SEARCHING FOR INPUTS TO INCREASE SOYBEAN YIELD

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Abstract

Commodity prices and production costs are both at higher levels than in prior periods, encouraging growers to maximize returns by managing costs and raising yields. We conducted experiments at three Illinois sites in 2012 to evaluate foliar fertilizer, foliar insecticide, lactofen herbicide, seed treatment, foliar fungicide, foliar fungicide + foliar insecticide, cytokinin, , and fertilizer N, alone or in combinations of factors, including some “deletion” treatments. Serious drought through the first half of the season was relieved by rainfall starting in August, and yields averaged 65 bushels per acre across locations. None of the independent factors or combinations of factors increased yields compared to the control at P = 0.1, though the “All” package, with seed treatment, foliar fungicide, insecticide, and fertilizer N yielded more than a few single-addition treatments, and deleting insecticide from this package decreased yield. From these results we conclude that while individual inputs and combinations of inputs may sometimes increase soybean yield, they will not do this consistently.

Introduction

Soybean and other commodity oilseed prices have increased over the past decade, reflecting global growth in demand for edible oil and meat protein. This demand is projected to accelerate in the foreseeable future (FAO, 2012). Increased demand coupled with increasing input costs, cash rent, and land prices (Duffy and Smith, 2013) combine to make production agriculture competitive, with successful growers looking for ways to increase yield or reduce production risk and cost per bushel. Increasing the “intensity” of soybean management – increasing input expenditures that provide a positive return – could be a means of achieving these goals.

Pesticides are a common management tool, and it is well established that pesticides increase profitability when biotic organisms reach economic injury levels. Some registered pesticides also produce physiological effects unrelated to disease or pest control. Strobilurin fungicides can, for example, increase leaf greenness, delay senescence, and increase yield in the absence of foliar disease (Grossmann and Retzlaff, 1997; Grossmann et al., 1999). Swoboda and Pedersen (2009) found that strobilurin fungicide in the absence of foliar disease increased stem weight and leaf area index (LAI), but not yield. However, Jeschke and Ahlers (2012) reviewed DuPont Pioneer’s small plot and on-farm research from across the US Corn Belt, and found that fungicide increased yield by 3.1 bu/ac, and foliar fungicide plus insecticide increased yield by 4.9 bu/ac. Disease and insect pressure was not recorded in these trials.

Soybean yield increases from seed-applied pesticides have been found to be inconsistent. Most authors indicate yield increases are highly dependent on the environment (Bradley, 2008; Esker and Conley, 2012). Environments most conducive to yield increases from fungicide seed treatments are those where precipitation soon after planting and poorly-drained soil combine to increase potential for stand loss (Dorrance et al., 2009; Bradley, 2008). Such oxygen-restricted soil conditions decrease or delay seed germination and emergence, and often leading to development of fungal diseases such as *Phytophthora sojae*. Esker and Conley (2012) conducted an economic analysis of seed treatment use in soybean production, and concluded that growers can expect to at least return the costs of seed treatment when commodity prices are good and seed treatments are reasonably priced. Chances of a positive economic return were increased by the addition of an insecticide to fungicidal seed treatment.

Higher soybean prices have also spurred a great deal of activity in developing and marketing "non-traditional" inputs. Some of these are novel, some are not, but not all have a sound rationale for their use. Nitrogen fertilizer is not often used on soybeans in the US Corn Belt, but because soybean has a large N requirement – about 4.7 lb N per bu (Salvagiotti et al., 2008) – and N fixation has a metabolic cost, adding some N as fertilizer has been tried for decades as a way to increase yield and profit. The metabolic cost to the plant for fixing its own N has been estimated at 14% of growth respiration (Finke et al. 1982). Biological N_2 fixation (BNF) can also be unreliable under non-optimal environmental conditions, including saturated soils (Bacanamwo and Purcell, 1999), and drought (Sprent, 1976). In a recent review, Salvagiotti et al. (2008) suggested that soybean yield is most likely to be increased by supplemental N fertilizer at yields greater than 70 bu/ac. In such environments, soil N supply coupled with BNF may not meet the high demand for N. Still, most reported research has shown that fertilizer N is unlikely to increase soybean yield consistently, or by enough to cover the cost, regardless of yield level.

