생명과학회지
Korean J. Life Science, 8(4), 437－442, 1998

Genetic Relationship between Seed Size and Leaf Size in 66 F_2 Populations Derived from Mating of 12 Soybean Strains

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Abstract

Seed and leaf size is the important morphological traits considered by plant breeder and is the important yield components in soybean. The objective of this research was to know the relationship between seed size and leaf size in 66 F_2 populations derived from half diallel mating system with 12 soybean strains, representing distinct seed and leaf size. The range of seed size for 12 parents used was 6.7 to 43.8 g/100 seed. Leaf width and leaf length ranged 5.7 to 8.6 cm and 9.4 to 12.9 cm, respectively. Leaf width was highly correlated with leaf length with an R square of 0.754 in the F_2 generation. The F_2 regression coefficient indicated that leaves were, on average 1.4 times greater length than in width. Leaf size (width) was highly correlated (r=0.91) with seed size (g/100 seed) in the F_2 generation with an R square of 0.833. Our results indicate positive correlation within seed and leaf size is common in F_2 segregating populations derived from crossing with soybean. The strong linear relationship we observed between leaf size and seed size in F_2 segragating population is useful in that indirect selection for a secondary character may be superior to direct selection for the primary character.

Key words : *Soybean, seed size, leaf width, leaf length, F_2 population*

Introduction

Seed yield of a cultivar is the product of the number of seeds produced per unit area and the mean size of those seeds. Seed size is an important yield component in soybean. Seed size of soybean cultivars ranges from 4 to 55 g/100 seed Hartwig[7]. Lee and Huang[8] reported leaf length and width ranged from 4.3 to 14.7 cm, and 2.8 to 9.7 cm with 884 soybean accessions. Bravo et al.[1] evaluated the use of pod width for indirect selection of seed size (seed weight) in soybean. These authors noted that selection for seed weight was more effective using pod width than using direct selection for seed weight per se on an individual-plant basis. The phenotypic correlations between the two characters were highly significant ($P<0.01$) and ranged from r=0.55 on an individual-plant basis to r=0.64 on an entry-mean basis. The genotypic correlation on an entry-mean basis was r=0.72. Fraser et al.[4] reported that pod length and width were significantly correlated with final seed size (r=0.90 and r=0.96, respectively), as well as with each other (r=0.89) in soybean. Chung and Specht[2] observed seed size was positively assoicated with leaf width (r=0.918) and leaf length(r=0.925). Also, these authors suggested use of leaf size for indirect selection of seed size in soybean. Although, the research for leaf size like as indirect selection, genetic correlation between seed size and leaf size, and genome size is

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increasing, there is little study on the relationship between seed size and leaf size in crossed soybean population. The objective of this research was to know the relationship between seed size and leaf size in 66 F_2 populations derived from half diallel mating system with 12 soybean strains, representing distinct seed and lead size.

Materials and Methods

Experimental Materials

The parental lines used in this study are presented in Table 1. Hereafter, these lines will frequently be referred to by their symbol names as shown Table 1. The parents were chosen to represent three distinct seed and leaf size groups. Among the 12 parents, four (M1, M2, M3, and M4) have a normal seed and leaf siz, four (S1, S2, S3, and S4) have small seed and leaf size, and four (L1, L2, L3, and L4) have large seed and leaf size. 'Colfax' (M1), 'Charleston' (M2), 'Lancaster' (M3), and 'Ripley' (M4) are adapted cultivars with high yield in the midwestern USA (Cooper et al.ed[3]and Graef et al.[5]). 'Mercury'(S1), and 'Saturn' (L1) are small- and large-seed cultivars with good but not exceptional yield potential (Specht et al.[10]and Graef et al.[6]). The other six parental lines are plant introductions obtained from the USDA soybean germplasm collection maintained at the U. S. Regional Soybean Laboratory, Urbana, IL. All lines are maturity group II, III, or IV and have a yellow seed coat which is a desirable phenotype for US commercial production.

