A FIELDPRINT CALCULATOR ANALYSIS OF RESOURCE AND COST EFFICIENCIES IN THE SOUTHERN HIGH PLAINS

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Abstract

The Fieldprint Calculator was developed by Field to Market: The Alliance for Sustainable Agriculture to assist producers in evaluating their sustainability. Producers can use this tool to compare their operations to county, state, and national averages. The objective of this study was to revisit previous analysis on metric rankings to compare the 2009 and 2016 crop years. The data for this project came from irrigated cotton production demonstrations sites associated with the Texas Alliance for Water Conservation located in nine counties across the Southern High Plains. Results show metric improvements on some sites.

Introduction

The Texas Alliance for Water Conservation (TAWC) is an ongoing demonstration project that began in 2005. The TAWC works with over 20 producers covering over 6,000 acres in nine counties across the Southern High Plains of Texas. Producers involved in the project represent a variety of agricultural production systems including cotton monoculture systems to fully integrated livestock systems, crop rotations, and tillage practices. Producers use furrow irrigation, LEPA, LESA, and MESA center pivot irrigation systems, as well as sub-surface drip (SDI) irrigation systems. TAWC activities are monitored for soil moisture depletion, crop productivity and economic returns. The TAWC has a cotton pilot with the National Cotton Council. Data for the Fieldprint Calculator includes crop production years from 2007-2015, which represents 26 producers, 34 sites, and 193 observations. Field sizes range from 13 acres to 400 acres. Tillage practices include no-till, strip till (minimum till) and conventional tillage.

Field to Market evaluates sustainability based on seven metrics: land use (ac/lb lint), irrigation water use (inches/lb lint), energy use (gal diesel/lb lint), greenhouse gas emissions (lbs CO2/lb lint), soil conservation (tons of soil loss/ac/yr), a soil carbon index, and a water quality index. This study concentrates on the first five sustainability metrics. The soil carbon and water quality indices were excluded from this analysis.

The objective of this study was to build on the analysis of Robertson (2013), Stokes et al. (2014), and Gillum and Johnson (2015) by comparing the results of the metrics estimated by the Fieldprint Calculator for the 2009 and 2016 crop years using TAWC data to determine if any sites showed significant improvement in their scores.

Materials and Methods

This analysis compared Fieldprint Calculator results for the land use, soil conservation, soil carbon, irrigation water use, greenhouse gas, and energy use metrics as well as the total variable cost for all cotton producing sites in 2009 and 2016. The Fieldprint calculator measures land use as the amount of acres used to produce a pound of cotton lint. For the purposes of this analysis, crop lint yield equivalent is used as a proxy for the land use metric. Sites that have higher yields indicate higher crop productivity, and receives a more positive sustainability score. The soil conservation metric is a measure of the tons of soil loss per acre. This metric is highly sensitive to the slope and soil texture of the land, as well as management practices including tilling, plowing and other forms of soil disturbance. Sites with cover receive improvements in their scores due to a reduction in soil loss from wind and water erosion (Field to Market, 2018). For this metric, low soil conservation numbers indicate less soil lost. Soil carbon is represented by a soil conditioning index. This index measures the amount of organic matter in the soil and is impacted by tillage practices and erosion. Positive values indicate increases in soil carbon, values of 0 indicate no change in soil carbon, and negative values represent decreases in soil carbon (Field to Market, 2018). Irrigation water use is another metric used to assess sustainability within the calculator. It is calculated as the amount of water applied in inches per acre. Lower irrigation values are more desirable, as less water is required to generate yield.

The energy use metric is calculates direct energy use from irrigation application, machinery use and hauling. Embedded energy is also taken into account such as energy used in seed and chemical production. This metric is presented in gallons of diesel equivalent/acre (Field to Market, 2018). Greenhouse gas emissions are measured by the pounds of CO2 equivalent per lb of lint produced. This metric measures the carbon dioxide released into the atmosphere from fuel use and the nitrous oxide released from fertilizers. Lower metric values are more desirable (Field to Market, 2018). This analysis also compared the total variable cost of each site to determine how profitable each site may be through cost minimization.

Results and Discussion

Figures 1 and 2 in the Appendix indicate the 2009 and 2016 lint yield equivalent, respectively. Crop yields in 2009 averaged 1,476 lbs/acre in 2009 and 1,630 lbs/acre in 2016. Figures 3-4 show the TAWC results for the soil conservation metric for 2009 and 2016 and Figures 5-6 indicate the conservation efficiency, which was calculated as the lint yield equivalent/soil erosion. Results show an increase in the metric score in 2016 (3.36), implying that sites experienced on average more soil erosion than in 2009 (1.76), resulting in less yield efficiency, although not by a significant amount. Metric results for soil carbon are shown in Figures 7-8. The average soil conditioning index in 2009 was -0.15 in 2009 and -0.14 in 2016, suggesting about the same amount of soil loss for both years. Irrigation water use for 2009 and 2016 are depicted in Figures 9-10. On average, cotton producing sites applied 12.55 acres inches of water in 2009 and 10.79 acre inches in 2016. Irrigation efficiency relative to yield is depicted in Figures 11-12. Producers seem to be much more efficient with their water in 2016 compared to 2009. In 2009, there were 4 furrow, 3 LEPA, 3 SDI, 5 LESA, and 3 MESA systems. In 2016, there were 1 furrow, 5 LEPA, 4 SDI, 5 LESA, and 1 MESA system. The adoption of more efficient irrigation systems had positive effects on the sustainability scores in 2016. Energy use and energy use efficiency are illustrated in Figures 13-16. Average energy use in 2009 was slightly higher than in 2016, and therefore less efficient with respect to yield. With respect to total variable cost, producers spent $200 more per acre in 2016 than in 2009 to generate more yield.

Tables 1 and 2 illustrate the site rankings of each metric and total variable cost for 2009 and 2016, respectively. Rows that are highlighted indicate the same sites for both years. There were 19 irrigated producers in 2009 and 16 in 2016. The differences in the site and field numbers in each year are due to some producers leaving and joining the project, differences in crop mix, and changing of the field configurations. The rankings for the Overall Resource Efficiency include the total scores from the efficiencies calculated from the metrics with respect to yield, with 1 being the most efficient. Site 11 had the least overall resource efficiency in both years, suggesting that the sustainability scores are not due to poor management skills, but rather that the effects of inherent soil characteristics (type, slope) are hard to overcome. In 2009, site 6 was ranked 2, 4, and 6 and in 2016 was ranked 10th, but there were some positive changes in some of the metric scores despite the overall ranking. Site 22 and 4 had the most dramatic changes in scores moving from 13 and 19 in 2009 to 2 and 3 in 2016.

Summary

Overall, TAWC cotton producers in 2016 saw improvement in some of their sustainability scores compared to 2009. Sites in both years had poor soil conservation scores. The increased soil erosion had negative impacts on soil health as represented by the soil carbon metric. In 2016, producers applied less water than 2009 and was therefore more energy efficient. However, the greenhouse gas emissions in 2016 was much higher than in 2009 which is also reflected in the increased variable cost in 2016 (likely due to an increase in chemical applications).

