**Double-Crop Soybean Yields Affected by Different Management Practices in Kansas**

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**Summary**

Double-cropping is a way to use the same agricultural land for cultivating two crops in a year instead of one. This system allows better use of the farm’s resources as well as it can increase net-return to the farmer. However, double-crop (DC) soybean still presents a yield gap in relation to full season (FS) soybean. An eight-site-year experiment was conducted at Ottawa and Ashland Bottoms, KS, during the 2016 and 2017 growing seasons. In both years, the soybean variety planted was Asgrow 4232 (MG 4.2). Soybean was planted right after two different wheat harvest timings (Study 1, 3, 5 and 7, early-wheat harvest 18–20%; and Study 2, 4, 6 and 8, conventional-harvest 13–14%). Seven treatments were evaluated in each of the soybean planting dates: 1) common practice; 2) no seed treatment (without seed fungicide+ insecticide treatment); 3) non-stay green (without foliar fungicide + insecticide application); 4) high seeding rate (180,000 seeds/a); 5) wide rows (30-inch row-spacing); 6) nitrogen (N) fixation (without late-fertilizer N application); and 7) kitchen sink (includes all management practices). In the 2017 season, a treatment was added with the purpose of isolating the fertilizer effect, 8) no fertilization (F). Aboveground biomass and yield were recorded. For the 2016 season, there was a different response for early and late planting in relation to yield responses. For the early planting, there were no differences in yield. However, for the late planting, high plant population, wide-rows and kitchen sink showed greater yields. For the early planting, the differences in biomass were not related to differences in yield. For the late planting, greater biomass corresponded to superior yields, except for the kitchen sink treatment that presented low biomass and greater yields, potentially via increasing biomass partitioning to the seed. For the 2017 season, biomass and yield followed the same pattern, yields increased in parallel to biomass. For the early planting, greater yields were observed for the high plant population, no nitrogen applied in reproductive R3, and kitchen sink. There were no significant differences in yield among treatments for the late planting date in 2016. However, in both years’ yields were lower for late planting dates when compared with the early planting.

**Introduction**

Double-crop (DC) soybean is cultivated in many regions of United States. In most double-crop systems, soybean is planted immediately after wheat harvest, which increases potential profit where there would be fallow or a non-cash cover crop. Also, soybean can be managed in no-till (NT) systems, reducing costs with less machinery expense after the wheat harvest. Furthermore, NT maintains wheat residue on soil surface, enhancing good soil properties. However, there are many challenges that discourage farmers from planting double-crop soybean. The yield gap between full-season and double-crop soybeans is large, with the high risk of crop failure due to heat and drought during the late summer. To improve yields for DC soybean there are some management practices that should be further investigated: 1) fertilizer application, promoting stronger plant growth and earlier canopy closure to overcome stresses due to a late planting season; 2) ideal row spacing and seeding rate, allowing more plants in the same unit area, potentially suppressing weed establishment and increasing yield; 3) integrated pest management, due to the late planting, the risk of late summer soil and foliar disease and insects could decrease yield; and 4) earlier planting time to lengthen growing season and allow more time for soybean plants to set pods and seed before the first killing frost.

The objectiveof this study was to improve yields in double-crop soybean planted after wheat harvest and identify the main yield-limiting factors affecting crop productivity from a perspective of environment and management practices.

***Site Characteristics***

The soil type at the Ottawa location was a Woodson silt loam (Mollisols) and at Ashland Bottoms location it was a Belvue Silt Loam. Soil samples were taken prior to planting at a depth of 0 to 6 in. Soil chemical parameters analyzed were pH, Melich P, cation exchange capacity (CEC), organic matter (OM), calcium, magnesium, and potassium (K) availability (Table 1).

The studies were arranged in a randomized complete block design with 4 replications. Plot size was 10-ft wide × 60-ft long. The soybean variety utilized was Asgrow 4232, maturity group 4.2. Soybean was planted immediately after wheat harvest of the cultivar WB Cedar. Study 1 (early wheat harvest) was planted on June 10, 2016, and June 13, 2017, and Study 2 (conventional wheat harvest) on June 23, 2016, and June 22, 2017. Seven treatments were evaluated in 2016 season: 1) common practice, CP; 2) no seed treatment, NST; 3) non-stay green, NSG; 4) high plant population (180,000 seeds/a), HP; 5) wide rows, WR (30-in.); 6) N fixation, NF (without late-season fertilizer N); and 7) kitchen sink, KS. In the 2017 season, the same eight treatments from the previous year were evaluated, plus a treatment isolating the effect of fertilization (without fertilization—treatment 8). The specific management practice included for each treatment is listed in Table 2.

The seed treatment was Acceleron Standard (Monsanto Company) which contains a fungicide + insecticide. For the foliar fungicide + insecticide application, the chemicals used were Aproach Prima + Prevathon (6 + 17 fl oz/a) and applied to soybean at the R3-R4 growth stage. Herbicides and hand weeding were used to maintain no weed interference for the entire season. Fertilizer application was performed on treatments 2 to 7 using the formulation 7-7-7-7S-7Cl (chloride). The application rate was 10.93 lb/a of N, phosphorus (P), K, S and Cl. In treatment 2 to 6, late N was applied at a rate of 51 lb/a, in the formulation of 32-0-0 (N-P-K). Biomass was collected in a 12.5 ft2 area, sampled outside the area collected for yield.