In-season management with foliar-applied macro- and micronutrients can increase yields in certain situations, but such responses are less frequent than those from pesticides or N fertilizer (Mallarino et al., 2001). Lactofen, the active ingredient in Cobra® and Phoenix® herbicides, is used for post emergence control of weeds in soybean (Wessel and Butzen, 2012). It also provides some suppression of white mold (*Sclerotinia* stem rot) if applied at early flowering on susceptible cultivars (Oplinger, 1999). Lactofen has also been promoted by some as a way to increase branching, node number, and yield when applied during early vegetative growth. Such applications usually cause some leaf damage, and can sometimes defoliate plants. Depending on recovery conditions and timing, such loss of leaf area might decrease light interception into reproductive stages, which can lower yields (Ma et al., 2002).

With higher soybean prices, growers want to protect or enhance yield with management inputs whenever such inputs are expected to provide a positive return. Because yield responses to most such inputs are considered both inconsistent and unpredictable, the decision to use them is usually influenced by publicity and marketing, more than informed by careful comparisons. Part of marketing includes raising questions or making assertions regarding synergies among these factors as well. Our objectives were to (i) evaluate several common and some non-traditional management factors independently, (ii) and to determine the effect of combinations of management factors on the grain yield of soybean.

Materials and Methods

Studies were conducted in 2012 at the University of Illinois Crop Sciences Research & Education Centers at DeKalb, in north-central Illinois, at Urbana, in east central Illinois, and at

Brownstown, in south central Illinois. Soils at DeKalb and Urbana are highly productive silt loam or silty clay loam, and at Brownstown is a Cisne silt loam with a natural claypan.

Soybeans were planted in 15-inch rows at all sites, with Pioneer variety 92Y80 planted on May 22 at DeKalb, Asgrow AG3832 planted on May 19 at Urbana, and Pioneer 94Y80 planted on May 31 at Brownstown. Plots were seven rows wide by 28 to 36 ft. long. Treatments were arranged a in randomized complete block design with four replications.

There were 16 treatments, including eight – foliar fertilizer, foliar insecticide, lactofen, seed treatment (fungicide and insecticide), seed treatment + *Bradyrhizobium* inoculant, foliar fungicide, foliar fungicide + insecticide, and N fertilizer were all included as single-factor "additions" (Table 1). Seed treatment, foliar fungicide, foliar fungicide + insecticide, and N fertilizer were applied in a combination designated as "All". Each of these inputs was dropped singly from the "All" package to form four "deletion" treatments. The final two treatments consisted of adding lactofen (Cobra®) and cytokinin (X-Cite from Stoller Enterprises) to the "All" package. Rates and timing of applications are in Table 3.

Four of the seven center rows (5 ft.) were harvested for grain yield with a small plot combine. Statistical analysis was performed with PROC MIXED in SAS (SAS Institute, 2012). Treatments did not interact with location; therefore, grain yield was analyzed across location. Means were separated at alpha = 0.1.

Table 1. Description of treatments.

Input	Timing	Active ingredient(s) and rate(s)
Lactofen	V4	Lactofen - 12 fl oz/acre
^Fol. fertilizer	V6	N, P, K, B, Co, Cu, Fe, Mn, Mo, Zn - 64 fl oz/acre
Seed treatment	Planting	Pyraclostrobin 0.4, metalaxyl 0.8, imidacloprid 1.6 fl oz/100 lb seed
Seed trt. + inoculant	Planting	Bradyrhizobium + [$]LCO - 2.8 fl oz/100 lb seed
Fol. fungicide	R3	Pyraclostrobin - 6 fl oz/acre
Fol. insecticide	R3	Lambda-cyhalothrin - 2 fl oz/acre
N fertilizer	V4	Urea+Agrotain - 75 lb N and ESN - 75 lb N/acre
PGR	V6	Cytokinin - 16 fl oz/acre

^Product is Task Force 2
[$]LCO - lipooligosaccharide

Results and Discussion

The first half of the 2012 growing season was one of the warmest and driest on record, with a resumption of normal to above-normal rainfall coming in August (Table 1). Despite poor early reproductive conditions, yields were good, averaging 67, 76, and 51 bu/acre at DeKalb, Urbana, and Brownstown, respectively.

Analyzed across sites, the effect of treatment was not significant (Pr>F = 0.67). There were a few differences identified by contrasts that will be discussed below, but we have to conclude that no treatment stood out as having a consistent effect, especially an effect that we would expect to see again under similar conditions.

