Analysis of Yields and Profitability of Utilizing Blended Soybean Seed in Kansas

by

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ABSTRACT

Kansas farmers must continue to find ways to alleviate risk and increase profits, especially in a challenging agriculture economy. This study analyzes the economic feasibility of blending two different soybean seed varieties together to create a blended variety of soybean seed. Utilizing eight years of plot data (2012-2019) across fifteen plot locations in Kansas, an analysis is conducted comparing blended soybean seed varieties to single soybean seed varieties.

A single-factor analysis of variance is used to analyze the difference in yields between blended soybean varieties and single soybean varieties. A partial budget analysis is used to evaluate economic feasibility. Results show two years, 2012 and 2013, having statistical significance in yield difference, with higher yields for blended varieties. Results of analysis by location show six out of fifteen locations having statistical significance, with higher yields by blending soybean varieties. An overall analysis of the combined data set shows a 4.68 bushel per acre yield advantage by blending soybean seed varieties. A partial budget analysis shows an increase in net revenue per acre of $30.14, using a $10 cost premium on blended soybean seed varieties.

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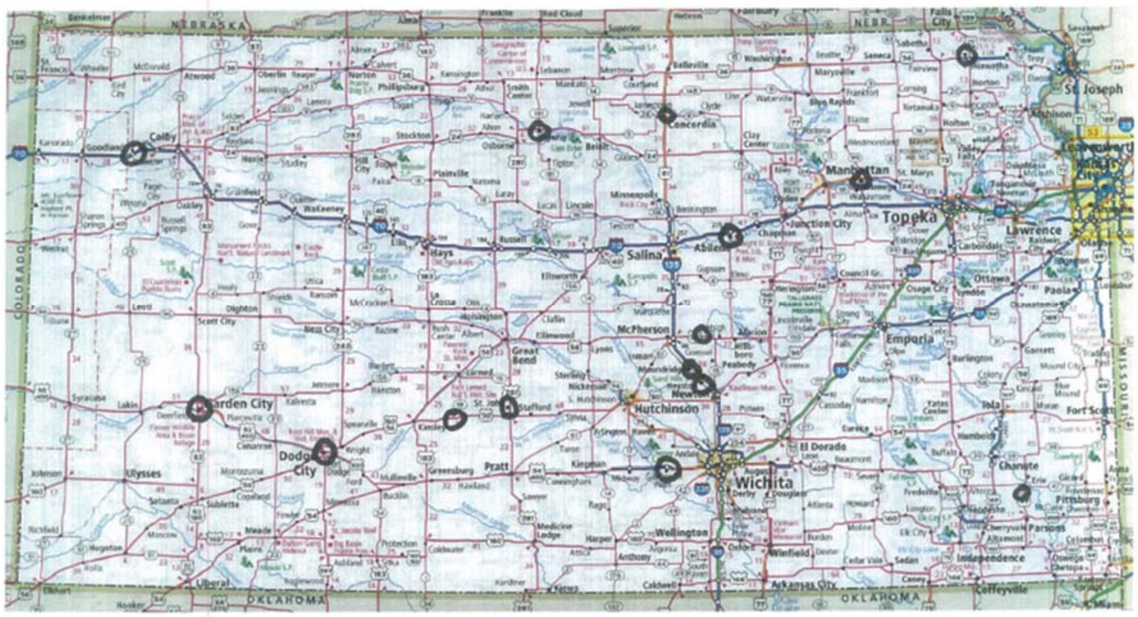
CHAPTER I: INTRODUCTION

For years, Kansas wheat farmers and seed dealers have used blended seed varieties to create a single variety of seed to optimize wheat production. The perceived advantages of this approach include yield stabilization, higher profits, and reduction in pest pressure (Agronomy 2012). However, there is limited research pertaining to blending soybean seed varieties and the effects on economic return. Therefore, yield and financial analysis is needed to understand the feasibility of blending soybean seed varieties into one variety to optimize economic returns.

Traditionally, soybean seed companies would analyze soybean characteristics through science and biology, especially with the advent of genetically modified seeds. Soybeans were classified into two groups: offensive soybeans and defensive soybeans. Essentially, offensive soybeans produce very well in optimum growing conditions and soil types. Defensive characteristics include tolerance under stressful conditions or soil-borne insects or diseases. Genetically modified seeds include tolerance to multiple herbicide traits that allow multiple modes of action of herbicide use.

The amount of variability across Kansas soils and growing conditions from east to west is difficult to quantify. Soil fertility levels, annual rainfall, and elevation are all factors in grain production. Furthermore, irrigation is prevalent in some areas, whereas other areas are primarily dryland production. To account for the variance, data is used from fifteen plot locations in Kansas over eight years: St. John, Garden City, Garden Plain, Hesston, Canton, Downs, Wamego, Thayer, Moundridge, Hiawatha, Brewster, Belpre, Abilene, Dodge City and Concordia.

Figure 1.1: Plot Locations in Kansas

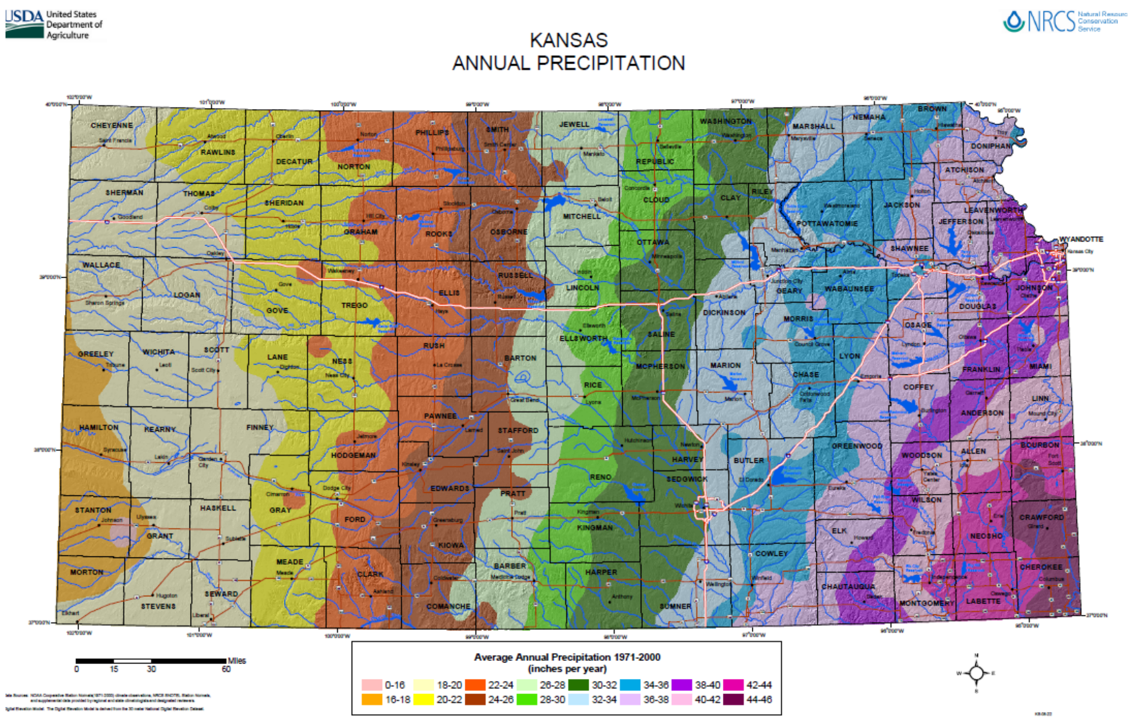


Source: (Kansas Road Map 2017)

Additionally, soil test and fertility ranges vary greatly across the state. Certain areas have higher concentration of soybean cyst nematodes, which result in sudden death syndrome. Soil types and organic matter content vary significantly from sandy soils to clay loams. Plant available potassium, phosphate, cation exchange capacity, as well as pH ranges play a significant role in growing soybeans. Variety placement is critical to tailor to each farm individually. There are multiple factors to take into consideration including rainfall variations and temperatures. Specialized genetic breeding of soybeans can help with wavering conditions, but it is nearly impossible to cover all aspects.

