Evaluation of water use, water quality and crop yield impacts of corn and peanut irrigation and nutrient BMPs in the springsheds of Suwannee River Water Management District

Project Final Report

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Deliverable 4

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Executive Summary

This report presents a summary of the results obtained from 2015 to 2017, the three-year irrigation and nutrient Best Management Practice (BMP) project. Within this final report, the main results per crop season are shown; however, in some cases combined results for each crop rotation (i.e. 2015-2017 data) are presented. The objectives of this project were to provide a research based recommendations on the use of soil moisture sensors for irrigation scheduling, evaluate the ability of electrical conductivity probes to provide real-time nutrient loss feedback, provide measurements of irrigation savings and differences in nutrient leaching comparing traditional and recommended practices, and analyze water balance components of each irrigation treatment.

This project was initiated in February 2015 with installation of drainage lysimeters in select plots and a new variable rate (VRI) linear move irrigation system at the North Florida Research and Education Center – Suwannee Valley (NFREC-SV). A total of 72 zero tension drainage lysimeters were installed at a three foot nominal depth to capture leachate percolating through the profile. In addition, 54 soil moisture sensors with automated reporting to the cloud were installed to allow tracking of moisture content at four inch increments down to three feet. These sensors also measure electrical conductivity (EC) which was correlated with nitrate (NO_3-N) and ammonium (NH_4-N) nitrogen in the soil profile.

Five irrigation treatments were implemented as follows: I1, mimic grower irrigation practices; I2, a daily soil water balance (i.e. checkbook method) that tabulates water inputs and losses aimed at scheduling irrigation to meet crop demand based on developmental stage; I3, soil moisture profile probes to determine when to irrigate based on water extraction patterns; I4, 60% of I1; and I5, no irrigation.

Corn fertility consisted of three levels: F1, 300 lb N/ac, F2, 220 lb N/ac and F3, 140 lb N/ac where F2 approximates the IFAS recommended rate (i.e. 210 lb N/ac for irrigated corn). Peanut did not include N fertility treatments following UF/IFAS recommendation and typically receives little if any N fertilizer for growers in the Suwannee Valley region.

From 2015 to 2017, a total of 15,048 and 12,384 soil subsamples were collected in the corn and peanut seasons, respectively. Bi-weekly soil samples were collected at 0-6, 6-12, 12-24 and 24-36 inch depths during the growing season and monthly after harvest. Additionally, deep samples were collected in corn I3 treatment at 36-48, 48-60 and 60-72 inch depths in 2016 and 2017. Subsamples were analyzed for moisture content (i.e. gravimetric water content) and sent to the lab for NO_3-N and NH_4-N analysis. Lysimeters were pumped as needed depending on rainfall and irrigation. Leachate volumes were determined and 1,058 and 1,180 subsamples were collected in corn and peanut and sent for NO_3-N and NH_4-N analysis. Plant biomass samples were collected five to six times in corn and peanut during the season representing primary growth stages; samples were dried and ground for TKN analysis. Data and interpretation of crop nitrogen uptake is included in this report.

Following the BMP protocol, supplemental N applications were applied to compensate for N loss early in the season if heavy rainfall events occurred after the application of fertilizers during the corn growing season. Corn growing seasons spanned (planting to harvest) from April 4 to August 18, March 22 to August 3, and March 21 to August 16 in 2015-17, respectively.

Monthly rainfall amounts and distributions were highly variable during the experimental years. Overall, rainfall in 2015 and 2016 was below historical average for corn and peanut growing seasons, whereas in 2017 rainfall amounts were overall higher than historical average; especially during the late peanut growing season which was influenced by Hurricane Irma. Rainfall monthly variability influenced the amounts of irrigation required during each growing season.

Due to volume collection inconsistencies in the lysimeters in 2015, it was determined that only NO_3-N and NH_4-N concentrations were considered. Using the CERES- Maize model in DSSAT, drainage was simulated for I1, I3 and I5 treatments during each corn growing season resulting in: 14.0, 7.3 and 4.4 inches in 2015, 14.3, 6.4, and 4.4 inches in the 2016 season; and 26.8, 17.4 and 10.1 inches in 2017. In all corn seasons, the I1 treatment resulted in the highest drainage amounts. Low drainage occurred in the I5 treatment, except in 2017, when rainfall amounts were above the historical average. In the peanut growing seasons, the simulated drainage volumes for I1, I3 and I5 treatments were 14.7, 10.7, and 9.5 inches, respectively in 2015; 26.5, 14.4 and 11.9 inches in 2016; and 30.1, 19.7 and 16.7 inches in 2017. Similar drainage patterns occurred in the peanut growing seasons; where I1 resulted in the highest and I5 in the lowest. However, overall highest drainage resulted in 2016 and 2017 due to rainfall amounts influenced by Tropical Storm Hermine and Hurricane Irma.

Rainfall was the main factor for N leaching. The highest N leaching concentrations occurred after heavy rainfall events. In the 2016-17 corn growing seasons, the highest NO_3-N leaching concentration occurred on 11 August 2016 (I1, I3 and I5 average NO_3-N = 6.9, 47.7 and 180 mg/L) after a rainfall event of 5.1 inches. High leaching concentrations in the non-irrigated treatment were found in subsequent samplings as well. In this case, inability of the corn plants to take up N in the soil solution within the growing season, resulted in nitrate-N leaching later in the season when heavy rainfall events occurred. In comparison, the I1 treatment resulted in more frequent leaching events within the growing season as a result of frequent irrigation combined with rainfall events of lower magnitude. Thus, nitrate-N concentrations were already reduced when heavy rainfall events happened later in the season.

The salinity (vic) measured using Sentek probes during the 2016-17 corn seasons reflected the N leaching events in both seasons. The soil NO_3-N concentrations collected in I3 deep samples in corn 2016-17 seasons showed increments in nitrate-N after heavy rainfall events, which also was reflected in the N leaching sampling events.

Cumulative irrigation applied was 12.6, 7.3, 6.0, 8.3 and 0.6 inches for I1-I5 respectively in 2015, 20.0, 12.2, 11.5, 12.6 and 1.0 inches for I1-I5 in 2016 and 21.5, 12.4, 11.9, 13.7 and 1.9 inches for I1 through I5, respectively in 2017. The small amounts applied to I5 were needed to incorporate fertilizer and were applied equally to all treatments. Final corn yield averages per irrigation treatment were: 193, 178, 191, 201 and 143 bu/ac for I1 through I5 in 2015; 202, 184, 188, 191 and 127 bu/ac for I1 through I5 in 2016; and 200, 203, 194, 194 and 92 bu/ac in 2017 for I1 through I5, respectively. All irrigated treatments (I1- I4) resulted in statistically higher grain yields in comparison to I5 (non-irrigated) except in 2015 I2 and I5 grain yields were not different). Final yield means per fertility rates were (F1- F3): 196, 180 and 168 bu/ac in 2015; 183, 180 and 173 bu/ac in 2016; and 185, 175 and 171 bu/ac in 2017 with significantly lower yield only on F3 compared to F1 during 2015 and 2017. In 2016, there were no significant differences among the three fertility rates evaluated.

Peanut seasons (planting to harvest) spanned from May 19 to October 20 2015, from May 13 to October 4 2016, and from May 9 to October 4 2017. Total rainfall summed up to 25.6, 25.9 and 34.2 inches during the peanut 2015-17 growing seasons. Total irrigation amounts were 5.2, 0.5, 1.0, 3.0 and 0.0 inches for I1-I5 in 2015; 21.7, 8.4, 8.1, 13.2 and 1.2 inches for I1-I5 inches in 2016; and 15.3, 5.0, 4.8, 9.5 and 0.8 inches for treatments I1-I5, respectively. Final peanut yield means per irrigation treatment were 6068, 6502, 6687, 5938 and 6244 lb/ac for I1-I5 in 2015; 7201, 6646, 6695, 7117 and 4577 lb/ac for I1-I5 in 2016; and 4798, 5431, 4799, 4914, 5013 lb/ac for I1 through 5 in 2017, respectively. No significant differences were found among treatments in 2015 and 2017. During 2016, the non-irrigated treatment resulted in significantly lower yield compared to the irrigated treatments (I1-I4). No significant differences were found due to fertility treatments applied in previous corn growing seasons.

Introduction

Pursuant to the Florida Watershed Restoration Act (FWRA), section 403.067(7) (c) 3, F.S., the Florida Department of Agriculture and Consumer Services (FDACS), Office of Agricultural Water Policy (OAWP), develops, adopts, and assists with the implementation of agricultural Best Management Practices (BMPs) to protect and conserve water resources. Funding for BMP projects that complement the OAWP's mission is consistent with FWRA objectives. In this regard, the University of Florida's, Institute of Food and Agricultural Sciences (UF/IFAS) continues to play an important role in assisting the industry with implementing BMPs. This three-year project proposes to determine the effect that precision irrigation management and electrical conductivity tracking have on management of water and fertilizer and the subsequent effect on leaching of nitrogen and impact on crop productivity.

Objectives

The specific objectives of this work are as follows:

1. Develop a research-based recommendation to advise growers when and how much to irrigate based on soil moisture sensor readings.
2. Evaluate the ability of the soil moisture/electrical conductivity probes to detect nutrient leaching events and thus provide real-time nutrient loss feedback to growers.
3. Provide scientifically defensible measurements of water savings reductions in nutrient leaching when soil moisture sensors and IFAS recommended fertilizer rates are used compared to grower practices.
4. Analyze water balance components including rainfall and irrigation applied, volume of water leached and changes in soil moisture storage for each irrigation treatment.

Materials and Methods

Field experiment

The experimental field for this study is located at the North Florida Research and Education Center – Suwannee Valley (NFREC-SV), near Live Oak, FL (30.31353N, -82.90122W). Predominant soils in the field are: Blanton-Fox worth-Alpin complex (48.7%), Chipley-Fox worth-Albany (31.6%) and Hurricane, Albany and Chipley soils (19.6%) generally characterized as sandy (95.9% sand, 2.3% silt and 1.8% clay) (Figure 1) (USDA 2013). Corn pre-plant soil analysis indicated on average for the four soil layers evaluated: 0.88% organic matter, 256.6 mg/kg TKN, 2.0 mg/kg NO_3-N, 2.2 mg/kg NH_4-N, pH of 5.7, respectively (Table 1). Peanut pre-plant soil analysis indicated: 0.47% organic matter, 123.5 mg/kg TKN, 0.4 mg/kg NO_3-N, 1.3 mg/kg NH_4-N, pH of 5.6, respectively (Table 2).

This experiment represents a range of water and fertility treatments that allowed the evaluation of nutrient and irrigation BMPs in the Suwannee River Valley. The cropping system consists of a conventional corn and peanut rotation.

The experimental design was a randomized complete block arranged in a split plot. This design included four replicates (i.e. blocks) for each treatment. Main plots were the irrigation treatments with subplots comprising nitrogen applications. A total of 60 plots per crop (5 irrigation treatments x 3 fertility levels x 4 replicates) were evaluated. Each plot was 40 ft long x 20 ft wide separated by 20 ft alleys. An alley of 40 ft was included between the blocks (Figure 2). Alley dimensions insured water treatments were adequately separated from any threat of overspray from individual nozzles from other plots. A detailed description of the plots is shown in Figure 3.

Treatments

Irrigation

Five irrigation treatments at three fertility levels were evaluated as follows:

1. I1 (Grower): Irrigation mimicked grower's irrigation practices. Consisted of zero irrigation for the first 30 days after planting (DAP) unless severe windy conditions that caused blowing sand to burn the plants. Beginning on 31 DAP, a target amount of 1.2 inch/wk was established and could be made up of rain or irrigation but rain events had to be 0.25 inch or larger. For 40-59 DAP a 1.6 inch/wk target was established with irrigation events of 0.4 inch. Irrigation was skipped if 0.5-0.75 inch rainfall occurred and two irrigations were skipped if >0.75 inch of rain occurred. For 60-105 DAP a 2.0 inch/wk irrigation target was used unless 0.5-1 inch of rain occurred the day prior to a scheduled irrigation. Two irrigations were skipped if >1 inch of rain occurred. Finally, around 105 DAP at full dent stage, weekly irrigation targets were reduced to 1.6 inch/wk for one week and 0.8 inch/wk for another week until finally irrigation was terminated approximately 115 DAP.
2. I2 (SWB): Irrigation was determined using a theoretical soil water balance. As part of the inputs, rainfall data was obtained from the FAWN weather station located in Live Oak, FL and crop evapotranspiration (ET_c) was used to estimate daily soil moisture and schedule irrigation when 50% or 33% of the available moisture was depleted during vegetative and reproductive stages, respectively
3. I3 (SMS): The Sentek Drill & Drop MTS (Stepney, South Australia, Australia) capacitance probes were used to monitor volumetric water content. Probes consists of nine sensors placed every 4 in starting from 2 in to 34 cm. Irrigation was determined using a 50% maximum allowable depletion (MAD) and field capacity (FC) points to refill the soil profile with irrigation according to guidelines proposed by Zotarelli et al. (2013) (Figure 4). A total of 0.4 inches were applied per irrigation event. A comparison between theoretical and actual values of FC, MAD and PWP was performed for 0-35 in depth resulting in close values among them. Therefore, based on the published Soil Survey from Florida theoretical values for Chipley-Foxworth-Albany soil were used in this study (FC = 9.1%, 50%MAD = 6.3%, AWHC = 0.05 cm/cm and PWP = 3.5%) (NRCSS, 2016). While individual replicate plots were monitored, when any one of the replicate plots showed that irrigation was needed, all replicates were irrigated to satisfy the needs of that plot.
4. I4 (60% I1- Reduced): This treatment irrigates with the same frequency as I1, but applies only 60% of I1.
5. I5 (NO): Non-irrigated plots.

ET_c was calculated using phenological based crop coefficients (K_c) (K-State Research & Extension Mobile Irrigation Lab 2014) (Table 3) and reference evapotranspiration (ET_o) as:

$$ET_c = K_c ET_o$$

ET_o was calculated using weather data (daily minimum and maximum temperature, solar radiation, relative humidity and wind speed) from an onsite Florida Automated Weather Network (FAWN) with the FAO-56 Penman-Monteith equation (Allen et al. 1998)

Variable Rate Irrigation System

The irrigation system consisted of a two span Valley Linear End feed 8000 (i.e. galvanized pipe of 402.6 ft long, 6.42 inch I.D., C-Factor 170 and a total loss of 0.6 psi) with a Variable Rate (VRI) package. This machine was capable of irrigating a field area of 16.6 acres, using a flow of 300 GPM (18.03 GPM/acre) providing an application rate (AR) of 0.96 in/day at maximum capacity. The LRDU Drive Train used a 56 RPM Center Drive @60 Hz frequency. Therefore, the pass duration was 2.3 hours/pass at 100% (i.e. 12.98 ft/min).

Senninger (Senninger Irrigation, Inc., Clermont, FL) LDN-UP3 Flat Medium Grove ¾ M NPT nozzles were attached to drops at a 10 ft sprinkler spacing. Every fourth sprinkler was turned off, since it corresponded to the alleys between plots (Figure 2). At each sprinkler, Valley 10 psi pressure regulators (PSR-2 10 10(PSI) 3/4 F NPT) were used to maintain a consistent flowrate.

Linear Modifications

The VRI performance of the first linear installed in 2015 did not entirely meet expectations. Testing was run by both University of Florida (uniformity distribution/ catch can tests) and Valmont during fall 2015 to determine some of the operating characteristics of the linear machine. After testing, it was considered to focus on modifying the performance of the valves, and particularly, the delay of the valves turning off.

During the winter 2015, Valmont ran a series of tests on the valves and confirmed characteristics of the valves that appeared to have led to what was observed in the field. The two key characteristics determined were: (i) minimum shutoff time for valves and (ii) air entrapment impacts the valve shutoff time.

Then, using this information simulations were run to evaluate impact of what had be learned from the testing both field and wet cell. Based on the testing and simulation work a plan was developed for the spring of 2016 described as follows:

Valley Auto-linear control panel settings:

1. Change the cycle time in the VRI constants to 20.
   Originally to ensure the best uniformity in the direction of travel, Valmont recommended a cycle time setting of 10.
   Based on testing and simulations it was determined that depending on the base application depth and the prescription setting a cycle time setting of 10 would probably not allow sufficient time for the valves to completely cycle off due to their hydraulic characteristics.
   See simulations in Appendix 4.

Valve hydraulics

2. Minimize the impact of trapped air in the control lines.
   - Testing in the wet cell indicated air entrapment could lead to valves closing slower than optimum until the air was purged from the control lines.
     In commercial field applications this is not a problem as typically a pivot is started and run from 24 to 72 hours or more and does not go through as many startup cycles.
   - The solution was the addition of a small valve on the end of the control line to each valve to be manually opened on startup to allow the air to be pushed out and then manually closed. Valmont realized manual open and close was not optimum but wanted to try in the field to see if that would improve the valve closing characteristics.
   - Jake began to install the small valves on the ends of the control lines and noticed the way the control lines had been installed would potentially lead to more air entrapment.
   - The control lines were installed such that for a single zone the control lines ran from the VRI control box all the way to each valve rather than being daisy chained through each valve.
   - Tri County Irrigation was contacted to change the way the control lines were routed.
   - Due to travel budget constraints Valmont was not able to have anyone visit the linear during the summer or fall to check performance.

Fertility

The nitrogen fertility treatments were implemented only in corn. These treatments consisted of: low (140 lb N/ac), medium (220 lb N/ac) and high (300 lb N/ac). The medium fertility treatment was similar to UF/IFAS recommendations (210 lb N/ac) (Mylavarapu et al. 2015), whereas the low and high treatments were 36.4% lower or higher than the medium fertility treatment.

Agronomic Practices

Land Preparation, planting and fertilization

Before 1 January 2015, the experimental field was harrowed with a long cutting harrow. Subsequently, on 29 January the field was bottom plowed with a four row plow, on 4 February harrowing occurred twice using a 3 point hitch leveling harrow with tube drag. Finally, the field was harrowed using a 16 ft offset harrow on 2 March 2015.

2015-2017 CORN

Field preparation:

In 2015, following the land preparation practices described above, drainage lysimeters were installed and buried in corn plots during 26-27 March. Subsequently, the field was box dragged and harrowed with a 16 ft offset harrow on 30 and 31 March 2015. Plot alleys were occasionally trimmed with a roto-tiller as needed. In 2016, the corn field (North field) was harrowed twice pre-planting on 15 March 2016. In 2017, the corn field was harrowed twice pre-planting on 3 March and 10 March 2017. During 2016 and 2017, plowing was not performed due to potential damage to lysimeter hoses.

During the first weeks of January 2017, the peanut and the corn residue were disced using a heavy cutting harrow (two passes).

Planting:

Corn (*Zea mays L.*) was planted on 3 April 2015, 22 March 2016 and 21 March 2017 during the three years of evaluation. The corn hybrid Pioneer 1498 YHR/Bt was planted in a row spacing of 30" and 6.5" plant spacing for a total plant population of 32,500 plants/ac during all growing seasons.

Fertilization:

In corn, three fertility rates were evaluated during the three experimental years: F1= 300 lb N/ac, F2= 220 lb N/ac and F3= 140 lb N/ac; where F2 approximates the IFAS recommended level (i.e. 210 lb N/ac for irrigated corn). These total N amounts were distributed across several applications during the growing season, explained as follows:

A pre-plant soil sampling analysis was performed to determine initial soil conditions each year. At planting an initial liquid application of 30 lb/ac of 16-16-0 was applied (2 in deep and 2 in to the side of the row through double disc openers) across all treatments. The N fertility rates started 14 DAP with the first granular application (at 347, 262 and 359 cumulative GDDs in 2015, 2016, 2017 respectively, at V3 corn growth stage). Total N applied on the low, medium and high rates were: 8, 22 and 30 lb N/ac, respectively using a 33-0-0 fertilizer (16.49% ammoniacal N and 16.51% nitrate-N).

The second granular application (33-0-0) took place close to V6 corn growth stage at 651, 663 and 617 GDDs in 2015-17 growing seasons. A total of 10, 24 and 40 lb N/ac were applied on the low, medium and high rates, respectively. Afterwards, split liquid sidedress applications (28-0-0) were applied between V8 and VT- (tasseling) corn growth stages. At each liquid sidedress application a total of 23, 36 and 50 lb N/ac were applied on F3, F2 and F1 rates, respectively.

Heavy rainfall events occurred on 2 April 2016 (3 inch), thus, following the BMP protocol, an application of 30 lb N/ac (21-0-0-24S, ammonium sulfate) was performed on 19 April 2016. In 2017, a few days after the starter application a heavy rainfall occurred on April 4 (3.73 inch), hence a supplemental application of 15 lb N/ac was performed to compensate for possible N leaching, following the BMP protocol recommendations (FDACS 2015).

Phosphorus and potassium applications were performed based on soil analysis results and equally applied across all fertility rates as required. In all years, 30 lb P/ac were applied at planting (16-16-0). In 2015, based on analysis results, 75 lb P/ac of 0-46-0 (Triple Superphosphate) was applied during the first granular application; whereas no phosphorous was required in 2016 nor in 2017. In terms of potassium, 98 lb K/ac and 77 lb K/ac of 0-0-60 were applied during the first and second granular applications in 2015. In 2016, 35 lb K/ac of 0-0-60 were applied on both granular applications; whereas, 73 and 66 lb K/ac of 0-0-60 were applied in the first and second granular applications in 2017. In addition, a supplemental application of 21 lb K/ac of K-Mag (0-0-22) was added to the second granular K applications to address sulfur and magnesium concerns in the crop.

A summary of the fertilizer/pesticide chronological applications is shown in Figure 5.

2015-2017 PEANUT

Field preparation:
In 2015, the peanut experimental field (North field) was box dragged on 30 April after the installation of the lysimeters (29 April 2015). Subsequently, the field was harrowed with a three-point hitch leveling harrow on 14 May, a few days before planting. Plot alleys were trimmed with a roto-tiller as needed.

In 2016, the peanut field (South field) was harrowed on 15 March and on 11 May a few days before planting. No plowing was performed due to potential damage to lysimeter hoses.

In 2017, the peanut field (North field) was harrowed on 12 April (one pass) and again on 2 May 2017 (two passes) a few days before planting. No plowing was performed due to potential damage to lysimeter hoses. Pre-plant soil sampling analysis was performed to determine initial soil conditions per year (Tables 1, 2 and 4).

Planting:
Peanut (Georgia 06G) was planted on 15 May 2015, 13 May 2016 and 9 May 2017 at a row spacing of 30” and 5-6 seed/ft for a total plant population approximately 90,000 seed/acre. At planting, a fungicide and an inoculant (i.e. Macho + Lift Inoculant) were applied through the planter directly in the furrow in all growing seasons.
In all seasons, a granular and a gypsum application were performed. In 2015 and 2016, 3-7-28 at 500 lb/ac granular application and a 2000 lb/ac gypsum application of were performed. In 2017, a 350 lb/ac granular application of 8-0-39 and a gypsum application of 1500 lb/ac (i.e. GypsuMax) were performed. Both products were broadcast with a Tag-Along spreader. A summary of the fertilizer/pesticide applications in 2015-17 is shown in Tables 5, 6 and 7.

