DOUBLE CROPPING SOYBEANS IN VIRGINIA

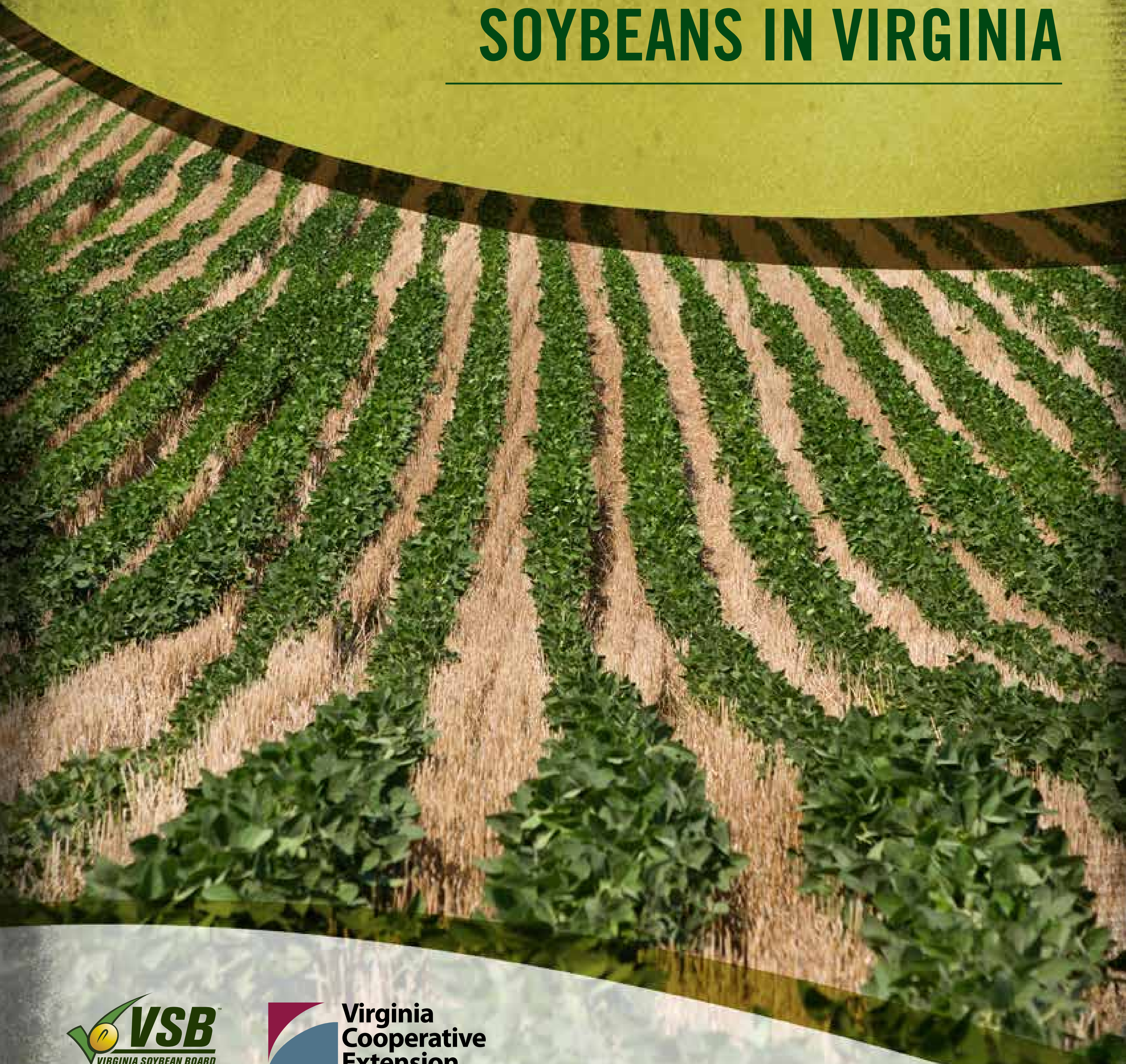

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TABLE OF CONTENTS

FOREWORD

Double-crop soybeans have been a mainstay to Virginia and mid-Atlantic cropping systems for decades. A relatively long frost-free period and the ability of the soybean plants to complete their life cycle within this period allow the system to flourish. Intensively managing small grains, followed by high-yielding soybeans, provides for greater profitability and more efficient use of land, labor, equipment and inputs. The double-crop system also provides environmental benefits by preventing runoff, mining leached nutrients and improving soil quality.

However, higher commodity prices in recent years have resulted in a greater income disparity between full-season and double-crop soybeans, due to lower yields with double-crop soybeans. In addition, greater seeding rates needed for double-crop soybean production, combined with higher seed prices, result in greater input costs compared with full-season soybeans. Finally, with increasing farm size comes an additional challenge of harvesting large acreages of double-crop soybeans before wet winter weather sets in. Therefore, farmers need to improve the soybean component of their double-crop system through greater soybean yields and input efficiency.

So, why a publication focused solely on double-crop soybeans? From a global perspective, we need to increase production of food, feed, fiber and fuel for a growing world. With limited land area, double-crop systems may be our best opportunity to increase world food production. From Virginia's perspective, double-cropping systems offer farmers the best opportunity to sustainably increase their profits.

It must be emphasized that this publication is not a soybean-production guide. It will not cover all details of double-crop soybean production. Instead, it will discuss how full-season and double-crop soybean production systems differ and emphasize practices that will close the yield gap between the two systems. This publication is patterned after a Focus on Soybean webcast produced in 2013, which can be accessed by searching "Double-Cropped Soybean" at *www.plantmanagementnetwork.org*.

I would like to acknowledge the support, ideas, constructive criticism and open-mindedness of our soybean farmers, extension specialists and agents, crop advisers, agribusiness personnel and other researchers in Virginia and the mid-Atlantic region. Free and open information exchange allows greater productivity of all involved. It is a pleasure and privilege to serve such a great industry. I also acknowledge the Virginia Soybean Board and United Soybean Board for financial support of this publication. Without soybean farmers' checkoff dollars, this publication would not have been possible.

David L. Holshouser

INTRODUCTION

Double cropping is simply growing and harvesting two crops in one year. In the mid-Atlantic region of the United States, soybeans are commonly double-cropped after a winter small-grain crop, usually wheat. However, double cropping is not limited to the small-grain-soybean system. Other crops, such as grain sorghum or even corn, could fit into a double-cropping system with small grains. Soybean can be grown after other winter crops, such as canola, or after a spring crop, such as snap beans. As long as both crops can complete their development in time to allow profitable production of the entire system, numerous double-cropping systems are possible.

It has been well documented that double cropping provides many benefits, which include:

- Increasing cash flow and profits.
- Improving soil quality and reducing erosion.
- Providing for a more intensive use of land, equipment, labor and capital.
- Probably most importantly, it allows greater overall production of food and feed for our growing world population.

Soybeans are the most suitable summer crop for double cropping in Virginia. This is due to their ability to completely develop and yield well, even when planted late. It takes 90 to 130 days to grow a soybean crop, depending on planting date. This wide flexibility in days to maturity is due to soybeans being a photoperiod-sensitive crop. Flowering occurs once nights reach a certain length. After flowering, development of late-planted soybeans will proceed more rapidly than soybeans planted in April or May. Therefore, even soybeans planted in mid-July will usually mature before terminated by a frost in late October or early November.

DOUBLE-CROP SOYBEAN IN VIRGINIA

Progress

Soybean production in Virginia increased from 88,000 acres in 1924 to a high of 750,000 acres in 1984, gradually declined to about 500,000 acres in the late 1990s and has increased to around 600,000 acres today (Figure 1). On the other hand, wheat acreage declined from 1924 to the early 1960s and has fluctuated between 200,000 and 300,000 acres ever since. Barley acreage rose during this same period, up to 115,000 acres in 1968, and then declined to the 30,000 to 40,000 acres being grown today.

More than 90 percent of Virginia's wheat acres will be double cropped to soybeans. Although not completely accurate, you can estimate the number of double-crop acres from the acres of wheat and barley harvested. Therefore, double-crop soybean acreage has fluctuated between one-third and two-thirds of the crop's total acreage.

