

High Yielding Corn Production with Subsurface Drip Irrigation

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Summary

This corn intensification study was conducted under subsurface drip irrigation (SDI) from 2017 to 2021 at the Kansas State University Northwest Research-Extension Center near Colby, KS. Two corn hybrids (Pioneer 1151 and Pioneer 11197) were grown with advanced fertilization at three plant densities (42,000, 38,000, and 34,000 plants/a) using three irrigation levels (115, 100, or 85% of calculated well-watered ET minus rain). Average yields were 259, 257, and 254 bu/a for the 115, 100, and 85% ET - Rain irrigation levels respectively, indicating that irrigation does not have to increase with crop intensification when using SDI. Both corn hybrids yielded well, and plant densities that were greater than 34,000 plants/a attained slightly greater yields.

Introduction

Crop production intensification is a key factor for addressing one of the greatest challenges of this century: feeding 9.5 billion people by the year 2050. Inherent in this challenge are the limitations of arable land as well as a shortage of fresh water sources. Ecologically, crop intensification can protect marginal lands from further development and save water resources. Intensification on a smaller land area also has potential to reduce inputs required for crop production and crop protection. These include seed, fertilizer, herbicides, pesticides, crop scouting, crop insurance, harvesting costs and any other input cost that has a fixed cost per land area basis. Crop water productivity (WP) is defined as the crop grain yield divided by the total crop water use. Optimization of irrigation water resource usage is often guided by WP. This term is often used to guide sound use of water resources. In this study, efforts concentrated on increasing the numerator of WP (i.e., corn grain yield), while not adversely increasing the denominator (i.e., crop water use). A subsurface drip-irrigated corn study was conducted from 2017 to 2021 at the K-State Northwest Research-Extension Center at Colby, KS, to intensify corn production through hybrid selection, increased plant density (aka plant population) and through advanced fertilization. A wind storm heavily damaged the crop in 2018 and it was abandoned for research and will not be further discussed in this summary.

Experimental Procedures

Corn was planted in late April or early May in all years at seeding rates of approximately 42,000, 38,000 and 34,000 seeds/a. Selected corn hybrids were Pioneer 1151 and Pioneer 1197. Advanced fertilization procedures varied between years and are listed in

¹ Sadly, Freddie Lamm passed away during the process of publishing this report, May 26, 2022.

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Table 1. Typical pesticide control procedures were used to minimize pests. Soil water was monitored periodically to an 8-ft depth in 1-ft increments with neutron moderation techniques. Corn yield and yield components were determined by hand harvesting at physiological maturity. Crop water use was determined as the sum of the seasonal soil water change, irrigation, and rainfall. Crop water productivity was calculated as grain yield/crop water use. Irrigation was scheduled only as needed to match 115, 100, or 85% of the previous period's ET - Rain. Irrigation amounts per event were generally 1 inch.

Results and Discussion

Growing conditions were favorable for good corn production in all 4 years of the study (2017, 2019-2021), but a wind storm during the overnight period of July 1–2, 2020, definitely limited yields in that year. The wind, coupled with a small amount of small hail, reduced leaf area by 10–20 % when the corn was approximately 5 ft tall. When averaged over the 4 crop years, irrigation amounts were 16.99, 14.65, and 12.30 inches for the 115, 100, and 85% ET - Rain treatments respectively.

Average corn yields were 257 bu/a during the study (Table 2) but varied between years (Figure 1). Yield differences between irrigation levels were very small indicating that replacing irrigation at 85% of ET - Rain would be an acceptable irrigation strategy. Both hybrids yielded well, with Pioneer 1197 yielding better in 3 of the 4 years. There was a 6 bu/a yield benefit of increasing plant density above 34,000 plants/a. Crop water productivity was also high for this study, averaging 520, 558, and 577 lb/acre-in. for the 115, 100, and 85% ET - Rain treatments, respectively (Figure 2). These high yields and high water productivity indicate that intensification of corn is a realistic cropping scenario for the region.

