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LABOUR REDUCTION OF TEA PLUCKING OPERATION WITH PORTABLE TYPE MACHINE

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ABSTRACT

With the purpose of labour reduction in tea plucking operation with portable type machine, the influence of frame angles and tea leaves weight on the grasping forces of each finger were investigated. At the measurement of the grasping forces of each finger except for thumb, grip strength dynamometers were attached at the grasping position of the frame instead of handle grips. A series of measurement was carried out changing frame angles of the tea plucking machine and the weight of tea leaves.

With the obtained results of the experiments, the influences of the frame angles and the weight of the tea leaves on the grasping forces of each finger were analyzed.

Some reasonable suggestions for the labour reduction in the tea plucking operation with portable type machine were obtained in the aspect of normalizing the balance of the grasping force on each finger and these suggestions are expected to contribute the labour reduction of the tea plucking operation.

Key Word : Labour, Tea, Grasping, Finger

INTRODUCTION

In former times hand plucking or scissors plucking were the main methods for tea harvesting 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 in JAPAN. Now the riding type tea plucking machines can be used in wide and flat field but in accordance with the land condition or the inclination of fields, portable type tea plucking machines to be carried by two operators with hands are still widely used.

As shown in Fig.1, the engine and cutting blades are mounted on the machine frame, the operators are suffered by the engine vibration and also should support the weight of the machine and the additional weight of the harvested tea leaves gathered in the bag equipped behind the cutting

blade. To harvest tea leaves in a good quality, harvesting period is limited and one cyclic operation is continued around two hours. In these aspects, the tea harvesting operation with the portable type machine is considered to be one of the most hard work for the operators.

As to a portable type tea plucking machine, Miyabe (1991) investigated the handle-grip-vibrations of the machine and Miyabe *et al.*(1992) measured grasping forces in a basic frame angle conditions. In this paper, grasping forces of each finger were measured in a various frame angles and in a various tea leaves weight for the purpose of giving some reasonable suggestions that lead to the labour reduction of tea plucking operation with portable type machine.

EXPERIMENTAL APPARATUS AND METHODS

The schematic diagram of the tea plucking machine is shown in Fig.2. As shown in this figure, the frame angles are adjustable at 4 points. For the measurement of the grasping force on each finger, grasping force dynamometers were attached instead of handle grips (cf. Fig.3).

For the measurement of the influences of the frame angle, the angle between the main frame and the side frame γ and the angle between the side frame and the handle δ were changed at each 22.5deg on the engine side resulting the inclined angle of the handle from the horizon changed from around 0deg to nearly 90deg. Also as shown in Fig.4, as the frame angle γ was changed the location of the handle on the engine side came close to the gravity center of the machine, and the weight distribution on engine side increased from 50% to 60%. At the measurement the operators kept the handle grips in a certain position for 30sec and the grasping forces were recorded.

For the measurement of the influence of the tea leaves weight, tea plant model with the height of 800mm, width of 1500mm and the length 5000mm was used and the weight of the tea leaves (actually papers cut in a leaf size were used) were changed every 30N from 0 to 120N. The operators walked along the tea plant model in a speed of 0.4m/sec and the grasping forces were recorded.

RESULTS AND DISCUSSIONS

Influence of the Weight Distribution of the Machine

The total grasping forces at various weight distribution on the engine side handle are shown in Fig.5.

In this paper, "total grasping force" means the total force of measured each grasping force from the 2nd to the 5th finger. As shown in this figure, the total grasping force increased gradually with the increase of the weight distribution percentage from around 50% to 60%. With the results of linear regression the total grasping force increased 1.25 times as the weight distribution percentage increased from 50% to 60%.

The grasping force percentage of each four finger are shown in Fig.6 at each weight distribution and on the right end, original gasping ability percentage is also shown. The "original grasping ability" was measured by grasping the force dynamometer in a free posture for a several seconds and it means the force that can be originally produced by each finger. As shown in this figure, at any weight distribution the grasping force percentages kept nearly constant value. But the percentages showed smaller value for the 2nd and 3rd finger while large value for the 4th and the 5th finger considering the original grasping ability.

