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Control of Growth Habit by Grafting between Determinate and Indeterminate Lablab Bean (*Lablab purpureus)* Plants

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Determinate (D) and indeterminate (In) lablab bean (*Lablab purpureus*) plants were grafted to clarify the possibility of the change of the growth habit from determinate to indeterminate or vice versa in the graft union of In/In (scion/stock), In/D, D/In and D/D plants at 20, 25 and 30°C under 12 h daylength. Plant height and number of nodes were affected by each other, but grafting could not alter the growth habit in any combination of grafting.

INTRODUCTION

Long days and high temperatures changed the growth habit of normally determinate lablab bean (*Lablab purpureus*) to indeterminate (Kim and Okubo, 1995). The critical daylength for the change was 13 h at 25°C and was between 10 and 11 h at 30°C. No change in habit occurred at 20°C in any daylength.

Grafting has been often employed as a method in the physiological studies on flowering and dwarfism as well as in the practical cultivation of various crops to obtain dwarfness, disease resistance, and so on. For example, dwarf pea (*Pisum sativum*) 'Little Marvel' grafted on a tall pea 'Alaska' grew at a higher rate than 'Little Marvel' grafted on 'Little Marvel' (Went, 1938). Dwarf rootstocks will dwarf scion trees in apple, and the dwarfing influence extends to the tree only and not to the fruits produced by the trees, although some citrus rootstock can strongly influence the quality of fruit on the scion tree (Hartmann et *al.,* 1981). Improved resistance to bacterial wilt and root-knot nematode can be achieved in susceptible scion plants of tomato (*Lycopersicon esculentum*) when they were grafted on resistant *Solanum* root-stocks (Matsuzoe *et al., 1993).* Mechanisms involved in such influences have been considerably studied but physiologically convincing explanation has not yet been obtained. It is also well known that photoinduced (Hamner and Bonner, 1938) or vernalized (Melchers, 1939) flowering stimuli can be transmitted across graft union. Transmission of some growth regulating substances has been also reported in dwarf pea grafted on strawberry petiole (Thompson, 1960). Evidence for translocation of gibberellin A, and gibberellin-like substances in grafts between normal and dwarf seedlings of *Zea mays* was also reported (Katsumi *et al.,* 1983).

Since the dwarfism caused by determinate growth habit is different from the phenomenon due to shortened stem in plants, and the determination of growth habit is

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thought to be independent from flowering in soybean plant (Koda et al., 1991), effects of grafting on the growth habit have not been studied in detail. In this report, response of the growth habit in the determinate lablab bean plants to grafting with an indeterminate twining cultivar in relation to temperature was described for the possibility of the translocation of the controlling factors.

MATERIALS AMD METHODS

Effect of grafting on plant height, number of nodes and growth habit of scion plants

An indeterminate twining lablab bean (*Lablab purpureus*) **cv.** Akabanafujimame (In), a commercial cultivar in Japan and a determinate variety (D) introduced from India were used. The seeds were sown in plastic pots (12 cm in diameter) containing a mixture of pumice : vermiculite : sand (1: 1 : 1, v/v/v) on 19 September 1991, and grown in a plastic-film. greenhouse. The plants were fed with a 0.1% solution of a compound fertilizer, OK-F-l (N : P_2O_5 : K_2O = 15 : 8 : 17, Otsuka Chemical Co., Tokyo). The seedlings were approach-grafted as shown in Fig. 1 on 29 or 30 September and raised in the greenhouse. Combinations of the grafting were In/In (scion/stock), In/D, D/In and D/D. After graft unions healed, the top of the stock plants and the base of the scion plants above and below the graft, respectively, were removed. On 14 October, the graft unions were placed at 20, 25 and 30°C in the growth chambers (70% relative humidity, 12 h daylength, 250 μmolm^{-2}s^{-1}) of the Biotron Institute, Kyushu University until 2 December. Without grafting, the normally determinate plants are determinate at 20 and 25°C and change their growth habit from determinate to indeterminate at 30°C in 12 h daylength (Kim and Okubo, 1995), whereas the indeterminate