Parameters evaluated

Soil: N and Moisture

a. Soil Sampling

Sampling Schedule
Pre-plant soil samples were taken on I1, I3 and I5 across all fertility rates to determine initial soil conditions in corn (pre-plant/fertilization) (Table 1). To determine N levels throughout the soil profile, soil samples were taken biweekly during the crop growing season and monthly after harvest.

Protocol
Soil samples were collected using a hand auger at four different depths (0-6, 6-12, 12-24 and 24-36 inches). Each sample was well-mixed and a sub-sample was collected, sealed in plastic bags, kept refrigerated and transported in coolers for processing. Field samples fresh weight was recorded and samples were divided in two sub-samples placed in aluminum plates:

(i) ARL subsample: fresh weight was measured. Then samples were air-dried for 48 hours, sieved using a 2 mm sieve, placed in paper bags and delivered to the ARL lab (UF/IFAS Anserv Labs 2011) for NO_3-N and NH_4-N analysis following the EPA 353.2 and the EPA 350.1 procedures, respectively.

(ii) ABE subsample: fresh weight was recorded. Samples were oven-dried at 105 °C for 48 hours. Dry weight was recorded to determine gravimetric water content. Volumetric water content was calculated based on field bulk density measurements (bulk density values per soil type and depth can be found in Table 1) (Appendix 1).

b. Sentek probes

Sentek probes (Drill & Drop MTS Probe) consist of the three main associated sensors (i.e. moisture, salinity and temperature) all encapsulated in one probe. The sensors are spaced at 4 inch intervals, with the first sensor 2 inches from the top of the probe and a total probe length of 36 inches. Sensor numbers increase with sensor depth (Sentek Pty Ltd 2003). To monitor soil moisture and salinity at different depths in the soil profile, 54 Sentek probes were installed in treatments I1, I3 and I5 across all fertility rates (F1-F3) in both crop fields. Sensors collected data during the 2015-17 crop seasons.

The sensor provides three outputs: soil moisture content, salinity and temperature. Two of them are explained below (Sentek Pty Ltd 2003):

(i) The first output is a signal of dimensionless frequency (raw count) that is converted into volumetric water content (Vol %) or millimeters of water per 100 mm of soil depth.

(ii) The second output is a dimensionless frequency (raw count) that in conjunction with the first output signal, is proportional to changes in soil water content and salinity. The output of the data model is nominal Volumetric Ion Content (VIC). These measurements can be quantitatively related to the soil Electric conductivity (EC) through site specific soil sampling and analysis.

Drainage: N –Water

a. Drainage lysimeters

Zero tension drainage lysimeters were used to monitor N leaching dynamics. The lysimeters consisted of 55 gal barrel halves installed about three ft nominal depth to capture leachate volume. The lysimeters were purged as needed after heavy rainfall events during each crop season. The aboveground leachate collection system consisted of vacuum pumps and tanks connected through a tubing system (1/2” braided PVC; (Hosecraft 2006), that reached the lysimeters installed underground. Each vacuum pump-tank complex was connected to three lines of lysimeters and each line contained three lysimeters. Two vacuum-tanks were used in Blocks 1 and 2 and two were used in Blocks 3 and 4. In order to collect the leachate volumes and provide a stable vacuum in the system, 5 gal heavy duty vacuum bottles (Thermo Fisher Scientific Inc. 2015) were used. These bottles serve as a connection to the ‘pressurized line’ and to the ‘lysimeter line’. Thus, using ball valves installed at the top of the bottles, the pressurized line was opened allowing vacuum to be created inside the bottles, afterwards, the lysimeter line which was connected to a 3/8” tubing (PT5 class reinforced with wire (Hosecraft, Chicago, IL)) was opened. Lysimeter leachate was collected from the bottles after suction. Leachate volume was recorded by weighing the vacuum bottles that yielded water following the protocol described in Appendix 2. Samples were collected and preserved using half strength sulphuric acid solution (9M) and maintained in ice-water (below 4°C) until delivery to the Analysis Research Lab (UF/IFAS Anserv Labs 2011) EPA certified N protocol for leachate samples can be found in Appendix 2. Equipment blanks, lab blanks and duplicates were delivered along with the leachate data following the corresponding protocol (Appendix 2). The aboveground system workflow was the same as in all years of evaluation.

The number of bottles possible to be purged simultaneously depended on the suction created within the system. Suction levels below 15 inches of mercury were not acceptable; thus, fewer bottles could be pumped out at the same time. When pressure levels were low (<15 in of mercury), then each lysimeter was pumped out individually. The sequence of the bottles to be pumped per line was alternated biweekly during the pumping period. This procedure was followed for each lysimeter line.

Crops: N –Tissue

Tissue samples were taken during key growth periods for both corn and peanut.

CORN

In 2015, corn tissue sampling was performed at 12 DAP, 34 DAP, 70 DAP at 80% tasseling, 98 DAP at dough stage, and 138 DAP at mature stage (i.e. 15 April, 11 May, 12 June, 10 July, and 19 August, 2015). In 2016, sampling was performed at 17 DAP, 80 DAP at 80% tasseling, 105 DAP at dough stage, and 133 DAP at mature stage (i.e. 8 April, 10 June, 5 July, and 2 August, 2016). Finally, in 2017, corn tissue sampling was performed at 14 DAP, 46 DAP, 80 DAP at 80% tasseling, 100 DAP at dough stage, and 140 DAP at mature stage (i.e. 4 April, 5 May, 8 June, 28 June, and 7 August, 2017).

During the three years of evaluation, samples were taken on I1, I3 and I5 during the first sampling; whereas only on I3 irrigation treatment at subsequent sampling events. At harvest, the final sampling was performed in all plots (i.e. all irrigation and fertility treatments).

PEANUT

In 2015, peanut tissue samples were taken at 59 DAP (representing peak pod formation and beginning maturity), 105 DAP (primary seed maturity phase), 136 DAP (physiological maturity), and 146 DAP (harvest), on 17 July, 1 September, 2 October, and 12 October, respectively. In 2016, in peanut, tissue samples were taken at 39 DAP, 59 DAP (peak pod formation), 80 DAP, 102 DAP (primary seed maturity phase), and 137 DAP (physiological/harvest maturity), on 21 June, 11 July, 1 August, 23 August, and 27 September. In 2017, samples were taken at 41, 62 DAP (i.e. peak pod formation and beginning maturity), 78 DAP, 98 DAP (primary seed maturity phase), 120 DAP, and 141 DAP (physiological maturity), on 19 June, 10 July, 26 July, 15 August, 6 September, and 27 September, respectively. Samples were taken on I1, I3 and I5 during the first sampling; whereas, only on I3 irrigation treatment at subsequent sampling events. At harvest, the final sampling was performed in all plots (i.e. all irrigation and fertility treatments). Tissue sampling followed the protocol used in previous years.

Procedure:

For both crops, the samples were collected from a 39 inch section within a row. The total number of plants were counted. For corn tissue samples, plants were sectioned into stalks, leaves, and ears. Parameters measured included: number of leaves per plant and number of ears. For peanut tissue samples, plants were separated into stems, roots, and pods (shell and seed). All samples (corn and peanut) were dried in 60°C for 72 hours. Dry weight was recorded. Dry corn samples (from plant sections) were chopped with a chipper machine prior to grinding. Afterwards, samples were ground in a Wiley mill using a 2 mm screen and mixed well before taking a subsample for the lab analysis. Samples were analyzed for Total Kjeldahl Nitrogen (TKN) digestion For nitrogen analysis, samples were digested using a modification of the aluminum block digestion procedure of (Gallaher et al. 1975) Sample weight was 0.25 g, catalyst used was 1.5 g of 9:1 K_2SO_4:$CuSO_4$, and digestion was conducted for at least 4h at 375°C using 6 ml of H_2SO_4 and 2 ml H_2O_2. Nitrogen in the digestate was determined by semi-automated colorimetry (Hambleton 1977).

Harvest

Corn

Corn harvest took place on 18 August 2015, 3 August 2016 and 16 August 2017 at the North Florida Research and Education Center – Suwannee Valley (NFREC-SV), Live Oak, FL. Yield determination was performed mostly on the 6th and the 7th planting rows starting ten feet inside each plot to avoid border effects. Representative rows were selected for yield determination when rows 6th and 7th were impacted by low seed density at planting. A total length of 20 ft in each row was harvested for data analysis. Before harvesting, all plants within the 20 ft on the 6th and 7th rows were counted. Immediately after, ears were hand harvested and placed in labeled bags. Ears were counted and after removing the husk, total ear weight was recorded. Total ears per plot were shelled using a manual sheller and corn kernels placed in sacks. Finally, three replicate grain moisture measurements were taken from each plot for final average moisture calculation. The moisture content percentage was determined using a moisture meter (John Deere Grain Moisture Tester SW08120). Final corn yield was calculated to meet the standards of 15.5% market moisture and 56 pounds per bushel.

Peanut

Maturity level tests utilizing the hull scrape and profile board were performed to determine the harvest time. Digging was performed on 16 October 2015 at 150 days after planting (DAP), on 30 September 2016 at 140 after planting (DAP) and on 29 September 2017 at 143 after planting (DAP). Peanuts were dug using a digger. Peanuts were dried approximately four days before harvest. Pods were harvested on 20 October 2015, 4 October 2016, and 4 October 2017 using a KMC 3300 peanut combine.

Yield determination was performed on the 7th and the 8th planting rows starting ten feet inside each plot to avoid border effects. Representative rows were selected for yield determination when rows 7th and 8th were negatively impacted (e.g. seed density, climatic conditions after hurricane). A total length of 20 ft in each row was harvested for data analysis. The parameters measured per plot were: peanut weight and percentage of moisture (wet basis). All samples were taken to a drying facility located in the Plant Science Research and Education Unit (PSREU), near Citra, FL. When average moisture reached 10.5%, the samples were removed from the driers and moisture content was taken (dry basis) on each sample. Moisture readings were used to determine final pod yields at 10.5% market moisture.

Statistical Analysis

Data for corn and peanut yield, biomass, soil N, leachate and yield were performed using PROC GLIMMIX in SAS (SAS, Cary, NC). ANOVA and least squared means differences with normal p-values for multiple comparison were used for final yield, biomass and N content. ANOVA and LSM with log values were used for leachate sample analysis; however, data in this report is presented as mean values. A contrast analysis was performed to compare irrigation treatments that were of most interest in order to illuminate subtle differences or unexpected similarities between treatments.

Results

A summary of the parameters evaluated, samples collected and analyzed results through the three experimental years for corn and peanut are shown in Table 8 and Table 9, respectively.

Monthly average rainfall during 2015-17 was compared with historical rainfall (September 2002 to December 2014) (Figure 6). In 2015, monthly average rainfall from March to June was 69%, 72%, 37% and 44% below historical values. Although total amounts were below historical averages, rainfall was distributed in small events through the season. Afterwards, rainfall in July and August was 20% and 11% above and below historical average, respectively; occurring during late corn and mid- peanut production. The contributions of rainfall during reproductive stages in corn, as well as, in mid peanut production, could have influenced on the final yield of both crops, resulting in no statistical differences among the irrigation treatments (except on corn I2 vs. I5, which did not differ statistically).

In 2016, rainfall monthly means during early corn season (March-April) were close to historical; however, rainfall amounts were 19%, 154% and 80% lower than historical in May, June and July 2016. The lack of precipitation increased the need for irrigation in both crops. During August and September, rainfall was 54% and 7% above historical monthly means (influenced by the Tropical Storm Hermine); occurring during mid- peanut production. The effect of rainfall could have influenced on peanut final yield, resulting in no statistical differences among the irrigated treatments.

In 2017, during mid corn season, monthly rainfall means for April, May and June were 15, 33 and 28% above historical monthly average. July monthly mean rainfall was 26% below historical, followed by August and September resulting in 10% and 47% above historical monthly rainfall, respectively (the latter influenced by Hurricane Irma). The 2017 season was considered an “off” year due to unknown effects experienced in the field experiment, as well as, in the Live Oak region. Particularly in peanut, growers from the region also experienced lower yields due to seed damage and inconsistencies in seed germination.

Irrigation & Water Balance

The VRI system was functional since the beginning of the crop seasons in 2016-17. Different irrigation application rates were programmed into the linear to satisfy the irrigation treatment rates. A water balance was simulated using the CERES Maize crop model within the Decision Support System for Agrotechnology Transfer (DSSAT) (Hoogenboom et al. 2015). Results from corn and peanut irrigation treatments are described as follows:

Corn

2015

In 2015, the corn season was 3 April to 18 August 2015. The first irrigation event occurred on 4 May (31 DAP) to water in the second granular application performed on 1 May (0.6” flat rate applied across all treatments. Irrigation treatments started at 35 DAP. Growing season cumulative rainfall totaled 21.9 inches; whereas cumulative estimated crop evapotranspiration (ET_c) summed up to 19.5 inches (Figure 7). Note that this estimated ET_c applies to the well irrigated plots that did not experience water stress (i.e. I1-I4). Cumulative irrigation applied per treatment was: 12.6, 7.3, 6.0, 8.3, and 0.6 inches for I1 through I5, respectively (Figure 8). Irrigation treatments I2 through I5 applied 42%, 53%, 34% and 95% less water than I1, which simulates corn grower’s irrigation practices.

Using the CERES Maize crop model simulation, a water balance for each crop season was simulated and described as following:

- Total inputs were: change in soil water storage (ΔS) = -0.2 and precipitation 21.5 (same for all treatments). Irrigation = 12.6 in, 5.9 in and 0.6 in for I1, I3 and I5, respectively.
- Total outputs for I1, I3 and I5 were: drainage = 14.0 in, 7.3 in and 4.4 in for I1, I3 and I5, respectively. Soil evaporation = 3.0 in, 2.7 and 2.9 in, respectively. Transpiration = 16.9 in, 17.2 in and 14.6 in. Potential ET_O was estimated as 22.9 inches (Table 10).

2016

The corn growing season was 22 March to 3 August 2016 (planting and harvest dates, respectively). No irrigation was applied within the first 30 DAP. However, on 23 March (1DAP), on 20 April (29 DAP) and on 28 April (37 DAP), a 0.3” flat rate was applied across all treatments to provide adequate moisture for the seed germination, supplemental and second granular fertilizers. Irrigation treatments started at 35 DAP. The corn growing season cumulative rainfall totaled 14.6 in; whereas the estimated cumulative ET_c summed up to 18.6 in during the crop season (Figure 7). Cumulative irrigation applied per treatment was: 20.0, 12.2, 11.5 in, 12.6, and 1.1 inches for I1, I2, I3, I4 and I5, respectively (Figure 8). Therefore, irrigation treatments applied about 39%, 43%, 37% and 95% less water than I1, treatment that simulates corn grower’s irrigation practices. Irrigation was terminated on 20 July 2016 when reaching physiological maturity.

A simulated water balance for the corn season 2016 is described below:

- Total inputs were: change in soil water storage (ΔS) = -1.1 in, -1.5 in and -2.4 in for I1, I3 and I5, respectively. Precipitation accounted for 14.6 inches, whereas irrigation was = 20.0 in, 11.4 in and 1.0 in for I1, I3 and I5 treatments, respectively.
- Total outputs for I1, I3 and I5 were: drainage = 14.3 in, 6.4 in and 4.4 in, respectively. Soil evaporation = 3.9 in, 3.2 in and 2.7 in; whereas transpiration resulted in 17.5 in, 18.0 in and 11.0 in. Potential ET_O was estimated as 24.6 inches (Table 10).

2017

The corn season was 21 March to 16 August 2017 (planting and harvest dates, respectively). No irrigation was applied within the first 30 DAP (exceptions due to dry and windy conditions or to provide adequate moisture for fertilizations). The exceptions in which irrigation was applied across all treatments within 30 DAP were: 20 March (pre-planting, 0.5 in) and 24 March (3DAP, 0.5 in) to perform an herbicide application and provide adequate moisture conditions for seed germination. On 14 April a flat rate (24 DAP, 0.3 in) was applied across all treatments due to dry and high wind conditions during previous days. Two more irrigations were applied on 19 and 21 April (29-31 DAP) to provide moisture for second granular application.

Irrigation treatments started at 34 DAP. Corn growing season cumulative rainfall totaled 26.8 in; whereas the estimated cumulative ET_c summed up to 19.1 in during the crop season (Figure 7). Cumulative irrigation applied per treatment was: 21.5, 12.4, 11.9 in, 13.7, and 1.9 inches for I1, I2, I3, I4 and I5, respectively (Figure 8). Therefore, irrigation treatments applied about 42%, 45%, 36% and 91% less water than I1, treatment that simulates corn grower's irrigation practices. Irrigation was terminated on 22 July 2017 when reaching physiological maturity.

Soil water balance simulations resulted in:

- Total inputs were: change in soil water storage (ΔS) = 0.1 in (for all treatments), precipitation= 25.6 in; and irrigation was = 21.6 in, 11.9 in and 1.9 in for I1, I3 and I5 treatments, respectively.
- Total outputs for I1, I3 and I5 were: drainage = 26.8 in, 17.4 in and 10.1 in, respectively. Soil evaporation = 3.6 in, 3.3 in and 2.9 in; whereas transpiration resulted in 16.4 in, 16.5 in and 14.2 in. Potential ET_O was estimated as 23.6 inches (Table 10).

Overall, the largest amount of drainage resulted in the I1 in all growing seasons, whereas the lowest in the I5 as a result of heavy rainfall events. Similar transpiration rates were found in I1 and I3; however, these were lower in comparison to the I5 treatment across all seasons, except in 2015 due to contributions of rainfall. Therefore, a reduction in irrigation amounts did not affect plant transpiration, but resulted in lower drainage amounts compared to conventional practices (i.e. I3 vs. I1 treatment). A detailed water balance for each corn growing season is shown in Table 10.

Peanut

2015

The peanut crop season started on 19 May (planting day) and ended on 20 October 2015 (harvest day). During the crop season, cumulative rainfall and estimated ET_c summed up to 26.9 and 20.4 inches, respectively. The first irrigation event occurred on 10 July (52 DAP), when irrigation treatments started. Cumulative irrigation applied per treatment was: 5.2, 0.5, 1.0, 3.0 and 0.0 inches for I1, I2, I3, I4 and I5, respectively (Figure 8). Therefore, irrigation treatments applied about 90%, 81%, 42% and 100% less water than I1, which is intended to simulate peanut grower's irrigation practices. Due to the consistent rainfall patterns, peanut required relatively little irrigation throughout the season.

Simulated water balance for 2015 peanut season resulted in:

- Total inputs: change in soil water storage (ΔS) = -2.4 in (for all treatments), precipitation = 25.6 in; and irrigation was = 5.2 in, 1.2 in and 0.0 in for I1, I3 and I5 treatments, respectively.
- Total outputs for I1, I3 and I5 were: drainage = 14.7 in, 10.7 in and 9.5 in, respectively. Soil evaporation = 4.3 in, 4.2 in and 4.1 in; whereas transpiration resulted in 14.2 in, 14.2 in and 14.3 in. Potential ET_O was estimated as 24.0 inches (Table 11).

2016

The peanut growing season spanned 13 May to 04 October 2016 (planting and harvest dates, respectively). During the crop season, cumulative rainfall and estimated ET_c summed up to 25.9 and 22.4 inches, respectively. A flat irrigation rate of 0.5 in and 0.7 in were applied across all plots the day before planting and on 15 May to apply a herbicide. Irrigation treatments started on 1 June (19 DAP). Cumulative irrigation applied per treatment was: 21.7, 8.4, 8.1, 13.2 and 1.2 inches for I1, I2, I3, I4 and I5, respectively (Figure 8). Therefore, irrigation treatments applied about 61%, 63%, 39% and 94% less water than I1, which is intended to simulate peanut grower's irrigation practices. For the initial stages of the crop (May-July), monthly average rainfall was 13%, 58% and 45% below the historical average (Cum average May-July: 8.06 in rainfall). And by contrast, excessive rainfall events occurred in August (monthly average 12.4 in) and September (5.52 in) resulting in a cumulative monthly average 49% and 9% above historical average (7 in and 3.5 in, respectively) (Figure 6). Due to the low water holding capacity characteristic of sandy soils, most of the rainfall was not used by the crop and thus, it was lost through drainage (I1, I3 and I5 simulated drainage = 26.5 in, 13 in and 11.9 in, respectively).

The soil water balance simulation for I1, I3 and I5 treatments in the 2016 peanut season was:

- Total inputs: change in soil water storage (ΔS) = -1.7 in, -1.8 in and -2.2 in, respectively. Total precipitation= 25.9 in; and irrigation was = 21.4 in, 7.6 in and 0.7 in for I1, I3 and I5 treatments, respectively.
- Total outputs for I1, I3 and I5 were: drainage = 26.5 in, 14.4 in and 11.9 in, respectively. Soil evaporation= 4.9 in, 3.6 in and 3.3 in; whereas transpiration resulted in 17.4 in, 17.2 in and 13.4 in. Potential ET_O was estimated as 26.5 inches (Table 11).

2017

The peanut growing season covered from 9 May to 4 October 2017 (planting and harvest dates, respectively). During the crop season, cumulative rainfall and estimated ET_c summed up to 34.2 and 19.2 inches, respectively. To provide adequate moisture conditions, an irrigation rate of 0.5 in was applied one day before planting and a 0.3 in was applied on 10 May to apply an herbicide across all treatments. Irrigation treatments started on 26 June (48 DAP). Cumulative irrigation applied per treatment was: 15.3, 5.0, 4.8, 9.5 and 0.8 inches for I1, I2, I3, I4 and I5, respectively (Figure 8). Therefore, irrigation treatments applied about 67%, 69%, 38% and 95% less water than I1, which is intended to simulate peanut grower's irrigation practices. For the initial stages of the crop (May-June), monthly average rainfall was 35%, 32% above the historical average (Cum average May-June rainfall: 15.0 in). Fewer rainfall events occurred in July (monthly average 3.9 in); however, rainfall increased later in September (9.7 in) resulting in a monthly average 48% above historical average (9.7 in vs. 5.0 in, respectively) (Figure 6). Due to the low water holding capacity characteristic of sandy soils, most of the heavy rainfall events was not used by the crop and thus, it was lost through drainage (I1, I3 and I5 simulated drainage = 30.1 in, 19.7 in and 16.7 in, respectively).

Results from the simulated soil water balance for peanut 2017 growing season are described as follows:

- Total inputs: change in soil water storage (ΔS) = -2.0 in (for all treatments), precipitation= 34.7 in; and irrigation was = 14.8 in, 4.3 in and 0.3 in for I1, I3 and I5 treatments, respectively.

