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Effective grafting method for Korean jujube nursery tree

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An effective grafting method for jujube nursery trees was developed to shorten the operation time, improve the percentage of "takes" and shoot emergence, and form the better graft union. Out of 7 grafting methods, the splice, modified scion Ono graft and the bark graft showed relatively short operation time during the grafting operation comparing to the modified rootstock Ono graft or the chip budding. Among these methods, the bark graft demonstrated 100% "takes", but the modified scion Ono graft or the standard Ono graft showed 58.3% of "takes". The percentages of the vegetative shoot emergence were 100% for the bark graft, 70% for the modified scion Ono graft and lower emergence percent for the rest grafting methods. The union tissue formation for the modified scion Ono graft, the bark graft, or the whip-and-tongue graft was significantly larger than the standard Ono graft or the splice graft. In a close examination of the cross sectional areas of the graft union formation through the microscope, the bark graft was superior, the standard Ono graft was inferior and rest of the grafting methods were intermediate.

Key words : Jujube, Grafting method, Yakes, Modified scion Ono graft, Union tissue formation

1. Introduction

The plants of *Zizyphus* genus are distributed throughout the tropical, subtropical and temperate zones with about 400 cultivars of 40 species. The cultivated species of jujube in the world are divided into 3 ecological jujube species; i.e., Chinese jujube (*Zizypus jujuba* Miller), Indian jujube (*Zizyphus mauritiana* Lamarck) and Israeli jujube (*Zizhahus spina-christi* Willd).

Fruits of jujube have been used as one of the fruits offered for ritual ceremony paying respect for their deceased ancestors from the time of 106 B.C. until present days. The jujube fruits have been considered as valuable fruits because of their high sugar contents, medicinal effects and their suitability for long-term storage. Yet, the total number of nursery jujube trees in Korea is far behind to meet with the demand of people wanting to plant in their garden or establishing orchards with jujube trees.

Curiously enough, there have been few works on the propagation of jujube trees in and out of Korea. According to the literature that was searched, seven groups[1,2,4~8] have worked on the propagation of jujube trees by seed germination, micropropagation, cutting, budding or grafting. However, no works have shown investigation into improvement of grafting methods by comparing different grafting methods. Hence this study has concentrated on developing an effective grafting method of jujube propagation to contribute for rapid and high quality nursery jujube tree production.

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2. Materials and Methods

2.1 Experimental plants, field management and planting

Natively growing jujube suckers (*Zizyphus jujuba* Miller) used for rootstocks were collected from several places in Korea. The size

of root and the thickness of shoot were various but the root parts of the suckers were trimmed to make individual tree in similar size. The shoot size was about 4mm in diameter. The rootstocks planted in the previous year were used and the average size of shoots was about 6mm in diameter.

Grafting scions were collected from a 12-year-old wild jujube tree. Scions were collected from the mother plant of "Keumsung" jujube. This cultivar was one of the best two jujube cultivars selected out of 27 native jujube strains during the years from 1968 to 1971.

Rootstock trees were planted in the excavated trench form of the ploughing hole with ploughing space of 100cm between the rows and 40cm between the trees in a row. The roots of jujube rootstocks were cared to be well spread and the weathered surface soil was packed-in between the roots.

2.2 Layout of the experimental trees

Seven grafting experiments were laid out in the field according to randomized block design with 12 replications of 3 trees per block in 1986. In 1987, the trial consisted of 4 grafting methods with 6 replication of 2 trees per block, making total plants to be 48, was laid out in the field in randomized block design on April 27, about 10 days before leafing.

2.3 Grafting operation

In grafting operation, the rootstock shoot was slantly knife-cut at about 10cm above ground level and the size of rootstock wound prepared to match with scion wound was about 20mm long. The size of scion wound made to match with its counterpart, rootstock wound, made to be about 23mm long by knife-cut for each of the standard Ono graft, the scion Ono graft, the modified rootstock Ono graft, the chip budding and the bark graft. However, the size of scion wound for the splice graft or for the whip-and-tongue graft was made to be 23mm long, making it exactly the same as the size of rootstock.

