HANDLING MECHANISM IN GRAFTING ROBOT

T. Kajikawa, Y. Nishiura

Graduate school of Agriculture and Life science, Osaka Prefecture University
1-1, Gakuen, Sakai, Japan
E-mail: kajikawa@bics.envi.osakafu-u.ac.jp

ABSTRACT

In this research, a grafting robot with plug in method is used. Plug in method is a method that uses a tapered axis for scion and a tapered hole for stock as processing style of conjugation parts. In the case of handling a grafting seedling, gripping a stem is doing with simple mechanisms of devising to reduce damages to stems. For example, providing cushions between gripper and stem, and fitting a gripper to a stem. Both scions and stocks need cutting, but there is bigger influence for scions than stocks, so problems of cutting scions and special qualities of grippers are necessary to investigate.

Key Word : Grafting Robot, Plug-in Method, Handling Mechanism

INTRODUCTION

Grafting is the technique whereby a cut scion and stock are joined together to produce a new plant. Grafting is required for tomatoes, eggplants, watermelon and etc to make their quality better. Because most seedlings that have high quality fruits are susceptible to diseases, pests, and other severe environmental conditions. This problem can be solved by the grafting using stocks with strong resistance for disease. Now the number of farmers who have been producing good grafted seedlings has been decreasing. So there are a lot of demands for the grafting robot development.

The Japanese agricultural market is waiting for the availability of fully automatic, labor and energy saving, low cost, high performance grafting system. Onoda et al. (1922) reported about the grafting robot using "Cutting-a-Cotykedon-off-Grafting" method. However, the current technologies for handling seedlings are unsatisfactory to both seedling producers and consumers. Nishiura et al. (1995) developed a prototype robot for grafting seedlings. The robot used the "Plug-in Method" reported by Honami et al. (1992). However, the seedling handling mechanism did not perform satisfactorily, and thus required improvement to achieve an optimum performance level.

For the design of the handling mechanism, several properties of the seedlings have to be considered. These include physical properties such as morphological features (e.g., shape and location of leaves on the stem), dynamic properties (e.g., acceleration in gripping

width and acceleration in gripping force), and physiological characteristics (e.g., the cell propagation rate at the position injured by gripping). Seedlings are delicate and easily damaged, even when a slight external force is exerted. Therefore, any design of a system for handling the seedlings must take this into account. Th e number of movable parts of the handling system should be low so that the total error due to use of many assemblies can be minimized. In addition, a simple mechanism is more durable.

The objective of this research is to investigate the gripping characteristic of grafting robot gripper designed to implement the "Plug-in Method". Plug-in Method is a grafting technique consisting of a joining method using a tapered axis for scion and a tapered hole for stock as processing style of conjugation parts.(fig1) Plug-in Method is excellent in success rate, if cutting were succeeded the take probability is almost 100 %. There are some problems need to be solved in handling a grafting seedling. For example, there are a slip between the gripper and a stem. The slip caused some damage to the stem. The cutting has to be performed on both scions and stocks. Scions are more sensitive to the processing than stocks. In this reason, the gripping characteristic of cutting scions must be studied primarily.