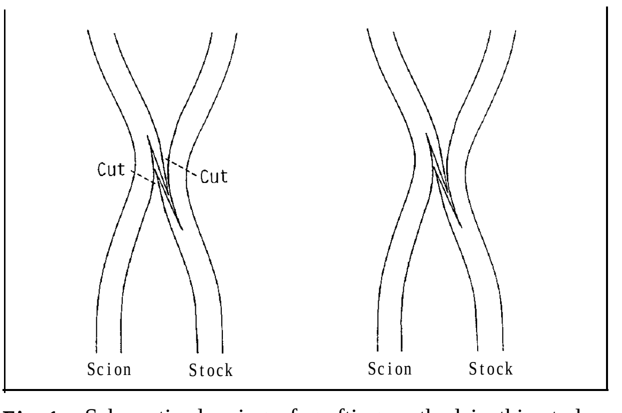

Fig. 1. Schematic drawing of grafting method in this study. Left ; Experiment 1. The top of the stock plants and the base of the scion plants above and below the graft, respectively, were removed after the graft unions healed. Right ; Experiment 2. Both the base of the scion plants and the top of the stock plants were remained after the healing of graft unions.

plants are indeterminate at any temperature. Five grafted plants were used for each treatment.

Effect of grafting on plant height, number of nodes and growth habit of scion and stock plants

Seeds of the both varieties were sown on 4 July 1992, and grown in the plastic-film greenhouse. After germination, the seedlings were approach-grafted on 12 July and raised in the greenhouse. The difference in this experiment from the former experiment was that both the base of the scion plants and the top of the stock plants were remained even after the healing of graft unions. The grafting combinations were In/In (scion/stock), In/D, D/In and D/D where the definition of scion and stock is shown in Fig. 1. They were placed at 20, 25 and 30°C in the growth chambers on 14 July, and growth measurements took place on 18 August for the plants grown at 30°C and on 4 and 5 September for the remainders. Five graft unions for each treatment were used.

Definition of the growth habit

In the previous experiments (Kim et al., 1992), it was indicated that the main stem terminated in an inflorescence in determinate lablab bean, but that the apex of the main stem of the plants whose growth habit had been changed to indeterminate remained vegetative. Bernard (1972) considered that a determinate stem is simply an abruptly terminating one. When the terminal of the main stem abruptly terminated without flowering in lablab bean, our definition of growth habit follows Bernard (1972) for soybean.

RESULTS

Effect of grafting on plant height, number of nodes and growth habit of scion plants

Plant height and number of nodes were not statistically significant in the plants of any combination of the grafting at 20°C (Table 1). Plant height of In/In (scion/stock) was as twice as that of In/D at 25°C, but number of nodes of the both was insignificant. Plant height and number of nodes were not significantly different among D/In, In/D and D/D at 25°C. At 30°C, there were no differences in plant height and number of nodes between In/In and In/D and between D/In and D/D.

Growth habit of the scion plants was not affected by the grafting of any combination at these temperatures; the determinate scion plants were determinate at 20 and 25°C and indeterminate at 30°C as were the intact determinate plants, whereas the indeterminate scion plants were indeterminate.

Effect of grafting on plant height, number of nodes and growth habit of scion and stock plants

Both the scion and stock of In/In were the tallest and number of nodes of them were the highest at 25°C among the treatments (Table 2). Plant height of the scion in In/D was about a half of that in In/In. Comparing the stock D in In/D with that in D/D, plant height was not significant but number of nodes was higher in In/D than in

Table 1. Effect of grafting on plant height, number of nodes and growth habit of scion plants.

Temperature (°C)	Graft union (scion/stock)	Plant height (cm)	Number of nodes	Growth habit[z]
20	In/In	11.6 a	6.8 a	In
	In/D	13.9 a	7.5 a	In
	D /In	24.7 a	8.3 a	D
	D /D	18.1 a	8.5 a	D
25	In/In	106.8 b	15.0 bc	In
	In/D	42.6 a	11.3 ab	In
	D /In	37.3 a	8.7 a	D
	D /D	33.7 a	8.3 a	D
30	In/In	145.8 b	17.0 cd	In
	In/D	140.6 b	19.5 d	In
	D /In	37.0 a	8.5 a	D
	D /D	29.5 a	8.0 a	D

[z] D ; determinate, In ; indeterminate.
Mean separation within columns by Duncan's multiple range test, 5%.

Table 2. Effect of grafting[z] on plant height, number of nodes and growth habit of scion and stock plants.