Rainfall variation is substantial across the state. According to a map from the United States Department of Agriculture, an annual study of precipitation from 1971-2000 suggests that far southeast Kansas receive 44-46" of annual rainfall far northwest Kansas receives 18-20" of rainfall. Plot locations used in this study represent counties that fall within that range of precipitation. McPherson county in central Kansas is the only county that represent two plot locations, Canton and Moundridge, with annual precipitation of 28-32" of annual rainfall.

Figure 1.2: Kansas Annual Rainfall



Source: (USDA 2018)

The purpose of this thesis is to compare blended soybean seed varieties against single soybean seed varieties to see if there is a yield difference and economic return by blending two varieties into one. Currently, blended soybean seeds on the market are blended with 70,000 seeds as offensive traits and 70,000 seeds as defensive traits to reach the 140,000 seed unit. This research will analyze whether blended varieties provide higher yields and if the additional investment for blended soybean seed pays for itself over time. The range of plot locations provide many variables that cannot be duplicated outside of in-field trials. It is hypothesized that the blended soybean varieties will provide yield advantages and show higher economic returns than non-blended varieties.

CHAPTER II: LITERATURE REVIEW

The range of factors Kansas farmers deal with create unique challenges, many of which are driven by nature. However, some of those factors may be alleviated by product placement with a range of factors that affect growth of soybeans. A detailed look into Kansas soil variabilities, temperature and rainfall fluctuation across the state, as well as soybean traits and previous research on soybean yields and economics will be reviewed.

2.1 Kansas Soil Variability

Variability across Kansas soils is area-specific, from the sandy loams along rivers to the heavy clay loams in western Kansas. Soybean cyst nematode populations are concentrated in specific areas, although they can be transferred from one farm to another by farm equipment. Soil pH has a wide range of variability across the state and plays a pivotal role in growing all crops.

Soil pH values range from 0 to 14, with a pH of 7 being considered neutral. If pH values are above 7 the soil is considered alkaline, whereas if the pH falls below 7, the soil is considered acidic (USDA Natural Resources Conservation Service 2011). The significance of soil pH is crucial because it affects plant growth and ties up nutrients from the plant. As Table 2.1 illustrates, pH levels have a significant impact on yields.

Table 2.1: pH Levels and Effect on Yields

Crop	pH				
	4.7	5	5.7	6.8	7.5
	Relative Average Yield				
Corn	34	73	83	100	85
Wheat	68	78	89	100	99
Oats	77	93	99	98	100
Barley	0	23	80	95	100
Alfalfa	2	9	42	100	100
Soybean	65	79	80	100	93
Timothy	31	47	66	100	95

Source**:** (USDA Natural Resources Conservation Service 2011)

Table 2.1 reflects the effect of pH. The total variability of pH across a field has a wide range. Using a process of soil sampling called grid sampling, a farm is broken into 2.5-acre grids. In each 2.5-acre grid, ten soil samples are pulled to evaluate soil conditions. To put this into perspective, a quarter section is 160 acres. In that quarter section, 64 different grids are pulled to evaluate soil variability and fertility. Figure 2.2 illustrates the variance of pH across a small portion of grid samples pulled off a quarter of land in southern Cloud County.

Figure 2.1: Grid Sample Results

INFO SHEET: 562224

LAB NUMBER *254*	SAMPLE IDENTIFICATION	ORGANIC MATTER L.O.I. percent	RATE	PHOSPHORUS P_1 (WEAK BRAY) 1:7 ppm	RATE	PHOSPHORUS P_2 (STRONG BRAY) 1:7 ppm	RATE	PHOSPHORUS OLSEN BICARBONATE P ppm	RATE	POTASSIUM K ppm	RATE	MAGNESIUM Mg ppm	RATE	CALCIUM Ca ppm	RATE
57210	41	1.8	L	22	H	52	H			358	VH	176	M	1859	M
57211	42	2.2	L	25	H	55	H			438	VH	232	H	2236	M
57212	43	2.2	L	26	H	79	VH			480	VH	190	M	3929	VH
57214	44	2.1	L	15	M	42	H			389	VH	269	H	2915	H
57215	45	2.4	L	36	VH	60	VH			468	VH	319	H	3523	M
57216	46	2.0	L	34	VH	64	VH			422	VH	262	VH	1739	M
57217	47	2.5	L	31	VH	60	VH			443	VH	338	VH	2238	M
57218	48	2.3	L	18	M	32	M			335	VH	256	VH	1912	M
57219	49	2.2	L	29	H	39	M			361	VH	233	H	1648	M
57220	50	2.4	L	27	H	52	H			403	VH	238	H	1950	M

LAB NUMBER	SODIUM Na ppm	RATE	pH SOIL pH 1:1	pH BUFFER INDEX	CATION EXCHANGE CAPACITY C.E.C. meq/100g	PERCENT BASE SATURATION (COMPUTED) % K	% Mg	% Ca	% H	% Na
57210			5.6	6.6	15.3	6.0	9.6	60.8	23.6	
57211			5.7	6.6	18.0	6.2	10.7	62.1	21.0	
57212			7.2		22.5	5.5	7.0	87.5	0.0	
57214			5.9	6.6	21.4	4.7	10.5	68.1	16.7	
57215			5.8	6.5	26.5	4.5	10.0	66.5	19.0	
57216			5.4	6.5	16.8	6.4	13.0	51.8	28.8	
57217			5.7	6.6	19.1	5.9	14.7	58.6	20.8	
57218			5.5	6.5	17.0	5.1	12.5	56.2	26.2	
57219			5.3	6.2	16.1	5.7	12.1	51.2	31.0	
57220			5.3	6.2	18.5	5.6	10.7	52.7	31.0	

Source: (Studt 2013)

With a pH range from 5.3 to 7.2 in this example, there is a wide range of disparity. According to a 2009 report from Nebraska Extension, the economic threshold for lime applications in a corn and soybean rotation is a pH of 5.6-5.8 (Mamo 2003). The calcium in the lime helps to increase soil pH, which increases relative yield according to Table 2.1. In instances that the soil pH is well above 7.0, gypsum can be applied to lower the soil pH to try to get back to neutral. The significance of soil variability on soybean traits is reflected in Figure 2.1, showing fertility and pH ranges.