Figure 1: Soybean, Wheat and Barley Acres, 1924-2014

Double-Crop Yields

Soybean yields in Virginia, as well as throughout the United States (representing primarily Midwestern states), continue to increase at a rate of approximately 0.4 bushel per acre per year (Figure 2). However, soybean yields in Virginia lag behind those of the rest of the country by approximately 7 bushels per acre. Moreover, the variations in Virginia yields are much greater than that of the U.S. as a whole. This variation can be principally attributed to the greater

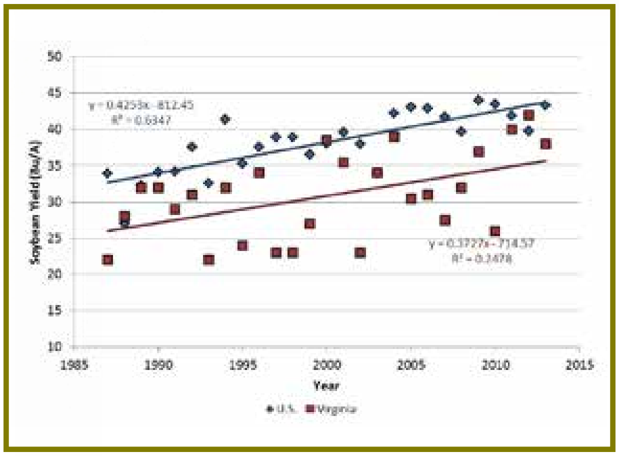

Figure 2: Average and trendline U.S. and Virginia soybean yields from 1987 to 2013.

frequency of drought stress in Virginia, caused by soils with low water-holding capacity in the Piedmont and Coastal Plain. Drought-prone soils are likely one of the causes of Virginia's lower yields.

However, the high percentage of double-cropped soybeans in Virginia could also contribute. Figure 3 shows data taken from Virginia's Official Variety Tests since 1987, where full-season and double-crop experiments are performed annually. Although not necessarily grown in the same field, the full-season and double-crop tests are usually near each other. Therefore, these data represent an average difference of 4 to 8 bushels per acre between the two cropping systems. Fortunately, it appears that double-crop yields increase at a rate of 0.4 bushel per acre versus full-season yield increasing at a rate of 0.3 bushel per acre

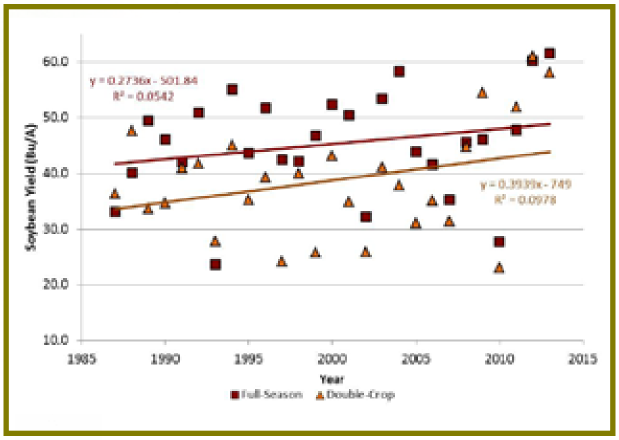

Figure 3: Average and trendline full-season and double-crop soybean yields from 1987 to 2014 in the Virginia Official Variety Tests. Yields are averaged over all locations and varieties.

WHY DOUBLE CROPPING?

Double cropping increases total production of food, feed, fiber and fuel without requiring additional acreage. This is becoming increasingly important with the growing world population, greater demand for higher-protein diets and dwindling land resources. Yield gains alone will likely not meet the world's needs. Additional crop acreage will also be needed, and this acreage can come through double-cropping.

Double cropping also has significant environmental benefits. When combined with no-till practices, the addition of the high-residue small grain crop to a soybean-cropping system increases soil organic matter and improves physical, chemical and biological soil properties. Such soil-quality improvements increase infiltration rates and result in less runoff of water, nutrients and pesticides. Continuous cover on the land reduces soil erosion and runoff throughout the year. A small-grain crop can also scavenge nutrients not used by the preceding crop. Without a winter crop, such nutrients could be lost to the environment through leaching or runoff.

Production-efficiency gains with double-cropping systems are also of great importance:

- By growing two crops in one year, the more effective harvest of solar radiation results in greater production.
- Double cropping also allows land expenses to be allocated over two crops.
- Usually adding a crop, enterprise or more acreage of the same crop will increase labor requirements. But with double-crop systems, the same labor is allocated over the entire year, reducing the need to hire additional labor during time-sensitive periods of the growing season.
- Wear and tear on equipment (and subsequent maintenance and repair costs) depends largely on the intensity of its use; more rapid depreciation may benefit the double-crop system (reducing fixed costs).
- Additional harvests and field operations more evenly spread throughout the year result in a better distribution of capital (income and expenses).
- Adequate cash flow is less of a problem.

- Inputs such as lime can be allocated over two crops, resulting in lower costs per crop acre. Nitrogen (N) fertilizer not used by the previous crop can be scavenged by a small-grain crop, resulting in lower fertilizer costs.

Most importantly, double-crop small-grain-soybean systems are usually more profitable than either crop grown alone. This is due to the increased net income gained from additional production, but the production efficiency gains are predominantly responsible for profitability gain over a full-season system. Detailed budgets comparing double-crop with full-season soybeans will be presented later in this guide.

Other production advantages of double-crop soybeans will be described in detail.

DOES DOUBLE CROPPING HAVE DISADVANTAGES?

Yes. The primary one for soybeans, as mentioned earlier, is the yield penalty from planting in late June and early July after wheat harvest. Although growing barley would solve much of this problem, since that crop is harvested earlier, usually in early June, there are few good markets for barley in Virginia. This limits the number of viable barley-soybean double-crop acres. Reasons for the yield penalty will be presented.

Another disadvantage is the inability to get a large number of double-crop acres harvested in a timely manner. A later harvest, due to later planting, becomes more challenging as the temperatures cool and soils become wetter. Therefore, full-season soybeans may have an advantage in this sense. Early-maturing varieties may help, but such varieties further shorten the growing season – hence yield potential is lower.

THEME:

We Can Increase Double-Crop Soybean Yields by Focusing on Practices That Enhance Its Advantages and Minimize Its Disadvantages

The yield gap between full-season and double-crop soybeans is the main reason for not double-cropping. The yield gap is smaller or not present at all when farmers plant soybeans after barley at an earlier planting date.

One could argue, and it may be true in some years, that low wheat price is the greater influence for not double cropping. Low wheat prices are usually temporary and will eventually rise. Moreover, the year-to-year flexibility of growing full-season or double-crop soybeans can be advantageous to the farm business. Even if low wheat prices reduce profitability of double cropping, narrowing the yield gap between full-season and double-crop soybeans would greatly decrease year-to-year profitability differences and therefore make it less likely for one to change the cropping system. Thus, reduced soybean yield is the primary reason for not double cropping over the long run.

Greater double-crop soybean yields that lead to greater profitability would entice those who are not double cropping to do so. Therefore, this publication will focus on practices that enhance double-crop soybean advantages and minimize its disadvantages. Differences between the two methods of growing soybeans will be examined, and management strategies and tactics that reduce the yield disparity will be presented.

ENHANCING ADVANTAGES AND MINIMIZING DISADVANTAGES OF DOUBLE-CROP SOYBEANS

The main differences between double-crop and full-season soybeans can be divided into three broad categories:

1. The small-grain crop
2. Planting date
3. Pest management

Each category has its advantages and disadvantages. Therefore, as each is discussed, methods to enhance double-crop advantages and minimize disadvantages will be emphasized.

SMALL-GRAIN CROP

The small-grain crop that precedes soybean planting will likely have the following effects:

1. Add residue to the soil surface
2. Change soil moisture
3. Alter soil fertility

Consideration needs to be given to all of these factors for a successful soybean crop.

RESIDUE

Soybeans should be planted using no-till after a small grain to prevent soil erosion, limit water and nutrient runoff, and preserve surface-soil moisture. Where continuous no-till is used, the small-grain crop will add to accumulated crop residues. The additional residue at soybean planting may appear to be the greatest challenge. However, with careful management, it can prove to be a benefit. A successful no-till, double-crop soybean planting requires that you properly handle the small-grain residue and set the planter/drill to ensure good stands and rapid early-season growth. In reality, this is no different from a full-season no-till system, except that there may be more residue.

Strategies to Properly Handle the Extra Residue

To ensure a good soybean stand under no-till settings, follow these four sequential steps:

1. Uniformly spread the small-grain residue. Cut the small grain high, harvesting only the heads, to leave as much of the straw standing as possible. It is much easier to cut through standing residue than residue lying on the ground. Better yet, use a stripper header that leaves all the straw standing.

2. Cut through the residue. This means sharp coulters set correctly, proper down pressure and enough weight on the planter or drill to complete the next step.

3. Penetrate the soil to the proper seeding depth. Plant soybeans ¾-inch to 1½ inches deep into moist soil.

4. Ensure good soil-to-seed contact. The closing wheels need to be set properly to ensure that the seed is only touching soil and that the seed-V closes.

By following these steps, you can avoid stand problems resulting from improper depth and poor soil-to-seed contact. More information on properly setting planters and drills for no-till can be found in the Virginia Cooperative Extension publication 442-457, "Planter/Drill Considerations for Conservation Tillage Systems" (Grisso et al., 2014).

SOIL MOISTURE

In a winter fallow setting, the soil will have a chance to capture and store moisture from winter rains. But the small-grain crop will require a substantial amount of soil moisture. By the time the small grain matures, much, if not all, of the soil moisture may have been used. Slow vegetative growth after emergence can be partially attributed to the lack of soil moisture. Even if topsoil moisture is available, subsoil moisture may be limited.

