Developing Profitable Double-Crop Systems after Winter Barley

NCR- SARE Partnership Project Report

Brook Wilke and Maninder Singh

Double Cropping After Winter Barley

Replicated trials were conducted in 2018 and 2019 at the W.K. Kellogg Biological Station (KBS) to evaluate the potential and profitability to double crop soybeans, forage crops and cover crops after a crop of winter malting barley (Puffin). Soybean maturity groups (MG) included 1.9, 2.4 and 2.8, all of which were planted at 140,000 seeds per acre and 200,000 seeds per acre. Additionally, one large block of the experiment was irrigated whereas another block was not irrigated. In each block, we also included a treatment of sorghum-sudan for forage, and a diverse cover crop mix.

2018 Research

In 2018, the winter barley was harvested on June 30th, and the second crops were no-till planted on July 2nd. We received ample rainfall in August and September of 2018, but still applied 5 inches of irrigation water to the irrigated block, mostly in July after seeding. Due to a significant amount of rainfall in the fall, soybean plots weren't harvested until mid-December.

Figure 1. *Double crop soybean project at KBS shown at the time of first frost (left) and harvest (right)* in 2018.

The 1.9 and 2.4 MG soybeans matured prior to the first frost in mid-October, but the 2.8 MG soybeans were still green and immature at the time of the first frost. Planting rate did not affect soybean yield, but maturity group did affect yield under irrigation, as shown in Table 1. Other metrics including harvest moisture, test weight, plant population, protein and oil are also shown in Table 1. The highest producing treatments resulted in over 45 bushels per acre, which is worth $400-$600 per acre in gross profits, with as little as $40 per acre in direct input costs (not counting labor or machinery depreciation).

***Table 1**. Data for important soybean metrics are shown for 2018. The design doesn't allow for direct statistical comparison of irrigated vs. dryland, so maturity groups and seeding rates are used in a factorial analysis with year and irrigation blocks analyzed separately. Different letters within a column indicate statistical significance (P<0.10).*

2018 Dryland							
Maturity Group	Seeding Rate x1,000	Yield (bu/A)	Harvest Moisture (%)	Test Weight (lb/bu)	Final Population (plants/acre)	Grain Protein (%)	Grain Oil (%)
1.9	140	37.8	17.8 b	54.2 a	88359	39.3 b	20.9 bc
1.9	200	38.7	18.2 b	54.4 a	179733	39.1 b	21.1 b
2.4	140	42.2	18.3 b	53.2 a	134053	41.1 a	20.9 bc
2.4	200	33.0	18.7 b	53.7 a	228694	41.6 a	20.5 c
2.8	140	34.2	20.0 a	50.6 b	93363	39.6 b	21.7 a
2.8	200	34.4	20.4 a	51.3 b	125509	39.8 b	21.2 b

2018 Irrigated							
Maturity Group	Seeding Rate x1,000	Yield (bu/A)	Harvest Moisture (%)	Test Weight (lb/bu)	Final Population (plants/acre)	Grain Protein (%)	Grain Oil (%)
1.9	140	44.3 a	18.5 b	53.5 a	124854	39.9 b	20.9 ab
1.9	200	44.5 a	18.7 ab	54.2 a	134310	40.3 b	20.7 b
2.4	140	42.6 a	18.4 b	54.4 a	82064	42.0 a	20.5 b
2.4	200	45.6 a	19.1 ab	53.4 a	151791	42.7 a	20.6 b
2.8	140	31.4 b	20.0 a	50.8 b	126406	40.2 b	21.4 a
2.8	200	33.6 b	20.1 a	50.7 b	142013	40.6 b	21.3 a

Soybean seed from each treatment was evaluated for quality using test weight, protein and oil, with expected reductions with the 2.8 maturity group since the plants did not reach physiological maturity (R8) prior to the first frost. Data suggest that test weight and grain moisture were influenced by this frost damage, but not oil and protein, which seem to be primarily influenced by variety.

