BREEDERS VS. AGRONOMISTS: WHAT WE LEARNED FROM THE SOYBEAN DECADES STUDY

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Soybean [*Glycine max* (L.) Merr.] yields in the United States have improved at a rate of 0.35 bu yr^{-1} (23.4 kg yr^{-1}) since national soybean yield data was first recorded in 1924 (USDA-NASS, 2010). The consistent annual yield gain observed in soybean has been attributed to continued varietal improvement via plant breeding and the adoption of improved agronomic practices by U.S soybean producers (Specht and Williams, 1984). Previous research has found that past genetic improvements have resulted in an annual increase in soybean yield of 0.15-0.44 bu ac^{-1} yr^{-1} (10-30 kg ha^{-1} yr^{-1}), or approximately 0.5-1.0% yr^{-1} (Specht et al., 1999). The relative contribution of genetic improvement made by soybean breeders towards overall yield gain is estimated to be 0.184 bu ac^{-1} yr^{-1} (12.5 kg ha^{-1} yr^{-1}), or 50%, among hybridized cultivars released post-1940 (Specht and Williams, 1984).

Although half of yield gain in soybean can be attributed to genetic improvement made by soybean breeders, the remaining half of yield improvement is hypothesized to be the result of improvements in agronomic practices by soybean growers and the interactions of these agronomic practices with improved genetics. Researchers have speculated that changes in a number of agronomic practices by soybean growers have contributed to overall soybean yield improvement, including: earlier planting dates, narrower row spacing, planting at optimum seeding rates, improved weed control and herbicide use, and reduced harvest losses (Specht et al., 1999).

Arguably, the most critical and cost-free cultural management decision that a grower can make to maximize soybean grain yield is to plant soybean at the appropriate planting date (Cartter and Hartwig, 1963; Robinson et al., 2009). Currently, optimum planting dates in the northern U.S. range from early to mid-May (Heatherly and Elmore, 2004), although recent literature suggests that even earlier planting in late April can help to maximize soybean yields in the Midwest (De Bruin and Pedersen, 2008; Robinson et al., 2009). Based on these more recent publications, the trend has been towards planting soybean earlier in the Midwestern U.S. than historical planting trends (USDA-NASS, 2011). We hypothesize that this has thus contributed to the observed increase in soybean yields over time.

The objectives of this study were to determine the effects of earlier soybean planting on (i) seed yield, (ii) seed quality & mass, and (iii) soybean phenology over time. Research was conducted in 2010 and 2011 at Arlington, WI, Urbana, IL, and West Lafayette, IN. Fifty-nine MGII varieties (released 1928-2008) and 57 MGIII varieties (released 1923-2007) were planted at target dates of 1 May (early) and 1 June (late), representing a distribution of historical release years. A mixed-effect regression analysis was used to model change over time in yield, seed quality, and seed mass parameters for each maturity group.

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Results

Yield

Soybean yields for MGII varieties were not affected by planting date (p=0.78), indicating no yield penalty for delaying planting from the beginning of May until the first week in June (Figure 1). The failure to observe negative response to delayed planting in MGII soybeans contradicts past research across the upper Midwest advocating late April-early May planting for yield maximization (De Bruin and Pedersen, 2008; Pedersen and Lauer, 2003; Robinson et al., 2009), although results from this study were similar to the work of Oplinger and Philbrook (1992) who noted no difference in soybean yield at 1 May and 31 May planting dates at the Arlington Research Station.

The magnitude of yield response to early planting is very location and year specific (De Bruin and Pedersen, 2008), which may be the reason for similar yields at both May and June planting dates for the MGII varieties. There was evidence of a linear increase in soybean yields over the year of variety release (p<0.0001). The lack of evidence of a planting date by release year interaction indicated that an equal slopes model was valid for examining yield gains over time for the MGII varieties. When regressed over all release years, the annual rate of yield gain was estimated to be 0.27 bu yr^{-1} at both planting dates. The annual rate of yield improvement observed in this study represents an average gain of 0.55% yr^{-1} and is consistent with previous estimates of annual yield gain in MGII soybeans.

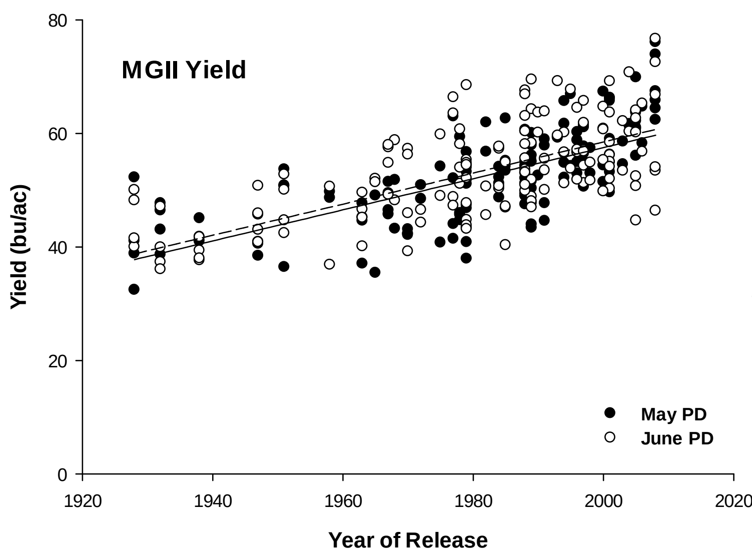

Figure 1. MGII soybean yield at early and late planting (2010-2011).

