Variation of Leaf Gas Exchange Capacity and Morphological Character of Leaf in Soybean [*Glycine max* (L.) Merr.] Recombinant Inbred Lines

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Leaf morphology can be an attractive target of the genetic improvement for photosynthetic capacity. It has been suggested that *Dt1* and *E1* loci, or the vicinity of these regions are involved in the variation of stomatal density (N_s) and guard cell length (L_g). A considerable variation of these morphological characters was detected among the recombinant inbred lines from a cross between 'Stressland' and 'Tachinagaha' (ST-RILs), but it is not clear if these characters vary or not among lines with same genotype of *Dt1* and *E1*. Therefore, we investigated the variation of the morphological characters with same genotype of *Dt1* and *E1*, and also tested whether or not the potential stomatal conductance (g_p) theoretically estimated from the morphological characters of leaves corresponds to the measured stomatal conductance (g_s) in ST-RILs.

Materials and Methods

Two soybean cultivars (1 from the US ('Stressland') and 1 from Japan ('Tachinagaha')), and 9 recombinant inbred lines derived from a cross between them were used in this study (Table 1).

Potential stomatal conductance (g_p):

Seeded at experimental field of Grad. Sch. of Agric., Kyoto Univ. on June 28th, 2010. The leaf morphology (N_s, L_g) was measured and g_p was obtained by using the model shown in Fig. 1.

Leaf photosynthesis measurement:

Seeded at Exp. Farm of Grad. Sch. of Agric., Kyoto Univ. on June 28th, 2012. The stomatal conductance was measured by porometer AP4 (Delta-T Devices, UK). The measurement was conducted on Jul. 31st & Aug. 1st (as V6**), and Aug. 20th & 21st (as R5). Also in 2013, conducted as same as Tanaka *et al.* (2013, poster #612).

Canopy surface temperature (T_{CS}) measurement:

The temperature of the canopy surface was recorded by Thermo Gear G100 on same day with the leaf photosynthesis in 2012 and on Aug. 19th (as R5) in 2013.

Carbon isotope discrimination (CID) analysis:

Sampled for CID analysis on Aug. 19th, 2013. After well dried, mass spectrometry measurement was conducted by using EA Conflo IV and DELTA V Plus (Thermo Fisher Scientific Inc., USA). CID was obtained by using the following model of Farquhar *et al.* (1989).

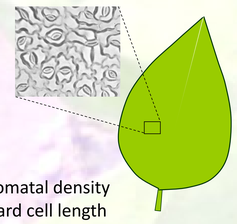
$$\Delta^{13}C = (C_a - C_p)/(1 + C_p/1000) \quad C_a = -8‰,\ C_p = \delta^{13}C \text{ of sample}$$

Table 1.
Genotypes used in this study.

	genotype			
	Dt1	*E1*	*E2*	*E3*
Stressland	1*	2	1	1
Tachinagaha	2	1	2	2
ST048	2	1	1	2
ST053	2	1	2	2
ST068	2	1	2	2
ST100	2	1	2	2
ST107	2	1	2	2
ST128	2	1	2	2
ST178	2	1	2	2
ST203	2	1	2	1
ST283	2	1	1	2

* 1 and 2 in columns indicate 'LARGE' and 'small', respectively.

** According to Fehr and Caviness (1977).



N_s : stomatal density
L_g : guard cell length
g_p : potential stomatal conductance

d : diffusivity of water in air
a : fraction of stomatal aperture to stomatal size
v : molar volume of air

$$g_p = \frac{d\alpha N_s \times L_g}{v(0.5 + 0.627\sqrt{\alpha})}$$

Fig. 1.
Model for potential stomatal conductance (Tanaka *et al.*, 2010).

Conclusions

➢ **The morphological character of leaves can vary even among lines with the same genotype of *Dt1* and *E1*.**

➢ **It is possible to evaluate the photosynthetic capacity by the morphological characters of leaves to a certain extent, at least in vegetative stage.**

Future Subjects

➢ **What is the factor independent of *Dt1* and *E1* loci that operate to vary the leaf morphological characters?**

As the lines used in this study, some of ST-RILs showed variations in N_s and L_g with the same *Dt1* and *E1* genotypes as Tachinagaha.

➢ **Potential usefulness of T_{CS} and CID?**

T_{CS} and CID also may represent the photosynthetic capacity.