In addition, lack of topsoil moisture after soybean planting can lead to poor emergence and slow growth. This is shown in the photo below of an experiment evaluating the effect of different small-grain crops used as a cover crop on the right or harvested for grain on the left.

When the small-grain crop was killed early, good soybean stands were achieved due to more available soil moisture. Plus, there was little difference in the growth of the soybeans, regardless of whether that land grew a small-grain cover or remained fallowed during the winter, as you can see in the photo.

After small-grain harvest (and the removal of most of the topsoil moisture), only soybeans planted in the fallow ground emerged well.

However, fallowing does not always ensure good stands, as shown by the data below (Figure 4).

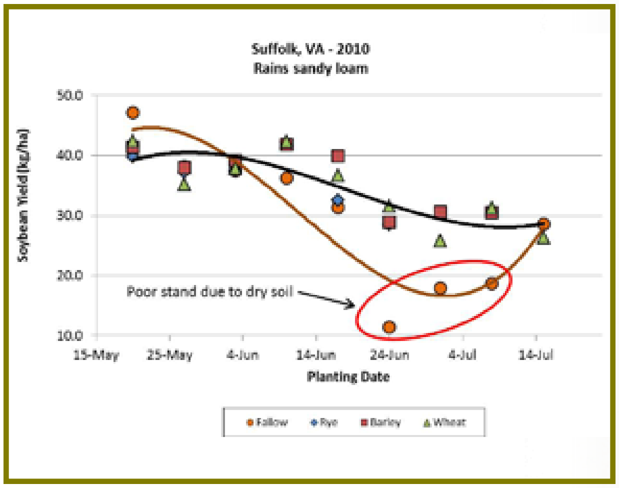

Figure 4: Effect of planting date and previous crop (fallow - corn residue only, rye, barley or wheat) on no-till soybean yield. Winter crops were either killed with herbicide two weeks before planting or harvested for grain. Poor yield in the fallow plots planted in late June through early July were the result of poor stands caused by dry topsoil.

This graph shows the effect of different winter small grains and soybean planting date on soybean yield. Regardless of the small grain used, soybean yield gradually declined with later planting dates, which is a common response. However, by late June, soybean emergence was poor where the land was fallowed due to lack of residue cover that allowed excess evaporation from the soil surface. These poor stands resulted in low soybean yields in those plots. In other words, during a dry planting season, the presence of a small-grain crop may actually conserve surface soil moisture due to less evaporation.

Strategies for Conserving Soil Moisture

So how do we manage this lack of soil moisture after small-grain harvest? First and foremost, maintain the residue. Do not bale the straw. Never burn the straw or till the soil. Baling, burning or tilling will expose the soil surface to evaporation and further dry it out.

If the soil surface is dry at planting, there are three options.

1. The preferred option is to plant into moist soil. Although soybeans should not normally be planted deeper than 1 inch in a full-season situation, the soil is much warmer in June and July. Therefore, the seed will germinate and emerge faster. There is less danger of seedling disease and other problems from planting too deep. Therefore, farmers can plant 1½ to 2 inches deep, but no deeper, to reach soil moisture in a June- or July-planted double-crop system.
2. If there is no soil moisture down to 2 inches, another possibility is to wait for a rain. Considering that yield declines as planting is delayed – about half-bushel per day – this may not be the best option, especially if you have thousands of acres to plant.
3. The final and least-preferred option is to plant into dry soil and wait for rain. If the soil is completely dry, then the seed will not germinate and will usually wait for a rain. Here, at least the crop is planted. If water comes, it will germinate and hopefully emerge. The big problem with this approach is soil variability. Rarely is the field completely dry – some areas may have enough moisture to allow germination but not emergence or adequate early-season growth.

Strategy to Ensure Subsoil Moisture

Unfortunately, there is no method to improve the subsoil-moisture status of dryland soybean fields apart from the moisture-conserving strategies already listed. However, if irrigation is available, it is prudent to irrigate soon after planting if you have verified that there is little subsoil moisture and rainfall is not in the forecast.

Most Virginia soils will hold 1 to 2 inches of plant-available water per foot of soil, with sandy soils holding less and soils with more silt and clay holding more. So 1 inch of irrigation may only wet between 6 inches and a foot of soil. Refer to county soil surveys to determine your soil's available water capacity. Providing adequate subsoil moisture to late-planted vegetative-stage soybeans will allow roots to go deeper, increase leaf area and permit greater yield.

SOIL FERTILITY

The small-grain crop will also remove a significant amount of nutrients. Most of the potassium and much of the nitrogen, magnesium and sulfur will return to the soybean crop later in the season after the residue begins to break down, as shown in the bottom line of Table 1. However, there could be some deficiencies of these nutrients early on.

Strategies to Ensure Adequate Soil Fertility and Plant Nutrition

First and foremost, maintain the residue to preserve the nutrients. Don't remove the straw unless you're prepared to replace the nutrients shown in the table above. Burning may release some nutrients quickly, but the soybean crop

Table 1: Nutrient uptake by small-grain crops

Crop	Yield (Bushels/Acre)	N	P_2O_5	K_2O	Mg	S
Barley	100	150	55	150	17	20
Wheat	70	130	47	142	21	18
Wheat	100	188	68	203	30	25
Wheat Straw	100	73	13	169	15	15

International Plant Nutrition Institute (IPNI), Norcross, GA

Table 2: Effect of inoculants on soybean yield in Virginia. Underlined values indicate that yield with inoculant was significantly greater than the control.

		LOCATION[1]										
YEAR	**INOCULANT**	**BLK FS**	**MEC FS**	**ORG FS**	**ORG DC**	**PTR FS**	**PTR DC**	**SUF FS**	**SUF DC**	**WAR FS**	**WAR DC**	**AVERAGE**
2012	**Control**	52.8	53.4	64.7	42.9	56.3	73.1	64.8	69.4	53.0	58.6	58.9
	Optimize	62.3	55.5	70.6	44.1	44.5	78.6	58.7	74.8	56.5	55.6	60.1
	Tag Team LCO	67.9	56.2	57.6	47.6	52.3	70.1	59.7	74.7	53.4	60.2	60.0
	SoyRhizo	67.0	57.4	64.8	44.8	52.8	71.1	60.7	70.7	53.6	60.4	60.3
	Primo CL	76.2	61.1	65.5	44.2	50.3	73.8	60.4	76.9	51.4	58.8	61.9
	Vault NP	62.3	54.7	69.0	42.1	58.1	64.3	59.6	69.9	52.0	56.5	58.9
	Average	64.8	56.4	65.4	44.3	52.4	71.9	60.7	72.7	53.3	58.4	---
	LSD (P=.05)	7.7	6.5	9.5	5.4	7.5	9.9	6.3	6.5	7.0	5.0	---
2013	**Control**	59.1	---	45.9	---	40.7	53.5	81.8	75.2	67.4	47.6	58.9
	Optimize	65.6	---	42.8	---	38.1	53.5	81.8	75.2	67.4	47.6	58.9
	Tag Team LCO	57.2	---	45.9	---	40.6	54.8	74.2	77.3	72.5	48.2	59.2
	Primo CL	59.0	---	41.1	---	43.5	53.5	77.4	75.9	67.4	47.4	58.2
	Vault HP	58.4	---	49.1	---	38.1	52.2	81.6	69.0	72.2	46.0	58.1
	Average	59.7	---	45.1	---	40.3	54.8	79.1	74.0	69.5	47.6	---
	LSD (P=.05)	11.0	---	7.7	---	5.5	6.8	7.2	9.5	5.8	4.4	---

[1]Locations: BLK = Blackstone; MEC = Mechanicsville; ORG = Orange; PTR = Painter; SUF = Suffolk, WAR = Warsaw.

does not need most of these until later in the season. Plus you lose any nitrogen remaining in the residue by burning – so don't burn!

Regardless of how you manage the residue, make sure that you fertilize for both crops before small-grain planting. This practice will provide sufficient nutrients for both crops.

Are starter or pop-up fertilizers required? There is not enough data to justify starter or pop-up fertilizer on double-crop soybeans. However, recent research has suggested that a small amount of nitrogen injected between the rows slightly increases leaf area and yield. This research is ongoing.

Is there a need to inoculate soybeans to ensure adequate nitrogen fixation? Table 2 shows the effect of seed-applied inoculants on soybean yield from 18 experiments conducted on land that had a history of soybean in the rotation. Inoculants consistently increased yield in only one of the locations. At that location, soybeans had only been grown once, two years before this experiment was conducted. Most research says "no" if soybeans have been regularly grown in the field. However, research continues to evaluate various inoculant products in double-crop systems with new varieties and ever-increasing yield potentials.