Influence of the Handle Angle from the Horizon

The total grasping forces at various angles of the handle from the horizon are shown in Fig.7. As shown in this figure, the total grasping force increased gradually with the increase of the handle angle from the horizon from around 0 to 90deg. With the results of linear regression, the total grasping force increased 1.19 times as the handle angle from the horizon increased from 0 to 90deg. The reason is considered that the "grasping difficulty" increased as the handle came closer to vertical.

The grasping force percentage of each four finger are shown in Fig.8 at each handle angle from the horizon and on the right end, original gasping ability percentage is also shown. As shown in this figure, as the handle angle from the horizon increased the grasping force percentages of the 2nd and the 3rd finger decreased while the percentages of the 4th and the 5th finger increased. The grasping force percentages became much smaller as the handle angle from the horizon increased, while the grasping force percentage increased for the 4th and the 5th finger.

In the aspect of regarding the original grasping ability, the unbalanced situation increased with the increase of the handle angle from the horizon.

Influence of the Tea Leaves Weight

The total grasping forces at various tea leaves weight on each four handle are shown in Fig.9. As shown

in this figure, the total grasping force of the engine side left and blade side right handle increased gradually with the increase of the tea leaves weight, while that of the engine side right and blade side left handle kept nearly constant value. The handles where the total grasping forces were increased are both on the tea leaves gathering bag side and the rate was 1.4 to 1.5 times as the weight of the tea leaves increased 0 to 120N.

The grasping force percentage of each four finger on the blade side right handle are shown in Fig.10 at each tea leaves weight and on the right end, original gasping ability percentage is also shown. As shown in this figure, at any tea leaves weight the grasping force percentages kept nearly constant value. While the total grasping force increased at this handle, it is considered that the increase of the total grasping force was caused by the increase of grasping force on each finger.

The percentages showed smaller value for the 2nd and the 3rd finger while large value for the 4th and the 5th finger considering the original grasping ability. This means the unbalanced situation of grasping force percentages were kept all through the operation. And also the 3rd and the 4th fingers were the main fingers that supported the load, and they are the same fingers as Miura *et al.* (1966) reported to have occurred Raynaud's phenomenon in chain saw operators.

Suggestions for the Labour Reduction

With the results obtained above, some ideas can be suggested for the labour reduction of tea plucking operation with portable type machine.

1. To avoid the the unbalance of the weight distribution both on the engine side handle and on the blade sides handle, the frame angle between the main frame and the side frame γ is expected to be small.
2. To avoid the increase of "the grasping difficulty of the handle", the handle angle from the horizon is expected to be small.
3. To avoid the influence of tea leaves weight on the tea leaves gathering bag side, the operators are expected to change their position often. And the machine is expected to be designed considering the additional weight of harvested tea leaves.

CONCLUSIONS

By the measurement of grasping force in various operating conditions, the influences of frame angles and

the tea leaves weight were elucidated.

The total grasping forces increased gradually with the increase of the weight distribution percentage or the increase of the handle angle from the horizon. The grasping force percentage of each four finger kept nearly constant value for the increase of the weight distribution. But the percentages showed smaller value for the 2nd and the 3rd finger while large for the 4th and the 5th finger considering the original grasping ability. This unbalanced situation was increased with the increase of the handle angle from the horizon.

The total grasping force of the engine side left and the blade side right handle increased gradually with the increase of the tea leaves weight, while that of the engine side right and the blade side left handle kept nearly constant value. At any tea leaves weight the grasping force percentages kept nearly constant value. For the labour reduction of the tea plucking operation, the frame angle between the main frame and the side frame and the handle angle from the horizon are expected to be small. The operators are expected to change their position often. At an actual operation, operating condition varies according to the height of the tea plant, the inclination of the fields, the body size of the operator and so forth, the adjustable points should be limited. Some improvement on machine itself such as the shape of the handle grip to realize the reasonable balance of the grasping force of each finger is expected.

