# Analysis of Yield Variation in Soybean Genotypes Focused On the Biomass Production of Source and Sink Organs

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**Introduction** Soybean [*Glycine max* (L.) Merrill] seed production is required to be increased. Identification of the plant traits involved in genotypic difference in yield is essential for understanding of yield determination process and conducting efficient selection for high yield.
We explored the important yield attributes in terms of biomass production in source and sink organs using a total of 20 soybean genotypes, including Japanese and US commercial cultivars and recombinant inbred lines (RILs) from a cross between cv. Stressland and cv. Tachinagaha (**Table1**).

**Table 1.** Yield and yield-related traits of genotypes used in the present study. This experiment was conducted in 2011 at Takatsuki experimental farm of Kyoto University in Osaka, Japan. (Sowing date: June 28, 2011 // Planting density: 9.52pl./$m^2$)

| | Genotype | Introduced Year | Maturity (MG) | Yield ($t\ ha^{-1}$, WC:14%) | Biomass at R8 ($t\ ha^{-1}$) | Apparent HI | LAI at R5 ($m^2\ m^{-2}$) | 100SeedWeight (g, WC:14%) | Seed/PodWall (Dry weight) |
|---|---|---|---|---|---|---|---|---|---|
| JPN | Akita | Native | 10/21 | 2.83 ± 0.09 | 5.36 ± 0.15 | 0.46 ± 0.00 | 4.43 ± 0.17 | 33.4 ± 0.3 | 2.45 ± 0.33 |
| | Norin-1 | 1939 | 10/6 | 2.69 ± 0.11 | 4.84 ± 0.26 | 0.49 ± 0.01 | 5.39 ± 0.74 | 19.5 ± 0.3 | 2.32 ± 0.11 |
| | Fujimijiro | 1964 | 10/26 (IV) | 4.02 ± 0.18 | 6.95 ± 0.26 | 0.51 ± 0.00 | 5.95 ± 0.41 | 32.9 ± 0.5 | 2.65 ± 0.03 |
| | Misuzu-daizu | 1968 | 11/1 (V) | 3.80 ± 0.16 | 6.84 ± 0.36 | 0.49 ± 0.01 | 6.36 ± 0.28 | 36.8 ± 0.1 | 3.02 ± 0.13 |
| | Fukuyutaka | 1980 | 11/11 (VI) | 4.53 ± 0.47 | 7.94 ± 0.53 | 0.50 ± 0.02 | 7.09 ± 0.47 | 31.5 ± 0.3 | 3.20 ± 0.07 |
| | Tachinagaha | 1986 | 10/31 (V) | 3.57 ± 0.23 | 6.69 ± 0.23 | 0.47 ± 0.01 | 4.45 ± 0.16 | 36.8 ± 0.7 | 2.57 ± 0.09 |
| | Ayakogane | 1999 | 10/19 | 3.93 ± 0.58 | 6.25 ± 0.74 | 0.55 ± 0.02 | 5.12 ± 0.34 | 30.9 ± 2.2 | 2.62 ± 0.13 |
| | Sachiyutaka | 2001 | 10/31 | 4.03 ± 0.32 | 6.53 ± 0.46 | 0.54 ± 0.01 | 5.92 ± 0.25 | 35.1 ± 0.8 | 2.92 ± 0.08 |
| US | Lee | 1954 | 11/10 (VI) | 3.85 ± 0.08 | 7.32 ± 0.15 | 0.46 ± 0.00 | 6.36 ± 0.34 | 20.4 ± 0.2 | 3.12 ± 0.03 |
| | Essex | 1972 | 11/1 (V) | 4.00 ± 0.23 | 6.96 ± 0.49 | 0.51 ± 0.01 | 5.48 ± 0.27 | 18.4 ± 0.1 | 3.05 ± 0.07 |
| | Elf | 1977 | 10/17 (III) | 3.51 ± 0.20 | 6.10 ± 0.18 | 0.50 ± 0.02 | 3.83 ± 0.23 | 25.4 ± 0.4 | 2.68 ± 0.08 |
| | Williams82 * | 1982 | 10/20 (III) | 3.85 ± 0.22 | 6.68 ± 0.35 | 0.51 ± 0.00 | 4.35 ± 0.31 | 21.2 ± 0.4 | 2.65 ± 0.08 |
| | Hutcheson | 1988 | 11/1 (V) | 4.81 ± 0.27 | 7.85 ± 0.48 | 0.54 ± 0.00 | 5.66 ± 0.20 | 19.6 ± 0.1 | 3.71 ± 0.02 |
| | Spry | 1991 | 10/29 (IV) | 4.58 ± 0.23 | 6.97 ± 0.38 | 0.58 ± 0.01 | 4.19 ± 0.12 | 25.3 ± 0.4 | 3.38 ± 0.02 |
| | 5002 T | 2001 | 10/22 | 3.92 ± 0.29 | 7.00 ± 0.45 | 0.49 ± 0.01 | 5.74 ± 0.19 | 20.5 ± 0.3 | 3.31 ± 0.08 |
| RILs | ST_048 | | 10/19 | 4.08 ± 0.18 | 6.25 ± 0.23 | 0.57 ± 0.01 | 5.26 ± 0.22 | 22.2 ± 0.8 | 3.06 ± 0.05 |
| | ST_100 | | 10/10 | 3.80 ± 0.35 | 5.96 ± 0.47 | 0.56 ± 0.01 | 4.77 ± 0.17 | 23.9 ± 0.1 | 2.73 ± 0.01 |
| | ST_128 | | 10/15 | 4.26 ± 0.16 | 6.37 ± 0.24 | 0.59 ± 0.01 | 5.41 ± 0.24 | 25.6 ± 0.9 | 2.98 ± 0.01 |
| | ST_203 | | 10/22 | 3.31 ± 0.21 | 5.98 ± 0.42 | 0.49 ± 0.01 | 4.21 ± 0.25 | 28.0 ± 0.9 | 2.50 ± 0.10 |
| | ST_283 | | 11/24 | 4.10 ± 0.11 | 8.29 ± 0.43 | 0.43 ± 0.01 | 4.09 ± 0.30 | 30.2 ± 0.1 | 2.79 ± 0.17 |