- Total outputs for I1, I3 and I5 were: drainage = 30.1 in, 19.7 in and 16.7 in, respectively. Soil evaporation= 4.8 in, 4.6 in and 4.3 in; whereas transpiration resulted in 15.3 in, 15.5 in and 14.7 in. Potential ET_O was estimated as 24.2 inches (Table 11).

Lower transpiration rates were found across irrigated treatments only in 2016. Large amounts of rainfall resulted in large amounts of drainage across all treatments; however, greater drainage was found in the I1 treatment across all growing seasons. A detailed water balance for each peanut growing season is shown in Table 11.

Soil- N

Corn

Soil samples from four depths (0-6 in, 6-12 in, 12-24 in and 24-36 in) were sent to the ARL lab for NH_4-N and NO_3-N analysis. Result analyses (mg/kg) from 2015 to 2017 are shown in this section. Additionally, an N analysis from deep samples (36-48 in, 48-60 in and 60-72 in) collected in corn 2016 and 2017 will be shown at the end of this section.

NH_4-N

Among the four soil layers analyzed, the top layer (0-6 in) was the most variable to NH_4-N concentrations across all years of evaluation. This layer showed the highest average NH_4-N during all seasons. The main NH_4-N spike across the four layers was associated with the starter fertilizer application (30 lb N/ac across all plots) performed at planting (3 April 2015, 22 March 2016 and 21 March 2017). Maximum mean NH_4-N concentrations at top layer for F1, F2 and F3 reached 18.8, 13.4 and 14.3 mg/kg in 2015 and 6.3, 11.3 and 13.5 mg/kg in 2016. In 2017, maximum mean NH_4-N concentrations were present at the 6-12 in layer reaching 5.7, 3.5 and 6.0 mg/kg in F1, F2 and F3 rates, respectively (Figures 9, 13 and 17).

In 2015, the second highest increase in soil NH_4-N concentration occurred after all fertilizer applications were performed. Concentrations at the top layer (0-6 in) were 6.8, 4.9 and 3.1 mg/kg for F1-F3, respectively. Although other layers showed a slight increase in NH_4-N, average concentrations remained below 3.7 mg/kg across all fertility rates in the deeper soil layers (12-24 in and 24-36 in).

In 2016, after the starter and the first granular application, NH_4-N concentrations in the top layer (0-6 in) resulted in 6.3, 11.3 and 13.5 mg/kg for F1, F2 and F3, respectively (12 April soil sampling). Early in the season after the starter fertilizer application, a leaching rain occurred (cum. rainfall= 5.08 in), therefore, following the BMP manual recommendations, a supplemental granular application (30 lb N/ac) was applied on 19 April across all plots in corn. This application was reflected in the subsequent soil sampling (21 April) where top soil (0-6 in) NH_4-N man concentrations increased to 11.2, 6.5 and 13.4 mg/kg on F1, F2 and F3, respectively. The same trends (i.e. increase NH_4-N after fertilizations) but with lower concentrations were followed by the deeper layers in the soil. For example, in 2016, a 7.6 mg NH_4-N/kg were reached at the 6-12 in layer on 12 April (after the 1^{st} granular application), as well as, on 11 June and 24 June 2016 (4.0 and 5.2 mg NH_4-N /kg after all fertilizations were done). A similar pattern occurred in 2017, where a high NH_4-N concentration was present in the top layer after first granular application (5.1 mg/kg NH_4-N on 10 April) and another one after all fertilizations (5.3 mg/kg NH_4-N on May 8). The 6-12 in layer only showed high NH_4-N concentrations on 10 April (6.0 mg/kg NH_4-N) (Figure 13).

Below the 0-6 in depth, the average NH_4-N for the three fertility levels showed a similar trend, all exhibiting slight increases of NH_4-N concentration in response to the granular or final fertilizer applications. Relatively stable concentrations NH_4-N prevailed in all soil layers a month after the fertilization events were performed (Figures 9, 13 and 17). The deepest layers showed a slight increase in NH_4-N concentrations (12-24 in and 24-36 in) averaging 1.45 mg NH_4-N/kg on 21 April 2016 (Figure 13) and 1.66 mg NH_4-N/kg on 15 March 2017 (Figure 17).

In 2017, heavy rainfall events occurred after the starter fertilizer application. Thus, following the BMP protocol, a supplemental application of 15 lb N/ ac was performed across all corn field. The highest NH_4-N concentrations were present in the two top layers after the first granular and supplemental applications. Maximum mean NH_4-N concentrations were present at the 6-12 in layer reaching 5.7, 3.5 and 6.0 mg/kg in F1, F2 and F3 rates, respectively. Through the year, the maximum mean concentration in deeper layers was 2.6 mg/kg (F1 at 12-24 in).

Overall, NH_4-N concentrations were dynamic based on rainfall amounts and crop residue left drying in the field. Less concentrations were present in the soil layers when heavy rainfall events occurred. In contrast, slight increments on NH_4-N were present after the corn residue was left in the field after harvest.

NO_3-N

In 2015, soil NO_3-N average concentrations sharply increased after the starter fertilization (30 lb N/ac) performed at planting (3 April 2015), resulting in NO_3-N concentrations of 9.4, 8.1 and 7.3 mg/kg for F1-F3 in the top 0-6 in soil layer, and 13.7, 9.9 and 8.5 mg/kg in the 6-12 in layer. However, the highest soil NO_3-N were reached after all fertilizations were applied, which was observed at the soil sampling performed on 1 June 2015. In particular, F1 showed the highest NO_3-N in comparison to F2 and F3 across all layers: 19.5, 18.1, 10.3 and 6.2 mg/kg for 0-6 in, 6-12 in, 12-24 in and 24-36 in soil layers, respectively. The pattern of increase concentrations after the fertilizations was present in all layers at different magnitudes; concentrations decreased as depth increased. Afterwards, soil NO_3-N was significantly reduced across all layers and remained below 3.1 mg/kg from July until October 2015. After harvest, during the fallow period (late August through March 2015), maize residue was chopped and left aboveground. Mineralization processes started in the ground resulting in an increase of NO_3-N concentrations from the top to the bottom layer with a delay in time. NO_3-N concentrations averaged 3.2, 3.9, 4.5 and 2.7 mg/kg in 0-6 in, 6-12 in, 12-24 in and 24-36 in soil layers from October 2015 to January 2016, respectively (Figure 10).

In 2016, the highest NO_3-N concentrations occurred after the starter and first granular application in all layers. Average concentrations decreased as soil depth increased. In 2016, after the starter and first granular applications, heavy rainfall events occurred from 24 March to 28 March (cum rainfall =2.07 in), 2 April (cum rainfall= 3 in) and on 21-22 April (cum rainfall= 0.52 in). Therefore, following the BMP protocol, a supplemental application of 30 lb N/ac were applied across all plots in the corn field on 19 April 2016. As a result, elevated NO_3-N concentrations were observed on all N rates on the soil samplings performed on 12 April and 21 April 2016. The maximum mean NO_3-N concentrations were 28.7, 23.6 and 25.8 mg/kg for F1-F3, respectively in the top soil layer (0-6 in). These concentrations were the highest across all years of evaluation. On April 21, nitrate-N concentrations in the 12-24 in soil layer were 12.1, 7.7 and 7.4 mg/kg for F1-F3, respectively, where as in the 24-36 in NO_3-N averaged 5.2, 4.3 and 4.0 mg/kg. Therefore, these high NO_3-N concentrations could have been the result of N moving through the soil profile to deeper layers after heavy rainfall events (Figure 14).

The high fertility rate (F1) showed a sharp NO_3-N increment in the top two soil layers (28.7 mg/kg at 0-6 in and 20.6 mg/kg at 6--12 in). From 24 June until 19 September 2016, concentrations decreased and averaged 1.1 mg/kg. The medium and low N rates, along with the sharp NO_3-N increase at the 0-6 in depth (F2=23.6 and F3=25.8 mg/kg), also showed an increase in NO_3-N concentrations subsequent to the fertilizations (F2=6.6 mg/kg on 24 May and F3=6.3 mg/kg NO_3-N on 20 June). The same pattern of increase occurred in the 6-12 in soil layer with slightly higher concentrations (F2=8.6 mg/kg NO_3-N on 24 May and F3=7.1 mg/kg NO_3-N on 20 June) (Figure 14).

During the fallow period (after harvest on 3 August 2016), NO_3-N concentrations in the top two soil layers started to increase due to mineralization processes peaking in December. NO_3-N concentrations for F1-F3 were: 2.9, 2.1 and 3.5 mg/kg, respectively on the 0-6 in soil layer; whereas 2.1, 2.4 and 3.6 mg NO_3-N /kg for F1-F3, respectively in the 6-12 in soil layer. In deeper layers, average nitrate concentrations remained low (average 0.8 from August to

December 2016), except on F1 at 24-36 in soil layer, where concentrations increased up to 3.5 mg/kg NO_3-N in December (Figure 14).

During 2017, nitrate present in the soil increased in all soil layers after the starter and first granular applications, or after all fertilizations were performed. After the starter fertilizer was applied, heavy rainfall events occurred early in the season (cum rainfall= 4.69 in); thus a supplemental application of 15 lb N/ac was performed on 4 April 2017 across all plots in the corn field to compensate for potential N leaching from starter fertilizer. Overall, NO_3-N concentrations in the soil layers were lower compared to 2015 and 2016. Also, the supplemental application was half the rate applied in 2016 (15 lb N/ac vs. 30 lb N/ac). In the 0-6 in layer, high concentrations were present during 8 May (6.6, 7.9 and 2.2 for F1- F3, respectively). During the season, F1 showed the highest NO_3-N in the 6-12 in soil layer (9.1 mg/kg NO_3-N) after all fertilizations were performed on 23 May 2017. A similar pattern was observed in the F2 and F3 rates. F2 maximum mean NO_3-N slowly increased peaking on May 8 (7.8 mg/kg NO_3-N) and F3 remained below 5 mg/kg NO_3-N through all the growing season. Deeper layers showed slight increments in nitrate concentrations after the granular applications and after all fertilizations were performed in the field (Figure 18).

Peanut

Minimal N applications were performed in the peanut field from 2015 to 2017. A granular application was applied on 22 June 2015, 23 June 2016 and on 30 June 2017, whereas a gypsum application was performed on 8 July 2015, 24 June 2016 and on 16 June 2017 (Tables 5, 6 and 7). Results from NH_4-N and NO_3-N soil analyses are described as follows:

NH_4-N

In 2015, pre-planting NH_4-N concentrations were on average 3.9, 4.5, 3.5 and 2.6 mg/kg across fertility rates in the 0-6 in, 6-12 in, 12-24 in and 24-36 in soil layers, respectively. At the beginning of the peanut season, on 1 June 2015, F1, F2 and F3 NH_4-N concentrations increased to 8.5, 6.8 and 6.0 mg/kg in the top 0-6 in soil layer, due to mineralization processes after field preparations (i.e. soil plowing and harrowing). Afterwards, NH_4-N concentrations in all soil layers increased subsequent to the application of 3-7-28 granular fertilizer on 22 June 2015 and a gypsum application on 8 July. NH_4-N concentrations observed in 13 July soil sampling averaged: 5.9, 5.7, 5.6 and 5.0 mg NH_4-N in the 0-6 in, 6-12 in, 12-24 in and 24-36 in soil layers, respectively. All treatments showed an increase in NH_4-N nearly four times the concentration from previous sampling. Results showed very similar trends for all fertility levels in all the soil profile layers (Figure 11). It is important to know that no N fertility rates were applied in peanut. The fertility rates are designations for the corn N rates that might have an impact on the following peanut production.

In 2016, a few days after field preparation for planting, NH_4-N concentrations in the top layer increased on May 24 across all fertility rates (8.9, 5.3 and 6.1 mg/kg for F1-F3, respectively). Concentrations were lower in all deeper layers across N fertility rates (i.e. N rates correspond to corn on previous year) through the growing season averaging 1.7, 1.4 and 1.4 mg NH_4-N/kg for 6-12 in, 12-24 in and 24-36 in soil layers, respectively. A slight increase in NH_4-N concentrations occurred in December 2016 due to mineralization processes (Figure 15).

In 2017, high NH_4-N concentrations were observed on 23 May and 5 July, where F1-F3 averaged 4.3, 3.8 and 6.1 mg/kg, and 5.5, 3.7 and 2.5 mg/kg, respectively at the 0-6 in soil layer. Mean NH_4-N concentrations also increased in deeper layers, but in less magnitude. Overall, NH_4-N averages in the year (Jan-July) were 1.3, 1.0 and 1.0 mg/kg for 6-12 in, 12-24 in and 24-36 in soil layers, across all fertility rates (Figure 19).

In all years, there was an effect of the gypsum application ($CaSO_42H_2O$) and the release on NH_4-N in the soil profile, especially on the top layer where it is broadcast applied, reducing volatilization. The effect of gypsum application over N volatilization has been studied resulting in positive effects in the reduction on N losses. Thus, this potential increment in NH_4-N could be an effective way to provide N for plant uptake.

NO_3-N

In 2015, soil NO_3-N average concentrations obtained on 18 May 2015 (pre-planting sampling), resulted in high NO_3-N across the soil profile. In the 0-6 in soil layer, NO_3-N concentrations observed averaged: 8.3, 16.8, 7.0 mg/kg for F1-F3, respectively. In the subsequent soil layer (6-12 in), concentrations averaged 10.9, 14.8 and 11.0 mg/kg; in the 12-24 in NO_3-N averaged 5.3, 5.7 and 6.7 mg/kg. The bottom soil layer analyzed showed average values lower than the upper layers averaging 4.1, 3.2 and 3.4 mg/kg; however those values remained within that range (4.7-2.1 mg/kg) from May until July 2015. Large variations were present at each of the soil layers. The top two layers showed a substantial decrease in NO_3-N after the first sampling and early stages of the crop. Concentrations remained low (overall average= 0.7 mg/kg) from July until September 2015. After harvest (20 October), crop residue was chopped and it remained aboveground, thus, mineralization processes started occurring from top layer and moving to deepest layers with time. Therefore, soil NO_3-N concentrations for F1-F3 resulted in 3.3, 4.7 and 3.7 mg/kg in 0-6 in layer, 5.8, 6.0 and 5.2 mg/kg in 6-12 in layer; and 4.9, 5.2, and 6.5 mg/kg in the 12-24 in layer in January 2016. The deepest layer analyzed (24-36 in) increased up to 3.3, 2.9 and 2.9 mg/kg on average in 28 January 2016 (Figure 12).

NO_3-N average concentrations in 2016 varied across the soil profile; however, soil layers showed similar trends with lower magnitude in deepest layers. Overall, nitrate-N concentrations decreased with soil depth. During the season, two main events caused an increment in NO_3-N: field operations prior planting in which NO_3-N concentrations increased due to field plowing and incorporation of the previous year crop residue, and after the granular application. Therefore in the soil sampling of 11 May, average NO_3-N concentrations for F1-F3 were: 3.9, 4.2 and 3.6 mg/kg in the 0-6 in; and 4.3, 3.6 and 3.5 mg/kg in the 6-12 in soil layer. The highest average concentration was observed in F1 (6.2 mg/kg) on 24 May in the top 0-6 in soil layer (Figure 16). In deeper layers, concentrations remained low from July to December. However, after harvest, there was an increment in NO_3-N across all layers, but in particular on the top 0-6 in and 6-12 in soil layers due to mineralization processes (average 3.9 and 3.3 mg/kg for those layers, respectively) (Figure 16).

Similar as in previous years, in 2017, the increase in NO_3-N concentrations was more pronounced on the two top layers on 11 May and 6 July; after field preparation activities (harrowing the field) and after the granular application. In the deeper layers (12-24 in and 24-36 in) nitrate-N concentration slightly increased compared to the top layers (highest concentration=2.8 mg/kg and average= 2.1 mg/kg across all N rates). After harvest, crop residue was left aboveground allowing for mineralization processes to occur. Therefore, all layers experienced an increase in nitrate concentrations, in which the highest amounts were present in the 0-6 in top layer (NO_3-N average=3.9 mg/kg across all fertility rates) (Figure 20).

Soil N in deep layers – Corn 2016-17 seasons

Deep samples taken in I3 from 36-48 in, 84-60 in and 60-72 in were analyzed for NH_4-N and NO_3-N during corn growing seasons 2016 and 2017. Nitrate-N results for both seasons are shown in Figures 21 and 22, respectively.

In 2016, after the starter fertilizer application performed at planting (30 lb N/ac of 16-16-0 on 22 March), consecutive rainfall events occurred in 26-27 March (cum rainfall = 1.5 in) followed by a heavy rainfall event on 2 April (rain = 3.0 in). The first granular application was performed on 5 April 2016. After these events, a sharp increase in soil NO_3-N concentrations was observed in all deep layers (36-48 in, 48-60 in and 60-72 in) (Figure 21). The highest nitrate concentrations resulted in the 60-72 in layer averaging 9.1, 5.2 and 8.0 mg/kg NO_3-N in the F1, F2 and F3 treatments. Due to the previously described leaching rain, a supplemental application (30 lb N/ac) was done on 19 April, followed by the second granular application on 27 April and the four liquid sidedress fertilizations (applied on 3, 9, 13 and 19 May). Afterwards, nitrate concentrations decreased in all deep layers until more rainfall events occurred from 17-20 May (cum rainfall 1.9 in). Small increments in soil nitrate resulted in all N fertility rates that further increased during the rainfall events occurring on 5-6 June (rainfall= 1.69 in) and 10 June (0.79 in). Therefore, NO_3-N concentrations for F1, F2 and F3 averaged 4.6, 1.7 and 2.1 mg/kg in the 36-48 in layer, 3.7, 1.3 and 3.0 mg/kg in the 48-60 in; and 4.7, 1.8 and 4.4 mg/kg in the deepest 60-72 in soil layer. At the very end of the season, heavy rainfall events occurred influenced by the Tropical Storm Hermine (4-14 August cum rainfall= 10.4 in). The deep sampling performed later at the end of the season (22 August) resulted in lower concentrations in the 36-48 in layer (0.4, 0.9 and 0.6 mg/kg for F1-F3 rates, respectively), however, slightly higher concentrations in the deepest soil layers: 0.8, 3.2 and 0.5 mg/kg for F1-F3 in the 48-60 in layer; whereas 2.8, 2.6 and 1.0 mg/kg. Since the sampling occurred several days after the large amounts of rainfall, it could have been possible that nitrate concentrations were higher in days prior.

In 2017, similar patterns in nitrate-N were observed after the starter fertilizer was applied (21 March) and a subsequent heavy rainfall event occurred (3-4 April cum rainfall 4.3 in). Due to the leaching rain, a supplemental fertilization (15 lb N/ac) was applied on 6 April in conjunction with the first granular application. During the soil sampling performed on 10 April, increments in NO_3-N were observed in the 36-48 in soil layer averaging 4.3, 2.7 and 2.8 mg/kg in the F1, F2 and F3 treatments, respectively. The second granular application was performed on 20 April followed by the four liquid sidedress fertilizations (applied on 27 April, 3, 9 and 15 May). Afterwards, a series of consecutive rainfall events occurred from 20-24 May (cum rainfall= 3.0 in) and 3-7 June (cum rainfall= 6.7 in) resulting in an increase in nitrate concentrations in the two soil deepest layers. In the 23 May sampling, average nitrate concentrations in the F1-F3 N rates were: 1.5, 1.9 and 4.2 mg/kg in the 48-60 in soil layer, and 2.2, 2.0 and 5.8 mg/kg in the 60-72 in soil layer. In the following soil sampling (5 June) average values for F1-F3 were: 0.5, 2.6, 1.1 mg/kg in the 48-60 in layer, and 1.2, 4.1 and 2.0 mg/kg in the 60-72 in layer, respectively. During the final soil sampling (21 June), NO_3-N concentrations were lower than 1.3 mg/kg in all layers and N rates, except in the deep 60-72 in layer F2 resulted in 2.3 mg/kg (Figure 22).

Nitrate- N concentration spikes in deep soil layers, (where N uptake is reduced), were found in both growing seasons. As well, due leaching rains occurring early in the season, additional fertilizer applications were required. Increased nitrate concentrations resulted after heavy rainfall events; either individual events of large magnitude or consecutive rainfall events of lower magnitude.

Salinity

Corn 2015-2017

Sentek MST (Moisture-Salinity-Temperature) sensors provide a salinity output measured in volumetric ion content (VIC). Is important to recognize that VIC does not represent the exact soil electrical conductivity (EC) value. Changes of units of VIC represent changes in units of soil EC. Using these measurements, insights of fertilizer movement in the soil profile can be identified.

A total of 27 Sentek MST probes were installed per growing season. The following section provides a summary of the most relevant results in corn 2015-17 from three irrigation treatments (I1, I3 and I5) across three fertility rates (300, 240 and 140 lb N/ac) evaluated.

The salinity data was graphed as the invert of the raw data. The minimum value observed at each sensor was considered as the 'baseline'. Then, all values were subtracted from the baseline to obtain a graph showing how values differed from the baseline (negative values). Data is shown as the salinity measured throughout the corn growing seasons at all depths (0-85 cm) and at the deepest layers (45 -85 cm), where ions moving throughout the soil profile can be observed. These graphs provide a better visualization of ions moving throughout the soil profile as an effect of irrigation and/or rainfall events.

The salinity data (VIC) was correlated with soil NO_3-N measurements taken at four depths in the VIC –NO_3-N correlation analysis section below to identify potential relationships between these two variables.

2015

During 2015, rainfall contributions reduced the total irrigation amount by providing enough moisture for the crop during almost all the season. Fertilizations consisted of a starter fertilizer (30 lb N/ac of 16-16-0) applied at planting across all treatments, followed by two granular applications (33-0-0, 0-46-0 and 0-0-60) performed on 17 April and 1st May during V3 and V6 stages approximately. Total N applied on the F3, F2 and F1 rates were: 8, 22 and 30 lb N/ac, respectively using a 33-0-0 fertilizer (16.49% ammoniacal N and 16.51% nitrate-N).In the second granular application a total of 10, 24 and 40 lb N/ac was applied in F3, F2 and F1 rates, respectively. Afterwards, split liquid sidedress applications (28-0-0) were applied on 8, 15, 22 and 29 May 2015 (between V8 and VT- (tasseling) corn growth stages). At each liquid sidedress application a total of 23, 36 and 50 lb N/ac was applied on F3, F2 and F1 rates, respectively.

Salinity data from F1, F2 and F3 fertility rates was compared across irrigation treatments (I1, I3 and I5). Salinity measured in the 5 cm layer is the most variable across all layer due to the different soil water dynamics and fertilizer applications (e.g. soil evaporation, drainage, saturation, ion uptake).