Matings and Generation Advance

During the summer 1993, seed of the 12 parents were planted on three different dates in the University of Nebraska-Lincoln (UNL),USA, East Campus mating nursery. F_1 hybrids were obtained for the 66 crosses that are possible in a 12-parent half-diallel without reciprocals. When mature, the hybrid seed borne on each female parent was collected and hand threshed. Generation advance from the F_1 seed to F_2 seed generation is accomplished by planting F_1 seed of each mating on 10 November 1993 in the UNL Agronomy greenhouse. Three F_1 plants of the same mating were grown per pot. The photoperiod was a 14-hr day and 10-hr night, with lights on from 6 : 00 am to 8 : 00 pm (Central Standard Time). The temperature was set to 31℃ during the day and 16℃ during the night. The hybridity of each F_1 plant (all matings) was verified by evaluating the observed F_1 phenotype against the expected F_1 phenotype for parental matings differing in genetic markers for flower, pod, or pubescence color. F_1 plants confirmed for hybridity in the greenhouse were harvested in bulk and labeled by mating.

Table 1. Mean seed size and leaf size of 12 parents used in this study

Parent	symbol	Seed size (g/100 seed)	Leaf size(cm) Width	Length
········· Large-seed parent ·········				
Saturn	L1	36.6	8.0	11.3
PI 417.339	L2	41.4	8.3	12.4
PI 417.468	L3	43.8	8.4	12.1
PI 423.894	L4	43.3	8.6	12.9
········· Medium-seed parent ·········				
Colfax	M1	19.7	7.9	9.7
Charleston	M2	17.5	7.0	10.5
Lancaster	M3	17.9	7.0	10.3
Riplay	M4	14.2	7.1	10.5
········· Small-seed parent ·········				
Mecury	S1	9.3	5.7	9.7
PI 398.374	S2	8.9	6.2	9.4
T208	S3	6.7	5.9	9.6
T215	S4	8.1	5.9	9.4

Experimental Design

In the 1994 F_2 plant generation field trials, the 66 F_2 and 12 parental entries were randomly assigned to each of five replicates of an RCB design. Care was taken to draw a random 25- seed sample of F_2 seed from each of the 66 matings. 66 F_2 seeds and 12 parents were planted on 7 May 1994 in Field PN located on the UNL East Campus. The soil type in both fields was a Zook silty clay loam. The test areas had previous crops of sorghum (1993), had been fall-plowed, were field-cultivated in the spring, then were sprayed with a herbicide (mixture of trifluralin [trifluoro-2,6 dinitro-N, N- dipropyl-P -to-luidine] and metribuzin[y-amino-6-(1, 1- dimethylethyl) -3-(methylthio)-1,2, 4-triazin-5(4H)-3-(methylthio)- 1,2,4,- triazin-5 (4H)-one]. Irrigation was initiated at the pod elongation stage (late July) and continued as needed to keep the soil at or near field capacity during the rest of the season. Rainfall (total and seasonal distribution) and temperature were near-average in 1994.

Data Collection and analysis

In 1994, plants were cut at the ground level by hand and the plots harvested with a stationary thresher. The harvested seed was air-dried to a seed moisture content of about 8.0%. Two 100-seed samples were drawn from the seed of each plot and were weighed to measure seed size (g/100 seed). Leaf width and length (cm) of 12 parents and 66 F_2 generation matings was measured on the terminal leaflet of the fourth trifoliolate before flowering. In F_2 segregating populations, 10 random plants per each plot were selected and measured. A mean value for the two 100-seed sample estimates of seed size (per entry) was first computed for all plots in 66 F_2 generations and 12 parents. Then, a mean value of five replications for seed size was computed. A mean value for leaf size of ten random plants in each plot size was computed. Also, a mean value of five replications was computed. Correlation and regression analysis between leaf size (width and length in cm) and seed size (g/100 seed) in 66 F_2 generations and 12 parents was conducted.