The number of bud bearing on a grafting scionwood was made to be one for trees grafted in 1986 but the number of bud on a grafted scionwood in 1987 was made to be two.

The cambium layers on rootstock and those of on the scion wound were carefully matched along the lines of easily matching side of the two contacting wounds, following operation was to tie tightly the well-matched rootstock and scion with poly-ethylene film strip of about 30mm width, 250mm in length and 0.03mm in thickness.

To prevent scion desiccation caused by loss of moisture through the cut-surface made on the upper side of the scion, topsin paste [1,2-bis (3-methoxy-carbonyl-2-thiourade) benzen] was thoroughly dressed on the knife-cut surface immediately after tying. The standard Ono graft, the splice graft, the whip-and-tongue graft and chip budding were carried out by the traditional method (Table 1).

The modified scion Ono graft is a new grafting method to improve the poor union formation between the rootstock and the scion in the standard Ono graft (veneer grafting). The scion has a long-slant-cut on the outer side of the scion to get a full cambium surface matching between the cambium layer of the inner side of the rootstock rind and the cambium layer exposed outer side of the scion having a long-cut as big as the cut of the rind (Fig. 1-2).

The modified rootstock Ono graft is a grafting work process practised by some professional grafter whose method of 23mm long rootstock wound cut is made to be approximately 15℃ slanted inwardly, instead of vertical line cut made in the standard Ono graft, when grafting cut is made form top part of rootstock toward bottom part of it to receive a scionwood of 20mm between the inward cut face and the rind cut face (Fig. 1-3).

The bark graft was conducted both on July 10, 1986 and on July 13, 1987. The rootstock bark was knife-cut in the way that on the higher bark part of the slant cut of rootstock, the end of knife blade was inserted into the rootstock incising the bari throughly by an operation of the knife blade touching the xylem. This incision made to be two incision lines parallel on the top 20mm length of the rootstock and to have approximately 4mm width between the two parallel lines. The incised bark rind was lifted by fingers leaving cambium layers on the rootstock and on the

inner side of the rind. The scionwood was prepared exactly the same as the scionwood in "the modified scion Ono graft". The straight cut surface of the scion was put against the cambium layers on the rootstock and the slant cut surface of the scion was put together against the cambium layers on the inner part of the lifted rind of the rootstock (Fig. 1-7).

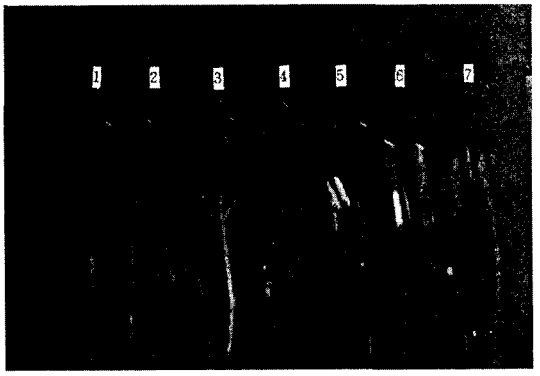

Fig. 1. Grafting methods showing rootstock preparation, scion preparation and way of matching scion onto rootstock moving along with left to right each grafting pair.
1: standard Ono graft
2: modified scion Ono graft
3: modified rootstock Ono graft
4: splice graft
5: whip-and-tongue graft
6: chip buddiing
7: bark graft

3. Results and Discussion

3.1 Time required for each grafting operation

In 1986 and 1987, the splice graft consistently showed the shortest operation time to complete individual grafting operation comparing to the standard Ono graft which is the most common method of grafting used for jujube trees in Korea. The whip-and-tongue graft showed significantly longer operation time comparing to the splice graft both in 1986 and 1987, demonstrating the same result of time taking with previous report in 1984. The modified scion Ono graft showed no significant difference in the operation time between the modified scion Ono graft and the standard Ono graft or the

