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콩 遺傳子型間 相互接木이 地上部 生育과 莢實比率에 미치는 影響

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Root vs. Shoot Genotype Effects on Growth Characters and Seed to Pod-Shell Ratio in Grafted Soybean Plants

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ABSTRACT : The partitioning of dry matter into seed and pod-shell is important because yield increase can be achieved by improving the distribution rate of assimilation products to seeds. The present study was undertaken to characterize whether the partitioning of dry matter into seed was shoot- or root-controlled through graftiong techniques. Self- and reciprocal-grafts were made among four soybean genotypes, which were "Baekunkong", "Suwon 168", and two local soybeans with black seed coat (hereafter referred to as the "black soybean"), "Kangleungjarae" and "Keumleungjarae". Self-grafted black soybeans showed lower ratio of seed to pod-shell dry wight than self-grafted Baekunkong and Suwon 168. Varying the shoot genotypes in grafts resulted in significant differences in growth characters as well as pod and seed dry weight per plant at physiological maturity. There were significant effects of shoot genotypes on the ratio of seed to pod-shell dry weight, indication that the partitioning of dry matter into seed and pod-shell should be shoot- rather than root-controlled. The grafts with large pod-shell dry weight tended to partition relatively smaller dry matter into seed than pod-shell.

Key word : Partitioning, Grafting, Pod-shell, Physiological maturity

Crop growth and yield are determined by the interaction between shoot and root(Jong et al. 1992;White and Castillo, 1989). Shoot characteristics have been considered important in producing photosynthates mainly in the leaves, whereas root-borne factors play a great role in water and nutrient uptake from the soil around the root system.

Reciprocal grafting has been widely used to estimate the relative importance of shoot and root factors in the physiological aspects of plant growth such as nutrient uptake, carbohydrate metabolism, seed quality, nodulation etc. Since the development of improved "straw-band" technique for reciprocal soybean grafting by Bezdicek et al(1972), it has been easier to estimate the interaction effect of scion and rootstock due to the higher survival

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rate of improved grafting than conventional one with pressure-tape.

Grafting studies revealed that shoot characteristics were of primary importance in herbage regrowth and carbohydrate metabolism after cutting of alfalfa(Fankhauser and Volenec, 1989). Other studies in soybean plants have shown that shoot genotype was more important than root genotype in stem dry weight and yield(Jong et al, 1992) as well as supernodulating characters(Delves et al, 1986;Lee et al, 1991). In contrast, Sullivan and Brun(1975) reported that root genotype had a significant effect on the shoot water relations in soybean plants. Intervarietal grafting studies showed that soybean root genotype affected nitrogen fixation ability (Lawn and Brun, 1974). Non-nodulation characters(Tanner and Anderson, 1963), tolerance to high levels of P(Foots and Howell, 1964), and seed fatty acid composition(Carver et al, 1987) were controlled by shoot genotype in soybean.

Local soybean cultivars with black seed coat were collected extensively throughout the country on 1991(Kim et al, 1993a, 1993b), and were evaluated for their seed characteristics. Relative seed filling to pod size is low in almost all collected black soybeans, which was indirectly evidenced from the fact that black soybean seed was generally in the shape of oval(Kim et al, 1993b), and showed low ratio of seed to pod-shell dry weight. It has been still unknown whether this incomplete seed filling in black soybean was due to insufficient photosynthates supply from the top or poor uptake of nutrient and water from the root system. A full understanding of relative importance of root and shoot in seed filling will be helpful for the development of efficient strategies for screening for relatively complete soybean seed filling by focusing attention on root part or top growth characters.

The present study was undertaken to evaluate the relative effects of root and shoot on the relative seed filling to pod size in soybean plants by intergenotypic grafting. Self- and reciprocal- graftings were made among four soybean genotypes, two of local black soybean cultivars, "Kangleungjarae" and "Keumleungjarae", characterized with low ratio of seed to pod-shell dry weight as well as Baekunkong and Suwon 168 with high ratio.

Materials and Methods

Baekunkong, Suwon 168, and two local black soybean collections, Kangleungjarae and Keumleungjarae, were used for this study. The seed of Baekunkong and Suwon 168 had round shape, suggesting that seeds were completely lengthened, widened, and thickened during seed filling. Contrary to this, two local black soybean cutivars had incomplete seed filling, and showed low ratio of seed to pod-shell dry weight at harvest.