Acknowledgements

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Appendix

Table 1. Ranking of Resource and Total Variable Cost Efficiencies for 2009

TAWC Producer & Field Number	Lint Yield Equivalent	Conservation Efficiency	Soil Carbon	Irr Water Use Efficiency	Energy Use Efficiency	GHG Emission Efficiency	Overall Resource Efficiency	Total Variable Cost Efficiency
3--2	7	1	1	1	3	3	1	1
6--6	9	4	2	3	7	8	2	3
15--8	6	5	6	19	2	2	3	15
6--7	10	12	3	4	6	7	4	4
18--2	12	18	4	2	1	1	5	2
6--8	11	7	9	5	8	9	6	5
14--2	8	6	5	9	9	12	7	10
28--1	4	13	17	6	4	4	8	7
15--9	2	3	7	15	14	14	9	8
20--1	1	2	13	12	18	17	10	6
19--9	17	11	8	8	11	10	11	13
9--2	19	17	10	7	5	5	12	14
22--3	5	10	14	11	16	15	13	17
10--2	14	8	12	13	12	13	14	16
27--3	3	9	18	10	17	18	15	9
11--1	16	15	15	16	10	6	16	11
2--1	15	16	11	14	13	16	17	18
11--3	13	14	16	17	15	11	18	12
4--1	18	19	19	18	19	19	19	19

Table 2. Ranking of Resource and Total Variable Cost Efficiencies for 2016

TAWC Producer & Field Number	Lint Yield Equivalent (r)*	Conservation Efficiency (r)	Soil Carbon (r)	Irr Water Use Efficiency (r)	Energy Use Efficiency (r)	GHG Emission Efficiency (r)	Overall Resource Efficiency (r)	Total Variable Cost Efficiency (r)
21--1	1	5	5	1	2	3	1	4
22--3	2	1	1	3	7	9	2	5
4--10	11	3	4	4	4	4	3	8
60--1	13	2	2	11	1	1	4	11
32--1	3	6	9	9	3	2	5	2
35--2	4	4	3	6	10	10	6	10
31--1	9	9	6	8	9	6	7	6
21-2	8	10	8	12	6	8	8	9
51--1	6	13	16	10	5	5	9	1
6--10	5	7	10	5	16	14	10	3
50--1	12	14	15	2	8	7	11	7
9--2	7	11	12	7	11	11	12	12
10--7	10	8	7	13	13	12	13	13
11--2	15	12	11	14	14	15	14	16
11--5	16	16	14	15	12	13	15	15
11--3	14	15	13	16	15	16	16	14