None of the eight “addition” treatments produced a yield different than the control when averaged across sites (Table 3). We expect that the warm, dry conditions limited development of seedling or foliar diseases, hence provided little opportunity for a yield response from disease control. Bradley (2008) reported similar results under similar conditions. The lack of response to foliar fungicide also suggests little or no physiological response, which result is similar to that reported by Swoboda and Pedersen (2009). Podsetting was limited by hot, dry conditions throughout July, and only accelerated after rainfall in August, several weeks after fungicide application.

Despite what might have been a reduction in N fixation under dry conditions (Sprent, 1976), we found no yield response to application of 150 lb N/acre, or close to half the amount of N the crop would have taken up. It’s likely that the N we applied at stage V4 was not moved into the soil very well under such dry conditions, and its availability to the crop was never very high. Nitrogen from soil organic matter would have become available as well before rain returned in August, and so even if BNF was decreased by the plant’s need to devote much of its photosynthetic capacity to reproductive growth late in the season, N was not limiting whether it had been applied as fertilizer or not.

The “All” combination of inputs yielded more than the single-factor additions of foliar insecticide or fungicide + insecticide, but the only “deletion” treatment that lowered yield compared to the “All” package was deletion of the foliar fungicide + insecticide treatment (Table 3). While we need to remember that single comparisons like this can be influenced by chance (for example, that one or two plots happened to be in higher- or lower-yielding parts of a field), it is intriguing that, averaged across sites, it’s intriguing that the only treatments with foliar insecticide seemed to have any effect on yield, adding yield when all other inputs were present but not when added on its own. It’s possible that effect on beneficial inputs might have been more important than those on harmful insects, none of which were noted in any case. None of the other “deletion” treatments affected yield compared to the “All” package.

Adding lactofen or PGR (cytokinin) to the “All” package of inputs had no significant effect on yield (Table 3). Lactofen did produce some foliar damage, but any growth reduction due to this might have been insignificant compared to growth reduction due to drought, and the revival of the crop’s prospects after rainfall in August was probably not much affected by small differences in vegetative growth before that. While soybean often produces more leaf area than is needed for maximum light interception (Nafziger, 2009), defoliating the canopy is counterintuitive to managing soybean for high yields, and may pose a risk when conditions are not favorable for recovering lost leaf area.

We fully understand that single trials, or even several trials with results combined over different soils and seasons, cannot “prove” that treatments “don’t work.” As our results here indicate, however, it is not easy to find treatments or combinations of treatments – even those considered by some now to be “routine” – that will produce consistent increases in yield large enough to cover their costs. While there are enough data to indicate that fungicides should be used when fungal diseases (that are controlled by the fungicide) threaten, that insecticides should be considered when insects reach economic thresholds, that herbicides are often very helpful, and that crop nutrients can alleviate deficiencies, we need to carefully and realistically balance costs, both environmental and economic, when we consider applying “solutions” to problems that we can’t really see in our fields.

Table 2. Monthly precipitation at the three sites in 2012.

Location	May	June	July	Aug	Sept
	---------------------inches---------------------				
DeKalb	2.87	0.81	2.26	2.61	1.31
Urbana	3.14	2.20	0.81	6.04	6.35
Brownstown	4.44	0.99	0.03	8.94	7.41

Table 3. Effects of inputs and combinations of inputs on soybean yield. Data are averages across three Illinois sites in 2012. Means followed by the same letter are not significantly different at P = 0.1.

Category	Treatment	Yield	
		bu/acre	
Untreated check	Untreated check	65.6	ab
Additions to check:	Seed treatment	64.4	abc
	Foliar fertilizer	67.0	ab
	Lactofen	66.4	ab
	Foliar fungicide	64.3	abc
	Foliar insecticide	63.4	bc
	Fol. fungicide + insecticide	63.5	bc
	Fertilizer N	64.7	abc
"All" package	Seed trt, N, fol. fert, fung, ins	68.7	a
Deletions from All:	No foliar fungicide	65.2	abc
	No fertilizer N	66.1	ab
	No fol. fungicide or insecticide	60.7	c
	No seed treatment	64.8	abc
Additions to All:	All + lactofen	64.1	abc
	All + PGR	65.1	abc

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