PLANTING DATE

The main reason for reduced yield with double-crop soybeans is the late planting date. A general rule of thumb is that soybean yield in Virginia will be reduced by a half bushel per acre per day after mid-June. The reason for the reduced yields is that the soybean crop does not have enough time to develop a full canopy that efficiently captures 90 to 95 percent of the sunlight during the reproductive stages. In addition, reproductive development stages are shortened, allowing less time to fully develop pods and seed.

LEAF AREA, LIGHT INTERCEPTION AND YIELD

Planting in late June or early July does not usually allow sufficient time to develop sufficient leaf area to maximize soybean yield. Leaf area can be measured by leaf area index (LAI), which is the area of leaves per area of ground. Previous Virginia research has shown that an LAI of 3.5 to 4.0 is needed by early pod formation to maximize yield potential. In other words, soybeans need to accumulate 3.5 to 4.0 square feet of leaves for every square foot of ground to ensure that enough sunlight is captured during the reproductive stages. Without the necessary leaf area, yields will suffer.

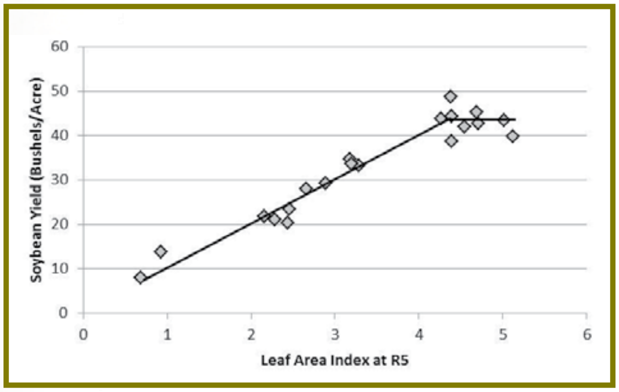

Figure 5: Effect of leaf area index on soybean yield in Suffolk, Va. (Malone, 2001). Leaf area indices were established by manually defoliating soybean leaves over a 1-month period from stage R2 until R5.

In addition to leaf area, late planting pushes the critical pod- and seed-fill stages into mid-August and September, when the days are shorter. Shorter days mean less light. Therefore, not only does the plant not have enough leaf area, the leaf area present will absorb less light per day compared with soybeans planted in April or May. Therefore, the lack of total light intercepted by double-crop soybeans reduces yield potential.

Figure 6 represents a typical soybean-yield response to planting date and maturity group. Yield begins declining sooner with early-maturing varieties due to an even shorter growing season.

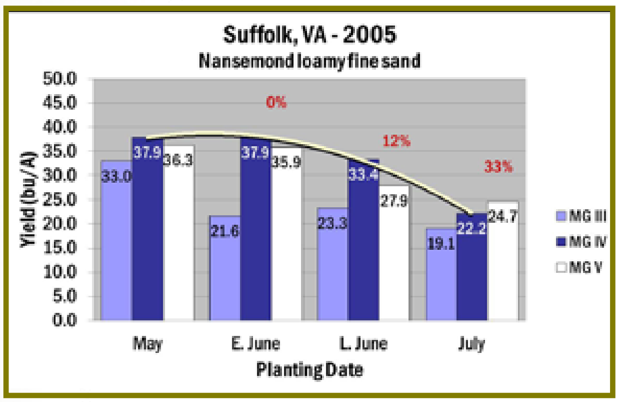

Figure 6: Effect of maturity group and planting date on soybean yield. Percentages shown are the estimated yield reduction of maturity group IV and V varieties.

Still, each year and field is different. If more rain falls when double-crop soybeans are producing seed than when full-season soybeans are producing seed, the yield disadvantage due to lack of growth can be minimized. In the examples in Figure 7, late-June-planted soybean yields were only reduced by about 10 percent.

Regardless of year-to-year and field-to-field variations, planting double-crop soybeans after mid June will result in, on average, a half-bushel/acre decrease in yield for every day delay in planting. So how do we minimize the disadvantages of late planting?

Since less light interception, largely because of lack of leaf area, is the main reason for low double-crop soybean yields, you must focus on those strategies that capture more total light during the growing season.

Strategies to Increase Light Interception – Plant As Early As Possible

One strategy is relay cropping, which is planting into unharvested wheat. This has several disadvantages; the most important being damage to the wheat, resulting in lower yields. Another is damaging seedling soybean plants by running over them with the combine. In general, this strategy has not proven effective in Virginia.

A more effective strategy can be using an early-maturing, high-yielding wheat variety. But beware – early-maturing wheat usually yields less than late-maturing varieties. Planting five days earlier is roughly the equivalent of 2.5 bushels/acre of soybeans. Depending on the relative value of each crop, this equals 4 to 5 bushels of wheat. As an alternative, barley, which matures approximately two weeks before wheat, allows an early-June planting, which provides for greater yield as shown in Figures 6 and 7.

Soybean variety selection is also important. Plant as late of a maturity group as possible that will mature before the first frost. This will allow more time for more growth. In addition, later-maturing varieties will perform better on less-productive soils for the same reason.

Finally and most importantly, plant the soybeans on the same day that you harvest the small grain. The planter or drill needs to be following the combine in the field on the same day.

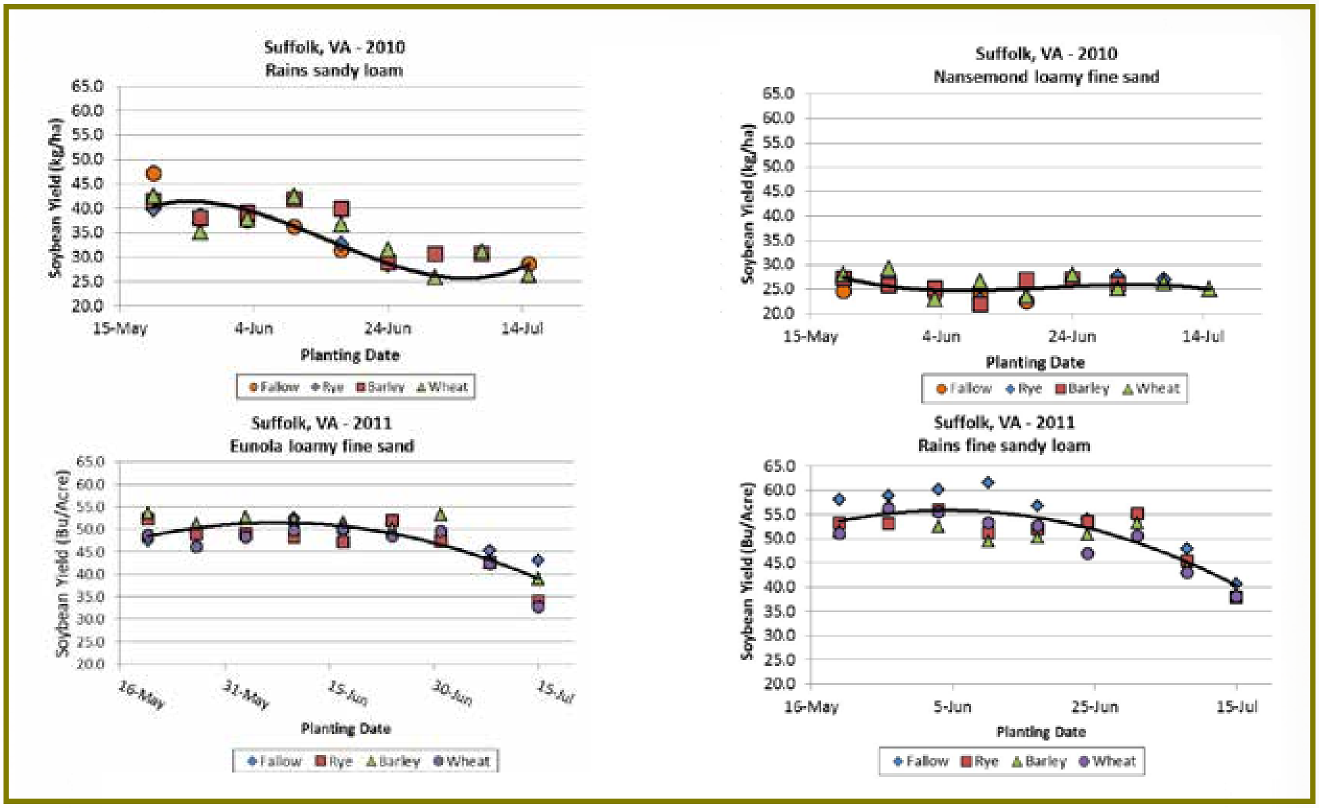

Figure 7: Effect of year, location, planting date, and previous crop (fallow - corn residue only, rye, barley, or wheat) on no-till soybean yield. Winter crops were either killed with herbicide two weeks before planting or harvested for grain.

Strategies to Increase Light Interception – Variety Selection

Select a variety that yields well in double-crop production systems. We occasionally see varieties, for one reason or another, that perform better in double-crop systems than in full-season systems. Of course, there may also be varieties that perform better in full-season than in double-crop systems. So pay attention to variety test data.