Acknowledgments

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Table 1. Advanced fertilization procedures used in the sprinkler-irrigated corn intensification study in 2017, and 2019 to 2021

| Application type | Date | Product | Amount |
|--------------------|--------------------|--|---|
| 2017 Crop season | | | |
| Preplant broadcast | 5-08-17 | UAN 32-0-0 and NACHURS 9-20-3 | 44 lb N/a and 11.4 gal/a |
| Planting in-furrow | 5-09-17 | Zinc 9% | 2 qt/a |
| Fertigation | 6-20-17 | UAN 32-0-0 and NACHURS | 66 lb N/a and 1.875 gal/a total applied in the 4 equal events |
| | 6-26-17 | Aquatech 7-20-4 | |
| | 7-06-17 | | |
| | 7-10-17 | | |
| Fertigation | 7-14-17 | UAN 32-0-0 and NACHURS | 66 lb N/a and 3.75 gal/a total applied in the 4 equal events |
| | 7-18-17 | Aquatech 7-20-4 | |
| | 7-21-17 | | |
| | 7-24-17 | | |
| Fertigation | 7-31-17 | NACHURS RhyzoLink LF and NACHURS K-Fuel | 28 oz/a and 2 gal/a |
| Fertigation | 7-31-17 8-4-17 | UAN 32-0-0, NACHURS Aquatech 7-20-4 and NACHURS 2-6-16 | 44 lb N/a, 1 gal/a, and 3 gal/a total applied in the 2 equal events |
| 2019 Crop season | | | |
| Preplant broadcast | 4-29-19 | UAN 32-0-0 and NACHURS 10-18-4 | 44 lb N/a and 12.6 gal/a |
| Planting in-furrow | 4-29-19 | Zinc 9% | 1 qt/a |
| Fertigation | 6-14-19 | UAN 32-0-0 and NACHURS | 66 lb N/a and 1.875 gal/a total applied in the 3 equal events |
| | 6-20-19 | Aquatech 7-20-4 | |
| | 6-25-19 | | |
| | 6-29-19 | | |
| Fertigation | 7-02-19 | UAN 32-0-0 and NACHURS | 66 lb N/a and 3.75 gal/a total applied in the 4 equal events |
| | 7-11-19 | Aquatech 7-20-4 | |
| | 7-18-19 | | |
| Fertigation | 7-18-19 | NACHURS RhyzoLink LF and NACHURS K-Fuel | 28 oz/a and 2 gal/a |
| Fertigation | 7-26-19 7-31-19 | UAN 32-0-0, NACHURS Aquatech 7-20-4 and NACHURS 2-6-16 | 44 lb N/a, 1 gal/a, and 3 gal/a total applied in the 2 equal events |
| 2020 Crop season | | | |
| Preplant broadcast | 5-05-20 | UAN 32-0-0 and NACHURS 10-18-4 | 44 lb N/a and 12.6 gal/a |
| Planting in-furrow | 5-05-20 | Zinc 9% | 1 qt/a |
| Fertigation | 6-18-20 | UAN 32-0-0 and NACHURS | 198 lb N/a and 1.875 gal/a total applied in the 3 equal events |
| | 6-22-20 | Aquatech 7-20-4 | |
| | 6-25-20 | | |
| | 6-30-20 | | |
| Fertigation | 7-07-20 | NACHURS Aquatech 7-20-4 | 3.75 gal/a total applied in the 4 equal events |
| | 7-14-20 | | |
| | 7-17-20 | | |
| Fertigation | 7-17-20 | NACHURS RhyzoLink LF and NACHURS K-Fuel | 28 oz/a and 2 gal/a |
| Fertigation | 7-23-20 7-31-20 | NACHURS Aquatech 7-20-4 and NACHURS 2-6-16 | 1 gal/a and 3 gal/a total applied in the 2 equal events |

continued

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| Application type | Date | Product | Amount |
|-------------------------|-------------------------------|---|--|
| 2021 Crop season | | | |
| Preplant broadcast | 5-05-20 | UAN 32-0-0 | 44 lb N/a |
| Planting in-furrow | 5-05-20 | NACHURS ImPulse and NACHURS Crop Watch | 6 gal/a and 1 qt/a |
| Fertigation | 6-16-21 6-25-21 6-30-21 | UAN 32-0-0, NACHURS Aquatech 7-20-4, NACHURS K-Flex Max and NACHURS Sideswipe | 64 lb N/a, 1.875 gal/a, 1 gal/a, and 1 qt/a, total applied in the 3 equal events |
| Foliar | 6-11-21 | NACHURS FinishLine and NACHURS K-Fuel | 1 qt/a and 1 gal/a |
| Fertigation | 7-02-21 7-09-21 | UAN 32-0-0, NACHURS Aquatech 7-20-4, NACHURS K-Flex Max and NACHURS Sideswipe | 63 lb N/a, 3.75 gal/a, 1 gal/a, and 1 qt/a, total applied in the 2 equal events |
| Fertigation | 7-20-21 7-25-21 | UAN 32-0-0, NACHURS Aquatech 7-20-4, NACHURS K-Flex and NACHURS Sideswipe | 45 lb N/a, 3 gal/a, 1 gal/a and 1 qt/a in the 2 equal events |