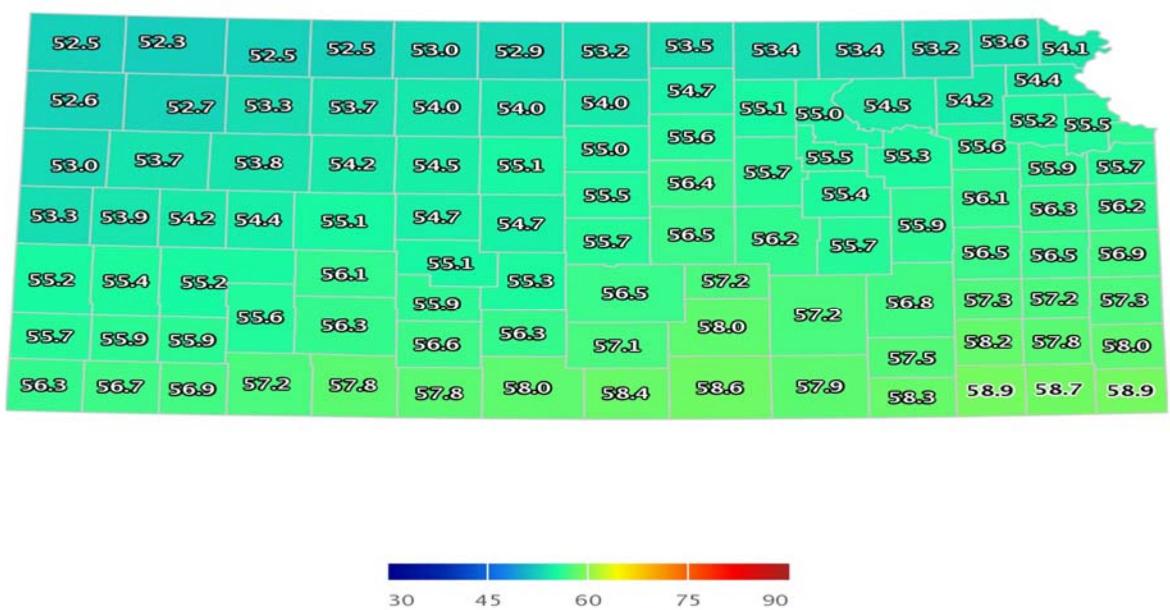
2.2 Kansas Temperature Variability

Daytime and nighttime temperatures have a significant impact on soybean production. As it gets hot in the summer months throughout the state, the high temperatures cause the plant to drop blooms during their reproductive stage. Each bloom that is dropped is a pod of soybeans being aborted, which could be 1-4 seeds per pod. Research in Kentucky indicates that there is an average of 2,500 seeds per pound in soybeans (Herbek 2005). A bushel of soybeans weighs 60 pounds; therefore, the abortion of pods can have a significant impact on yields.

Similarly, nighttime temperatures need to cool off for optimum soybean production. The process of photosynthesis where chlorophyll is converted to amino acids is affected by night-time temperatures, due to high evening and morning temperatures. Amino acids assist production by helping the plant resist stress such as high temperatures, low humidity, and drought (Independent Agriculture n.d.). Under conditions of high nighttime temperatures, soybeans continue to drop blooms resulting in loss of yield.

The variability of temperatures throughout the state is significant. On average, the southern counties of the state experience warmer temperatures than northern counties. Figure 2.2 represents temperatures by county in 2019. Cherokee and Montgomery counties in southeast Kansas share the highest average temperature at 58.9 degrees Fahrenheit. Rawlins County in northwest Kansas had the lowest average temperature at 52.3 degrees Fahrenheit. That is a difference of 6.6 degrees of difference in annual temperature.

Figure 2.2 2019 Kansas Average Temperatures by County

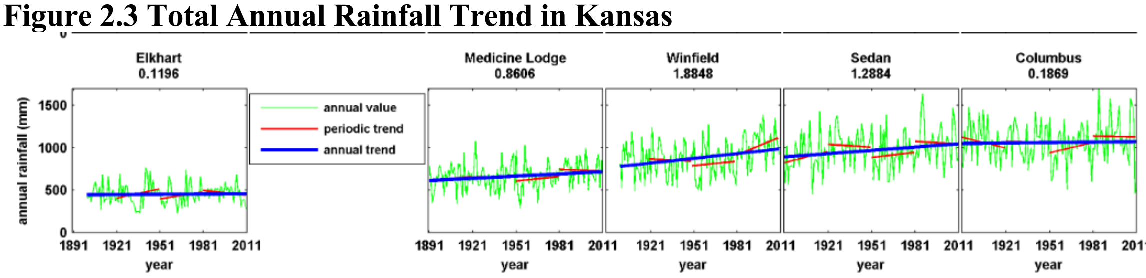


Source: (Kansas State University Kansas Climate 2019)

2.3 Rainfall Variation Across Kansas

Like Kansas temperatures, rainfall ranges are variable from east to west. In a 2011 study conducted by Kansas State University, a trend analysis of annual and seasonal rainfall in Kansas was conducted. Throughout the study, twenty-three weather stations throughout the state were used to analyze rainfall from 1890 through 2011. Figure 2.3 characterizes the increase of rainfall over the one hundred twenty-one-year period by location, with Elkhart being in the southwestern area of the state and Columbus representing a far southeastern area.

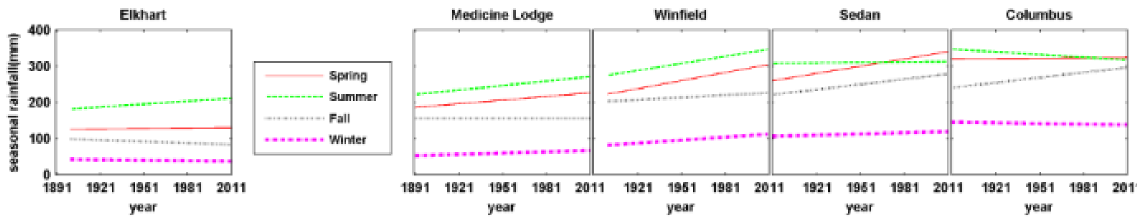
Figure 2.3 Total Annual Rainfall Trend in Kansas



Source: (Rahmani 2011)

Additional analysis was conducted to analyze what time of year the rainfall occurs. This is important in soybean production because of the timing of rainfall and the maturity length of varieties. For example, in north-central Kansas, if a 4.0-4.3 maturity length is planted on dry land, late summer rains are needed for the plant to produce soybeans. Without late season rainfall, in this example, soybean yields are dramatically lower. Figure 2.4 illustrates when rainfall occurred in the same locations represented in Figure 2.3.