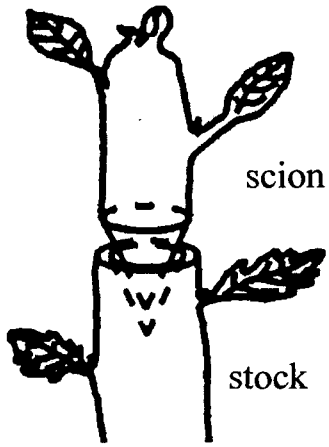

Fig. 1 Plug-in Method

PLUG-IN□METHOD

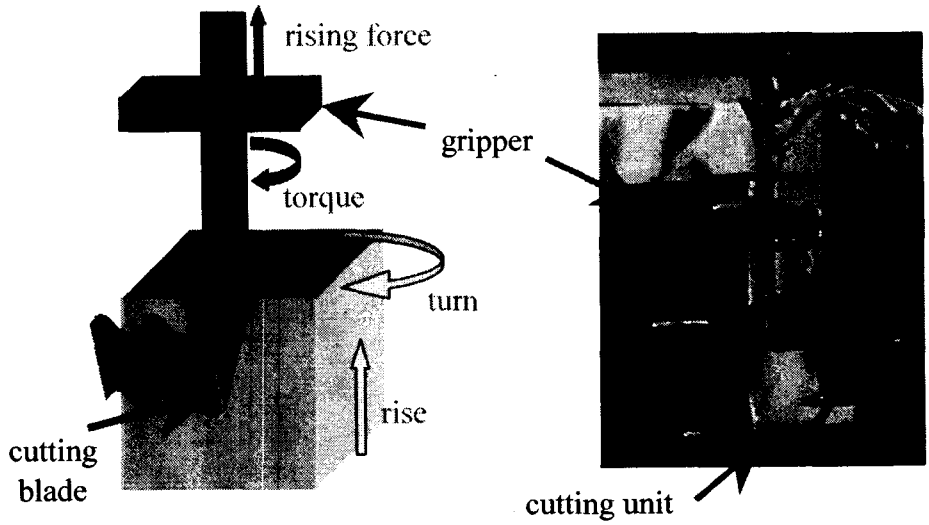

Fig. 2 outline of scion processing

A gripper for a grafting robot that uses the Plug-in Method was developed. Since the

gripper is an important handling mechanism of the robot, its design requires special consideration. When cutting the end of the scion and stock for the Plug-in Method, the gripper exerts rotational force and rising force. The gripper also exerts static forces when it firmly holds a seedling. Rising and rotational forces occur when the seedling is cut, tapered and drilled to make a conical hole. Tomato seedlings with different physical properties were used for the determination of the gripper design parameters. The seedlings were subject to both compression and cutting test.

GRIPPER MECHANISM

The gripper has four links and is controlled by spring. Before when hold the stem the gripping part was changed and slipping was occurred. Now using the shock absorber in the gripping part, in the case the slipping was improved than before but there is still slipping and twisting in scion processing.

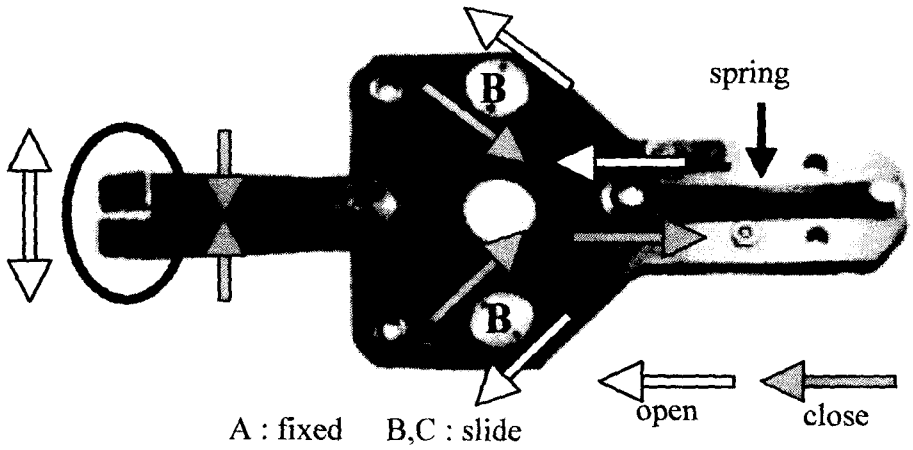

Fig. 3 Gripper mechanism

Experiment 1

1.Materials and methods

The gripping position of seedlings was investigated when scions were cut without damages. Tomato scions (MOMOTARO) were used. Chloloprene sponge and cloloprene rubber were used as shock absorbers in gripping part. The gripping position A (under the first leaf) and B (the root of first leaf) were set. In holding the seedling with the gripper the seedling was pulled and the longitudinal resistance between seedling and gripper were measured.

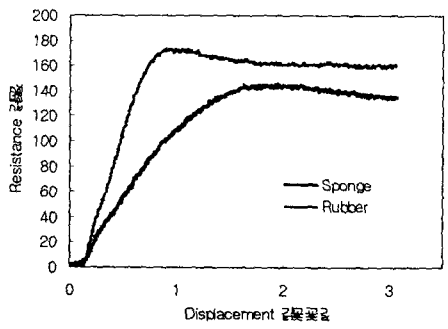

Fig4 Relationship between Displacement and Resistance

2.Results and discussion

Fig4 shows the result of longitudinal

resistance. The resistance of the gripping position A was bigger than the gripping position B. The change of resistance with sponge was smoother than rubber. Because the transformation of the sponge made the transformation of the seedlings small.