Table 2. Average (2020 to 2021) corn yields, harvest plant density, total crop water use, and water productivity (WP) in a subsurface drip-irrigated corn intensification study

| Irrigation treatment | Hybrid | Plant density treatment | Yield | Plant density | Water use | WP | |
|-----------------------------|----------------------|--------------------------------|--------------|----------------------|------------------|-------------|-----|
| | | | bu/a | plants/a | inches | lb/acre-in. | |
| 1.15 ET 16.99 in. | P 1151 | 42K | 255 | 41055 | 27.05 | 527 | |
| | | 38 K | 261 | 37189 | 26.99 | 541 | |
| | | 34K | 248 | 33323 | 26.98 | 514 | |
| | | Mean | 255 | 37189 | 27.01 | 527 | |
| | P 1197 | 42K | 268 | 41382 | 27.48 | 545 | |
| | | 38 K | 265 | 37135 | 28.10 | 528 | |
| | | 34K | 257 | 33215 | 27.13 | 532 | |
| | | Mean | 263 | 37244 | 27.57 | 535 | |
| | Mean | | 259 | 37217 | 27.29 | 531 | |
| | 1.00 ET 14.65 in. | P 1151 | 42K | 247 | 41164 | 24.51 | 611 |
| | | | 38 K | 254 | 37788 | 25.32 | 562 |
| | | | 34K | 254 | 33487 | 25.29 | 562 |
| Mean | | | 252 | 37480 | 25.04 | 578 | |
| P 1197 | | 42K | 265 | 41110 | 26.15 | 567 | |
| | | 38 K | 262 | 37353 | 25.49 | 576 | |
| | | 34K | 261 | 33487 | 26.07 | 564 | |
| | | Mean | 263 | 37316 | 25.90 | 569 | |
| Mean | | | 257 | 37398 | 25.47 | 574 | |
| 0.85 ET 12.30 in. | | P 1151 | 42K | 252 | 40729 | 24.22 | 585 |
| | | | 38 K | 251 | 37516 | 23.64 | 597 |
| | | | 34K | 241 | 33541 | 23.43 | 578 |
| | Mean | | 248 | 37262 | 23.76 | 587 | |
| | P 1197 | 42K | 265 | 40892 | 24.86 | 599 | |
| | | 38 K | 258 | 37462 | 24.86 | 581 | |
| | | 34K | 256 | 33215 | 24.88 | 578 | |
| | | Mean | 260 | 37189 | 24.87 | 586 | |
| | Mean | | 254 | 37226 | 24.32 | 586 | |
| | Grand mean | | | 257 | 37280 | 25.69 | 564 |

continued

Table 2. Average (2020 to 2021) corn yields, harvest plant density, total crop water use, and water productivity (WP) in a subsurface drip-irrigated corn intensification study

| Irrigation treatment | Hybrid | Plant density treatment | Yield | Plant density | Water use | WP |
|-----------------------------|---------------|--------------------------------|--------------|----------------------|------------------|-------------|
| | | | bu/a | plants/a | inches | lb/acre-in. |
| Mean by category | | | | | | |
| | | | 259 | 37217 | 27.29 | 531 |
| | | | 257 | 37398 | 25.47 | 574 |
| | | | 254 | 37226 | 24.32 | 586 |
| | P1151 | | 251 | 37310 | 25.27 | 564 |
| | P1197 | | 262 | 37250 | 26.11 | 563 |
| | | 42K | 259 | 41055 | 25.71 | 572 |
| | | 38K | 259 | 37407 | 25.73 | 564 |
| | | 34K | 253 | 33378 | 25.63 | 555 |