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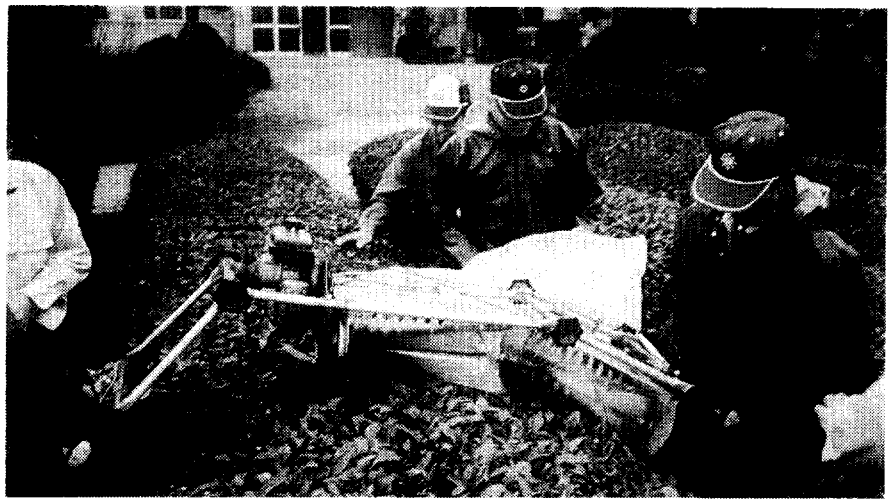