Figure 2.4 Seasonal Rainfall Trend in Kansas



Source: (Rahmani 2011)

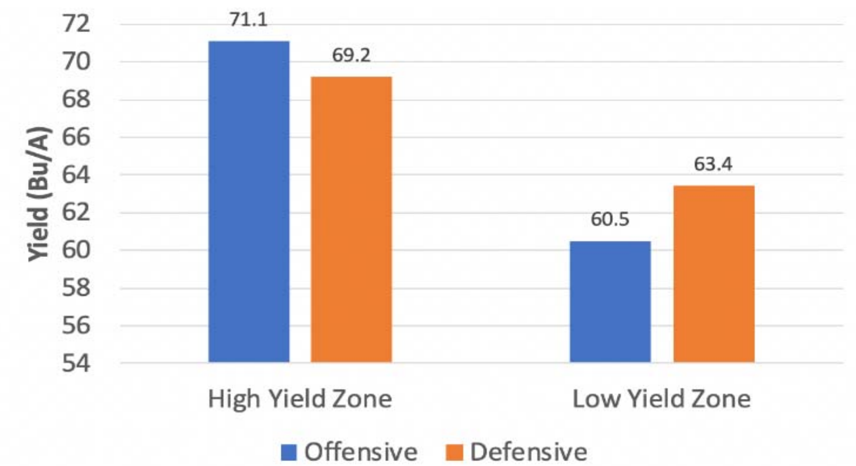
Soybeans require well-aerated soils to grow vigorously. Saturated soils, with no water on the above-ground portion of the plant, can result in poor root and plant growth and some plant death from root rot diseases (P. Agronomy 2000). Soybeans require a soil temperature of 55-60 degrees Fahrenheit to germinate, so timely planting is crucial to optimization of soybean yields. Combined with the rainfall differences across Kansas, it adds another variable to consider when producing soybeans in Kansas.

2.4 Modern Soybean Traits

From 1980 to 2011, total soybean production increased 96%, and yields (bushels per planted acre) increased 55%. Part of that improvement can be attributed to biotech-enhanced seedstock, which has grown from 77% of total soybean acres in 2002 to 94% in 2018 (Kansas Soybean Commission 2019). Some soybean seed companies have begun blending two different soybean varieties into one variety to help increase yields.

In a 2018 study, the Iowa Soybean Association analyzed split planting a farm with two different varieties of soybeans. In the study, the farm was divided into areas of high yield potential and areas of lower potential. The zones were created from years of yield data. The goal of the study was to determine if varieties performed differently under various field conditions. The varieties were termed “offensive” and “defensive” by their seed company. The offensive variety was characterized by being high yielding in good soils with little disease and stress tolerance. The defensive variety was characterized as lower yielding, but more tolerant of diseases and moisture stress (Nelson 2018). Yield results are shown in Figure 2.5.

Figure 2.5 Offensive vs. Defensive Traits Yield Results from Iowa



Source: (Nelson 2018)

This data illustrates the importance of variety selection and placement in a field setting. In the high yielding areas, the offensive beans outperformed the defensive beans by 1.9 bushels per acre. In the less productive areas of the farm, the defensive beans prevailed by 2.9 bushel. Defensive traits include soybean cyst nematode resistance, disease resistance, iron deficiency chlorosis tolerance and stress tolerance (Winfield United Genetics 2019). This is in comparison to offensive traits, that excel in good soils and growing conditions.

2.5 Economic Analysis of Soybean Production

The cost of crop production varies greatly. Farmers may own the land, have cash rent they pay landowners, or farm land on a crop share basis. Furthermore, it may be a no-till operation where sprayers make multiple trips a year, minimum till operation, or full tillage where equipment is used across each acre multiple times a year. Every farming entity varies on payments of land, labor, and equipment.

In a 2019 study by Iowa State University Extension and Outreach, a budget was put together to reflect costs of herbicide tolerant soybeans. The major differences between the low-till and conventional budgets are the preharvest machinery, labor, herbicide and seeding cost (Extension Iowa State 2019). Figures 2.6 represents variable and fixed costs per acre to grow a bushel of soybeans, costs that can be adjusted to become specific to each area of the state.

Figure 2.6 Estimated Costs Herbicide Tolerant Soybeans Following Corn in Iowa

	50 bu. per acre		56 bu. per acre		62 bu. per acre	
	Fixed	Variable	Fixed	Variable	Fixed	Variable
Preharvest Machinery [1/]	$21.20	$18.80	$21.20	$18.80	$21.20	$18.80
Seed, Chemical, etc.	Units		Units		Units	
Seed @ $50.80 per 140 k.	140	$50.80	140	$50.80	140	$50.80
Phosphate @ $0.42 per lb.	40	16.80	45	18.90	50	21.00
Potash @ $0.31 per lb.	75	23.25	84	26.04	93	28.83
Lime (yearly cost)		5.71		5.71		5.71
Herbicide [2/]		55.57		55.57		55.57
Crop insurance		7.80		8.80		9.80
Miscellaneous		9.00		10.00		11.00
Interest on preharvest variable costs (8 months @ 6.0%)		7.51		7.78		8.06
Total		$176.44		$183.61		$190.77
Harvest Machinery						
Combine	$8.40	$4.10	$8.40	$4.10	$8.40	$4.10
Grain cart	6.30	3.00	6.30	3.00	6.30	3.00
Haul	2.18	1.89	2.44	2.11	2.71	2.34
Handle (auger)	0.88	0.97	0.99	1.08	1.09	1.20
Total	$17.76	$9.95	$18.13	$10.30	$18.50	$10.64
Labor						
2.20 hours @ $14.25	$31.35		$31.35		$31.35	
Land						
Cash rent equivalent	$185.00		$223.00		$258.00	
Total fixed, variable						
Per acre	$255.31	$205.19	$293.68	$212.70	$329.05	$220.21
Per bushel	$5.11	$4.10	$5.24	$3.80	$5.31	$3.55
Total cost per acre	$460.51		$506.38		$549.26	
Total cost per bushel	$9.21		$9.04		$8.86	

[1/] Chisel plow, tandem disk, field cultivate, plant, and two sprays. See the Estimated Machinery Costs table.
[2/] Estimates do not include any insecticide or fungicide costs.

Source: (Extension 2019)

Typically, in Kansas, cash rents are not in the $185-$259 range that is represented in Figure 2.6. However, it is a good starting point and reflection of investments per acre. When a producer is spending $460 to $549 per acre on soybeans, investments need to be made in the correct area to optimize return on investment. Figure 2.7 reflects the return on investment utilizing different fertilizer. A 2011 study by Michigan State University Extension characterizes fertilizer investments on soybeans where four of the five test sites had low to medium phosphate fertilizer readings in soil tests. The significance of Figure 2.7 is shown in the investment cost of 11-52-0 versus the other fertilizers pertaining to return on investment. Furthermore, soil texture analysis may be required on a farm by farm basis to evaluate phosphate soil test readings. Adequate phosphate readings are critical to plant health and can even help with plant canopy performance to eliminate in-season weed pressure. Fertilizer investments vary year-to-year, especially comparing liquid forms of phosphate to dry forms of phosphate.