The sorghum sudan crop was harvested once for forage, and produced between 2-4.5 tons of biomass per acre. The cover crop biomass was not measured, but visual evaluation (see plots in Figure 1 left) showed abundant growth of diverse species that will be returned to the soil prior to next year's crop.

2019 Research

In 2019, the winter barley was harvested on July 3rd, and the second crops were no-till planted on July 5th and 6th. Some small rain showers at the time of planting provided soil moisture for the soybeans to germinate, but subsequent months were drier than average, including 1.34 inches for the remainder of July, and 1.73 inches in August. Approximately 5 inches of irrigation water was added to the irrigated block. Due to a significant amount of rainfall in the fall, and slow dry-down of frosted, immature soybeans, the plots weren't harvested until early December.

Figure 3. *Double crop soybean project at KBS shown at the time of first frost (left) and harvest (right)* in 2019.

Similar to 2018, the 1.9 and 2.4 MG soybeans matured prior to the first frost in mid-October, but the 2.8 MG soybeans were still green and immature at the time of the first frost (Figure 3). Maturity group and seeding rate both affected yield (Table 2). Irrigation also appeared to influence yield, but we aren't able to determine statistical significance due to the design. Soybean plants were short in general, which led to difficulty at harvest time related to getting all the soybean pods harvested by the plot combine. Thus, a subset of the overall yield was left in the field, which may have been harvested by more sophisticated field scale equipment. The highest producing treatment resulted in 27 bushels per acre, which is worth $250-350 per acre in gross profits, with as little as $40 per acre in direct input costs (not counting labor or machinery depreciation). Sorghum sudan biomass harvested from the control plots in October ranged from 5.5 tons/acre (non-irrigated) to 6.25 tons per acre (irrigated).

***Table 2**. Data for important soybean metrics are shown for 2019. The design doesn't allow for direct statistical comparison of irrigated vs. dryland, so maturity groups and seeding rates are used in a factorial analysis with year and irrigation blocks analyzed separately. Different letters within a column indicate statistical significance (P<0.10).*

2019 Dryland							
Maturity Group	Seeding Rate x1,000	Yield (bu/A)	Harvest Moisture (%)	Test Weight (lb/bu)	Final Population (plants/acre)	Grain Protein (%)	Grain Oil (%)
1.9	140	5.3 b	18.2 b	55.8 a	100804 ab	38.0 b	21.9
1.9	200	9.2 bc	18.3 b	54.6 abc	128644 ab	38.4 b	21.9
2.4	140	15.8 a	18.3 b	55.2 ab	134278 a	40.5 a	21.3
2.4	200	14.2 ab	18.6 b	55.7 ab	113840 ab	40.3 a	21.2
2.8	140	7.6 c	21.6 a	53.0 c	71296 b	38.4 b	21.6
2.8	200	9.2 bc	21.8 a	53.5 bc	109005 ab	38.6 ab	21.7

2019 Irrigated							
Maturity Group	Seeding Rate x1,000	Yield (bu/A)	Harvest Moisture (%)	Test Weight (lb/bu)	Final Population (plants/acre)	Grain Protein (%)	Grain Oil (%)
1.9	140	14.0 b	18.0 b	55.9 a	158369	37.8 c	21.2 ab
1.9	200	19.9 ab	17.9 b	55.9 a	171507	37.7 c	21.2 ab
2.4	140	26.3 a	17.9 b	55.4 a	100712	40.0 a	20.9 ab
2.4	200	24.1 a	18.3 b	55.6 a	165627	40.7 a	20.8 b
2.8	140	13.3 b	24.2 a	51.7 b	118371	38.6 b	21.2 a
2.8	200	16.8 b	24.6 a	51.4 b	150642	38.9 b	21.0 ab

Soybean quality data indicate similar results in 2019 compared to 2018, with lower test weight in the 2.8 maturity group treatments, which were frozen. Differences in protein and oil are evident between treatments, but appears to be variety and not frost damage related.