Early in the growing season, after granular fertilizer applications and due to rainfall events occurring in mid-April, the I1F1 treatment (i.e. calendar based irrigation and 300 lb N/ac) showed a large movement of ions in the top soil layers (i.e. Sentek sensors located within 0-45 cm). However, in early June after all fertilizers were applied, the combination of frequent irrigation events (1-4th June) plus additional scatter rainfall (1st and 7th June) caused a greater movement of ions deeper in the soil reaching the deepest soil depth (85 cm). Thus, this could be a potential evidence of N leaching from the rootzone. Later on during the season, salinity levels remained stable in all soil layers (Figure 23). The I1F2 and I1F3 treatments showed same salinity patterns during early season in which ions moved only in the top 0-45 cm. Although these treatments received the same irrigation as I1F1, only 220 and 140 lb N/ac were applied, respectively. Thus, no greater movement was seen in the deepest soil depths after all fertilizers were applied. Based on the observed salinity in these plots, most of the ions remained in top soil layers during the growing season (Figure 24 and 25).

The salinity in the I3F1 treatment increased in top soil layers (0-45 cm) after fertilizer applications. This treatment uses soil moisture sensors to determine irrigation; therefore, the frequency of irrigation was lower than the I1 treatment. Ions moved to mid layers after rainfall events occurring early in the season. However, due to the lower irrigation frequency, ions were kept in the 0-65 cm layers. No increments in salinity were observed in the deepest layers (75-85 cm) during the growing season (Figure 26). Salinity in the I3F2 and I3F3 treatments was very similar. Most of the ions started moving from top to bottom soil layers early in the season after fertilizer applications and rainfall events; however, ions remained in the top layers (0-55 cm) during all season. The deepest layers did not experience high increments in salinity during the corn season (Figures 27 and 28).

Similarly as in the I3 treatment, the I5F1, i5F2 and I5F3 treatments showed high salinity increments in top soil layers (0-15 cm) after fertilizer applications; however, small salinity increments in deepest layers were observed later in the season after rainfall events (Figures 29, 30 and 31).

2016

Fertilizations in corn 2016 occurred on: 22 March (30 lb/ac of 16-16-0), first granular application at V3 growth stage (33-0-0: 16.5% ammoniacal N and 16.5% nitrate-N), and 35 lb K/ac of 0-0-60 was applied across all fertility levels. A supplemental granular application of 30 lb N/ac (21-0-0 at 145 lb/ac) was performed on April 19 due to a leaching rain. The second granular application (33-0-0) took place on 27 April, 2016 (V6 growth stage). A total of 10, 24 and 40 lb N/ac was applied on F3, F2 and F1, respectively. In addition, 35 lb K/ac of 0-0-60 was applied in all plots. Afterwards, split liquid side-dress applications (28-0-0) were performed at 42, 48, 52 and 58 DAP (i.e. between V8 and VT (tasseling)). At each liquid sidedresss application the fertility rates F3, F2 and F1 applied a total of 23, 36 and 50 lb N/ac, respectively. By 19 May, all fertilizations complete.

Unfortunately the probes were installed several days after the leaching rain occurred on 2nd April, thus, potential N leaching from starter and granular fertilizer was not possible to be observed using the sensor's salinity data.

The probes I1, I3 and I5 across the three fertility rates were compared. As described previously, 2016 was a dry year and irrigation was required. The I1 treatment uses a calendar based irrigation in which weekly amounts varied based on crop stage; increasing irrigation frequency as the crop grows. As a result, after the application of 300 lb N/ac combined with frequent irrigation events (23 May- 3rd June) plus the addition of rainfall (6 June), caused a continuous movement of ions from the 45 cm soil layer with a lag in time which finally reached the 85 cm deepest soil layer. The increments of ions in the 85 cm deep layer continued until 26 June 2016, period when numerous irrigation events were performed (Figure 32). This event represents a potential N leaching from the rootzone when high frequency of irrigation and large fertilizer amounts were applied. In contrast, the salinity in the I1F2 treatment increased in the deep soil layers (45-85 cm) during the rainfall events occurred in 5-6 June sand 10 June, 2016 following several irrigation events (31 May – 9-10 June). High VIC values were found in the 85 cm layer during the period of 6-14 June, 2016 (Figure 33). In comparison, the I1F3 treatment did not show VIC increments throughout the season, which might provide insights of low N inputs that could have been kept in the rootzone available for N uptake (Figure 34).

The I3F1 treatment showed that most of the ions remained in the top 0-45 cm layers during the majority of the season (late April to late June). However, high salinity increments in the deep soil layer were observed after 22 June until the end of the season (Figure 35). It is important to recognize that all treatments received 30 lb N/ac extra during the 2016 corn season; thus, if partial N was not taken up by the plants after it was applied, it can be leached later throughout the season. Therefore, this high VIC content in the deep layers could be the result of the extra N applied early in the season (due to the leaching rain). The increment occurred at the end of the growing season when corn N and water uptake was minimal; thus, rainfall plus last irrigation events could have contributed to mobilize ions to the deepest soil layers. In contrast, salinity in the I3F2 and I3F3 treatments was higher in the top layers. Small VIC increments were observed only after rainfall events occurred in 5 June. Otherwise, VIC was stable in deep layers during the corn season (Figures 36 and 37).

The salinity in the I5F1 and I5F2 treatments increased in the deep layers (75-85 cm) after rainfall events occurred in 20 May. There was a lag effect, thus salinity increased during the period of 21 May and high values were continuously observed until 16 June due to succeeding rainfall events (5-6 June and 10 June) (Figure 38 and 39). Salinity VIC values increased in the top soil layers but not in deep layers in the I5F3 treatment during the growing season (Figure 40).

2017

During 2017, the starter fertilizer was applied at planting (of 30 lb/ac of 16-16-0 on 21 March), two granular applications were performed on 6 and 20 April. During the first granular application, total N applied on the low, medium and high rates were: 8, 22 and 30 lb N/ac, respectively using a 33-0-0 fertilizer (16.49% ammoniacal N and 16.51% nitrate-N). Due to a leaching rain occurring early in the season, a supplemental 15 lb N/ac application was performed in all plots on 6 April. The second granular application (33-0-0) took place close to V6 corn growth stage. A total of 10, 24 and 40 lb N/ac were applied on the low, medium and high rates, respectively. Afterwards, four split liquid sidedress applications (28-0-0) were applied between V8 and VT- (tasseling) corn growth stages (on 27 April, 3, 9 and 15 May, respectively). At each liquid sidedress application a total of 23, 36 and 50 lb N/ac were applied on F3, F2 and F1 rates, respectively.

During 2017 rainfall amounts and frequency varied significantly. During the growing season, two heavy rainfall events occurred in early April and in late May causing potential N leaching from the rootzone. In between those major events, it was predominantly dry.

In general, after the fertilizer applications, a rapid salinity response was observed in the soil as volumetric ion content (vic) measured by the probes increased. Early in the season, continuous spikes can be observed in the top soil layers (5 -15 cm). Later in the season, the ion increment observed in the deep soil layers throughout time was in most of the cases as a result of heavy rainfall events. This behavior was observed in the I1F1 treatment, in which salinity in all the deeper soil layers (45-85 cm) increased after rainfall events occurring on 21-24 May (cumulative rainfall 3 in) (Figure 41). By contrast, the I1F2 and I1F3 treatments showed spikes in the top layers, but the volumetric ion content in the deep layers remained stable during most of the corn season, except after the rainfall events occurring on 21-24 May. The I1F2 and I1F3 graphs show a thick shaded area in the 85 cm; however, this is due the technique of using a benchmark of minimum conditions to subtract the data measured at each depth. Therefore, initial conditions were high in both treatments, which could be the effect of N leaching after heavy rainfall events occurring in 4 April (rainfall = 3.73 in). Afterwards, small changes in the salinity throughout the season in both treatments were observed (after heavy rainfall events in 21-24 May) (Figures 42 and 43).

High salinity values in all layers were observed in the I3F1 treatment at the beginning of the crop season as a result of the heavy rainfall events (April 4). During the mid-crop season when fertilizer applications were performed, fluctuations in salinity were seen in the top 0-45 cm layers. Nevertheless, the volumetric ion content increased slowly in deeper layers after rainfall events on 20-24 May (cumulative rainfall 3 in). High salinity values in the 85 cm soil layer continued after subsequent heavy rainfall events occurring from 3-7 June (cum rainfall 6.7 in). (Figure 44). The same behavior but in a lower magnitude was observed in the I3F2 and I3F3 treatments (Figures 45 and 46).

After fertilizations were applied there was a visual response in salinity in the top 0-45 cm layers in the non-irrigated treatment plots. After the heavy rainfall events occurred on April 4, 4 and 24 May, high volumetric ion content values were observed in the deepest layer (85 cm) in the non-irrigated treatment, across the three fertility rates (I5F1, I5F2 and I5F3)(Figures 47, 48 and 49) . These visualizations of salinity increments in the deepest layers, can help explain the conditions in which potential N leaching events occur.

Although the SMS treatment allowed enough soil moisture while regulating it as needed and avoiding overirrigation, when heavy rainfall events occur, the movement of ions from the top to the bottom layers is inevitable and N leaching occurs. This scenario also occurs under non-irrigated conditions. When extra N is applied exceeding the N uptake rate, then N easily leaches after heavy rainfall events.

VIC –NO_3-N correlation analysis

NO_3-N concentrations of soil samplings performed at four depths: 0-6 in, 6-12 in, 12-24 in and 24-36 in were compared with volumetric ion content (VIC) measurements recorded by the multisensory capacitance probes at nine depths (from 5 cm to 85 cm). The relationship between these variables during corn 2015 was analyzed.

Several trials were performed to compare both variables. Data was segregated using volumetric ion content values greater than 800, as minimum salinity values (i.e. close to initial salinity values before fertilizer applications) The relationship between all soil NO_3-N (mg/L) and VIC values (>800VIC) across all samplings showed a low correlation value (Pearson R^2=0.2308). Therefore, the data was further segregated by soil sampling dates. The highest correlation obtained across sampling dates resulted in the May 18, 2015 sampling date (R^2 0.1806). This sampling was performed after the starter fertilizer, two granular applications and two liquid side-dress applications in corn 2015. Further increased regression coefficient was obtained after those fertilizations under the highest application rate (300 lb N/ha) and only at 12-36 in depths (R^2=0.4439). Possible data transformation could increase the relationship of N data and VIC values. If a stronger relationship is established, these sensors could become an important tool to track and reduce N leaching in agricultural systems, hence reduce potential issues associated with it. (Figure 50).

Leachate - N

Volume

The volume collected from the lysimeters in each crop was pumped out biweekly or after heavy rainfall events during the 2015-17 crop seasons.

In 2015, leachate from corn lysimeters was not able to be collected. Under corn production, ET_c was relatively high and as a consequence there was no leachate detected in corn from April 22 to September 1, 2015. During the peak growth period in June and July, very little leachate was expected. Using the soil moisture probes as indicators of leaching indicated little potential for leaching since there was no increase in moisture content in the deeper layers. However, later in the season when the corn plants had senesced, and after harvest there was considerably more rain and ET_c was close to zero, drainage was not detected in corn lysimeters despite increases in deeper soil moisture content in SMS probes. Due to the lack of leachate collected in corn 2015, lysimeters were tested during the fall 2015. A known volume (60 gal) of water was dumped into several lysimeters for testing, and after an infiltration period of 48 hours, lysimeters were purged and leaching was collected. However, inconsistencies still were found across the volumes collected. The aboveground purging system was working effectively in most of them, but the total volume collected varied drastically between treatments. Lateral water movement and small leaks (from caps of barrels) were suspected to be potential causes of water not draining directly to or leaking from the lysimeters. Therefore, lysimeters were used to determine N concentrations (NH_4-N and NO_3-N) at the different irrigation treatments and N fertility rates.

Due to the inconsistencies described previously, estimations of drainage for each irrigation treatment were performed using the CERES-Maize model within DSSAT. Simulated cumulative drainage per irrigation treatment (I1, I3 and I5) during the corn seasons was: 14.0, 7.3 and 4.4 inches in 2015, 14.3, 6.4, and 4.4 inches in the 2016 season; and 26.8, 17.4 and 10.1 inches in 2017.

In peanut growing seasons, the simulated drainage volumes per irrigation treatments were 14.7, 10.7, and 9.5 inches, respectively in 2015; 26.5, 14.4 and 11.9 inches in 2016; and 30.1, 19.7 and 16.7 inches in 2017.

Corn 2016-17

In 2016, six leachate samplings were performed in corn on 25 May, 9 June, 1st July, 11 August, 16 August and 7 September 2016 (Figures 52-53). The three first samplings were performed after drainage events produced by rainfall and irrigation combined events. During the first three samplings, no leachate was obtained in the non-irrigated plots, only in I1 and I3. Prior to sampling, cumulative rainfall summed up to 2.03 in, 1.69 in, 0.55 in, 5.13 in, 6.05 in and 4.08 in, respectively. In 2017, six leachate samplings were performed in corn on 26 May, 8 June, 22 June, 25 July, 8 August, and 22 August 2017. Total cumulative rainfall prior these sampling events was: 2.96 in, 6.68 in, 2.74 in, 1.19 in, 2.98 in and 8.88 in. Collected leachate was analyzed for NH_4-N and NO_3-N for all samplings performed in corn 2016-17 seasons (Figures 52-53 and 56-57).

Significant differences in NH_4-N concentrations among sampling dates were observed; whereas the interaction of sampling date and irrigation resulted in a significant effect on NO_3-N concentrations for all three corn seasons.

NH_4-N

In the 2016 corn growing season, the overall average NH_4-N leachate concentrations in samplings were 0.08, 0.06 and 0.23 mg/L in I1, I3 and I5, respectively (Figure 52). In terms of fertility rates, NH_4-N leachate concentrations overall averaged 0.16, 0.04 and 0.03 mg/L in F1, F2 and F3, respectively (Figure 52). No statistical differences in NH_4-N were found between irrigation nor fertility rates.

During the 2017 corn season, average NH_4-N leachate concentration across sample events was 0.27, 0.29 and 0.53 mg/L in I1, I3 and I5, respectively. Whereas, the overall average NH_4-N leachate concentrations in terms of fertility rates resulted in 0.39, 0.25 and 0.49 mg/L in F1, F2 and F3, respectively (Figure 56).

No differences were found among main effects evaluated (i.e. irrigation and fertility). NH_4-N concentrations observed in 8 June, August 8 and 21 September 2017 samplings were statistically higher compared to the rest of the samplings. Nevertheless, average leaching NH_4-N concentrations from all irrigation treatments and fertility rates in the three corn growing seasons remained below 0.53 mg/L.

NO_3-N

N fertility rates, sampling dates and an interaction between irrigation and sampling date resulted in a significant effect on NO_3-N leaching in corn.

During 2016, the first three leachate samplings were performed on 25 May, 9 June and 1st July which occurred after all fertilizations were applied in corn. During the 25 May sampling, leachate was collected in I1 and I3 treatments only, resulting in 35.0 and 30.4 mg NO_3-N/L, respectively. During 9 June and 1st July subsequent samplings, leachate only occurred in the I1 plots across the field resulting in concentrations of 75.4 and 29.9 mg/L, respectively. Average NO_3-N in I3 was 30.4 mg/L at the 25 May sampling and concentrations were below detectable limits for the 9 June and 1st July samplings. No leaching was collected in the non-irrigated plots during these three first sampling events. Later in the season, the highest NO_3-N concentrations were found on the 11 August, 16 August and 7 September sampling events. These three samplings were performed due to heavy rainfall events occurred a few days prior (i.e. cumulative rainfall = 5.13 in, 6.05 in and 4.08 in, respectively). During the 11 August and 16 August samplings, I5 resulted in significantly higher average NO_3-N concentration compared to I1 (I5 = 180.6 mg/L vs. I1 = 6.9 mg/L; and I5 = 112.1 mg/L vs. I1 = 6.8 mg/L, respectively). Average concentrations in I3 during those sampling events resulted in 44.3 and 27.6 mg NO_3/L, not statistically different from I1 nor I5. Although nitrate-N concentrations in the I1 treatment were lower during the later sampling events, nitrate-N leaching occurred previously in the season mostly after frequent irrigation and rainfall events of lower magnitude, that combined, resulted in N leaching (i.e. average NO3-N were 35 mg/L on 25 May, 75.4 mg/L on 9 June and 29.9 m/L on 1 July. . Thus, the concentrations were already reduced when heavy rainfall events happened (Figure 53).

It is important to recognize that the highest nitrate-N leaching occurred in the non-irrigated plots with highest N fertility rate (300 lb N/ac + supplemental 30 lb N/ac) collected in individual leachate samplings performed after heavy rainfall events (highest concentrations from individual plot sampling found in corn 2016 were: 473, 299, 288 and 268 mg/L found in plots B4I5F2, B1I5F1, B2I5F1 and B4I5F1). Thus, N stored in the soil and unable to be taken up by the plants (i.e. not in soil solution) is prone to be leached in great concentrations after heavy rainfall events such as the ones occurred in August and September 2016 (Figure 53). In 2016, the overall average NO_3-N concentrations from all leachate samplings per N fertility rate were: 58.8, 53.7 and 35.3 mg NO_3-N /L for F1, F2 and F3, respectively. F1 and F2 resulted in significantly higher NO_3-N vs F3 during the season. Nitrate leaching was observed mostly after heavy rainfall events.

Initial samplings in 2017 were performed on 26 May, 8 June and 22 June after all fertilizations were applied in the corn field. Average NO_3-N concentrations resulted in: 43.5, 45.8, and 75.0 mg/L in I1 treatment; 49.5, 25.1 and 15.1 mg NO_3-N /L in I3 and; 39.3, 77.4 and 33.6 mg/L in I5. No significant differences were found among irrigation treatments during those sampling dates. Average NO_3-N leaching concentrations across the N fertility rates resulted in: 51.9, 68.0 and 41.4 mg/L in F1; then 39.9, 41.2 and 96.1 mg NO_3-N/L in F2; and 42.6, 36.7 and 12.6 mg NO_3-N/L for F3 fertility rate, respectively for 26 May, 8 June and 22 June leachate samplings (Figure 57). Significant differences were found across fertility rates.

Further sampling events in the season were performed on 25 July and 7 August 2017. Average NO_3-N concentrations for I1, I3 and I5 treatments resulted in 20.3, 0.35 and 0.50 mg/L, respectively on the sampling of 25 July; and 46.1, 11.3 and 39.8 mg NO_3-N/L, respectively on the sampling of 7 August 2017. No significant differences were found among irrigation treatments during these sampling dates. Average NO_3-N concentrations for the fertility rates F1-F3 resulted in: 1.9, 28.6 and 0.9 on the 25 July sampling, and in 63.3, 39.8 and 8.0 mg NO_3-N/L on the 7 August 2017 sampling. Significant differences were found across fertility rates (Figure 57). The average NO_3-N concentrations from all leachate samplings per N fertility rate were: 45.3, 49.1 and 20.2 mg NO_3-N /L for F1, F2 and F3, respectively. F1 and F2 were statistically higher than F3 during all three seasons. (Figure 57).

Peanut 2015-17

In 2015, leachate sampling was performed on 8 July, 20 July, 28 July, 4 August, 11 August, 19 August, 27 August, 10 September and 17 September. During the 2016 peanut growing season leachate sampling was performed on 11 August, 15 August and 6 September 2016. Cumulative rainfall occurring prior the sampling dates was 5.13, 6.05 and 4.08 in, respectively. In 2017, during the peanut growing season a total of five sampling events were performed on 12 June, 22 June, 25 July, 7 August, and 20 September.

Based on the statistical analysis for NH_4-N and NO_3-N of three peanut seasons, results showed significant differences in NH_4-N leaching concentrations across sampling dates, and a significant effect of the interaction between sampling dates and irrigation on NO_3-N leaching concentrations.

NH_4-N

In 2015, average NH_4-N concentrations ranged from 0.12 to 0.18 mg/L across irrigation treatments during leachate sampling performed during the peanut season. Overall NH_4-N average resulted in 0.15 mg/L in 2015 (Figure 51). During the 2016 peanut season NH_4-N averaged 0.08, 0.07 and 0.07 mg/L in I1, I3 and I5 across the three leachate sampling events performed. Similar values were found across the N fertility rates (applied in previous corn 2015 season), where NH_4-N averaged: 0.08, 0.08 and 0.07 mg/L. Significant differences were found in NH_4-N during the last sampling on 21 September 2017, in which NH_4-N concentrations were statistically lower in comparison to the previous leaching sampling dates (average = 0.10 mg/L) . All other leachate sampling events performed in the three peanut seasons did not differ statistically across irrigation treatments, fertility rates, nor sampling dates (Figures 51, 54 and 58).

NO_3-N

In 2015, statistically different NO_3-N concentrations were found between irrigation treatments on`` the 11 August and 15 August sampling dates, only. On July 8, I1 had the highest NO_3-N (67.4 mg/L) compared to I3 (21.6 mg/L) and I5 (20.2 mg/L). NO_3-N concentrations gradually decreased with time reaching values below 5.6 mg/L in all treatments (Figure 51). Nevertheless, NO_3-N found in the leached water is likely to be from N applied previously that remained in the soil, because minimal N applications were performed throughout the crop season.

In 2016, during the 11 August sampling, I1, I3 and I5 resulted in average NO_3-N concentrations of 7.1, 10.0 and 24.0 mg/L. Significantly higher nitrate-N in I5 versus I1. In the subsequent sampling on 15 August similar results were observed, I1, I3 and I5 resulted in 1.1, 3.1 and 10.1 mg NO_3-N/L, where significant differences were found between I1 compared to I3 and I5. Average NO_3-N leachate from all sampling events across irrigation treatments was 2.9, 4.9 and 12.2 mg NO_3-N/L for I1, I3 and I5 treatments, respectively. NO_3-N averages per fertility rates resulted in 5.7, 7.0 and 8.0 mg NO_3-N /L for F1, F2 and F3, respectively. The N fertility rates reflect the rates applied in corn the previous year, since no fertility levels were applied in peanut (Figure 55). During last peanut leachate sampling in 2016 (6 September), overall NO_3-N concentrations were reduced and averaged 1.4 mg/L across the field. No statistical differences between irrigation treatments nor fertility rates were detected in samplings after August 15, 2016.

In 2017, the NO_3-N concentrations from all leachate samplings were averaged per irrigation treatment resulting in: 20.1, 6.0 and 12.6 mg NO_3-N/L for I1, I3 and I5 treatments. As well, the NO_3-N averages per N fertility rate resulted in 14.8, 16.0 and 12.3 mg NO_3-N /L for F1, F2 and F3, respectively (Figure 59).