Figure 2.7 Soybeans Fertilizer Response

Treatment	Average Yield (bu/ac)	Yield Increase (bu/ac)	Cost ($/ac)	Net Response ($/ac) @ $10/bu Soybeans
Untreated	48.7	-	-	-
40 P_2O_5 + 70 K_2O incorporated + 3 gallons 6-24-6	52.3	3.6	$67.00	-$31.00
40 P_2O_5 + 70 K_2O incorporated	51.0	2.3	$51.50	-$28.50
40 P_2O_5 + 70 K_2O 2X2 Band	52.3	3.6	$51.50	-$15.50
3 gallons 6-24-6	50.8	2.1	$15.50	$5.50
25 $P_2O_5$with seed (11-52-0)	51.8	3.1	$12.50	$18.50

Source: (Steinke 2011)

2.6 Summary

There are many factors that contribute to soybean production. Throughout this literature review, there has been limited research done on blending soybean varieties together to test for an economic return. Kansas State Research and Extension put out the 2020 Kansas Soybean Management Guide. It provides management practices regarding tillage and rotations, variety selection, planting practices, weed management, fertilizer recommendations and disease management, but does not discuss blended varieties. Environmental conditions play a significant role in soybean production. By blending two soybean varieties into one, it may help alleviate some of the difficult environmental conditions to improve crop yields.

CHAPTER III: THEORY, METHODOLOGY, AND DATA

This research examines the yield advantages and economic feasibility of blending two separate soybean varieties together, into one variety, to reduce risk from environmental challenges and to see if there is an advantageous yield advantage. An analysis will be conducted using eight years of soybean plot data from Winfield United, examining the yield performance of single soybean varieties versus blended varieties. It is expected that blended varieties will provide a positive return on investment and add additional yield per acre with the offensive and defensive traits of blended soybeans.

3.1 Profit Maximization

Economic profits are the difference between the total revenue and the total opportunity cost of producing the firm's goods or services (Baye 2010). Profit maximization examines the cost of inputs and their relationship to total revenue generated. Profit maximization is more important than yield maximization due to input investments, keeping costs as low as possible and still increasing yield to an economically optimal level. Putting the correct soybean varieties on the right acre affects profit maximization. Minimizing input cost doesn't always result in additional yield but applying resources in the proper place can have a significant role in return on investment and profitability.

3.2 Single Factor ANOVA Analysis and Least Significant Difference (LSD)

To evaluate the variables in Kansas, such as yield differences by year, by location, and overall differences between blended and single variety soybeans, a single factor analysis of variation (ANOVA) will be used to accomplish the objectives of the research. A single factor ANOVA is designed to investigate one source of influence or effect data (Thayer 2001). In this case, due to the environmental variation between plot locations, the single factor will be blended soybean varieties versus single variety soybeans. The analysis will also use ANOVA to evaluate differences in yield by year and by location.

Three components of statistical analysis include: between group variance, within group variance, and total number of scores in all the groups. Variation between the groups represents the blended effect of soybeans varieties. The variation within the groups represent a variation due to chance, being a random variation that is not because of blending soybean varieties. All other components being equal, the greater number of observations in a dataset, the better representation of the total number of scores (Thayer 2001).

This research will use a five percent level of significance to determine significance. The results of the ANOVA analysis will use a p value < 0.05 to determine statistical significance and provide confidence that the result obtained is a true reflection of a statistical difference between the two estimates (Thayer 2001). ANOVA analysis will address the hypothesis of blended soybean seed varieties being better using a 95% significance level by testing the difference in average yields. Essentially, accepting the null hypothesis means that all population means are the same, while rejecting the null hypothesis shows that there is a difference.

In the event of statistical significance, analysis of least significant difference (LSD) will be conducted. To calculate LSD, the researcher needs a critical t value, MSW (means squared) from the ANOVA, and the sample size for each group (Vik 2014). The LSD acts as a test to determine the variation of means between the groups, analyzing the mean of single variety soybeans versus the means of the blended variety soybeans. It can also determine which years and locations have statistically higher yields. Using least significant difference analysis further validates the statistical significance of the analysis of variance.

3.3 Partial Budget Analysis

A partial budget analysis is defined as an estimate of the changes in income and expenses that would result from carrying out a proposed change in the current farm plan (Kay 2012). It includes additional costs, reduced revenues, additional revenue and reduction of costs. Farming operation inputs and outputs are variable when dealing with environmental conditions and a volatile grain market. Due to variability it is difficult to project annual expense and revenue.

Specifically, this research will analyze additional expense pertaining to the investment in blended soybean varieties. Currently, there is a ten to fifteen dollar per acre additional investment for blended soybean seed. Soybean units are measured by kernel count (140,000 seeds per acre is considered one unit). In this research, an estimated 140,000 soybean seed planting population will be used. The additional expense for the blended seed will be compared with the additional revenue from the expected higher yields that the blended varieties are expected to generate, to see if there is economic gain or loss from the blended varieties.

3.4 Data

The data gathered for this research was obtained from Winfield United, a national supplier of agriculture input products to cooperatives in the United States and parts of Canada. Since 1988, Winfield has provided an Answer Plot program that provides localized testing of seed varieties to give farmers greater confidence in their agronomic decision-making (Winfied United 2018). In this research, data was gathered from 2012 through 2019 Answer Plots throughout the state of Kansas.

There are fifteen plot locations: Wamego, Thayer, St. John, Moundridge, Hiawatha, Abilene, Belpre, Brewster, Canton, Concordia, Dodge City, Downs, Garden Plain, Garden City and Hesston. The primary location of the plots is in a dryland setting, with Garden City being the exception as the only irrigated location. The variability across Kansas as discussed in Chapter 2 is large. Utilizing multiple years of data and plot locations assist in accounting for the variability.

The year, plot location, yield, test weight, moisture and soybean variety are included in the dataset. Locations that include a single year of plot data are Belpre, Canton, Concordia, Garden City, and Hesston. Abilene, Garden Plain and St. John each have two years of plot data. Brewster, Downs and Moundridge have three years of data. Locations that represent the most data with five years of data are Dodge City, Hiawatha, Thayer and Wamego.

Price data for the partial budget is obtained from Kansas State University Department of Agriculture Economics, utilizing the grain basis dataset. The yield differences determined by the ANOVA analysis will be used in the partial budget. Additionally, a ten-dollar premium is used for the blended bean varieties throughout all years due to a premium added to blended beans on 2019 and 2020 Croplan seed price cards. Agronomically, the research and development that goes into blending the correct bean varieties incurs additional cost, thus the cost premium.

In the early years of the dataset, there are not as many blended soybeans varieties as there are in the last five years of data collected. It has been an evolving process of getting the correct varieties blended for the desired outcome. Furthermore, soybeans have been genetically modified to metabolize certain herbicides including Round Up, Liberty Link, certain 2,4-D’s (Enlist), and Dicamba. The genetic modifications affect performance of soybeans, adding additional research for selecting the correct varieties. This process has led to fewer, but better, blended varieties over time.

CHAPTER IV: DATA ANALYSIS

Throughout this research a single factor ANOVA analysis will be conducted between blended soybean varieties and single soybean varieties. The ANOVA will be analyzed by each year, each location, and an overall analysis for the entire dataset, over all years and locations. Statistical significance and difference in yield will be noted in a table for each analysis using a five percent level of significance. The actual ANOVA results can be found in Appendix A.

4.1 Single Factor ANOVA Analysis by Year

To evaluate variances between blended soybean varieties and single soybean varieties, a year-by-year ANOVA analysis is conducted. Table 4.1 reflects the results for each year.