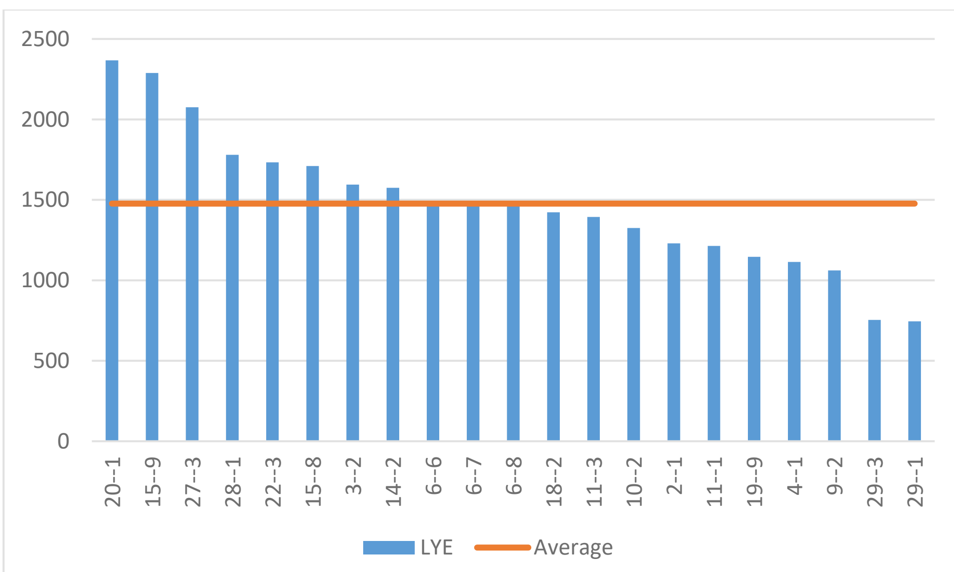

Figure 1. Lint Yield Equivalent (lb/ac), 2009

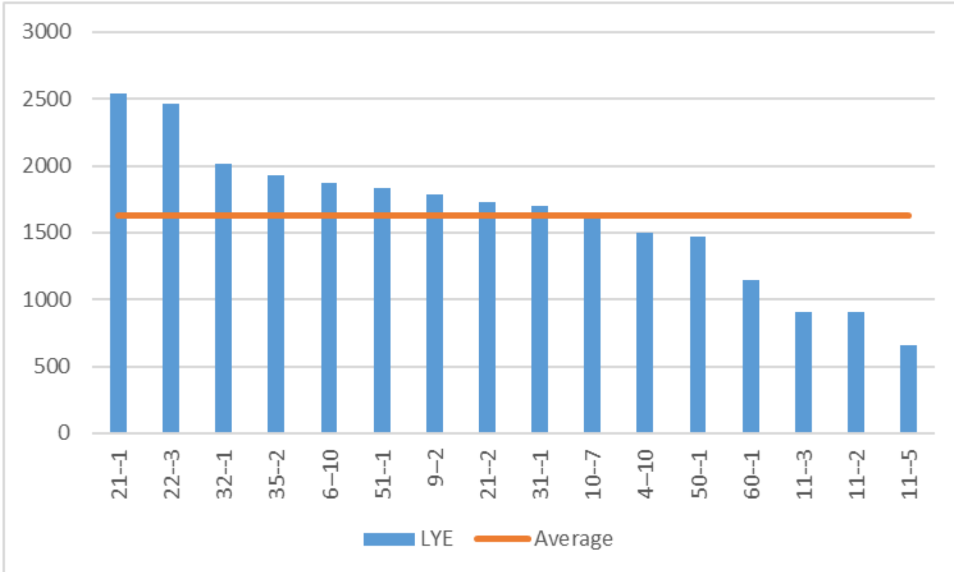

Figure 2. Lint Yield Equivalent (lb/ac), 2016

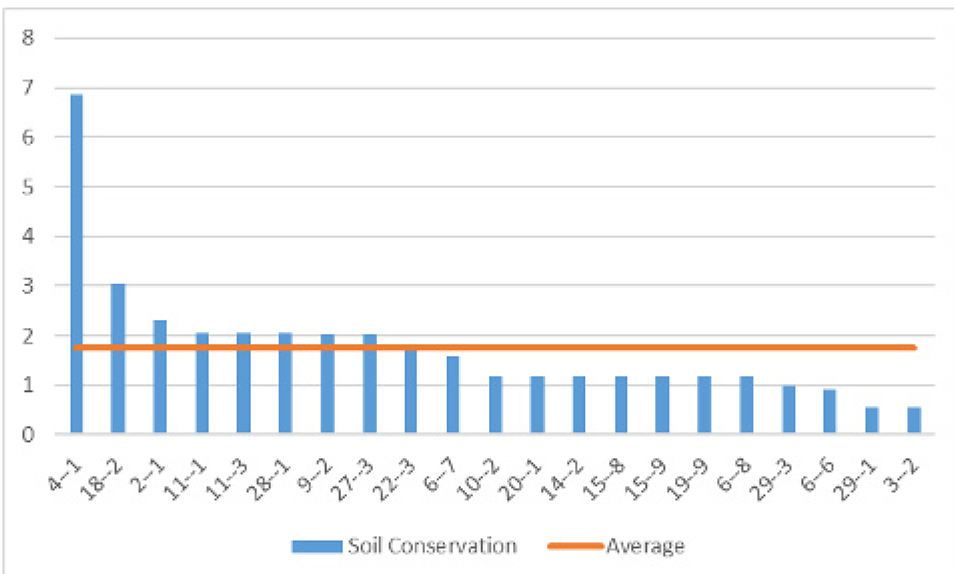

Figure 3. Soil Conservation (tons of soil loss/ac/year), 2009

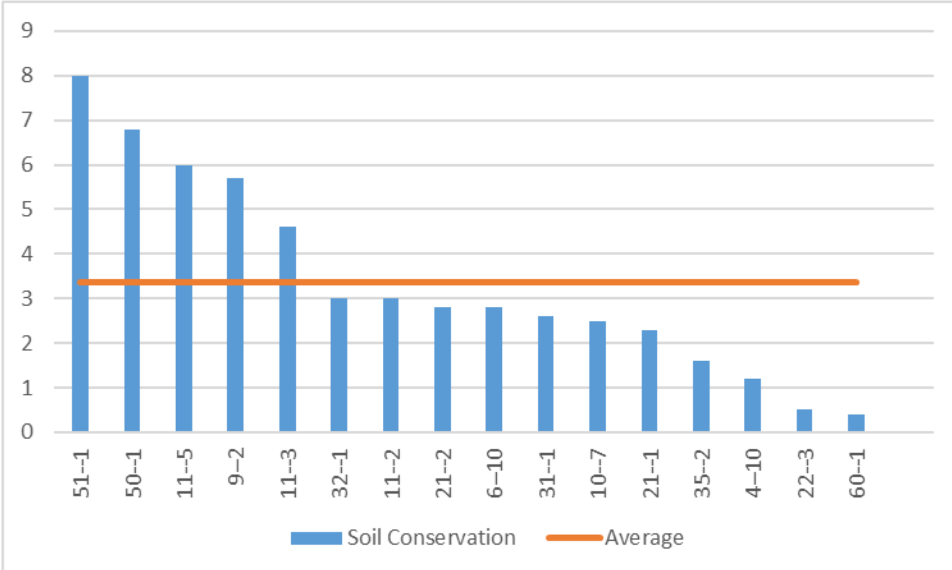

Figure 4. Soil Conservation (tons of soil loss/ac/year), 2016

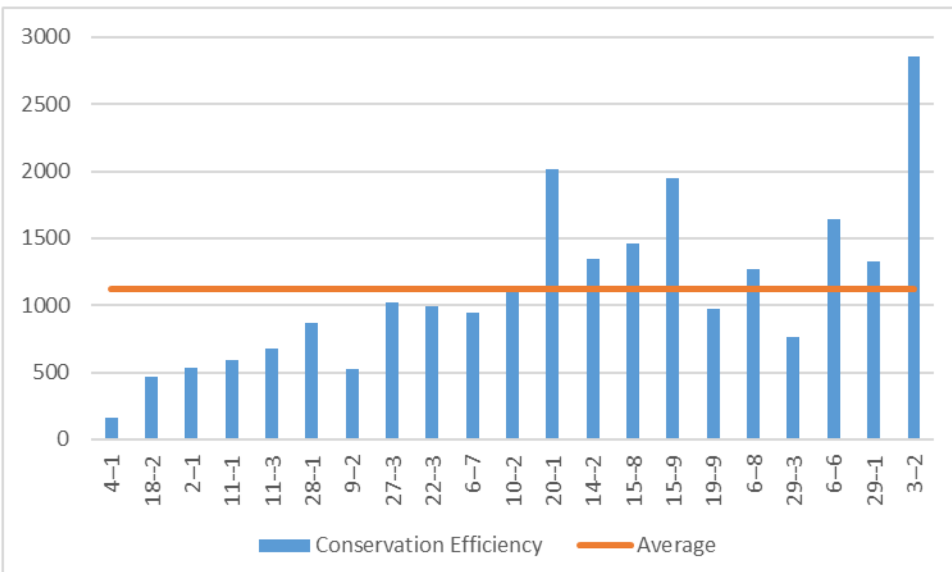

Figure 5. Conservation Efficiency (lint yield equivalent/soil conservation), 2009

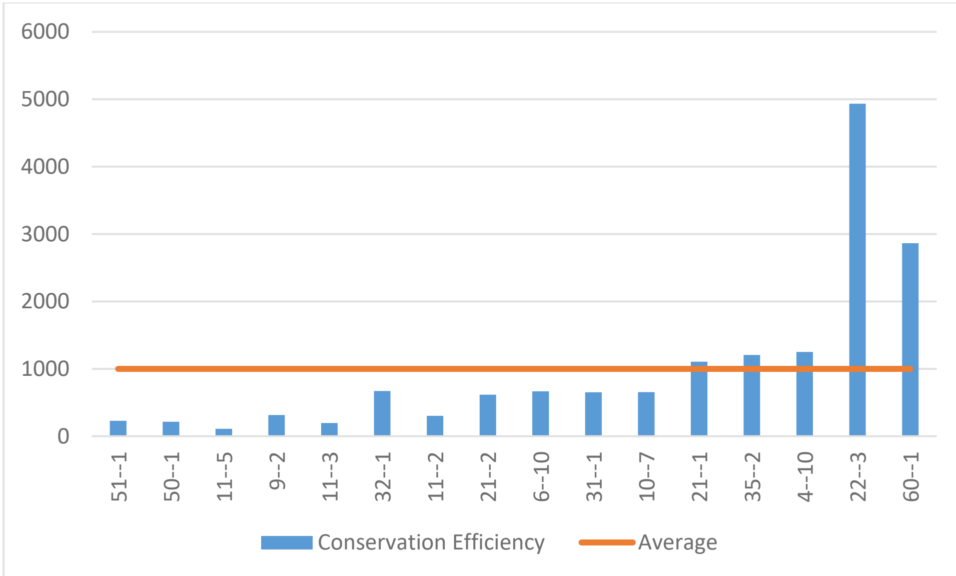

Figure 6. Conservation Efficiency (lint yield equivalent/soil conservation), 2016