Results and Discussion

The range of seed size for 12 parents used was 6.7 to 43.8 g/100 seed. Leaf width and leaf length ranged 5.7 to 8.6 cm and 9.4 to 12.9 cm, respectively (Table 1). Lee and Huang[8] observed variation of leaf width and leaf length ranged 2.8 to 9.7 cm and 4.3 to 14.7 cm, respectively in 884 soybean accessions originated from Brazil, China, Indonesia, Japan, Korea, and USA. These differences between leaf size of 12 parents used in this study and that of materials used by Lee and Huang[8] depend on genotypes. Lee and Huang[8] used soybean materials consisted of wide genetic diversity. 12 parents used in this study were chosen based on similar morphological traits except seed size and leaf size. Also, maturity group of 12 parents are II, III, and IV. The mean performance of the 66 F_2 populations for seed size and leaf width and length is presented in Table 2. The mean seed and leaf size in F_2 generations was influenced by female and male parents. This is similar to the results of Lee and Wang[9]. They reported that the mean 100-seed weight in the F_1 and F_2 generations was mainly influenced by male and female parents in the matings between the lines of interspecific hybrids and cultivars. In nearly all matings, there was little or no transgressive segregation for seed size and leaf width and length. The range of seed and leaf size in the F_2 plant progenies spanned the ranges of both parents, but rarely exceeded parental ranges. Correlation and regression analysis between leaf width and leaf length is presented in Figure 1. Leaf width was highly correlated with leaf length with an R square of 0.754 in the F_2 generation. The F_2 regression coefficient indicated that leaves were, on average 1.4 times greater length than in width. Correlation and regression analysis between leaf size (width) and seed size (g/100 seed) is presented in Figure 2. Leaf size (width) was highly correlated ($r=0.91$) with seed size (g/100 seed) in the F_2 generation with an R square of 0.833. Thus, it appears that leaf size (width and/or length) can be used as a predictor

Table 2. Mean performance of 66 (half-diallel mating) F_2 population for seed and leaf size. Missing data denoted with a dash (-)

Cross	Seed size (g/100 seed)	Leaf size(cm)		Cross	Seed size (g/100 seed)	Leaf size(cm)	
		Width	Length			Width	Length
L1xL2	36.9	8.4	12.2	L4xM4	25.4	7.8	11.4
L1xL3	38.7	8.5	11.9	L4xS1	21.2	7.3	11.2
L1xL4	38.1	8.5	12.2	L4xS2	18.9	7.8	11.7
L1xM1	24.3	7.9	10.4	L4xS3	16.8	7.3	11.5
L1xM2	24.2	7.9	10.8	L4xS4	19.0	7.5	11.6
L1xM3	22.1	7.6	10.7	M1xM2	19.5	7.5	10.0
L1xM4	22.1	7.7	11.1	M1xM3	19.9	7.9	10.5
L1xS1	18.4	6.9	10.3	M1xM4	17.1	7.7	10.4
L1xS2	16.4	7.1	10.3	M1xS1	13.1	7.2	10.3
L1xS3	15.5	6.9	10.5	M1xS2	12.8	7.2	9.8
L1xS4	16.9	7.0	10.4	M1xS3	12.2	7.1	10.4
L2xL3	37.9	8.9	12.3	M1xS4	13.3	7.1	9.9
L2xL4	42.2	8.8	12.8	M2xM3	17.7	7.0	10.3
L2xM1	27.2	8.2	11.3	M2xM4	15.7	7.2	10.7
L2xM2	26.8	7.9	11.6	M2xS1	12.4	6.7	10.3
L2xM3	26.3	7.8	11.5	M2xS2	12.7	6.5	9.7
L2xM4	24.6	8.0	11.8	M2xS3	11.5	6.8	10.5
L2xS1	20.3	7.2	11.2	M2xS4	11.5	6.7	9.9
L2xS2	-	-	-	M3xM4	15.4	7.1	10.4
L2xS3	17.4	7.3	11.3	M3xS1	13.0	6.6	10.12
L2xS4	18.7	7.3	11.2	M3xS2	12.7	6.8	9.8
L3xL4	42.8	8.8	12.7	M3xS3	11.8	6.7	10.2
L3xM1	26.4	8.1	10.9	M3xS4	12.3	6.6	10.0
L3xM2	26.5	8.0	11.1	M4xS1	12.2	6.6	10.2
L3xM3	26.2	7.9	11.2	M4xS2	11.0	6.9	10.1
L3xM4	24.8	7.6	10.9	M4xS3	8.7	6.0	9.6
L3x1S1	19.7	7.1	10.7	M4xS4	10.5	6.7	10.0
L3xS2	-	7.2	10.4	S1xS2	9.3	6.2	9.7
L3xS3	16.6	7.3	10.9	S1xS3	8.6	5.8	9.7
L3xS4	17.3	7.1	10.7	S1xS4	8.7	6.1	9.7
L4xM1	26.6	8.2	11.1	S2xS3	8.8	6.1	9.1
L4xM2	27.6	7.8	11.3	S2xS4	9.1	5.9	9.3
L4xM3	26.7	7.8	11.5	S3xS4	7.9	6.4	10.1