May Yield = 0.274x – 490.5; S.E. of the Slope: 0.024
June Yield = 0.274x – 489.5; S.E. of the Slope: 0.024

Crop Phenology

The duration of vegetative growth (V1 to R1) was affected by planting date (p = <0.001), with soybeans planted in early May spending a longer period of time in vegetative growth compared to those planted in early June planting. Similar results were presented by Bastidas et al. (2008), who also noted a decrease in the number of days soybeans took to reach beginning flower (R1) as planting date was delayed. Duration of vegetative growth stages of MG II soybean has decreased (*p*=0.0642) over variety year of release, with more recently released varieties spending less time in vegetative growth prior to flowering (Figure 2).

Although the duration of vegetative growth has decreased over variety year of release, the rate of time spent in vegetative growth was not the same (p=<0.001) for both planting dates. No change in the duration of vegetative growth was observed over variety year of release when soybean planted in early June. There was however a significant decline (0.05 days yr^{-1}) in the time spent in vegetative growth when soybeans were planted in early May. These results suggest that more recently released soybean varieties, when planted at the recommended time in early May, reach flowering and the reproductive stages of growth sooner than earlier released cultivars. The decrease in the time spent in vegetative growth is accompanied by an increase in the amount of time spent in reproductive growth among more modern varieties (discussed below).

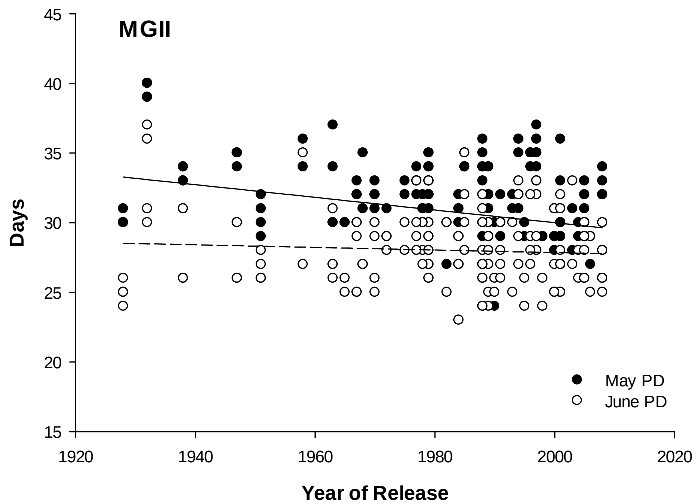

Figure 2. Duration of vegetative growth of MGII soybean at early and late planting (2010-2011).

May Yield = -0.0455x + 121.99; S.E. of the Slope: 0.025
June Yield = -0.0093x + 46.45; S.E. of the Slope: 0.015

The number of days spent in the reproductive phases of growth (R1-R7) has increased (p<0.0001) linearly with variety year of release in MGII soybeans (Figure 3). Additionally, the time spent in reproductive growth is longer for soybean planted in May compared to the June planting (p = 0.01). The rate of increase in reproductive duration over year of release was twice as high in the May (0.09 days yr^{-1}) planting versus the June (0.046 days yr^{-1}) planting, suggesting that more recently released varieties respond positively to earlier planting by spending a greater amount of time in reproductive growth and seed-filling period.

Because yield is often the main selection criteria for soybean breeders, we hypothesize that the decrease in vegetative duration and the increase in reproductive duration of soybean growth was an unintended consequence in breeding efforts. It is likely that while selecting for yield, breeders unknowingly selected for the varieties that reached the reproductive stages of growth sooner and were able to translate the longer period of time spent in the seed-filling period into yield at earlier planting. Preliminary investigation of our data suggests that there might be evidence that the number of days to maturity within the MGII grouping may also be increasing over release year. More modern varieties may be reaching maturity later than their earlier released varieties, and the impacts of lengthening maturity on soybean yield over time are under investigation.

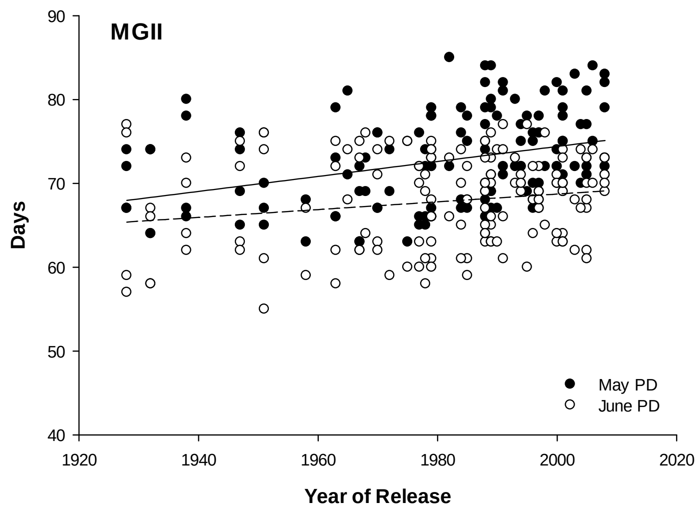

Figure 3. Duration of reproductive growth of MGII soybean at early and late planting (2010-2011).

May Yield = 0.0893x – 104.21; S.E. of the Slope: 0.031
June Yield = 0.04634x – 23.96; S.E. of the Slope: 0.016

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