Seeds were planted in paper pots(about 6cm in diameter and 12cm in height) at the greenhouse in the Crop Experiment Station, RDA in Suwon. Ten days after planting, self- and reciprocal-graftings were made with seedlings using a 'straw-band' techinque developed by Bezdicek et al(1972). The hypocotyl of the rootstock was severed, and cut in the shape of wedge, which was inserted with the V-cut hypocotyl of scion. Then the grafted region was wrapped with straw-band unit for support and to maintain contact between scion and rootstock.

Grafted plants were placed in a sealed polyvinyl chamber after spraying with water to

maintain high humidity(near 100% R. H.), which prevented the grafted region from losing water. The grafted plants left in the chamber for 7 to 8 days to regain turgor and to permit the grafted plant to adapt and become stable. Plants were then transferred from the chamber into the field. Row spacing was 0.6m, and each grafted plant was 0.3m apart within the row. At physiological maturity, plants were harvested, separated into each plant part(stem plus leaf, pod-shell, and seed). After drying at 80℃ for three days, dry matter of each plant part was weighed.

Two grafting experiments were conducted independently. Experiment I and Experiment II included full reciprocal grafts combinations among Baekunkong, Suwon 168, and Kangleungjarae, and those among Baekunkong, Suwon 168, and Keumleungjarae, respectively. A completely randomized design was employed in each grafting experiment with 3 to 6 grafted plant replications. Data from two experiments were analyzed separately using PROC GLM of SAS.

Results and Discussion

No significant root genotype effects were detected in all growth and yield characters in two independent experiments, whereas shoot genotype had a significant effect(Table 1). Most of all characters had no interaction effects between scion and rootstock genotype, except pod number per plant in Experiment I and stem plus leaf dry weight per plant in Experiment II. These results indicated the relative importance of shoot characteristics in determining the distribution of dry matter in each plant part as well as yield and yield-related characters in soybean plant. This was consistent with the results by Jong et al(1992) that the genetic characteristics of scion was more important than those of rootstock in determination of soybean yield and stem weight.

The simplest explanation for the large shoot effect on those growth and yield characters is that the shoot genotype directly affects leaf size, leaf orientation, leaf photosynthetic activity, and partitioning of dry matter into each

Table 1. Analysis of variance for growth and yield characters on the basis of single plant as affected by shoot and rootstock combinations

Source of variation	df	Mean squares						
		Plant height	Stem dry weight	Pod number	Pod-shell dry weight	Seed number	Seed dry weight	Total dry weight
		Experiment I+						
Scion(S)	2	16,712**	9,863**	136,329**	5,721**	289,300**	33,642**	127,102**
Rootstock(R)	2	104	236	3,105	172	6,543	1,737	4,854
S * R	4	102	29	5,359*	220	7,562	1,647	3,408
Error	26	89	275	1,669	99	3,861	636	1,829
		Experiment II+						
Scion(S)	2	20,874**	19,254**	118,502**	3,765**	320,882**	22,116**	120,465**
Rootstock(R)	2	73	1,153	73	24	404	153	974
S * R	4	68	1,349*	2,680	77	10,137	925	1,353
Error	29	49	403	1,697	82	4,653	517	2,042

*, ** Singificantly different at 0.05 and 0.01 probability level, respectively

+ Experiment I and II represent full reciprocal graft combinations among Baekunkong, Suwon 168, and Kangleungjarae, and those among Baekunkong, Suwon 168, and Keumleungjarae, respectively.

plant part. This postulate is close to the situation that crop growth and yield are mostly dependent on the amount of photosynthate supply from the shoot source.

Differences in 100 seed weight were observed for grafts derived from Baekunkong shoot source and any other shoot sources regardless of rootstock genotype(Table 2). Average 100 seed weight of grafts with Baekunkong shoot sources, across all three root genotypes, was 21.1g in Experiment I and 20.3g in Experiment II, and was smaller than that with Suwon 168 and kangleungjarae in Experiment I and Suwon 168 and Keumleungjarae in Experiment II. Root genotype effects on the 100 seed weight were not significant.

It has been clearly demonstrated that almost all growth and yield characters were shoot-dependent. In addition, as self-grafts were not different in the flowering and maturing date from the grafts with the same shoot genotype source(data not shown), the root genotype had no influence on the flowering and maturing responses of the grafts. From these results, it could be inferred that top growth and yield characters including flowering and maturing responses tended to be mostly shoot-controlled. However, it has not been clear that root characters of the grafted plants were controlled by rootstock genotype.