Overall NO_3-N leaching concentrations were higher during 12 June and 22 June sampling dates, resulting in 41.2 and 21.1 mg NO_3-N/L in I1, 8.4 and 6.1 mg/L in I3; and 19.5 and 11.9 mg NO_3-N/L in I5, respectively. Average NO_3-N leaching for fertility rates during these sampling dates resulted in: 26.9 and 12.8 mg NO_3-N/L in F1, 28.7 and 16.1 mg NO_3-N/L in F2; and 28.9 and 10.1 in F3. The samplings performed later in the season (25 July and 7 August) resulted in lower concentrations. During the 25 July sampling, average nitrate leachate concentration for I1-I5 was 9.3, 1.6 and 10.9, respectively, where I1 and I5 concentrations were significantly higher than I3. Significant differences between irrigation treatments were found only in this sampling throughout the peanut season 2017.

Finally, during the last two leachate samplings (7 August and 21 September), I1, I3 and I5 average concentrations were: 9.0, 7.3 and 8.0 on the 7 August sampling, and 5.4, 2.0 and 6.0 mg NO_3-N/L on the 21 September sampling. Overall lower concentrations were observed in the last sampling across the season.

In general, lower NH_4-N concentrations compared to NO_3-N were found in leachate samples across both crops in all samplings. By contrast, high NO_3-N concentrations were found in leachate water from both crops. Particularly, the highest concentrations were found after heavy rainfall events in the plots with high or without irrigation but high fertility rates (i.e. I1F1 and I5F1 plots). By contrast, overall I3 treatment resulted in lower leaching concentrations, giving potential insights for the use of moisture sensors to keep nutrients in the rootzone and avoid N leaching. In addition, the plots receiving high N fertility rates and no irrigation, serve as N storage plots with a high potential for N leaching after heavy rainfall events.

Crops: N-Tissue

Corn 2015-2017

Final dry weight and N content from corn plant sections (i.e. leaf, stem and ear) across irrigation treatments (I1-I5) and fertility N rates (F1-F3) were analyzed at the final tissue sampling from three corn seasons. Irrigation had a significant effect on final leaf, stem and ear dry weight. By contrast, fertility N rates did not have a significant effect on the dry weight of any of the corn sections analyzed (leaf, stem and ear), but did have significant effect on final N content in leaves.

Leaf dry weight and N content

Irrigation had a significant effect on final leaf dry weight. Irrigated treatment leaf dry weight means (I1-I4) were statistically higher compared to the non-irrigated in all years (Figure 60). Final leaf dry weight for irrigated treatments ranged from 229 to 249 g/m, from 192 to 202 g/m and from 179 to 201 g/m during 2015, 2016 and 2017 corn seasons, respectively. In comparison, statistically lower leaf dry weights occurred in the non-irrigated treatment: 188 g/m, 149 g/m and 132 g/m in 2015-17 seasons, respectively. Differences were found among the years of evaluation, in which leaf dry weight means in 2015 were statistically higher (229 g/m) than in 2016 and in 2017 (189 and 181 g/m), respectively (Table 12).

Significant differences in leaf N content were present across fertility rates. Leaf N content in the high and medium rates (F1=1.11% N and F2= 1.08%) was statistically higher compared to the low N rate (F3=0.97% N). As well, the N content present in the leaf significantly varied across all years of evaluation; where the highest leaf N resulted in 2016 (1.3% N), followed by 2017 (1.07 % N) and the lowest in 2015 (0.8% N) (Figure 60).

Stem dry weight and N content

Based on the irrigation treatment contrast analysis, irrigated treatments (I1-I4) resulted in statistically higher dry stem weight compared to the non-irrigated (I5) in all years. Statistical differences were not found in stem dry weight means for the irrigated treatments which resulted in dry weight ranges of 320-376 g/m, 277-313 g/m and 281-316 g/m in 2015, 2016 and 2017, respectively. In contrast, the I5 stem dry weight means were 243, 177 and 97 g/m in 2015-17 seasons, respectively (Figure 61).

A significant interaction between irrigation and year was found in final stem N content. Irrigated treatments had a statistically lower N concentration versus the non-irrigated in 2016 and 2017. During 2015, no statistical differences were found among irrigation treatments (I1-I5).

Ear dry weight and N content

Irrigation had a significant effect on final ear dry weight; hence, significant differences were found only between the irrigation treatments versus the non-irrigated. Irrigated treatments (I1-I4) final ear dry weight ranges were: 1385-1215 g/m, 1276-1243 g/m and 1182-1106 g/m in 2015-17 crop seasons, respectively. In comparison, I5 final ear dry weight resulted in 946, 832 and 561 g/m. Statistically lower ear weight resulted in I5 in all years compared to the irrigated treatments. Ear dry weight varied significantly across the years of evaluation. Final ear dry weight was statistically higher in 2015 than in 2017. Results in 2016 didn't differed statistically from 2015 nor 2017 (Table 13) (Figure 62).

Irrigation, N fertility rates and year resulted in a significant effect on the final corn ear N content. Ear N means in irrigated treatments were statistically lower (average 1.3% for I1-I4) compared to the N content in the non-irrigated treatment (1.45% N). The high and medium N fertility rates applied in corn resulted in significantly higher N content in the ears compared to the low N rate (1.36% N for both medium and high rates versus 1.32% N in the low rate). Final ear N content was significantly higher in 2016 versus in 2015 (1.38% and 1.32%). Final ear N content in 2017 did not differ statistically from 2015 nor 2016 (1.34%) (Figure 62)

Overall higher N content was found in plant tissues with lower final biomass accumulation through the crop season (i.e. lower final dry weight). The I5 treatment resulted in statistically lower dry weight in the different plant tissues; however, the N content in the tissues was higher compared to the irrigated treatments. Nevertheless, due to the overall lower significantly dry weight; final N uptake in this treatment was also lower in all years compared to the irrigated treatments.

Peanut 2015-17

Figures 63-65 show the average dry weight and N content in stem and leaves, pod and root obtained from all irrigation treatments at harvest during the final tissue sampling. From the main effects evaluated, only irrigation resulted in a significant effect on pod dry weight. Fertility applied in previous year corn season did not show an effect on final plant sections biomass. Significant differences were observed across the years of evaluation. N content within the plant sections were influenced by irrigation or year, only. Data is shown only on main effects with statistical significance.

Stem and leaf dry weight and N content

Significant differences were not found in stems and leaves final dry weight among irrigation nor fertility treatments (i.e. N rates applied previously in corn). Differences were only found across the years of evaluation, where 2015 and 2016 final stems and leaves were significantly higher than in 2017 (612, 636 and 354 g/m in 2015-17, respectively) (Figure 63).

In terms of N concentration in the stem and leaf, significant differences were found across the years as well. N concentration in stems and leaves was statistically higher in 2015 and 2016 (2.35% N and 2.38% N, respectively) versus in 2017 (2.07% N). In 2017, there was a significant reduction in final stem and leaf biomass that resulted also in a reduction of N content in leaves and stems (Figure 63).

Pod dry weight and N content

Final pod dry weight ranged from 587-534 g/m for I1-I5 treatments in 2015 with no statistical differences between irrigation treatments. In 2016 final pod dry weight for I1-I4 ranged from 566 to 518 g/m. Statistical differences were found between the non-irrigated (432 g/m) versus I2 (566 g/m). In 2017 no differences were found among irrigation treatments (I1-I5). The final N content in I1-I5 pods ranged from 5.34% to 5.19% in 2015, with no significant differences among treatments. In 2016, N content range was 5.06-4.60% and in 2017 pod N content was statistically lower in comparison to previous years (N% ranged 4.24 to 4.52%, no statistical differences between irrigation treatments) (Figure 64).

Root dry weight and N content

No statistical differences were found in final peanut root dry weight across main effects evaluated (i.e. irrigation, N rates and year). However, a significant interaction between year and irrigation was found in root N content during the final sampling, where final N concentrations were higher in 2016 in comparison to 2015 (Figure 65).

Yield

Corn

Statistical analysis for corn final yields showed a significant interaction between year and irrigation and significant fertility rate effect.

In 2015, corn mean yields by irrigation treatment were: 193, 178, 191, 201 and 143 bu/ac for I1 through I5, respectively. Significant differences were not found among treatments I1, I2, I3, and I4, however I5 (non- irrigated) mean yield was significantly lower than irrigated treatments except for I2. (Figure 66). The I2 treatment used a MAD of 50% during the entire corn growing season, allowing water depletion to reach stress during reproductive stages. Hence, in order to avoid stress and yield reductions, MAD was modified to 50% in vegetative stages and 33% in reproductive stages on the 2016-17 corn seasons. Significant difference in yield was not found between fertility treatments F1 and F2, or F2 and F3, however the F1 yield (196 bu/ac) was significantly higher than F3 (168 bu/ac) (Figure 67).

In 2016, corn yield means by irrigation treatments were: 202, 184, 188, 191 and 127 bu/ac for I1 through I5, respectively. No significant differences were found among treatments I1, I2, I3, and I4, however treatment I5 (non-irrigated) showed significantly lower yield than all other treatments. (Figure 66). No significant differences in yield were found between fertility treatments. Final yield means by fertility resulted in 183, 180 and 173 bu/ac for F1, F2 and F3, respectively (Figure 67).

In 2017, corn yield per irrigation treatments means were: 200, 203, 194, 194 and 92 bu/ac for I1 through I5, respectively. Significant differences were found only versus the I5 (non-irrigated treatment), which resulted in a significantly lower yield than irrigated treatments. (Figure 66). Final yield means by fertility resulted in 185, 175 and 171 bu/ac for F1, F2 and F3, respectively (Figure 67). F2 did not differ from F1 nor from F3; however, F1 had significantly higher yield than F3.

In summary, irrigation has a significant positive effect on final corn yield. All irrigated treatments resulted in statistically higher means than the non-irrigated treatment, except in 2015, in which I5 did not differ from I2 final yield.

For corn, a 100 kernel weight was also considered as a variable for final yield analysis. Statistical results were significant for irrigation and year effects. Therefore, data is shown separate by corresponding main effects. In terms of irrigation, significantly differences were found on the I5 (non-irrigated) versus the irrigated treatments. The I5 100 kernel weight mean (28.7 g) was significantly lower compared to the irrigated treatments 100 g seed weight (33.6, 32.4, 32.5, 33.1 g for I1 through I4, respectively) (Figure 68). Fertility means for F1-F3 were: 34.0, 33.3 and 31.4 g respectively in 2015, 34.3 33.5 and 32.6 in 2016 and 30.1, 29.8 and 29.4 g in 2017 (Figure 69). The 100 g seed weight across the years resulted in 32.9, 33.6 and 29.8 g for 2015, 2016 and 2017, respectively. Statistically lower 100 kernel weight resulted only in 2017 compared to 2015 and 2016 (Figure 68 and 69).

Peanut

Statistical analysis for peanut marketable yield showed a significant interaction between year and irrigation treatments only. In 2015, final peanut yield means was analyzed only with irrigation as main effect, since there were not fertility rates applied in previous years. Final peanut yield per irrigation treatment were: 6068, 6502, 6687, 5938 and 6244 lb/ac for I1 through I5, respectively. No significant differences among the irrigated treatments were found (Figure 70).

In 2016, peanut yield per irrigation treatment means were: 7201, 6656, 6695, 7117, and 4577 lb/ac for I1 through 5, respectively. I5 yield was significantly lower compared to the irrigated treatments (Figure 70). For fertility treatments, yield means were 6391, 6558, and 6393 for F1, F2, and F3, respectively. No significant differences were detected among fertility treatments (Figure 71).

In 2017, final peanut yield means per irrigation treatment were 4798, 5431, 4799, 4914, 5013 lb/ac for I1 through 5, respectively. No significant differences were found among treatments (Figure 70). For fertility treatments planted after corn in the second year, yield means were 4786, 5112 and 5074 for F1, F2, and F3, respectively with no significant differences (Figure 71). Overall, I5 resulted in a significantly lower yield in 2016 and in 2017 peanut yields were statistically lower compared to 2015 and 2016.

Conclusions

The evaluation of four irrigation strategies (I1-I4) resulted in no significant differences in corn yield in the 2015-17 growing seasons. However, the non-irrigated treatment (I5) resulted in significantly lower yield than the irrigated treatments except for I2 in 2015. Simulated cumulative drainage per irrigation treatment (I1, I3 and I5) during the corn seasons was: 14.0, 7.3 and 4.4 inches in 2015, 14.3, 5.6, and 4.4 inches in the 2016 season; and 26.8, 17.4 and 10.1 inches in 2017. The proposed irrigation strategies (I2, I3 and I4) compared to conventional practices (I1) achieved a total water savings of: 42%, 53% and 34% in 2015, 39%, 43% and 37% in 2016; and 42%, 45% and 36%, respectively in 2017.

The use of soil moisture sensors to determine irrigation (I3 treatment), resulted in no significant differences in yield compared to the conventional irrigation scheduling practices (I1 treatment) during the corn and peanut seasons 2015-17. Nevertheless, water savings of 53%, 43% and 45% were achieved during the three evaluated corn seasons. As well, simulated drainage when using SMS to schedule irrigation resulted in lower drainage in comparison to conventional practices.

In terms of N fertility rates evaluated, significant differences in yield were found between F1 (300 lb N/ac) and F3 (140 lb N/ac) in 2015 and 2017. No significant differences in yield were found between F1 and F2 (300 vs. 220 lb N/ac), nor F2 and F3 (220 vs. 140 lb N/ac). In 2016, yield did not differ across fertility rates. Therefore, N fertility applications can be reduced by 27% following UF/IFAS recommendations and achieve yields not statistically different than yields obtained with higher N fertilizer applications (i.e. 300 lb N/ac).

Irrigation did not result in a significant effect on yield in most of the peanut growing seasons due to large rainfall contributions. Therefore, no significant differences in yield were found across irrigation treatments (I1-I5) in 2015 nor 2017. Only in 2016, the I5 yield was lower in comparison to the irrigated treatments (I1-I4). Although cumulative rainfall in 2016 was 25.9 in, rainfall events were non-uniformly distributed during the growing season resulting in very low effective rainfall (i.e. large magnitude of the late season rainfall events resulted in drainage and N leaching). And therefore, yield reductions in the non-irrigated plots. The simulated drainage volume in I1, I3 and I5 treatments during the peanut growing seasons was 14.7, 10.7, and 9.5 inches, respectively in 2015; 26.5, 13.0 and 11.9 inches in 2016; and 30.1, 19.7 and 16.7 inches in 2017. Final water savings achieved per irrigation strategy were: 90%, 81% and 42% in 2015, 61%, 63% and 39% in 2016; and 67%, 39% and 38% in 2017. N fertility rates applied in previous corn seasons, did not have an effect on peanut growing seasons.

Therefore, growers could potentially save water and achieve same yields as conventional practices, when using irrigation strategies and tools such as the SWB, SMS or Reduced treatments for irrigation scheduling.

Results from nitrate-N and ammonium-N analyzed in the soil and leachate, showed higher concentrations obtained as nitrate-N due to rapid chemical conversion of ammonium-N to nitrate. Therefore, final conclusions are focus on nitrate-N. From the different soil depths evaluated, the highest N concentrations (NH_4-N and NO_3-N) were found in the top 0-6 in and 6-12 in soil layers, particularly after initial fertilizer applications. Afterwards, soil N concentrations are reduced during the growing season, as it is taken up by the crop. Nitrate-N concentrations were higher in F1 compared to F2 and F3 in all years. N concentrations were higher in 2016 than in 2015 and 2017 due to the supplemental N fertilization applied after a leaching rain (30 lb N/ac applied across all treatments).

An important increase in nitrate-N was observed across all fertility rates at the end of the corn and peanut seasons due to mineralization processes occurring after the crop residue was left aboveground. This increase was observed in a greater magnitude in the top two layers (0-6 in and 6-12 in); however, it sharply decreased before the following crop season. Therefore, potential N contributions from crop residue were lost in the fallow period. After this analysis, it is recommended to plant a cover crop (CC, e.g. oat, ryegrass) during the fallow period. The CC can serve as scavenger for residual nutrients that were not taken up by the previous crop, as well as, as for the nutrients released from mineralization processes after the residue is left aboveground. Therefore, this practice could potentially retain N and other nutrients until the following crop season, when it is incorporated into the soil, recycling the nutrients.

The evaluation of salinity data (volumetric ion content, VIC) using Sentek probes across the different irrigation and fertility rates provided information about the timing and magnitude of soluble ions moving throughout the soil profile. When high VIC values were present in the deepest soil depths (i.e. ~36 in), it was an indication of ions potentially leaving the rootzone (i.e. potential leaching). When comparing this data with leaching data, nitrate-N leaching data resulted in similar patterns. A correlation performed in 2015 showed a R^2 of 0.44 for salinity and NO_3-N values found in the 12-36 inches depth after fertilizers were performed in the high N fertility rate (300 lb N/ac). Further deep investigation is suggested, using data collected in other years. Data transformation might be required.

Heavy rainfall was the major contribute factor for N leaching in all years. However, frequent irrigation events in addition to lower magnitude rainfall events, also resulted in N leaching and in the greatest simulated drainage amounts (i.e. I1 treatment was higher in in all years).

For example, in corn 2016, the highest nitrate-N concentrations were found in the non-irrigated treatment after heavy rainfall events occurred in August. However, due to the lack of rainfall in prior months, the N applied was not in solution (not mobile), therefore, corn plants in the non-irrigated treatment were unable to uptake most of it during the season. However, it remained in the soil and leached after those heavy rainfall events and subsequent leachate samplings. On the other hand, lower concentrations of NO_3-N leached more frequently in the I1 treatment as a result of the numerous irrigation applications characteristic of the calendar-based irrigation scheduling method. In comparison, the I3 treatment resulted in overall lower nitrate-N concentrations in both years. Thus, not evaluating the soil moisture content prior an irrigation event can result in N leaching if irrigation amounts exceed water holding capacity in the rootzone. In 2016, similar N leaching concentrations were found in all fertility rates; however, a 30 lb N/ac was applied as supplemental fertilization early in the season which could have influenced N leaching amounts across N rates.

In corn, N leaching events occurred within the growing season, as well as, after harvest. In general, higher nitrate concentrations were found in the high fertility rate (300 lb N/ac). Thus, if the amount of N applied exceeds N taken up by the plants, the exceeded amount eventually would leave the rootzone and leach.

In peanut, the most relevant N leaching occurred in the first year after frequent rainfall events in early July 2015. Nitrate-N leaching continued in subsequent samplings but lower concentrations were found across all irrigation treatments. Due to the minimum N applications performed in peanut, this nitrate-N leached could be the result of N stored from previous years. In 2014, several grasses were grown in this field in addition to scatter peanut planted in prior years. Therefore, after the field preparations (i.e. box dragged and harrowing), remaining N from those years leached when rainfall events occurred.

Irrigation had a significant effect on the final N content and final dry weight in corn leaves, stems and ears during the years of evaluation, in which no significant differences were found across irrigated treatments (I1-I4) only the non-irrigated treatment showed a lower biomass and higher N content. However, the overall N uptake was lower than the irrigated treatments due to the lower biomass accumulation. In contrast, fertility N rates did not have a significant effect on leaf, stem nor ear dry weight, only resulted in a significant effect on final N content in corn leaves.

In peanut, irrigation and fertility rates applied in previous corn season did not result in significant effects on stem and leaves, nor on root dry weight. Irrigation resulted in a significant effect on pod dry weight, only. Fertility applied in previous year corn season did not show an effect on final biomass in the plant sections analyzed. Significant differences were observed across the years of evaluation. N content within the plant sections were influenced by irrigation or year, only.

Knowing that irrigation has the major effect on final biomass and yield, but no differences were found among the irrigated treatments, leads an important consideration on the total inputs applied for crop production. Final results showed that high irrigation and N amounts eventually leave the rootzone, which is further intensified after heavy rainfall events. Thus, careful irrigation and N management must be considered to avoid N leaching.

Due to the high spatial and temporal rainfall variability in Florida, irrigation scheduling is a difficult task for growers. Nevertheless, the proposed irrigation strategies can serve as tools to achieve water savings. If these are applied on the right timing and amounts, reductions on N leaching could also be achieved. As well, main results showed that a reduction in 27% on conventional fertilization practices can be implemented without impacting corn yield when following UF/IFAS fertilizer recommendations. Thus, further reductions in potential N leaching can be achieved. No statistical differences in N content across N fertility rates provides information about the potential N content in the different plant tissues as it reaches a plateau. Thus, applications that result in higher rates than the N uptake, will result in N losses. If potential losses are avoided, these will be converted into economic savings, allowing greater investment and overall grower's profits.

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Tables

Table 1. Soil chemical analysis. Pre-planting average initial soil conditions in corn field, NFREC-SV 2015.