**Results**

Despite DC soybean usually yielding significantly less than full-season soybean, the 2016 season was a very good year for summer crops, with weather conditions that favored high-yielding environment. In 2017, the weather conditions were normal. Double-crop soybean yields were lower than in 2016. Yields at Ottawa, in 2016 were between 50 and 70 bu/a, and in 2017 ranged between 40 and 60 bu/a. At Ashland Bottoms, yields were between 40 and 60 bu/a and 20 to 55 bu/a, for 2016 and 2017, respectively.

***Biomass and Grain Yield***

Across all site years, except for study 7, high population was one of the greater yielding treatments. Wide-rows were showed greater and lower yields depending on the study. The treatment that didn’t have the application of fungicide and insecticide showed lower yields in studies 2 and 3, while for the other site years, the response varied. In most of the studies, the treatment that had no late N application did not present lower yields. For seed yield, in Study 1, the N fixation treatment presented the greatest yield at 64 bu/a, while the common practice was the lowest yield level at 58 bu/a (Figure 1). Common practice presented lower yields for all the site-years, except for study 8.

At the Ottawa loactions yields were lower for the late planting compared with the early planting in 2017, even with the difference of 9 days in planting. Late planting did not present any significant differences in yield. However, early planting presented greater yields for the treatments of high population, N fixation, and kitchen sink. The greatest difference in productivity was between high population and common practices, with a 13 bu/a difference in yields. However, at the Ashland locations, late planting did not present lower yields than early planting.

**Conclusions**

When planting DC soybean, a higher plant population is required to overcome the stresses of planting out of the ideal timing. Yields were also maximized when all inputs were added. Late planting yielded less than early planting at the Ottawa location. Therefore, anticipating planting of DC soybeans is a strategy that was demonstrated to be efficient for increasing yields. Best management practices for DC soybean can improve overall productivity, increasing yield and biomass. Further evaluation and testing should be performed to better understand and predict the effect of management practices on DC soybean systems.

**Table 1.** **Pre-plant soil characterization at 0- to 6-in. depth at Ottawa, KS, for 2016 and 2017**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Soil parameters** | **Ottawa** | | **Ashland** | |
| **2016** | **2017** | **2016** | **2017** |
| pH | 5.8 | 5.7 | 5.9 | 6.1 |
| Mehlich P (ppm) | 14.5 | 19.6 | 57.7 | 62.5 |
| CEC (meq/100 g) | 15.4 | 23.6 | 7 | 9.4 |
| Organic matter (%) | 2.8 | 3 | 1.1 | 1.5 |
| Potassium (ppm) | 79.3 | 122.9 | 223.0 | 206.3 |
| Calcium (ppm) | 2248.7 | 2447.4 | 1028.8 | 1061.1 |
| Magnesium (ppm) | 303.5 | 348.7 | 105.8 | 118.3 |

**Table 2. Management practices for treatments imposed on double-crop soybean planted after wheat for the early- and late-planting studies at Ottawa and Ashland, KS, in 2016 and 2017.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Treatment | Description | Seed treatment | Fungicide / insecticide | Fertility | Population | Rows | Late nitrogen |
| 1 | Common practice | No | No | No | 140K | 30 | No |
| 2 | No seed treatment | No | Yes | Yes | 140K | 15 | Yes |
| 3 | Non-stay green | Yes | No | Yes | 140K | 15 | Yes |
| 4 | High population (180K) | Yes | Yes | Yes | 180K | 15 | Yes |
| 5 | Wide rows | Yes | Yes | Yes | 140K | 30 | Yes |
| 6 | Nitrogen fixation | Yes | Yes | Yes | 140K | 15 | No |
| 7 | Kitchen sink | Yes | Yes | Yes | 140K | 15 | Yes |
| 8 | No fertilization | Yes | Yes | No | 140K | 15 | Yes |

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Study 1 Study 2

Study 3 Study 4

**Figure 1.** Biomass and yield in studies 1 and 2 for 2016 (upper panels) and 3 and 4 for 2017 (lower panels) growing seasons, Ottawa, KS. Common practice, CP; no seed treatment, NST; non-stay green, NSG; high population, HP; wide rows, WR; nitrogen fixation, NF; kitchen sink, KS; no fertilizer - F (Table 1). Letters show significance (P < 0.05).

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Study 5 Study 6

Study 7 Study 8

**Figure 2.** Yield and biomass in studies 5 and 6 for 2016 (upper panels) and 7 and 8 for 2017 (lower panels) growing seasons, Ashland Bottoms, KS. Common practice, CP; no seed treatment, NST; non-stay green, NSG; high population, HP; wide rows, WR; nitrogen fixation, NF; kitchen sink, KS; no fertilizer - F (Table 1). Letters show significance (P < 0.05).