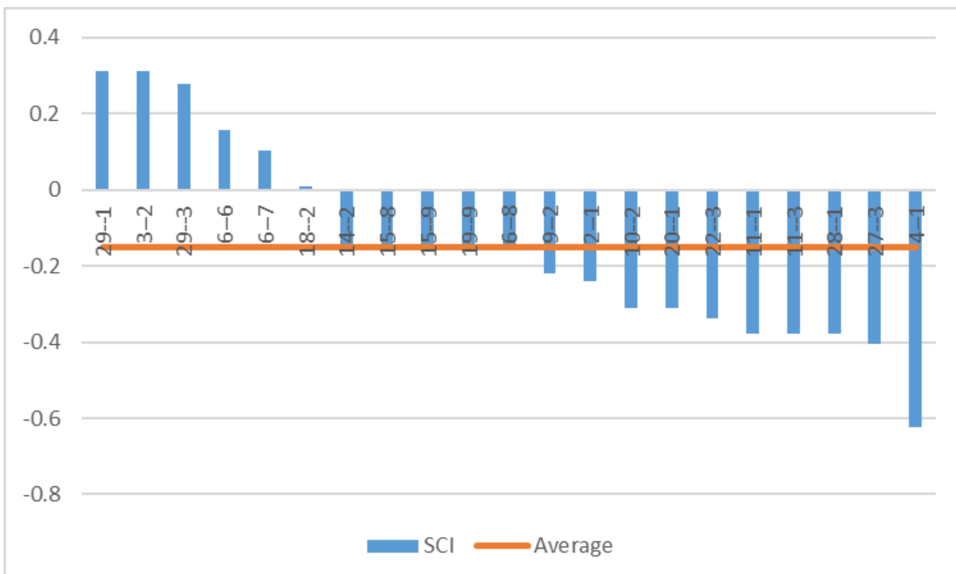

Figure 7. Soil Conditioning Index (SCI), 2009

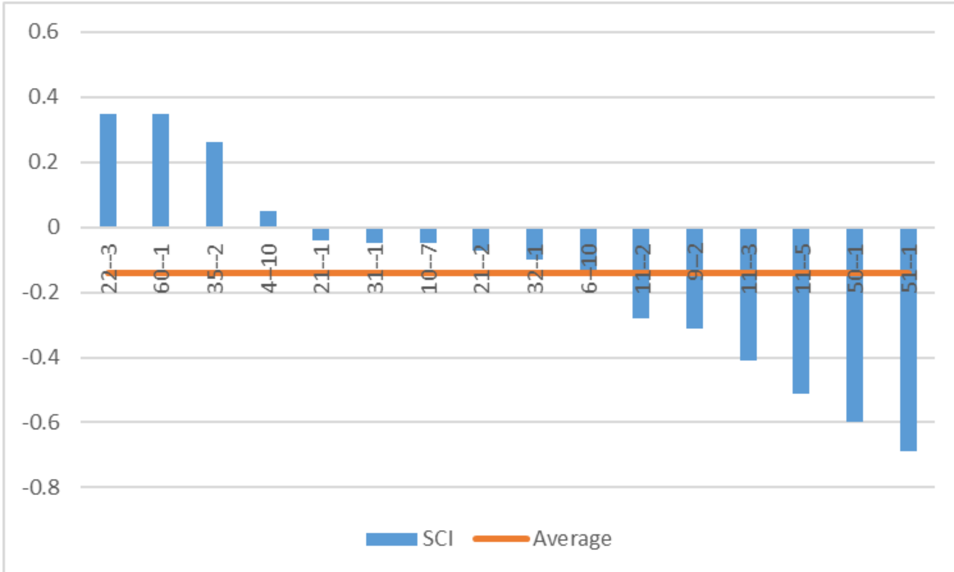

Figure 8. Soil Conditioning Index (SCI), 2016

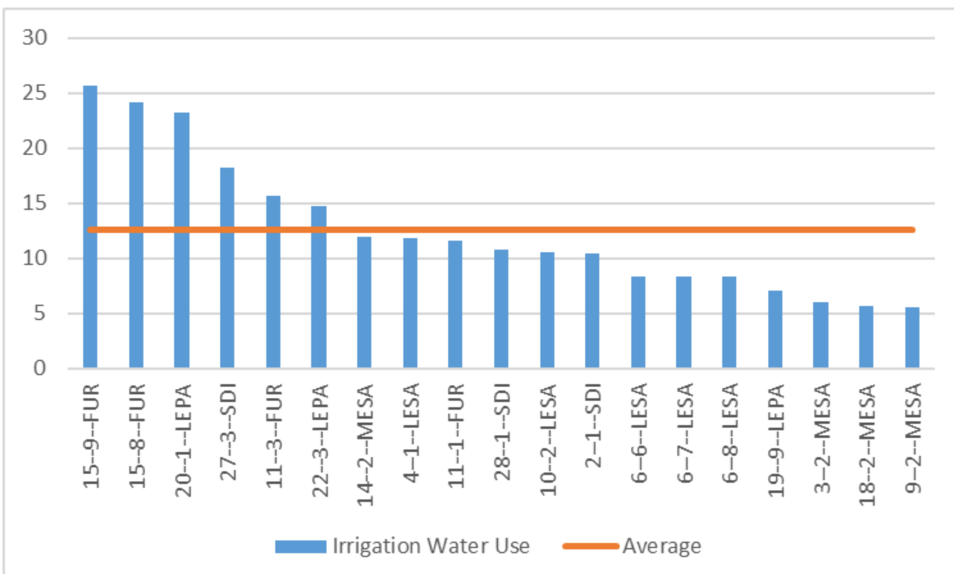

Figure 9. Irrigation Water Use (inches/acre), 2009

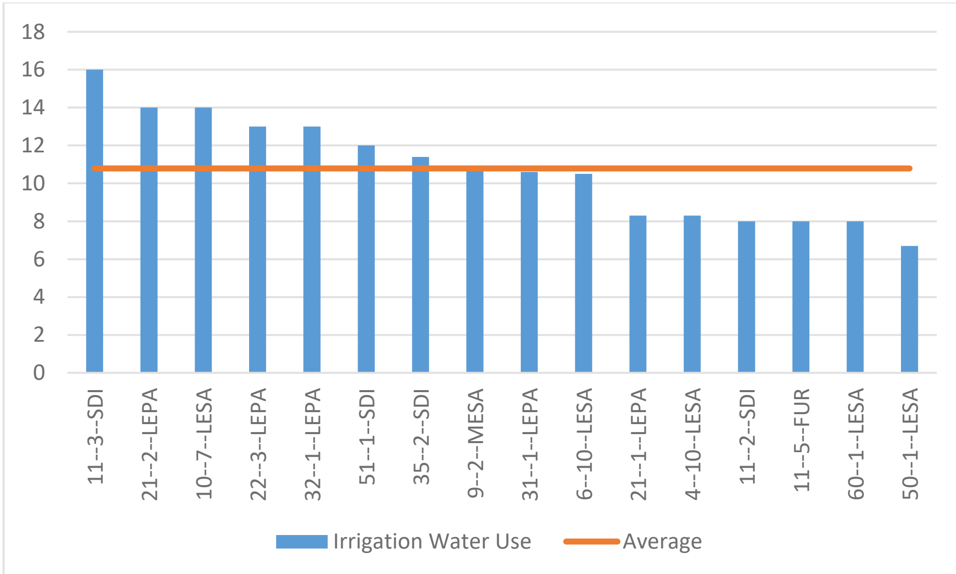