Each value represents mean ± standard error.

*) Only Williams 82 has indeterminate stem growth habit.

**Table 2.** Correlation coefficients between yield and yield-related traits. Leaf DW (Source organ) and seed# are positively correlated with yield. Pod-wall DW (Intermediate sink organ) was also positively correlated, but this retation was not statistically significant at P<0.05. Seed/Podwall showed close correlation with yield and seed#.

| | Yield | Leaf DW | LAI | LMA | Podwall DW | Seed /Podwall | Seed# | Single seed weight |
|---|---|---|---|---|---|---|---|---|
| Yield | 1 | | | | | | | |
| Leaf DW (R5) | 0.45 | 1 | | | | | | p<0.05 |
| LAI (R5) | 0.33 | 0.85 | 1 | | | | | p<0.01 |
| LMA (R5) | 0.15 | 0.05 | -0.48 | 1 | | | | p<0.001 |
| Pod-wall DW (R8) | 0.40 | 0.09 | -0.17 | 0.44 | 1 | | | |
| Seed/Podwall (R8) | 0.83 | 0.41 | 0.43 | -0.12 | -0.16 | 1 | | |
| Seed# | 0.48 | -0.01 | 0.09 | -0.21 | -0.23 | 0.63 | 1 | |
| Single seed weight | -0.10 | 0.18 | 0.04 | 0.24 | 0.41 | -0.32 | -0.79 | 1 |