Fig.1 Tea Plucking Operation with Portable Type Machine

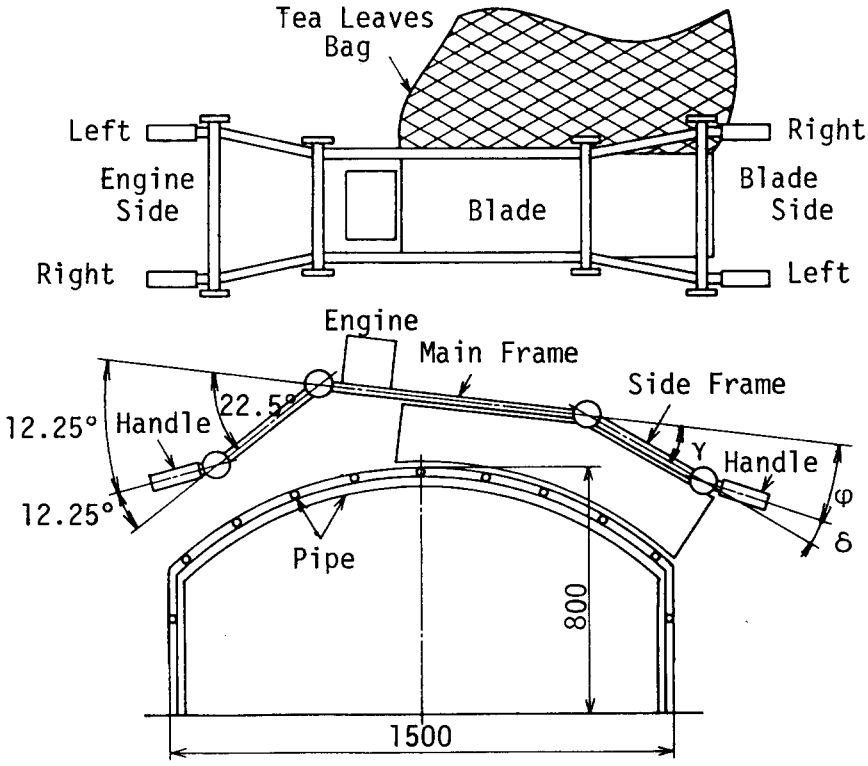

Fig.2 Schematic Diagram of the Tea Plucking Machine

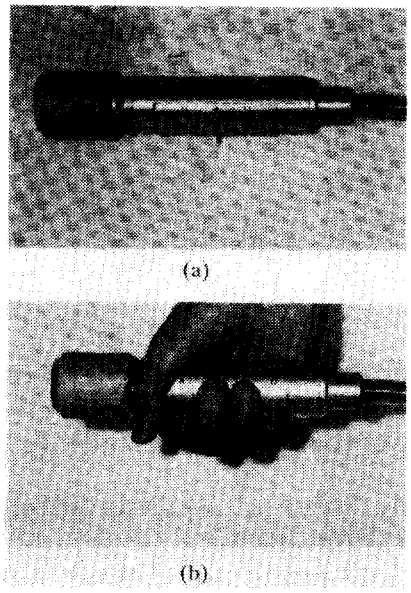

Fig.3 Grasping Force Dynamometer

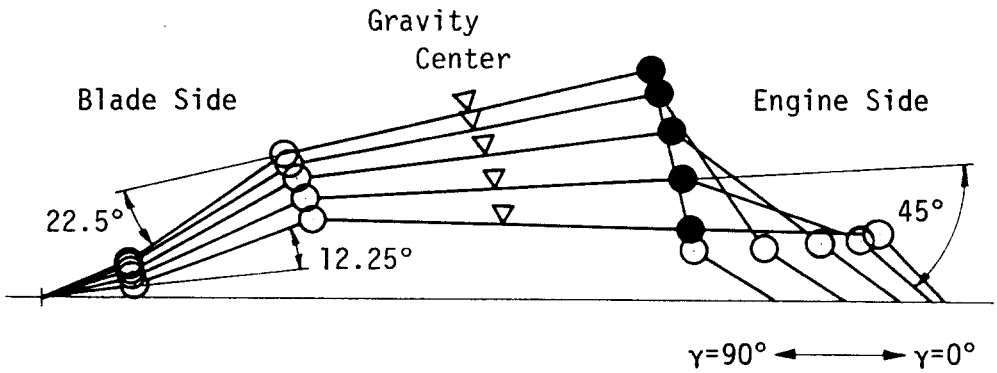

Fig.4 Location of the Handle and the Gravity Center of the Machine

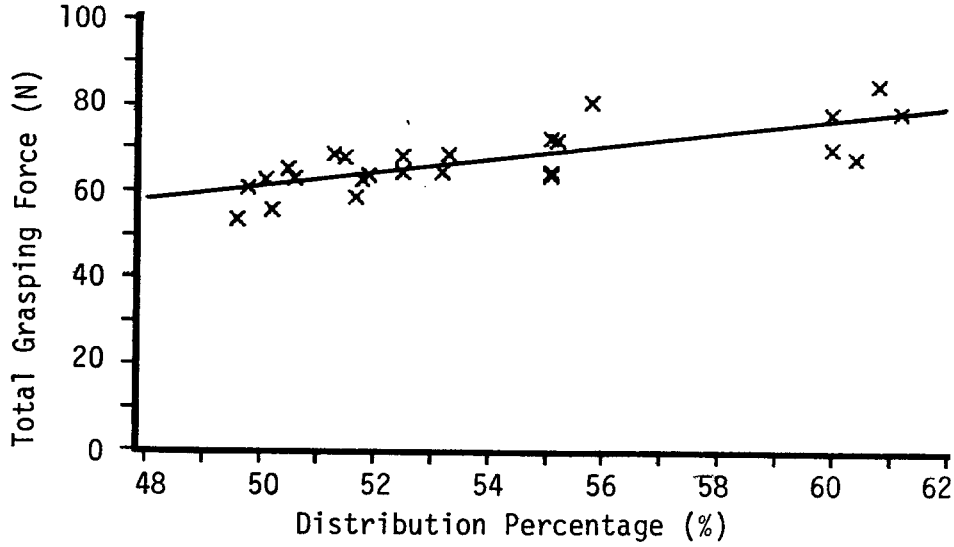

Fig.5 Total Grasping Force at various Weight Distribution on the Engine Side Handle