Figure 10. Irrigation Water Use (inches/acre), 2016

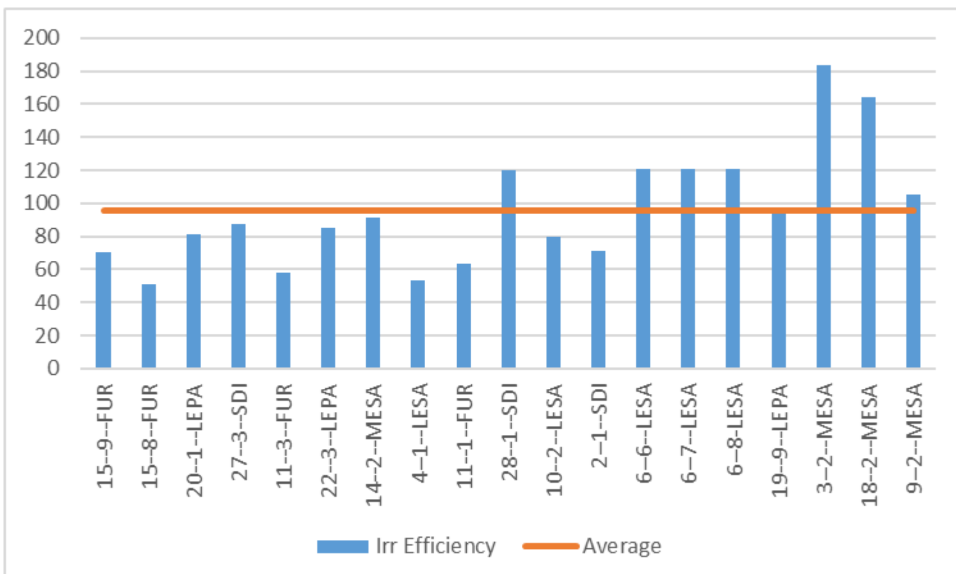

Figure 11. Irrigation Efficiency (Lint Yield Equivalent/Irrigation Water Use), 2009

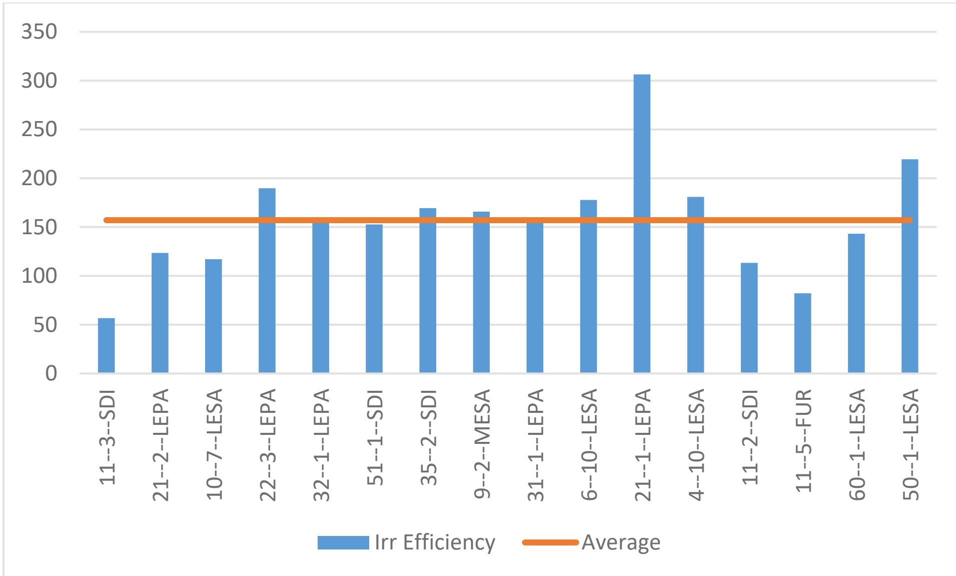

Figure 12. Irrigation Efficiency (Lint Yield Equivalent/Irrigation Water Use), 2016