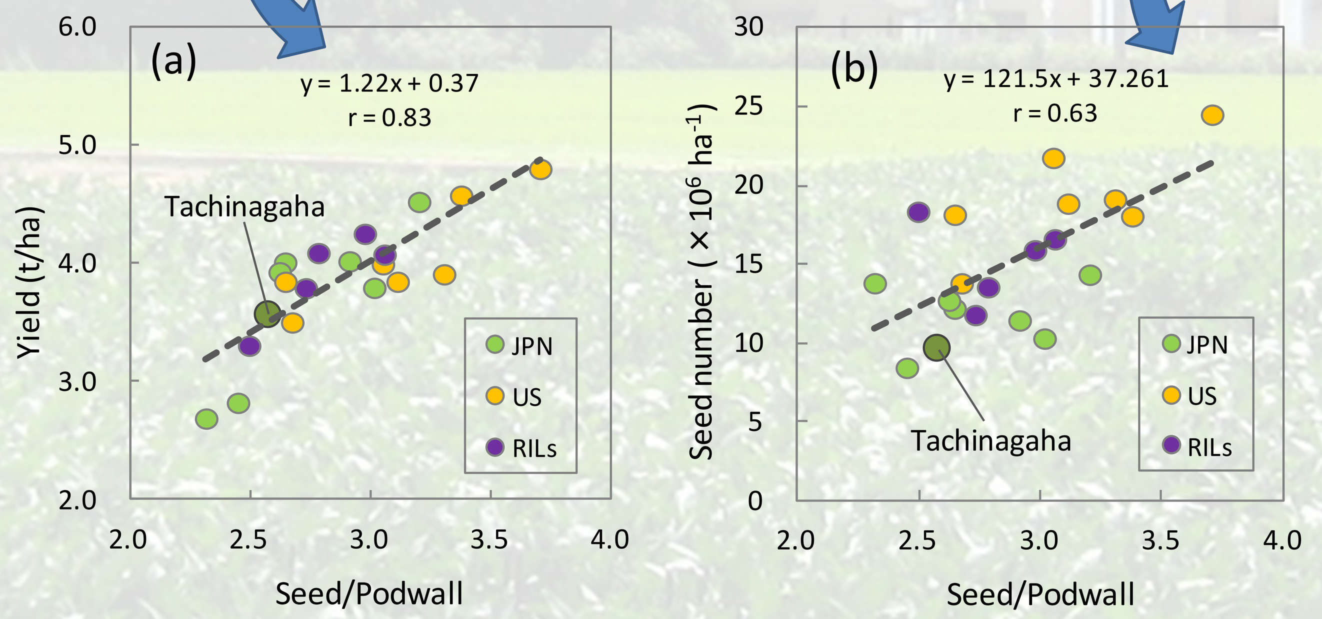


**Figure 1.** Remarkable results of correlation analysis. **(a)** Relation between Seed/Podwall and yield. High-yielding genotype tended to have high value of Seed/Podwall. **(b)** Relationship between Seed/Podwall and Seed#. Seed/Podwall may have something to do with seed#.

## Key properties of "Seed/Podwall"

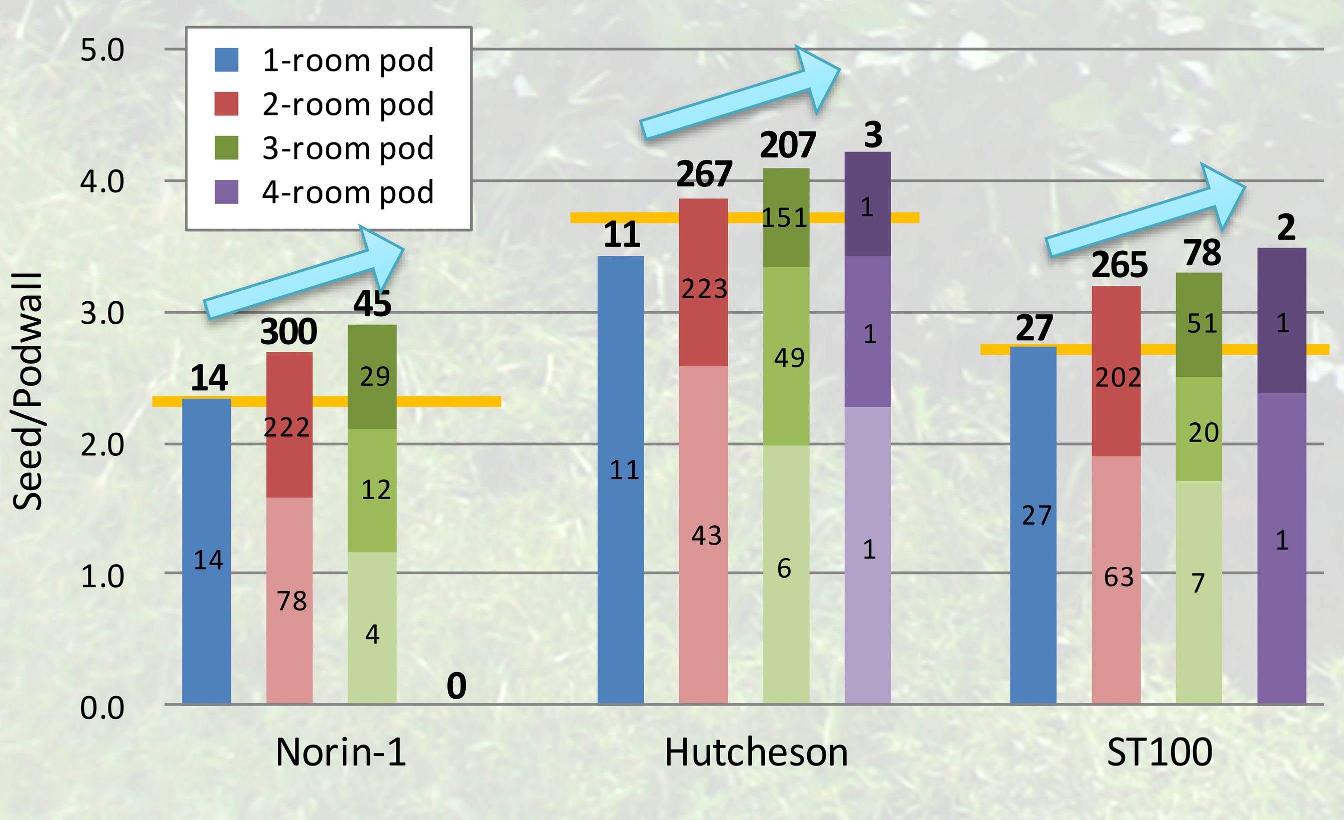


**Figure 2.** Relationship between seed number per pod and Seed/Podwall. Each value represents the total number of pods of 4 plants. Seed number per pod and seed abortion can affect Seed/Podwall. However there are large differences left among genotypes (→ Basic difference) .