Strategies to Increase Light Interception – Narrow Rows and Uniform Stands

With double-crop soybeans, narrowing the rows will result in greater leaf area, therefore capturing more light than wider row spacing. Narrow rows will always obtain complete ground cover sooner and capture more light for a longer period of time.

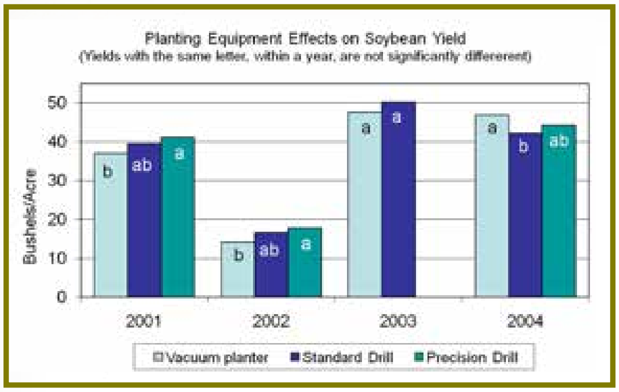

Figure 8: Effect of planting equipment on soybean yield. Soybeans were planted in 15-inch rows with the vacuum planter and in 7.5-inch rows with the standard and precision drills.

In addition to narrow rows, uniform stands or nearly equal spacing between plants within a row also matter. That is the reason that there is usually no yield advantage to using a drill over a narrow-row planter. The gaps that a standard drill leaves, using 50-plus-year-old technology, will hurt yield. Only if we can meter out the seed will we see an advantage of 7½-inch rows over 15-inch rows, as shown by the data in Figure 8.

In this research, conducted with farmer-owned equipment on large field-scale plots, we compared a 15-inch vacuum planter with a standard drill and a drill that meters out the seed. Both of the drills planted the soybeans in 7½-inch rows. In two of three years, the precision drill yielded more than the 15-inch planter. On the other hand, in three of four years, the 15-inch planter yielded just as much as the standard drill. In the final year of the study, the 15-inch planter out yielded the standard drill. **The take-home message is that uniform stands do matter, especially with double-cropped soybean.**

Strategies to Increase Light Interception – Proper Seeding Rate

More than 6 years of research in Virginia revealed that double-cropped soybeans planted in late June to early July need more than twice the number of plants per acre for maximum profit, compared with full-season soybeans. Plant-population recommendations (for adapted maturity groups) are:

- Full-Season: 80,000 to 100,000 plants/acre = 100,000 to 133,000 seeds/acre (75 to 80 percent emergence)
- Double-Crop: 180,000 to 220,000 plants/acre = 225,000 to 295,000 seeds/acre (75 to 80 percent emergence)

Table 3: Plant population suggestions for full-season and double-crop soybean in Virginia, and number of seeds per needed to obtain those plant populations.

	Desired Plant Population							
Row	Full-Season		Double-Crop Barley			Double-Crop Wheat		
Width	80,000	100,000	120,000	140,000	160,000	180,000	200,000	220,000
	(Seeds per foot assuming 80% emergence)							
36	6.9	8.6	10.3	---	---	---	---	---
30	5.7	7.2	8.6	---	---	---	---	---
24	4.6	5.7	6.9	---	---	---	---	---
20	3.8	4.8	5.7	6.7	7.7	8.6	9.6	10.5
18	3.4	4.3	5.2	6.0	6.9	7.7	8.6	9.5
15	2.9	3.6	4.3	5.0	5.7	6.5	7.2	7.9
10	1.9	2.4	2.9	3.3	3.8	4.3	4.8	5.3
7.5	1.4	1.8	2.2	2.5	2.9	3.2	3.6	3.9

Seeding rate = desired plant population density ÷ (43,560 sq. ft./acre ÷ row width in ft.) ÷ % emergence

Example: =180,000 ÷ (43,560 ÷ (15 ÷ 12)) ÷ 0.80
= (180,000 ÷ 34,848) ÷ 0.80
= 6.5 seed per ft. of row (15-inch row spacing)

As planting is delayed, increase seeding rate.
Use lower seeding rate on more productive soils.

However, this will vary greatly with year and field productivity. For instance, in 31 double-crop experiments, we found no yield response to plant population at four locations. At six locations, we found optimal plant population to be between 100,000 and 150,000 plants per acre. In 12 of the experiments, it took 150,000 to 200,000 plants per acre to maximize economic yield. Finally, in nearly one-third of these experiments, we needed over 200,000 plants per acre to maximize yield and profits.

Of course, the actual seeding rate that is needed on a particular farm will depend on where the field is located and how productive it is. In general, as one moves south, less seed is needed. Also, the more productive the field (therefore generating more leaf area), the less seed that is needed.

AIR AND SOIL TEMPERATURES AT PLANTING

Air and soil temperatures are much warmer in June and July, bringing good and bad issues. The good is that soybean will usually emerge much faster, assuming there is adequate moisture. Due to the rapid germination and emergence, there is less risk of planting too deep, though planting deeper than 1½ to 2 inches is usually not advised. The bad is that there is a risk of high-temperature inhibition of germination, but this will only occur if soil temperatures exceed 90 degrees Fahrenheit for several hours. Unprotected soil resulting from removal of residue will also result in rapid drying of the topsoil. Finally, the risk of seedling disease is much less due to less time for the disease to attack the emerging seedling – hence there is less need for a fungicide seed treatment.

Strategies for Warmer Air and Soil Temperatures

Maintain residue to protect the soil from high temperatures and rapid drying of soil.

Plant 1 to 1½ inches deep to ensure good soil-to-seed contact in moist soil. Deeper planting depths may also protect the seed from high temperature extremes.

There is less need to protect the seed with a fungicide seed treatment if conditions are right for rapid emergence. However, soybeans can still benefit from a fungicide seed treatment when wet or saturated soils persist at planting (as occurred in 2013).

COOLER SEED-FILL TEMPERATURES

Another advantage of late planting dates is the critical pod- and seed-development stages are pushed later into the season when days (late August to early September versus late July to early August). This could be viewed as a disadvantage because shorter days limit the amount of total sunlight absorbed; therefore, yield would suffer. Nevertheless, the days are also cooler. In the more southern parts of the United States, where double cropping is common, hotter days during these critical stages can be much more detrimental than shorter day lengths.

Seed-quality issues are less of a concern with late-planted soybeans. Poor seed quality is primarily due to *Phomopsis* seed decay, a disease that is favored by warm and humid conditions during soybean maturity stages (R7 through R8). Most double-crop soybeans enter the R7 stage (physiological maturity) one to two weeks later than full-season soybeans. Although the humidity can still be high in early to mid-October, the temperatures are usually much lower than in late September and early October, when full-season soybeans are maturing. Therefore, double-crop soybeans can remain in the field longer than full-season soybeans, with fewer seed-quality concerns.

Finally, cooler temperatures also favor foliar disease development. If you have a good soybean canopy and the relative humidity is high, foliar-disease incidence may be greater and develop more rapidly. One foliar disease in particular, *Cercospora* blight and leaf spot, is also the same organism that causes purple seed stain. Management of foliar disease will be discussed in more detail in the pest-management section.

Strategies for Cooler Seed-Fill Temperatures

Although seed quality is less of a problem, timely harvest is still important. In addition, the cooler temperatures that come later in the season mean less evaporation. Therefore, wet fields may hinder harvest. So harvest as soon as possible after soybeans reach 13 percent moisture.

PEST MANAGEMENT

Due to later planting date, pests in double-crop soybean may be greater or less of a problem, but it is difficult to make a general statement regarding this. Pest management will greatly depend on the pest in question. Certain weeds may be easier to manage and others more difficult. Likewise, specific insect pests and diseases may be avoided, but others may be more numerous or difficult to manage.

The amount of soybean growth will influence pest management – some pests do better in a full canopy (adequate leaf area), while others may prosper or do more damage when growth is lacking. Furthermore, the abundance of pests and their control will relate to the season and local environment. For detailed information on pest management, consult the Virginia Cooperative Extension publication 456-016, *Pest Management Guide Field Crops* (Herbert, 2014).

WEEDS

In general, weed control is easier due to the additional small-grain residue, residual herbicides used in the small grain and lack of soil disturbance. The small grain residue has been shown to provide a significant amount of weed control by itself, but farmers should not consider it their only solution. Weed control may be more difficult if the residue is removed. On the other hand, certain weeds may be larger, or half of the plant may have been cut off with wheat harvest, making control of such weeds at planting more difficult.

With Roundup Ready® and LibertyLink® varieties, there may be a temptation to wait to apply the burndown herbicide until after soybean emergence to allow additional weeds to emerge. It might appear that this practice saves time and possibly a later herbicide application. However, weeds will grow much faster during June and July than in April or May. Large weeds are more difficult to control, lead to more herbicide-resistance problems and cause lower yields by competing with seedling soybeans. The biggest mistake with double-crop planting may be to exclude a burndown herbicide. It is very important that a burndown herbicide be applied as soon as possible after planting. The proper attitude to take with double-crop soybeans is to start clean and stay clean!