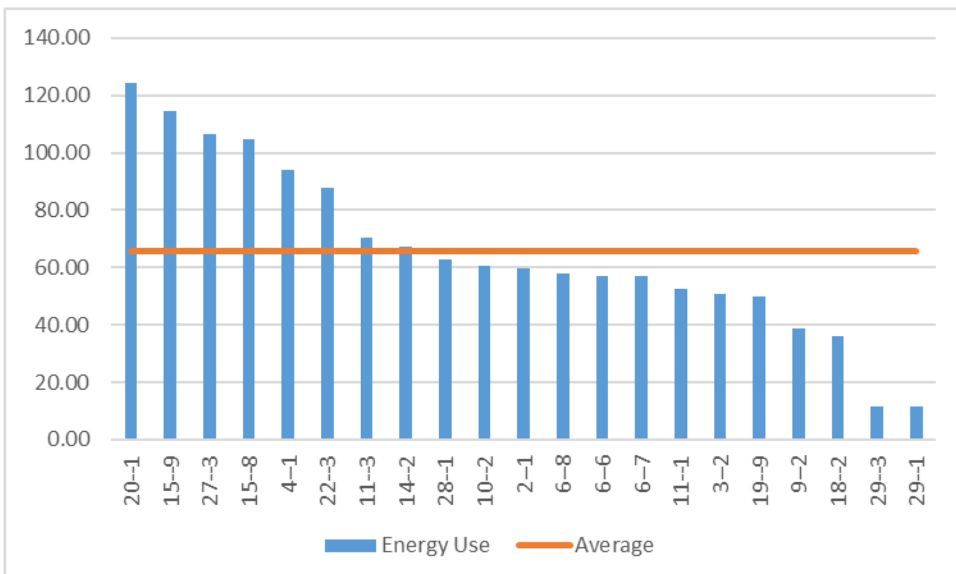

Figure 13. Energy Use (gallons diesel equivalent/acre), 2009

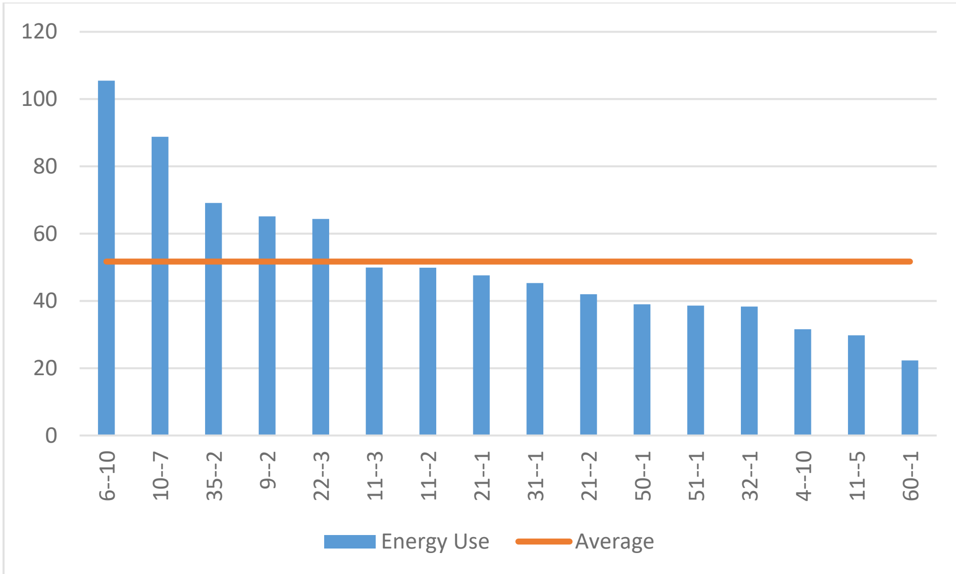

Figure 14. Energy Use (gallons diesel equivalent/acre), 2016

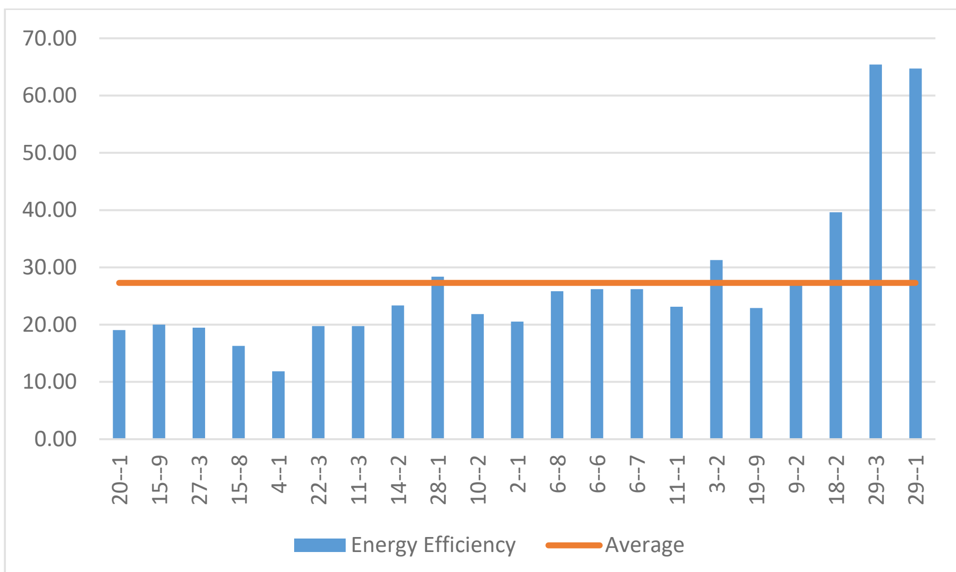

Figure 15. Energy Efficiency (lint yield equivalent/energy use), 2009

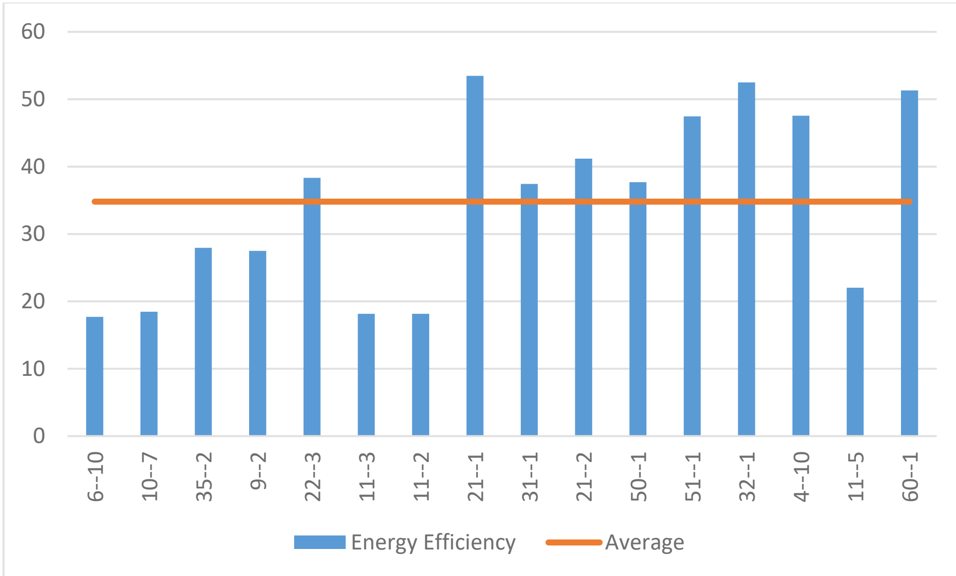

Figure 16. Energy Efficiency (lint yield equivalent/energy use), 2016

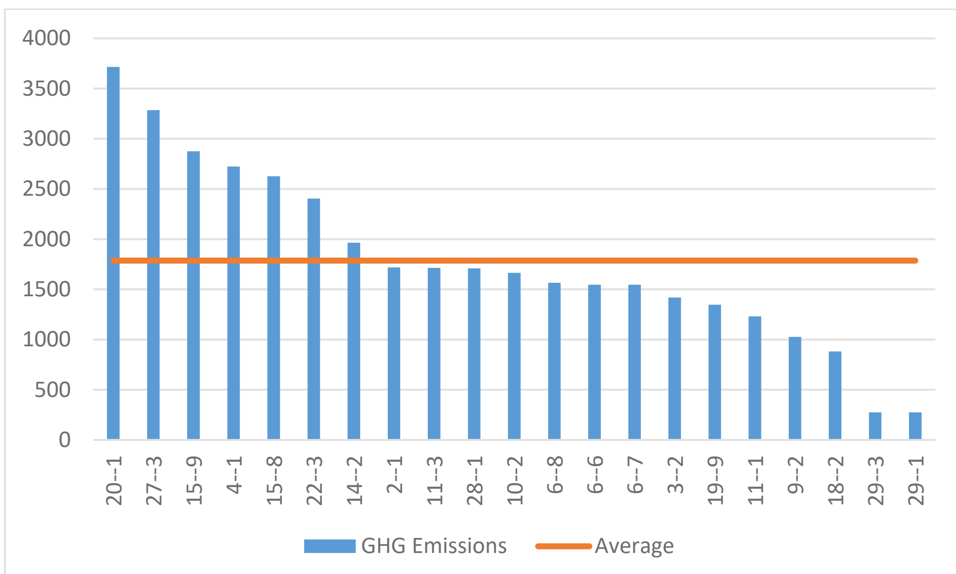