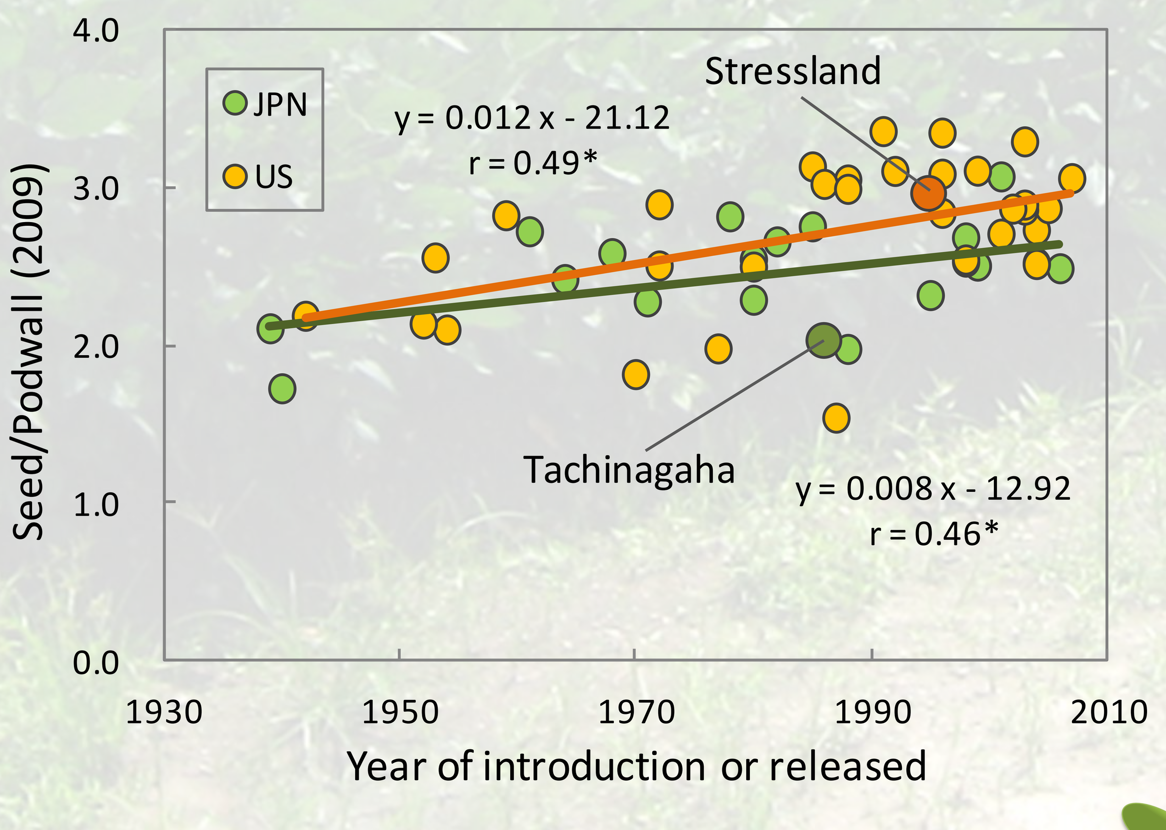


**Figure 3.** Transition of Seed/Podwall in Japanese and US. cultivars. Seed/Podwall is gradually increasing in both nations but the rate is faster in US. cultivars. These values ware measured in Kyoto 2009 (By single row cultivation).

## [Perspectives] What creates the basic difference in "Seed/Podwall" ?

### ① Variation in assimilate supply

Enhanced assimilate supply to the seed can increase seed biomass and Seed/Podwall. On the contrary, the shortage of assimilate supply would decrease these values.

### ② Assimilate remobilization from pod-wall to seed

Larger seed biomass and Seed/Podwall can be achieved through the assimilate remobilization from the pod-wall to the seed. Remobilization from the pod-wall to the seed, however, could not solely explain the yield differences in this study.

### ③ Existence of "Pod production efficiency" !?

Pod production takes place in a limited period of reproductive phase. Efficient pod production with the same pod-wall biomass may enlarge sink size through a large number of pod.