2020 Field Scale Implementation

Double crop soybeans were planted on June 29th and July 1st after winter barley in two dryland fields (5.5 acres total) with a 2.0 MG soybean, but without any additional research treatments. Both of these fields yielded between 35-40 bushels per acre, which was similar to the same variety of soybeans planted in adjacent fields in May. A period of drought during July and August limited yield for the soybeans planted in May, while the double crop soybeans were still able to utilize rains in late August and September for grain fill (Figure 5).

Figure 5. An August 31st picture of the soybean field double cropped after winter barley in 2020 at the Kellogg Biological Station.

Overall Research Conclusions

1. Moisture is a big factor that governs the success of double crop soybeans. In particular, soil moisture at the time of planting and during grain fill can be very influential in the success of the double crop.
2. Double crop soybeans are inexpensive to plant and manage, and can increase profitability for a particular field. But, the timing and details of the management practices are important. Winter barley provides a 7-14 day earlier planting window for soybeans compared to winter wheat. It's also critical to select appropriate soybean seeding rates, maturity groups and seed as soon as possible after barley harvest.
3. Choosing soybean varieties that mature earlier than the full season varieties for the area is important to avoid frost damage in the fall, delayed harvest, and high moisture soybeans. Our research suggests that at least 0.5 group rating less than typical full season soybeans may be optimal.

4. Through this project and others in Dr. Singh's lab (Siler 2020), it's apparent that higher seeding rates should be used for late planting of soybeans, with a target of at least 100,000 plants per acre for achieving optimal yields and avoiding short plants that present harvest challenges.

Farmer Partnerships

Two of the cooperating farmers were able to follow winter barley with soybeans in 2018. One farmer in Kawkawlin, MI harvested 26 bushels of soybeans per acre using a 1.1 MG soybean. Another farmer near Crosswell, MI attempted to relay intercrop soybeans within his winter barley without success. A third farmer wasn't able to get soybeans planted after barley because the summer schedule got too busy.

Three additional farmers that didn't have barley planted at the start of the grant, were able to plant barley in the fall of 2018 and double cropped soybeans in 2019. One of these growers relay-intercropped soybeans early in the spring, with little success, but continues to innovate with strategies to double crop after wheat and barley. His narrative is listed below.

"I got very poor yields out of both the barley and soybeans in the relay system last year. Most of the barley went down in a storm just days before harvest. Yields were around 15 bu/ac. Once the barley goes down, it can't really be picked back up in the beans. The barley then smothered the beans pretty well, and contributed to a lot of volunteer barley weed pressure during the rest of the season. I didn't manage the field as closely as I could have. For just the three acres I had, I fertilized and treated with fungicide when the wheat needed it, not necessarily the barley. I probably could have gotten a bit more bean yield if I had been aggressive about herbicide use though July and August, but the bean yield potential didn't seem to justify the costs. In contrast, the wheat this last year ran about 65 bu/ac and the relay soybeans 25 bu/ac. Not great for wheat, but I was happy with the beans."

Another grower in south central Michigan is comparing double cropping after wheat with double cropping after winter barley, and found that they gained 10-14 days earlier planting following barley compared to wheat in 2019 and 2020. This included double cropping over 100 acres under irrigation in 2020, with a yield average of 35 bushels per acre, with an estimate of at least 5 bushels per acre lost due to an early frost. This particular grower is particularly interested in comparing the soil health advantages of cover cropping after wheat or barley to double cropping, with the hypothesis that double cropping soybeans leads to soil health declines compared to cover cropping.

A farmer in southwest Michigan was unable to get soybeans planted after barley due to the later harvest in 2019 relative to normal, and workload associated with getting straw baled and manure hauled after barley harvest. In 2020, this farmer did plant soybeans in one field following winter barley, but mid-summer drought resulted in poor soybean growth. The grower chose not to manage weeds in the double crop due to the poor growth, and subsequently determined the crop was not worth harvesting.