It was not always and absolutely true that all top characteristics of grafted plants were dependent on the scion genotype, and that all root characteristics were on the rootstock genotypes. The root genotypes had significant effects on the yield under drought in common bean(White and Castillo, 1989) and on the shoot water relations of soybean (Sullivan and Brun, 1975). And other work in soybean indicated that root dry weight was affected by shoot genotypes(Lee et al. 1991). These inconsistent results from grafting experiments might be mainly due to the differences in grafted genotypes and their grafting combinations as a scion and a rootstock.

The ratio of seed to pod-shell dry weight was considered as a characteristics which indicated the distribution rate of assimilation products to seed in soybean. Two independent full sets of intergenotypic grafting data among four soybean genotypes were shown in Table 3. Self-grafted Kangleungjarae and Keumleungjarae were thought to be low in the ratio of seed to pod-shell dry weight, while the other two self-grafted genotypes were high. This suggested that seed of black soybean cultivars did not grow fully in comparison with its growth of pod-shell. Relative seed to pod-shell dry weight remained almost constant regardless of root genotype(Table 3), even

Table 2. The 100 seed weight of three soybean root and shoot sources in grafts among Baekunkong, Suwon 168, and Kangleungjarae, and those among Baekunkong, Suwon 168, and Keumleungjarae

Scion	Root stock				Mean
	Baekunkong	Suwon 168	Kangleungjarae	Keumleungjarae	
	g				
Baekunkong	21.8	20.6	21.0	–	21.1[b]*
Suwon 168	32.8	43.5	32.6	–	36.3[a]
Kangleungjarae	33.5	38.8	37.4	–	36.6[a]
Mean	29.4[a]*	34.3[a]	30.3[a]	–	
Baekunkong	20.4	19.3	–	21.1	20.3[b]*
Suwon 168	35.1	37.0	–	33.5	34.9[a]
Keumleungjarae	36.7	33.6	–	35.0	35.1[a]
Mean	30.7[a]*	30.0[a]	–	29.5[a]	

* Within graft combinations, means(column or row) not followed by the same letter are significantly different at $P \leq 0.05$ based on LSD.

Table 3. The seed/pod-shell dry weight ratio of three soybean root and shoot sources in grafts among Baekunkong Suwon 168, and Kangleungjarae, and those among Baekunkong, Suwon 168, and Keumleungjarae

Scion	Root stock				
	Baekunkong	Suwon 168	Kangleungjarae	Keumleungjarae	Mean
	g				
Baekunkong	2.80	2.99	3.09	–	2.96[a]*
Suwon 168	2.88	2.95	2.80	–	2.88[a]
Kangleungjarae	2.23	2.57	2.46	–	2.42[b]
Mean	2.64[a]*	2.84[a]	2.78[a]	–	
Baekunkong	2.57	3.14	–	3.10	2.94[a]*
Suwon 168	2.93	3.06	–	3.08	3.02[a]
Keumleungjarae	2.50	2.22	–	2.64	2.45[b]
Mean	2.67[b]*	2.81[ab]	–	2.94[a]	

* Within graft combinations, means(column or row) not followed by the same letter are significantly different at $P \leq 0.05$ based on LSD.

though there was a slight difference in the reciprocal grafts among Baekunkong, Suwon 168, and Keumleungjarae in Experiment II. The presence of Kangleungjarae and Keumleungjarae as a scion resulted in the low ratio of seed to pod-shell dry weight, indicating that the partitioning of dry matter into seed and pod-shell should be controlled by shoot genotypes.