Figure 17. Greenhouse Gas Emissions (lbs of CO2 equivalent/acre), 2009

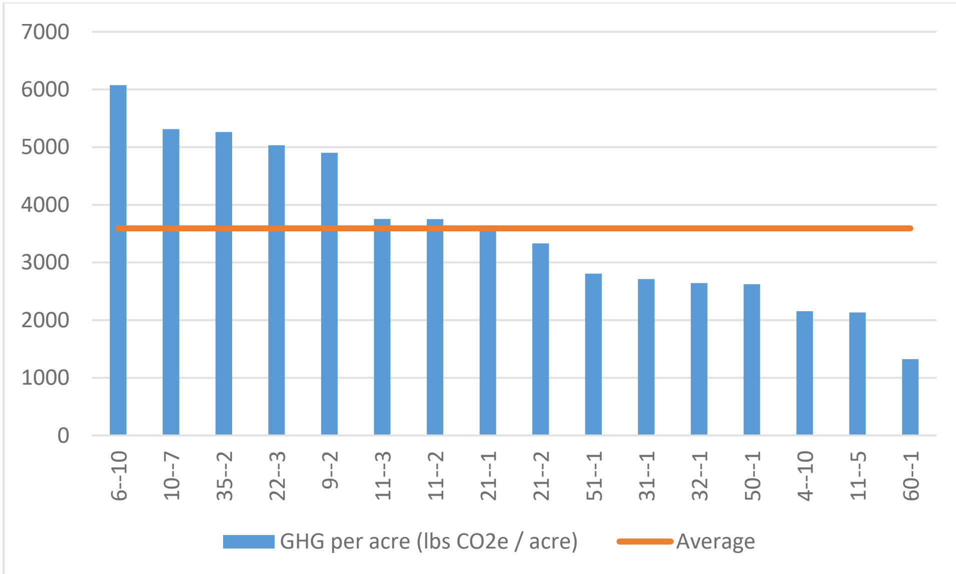

Figure 18. Greenhouse Gas Emissions (lbs of CO2 equivalent/acre), 2016

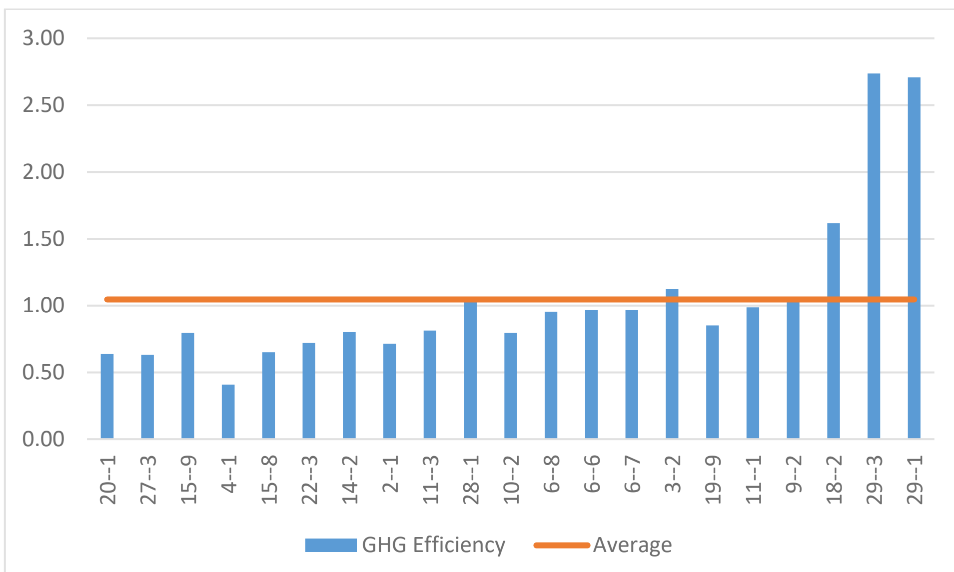

Figure 19. Greenhouse Gas Efficiency (lint yield equivalent/greenhouse gas emissions), 2009

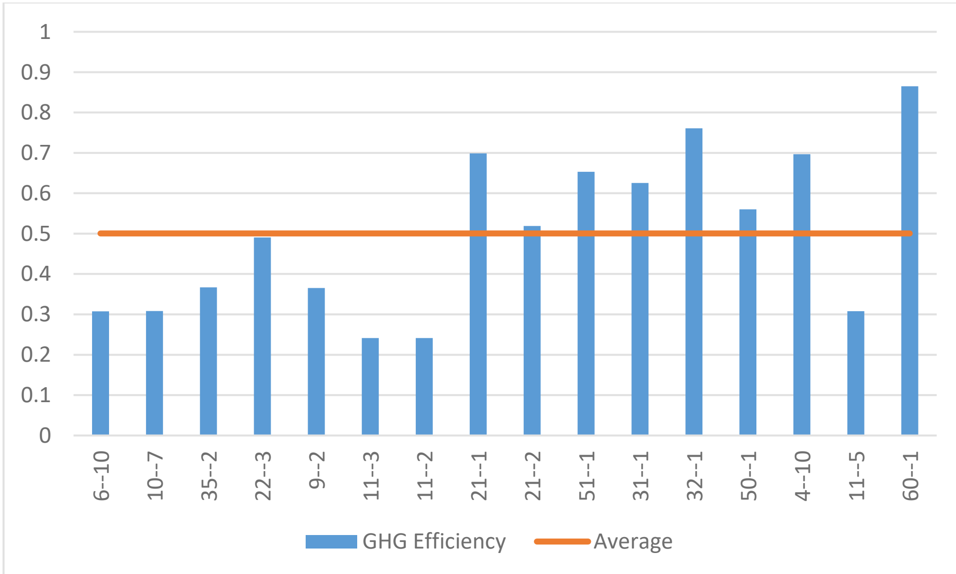

Figure 20. Greenhouse Gas Efficiency (lint yield equivalent/greenhouse gas emissions), 2016