Table 1. Time required for each grafting treatment per tree according to the designed grafting methods in 1986

Grafting methods	Grafting time per tree (second)	
	1986	1987
Standard Ono graft (control)	180.0	128.0
Modified scion Ono graft	156.0	123.2
Modified rootstock Ono graft	204.0	-
Chip budding	212.0	-
Splice graft	152.0	117.3
Whip-and-tongue graft	200.0	129.0
Bark graft	157.2	-
Least Significant Difference (LSD) 0.05	44.45	10.6

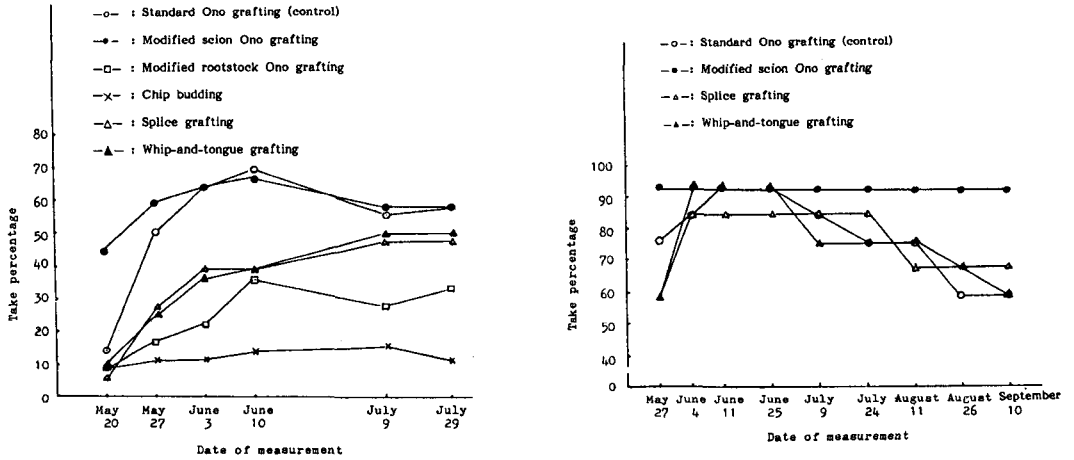

Fig. 2. Seasonal changes of takes percentages as affected by different grafting methods in 1986 (left) and 1987 (right).

splice graft in the intermediate length of time comparing to the other two methods (Table 1). The modified scion Ono graft, the splice graft and the bark graft all gave significantly shorter operation time during the grafting operation comparing to the modified rootstock Ono graft or chip budding in 1986 (Table 1). The chip budding showed requiring 212 seconds for the completion of one tree to be grafted (Table 1) while it took only 68 seconds for apple.[3] The reason of requiring 3 folds time for the jujube graft was the relative difficulty of exposing the minute bud uncovered while covering all incised part throughly by polyethylene strip for jujube than for apple.

3.2 Takes percentage between different grafting methods

The nursery tree "takes" percentage after grafting showed 100% for the bark graft, and 47% to 58% for the standard Ono graft, the modified scion Ono graft, the splice graft and the whip-and-tongue graft, and 11% to 33% for chip budding and the modified rootstock Ono graft in 1986 (Table 2). While the takes percentage influenced by different grafting showed significantly higher takes percentage in the modified scion Ono graft compared with the standard Ono graft in 1987 (Table 3).

These relatively low take percentages of various grafting methods for jujube tree are in sharp contrast with the takes percentages of various grafting for apple. In the work of 1984 with apple, the standard Ono graft, the modified scion Ono graft, the splice graft and the whip-and-tongue graft all showed 100% of "takes", and it is supposed the relatively low takes percentage of jujube tree in grafting was due to lack of active xylem sap movement in jujube than in apple.