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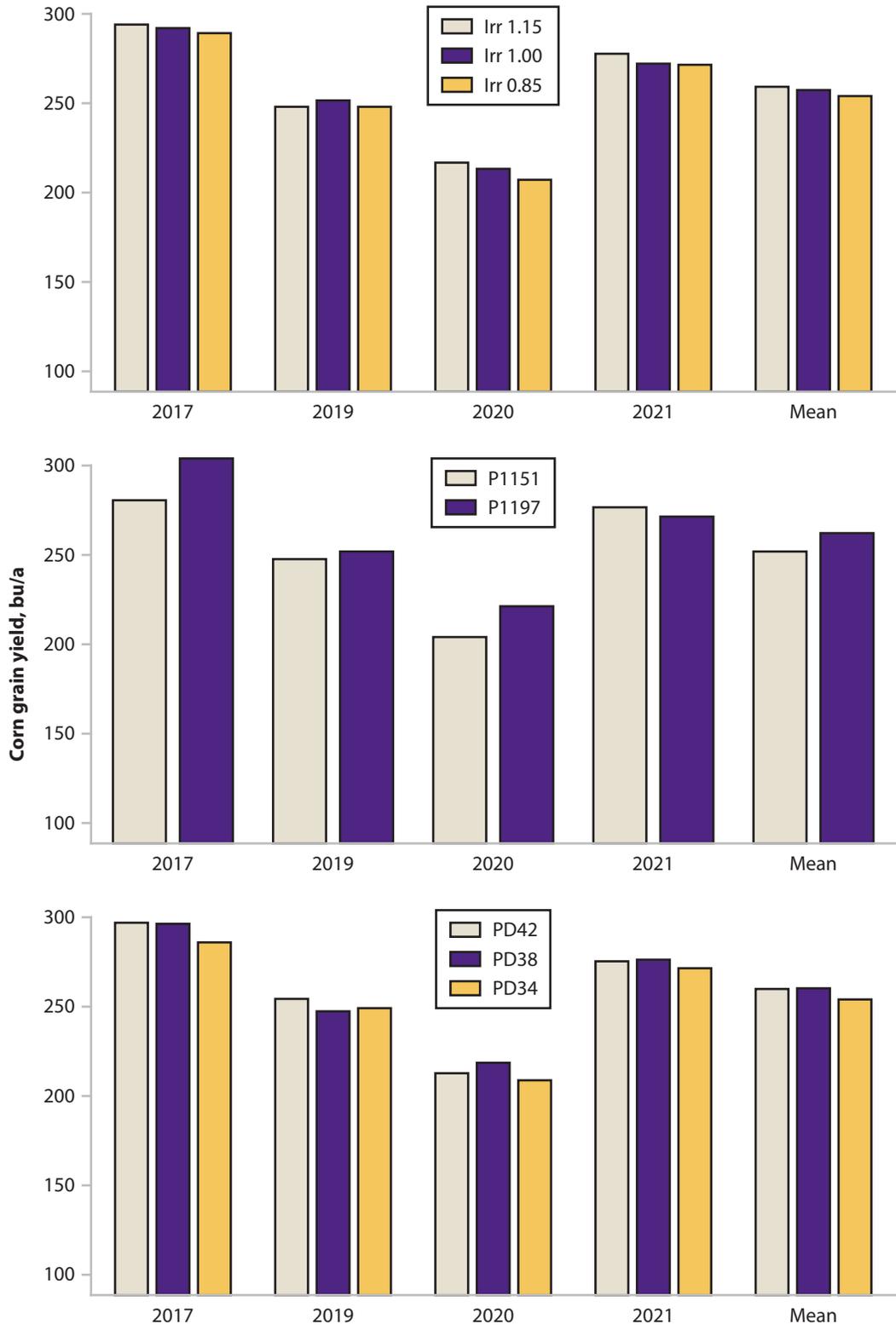


Figure 1. Corn grain yields (2017, 2019–2021) for a subsurface drip irrigation (SDI) crop intensification study at Kansas State University Northwest Research-Extension Center, Colby, KS. Upper panel is for the three irrigation levels designed to match 115, 100, or 85% of well-watered corn ET minus rain. Middle panel is for the two corn hybrids Pioneer 1151 and Pioneer 1197. Bottom panel is for the three plant densities, 42,000, 38,000, or 34,000 plants/a.