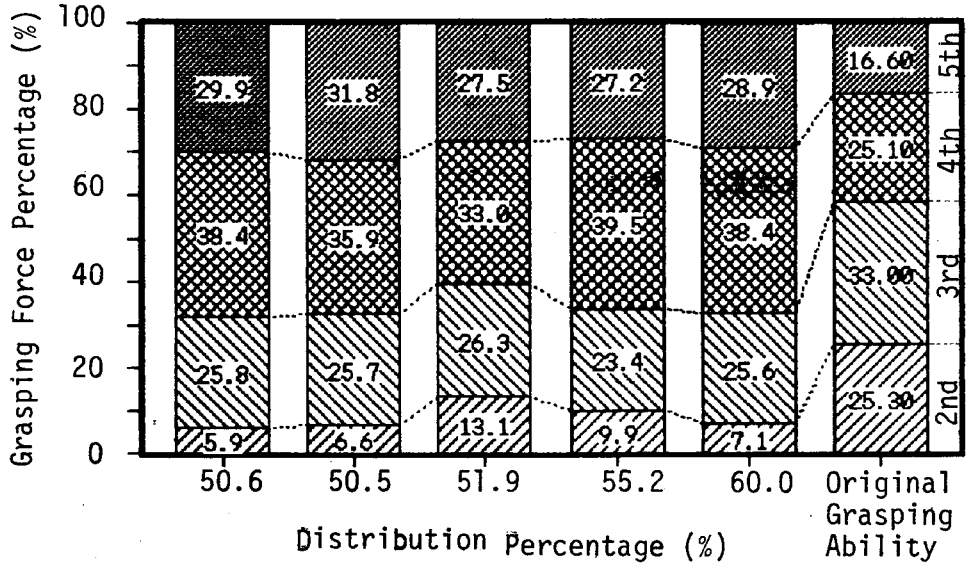

Fig.6 Grasping Force Percentage at various Weight Distribution on the Engine Side Handle