The outstanding high takes percentage of the bark graft (100%) in this work was in accordance with previous report with bark grafting using "Fuji" and other two apple cultivars all of which showed 100% "takes".

The seasonal changes of the "takes" percentages in accordance with different grafting methods showed the consistent higher "takes" percentage for the modified scion Ono graft compared to the other methods in 1986 and 1987. The "takes" percentages began to drop in early July for the standard Ono graft and the modified rootstock Ono graft in 1986, and for the standard Ono graft and the whip-and-tongue graft and the splice graft the "takes" percentages began to drop from late July in 1987. The reason for this "takes" drop phenomenon was supposed to be due to the lack of consistent supply of xylem sap from the root to the scion probably exhausting self sustaining ability of the scion by early July or a little later.

3.3 Emergence percentage and growth of vegetative shoots

Out of 7 different grafting methods, bark grafting is singled out by showing the 100% emergence of vegetative shoots while the emergence percentages of the splice graft 76.5%, the modified scion Ono graft 47.6% and the rest 4 methods attained less than 33.3% in 1986 (Table 4). While the vegetative shoot emergence percentages in 1987 were 70.0% for the modified scion Ono graft, 57.1% for the whip-and-tongue graft, 50% for the splice graft

Table 2. Take percentage of grafting as related to various grafting methods observed on August 18, 1986

Grafting method	Takes percentage of grafting
Standard Ono graft (control)	58.33
Modified scion Ono graft	58.33
Modified rootstock Ono graft	33.33
Chip budding	11.11
Splice graft	47.22
Whip-and-tongue graft	50.00
Bark graft	100.00

Table 3. Takes percentage of grafting as related to the various grafting methods carried out on April 27 and observed on September 10, 1987

Grafting method	Takes percentage of grafting	
	$\sqrt{x+0.5}$	Actual percentage
Standard Ono graft (control)	7.00	58.33
Modified scion Ono graft	9.52	91.67
Splice graft	8.07	66.67
Whip-and-tongue graft	7.58	58.33
LSD 0.05	2.20	

Table 4. Emergence percentage of vegetative shoots as related to the various grafting methods observed on August 18, 1986

Grafting method	Emergence percentage of vegetative shoots
Standard Ono graft (control)	33.3
Modified scion Ono graft	47.6
Modified rootstock Ono graft	25.0
Chip budding	0.0
Splice graft	76.5
Whip-and-tongue graft	22.2
Bark graft	100.0

Table 5. Emergence percentage of vegetative shoots as related to various grafting methods carried out on April 27 and observed on September 10, 1987

Grafting method	Emergence percentage of vegetative shoots
Standard Ono graft (control)	28.6
Modified scion Ono graft	70.0
Splice graft	50.0
Whip-and-tongue graft	57.1

Table 6. Annual growth amount of vegetative shoots as related to the various grafting methods measures on August 18, 1986 and November 3, 1987

Grafting[z] methods	Grafting time per tree (second)	
	1986	1987
Standard Ono graft (control)	26.55(121 days)[y]	20.10
Modified scion Ono graft	23.88(121 days)	30.55
Splice graft	24.38(121 days)	14.00
Bark graft	16.58(39 days)	51.05
Least Significant Difference (LSD) 0.05	NS[x]	-

z: The grafting date for bark grafting was July 10, 1986 and the grafting date for the other 3 grafting methods was April 19, 1986.

y: Days elapsed between grafting date and measured date.

x: NS: not significant at 5% level by LSD analysis.

and 28.6% for the standard Ono graft (Table 5). Thus it can be considered that the modified scion Ono graft and the splice graft gave consistently better emergence of vegetative shoots than the other grafting methods, though the data were not able to be statistically analysed owing to poor or no emergence of vegetative shoots in many trees.