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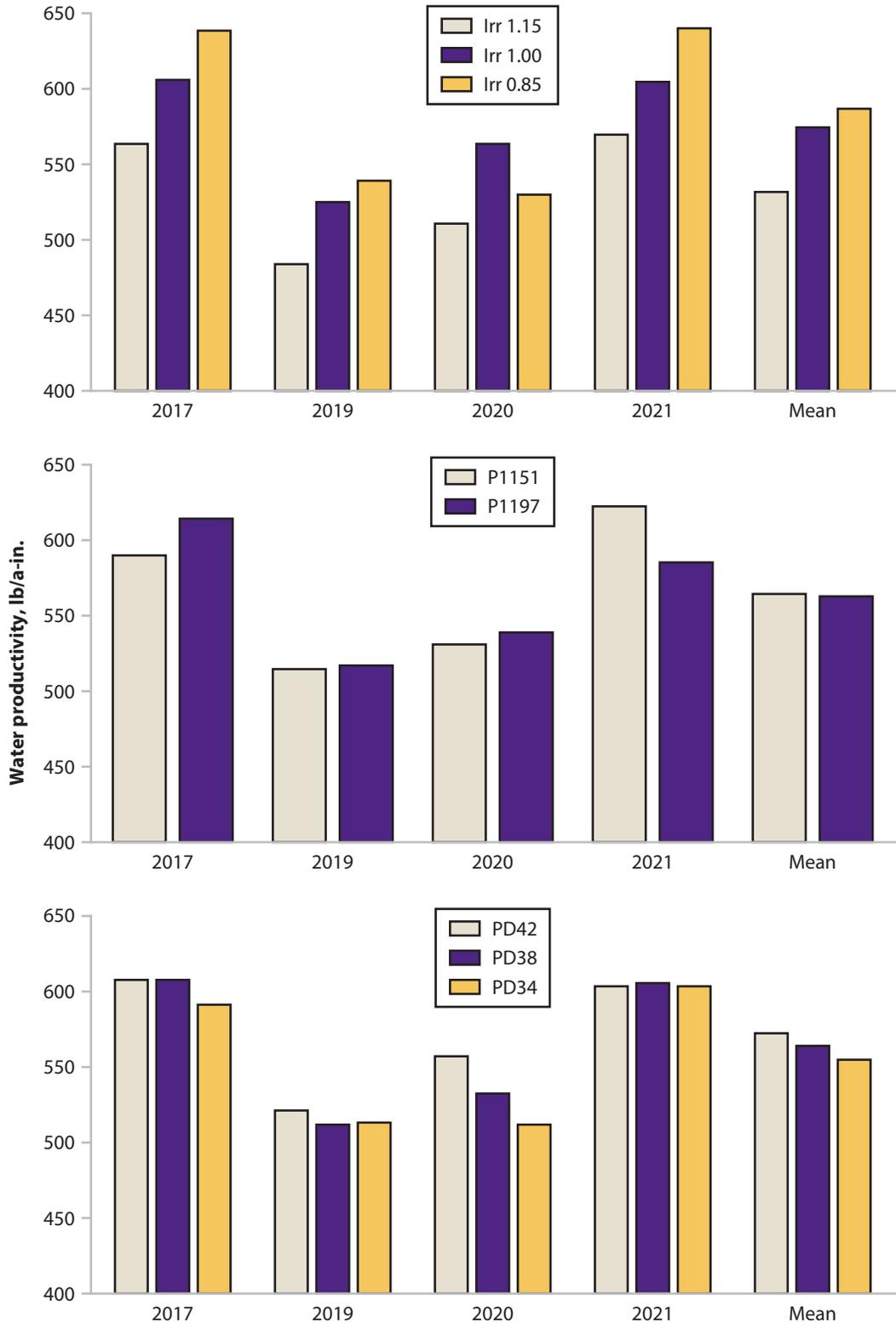


Figure 2. Crop water productivity (2017, 2019–2021) for a subsurface drip irrigation (SDI) crop intensification study at Kansas State University Northwest Research-Extension Center, Colby, KS. Upper panel is for the three irrigation levels designed to match 115, 100, or 85% of well-watered corn ET minus rain. Middle panel is for the two corn hybrids Pioneer 1151 and Pioneer 1197. Bottom panel is for the three plant densities, 42,000, 38,000, or 34,000 plants/a.