Significant differences in pod-shell dry weight were recognized among intervarietal grafts. Pod-shell dry weight of grafts with Suwon 168 shoot and Keumleungjarae root was about 1.7g/plant, whereas that of self-grafted Kangleungjarae was 58.7g/plant (Fig. 1). As shown in Fig. 1, negative correlation was present between pod-shell dry weight and ratio of seed to pod-shell dry

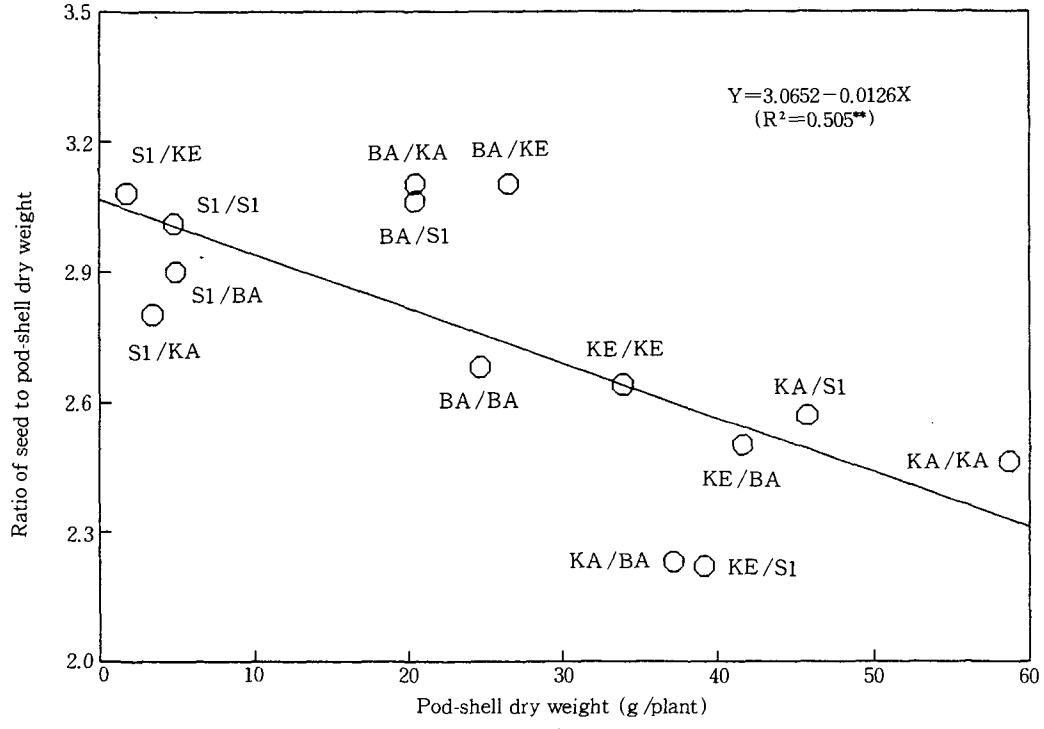

Fig. 1. Relationship between pod-shell dry weight and ratio of seed to pod-shell dry weight. (The left and right part of slash represent shoot/rootstock combinations. BA:Baekunkong S1:Suwon 168, KA:Kangleungjarae, KE:Keumleungjarae)

weight, suggesting that the grafts with great pod-shell dry weight tended to be low in the ratio of seed to pod-shell dry weight. As reported earlier by Nakamura and Nakazawa (1987), varietal difference in the ratio of seed to pod-shell dry weight was recognized significantly among one hundred and forty-two soybean cultivars, and the ratio was affected by the degree of seed growth to pod-shell size. These included that the ratio should be very important for selecting high yielding genotypes by improving partitioning of dry matter into seed rather than pod-shell.

摘 要

콩 遺傳子型간 相互接木을 통하여 地上部 生育과 콩깍지에 대한 種實乾物重 比率에 미치는 영향을 비교 검토하고자, 꼬투리의 비대가 충실한 백운콩과 수원 168호, 꼬투리 크기에 비하여 종실건물 축적이 불량한 수집검정콩 강릉재래 및 금릉재래를 공시하여, 自家接木 및 4개 유전자형간 相互接木을 한 후 移植栽培試驗한 結果를 要約하면 다음과 같다.

1. 지상부의 生育程度와 콩깍지 및 種實乾物重은 지상부 유전자형간 유의적인 차이가 인정되었으나, 지하부 유전자형간 차이가 없었다.
2. 百粒重 및 꼬투리에 대한 種實乾物重 比率도 지상부 유전자형에 의하여 결정되기 때문에, 상대적으로 養分吸收와 밀접한 관련이 있는 지하부 유전자형과는 관계가 적었다.
3. 接木된 개체들의 콩깍지 乾物重과 콩깍지에 대한 種實乾物 比率은 유의적인 負의 相關關係를 나타내고 있어, 콩깍지 건물중이 클수록 콩깍지에 대한 종실건물 비율이 낮아지는 경향이었다.

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