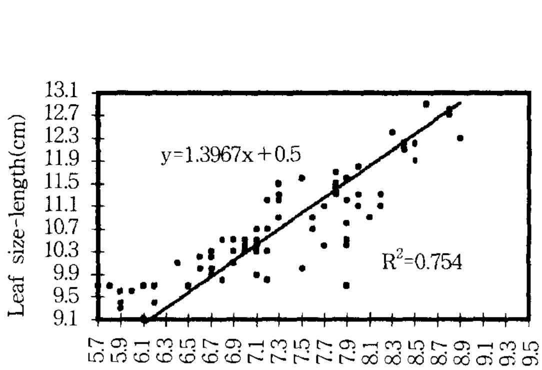

Fig. 1. Relatioship between leaf width and leaf length in 12 parents and 66 F_2 population.

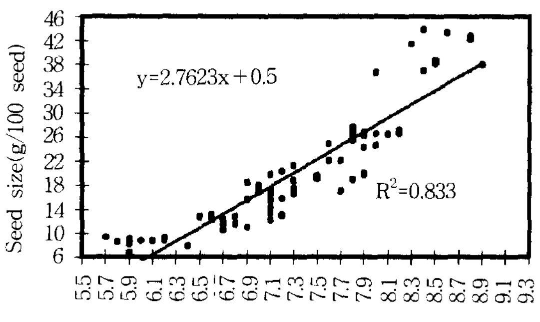

Fig. 2. Relatioship between seed szie and leaf width in 12 parents and 66 F_2 population.

of seed size in F_2 plant populations. Lee and Huang[8] reported highly significant positive correlation between seed size and leaf size with 884 soybean accessions. Our results indicate positive correlation within seed and leaf size is common in F_2 segregating populations derived from crossing with soybean.

The strong linear relationship we observed between leaf size and seed size is useful in that indirect selection for a secondary character may be superior to direct selection for the primary character. In the present case, one could use leaf size to select plants or lines with a desirable seed size.

Conclusion

The relationship between seed size and leaf size in 66 F_2 populations derived from half diallel mating system with 12 soybean strains, representing distinct seed and leaf size was observed. Leaf width was highly correlated with leaf length with an R square of 0.754 in the F_2 generation. The F_2 regression coefficient indicated that leaves were, on average 1.4 times greater length than in width. Leaf size (width) was highly correlated (r=0.91) with seed size (g/100 seed) in the F_2 generation with an R square of 0.833. Our results indicate positive correlation within seed and leaf size is common in F_2 segregating populations derived from crossing with soybean. The strong linear relationship we observed between leaf size and seed size in F_2 segragating population is useful in that indirect selection for a secondary character may be superior to direct selection for the primary character.

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초록 : 대두 12 모본의 half diallel cross로부터 생성된 66 F_2 분리집단에서의 종자크기와 잎 크기에 대한 관계

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대두에서 종자크기와 잎 크기와의 관계를 알아보기 위하여 두 형질에서 큰 차이를 보이는 12 strain을 선택하여 half diallel mating system으로부터 만들어진 66개의 F_2 분리집단을 대상으로 양 형질에 대한 관계를 조사한 결과는 다음과 같다.

종자크기 (g/100 seed)는 6.7에서 43.8의 변이를 보였고, 잎의 넓이와 길이(cm)에서는 각각 5.7에서 8.6과 9.4에서 12.9의 변이를 보였다. F_2 집단에서 잎의 넓이와 길이는 고도의 유의한 정의 상관관계를 보였고, 종자 크기와 잎크기에서도 동일한 경향을 보여, 잡종집단 및 germplasm 내에서 일반적으로 큰 잎 형질과 대립종자 형질은 고도의 정의 상관관계가 있는 것으로 사료된다. 따라서, 대두 잡종집단에서나 germplasm 내에서 어린 식물체를 대상으로 하는 생육초기에서 대립종자를 가진 genotype를 선발하기 위해서 큰 잎을 가진 genotype의 선발은 효과적인 수단이 될 것으로 보인다.