There are also fewer choices for burndown herbicides in double-crop soybeans. Dicamba, or 2,4-D, should not be used as a burndown herbicide due to the soybean-injury potential and risk of drift to nearby susceptible crops. This could change with the introduction of 2,4-D- and dicamba-resistant varieties. The inability to include growth-regulating herbicides in the burndown will present a challenge in controlling weeds that exist at small-grain harvest.

Again, weeds may grow faster and compete more in double-cropped soybean fields. Many weeds are hard to control if they exceed the recommended leaf stage or height listed on the herbicide label. Therefore, timely postemergence-herbicide applications are a necessity.

Finally, due to the increasing incidence of resistance to glyphosate and other herbicides, incorporating residual herbicides into the burndown and/or postemergence applications is prudent. Due to faster weed growth, resistant weeds can be more of a problem in double-crop soybeans.

Double-Crop Weed-Management Strategies

- Maintain small-grain residue to reduce weed emergence and growth.
- Cut small grain as high as possible to remove as little weed leaf area as possible from weeds. More exposed leaf area will allow burndown herbicides to work better.
- Apply burndown herbicide(s) as soon as possible after planting. Glyphosate (Roundup®, Touchdown®, etc.), glufosinate (Liberty®) or paraquat (Gramoxone®, etc.) should be the foundation of a burndown program. Herbicide choice should depend on the weed species present and if the weeds present are resistant to glyphosate. Consider including a residual herbicide with the burndown, especially if weed-resistance problems are an issue. Certain residual herbicides can also help control emerged weeds.
- Apply postemergence herbicides before weeds reach 4 inches tall. This will ensure good weed control and reduce future herbicide-resistance problems. As with burndown herbicides, consider adding a residual herbicide to prevent future weed emergence and manage resistant weeds.

INSECT PESTS

Some insect pests are less of a problem in double-crop soybeans. For instance, soil insects are rarely a problem in double-crop soybeans due to faster early-season emergence and growth. In addition, other early-season pests, such as thrips or bean leaf beetles, are less of a problem.

Other insect pests can be more of a problem. A smaller canopy means less tolerance to defoliating insect pests. Remember that a soybean crop needs a leaf area index (LAI) of 3.5 to 4.0 to maximize its yield potential. Hence, full-season soybeans with an LAI of 6.0 have two extra layers of leaves; therefore, they could theoretically tolerate the loss of one-third of its leaf area. In contrast, double-crop soybeans with an LAI of 4.0 have little leaf area to spare and cannot tolerate very much leaf loss. Virginia research documented this phenomenon through some manual defoliation studies (shown below). Therefore, defoliating insects generally cause greater damage in double-crop soybeans. Fortunately, most defoliating insects cause little damage to soybeans – it takes great numbers to defoliate enough leaf area to significantly reduce yield. An exception is the soybean looper, a particularly devastating defoliating insect. It is not usually a problem in Virginia soybeans because it needs to migrate from southern areas and usually does not arrive in time or in great enough numbers to cause significant damage. Still, this pest has a greater probability of reducing yield in double-crop soybeans, which will be in earlier development stages that are more susceptible to yield loss from defoliators.

Defoliating pests are much less of an issue in Virginia than pests that feed on the pods and seed. Since double-crop soybeans mature later in the season, the pod and seed stages are more likely to coincide with the movement of insects from other crops, second generations or the arrival of migrating insects. For instance, full-season soybeans may avoid the main migration of corn earworms from corn by reaching the R6 stage (full pod) earlier. Soybeans are more resistant to feeding at that stage than at earlier stages. The stinkbug, a sucking pest that feeds on young developing seed (R5 stage), could also cause more damage in double-crop soybeans for the same reasons. Still, population density and infestation timing will vary with the year; therefore,

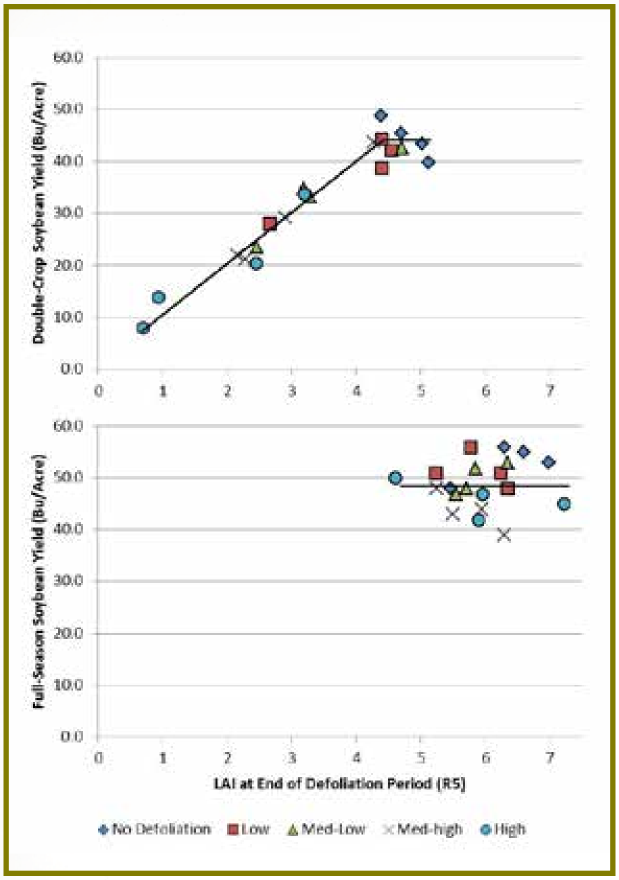

Figure 9: Relationship between LAI and yield at five different levels of manual defoliation for double-crop (upper graph) and full-season soybeans (lower graph) (Malone, 2001).

trends may not always hold true. Regardless, it is especially important to scout double-cropped fields to protect the vulnerable late-pod (R4) and early-seed (R5) stages.

The arrival of kudzu bugs will likely change how we manage insects in Virginia. Although less is known about this sucking pest, it does not appear to be more attracted to double-cropped fields than to full-season soybeans. The past two growing seasons (2012 and 2013) indicated that kudzu bugs are more attracted to full-season soybeans and tend to stay in earlier-infested fields. But 2014 is not fitting that pattern so far, indicating that there is still much to learn about this pest. With rapid vegetative growth being a priority for double-crop soybeans, it is possible that this pest could have a more devastating effect in that system.


STINK BUG


KUDZU BUG

Although not particular to double-crop soybeans, everyone must recognize that insecticides can kill or harm beneficial insects and other organisms. Prophylactically spraying for insects that are not present or below the economic thresholds will only reduce beneficial populations and release insect pests in greater numbers. For example, spraying with a pyrethroid insecticide will kill most insects (pests and beneficials) but have little effect on soybean loopers. Without beneficials to help in its control, soybean loopers can rapidly defoliate a soybean field during the critical seed-development stage.

Double-Crop Insect-Pest-Management Strategies

- Regularly scout all fields. Pay particular attention to areas of poor growth, as these are more susceptible to defoliating insects.
- Always base insecticide sprays on established economic thresholds. Spraying for insect pests below economic thresholds only disrupts biological control and leads to insecticide-resistance issues.

DISEASE

As alluded to earlier, seedling diseases are less of a problem in double-crop soybeans; therefore, fungicide seed treatments are not usually needed. A smaller canopy also provides a less conducive environment for foliar soybean diseases. Additionally, diseases that lower seed quality, such as anthracnose or *Phomopsis* seed decay, are less prominent because double-crop soybeans mature later in the year when temperatures are lower and not as conducive to disease development.

Although the canopy is not usually as large, more foliar diseases, such as frogeye leaf spot or *Cercospora* blight and leaf spot, could be present later in the year when double-crop soybeans move into the pod- and seed-development stages, when soybeans are more vulnerable to disease.

With this in mind, you must ask, "Will foliar fungicides pay in double-crop soybeans?" Yes, they will pay if you have:

1. High levels of a yield-robbing agent (pathogen)
2. A disease present on a susceptible variety (host)
3. Conditions occurring under optimal temperatures and relative humidity (environment)

These three conditions make up the familiar Disease Triangle (see figure 10). If any one of these components of the triangle is missing, the disease is prevented, and foliar fungicides will not pay.