Temperature (°C)	Graft union[y] (scion /stock)	Plant height (cm)		Number of nodes		Growth habit[x]	
		Scion	Stock	Scion	Stock	Scion	Stock
20	In/In	64.6 cd	80.7 cd	14.0 cd	16.2 de	In	In
	In/D	36.3 ab	40.6 a	9.6 ab	12.0 ab	In	D
	D /In	18.1 a	37.4 a	8.1 a	10.1 a	D	In
	D /D	33.9 ab	37.2 a	9.6 ab	10.1 a	D	D
25	In/In	118.7 f	142.3 e	19.3 e	20.6 f	In	In
	In/D	64.2 cd	84.8 d	12.2 bc	17.3 e	In	D
	D /In	37.5 ab	69.4 bcd	12.0 bc	12.2 ab	D	In
	D /D	32.9 ab	61.3 abcd	10.2 ab	12.5 abc	D	D
30	In/In	56.7 c	54.3 ab	14.9 d	14.3 bcd	In	In
	In/D	82.5 e	60.3 abcd	14.9 d	15.9 de	In	In
	D /In	35.1 ab	72.4 bcd	14.0 cd	14.6 cd	In	In
	D /D	46.7 bc	56.0 abc	13.8 cd	14.1 bcd	In	In

[z] Approach-grafting. Both the scions and stocks were remained and let them further grow even after the healing of graft unions.
[y] See Fig. 1.
[x] D; determinate, In; indeterminate.
Mean separation within columns by Duncan's multiple range test, 5%.

D/D. When D was scion, plant height and number of nodes in the scion were not significant in D/In and D/D, whereas those in stock In significantly decreased when compared with the plants of In/In. Stock D significantly affected scion In, but the stock D was also affected by the scion In in their plant height and number of nodes.

Similar tendency was observed at 20°C. At 30°C, D in In/D, D/In and D/D showed indeterminate growth habit. Number of nodes in both the stock and scion of any graft combination was not significantly different. Plant height was also insignificant in the stock of any combination. Plant height of scion In was taller in In/D than in In/In and that of scion D was taller in D/D than in D/In.

Change of the growth habit, however, was not induced by grafting in any combination and temperature in spite that the effects of scion and stock on plant height and number of nodes were observed.

DISCUSSION

Intact determinate plants become indeterminate at 30°C, but not at 20 and 25°C under 12 h daylength (Kim and Okubo, 1995). Indeterminate stock slightly increased the plant height and number of nodes of determinate scion at any temperature of 20, 25 and 30°C, but the differences were not significant. Determinate stock affected the plant height of indeterminate scion only at 25°C but did not affect the number of nodes. Growth habit was, however, not affected by either stock plants or scion plants in any combination of grafting. These results may indicate that factors controlling stem elongation and development of nodes are transmissible across graft union but those controlling growth habit are not. Since there are reports available that flowering stimuli or substances are transmissible across graft union in many plant species (Hamner and Bonner, 1938 ; Melchers, 1939 ; Roberts and Struckmeyer, 1939 ; etc.), it suggests that flowering factors may not be the same as the stimuli or substances determining the growth habit. However, it should be noted that there is an opposite example that photoinduced *Sinapis* stocks cause flowering of non-vernalized *Thlaspi* scions, whereas vernalized *Thlaspi* can not induce flowering of non-photoinduced *Sinapis* (Bernier, 1988).

Besides the evidence for the translocation of flowering and dwarfing stimuli in various plants, there are some reports on the transmission of branching agent across graft union in poinsettia (*Euphorbia pulcherrima*). Stimart (1983) found that branching of nonbranching cultivar of poinsettia was increased when the cultivar was grafted onto self-branching rootstocks and branching was decreased in self-branching cultivars grafted onto nonbranching rootstocks. He suggested that axillary shoot growth of the plant is governed by some endogenous factors translocated from the roots across graft union to the shoot. Recently, Dole and Wilkins (1992) demonstrated that a free-branching (selffbranching) cultivar of poinsettia contained a free-branching agent that was graft-transmissible to a restricted-branching (nonbranching) cultivar. From the results that the restricted-branching plants were transformed by the agent regardless of whether free-branching plants were used as scion or stock, they indicated that the agent moves basipetally and acropetally through the graft union. Since determinate growth habit in lablab bean plant accelerates lateral shoot growth (branching) and indeterminate growth habit restricts side shoot growth, it may be considered that branching vs. nonbranching has resemblance to determinate vs. indeterminate. However, the phenomena observed in poinsettia did not occur in lablab bean plant, namely, the growth habit in lablab bean plant can not be changed by grafting.

Factors determining the growth habit seem to be different from those determining stem length and node numbers although the plants of environmentally induced indeterminate growth habit from the normally determinate plants have increased number of nodes and a greater length of internodes than the non-induced plants (Kim et al., 1992 ; Kim and Okubo, 1995).

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