rd, the 4th, the 2nd and the 5th finger. But the distribution percentages of grasping forces were nearly constant and the value were:

2nd finger : 17.8% 3rd finger : 36.1%
4th finger : 31.7% 5th finger : 14.4%

(2) Right grip on the engine side [ER]

As shown in Fig. 4(b), although the weight of the gathering bag increased the grasping forces showed nearly constant value. And the distribution percentages of grasping forces were:

2nd finger : 15.5% 3rd finger : 30.8%
4th finger : 29.2% 5th finger : 24.5%

(3) Left grip opposite to engine side [OEL]

As shown in Fig. 4(c), although the weight of the gathering bag increased the grasping forces showed nearly constant value. And the distribution percentages of grasping forces were:

2nd finger : 24.1% 3rd finger : 33.0%
4th finger : 29.8% 5th finger : 13.1%

(4) Right grip opposite to engine side [OER]

As shown in Fig. 4(d), when the weight of the gathering bag increased, the respective grasping forces increased linearly. The sequence of the grasping forces was the 3rd, the 4th, the 2nd and the 5th finger. But the distribution percentages of grasping forces were nearly contant and the value were:

2nd finger : 17.7% 3rd finger : 34.0%
4th finger : 32.0% 5th finger : 16.3%

These trends mentioned above are considered to be due to the fact that as the location of the tea leaves gathering bag was on one side of the machine frame as shown in Fig. 3, all the added weight on the bag was supported by both left grip on the engine side and the right grip opposite to the engine side.

And even when the weight to be supported increased, the distribution percentages of each finer were constant. And this trend was also seen in the tight and the loose grasping tests.

Moreover, the two main fingers, the 3rd and the 4th finger, were the same fingers reported to have occurred Raynaud's phenomenon in chain saw operators[2]. So effective improvement for the tea plucking machine operators are expected such as, ① Improvement of the grip shape to attain uniform grasping force distribution on each finger, ② Reduction of the vibration affection on handle grips, ③ Reduction of vibration itself whether it is oriented to the engine or to the machine elements structure.

The presented results are the basic ones carried out in the laboratory, the measurement in the actual tea plucking work in the field and further analyses should be expected.

Summary

With the purpose of analyzing the vibration influences to the operators of the portable type tea plucking machines, grip grasping forces of the respective fingers at each handle were measured. The obtained results are as follows.

1. Grasping-force distribution-patterns at each handle grip were nearly equal and not affected by the location of the handle grips.
2. Distribution-patterns were different between oppeator A and B and the reason was considered to be due to the difference of grasping characteristics of each operator.
3. Both in the tight and the loose grip conditions the distribution percentages of grasping forces on each finger were individually nearly constant. And the percentages against total grasping forces were: as to operator A, the 2nd finger 22.0%, the 3rd finger 33.5%, the 4th finger 25.5%, the 5th finger 19.0%, and as to operator B, the 2nd finger 19.0%, the 3rd finger 32.5%, the 4th finger 29.5% and the 5th finger 19.0%.
4. Grasping force increasing ratios at tight and loose grips were nearly constant, this means that the grasping force distribution is not affected by the grasping magnitude.
5. When the weight of tea leaves gathering bag increases 0–10 kgf, the bag-attached-side gripping-forces were increased and the other side gripping forces were kept constant. The grasping forces increased linearly on the respective fingers and the distribution percentages of the respective fingers in average were on the 2nd finger 15.5–24.1%, on the 3rd finger 30.8–36.1%, on the 4th finger 29.2–32.0% and on the 5th finger 13.1–24.5%, respectively.

Throughout these examinations, the main grasping fingers were the 3rd and the 4th finger and the effective and rapid improvements on the portable type tea plucking machine for reducing vibration affection are expected.

References

1) Miyabe, Y.: Analysis of Vibration of a Tea-Plucking Machine, *Bul. Fac. Agr. Kagoshima Univ.*, **41**, p. 89–95 (1991) (in Japanese with English Summary)

2) Miura, T., Kimura, K., Tominaga, Y. and Kimotsuki, K.: On the Raynaud's Phenomenon of Occupational Origin due to Vibration Tools, *J. Science of Labour,* **42**, p. 725–747 (1966) (in Japanese with English Summary)