Lack of a yield-robbing disease is not usually due to the lack of the pathogen or strong resistance in the soybean variety (few if any soybean varieties have resistance to *Cercospora* blight) but to the lack of environmental

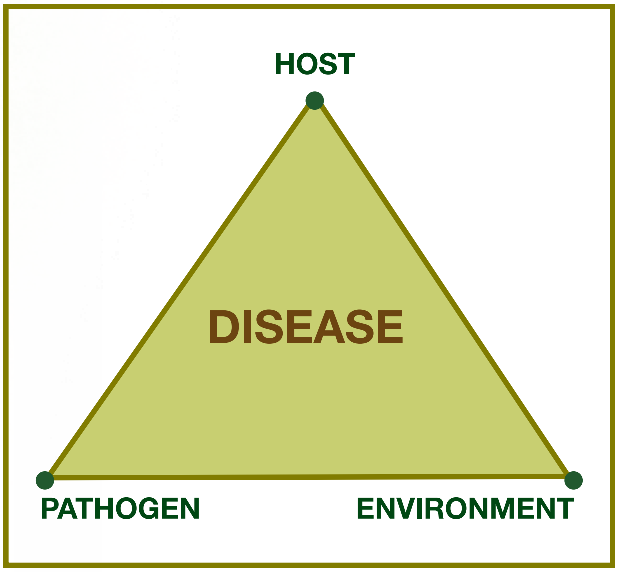

Figure 10: Plant triangle. For disease to develop, a yield-robbing disease must be present on a susceptible host under optimal environmental conditions.

conditions ideal for disease development. For most soybean pathogens, at least two consecutive days of optimal relative humidity (greater than 95 percent for 10-12 hours), and temperatures between 68 and 77 degrees Fahrenheit are ideal for pathogen infection. Since double-crop soybeans mature later in the year, these conditions are more likely to be met. Still, conditions need to remain favorable for additional disease development – dry or hot conditions will reduce disease.

Numerous small-plot and on-farm experiments in Virginia indicate that, on average, fungicides prevent yield loss in soybeans only about one-third of the time. However, in recent research, double-crop soybean yield was greater with fungicide application in 50 percent of the experiments (Dillon, 2014). This research indicated that double-crop soybeans might be more susceptible to foliar disease than full-season soybeans. However, researchers noted that in addition to optimal temperature and relative humidity, adequate soybean canopy was also required for a yield response. In other words, the environment within the soybean canopy allows a pathogen to develop into a yield-robbing disease. If the canopy is not fully closed (LAI is between 3.5 and 4.0), there is a lower probability that disease will develop. Another interesting finding with this research was that the R3 stage (early pod) is not always the best time to make a fungicide application. In some cases, environmental conditions were better for disease development at later stages, and applying fungicides too early resulted in less disease control and yield response.

Another problem is that foliar fungicides are generally preventive and do not offer control for more than two to three weeks. For adequate control, fungicides must be applied before the disease builds up to harmful levels. Even if all conditions are conducive to disease at the time of application, conditions afterward may not be. Or if the fungicide is applied too early when the environment is not optimal but it becomes optimal later, fungicide activity may no longer be great enough to control the disease. Regardless, without a good predictive system for foliar disease, we may never be very accurate with our soybean-fungicide applications. To complicate things further, we have seen soybean varieties vary in their response to foliar fungicides (see figure below). Therefore, variety selection may also need to be integrated into disease-management decisions.

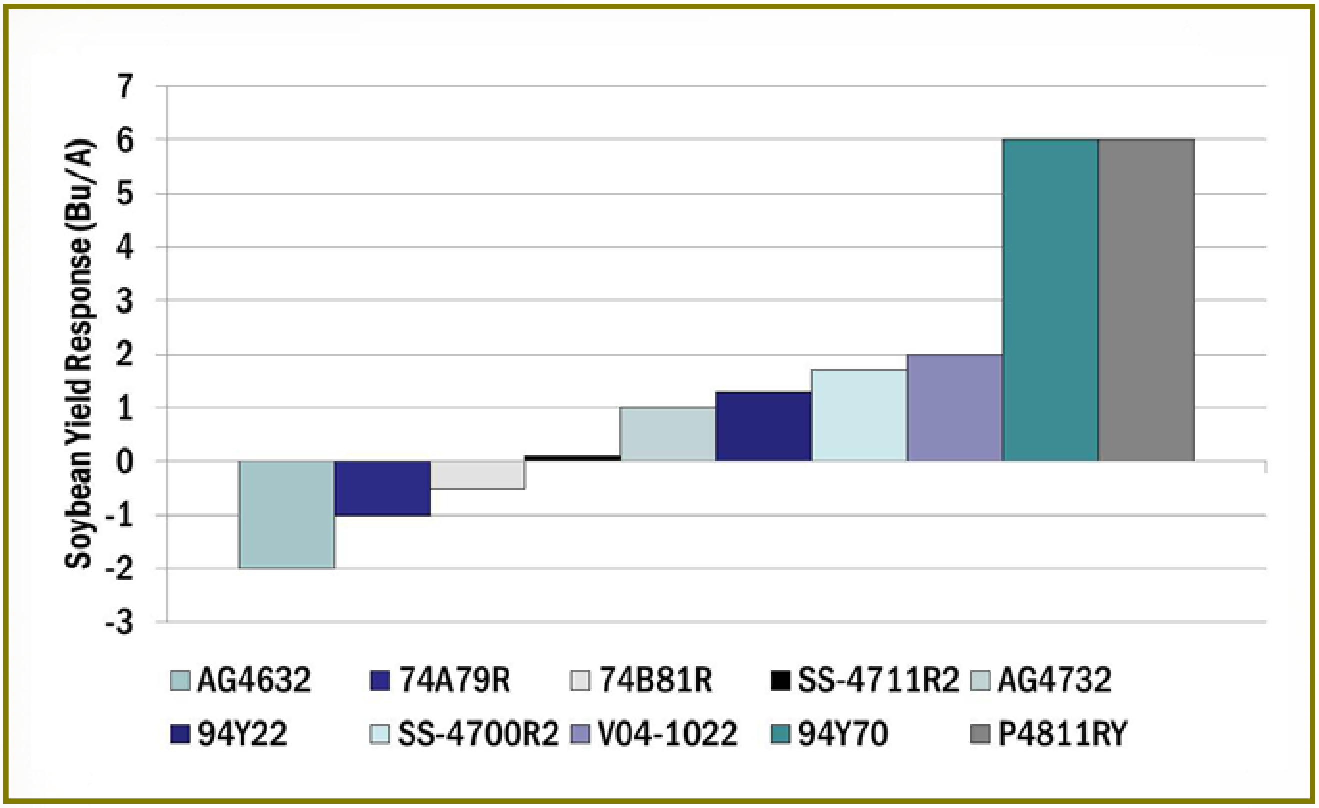

Figure 11: Variety specific yield response to foliar fungicide at Painter, Va., 2012. This is only an example of how varieties respond to yield. Results and ranking of varieties varied with year and location.

Finally, resistance management needs to be considered. Over-application of fungicide can lead to its ineffectiveness. Therefore, it is important to apply fungicide only if a disease is present and conditions are conducive for its further development. In addition, using two fungicides with different modes of action will help preserve their effectiveness and usually give better control.

Similar to insect-pest management, the season and environment will largely determine the amount of disease and likelihood of obtaining a yield response with fungicides. There is a great need for an effective weather model to predict foliar diseases in soybeans! Virginia Tech researchers are now validating a decision aid with on-farm trials that should assist future fungicide applications. Better disease-resistance information on specific varieties is also needed for more targeted disease management.

Double-Crop Disease-Management Strategies

- Unless soils are wet at planting (delaying emergence), there is less need for a fungicide seed treatment.
- Plant disease-resistant varieties, if available.
- Scout fields for disease signs throughout the season. Send plant samples to a qualified lab for proper identification.
- Beginning at flowering (R1-R2), scout for foliar disease and begin monitoring weather conditions. If the environment is conducive to disease development after R3 (early pod), apply a foliar fungicide containing two modes of action.

NEMATODES

There is less time for nematodes to feed in double-crop soybeans; therefore, double cropping may be a good long-term strategy. However, with less yield potential, there is less ability to outgrow damage. In general, there is little difference in nematode management between full-season and double-crop soybeans. Once identified as a problem, control strategies can be implemented. Resistant varieties and rotation to nonhosts will reduce numbers. There are a few nematicide seed treatments, but they provide limited control. For detailed information on soybean nematode management, refer to VCE publication AREC-9, *Soybean Nematode Management Guide* (Holshouser et al., 2011).

Double-Crop Nematode-Management Strategies

- Determine if nematodes are a problem by digging plants and having a trained plant pathologist identify the nematode by species (diagnostic sample).
- Sample confirmed and other suspected fields to determine the species and numbers (predictive sample). If soybean cyst nematode is confirmed, more detailed sampling may be needed in order to determine the type (commonly referred to as the race).
- Implement the following management options if nematode numbers justify control:
  - Prevention and sanitation: Prevent the spread to other fields by thoroughly cleaning equipment before moving into an uninfested field.
  - Rotate to a nonsusceptible crop.
  - Use resistant varieties. Note that varieties listed as moderately resistant will not usually lower nematode numbers; therefore, it is not usually a good long-term strategy.
  - Treat seed with nematicide. Note the nematicides do not usually reduce nematode numbers but only offer early-season protection.

DOUBLE-CROP AND FULL-SEASON SOYBEAN BUDGETS

Double-crop small-grain-soybean systems are usually more profitable than either crop grown alone. This is mainly due to the increased net income gained from additional production. Production efficiency gains are also important, though less quantifiable.