Table 4.1 ANOVA Results by Year

Test	**Blended Yield** (bu./A)	**Single Yield** (bu./A)	**p-value**	**Significant** (α=5%)	**Difference (If any)**
2012	67.02	59.42	0.036**	Yes	7.60 bu.
2013	58.49	48.55	0.007***	Yes	9.94 bu.
2014	58.84	54.75	0.113	No	4.09 bu.
2015	62.17	62.30	0.921	No	-0.13 bu.
2016	76.04	74.33	0.188	No	1.71 bu.
2017	60.53	60.55	0.992	No	-0.02 bu.
2018	67.14	66.59	0.830	No	0.55 bu.
2019	66.27	64.74	0.476	No	1.53 bu.

***Designates significance at a 1% level
**Designates significance at a 5% level

The results for 2013 show the most statistical significance with a 0.007 p-value, as well as the largest spread between soybean varieties with a 9.94-bushel advantage using blended soybean seed. The only other year with statistical significance is 2012, representing a 7.60-bushel advantage utilizing blended beans. The year with the highest p-value, at 0.992, is 2017, which also represents the narrowest spread between blended soybean varieties and single varieties at -0.02 bushels when using blended beans. In both cases where yield differences are statistically significant, the blended yields are higher than the single-variety yields.

A potential explanation would be environmental conditions experienced in 2012. It was one of the driest years since the Dust Bowl along with high temperatures in Kansas. The moisture in the soil profile was gone by the end of 2012 and beginning of 2013, leading to very dry conditions to start out 2013. It is possible that in years of dry conditions that the blended beans perform better.

4.2 Single Factor ANOVA by Location

To further analyze differences between blended soybean varieties and single soybean varieties, an ANOVA analysis by location is examined. Table 4.2 represents the results of the location analysis.

Table 4.2 ANOVA Results by Location

Test	**Blended Yield** (bu./A)	**Single Yield** (bu./A)	**p-Value**	**Significant** (α=5%)	**Difference (If any)**	**Years of Data**
Abilene	53.98	49.73	0.022**	Yes	4.25 bu.	2
Belpre	73.02	66.93	0.105	No	6.09 bu.	1
Brewster	76.93	74.30	0.049**	Yes	2.63 bu.	3
Canton	58.21	59.74	0.521	No	-1.53 bu.	1
Concordia	70.49	67.93	0.185	No	2.56 bu.	1
Dodge City	57.24	55.11	0.227	No	2.13 bu.	5
Downs	65.00	57.90	0.017**	Yes	7.10 bu.	3
Garden Plain	61.81	41.59	0.005***	Yes	20.22 bu.	2
Garden City	76.35	71.57	0.155	No	4.78 bu.	1
Hesston	52.44	51.71	0.124	No	0.73 bu.	1
Hiawatha	65.94	63.99	0.182	No	1.95 bu.	5
Moundridge	72.43	68.68	0.074*	No	3.75 bu.	3
St. John	87.38	84.11	0.065*	No	3.27 bu.	2
Thayer	66.94	55.70	0.002***	Yes	11.24 bu.	5
Wamego	73.12	63.89	0.002***	Yes	9.23 bu.	5

***Designates significance at a1% level
**Designates significance at a 5% level
*Designates significance at a 10% level

Table 4.2 shows that six out of fifteen locations have a statistically significant difference in yields: Abilene, Brewster, Downs, Garden Plain, Thayer and Wamego. The range within the statistically significant locations is 20.22 bushel per acre in Garden Plain to 2.63 bushel per acre in Brewster. In each of these locations the blended variety yields are higher than the single varieties. Canton is the only location that has a negative response to blending soybean varieties, but it is not statistically significant. There was one year of plot data (2016) in the ANOVA analysis at this location.

Other locations that have one year of plot data for analysis include: Belpre (2012), Concordia (2019), Garden City (2019), and Hesston (2019). Along with Canton, these locations do not show statistically differences in yield between varieties. The remainder of the locations used in the analysis have multiple years of data. Hiawatha, Moundridge, St. John and Dodge City have multiple years of plot data, but without statistical difference.

4.3 Single Factor ANOVA by Combined Dataset (2012-2019)

To quantify the difference in the year-by-year data and the location-by-location data, a total ANOVA is analyzed for the entire dataset. Table 4.3 shows the significance of blended soybean varieties, with an average yield of 4.68 bushel per acre higher than the single varieties.

Table 4.3 ANOVA Results For Entire Dataset

Test	**Blended Yield** (bu./A)	**Single Yield** (bu./A)	**p-Value**	**Significant** (α=5%)	**Difference (if any)**
Combined Location and Years	66.51	61.83	0.000000195***	Yes	4.68 bu.

***Designates significance at a 1% level

The significance of the ANOVA results from the dataset is represented in the p-value of .000000195. This result suggests that for the entire state of Kansas, blending soybean varieties versus planting single variety soybeans results in a 4.68 bushel advantage by planting blended soybean varieties for this time period.

To further validate the statistical significance of blended soybeans varieties across the entire dataset, a calculation of least significant difference (LSD) is performed. Essentially, the LSD represents the minimum number of bushels the soybean varieties can differ and still be considered significantly different. In this analysis, LSD equals 1.759 bushel which validates the 4.68 bushel difference found in the ANOVA analysis.

4.4 Partial Budget Economics of Blended Soybean Varieties by Combined Dataset

A partial budget includes an estimate in changes of income and expenses that would result from carrying out a proposed change in a current farm plan (Kay 2012). In this example, the proposed change is using blended soybean varieties, where the input cost of the blended beans versus single variety beans is ten dollars per acre extra input cost. An examination of the extra input cost versus the revenue differences will be conducted for the entire dataset, by year.

Appendix Q shows the annual average of soybean prices in Kansas from Kansas State Grain Basis Dataset. Therefore, an annual estimation of change in net revenue is shown in Table 4.4. The results are assuming a ten-dollar premium on blended soybean seed throughout the eight years of this study.

Table 4.4 Partial Budget Analysis

Yearly Budgets			Change in			Change in	
Year	Change in Yield	Price	Total Revene	Change in Cost		Net Revenue	
2012	7.601	$ 14.09	$ 107.10	$ 10.00		$ 97.10	
2013	9.931	$ 13.56	$ 134.66	$ 10.00		$ 124.66	
2014	4.092	$ 11.93	$ 48.82	$ 10.00		$ 38.82	
2015	-0.132	$ 8.76	$ (1.16)	$ 10.00		$ (11.16)	
2016	1.708	$ 9.01	$ 15.39	$ 10.00		$ 5.39	
2017	-0.017	$ 8.77	$ (0.15)	$ 10.00		$ (10.15)	
2018	0.544	$ 8.33	$ 4.53	$ 10.00		$ (5.47)	
2019	1.529	$ 7.81	$ 11.94	$ 10.00		$ 1.94	
Average	3.157	$ 10.28	$ 40.14	$ 10.00		$ 30.14	
Standard Deviation	3.760	$ 2.51	$ 52.78	0		$ 52.78	

Table 4.4 shows annual and overall yield advantages resulting in a change in net revenue utilizing blended soybean varieties. An average of 3.157 bushel per acre increase in yield, with an average price of $10.28 per bushel soybean price, results in an average increase in net revenue of $30.14 per acre after the $10 premium is taken off for the blended soybeans. Table 4.4 represents the plots throughout Kansas over the years the data was utilized. In recent years, the net revenue per acre is less than the first three years, and the price per bushel of soybeans is lower than the first three years, resulting in lower net revenue. The average net revenue change between 2015-2019 is only $6.11.