Block	Map unit	Depth	Bulk Density	Organic Matter	TKN	NO_3-N	NH_4-N	pH	Mehlich-1 P	Mehlich1 K	Mehlich-1 P	Mehlich-1 K
		(in)	(Mg/m^3)	(%)	--------- (mg/kg) --------				------- (mg/kg) ------		------- (ppm) -----	
1	43	0-6	1.45	1.2	419.3	2.6	2.1	6.3	45.4	22.6	11.3	5.7
1	43	6-12	1.31	0.8	405.8	2.1	1.3	6.6	39.8	23.7	9.9	5.9
1	43	12-24	1.53	0.3	231.0	1.6	1.5	6.3	35.5	8.2	8.9	2.0
1	43	24-36	1.54	0.3	94.0	0.8	0.7	6.0	32.0	5.9	8.0	1.5
1	43	0-6	1.43	1.2	219.6	1.6	1.1	6.2	37.1	15.0	9.3	3.7
1	43	6-12	1.70	1.1	213.4	1.1	1.4	6.0	31.7	9.6	7.9	2.4
1	43	12-24	1.61	0.8	112.3	0.7	1.0	5.6	24.4	7.5	6.1	1.9
1	43	24-36	1.50	0.2	90.5	0.4	1.4	5.4	19.1	6.9	4.8	1.7
1	43	0-6	1.51	2.1	544.5	3.7	2.0	5.8	109.5	41.1	27.4	10.3
1	43	6-12	1.29	1.3	335.0	3.3	2.5	5.6	85.6	23.9	21.4	6.0
1	43	12-24	1.47	1.0	209.4	2.4	1.9	5.7	60.8	6.9	15.2	1.7
1	43	24-36		0.2	128.5	2.0	1.1	5.5	46.6	4.6	11.6	1.1
2	45	0-6	1.64	1.8	542.1	1.7	2.4	5.8	47.5	18.7	11.9	4.7
2	45	6-12	1.60	1.4	396.6	0.3	1.9	5.8	38.6	26.0	9.7	6.5
2	45	12-24	1.47	0.5	109.7	0.3	3.2	5.6	14.6	8.2	3.6	2.1
2	45	24-36	1.33	1.2	410.8	2.7	1.3	6.2	70.5	33.4	17.6	8.3
2	26	0-6	1.47	1.2	434.5	3.1	1.6	6.2	72.9	33.6	18.2	8.4
2	26	6-12	1.49	1.0	325.5	1.5	1.1	6.0	42.3	15.2	10.6	3.8
2	26	12-24	1.50	0.9	173.5	0.9	1.1	5.5	36.6	6.5	9.2	1.6
2	26	24-36		0.5	109.0	1.5	1.3	5.2	37.1	5.3	9.3	1.3
3	45	0-6	1.40	1.6	624.1	3.1	3.3	5.7	53.4	37.2	13.4	9.3
3	45	6-12	1.53	1.7	452.9	1.1	2.3	5.9	33.0	28.4	8.2	7.1
3	45	12-24	1.48	0.8	202.9	0.7	1.2	5.7	26.2	16.1	6.5	4.0
3	45	24-36	1.34	0.3	98.9	0.6	3.9	5.5	16.5	6.2	4.1	1.6
3	26	0-6	1.32	1.2	731.2	2.2	1.5	5.2	45.8	18.6	11.4	4.6
3	26	6-12	1.46	0.8	343.0	0.6	1.5	5.5	42.4	22.8	10.6	5.7
3	26	12-24	1.51	0.2	174.5	0.7	5.4	5.6	30.1	12.3	7.5	3.1
3	26	24-36	1.63	0.5	127.8	0.4	3.8	5.2	19.7	15.8	4.9	3.9
4	45	0-6	1.39	1.5	596.2	4.0	1.3	5.4	51.5	17.7	12.9	4.4
4	45	6-12	1.56	0.8	468.2	2.5	2.0	5.6	39.9	28.3	10.0	7.1
4	45	12-24	1.50	0.5	186.8	1.3	1.7	5.5	30.6	15.5	7.6	3.9
4	45	24-36	1.61	0.1	105.8	0.5	3.9	5.3	17.9	12.2	4.5	3.0
4	26	0-6	1.46	1.2	489.0	3.6	1.8	5.7	68.5	29.3	17.1	7.3
4	26	6-12	1.60	0.8	511.3	3.3	2.4	5.7	65.7	28.5	16.4	7.1
4	26	12-24	1.47	0.5	241.3	1.3	1.1	5.6	42.7	5.3	10.7	1.3
4	26	24-36	1.45	0.8	160.4	1.1	1.3	5.3	31.0	3.6	7.7	0.9
Average				0.9	306.1	1.7	2.0	5.7	42.8	17.2	10.7	4.3
STD				0.5	179.8	1.1	1.0	0.3	20.4	10.5	5.1	2.6
Max				2.1	731.2	4.0	5.4	6.6	109.5	41.1	27.4	10.3
Min				0.1	90.5	0.3	0.7	5.2	14.6	3.6	3.6	0.9

Table 2. Soil chemical analysis. Pre-planting average initial soil conditions in corn field, NFREC-SV 2016.

Depth (in)	Irrigation	Fertility	Average NH_4-N	Average NO_3-N	Average TKN	Average OM (%)	Average P	Average K	Average pH
			------------------(mg/kg)		-----------------		--- (mg/kg) ---		
0-6	**I1**	F1	0.58	-0.03	317.04	1.08	44.47	66.82	6.35
		F2	0.44	0.07	384.27	0.96	43.27	85.63	6.42
		F3	0.48	-0.30	371.81	1.29	40.27	43.04	6.28
	I1 Avg.		**0.50**	**-0.09**	**357.70**	**1.11**	**42.67**	**65.16**	**6.35**
	I3	F1	0.65	0.32	421.57	1.31	46.05	57.66	6.59
		F2	0.61	-0.10	417.01	1.06	41.65	41.10	6.35
		F3	0.57	-0.27	394.98	1.05	38.53	44.06	6.36
	I3 Avg.		**0.61**	**-0.02**	**411.19**	**1.14**	**42.08**	**47.61**	**6.43**
	I5	F1	0.53	0.11	369.76	1.12	42.52	57.27	6.41
		F2	0.69	0.25	423.24	1.03	41.28	45.51	6.53
		F3	0.78	1.43	400.41	1.18	47.35	40.67	6.17
	I5 Avg.		**0.67**	**0.60**	**397.80**	**1.11**	**43.72**	**47.82**	**6.37**
0-6 Avg.			**0.59**	**0.16**	**388.90**	**1.12**	**42.82**	**53.53**	**6.38**
6-12	**I1**	F1	0.58	0.75	344.77	1.08			
		F2	0.55	0.99	414.93	1.41			
		F3	0.49	0.24	438.79	1.44			
	I1 Avg.		**0.54**	**0.66**	**399.50**	**1.31**			
	I3	F1	0.60	1.71	542.12	1.38			
		F2	0.51	0.91	387.25	1.13			
		F3	0.47	0.04	281.75	0.71			
	I3 Avg.		**0.53**	**0.88**	**403.71**	**1.07**			
	I5	F1	0.69	1.11	387.12	1.19			
		F2	0.50	0.64	389.00	1.36			
		F3	0.48	0.44	290.05	1.00			
	I5 Avg.		**0.55**	**0.73**	**355.39**	**1.18**			
6-12 Avg.			**0.54**	**0.76**	**386.20**	**1.19**			
12-24	**I1**	F1	0.61	0.35	142.56	0.69			
		F2	0.59	1.59	185.07	0.74			
		F3	0.51	0.54	277.47	1.05			
	I1 Avg.		**0.57**	**0.83**	**201.70**	**0.82**			
	I3	F1	0.61	0.89	220.75	0.86			
		F2	0.58	0.92	195.88	0.98			
		F3	0.47	-0.02	154.91	0.67			
	I3 Avg.		**0.55**	**0.60**	**190.51**	**0.84**			
	I5	F1	0.60	0.41	161.16	0.55			
		F2	0.52	-0.17	159.49	0.91			
		F3	0.51	0.51	156.29	0.57			
	I5 Avg.		**0.55**	**0.25**	**158.98**	**0.67**			
12-24 Avg.			**0.56**	**0.56**	**183.73**	**0.78**			
24-36	**I1**	F1	0.58	-0.26	86.09	0.41			
		F2	0.48	0.15	100.41	0.46			
		F3	0.43	-0.23	104.36	0.69			
	I1 Avg.		**0.49**	**-0.11**	**96.96**	**0.52**			
	I3	F1	0.44	1.14	118.86	0.52			
		F2	0.46	0.92	130.43	0.60			
		F3	0.48	-0.31	101.90	0.48			
	I3 Avg.		**0.46**	**0.58**	**117.06**	**0.53**			
	I5	F1	0.43	-0.11	88.59	0.28			
		F2	0.52	-0.03	88.15	0.70			
		F3	0.44	0.32	143.50	0.65			
	I5 Avg.		**0.46**	**0.06**	**106.75**	**0.54**			
24-36 Avg.			**0.47**	**0.18**	**106.92**	**0.53**			
STD			**0.08**	**0.56**	**134.31**	**0.32**	**2.80**	**15.09**	**0.12**
Overall Avg.			**0.54**	**0.41**	**266.44**	**0.90**	**42.82**	**53.53**	**6.38**

Table 3. Root development used to weigh VWC during the corn growing seasons 2015-2016. Kc values for maize used to calculate ETc for treatments under non-water stress conditions (i.e. GROW and SMS).

DAP	Root Depth (in)	K_c [a]
2	3.9	0.25
6	5.9	0.25
10	7.9	0.41
14	9.8	0.57
18	11.8	0.73
22	13.8	0.89
26	15.7	1.05
30	17.7	1.05
34	19.7	1.05
38	21.7	1.05
42	23.6	1.05
46	25.6	1.05
50	27.6	1.05
54	29.5	1.05
58	31.5	1.05
62	33.5	1.05

[a]Kc values: Kc-ini=0.25, Kc-max=1.05 and Kc-end= 0.55 (K-State Research & Extension Mobile Irrigation Lab 2014)

Table 4. Soil chemical analysis. Pre-planting average initial soil conditions in corn field, NFREC-SV 2017.

Depth (in)	Irrigation	Fertility	Average (mg/kg)	NH_4^-N Average (mg/kg)	NO_3^-N Average (mg/kg)	TKN Average OM (%)	Average pH
0-6	**I1**	F1	2.15	2.10	316.64	1.09	6.06
		F2	1.64	2.72	367.43	1.17	6.07
		F3	2.59	1.64	351.83	1.27	6.31
	I1 Avg.		**2.13**	**2.15**	**345.30**	**1.17**	**6.15**
	I3	F1	3.25	3.77	428.93	1.40	5.69
		F2	1.60	3.13	359.90	1.39	6.11
		F3	3.64	4.86	397.83	1.20	5.95
	I3 Avg.		**2.83**	**3.92**	**395.55**	**1.33**	**5.92**
	I5	F1	2.31	3.76	379.60	1.07	5.87
		F2	2.92	2.18	343.64	1.17	6.10
		F3	2.99	1.53	313.99	0.67	5.95
	I5 Avg.		**2.74**	**2.49**	**345.75**	**0.97**	**5.97**
0-6 Avg.			**2.57**	**2.85**	**362.20**	**1.16**	**6.01**
6-12	**I1**	F1	1.82	1.38	340.03	0.87	5.84
		F2	1.71	1.35	393.85	1.18	5.96
		F3	3.17	2.56	326.00	1.07	5.89
	I1 Avg.		**2.23**	**1.76**	**353.29**	**1.04**	**5.89**
	I3	F1	2.63	2.67	501.43	1.74	5.89
		F2	1.17	4.33	386.01	1.32	5.95
		F3	1.96	2.60	409.86	1.27	5.89
	I3 Avg.		**1.92**	**3.20**	**432.43**	**1.44**	**5.91**
	I5	F1	2.37	2.25	396.34	1.20	5.83
		F2	2.31	2.40	339.18	1.19	5.76
		F3	1.56	1.60	270.57	1.05	5.57
	I5 Avg.		**2.08**	**2.09**	**335.37**	**1.15**	**5.72**
6-12 Avg.			**2.08**	**2.35**	**373.70**	**1.21**	**5.84**
12-24	**I1**	F1	1.74	1.48	147.74	0.63	5.60
		F2	1.97	1.31	173.90	0.70	6.01
		F3	2.33	1.56	156.61	0.45	5.55
	I1 Avg.		**2.01**	**1.45**	**159.42**	**0.59**	**5.72**
	I3	F1	1.99	1.82	209.78	0.84	5.61
		F2	2.43	2.27	247.25	0.75	5.82
		F3	1.69	1.74	186.11	0.78	5.45
	I3 Avg.		**2.04**	**1.94**	**214.38**	**0.79**	**5.63**
	I5	F1	2.00	1.68	141.80	0.94	5.78
		F2	2.03	1.51	153.09	0.67	5.44
		F3	1.94	1.83	171.36	0.80	5.26
	I5 Avg.		**1.99**	**1.68**	**155.42**	**0.80**	**5.49**
12-24 Avg.			**2.01**	**1.69**	**176.40**	**0.73**	**5.61**
24-36	**I1**	F1	2.37	1.12	106.65	0.40	5.18
		F2	2.63	1.13	120.17	0.47	5.48
		F3	1.99	0.86	71.21	0.18	5.37
	I1 Avg.		**2.33**	**1.04**	**99.34**	**0.35**	**5.34**
	I3	F1	1.68	1.47	135.42	0.65	5.58
		F2	1.93	1.35	110.45	0.43	5.36
		F3	1.67	1.19	117.70	0.58	5.15
	I3 Avg.		**1.76**	**1.34**	**121.19**	**0.56**	**5.36**
	I5	F1	1.91	1.07	122.08	0.37	5.51
		F2	2.21	1.01	116.87	0.27	5.12
		F3	1.90	1.41	127.22	0.55	5.03
	I5 Avg.		**2.01**	**1.16**	**122.05**	**0.39**	**5.22**
24-36 Avg.			**2.03**	**1.18**	**114.19**	**0.43**	**5.31**
Overall Avg.			**2.17**	**2.02**	**256.62**	**0.88**	**5.69**

Table 4. Continued. Soil chemical analysis. Pre-plant average soil conditions in peanut field, NFREC-SV 2017.

Depth (cm)	Irrigation	Fertility	Average (mg/kg)	NH_4^-N Average (mg/kg)	NO_3^-N Average OM (%)	Average (mg/kg)	TKN Average pH
0-6	**I1**	F1	1.12	1.89	1.20	375.10	6.17
		F2	1.32	1.70	0.89	342.71	5.98
		F3	0.96	1.63	0.96	445.17	6.23
	I1 Avg.		**1.13**	**1.74**	**1.02**	**387.66**	**6.13**
	I3	F1	1.14	1.37	1.08	320.54	5.89
		F2	1.35	1.69	1.23	440.24	6.24
		F3	0.91	2.10	1.08	330.51	6.02
	I3 Avg.		**1.12**	**1.69**	**1.12**	**353.79**	**6.02**
	I5	F1	2.19	2.86	1.21	422.05	5.89
		F2	1.69	2.18	1.01	395.03	6.10
		F3	1.13	1.62	1.19	366.55	5.82
	I5 Avg.		**1.67**	**2.22**	**1.14**	**394.54**	**5.94**
0-6 Avg.			**1.31**	**1.88**	**1.09**	**378.66**	**6.03**
6-12	**I1**	F1	1.38	1.87	1.20	326.14	6.00
		F2	1.07	1.93	0.94	349.22	6.01
		F3	1.26	1.82	1.11	332.89	6.10
	I1 Avg.		**1.24**	**1.87**	**1.08**	**336.08**	**6.04**
	I3	F1	1.26	1.61	0.90	338.12	5.85
		F2	1.04	2.11	1.48	428.30	6.12
		F3	1.17	1.67	1.14	372.03	6.03
	I3 Avg.		**1.17**	**1.75**	**1.13**	**371.97**	**5.98**
	I5	F1	1.86	3.18	1.57	464.40	5.98
		F2	1.44	1.93	1.30	459.15	6.03
		F3	1.35	1.42	1.01	370.84	5.89
	I5 Avg.		**1.55**	**2.18**	**1.29**	**431.46**	**5.97**
6-12 Avg.			**1.32**	**1.94**	**1.17**	**379.84**	**5.99**
12-24	**I1**	F1	1.19	0.47	0.69	159.62	5.67
		F2	0.97	0.71	0.79	191.97	5.89
		F3	1.13	0.45	0.61	154.07	6.13
	I1 Avg.		**1.10**	**0.54**	**0.70**	**168.55**	**5.89**
	I3	F1	1.01	0.51	0.74	151.72	5.97
		F2	1.08	0.63	0.56	152.02	6.06
		F3	1.10	1.05	0.80	245.51	5.87
	I3 Avg.		**1.06**	**0.72**	**0.72**	**183.06**	**5.96**
	I5	F1	1.03	0.78	0.73	180.42	5.44
		F2	1.49	0.87	0.91	232.46	5.93
		F3	0.98	0.67	0.59	195.97	5.48
	I5 Avg.		**1.17**	**0.78**	**0.74**	**202.95**	**5.62**
12-24 Avg.			**1.11**	**0.68**	**0.72**	**184.85**	**5.82**
24-36	**I1**	F1	1.43	0.30	0.54	131.58	5.60
		F2	1.22	0.42	0.51	126.56	5.87
		F3	1.24	0.19	0.46	130.94	5.75
	I1 Avg.		**1.30**	**0.30**	**0.50**	**129.69**	**5.74**
	I3	F1	1.12	0.47	0.45	110.19	5.71
		F2	1.40	0.23	0.45	115.76	5.57
		F3	1.39	0.35	0.32	121.97	5.67
	I3 Avg.		**1.28**	**0.37**	**0.40**	**115.51**	**5.66**
	I5	F1	1.42	0.56	0.47	103.54	5.20
		F2	1.11	0.44	0.42	135.90	5.50
		F3	1.13	0.38	0.61	136.23	5.56
	I5 Avg.		**1.22**	**0.46**	**0.50**	**125.22**	**5.42**
24-36 Avg.			**1.27**	**0.37**	**0.47**	**123.47**	**5.61**
Overall Avg.			**1.25**	**1.22**	**0.86**	**266.71**	**5.86**

Table 5. Agrochemicals applied in peanut experimental field, NFREC-SV 2015.

Date	Agrochemical	Dose	Notes
20-Mar	Round-Up Powermax	22 oz/acre	
	AMS	32 oz/acre	
6-Apr	Round-Up Powermax	22 oz/acre	
	AMS@32oz/acre	32 oz/acre	
19-May	Dual Magnum	16 oz/acre	
	Outflank	2 oz/acre	
19-May	Abound	6 oz/acre	Fungicide
	Macho	8 oz/acre	Fungicide
	Optimize Lift Inoculant	12.1 oz/acre	Inoculant
19-May	PLANTING DAY		
10-Jun	Basagran	32 oz/acre	
10-Jun	Arrow	12 oz/acre	
	Crop Oil	32 oz/acre	
22-Jun	3-7-28	500 lb/acre	1st Granular Application
			Broadcast with Tag-Along Spreader
26-Jun	Cadre	4 oz/acre	
	80-20	32 oz/100 gal	
30-Jun	Bravo	24 oz/acre	
	Savannah 3.6	7.2 oz/acre	
	Dimilin	8 oz/acre	
2-Jul	Bravo	24 oz/acre	
	Savannah 3.6	7.2 oz/acre	
	Dimilin	8 oz/acre	
8-Jul	GypsuMax	2000 lb/ac	1st Gypsum Application (Broadcast w. Tag-Along Spreader)
	Headline SC	9 oz/acre	
16-Jul	Dimilin	8 oz/acre	
	Select	8 oz/acre	
21-Jul	Crop Oil	32 oz/acre	
	Cadre	4 oz/acre	
22-Jul	80-20	32 oz/100 gal	
	Bravo	24 oz/acre	
22-Jul	Tebuconozole 3.6	7.2 oz/acre	
	Dimilin	8 oz/acre	
	Convoy	20 oz/acre	
31-Jul	Dimilin	8 oz/acre	
	Bravo	24 oz/acre	
11-Aug	Tebucanozole 3.6	7.2 oz/acre	
	Dimilin	8 oz/acre	
	Abound	24 oz/acre	
27-Aug	Alto@5.5oz/acre	5.5 oz/acre	
	Dimilin	8 oz/acre	
	Bravo	24 oz/acre	
4-Sep	Tebuconozole 3.6	7.2 oz/acre	
	Dimilin	8 oz/acre	
	Bravo	24 oz/acre	
17-Sep	Tebuconozole 3.6	7.2 oz/acre	
	Dipel	16 oz/acre	
	Bravo	24 oz/acre	
29-Sep	Tebuconozole 3.6	7.2 oz/acre	
	Dipel	15 oz/acre	
16-Oct	DIGGING		
20-Oct	HARVEST		

Table 6. Agrochemicals applied in peanut experimental field, NFREC-SV 2016.

Date	Fertilizer/Pesticide	Dose	Notes
15-May	Dual Magnum	16oz/acre	
	Outflank	2 oz/acre	
	RoundUp Powermax	64oz/acre	
13-May	Optimize Lift Inoculant	12.1 oz/acre	Inoculant
13-May	Macho	8 oz/acre	Fungicide
13-May	PLANTING DAY		
16-Jun	Bravo	24 oz/acre	
	Dimilin	8 oz/acre	
23-Jun	GypsuMax	2000 lbs/ac	1st Gypsum Application Broadcast with Tag-Along Spreader
24-Jun	3-7-28	500 lbs/acre	1st Granular Application Broadcast with Tag-Along Spreader
28-Jun	Headline SC	9 oz/acre	
	Dimilin	4 oz/acre	
	Impose	4 oz/acre	
	Butyrac 175	28 oz/acre	
	90/10 Sticker	1qt/100 gallons	
	Clethodim	9 oz/acre	
	Crop Oil	1 qt/acre	
11-Jul	Priaxor	4 oz/acre	
	Tebucanazole	7.2 oz/acre	
25-Jul	Bravo	24 oz/acre	
	Dimilin	4 oz/acre	
08-Aug	Tebucanazole	7.2 oz/acre	
	Convoy	16 oz/acre	
	Dimilin	4 oz/acre	
18-Aug	Fontelis	18 oz/acre	
29-Aug	Alto	5.5 oz/acre	
	Tebucanazole	7.2 oz/acre	
07-Sep	Bravo	24oz/acre	

Table 7. Agrochemicals applied in peanut experimental field, NFREC-SV 2017.

Date	Fertilizer/Pesticide	Dose	Notes
09-May	Valor	3 oz/acre	
	Dual Magnum	1.3pt/acre	
09-May	PLANTING DAY		
10-May	Herbicide w/Dual Mag, Parazone		Pre-emergent herbicide
12-Jun	Willowood 2EC	12oz/acre	
	Crop Oil	1 qt/acre	
16-Jun	GypsuMax	1500 lbs/ac	Gypsum Application
22-Jun	Cadre	4 oz/acre	
	90/10	1 qt/100 gallons	
	Butyrac 175	16 oz/acre	
23-Jun	Bravo	24 oz/acre	
	Tebucanazole	7.2 oz/acre	
	Abound	24 oz/acre	
	Dimilin	4 oz/acre	
29-Jun	Priaxor	8 oz/acre	
30-Jun	8-0-39	350 lbs/acre	Granular Application
14-Jul	Elatus	7.3 oz/acre	
	Dimilin	4 oz/acre	
28-Jul	Abound	18.4 oz/acre	
	Alto	5.5oz/are	
	Dimilin	4 oz/acre	
11-Aug	Fontelis	24oz/acre	
	Dimilin	4 oz/acre	

Table 8. Summary of parameters measured during the second experimental year, total number of samples collected and percentage of samples analyzed in corn 2015-17.

Results from	Parameter evaluated	Number of samplings	Total sub-samples collected	Number of samples analyzed	Analyzed results (%)
Soils[1]	GWC	49	7056	7056	100
	VWC[4]	49	7056	7056	100
	NH_4-N	49	7056	7056	100
	NO_3-N	49	7056	7056	100
Deep samples[2]	NH_4-N	13	468	468	100
	NO_3-N	13	468	468	100
Leachate	NH_4-N	21	529	529	100
	NO_3-N	21	529	529	100
Sub-Total samples	NH_4-N		8053	8053	100
	NO_3-N		8053	8053	100
Total samples ARL[3]			16106	16106	100
Total	15,048 Soil subsamples, 1058 Leachate subsamples				

[1] Soil samplings were performed at 4 depths (i.e. 36 x 4= 144 samples collected in the corn field and sent for analysis). Soil samplings in corn 2015 started in March and ended in February 2016 (South field). Samples collected in corn 2016 started in March with corn growing season and ended in December (North field), and soil samples collected in corn 2017 spanned from January to December 2017 (South field)

[2] Deep soil samplings were performed at 3 depths (36-48, 48-60, and 60-72 inches) in corn I3 treatment only during 2016 and 2017.

[3] Total soil and leachate samples submitted to ARL lab for NO_3-N and NH_4-N analysis.

[4] Calculated VWC using GWC and bulk density from initial soil results. GWC and VWC were analyzed in the ABE lab.