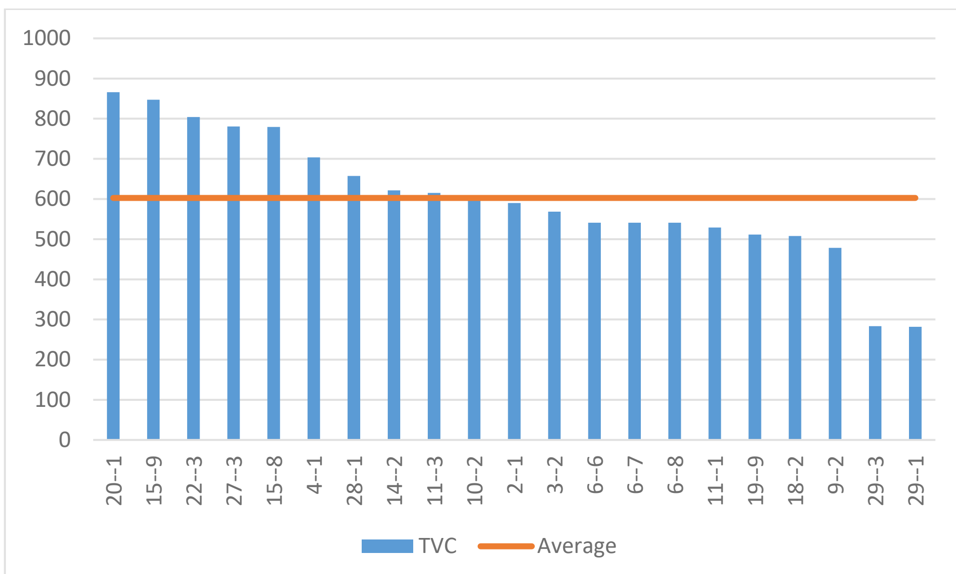

Figure 21. Total Variable Cost ($/acre), 2009

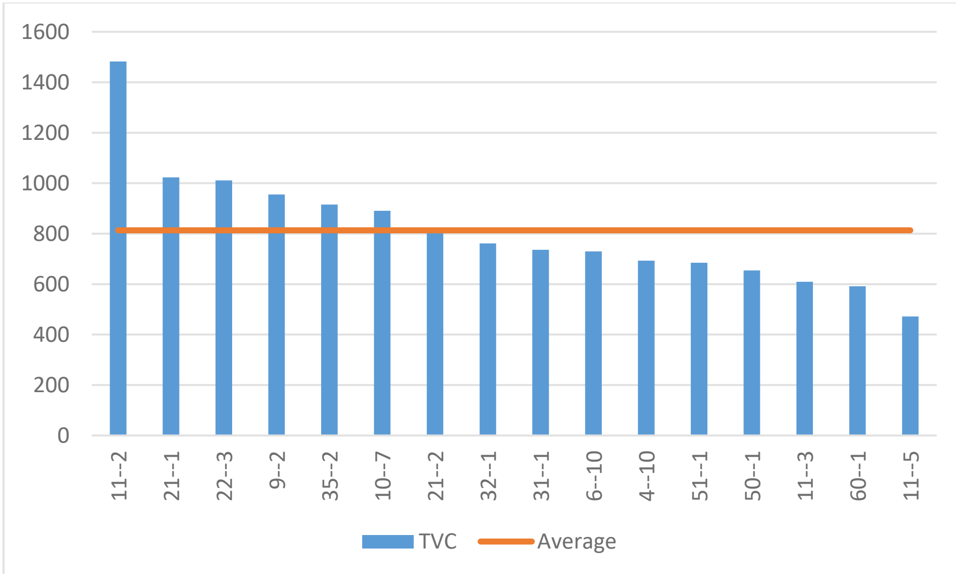

Figure 22. Total Variable Cost ($/acre), 2016

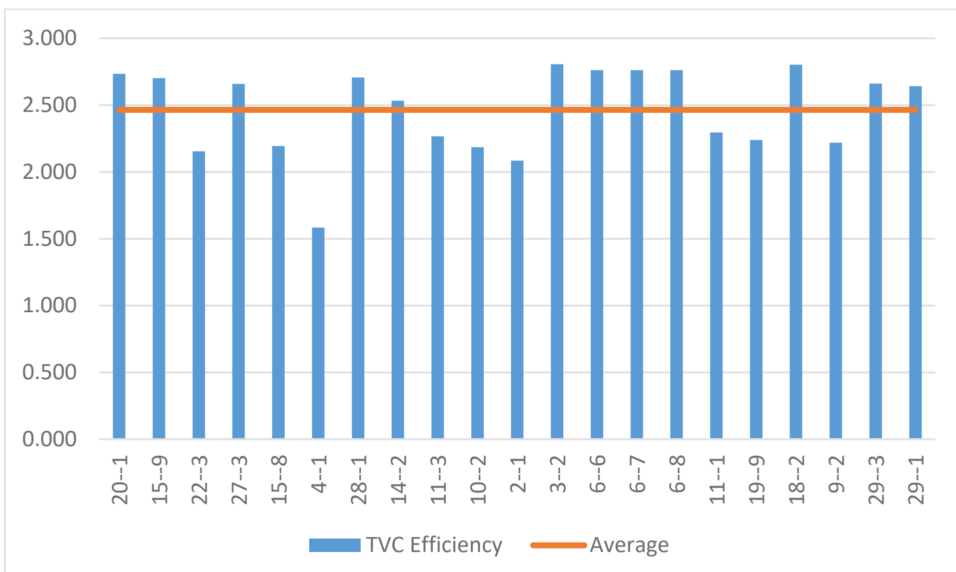

Figure 23. Total Variable Cost Efficiency (lint yield equivalent/total variable cost), 2009

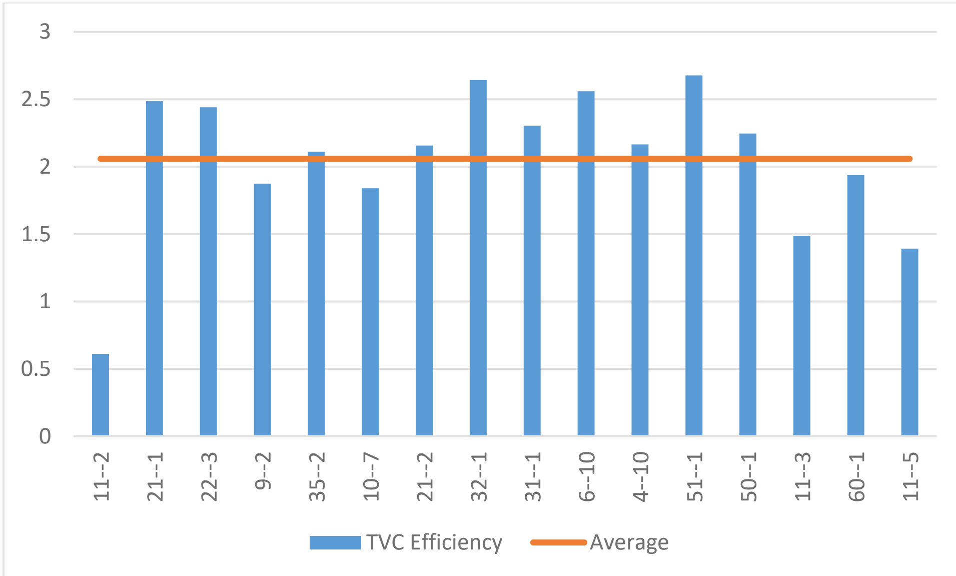

Figure 24. Total Variable Cost Efficiency (lint yield equivalent/total variable cost), 2016