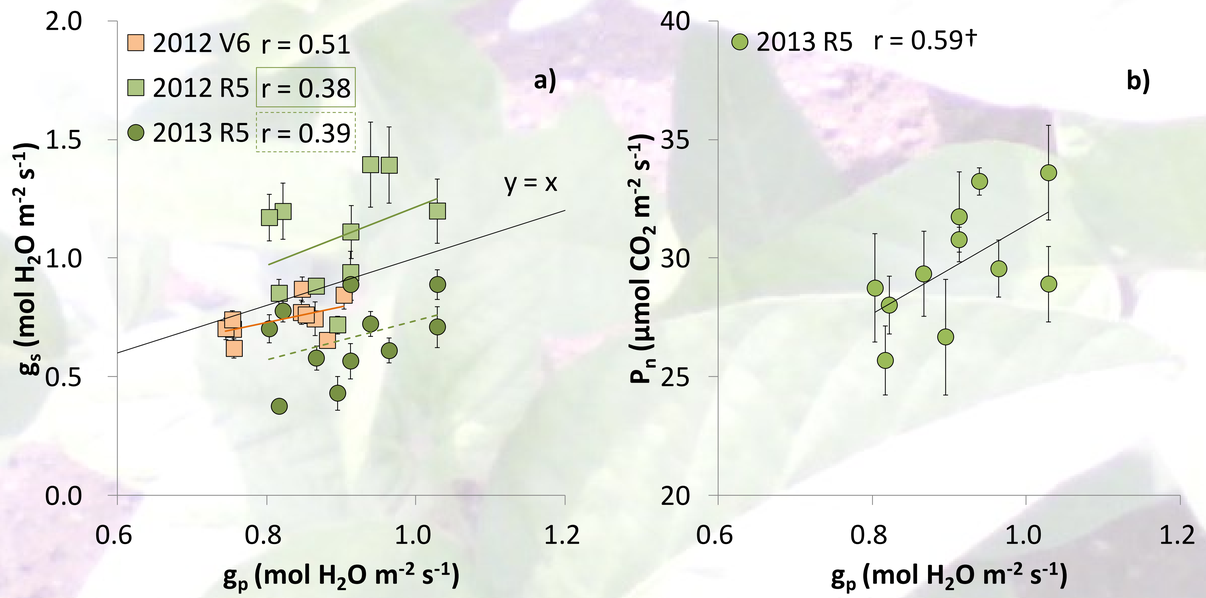


Fig. 2. The relationship between the potential stomatal conductance (g_p) and the measured stomatal conductance (g_s; a), and the photosynthetic rate (P_n; b). g_s and P_n were measured at the uppermost fully expanded leaf on the main stem.
† indicates 10% significance. Bars indicate SE (g_s; n = 8, P_n, CID; n = 4).

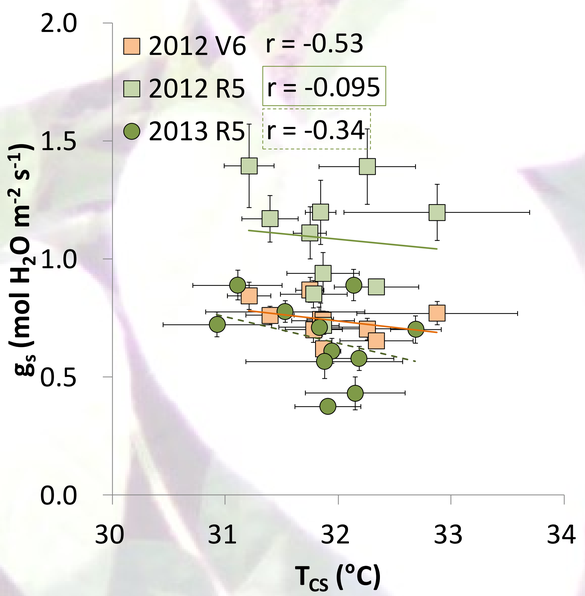


Fig. 3. The relationship between the canopy surface temperature (T_{CS}) and g_s.
Bars indicate SE (T_{CS}; n = 2~4, g_s; n = 8).

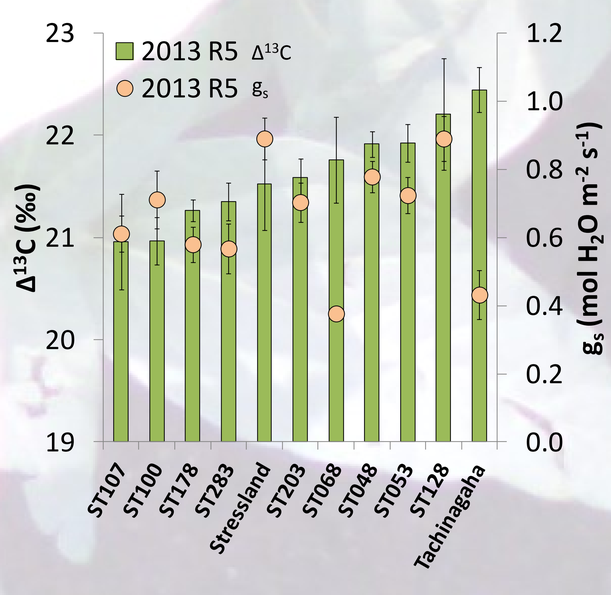


Fig. 4. Variation of the CID and g_s.
Bars indicate SE (CID; n = 4, g_s; n = 8).

Reference: Farquhar et al. 1989. Carbon isotope discrimination and photosynthesis. *Annu. Rev. Plant Physiol. Plant Mol. Biol.* 40: 503-537.
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