Table 9. Summary of parameters measured during the second experimental year, total number of samples collected and percentage of samples analyzed in peanut 2015-17.

Results from	Parameter evaluated	Number of samplings	Total sub-samples collected	Number of samples analyzed	Analyzed results (%)
Soils[1]	GWC	43	6192	6192	100
	VWC[4]	43	6192	6192	100
	NH_4-N	43	6192	6192	100
	NO_3-N	43	6192	6192	100
Leachate	NH_4-N	17	590	590	100
	NO_3-N	17	590	590	100
Sub-Total samples	NH_4-N		6782	6782	100
	NO_3-N		6782	6782	100
Total samples ARL[3]			13564	13564	100
Total	12,384 Soil subsamples, 1180 Leachate subsamples				

[1] Soil samplings were performed at 4 depths (i.e. 36 x 4= 144 samples collected in the peanut field and sent for analysis). The 2016 samplings started in May with peanut growing season and ended in December.

[2] Total soil and leachate samples submitted to ARL lab for NO_3-N and NH_4-N analysis.

[3] Calculated VWC using GWC and bulk density from initial soil results. GWC and VWC were analyzed in ABE lab.

Table 10. Simulated water balance for I1, I3 and I5 treatments in corn seasons 2015-17.

2015 Water balance parameters	**I1**	**I3**	**I5**
Initial soil water	3.5	3.5	3.5
Final soil water	3.7	3.7	3.7
Irrigation	12.6	5.9	0.6
Precipitation	21.5	21.5	21.5
Drainage	14.0	7.3	4.4
Runoff	0.0	0.0	0.0
Soil Evaporation	3.0	2.7	2.9
Transpiration	16.9	17.2	14.6
Potential ET	22.9	22.9	22.9
Inputs	33.9	27.3	21.9
Outputs	33.9	27.3	21.9
Balance	0.0	0.0	0.0

2016 Water balance parameters	**I1**	**I3**	**I5**
Initial soil water	3.5	3.5	3.5
Final soil water	2.3	2.0	1.0
Irrigation	20.0	11.4	1.0
Precipitation	14.6	14.6	14.6
Drainage	14.3	6.4	4.4
Runoff	0.0	0.0	0.0
Soil Evaporation	3.9	3.2	2.7
Transpiration	17.5	18.0	11.0
Potential ET	24.6	24.6	24.6
Inputs	35.7	27.5	18.0
Outputs	35.7	27.5	18.0
Balance	0.0	0.0	0.0

2017 Water balance parameters	**I1**	**I3**	**I5**
Initial soil water	3.4	3.4	3.4
Final soil water	3.6	3.6	3.5
Irrigation	21.6	11.9	1.9
Precipitation	25.6	25.6	25.6
Drainage	26.8	17.4	10.1
Runoff	0.2	0.2	0.2
Soil Evaporation	3.6	3.3	2.9
Transpiration	16.4	16.5	14.2
Potential ET	23.6	23.6	23.6
Inputs	47.0	37.4	27.4
Outputs	47.0	37.4	27.4
Balance	0.0	0.0	0.0

Table 11. Simulated water balance for I1, I3 and I5 treatments in peanut seasons 2015-17.

2015 Water balance parameters	**I1**	**I3**	**I5**
Initial soil water	3.8	3.8	3.8
Final soil water	1.4	1.4	1.4
Irrigation	5.2	1.2	0.0
Precipitation	25.6	25.6	25.6
Drainage	14.7	10.7	9.5
Runoff	0.0	0.0	0.0
Soil Evaporation	4.3	4.2	4.1
Transpiration	14.2	14.2	14.3
Potential ET	24.0	24.0	24.0
Inputs	33.1	29.1	27.9
Outputs	33.1	29.1	27.9
Balance	0.0	0.0	0.0

2016 Water balance parameters	**I1**	**I3**	**I5**
Initial soil water	3.4	3.4	3.4
Final soil water	1.7	1.3	1.2
Irrigation	21.4	7.6	0.7
Precipitation	25.9	25.9	25.9
Drainage	26.5	14.4	11.9
Runoff	0.2	0.2	0.2
Soil Evaporation	4.9	3.6	3.3
Transpiration	17.4	17.2	13.4
Potential ET	26.5	26.5	26.5
Inputs	49.0	35.4	28.8
Outputs	49.0	35.4	28.8
Balance	0.0	0.0	0.0

2017 Water balance parameters	**I1**	**I3**	**I5**
Initial soil water	3.5	3.5	3.5
Final soil water	1.5	1.5	1.5
Irrigation	14.8	4.3	0.3
Precipitation	34.7	34.7	34.7
Drainage	30.1	19.7	16.7
Runoff	1.2	1.2	1.2
Soil Evaporation	4.8	4.6	4.3
Transpiration	15.3	15.5	14.7
Potential ET	24.2	24.2	24.2
Inputs	51.5	41.0	37.0
Outputs	51.5	41.0	37.0
Balance	0.0	0.0	0.0

Table 12. Average corn leaf, stem and ear dry weight (g/m) per irrigation treatment obtained at final tissue sampling in corn (pre-harvest) across the three years of evaluation[1].

	Year	Irrigation treatment				
Yearly means		**Leaf dry weight (g/m)**				
228.7 A	2015	231.3 a	229.3 a	249.0 a	246.4 a	187.6 b
188.7 B	2016	199.7 a	200.9 a	191.6 a	202.4 a	148.8 b
180.7 B	2017	200.8 a	197.8 a	178.6 a	194.5 a	132.2 b
Irrigation means		210.6 a	209.3 a	206.4 a	214.4 a	156.2 b
		Stem dry weight (g/m)				
329.8 A	2015	320.2 a	354.5 a	376.4 a	355.2 a	242.5 b
273.0 A	2016	312.8 a	277.0 a	300.5 a	297.3 a	177.2 b
256.8 A	2017	316.4 a	308.0 a	280.9 a	281.7 a	96.9 b
		Ear dry weight (g/m)				
1221.3 A	2015	1227.2	1214.7	1332.6	1385.5	946.2
1176.4 AB	2016	1261.3	1269.4	1243.0	1276.3	832.2
1022.6 B	2017	1105.9	1182.5	1157.4	1106.3	560.8
Irrigation means		1198.1 a	1222.2 a	1244.3 a	1256.0 a	779.7 b

[1] N- application rates: F1: 300 lb/ac, F2: 220 lb/ac and F3: 140 lb/ac, resulted in no significant effect among the tissues evaluated. Therefore, data was aggregated and shown for significant effects only (i.e. irrigation and years)

Table 13. Average peanut leaf and stem, root and pod dry weight (g/m) per irrigation treatments obtained at final tissue samplings (pre-harvest) across the three years of evaluation.

		Irrigation treatment				
	Year	**I1**	**I2**	**I3**	**I4**	**I5**
Yearly means	**Year**	**Leaf and Stem dry weight (g/m) [1]**				
612.5 A	2015	630.2	580.9	607.9	597.0	646.4
636.0 A	2016	651.2	658.7	659.4	606.7	603.9
354.3 B	2017	347.9	347.3	343.2	375.5	357.7
Irrigation means		ns	ns	ns	ns	ns
Yearly means		**Root dry weight (g/m) [2]**				
18.6 ns	2015	17.4	18.2	20.5	18.5	18.3
20.2 ns	2016	21.3	21.7	19.8	18.7	19.6
20.2 ns	2017	21.6	22.5	15.9	20.4	20.4
Irrigation means		ns	ns	ns	ns	ns
Yearly means		**Pod dry weight (g/m) [3]**				
560.6 A	2015	574.6 a	535.8 a	571.9 a	533.7 a	587.0 a
518.6 B	2016	530.3 a	566.4 a	546.1 a	517.8 a	432.2 b
413.5 C	2017	436.2 a	392.7 a	417.4 a	448.0 a	373.4 a
Irrigation means						

[1]=Leaf+Stem dry weight showed significant effects by year only.
[2]=Root dry weight was not statistically significant across main effects (ns=not significant).
[3]=Pod dry weight showed an irrigation*year interaction effect. Pod dry weight was significantly different across years. No significant differences were found across irrigation treatments, except I5 pod dwt was significantly lower in 2016.

Figures

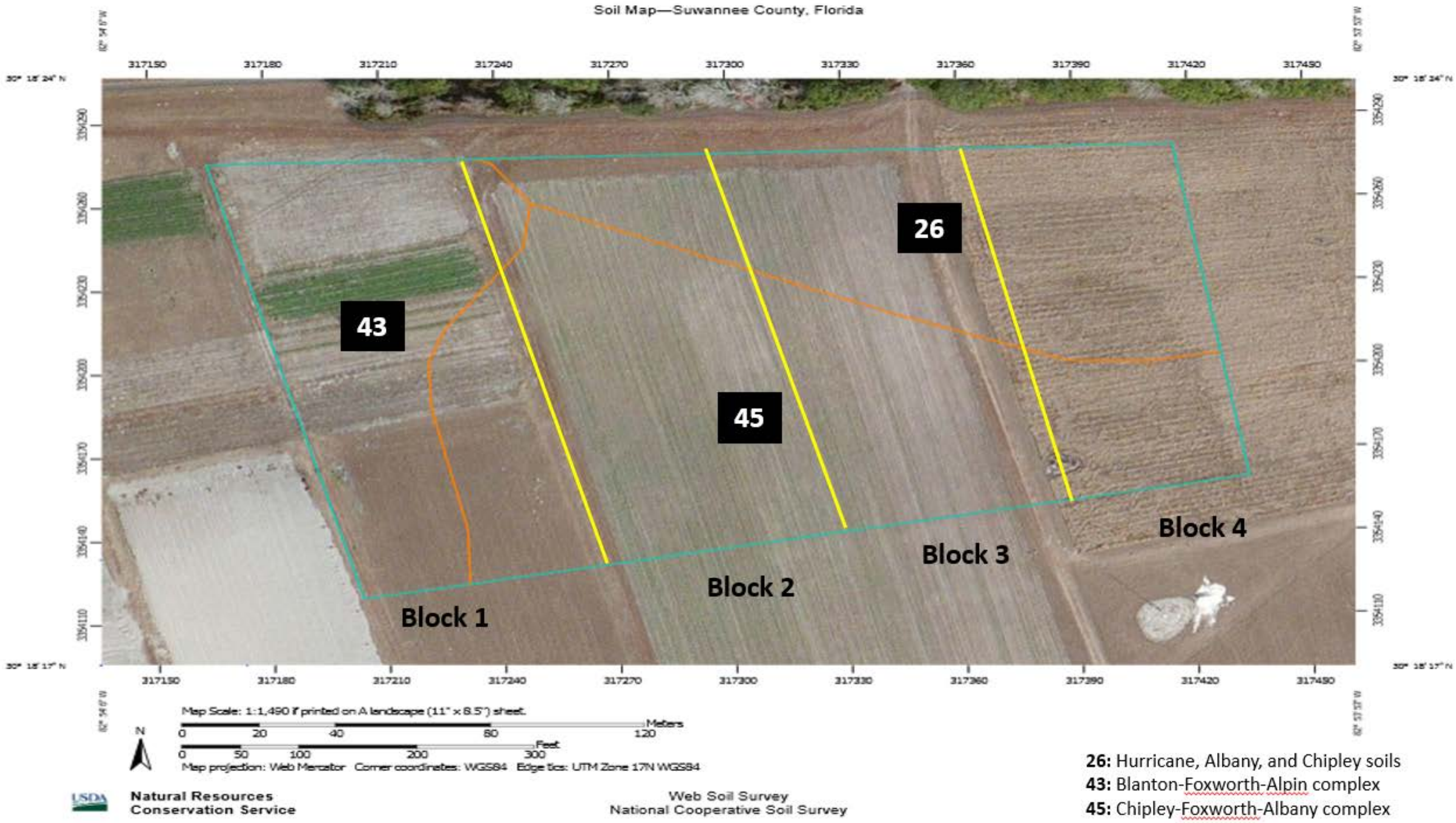


Figure 1. Soil map of experimental field. Live Oak, FL. Total four blocks divided by yellow lines. Orange lines delineate the three main soils identified in the experimental field (26, 43 and 45) (USDA 2013).

Figure 2. Field layout. Total of 60 plots per crop (green rectangles 40'X20'): four blocks, five irrigation treatments (red labels) and 3 fertility rates (black labels within the plots). Plots with an "L" represent lysimeter installation. The design included 20 ft. alleys between plots and 40 ft. alleys between blocks. Notes: Only corn is shown in this figure, since peanut consisted of a replication of this layout. Crop rotations are: Y1-3; corn, peanut, corn.

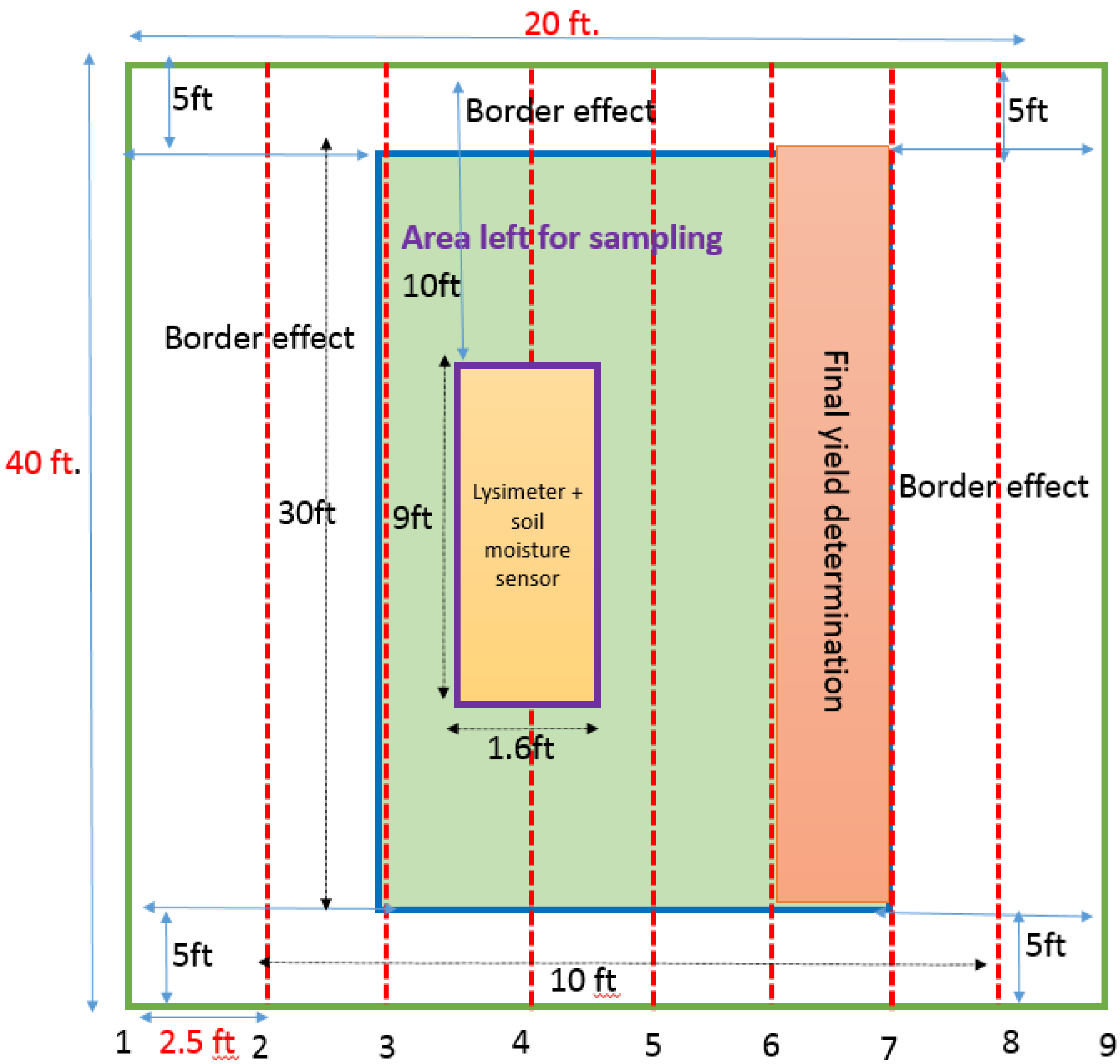


Figure 3. Plot design: lysimeter location (yellow), biomass and soil sampling areas (green), and yield determination area (red) within the plots.

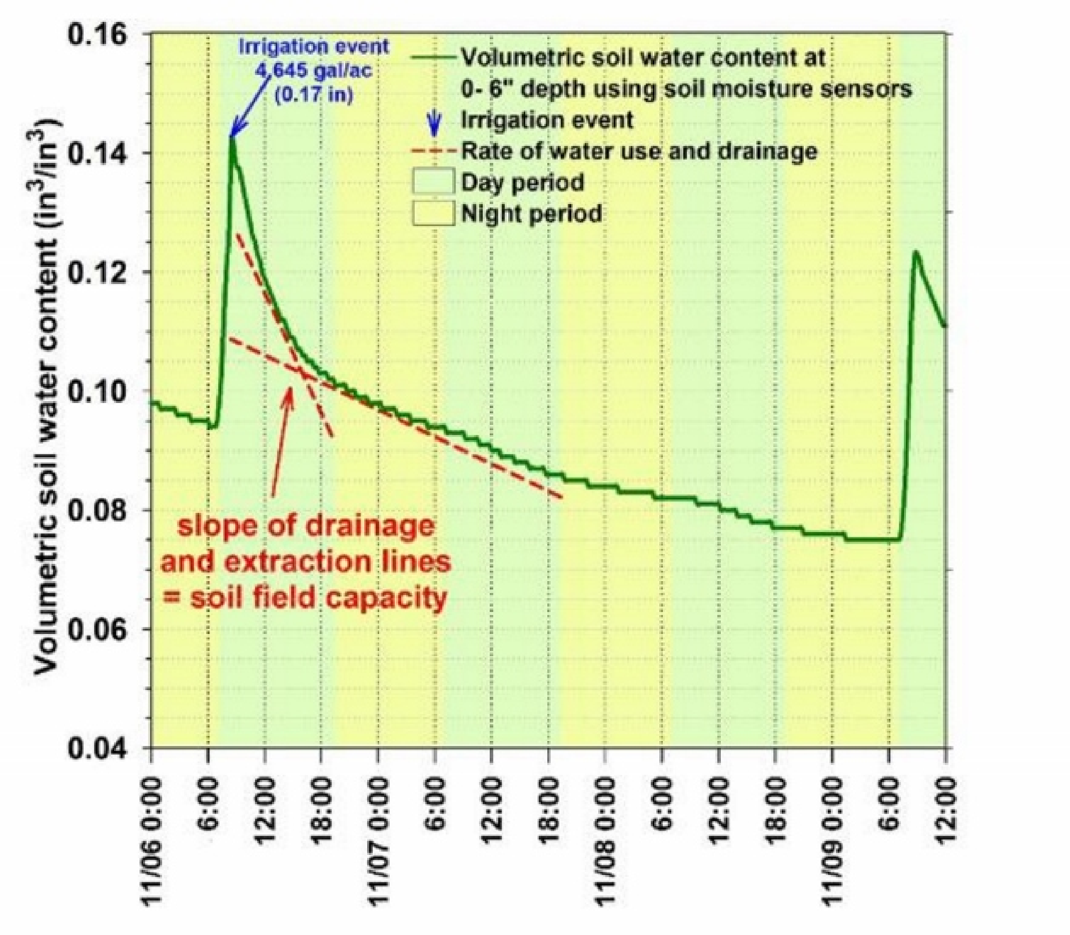


Figure 4. Guidelines proposed by Zotarelli, et. al. 2013 to determine soil field capacity for sandy soil after irrigation event. This guidelines were used to determine I3 treatment irrigation.

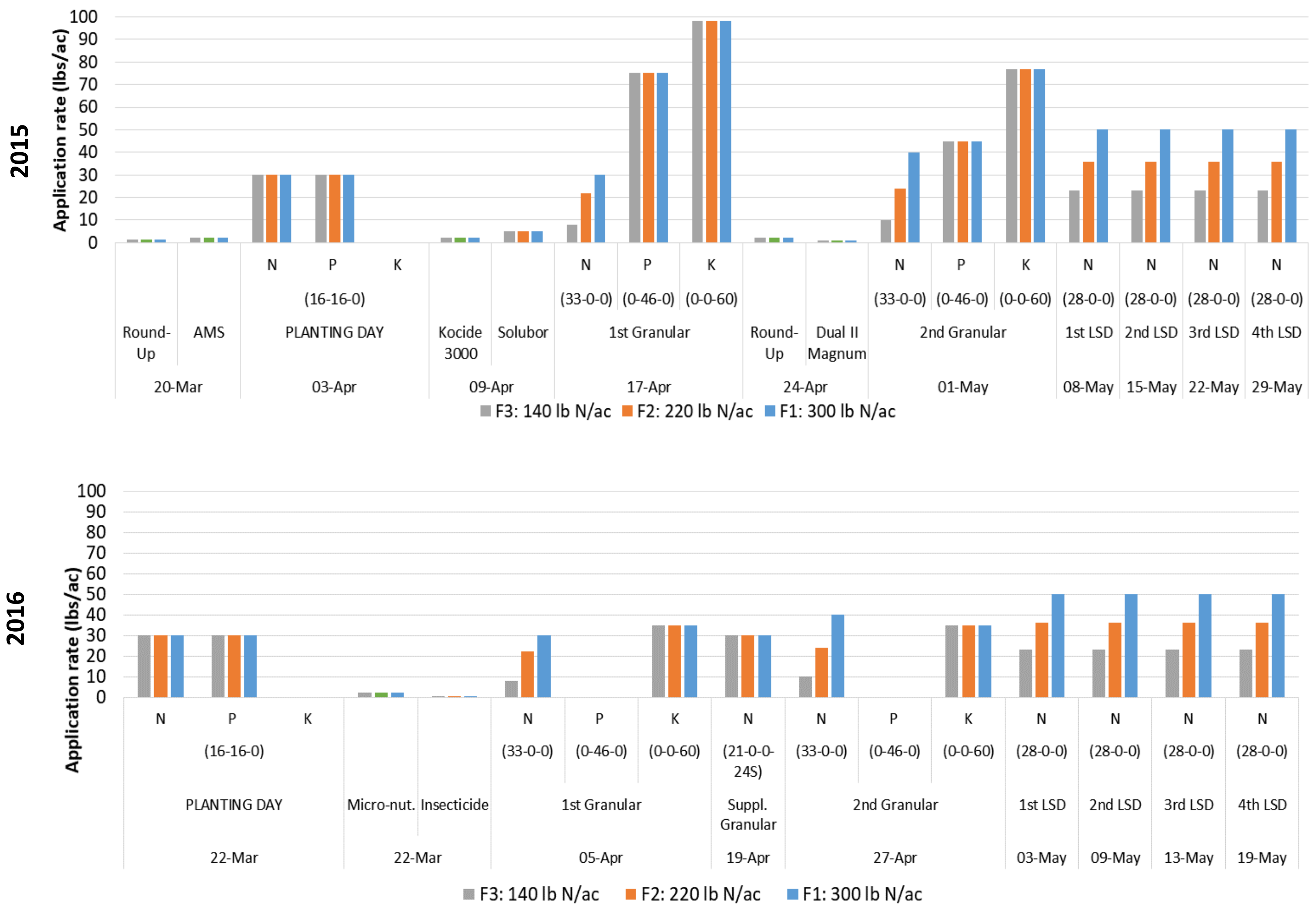


Figure 5. Agronomic practices performed during corn growing seasons 2015-17.