The economics of double-crop versus full-season soybeans will depend on yield potential, crop price and cost of production. A high-yielding small-grain crop is a prerequisite for a profitable double-cropping system. Therefore, closely follow extension recommendations for intensive small-grain production (Thomason, 2014). The yield disadvantage of double-crop soybeans can be minimized by following the suggestions previously discussed. Crop prices may vary widely over time; therefore, using multiyear averages is usually best when determining long-term profitability. Costs may also vary widely with year and location, but are largely dependent on the individual farm operation.

Budgets for full-season soybeans, double-crop wheat-soybeans and double-crop barley-soybeans, are shown in Figures 12 and 13 (pages 22 and 23). These budgets will change substantially with yield and price estimates. Costs are only estimates for comparison purposes and will vary depending on year, location and the individual farming operation. Equipment costs are based on new equipment and a 10-year depreciation schedule. Realize that these budgets are typical, or average, in nature, rather than fitting any given farm situation. Users of these budgets would be expected to modify them to fit their particular operation.

Not all production efficiency gains with a double-cropping system that helps make it more profitable are represented in these budgets. Land and certain inputs (e.g., lime) charges can be allocated over two crops easily. But these budgets do not include the following factors:

- Advantages of allocating labor over the entire year
- More rapid equipment depreciation
- Better distribution of capital (income and expenses) due to additional harvests and field operations being more evenly spread throughout the year
- Better distributed cash flow throughout the year
- Environmental benefits

Although difficult to quantify, such advantages need to be considered.

FULL-SEASON SOYBEANS - RR, No-Till (Group 1 - 3 Soils)

ESTIMATED COSTS AND RETURNS PER ACRE

		UNIT	QUANTITY PER ACRE	PRICE OR COST/UNIT	TOTAL PER ACRE	YOUR FARM
						Acres 1
1. GROSS RECEIPTS						
SOYBEANS		BU.	40.00	$12.70	$508.00	
TOTAL RECEIPTS:					**$508.00**	
2. PRE-HARVEST VARIABLE COSTS						
SEED: SOYBEANS-RR		BAG	0.80	$50.00	$40.00	
FERTILIZER*	Soil Test Recommendation					
NITROGEN		LBS	0.00	$0.57	$0.00	
PHOSPHATE		LBS	32.00	$0.70	$22.40	
POTASH		LBS	56.00	$0.70	$39.20	
FERTILIZER APPLICATION		ACRE	1.00	$7.25	$7.25	
LIME (PRORATED)		TON	0.50	$15.75	$7.88	
HERBICIDES		ACRE	1.00	$22.62	$22.62	
INSECTICIDES		ACRE	1.00	$3.12	$3.12	
FUNGICIDES		ACRE	1.00	$4.61	$4.61	
CHEMICAL APPLICATION		ACRE	0.00	$8.50	$0.00	
FUEL, OIL, LUBE		Eq Gallons	1.21	$3.41	$4.13	
REPAIRS		ACRE	1.00	$7.48	$7.48	
PRE-HARVEST LABOR		HRS	0.21	$14.50	$3.05	
CASH RENT OR LAND CHARGE		ACRE	1.00	$70.00	$70.00	
CROP INSURANCE		ACRE	1.00	$20.00	$20.00	
SCOUTING		ACRE	1.00	$0.00	$0.00	
OTHER COSTS		ACRE	1.00	$0.00	$0.00	
PRODUCTION INTEREST	6	MONTHS	$125.87	6.0%	$7.55	
TOTAL PRE-HARVEST COSTS			**$6.48**	**PER BU.**	**$259.29**	
3. HARVEST VARIABLE COSTS						
FUEL, OIL, LUBE		Eq Gallons	3.33	$3.41	$11.37	
REPAIRS		ACRE	1.00	$13.68	$13.68	
HARVEST LABOR		HRS	0.20	$14.50	$2.90	
HAULING		BU.	40.00	$0.25	$10.00	
STORAGE		BU.	40.00	$0.00	$0.00	
DRYING		BU.	40.00	$0.00	$0.00	
TOTAL HARVEST COSTS:			**$0.95**	**PER BU.**	**$37.95**	
	Breakeven Yield		Breakeven Price			
4. TOTAL VARIABLE COSTS	**23**	**Bushels**	**$7.43**	**PER Bushel**	**$297.24**	
5. RETURN OVER TOTAL VARIABLE COSTS					**$210.76**	
6. MACHINERY FIXED COSTS (BASED ON NEW EQUIPMENT COST)						
TRACTOR & MACHINERY		ACRE	1.00	$42.84	$42.84	
7. OTHER FIXED COSTS						
GENERAL OVERHEAD		DOL.	$297.24	8.0%	$23.78	
8. TOTAL FIXED COSTS:					**$66.62**	
			Breakeven Price			
9. TOTAL VARIABLE & FIXED COSTS			**$9.10**	**PER Bushel**	**$363.86**	
10. PROJECTED NET RETURNS TO LAND, RISK AND MANAGEMENT:					**$144.14**	

* This BUDGET is for PLANNING PURPOSES ONLY. Fertilizer rates are based on projected nutrient removal of harvested crop.

* Fertilizer requirements will vary with application method, manure use and/or residual nutrient levels in the soil.

Figure 12

DOUBLE-CROP WHEAT-SOYBEANS RR, No-Till (Group 1 - 3 Soils)					
ESTIMATED COSTS AND RETURNS PER ACRE					**Acres**
					1
	UNIT	QUANTITY PER ACRE	PRICE OR COST/UNIT	TOTAL PER ACRE	YOUR FARM
1. GROSS RECEIPTS					
WHEAT	BU	80.00	$6.08	$486.40	
SOYBEANS	BU	34.00	$12.70	$431.80	
TOTAL RECEIPTS:				**$918.20**	
2. PRE-HARVEST VARIABLE COSTS					
SEED: WHEAT	BAG	2.50	$13.50	$33.75	
SEED: SOYBEANS-STS	BAG	1.60	$45.50	$72.80	
FERTILIZER*	Soil Test Recommendation				
NITROGEN	LBS	130.00	$0.68	$88.40	
PHOSPHATE	LBS	77.00	$0.74	$56.98	
POTASH	LBS	78.00	$0.55	$42.90	
FERTILIZER APPLICATION	ACRE	1.00	$7.25	$7.25	
LIME (PRORATED)	TON	0.50	$15.75	$7.88	
HERBICIDES	ACRE	1.00	$25.09	$25.09	
INSECTICIDES	ACRE	1.00	$3.12	$3.12	
FUNGICIDES	ACRE	1.00	$4.61	$4.61	
CHEMICAL APPLICATION	ACRE	0.00	$8.50	$0.00	
FUEL, OIL, LUBE	Eq Gallons	2.75	$3.41	$9.38	
REPAIRS	ACRE	1.00	$15.31	$15.31	
PRE-HARVEST LABOR	HRS	0.48	$14.50	$6.96	
CASH RENT OR LAND CHARGE	ACRE	1.00	$70.00	$70.00	
CROP INSURANCE	ACRE	1.00	$40.00	$40.00	
SCOUTING	ACRE	1.00	$0.00	$0.00	
OTHER COSTS	ACRE	1.00	$0.00	$0.00	
PRODUCTION INTEREST	6 MONTHS	$242.22	6.0%	$14.53	
TOTAL PRE-HARVEST COSTS				**$498.96**	
3. HARVEST VARIABLE COSTS					
FUEL, OIL, LUBE	Eq Gallons	6.67	$3.41	$22.74	
REPAIRS	ACRE	1.00	$27.24	$27.24	
HARVEST LABOR	HRS	0.40	$14.50	$5.80	
HAULING	BU.	114.00	$0.25	$28.50	
STORAGE	BU.	114.00	$0.00	$0.00	
DRYING	BU.	114.00	$0.00	$0.00	
TOTAL HARVEST COSTS:				**$84.28**	
4. TOTAL VARIABLE COSTS				**$583.24**	
5. RETURN OVER TOTAL VARIABLE COSTS				**$334.96**	
6. MACHINERY FIXED COSTS (BASED ON NEW EQUIPMENT COST)					
TRACTOR & MACHINERY	ACRE	1.00	$90.90	$90.90	
7. OTHER FIXED COSTS					
GENERAL OVERHEAD	DOL.	$583.24	8.0%	$46.66	
8. TOTAL FIXED COSTS:				**$137.56**	
9. TOTAL VARIABLE & FIXED COSTS				**$720.80**	
10. PROJECTED NET RETURNS TO LAND, RISK AND MANAGEMENT:				**$197.40**	

* This BUDGET is for PLANNING PURPOSES ONLY. Fertilizer rates are based on projected nutrient removal of harvested crop.

* Fertilizer requirements will vary with application method, manure use and/or residual nutrient levels in the soil.

Figure 13

REFERENCE LIST

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