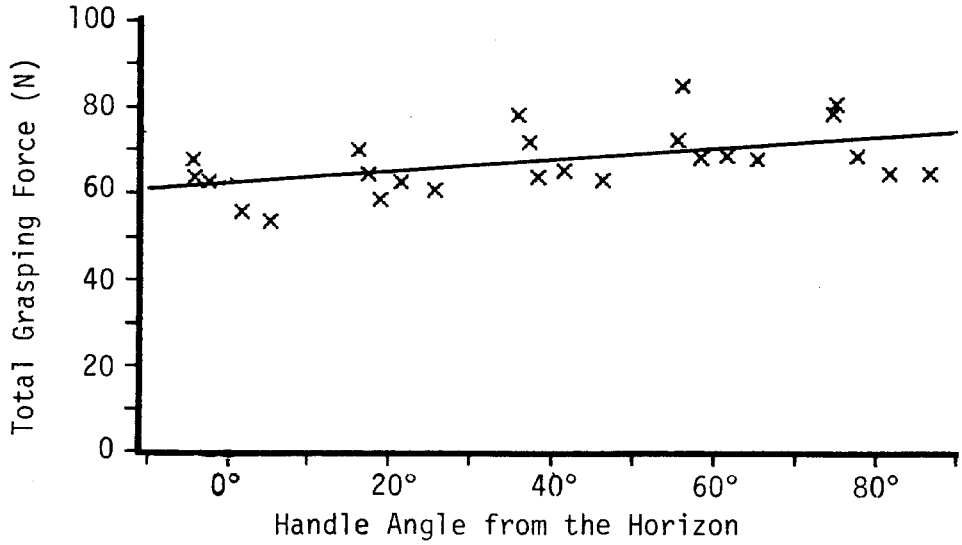

Fig.7 Total Grasping Force at various Angles of the Handle from the Horizon

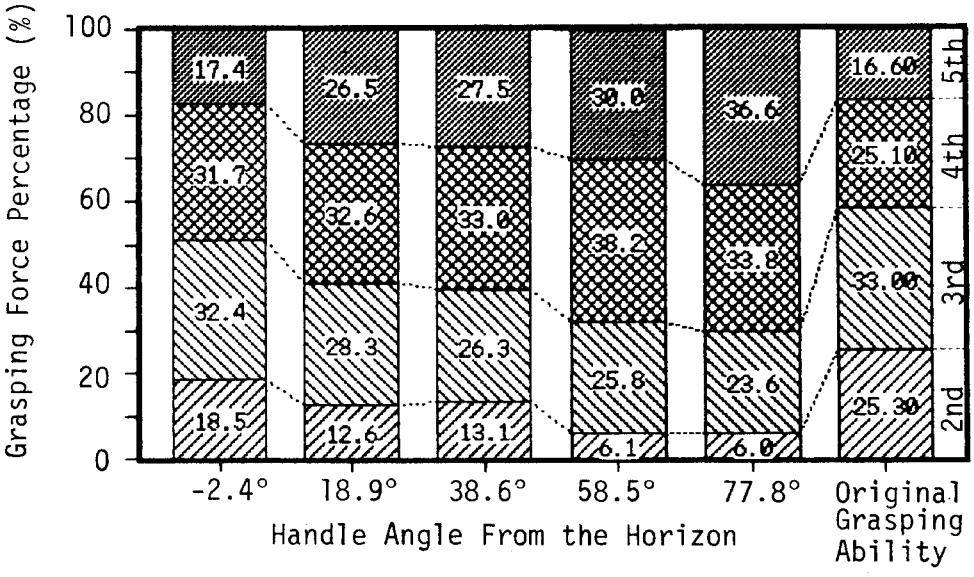

Fig.8 Grasping Force Percentage at various Angles of the Handle from the Horizon

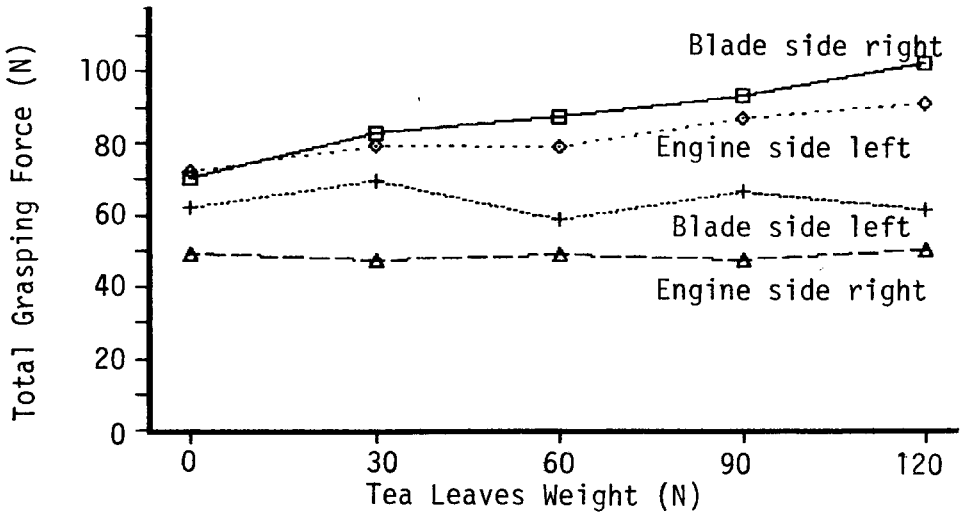

Fig.9 Total Grasping Force at various Tea Leaves Weight on each four handle

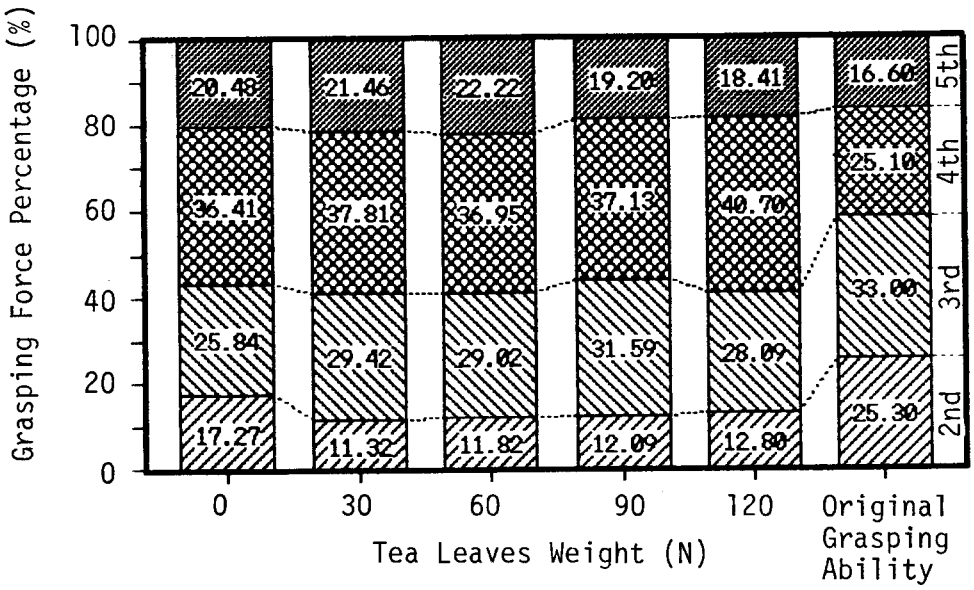

Fig.10 Grasping Force Percentage on the Blade Side Right Handle at various Tea Leaves Weight