Table 7. Length of the graft union tissue formed along with the cambium contact parts as related to the various grafting methods measured on 21st October in 1987

Grafting method	Length(mm) of the graft union tissue
Standard Ono graft (control)	19.7
Modified scion Ono graft	31.3
Splice graft	14.3
Whip-and-tongue graft	40.0
Bark graft	33.3
Least Significant Difference (LSD) 0.05	4.30

Length of vegetative shoots of different grafting methods showed no significant difference, but the bark graft gave the shortest growth compared with the period of the other 3 grafting methods, i.e., 121 days, in 1986. The shoot growth of jujube trees affected by different grafting methods was best for the bark graft followed by the modified scion Ono graft in 1987 (Table 6).

3.4 Graft union development and its anatomical observation

The modified scion Ono graft, the whip-and-tongue graft or the bark graft showed highly significantly longer length of union tissue formation compared to the standard Ono graft or the splice graft, respectively (Table 7). Thus it is thought to be that the longer union tissue formation helped the xylem sap uptake from root to scion which in turn helped early stage take and resulting in higher vegetative shoot emergence.

This better union formation in grafting methods with longer lines of cambium contact when grafted showed better and earlier bridge tissue formation between scion and rootstock as seen in Fig. 3 and 4.

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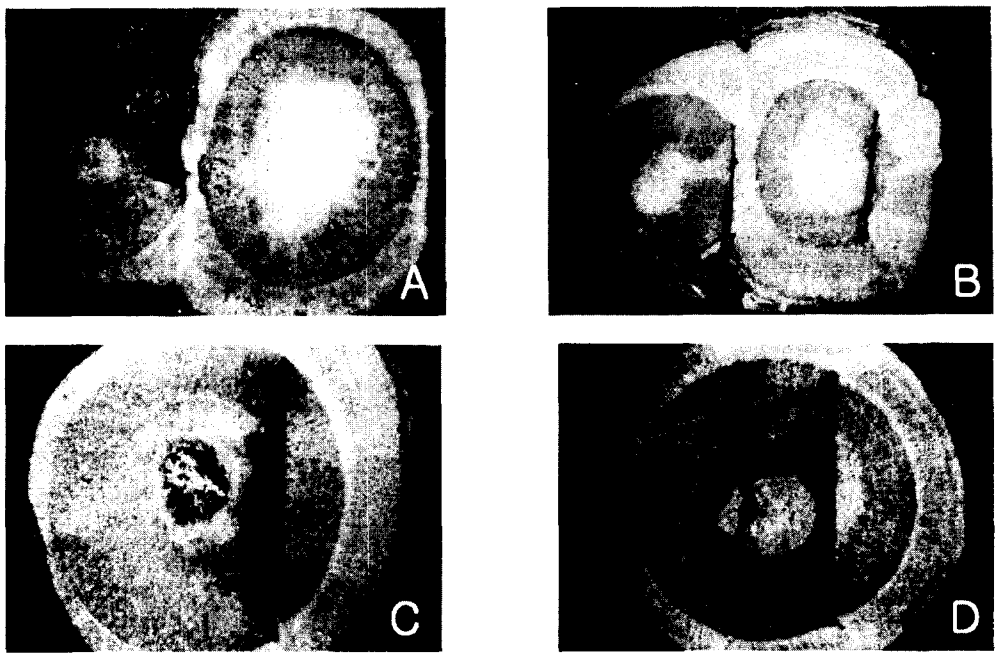

Fig. 3. Cross sections of various grafted tree union photographed on November 14, 1987, i.e., 208 days after grafting on April 21, 1987 showing rootstock (left) and scion (right) parts in magnification rate of 30 times.
A : Standard Ono graft, B : Modified scion Ono graft
C : Splice graft, D : Whip-and-tongue graft

Fig. 4. Cross section of the bark grafted tree union photographed on November 14, 1987, i.e., 124 days after grafting on July 13, 1987, showing rootstock (left) and scion (right) parts in magnification rate of 30 times.

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