Experiment 2

1.Materials and Methods

The aim is to select an optimum gripping force. The longitudinal resistance between seedling and gripper was measured and the slippage loads was investigated. Gripping force are 210, 300, 400, 800 and 1000g. The material in gripping part is acryl. Gripping width were 5 and 10mm. The seedling was gripped by the gripper and the upper part of the gripper was gripped with the push-pull tester. And the longitudinal resistance was measured by pull test, and slipping point was observed.

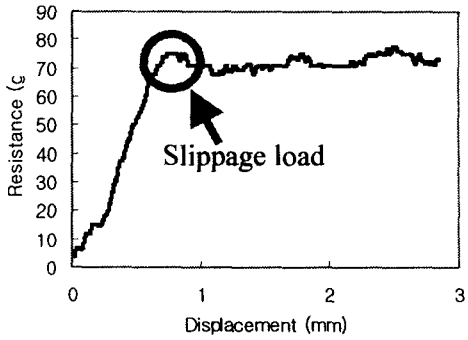

Fig. 5 Relationship between Displacement and Resistance

2.Results and discussion

Fig5 shows the relationship between the pull displacement and the resistance. The slippage load was found by observation.

Fig6 shows the relationship between the gripping force and the slippage load. The contact area is bigger, the slippage load became smaller. Because the gripping pressure became low. When the gripping force is high, the standard deviation will become high and the seedling damage increased.

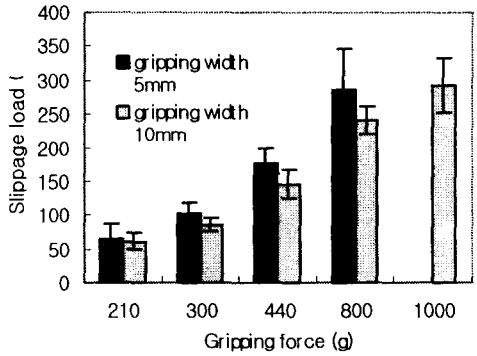

Fig. 6 Comparison between Gripping force and Slippage load

Table1 shows the seedling condition after the test. At gripper width 5 mm, when gripping force is increased, there is increase in abrasion, if gripping force were higher the abrasion become low but the destruction become high.

At gripper width 10 mm, when gripping force is increased, the abrasion has increased but the destruction is keeping low.

Table1 Seedling condition

gripping force (g)	210		300		440		800		1000	
gripping width (mm)	5	10	5	10	5	10	5	10	5	10
abrasion (%)	0	0	10	0	70	10	40	90	0	90
destruction (%)	0	0	0	0	0	0	60	0	100	0

Fig7 shows the relationship between the pressure and w_{10}/w_5. w_{10} means the slippage load of width 5mm and w_{10} same as w_5. At the beginning, w_{10}/w_5 was constant. If the pressure become high, w_{10}/w_{11} become low, and seedling damage has increased. So the pressure needs the value less than 50g/mm^2.

Fig8 shows the comparison of the slippage load with acryl (the result of experiment2), sponge and rubber (the result of experiment1). The rubber has high value.

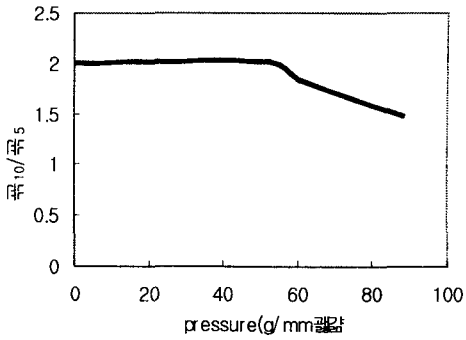

Fig. 7 Ratio between Contact area and Slippage load

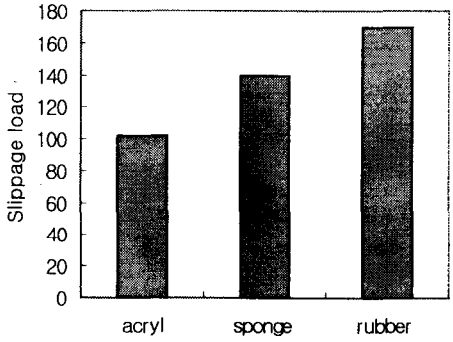

Fig. 8 The comparison of slippage load

CONCLUSION

When the contact area is high, slippage load became smaller. And the slippage load was cleared.

The pressure less than 50 g/mm^2 is in best to reduce the damage.

Rubber and sponge used to increase the resistance by reducing the slippage and to reduce abrasion.

REFERENCE

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