4.5 Summary

Year-by-year analysis differs significantly from location-by-location analysis, with 2012 and 2013 being a positive advantage in yield and statistically significant for the blended soybean varieties. The annual differences show 2015 and 2017 with a negative effect on yield utilizing blended soybean varieties, although these results are not statistically significant. The negative result in location-by-location analysis in Canton, with one year of plot data, was not statistically significant. Furthermore, there are eight years of annual data compared to fifteen locations analyzing differences. An overall analysis shows a 4.68 bushel per acre advantage planting blended soybeans varieties versus using single soybean varieties in Kansas. The least significant difference analysis validates this by a 1.75 bushel difference to be significantly different, particularly in comparison with the 4.68 bushel per acre ANOVA result.

In conclusion, the overall analysis showed a yield advantage of 4.68 bushel per acre utilizing blended variety soybeans and this is significant, both statistically and financially. This leads to an average increase in net revenue of $30.14 per acre, though the advantage of blended soybeans was lower in more recent years. The results of this research show that blending soybean seed varieties are similar to blending wheat seed varieties in Kansas to alleviate risk, increase yield, and add additional net revenue.

CHAPTER V: SUMMARY

Throughout this research, an analysis was conducted analyzing blended soybean seed varieties against single soybean seed varieties to evaluate yield differences and profitability. A single factor ANOVA analysis was used to compare blended soybean variety yields versus single soybean variety yields, with the data coming from fifteen plot locations in Kansas over eight years, 2012-2019. An analysis was conducted by year, by plot location, and an overall analysis combining the entire dataset. A partial budget analysis examined changes in net revenue and total revenue utilizing blended soybean seed versus single varieties and historic annual soybean prices in Kansas.

The results of the research by year showed two years having statistical significance in yield, with blended soybeans being higher in 2012 and 2013. These were both years with lower soil moisture, indicating that the blended soybean varieties may be most useful in dry years. Results of analysis by location showed six out of fifteen locations showing statistically different yields by blending soybean seed varieties. An overall analysis of the combined dataset showed a 4.68 bushel per acre yield advantage by blending soybean seed varieties. An overall partial budget analysis showed a change in net revenue of $30.14 per acre, with an additional cost of blended soybean seed being $10 per acre above that of a single soybean seed variety.

The significance of this research is shown in the overall yield analysis with a 4.68 bushel per acre yield advantage utilizing blended soybean varieties in Kansas. In recent years, the agriculture economy has gone through trials and tribulation. It has been difficult to make a profit. Increasing yield in a challenging economic and environmental condition by blending soybean seed varieties is significant. The blended soybean varieties help account for the variation of environmental conditions by alleviating risk and adding to farmer's net revenue, particularly in dry years.

Implications of this research include potentially increasing yield and profitability to Kansas farmers. Farmers should consider using blended varieties when soil conditions warrant, particularly for low soil moisture conditions. Producing additional bushels per acre helps local grain marketing firms in bushels they have to market in grain trade. This further validates the research and development of seed supply companies to ensure the correct seed varieties are blended to create economic return and soybean seed sales. Essentially, this research has many benefits to multiple entities.

Further research on the topic of blending multiple soybean seed varieties to create a single soybean seed variety could include blending three separate single varieties of soybeans to create one variety. The data obtained for this thesis included two separate varieties together to optimize yield. Many wheat seed varieties utilize three separate seed varieties for economic return. Potential analysis on blending corn and sorghum seed varieties could be conducted to analyze economic returns. Also, more research should be conducted on regional differences across the state. The results of this research showed no clear pattern regionally.

WORKS CITED

Agronomy, American Society of. 2012. *American Society of Agronomy.* January 11. Accessed December 21, 2019. https://www.agronomy.org/science-news/blending-wheat-varieties-better-traits.

Agronomy, Purdue. 2000. *Purdue Agronomy.* July. Accessed January 19, 2020. https://www.agry.purdue.edu/ext/corn/news/articles.00/Soy_Wet_Feet-0705.html.

Baye, Michael. 2010. "Managerial Economics and Business Strategy ." In *Managerial Economics and Business Strategy*, by Baye, 17. New York New York: McGraw-Hill Irwin .

Extension, Iowa State University. 2019. *Extension Iowa State.* January. Accessed January 24, 2020. www.extension.iastate.edu/agdm/crops/pdf/a1-20.pdf.

Herbek, Chad Lee and Jim. 2005. *University of Kentucky Cooperative Extension Service.* December. Accessed January 7, 2020. http://www2.ca.uky.edu/agcomm/pubs/agr/agr188/agr188.pdf.

n.d. *Independent Agriculture.* Accessed January 7, 2020. https://agriculture90.blogspot.com/2015/11/Easy-Guide-Make-Amino-Acids-and-Benefits-For-Plants.html.

2017. *Kansas Road Map.* Accessed March 8, 2020. https://adopteerightslaw.com/wp-content/uploads/2017/02/kansas-road-map-1800.jpg.

2019. *Kansas Soybean Commission.* Accessed January 6, 2020. https://www.kansassoybeans.org/news/faq/.

2019. *Kansas State University Kansas Climate.* Accessed January 7, 2020. http://climate.k-state.edu/.

Kay, Edwards, Duffy. 2012. *Farm Management.* New York, New York: McGraw-Hill Companies.

Mamo, Wortmann, Shapiro. 2003. *Nebraska Extension* . March. Accessed January 6, 2020. http://extensionpublications.unl.edu/assets/html/g1504/build/g1504.htm.

Nelson, Scott. 2018. *Iowa Soybean Association.* October 23. Accessed January 6, 2020. https://www.iasoybeans.com/news/articles/tips-for-selecting-the-best-soybean-varieties/.

Rahmani, Hutchinson, Hutchinson, Anandhi. 2011. *Kansas State University Department of Agronomy.* Accessed January 18, 2020. http://ipsr.ku.edu/CEP/Hyperlink_Documents/Posters2012Symposium/RahmaniPoster.pdf.

Steinke, Mike Staton and Kurt. 2011. *No Till Farmer.* April 19. Accessed January 23, 2020. https://www.no-tillfarmer.com/articles/1425-starter-fertilizer-may-benefit-soybean-growers.

Studt, Kent, interview by Dustin Newlin. 2013. (August 5).

Taylor, M. and R. Llewelyn. 2020. "Grain Basis Database." *Kansas State University Department of Agricultural Economics* . February.

Thayer, J. Rick Turner and Julian F. 2001. *Introduction to Analysis of Variance Design, Analysis, & Interpretation.* Thousand Oaks California: Sage Publications, Inc.

2011. *USDA Natural Resources Conservation Service* . April . Accessed January 6, 2020. https://nrcspad.sc.egov.usda.gov/DistributionCenter/pdf.aspx?productID=396.

USDA. 2018. *NRCS.* Accessed March 8, 2020. https://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_032018.pdf.

Vik, Peter. 2014. *Regression, ANOVA, and the Gerneral Linear Model A Statistics Primer.* Thousand Oaks California: Sage Publications, Inc.