Farmer Partnership Conclusions

Overall, farmers had mixed success with growing soybeans after winter barley. Below are some of our key conclusions from this partnership:

- Water availability is a major factor, both at planting and during flowering and grain fill. Late planted soybeans need to emerge as fast as possible, so soil moisture is critical at planting. Additionally, soybeans need moisture during grain fill, so late summer rainfall is critical. Irrigation can allow for much more reliable double cropping.
- Management factors and timeliness are important. Choosing barley allows for earlier soybean planting compared to wheat, but only if the farmer is ready to plant as soon as possible after the barley is harvested. Soybean maturity group is also an important choice to avoid frost damage in the fall, which leads to yield and quality loss, delayed harvest, and high moisture soybeans at harvest.
- When growers were asked what yields would be necessary from the double crop soybeans to make it worthwhile and profitable, 15 bushels per acre consistently came up as a threshold.

Outreach

Results of these trials have been presented at the AMBA BIC conference, and will be presented at the Great Lakes Hop and Barley Conference and other conferences / meetings that allow. We will also be creating a report that will be distributed through our listserv and social media, and posted to our website. Field days were held at KBS in June and November of 2018, and June and September of 2019. The early field days highlighted the plans for the project, and the later field days showed the field trials.

With the COVID pandemic in 2020, education activities were limited to virtual events, which included agronomy themed events through MSU Extension, MSU Virtual Happy Hour Series, Industry webinars (Origin Malt and Independent Barley and Malt), field video recordings, newspaper articles (e.g. Farmer's Exchange), and MSU Extension publications. We also are planning to submit a manuscript with research results to the journal Crop, Forage and Turfgrass Management.

After the project was initiated, we've developed a new relationship with Eric Richer with Ohio State University Extension – Fulton County (https://fulton.osu.edu/people/eric-richer), who is working with a number of farmers to evaluate double cropping after winter barley in northern Ohio. We invited Eric to join and present at our Great Lakes Hop and Barley Conference in Traverse City, MI, and have continued to develop that relationship to learn together. We've also initiated a relationship with Dr. Tim Boring, Vice President of the Michigan Agribusiness Association (https://miagbiz.org/index.php/about/staff). Dr. Boring is a leader related to innovative agricultural practices in Michigan, including implementing many trials on his own family farms, and leading innovation groups and networks such as the annual Underground Innovations Conferences in Frankenmuth, MI (Virtual 2021).

Origin Malt from Marysville, OH, and Independent Barley & Malt (which is being rebranded currently) from Battle Creek, MI, have continued to be strategic partners both on research and education. Origin, in particular, has been purchasing barley from farmers for the past couple of years, and double cropping soybeans is a key portion of profitability for those farmers. Dr. Wilke has been participating in a number of interactions (webinars, phone calls) with farmers that grow for Origin, helping assist with barley production as well as cropping system questions.

Next Steps

There are two primary areas of research that we are considering as a next step to evaluate and/or evaluate double cropping after winter barley. These include:

1. The effect of soybean seed priming on emergence when planted into dry soils. This could involve soaking the seed in water before planting in order to allow for soybean establishment in the presence of dry soil conditions.
2. Evaluate soil health, pest and disease outcomes of double cropping systems, particularly when compared to fallow and cover cropping activities. Our hypothesis is that double cropping soybeans may reduce soil health compared to cover crops potentially grown at the same time, and may also lead to persistence of pests and diseases (e.g. soybean cyst nematode) that are specific to soybeans.

References

Siler, T.B. (2020). *Identifying Optimal Management Decisions Based on Soybean Planting Date: Seeding Rate, Seed Treatment, and Maturity Group Selection.* Master's Thesis. Michigan State University.