

Is Patience a Virtue? Maturity Time and Phosphorus Efficiency in Soybean

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Introduction

Soybean (*Glycine max*) is the world's most important legume crop, producing fodder as well as food. In tropical and subtropical Asia soybean is the protein staple for a large population, but yields are limited by acidic and highly weathered soils low in available phosphorus. The mobility of Phosphorus in soil is very limited, so soil exploration by roots is important in accessing soil P.

Some plant species respond to P deficiency by delaying maturity^{2,3}. We hypothesize that time could be an important factor in response to P deficiency, as longer growth time allows for:

- Larger explored soil volume
- More root growth
- More diffusion of P to plant roots
- Recharge of solution P from the soil buffering sites

Soybean has been selected for a wide variety of environments, and there is a wide range of maturity time in soybean. Here we investigate the relationship between maturity time and P in two field experiments.

Results

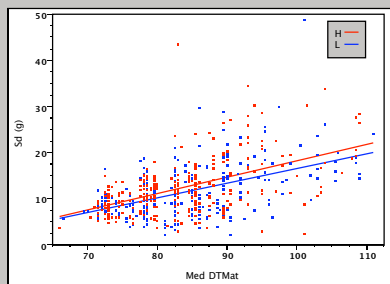


Figure 2: Increased time to maturity is correlated with increased seed yield ($R^2 = 0.26$, $p < 0.0001$) in 284 genotypes. Phosphorus availability does not affect this relationship ($p = 0.59$). Data from 2002 screening.

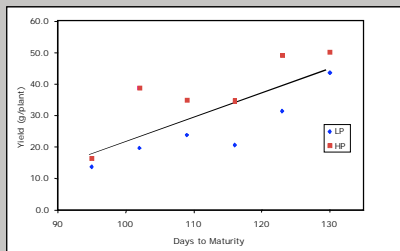


Figure 3: Yield increase correlated with longer growth time in 2004 ($R^2 = 0.59$, $p = 0.005$).

Selected References

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Figure 1: A senescent early maturing soybean variety surrounded by actively growing late maturing varieties.

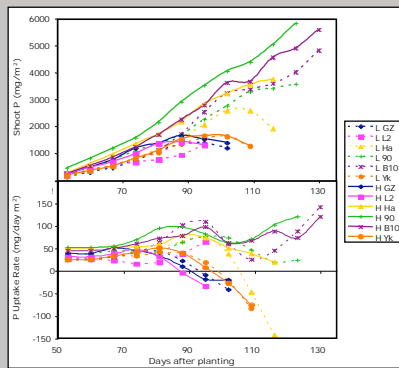


Figure 4: P accumulation and uptake rates

- Later genotypes accumulate more P in High P conditions than early genotypes.
- Early genotypes accumulate less P and stop accumulating P at 80-100 DAP
- Early genotypes are less affected by Low P than later genotypes
- P uptake rates initially similar, diverging over time
- Genotypes affected differently by Low P:
 - some are hardly affected (B10)
 - some show reduced P uptake (L 90)
 - some show earlier senescence (L Ha)
- Genotype B10 accumulates high levels of P late in season, with high uptake rate, suggestive of continued root activity

Methods and Materials

- **Screening:** 284 genotypes of soybean from an applied core collection were screened in 2002. Time to maturity, seed, shoot, and root weight were determined.
- **2004:** Six genotypes chosen; two early, two intermediate, and two late maturing (90, 105, and 120 days), with one deep and one shallow root system for each group. These were planted on March 1, 2004 in raised beds, 10 by 0.5 m, typical of southern Chinese agricultural practices. Three rows planted per bed with row spacing of 0.2 m and in-row density of 6/m of row. Three plants harvested in each unit every week from late April - early July, data collected included:
 - Dry mass and P content of stems, leaves, pods, seeds, and senesced leaves
 - Stand density, specific leaf weight and chlorophyll content
 - Numerical analysis methods were used for smoothing and differentiation⁴
- **Field Conditions:** Experiments were carried out at the Boluo Experimental Farm in Guangdong Province, P.R.China (113°50' E, 23°07' N). Two phosphorus fertility levels were applied: no added phosphorus (LP) and sufficient phosphorus added (HP). Field soil was a typical acid red soil low in available phosphorus. Conventional methods of irrigation and pest control were used.

Conclusions

- Longer maturity time is correlated with increased yield; later maturing varieties can accumulate more P, and so can produce higher yields
- Evidence that this relationship differs between High and Low P conditions is insufficient
- Earlier maturing varieties show less difference between LP and HP than later maturing varieties, but their overall productivity is lower
- In B10, a P efficient genotype, shoot P increases even during early leaf senescence, leading to overall higher yield. This is probably due to continued root uptake; evidence for programmed root senescence is lacking⁵.
- Inefficient genotypes demonstrate two responses:
 - Earlier senescence
 - Lower P uptake rate
- Further research is needed to better characterize these responses, particularly root system responses.

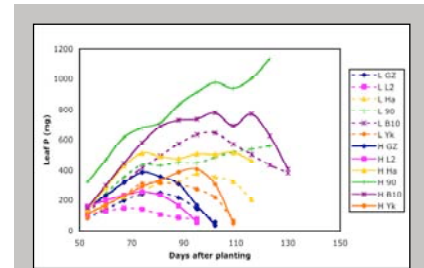


Figure 5: Decreased leaf P suggests P is translocated from leaves. Yk, L2, Ha and B10 begin this process earlier in LP than in HP.

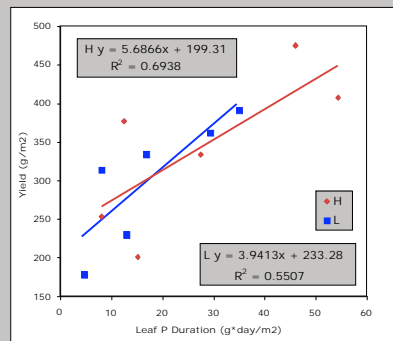


Figure 6: Yield is higher in plants that have higher leaf P duration; additional leaf P duration should allow additional photosynthetic activity in leaves. Leaf P duration is the integral of leaf P content. High and low P slopes are not different, but suggestive; we expect that in P deficiency, plant response to additional P duration would be stronger.

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