2018. *Winfied United* . April 18. Accessed February 10, 2020. https://www.winfieldunited.com/news-and-insights/answer-plot-program-insights-reveal-yield-opportunities.

2019. *Winfield United Genetics.* Accessed January 6, 2020. https://www.winfieldunited.com/product/croplan-seed/crops/soybean/genetics.

APPENDIX A

Blended vs. Single Variety Soybeans ANOVA

Anova: Single Factor **Statistically Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	5150	318436.2	61.83227	274.3346
Blended	359	23876.93	66.50956	213.6397
		Positive	4.67729	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	7342.053	1	7342.053	27.15368	1.95E-07	3.843148
Within Groups	1489032	5507	270.3889			
Total	1496374	5508				

APPENDIX B

Abilene ANOVA (2017 & 2018 Plot Data)

Anova: Single Factor **Statistically Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	157	7806.9	49.7254 8	80.1794 7
Blended	27	1457.5	53.9814 8	65.4584 9
		Positiv e	4.25600 4	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	417.301 2	1	417.301 2	5.34477 5	0.021904	3.89306 1
Within Groups	14209.9 2	182	78.0764 8			
Total	14627.2 2	183				

APPENDIX C

Belpre ANOVA (2012 Plot Data)

Anova: Single Factor **Not Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	165	11043.85	66.93244	41.55725
Blended	3	219.0669	73.02231	0.7027
		Positive	6.089876	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	109.273	1	109.273	2.660975	0.104733	3.898089
Within Groups	6816.794	166	41.06502			
Total	6926.067	167				

APPENDIX D

Brewster ANOVA (2012, 2014, 2015 Plots)

Anova: Single Factor **Statistically Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	471	34995.27	74.29994	67.02599
Blended	40	3077.404	76.9351	51.3621
		Positive	2.635166	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	256.0213	1	256.0213	3.889376	0.049133	3.859793
Within Groups	33505.34	509	65.82581			
Total	33761.36	510				

APPENDIX E

Canton ANOVA (2016 Plot Data)

Anova: Single Factor **Not Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	153	9140.464	59.74159	47.78998
Blended	9	523.8982	58.21091	54.56469
		Decrease	-1.53068	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	19.9154	1	19.9154	0.413794	0.520971	3.900236
Within Groups	7700.595	160	48.12872			
Total	7720.51	161				

APPENDIX F

Concordia ANOVA (2019 Plot)

Anova: Single Factor **Not Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	56	3803.9	67.92679	27.49363
Blended	8	563.9	70.4875	10.50125
		Positive	2.560714	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	45.9008	1	45.9008	1.794743	0.185239	3.995887
Within Groups	1585.659	62	25.57514			
Total	1631.559	63				

APPENDIX G

Dodge City ANOVA (2014, 2015, 2016, 2017, 2018 Plots)

Anova: Single Factor **Statistical Insignificane**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	558	30751.72	55.1106	184.0264
Blended	68	3892.287	57.23952	223.165
		Positive	2.128915	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	274.7168	1	274.7168	1.459484	0.22747	3.856404
Within Groups	117454.8	624	188.2288			
Total	117729.5	625				

APPENDIX H

Downs ANOVA (2014, 2015, 2016 Plots)

Anova: Single Factor **Statistically Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	478	27677.44	57.90259	330.9526
Blended	40	2600.112	65.0028	266.3522
		Advantage	7.100213	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1860.805	1	1860.805	5.706767	0.017258	3.859543
Within Groups	168252.1	516	326.07			
Total	170112.9	517				

APPENDIX I

Garden Plain ANOVA (2014 AND 2016 Plots)

Anova: Single Factor **Significantly Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	207	8609.365	41.59114	206.3998
Blended	4	247.2401	61.81002	21.69863
		Positive	20.21888	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	1604.213	1	1604.213	7.873494	0.00549	3.886337
Within Groups	42583.46	209	203.7486			
Total	44187.67	210				

APPENDIX J

Garden City ANOVA (2019 Plot)

Anova: Single Factor **Statistically Insignificant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	41	2934.5	71.57317	20.85451
Blended	2	152.7	76.35	15.125
		Positive	4.776829	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	43.51358	1	43.51358	2.100607	0.154847	4.078546
Within Groups	849.3055	41	20.71477			
Total	892.8191	42				

APPENDIX K

Hesston ANOVA (2019 Plot)
Anova: Single Factor   Statistically Insignificant

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	56	2895.5	51.70536	20.44197
Blended	5	262.2	52.44	14.698
		Advantage	0.734643	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	2.477312	1	2.477312	0.123541	0.726477	4.003983
Within Groups	1183.1	59	20.05255			
Total	1185.578	60				

APPENDIX L

Hiawatha ANOVA (2012, 2013, 2015, 2016, 2017 Plots)

Anova: Single Factor **Statistically Insignificant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	737	47167.19	63.9989	91.58423
Blended	46	3033.466	65.94492	94.36118
		Positive	1.946024	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	163.9684	1	163.9684	1.787234	0.181653	3.853393
Within Groups	71652.25	781	91.74423			
Total	71816.22	782				

APPENDIX M

Moundridge ANOVA (2012, 2014, 2015 Plots)

Anova: Single Factor   Statistically Insignificant

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	497	34135.3	68.68269	55.2108
Blended	13	941.5324	72.42557	57.4415
		Positive	3.742877	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	177.4765	1	177.4765	3.211459	0.073719	3.859829
Within Groups	28073.85	508	55.26349			
Total	28251.33	509				

APPENDIX N

St. John ANOVA (2016 and 2018 Plots)

Anova: Single Factor Statistically Insignificant

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	178	14971.43	84.10916	50.77232
Blended	17	1485.461	87.38003	21.4644
		Positive	3.27087	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	166.0202	1	166.0202	3.434238	0.065385	3.890092
Within Groups	9330.131	193	48.34265			
Total	9496.152	194				

APPENDIX O

Thayer ANOVA (2013, 2014, 2015, 2016, 2017 Plots)

Anova: Single Factor — Statistically Significant

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	784	43672.06	55.70416	418.5547
Blended	34	2275.906	66.93842	207.1352
		Advantage	11.23426	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	4112.734	1	4112.734	10.03095	0.001597	3.85288
Within Groups	334563.8	816	410.0047			
Total	338676.5	817				

APPENDIX P

Wamego ANOVA (2012, 2014, 2015, 2016, 2019 Plots)

Anova: Single Factor **Statistically Significant**

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
Single	697	44528.73	63.88627	362.8584
Blended	43	3144.258	73.12228	196.361
		Advantage	9.23601	Bushel

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	3454.922	1	3454.922	9.776708	0.001837	3.85409
Within Groups	260796.6	738	353.383			
Total	264251.5	739				

APPENDIX Q

Table 4.4 Grain Basis Database

Crop Name	**Year**	**Cash Price**	**State**
Soybeans	2012	$14.09	Kansas
Soybeans	2013	$13.56	Kansas
Soybeans	2014	$11.93	Kansas
Soybeans	2015	$8.76	Kansas
Soybeans	2016	$9.01	Kansas
Soybeans	2017	$8.77	Kansas
Soybeans	2018	$8.33	Kansas
Soybeans	2019	$7.81	Kansas

Source: (Taylor 2020)