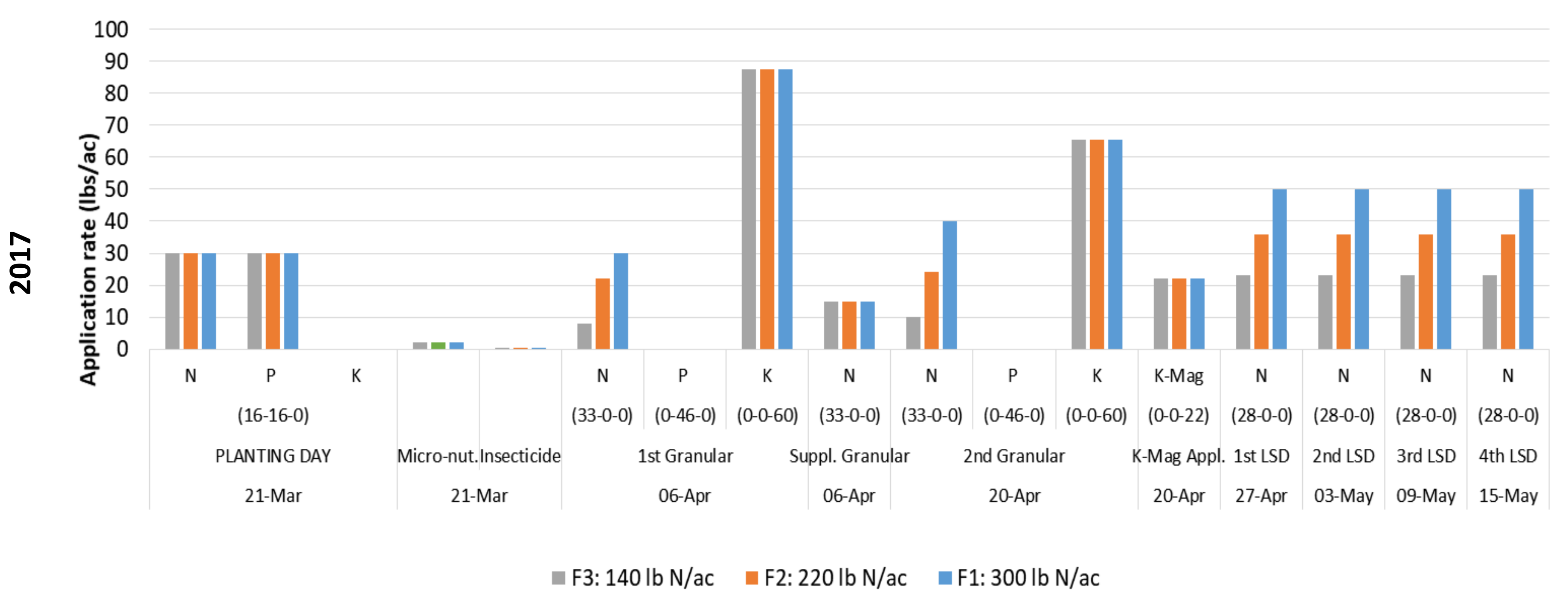


Figure 5 (continued). Agronomic practices performed during corn growing seasons 2015-17.

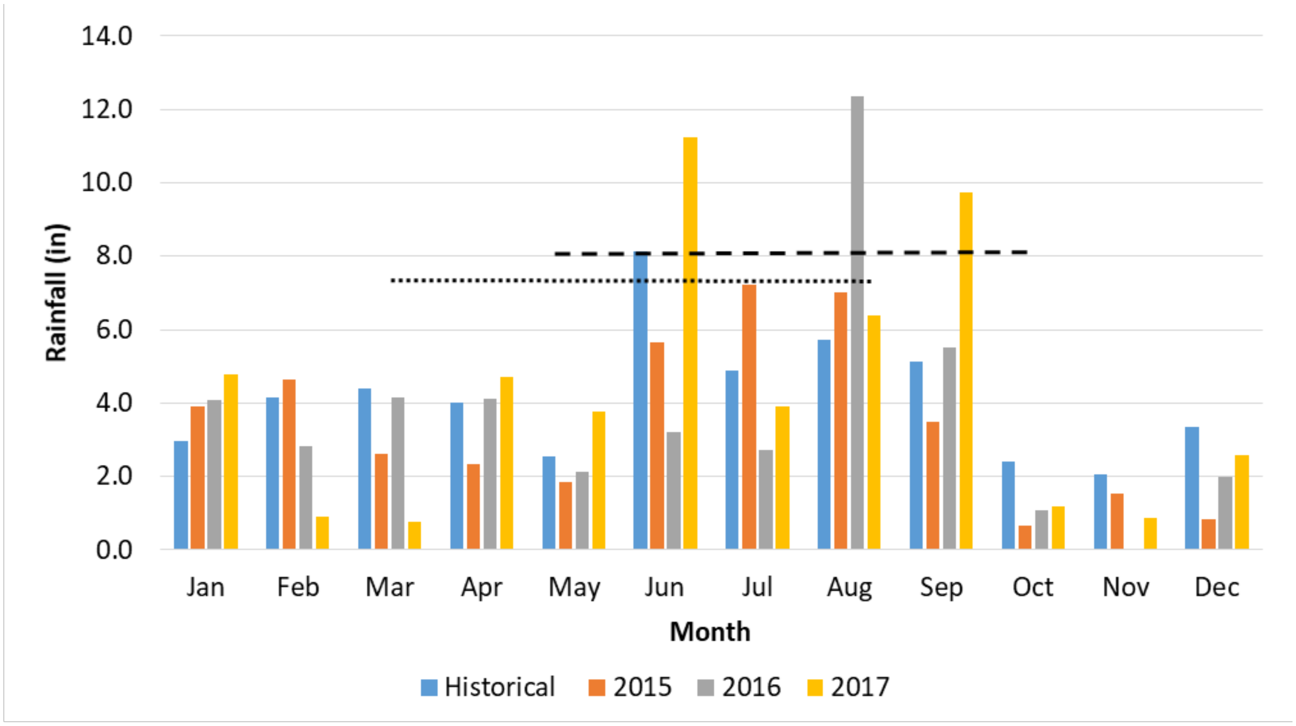


Figure 6. Historical monthly rainfall average (Sept 2002- Oct 2016) compared with monthly rainfall average occurred during 2015, 2016 and 2017. Dotted line represents corn growing season (March-August) and dashed line represents peanut growing season (May- October).

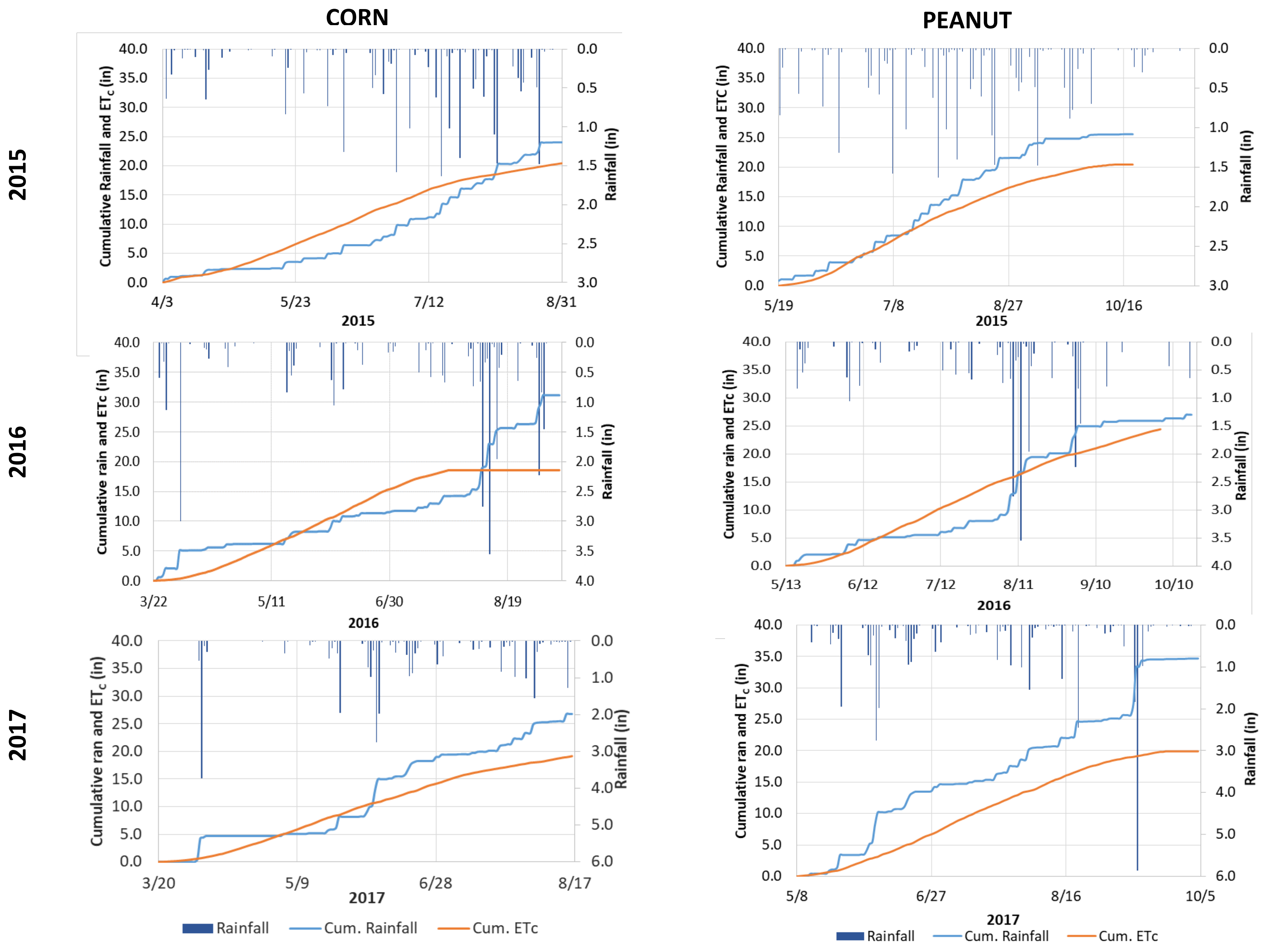


Figure 7. Daily rainfall, cumulative rainfall and calculated cumulative estimated ET_C (inches) during corn (left) and peanut (right) growing seasons 2015-2017.

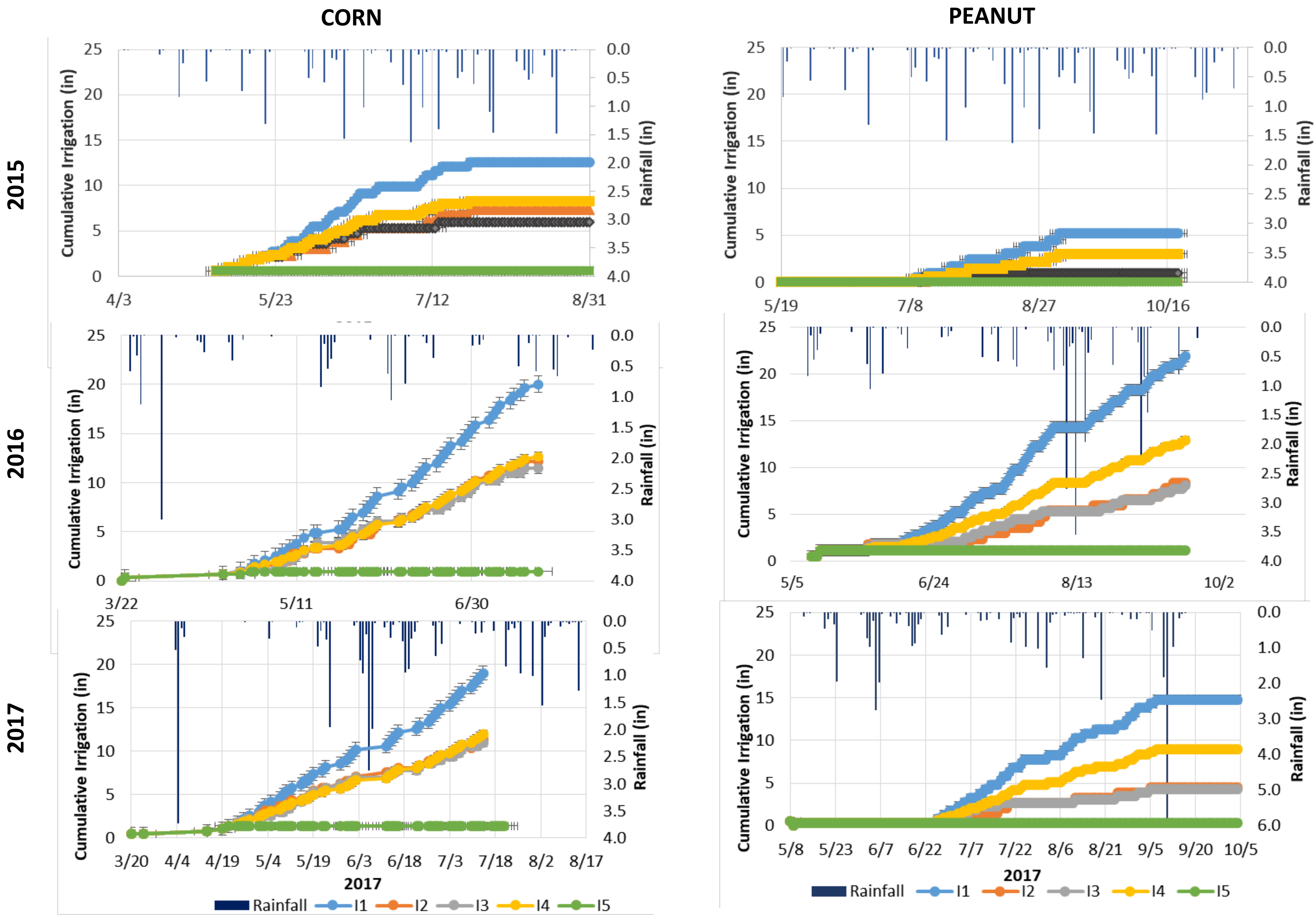


Figure 8. Treatment cumulative irrigation applied in corn and peanut growing seasons 2015-17 (Error bars show SE from application depths after linear modifications).

Soil N

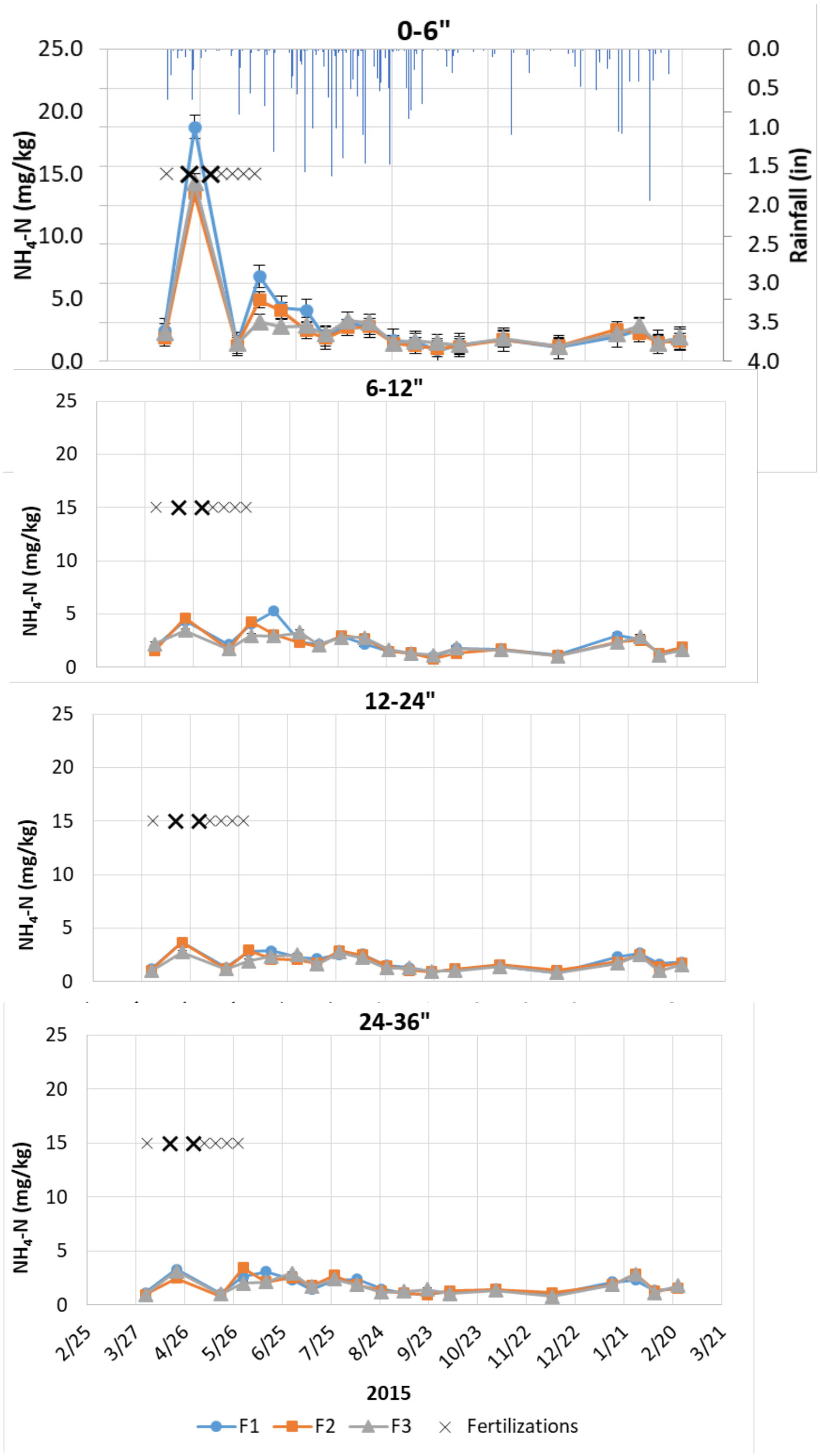


Figure 9. Average soil NH_4-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in, 6-12 in, 12-24 in and 24-36 for corn 2015. Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NH_4-N means.

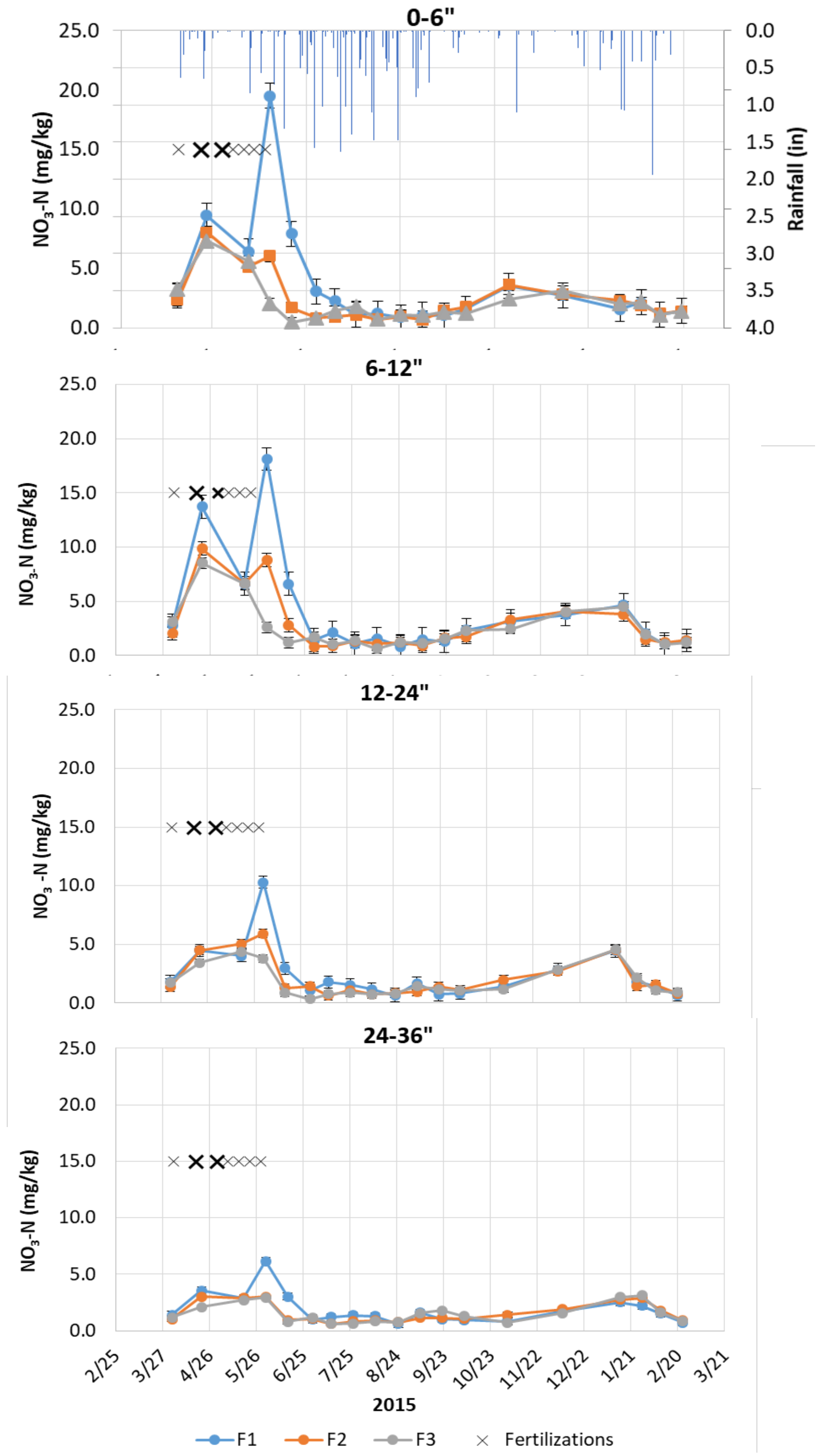


Figure 10. Average soil NO_3-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in, 6-12 in, 12-24 in and 24-36 for corn 2015. Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NO_3-N means.

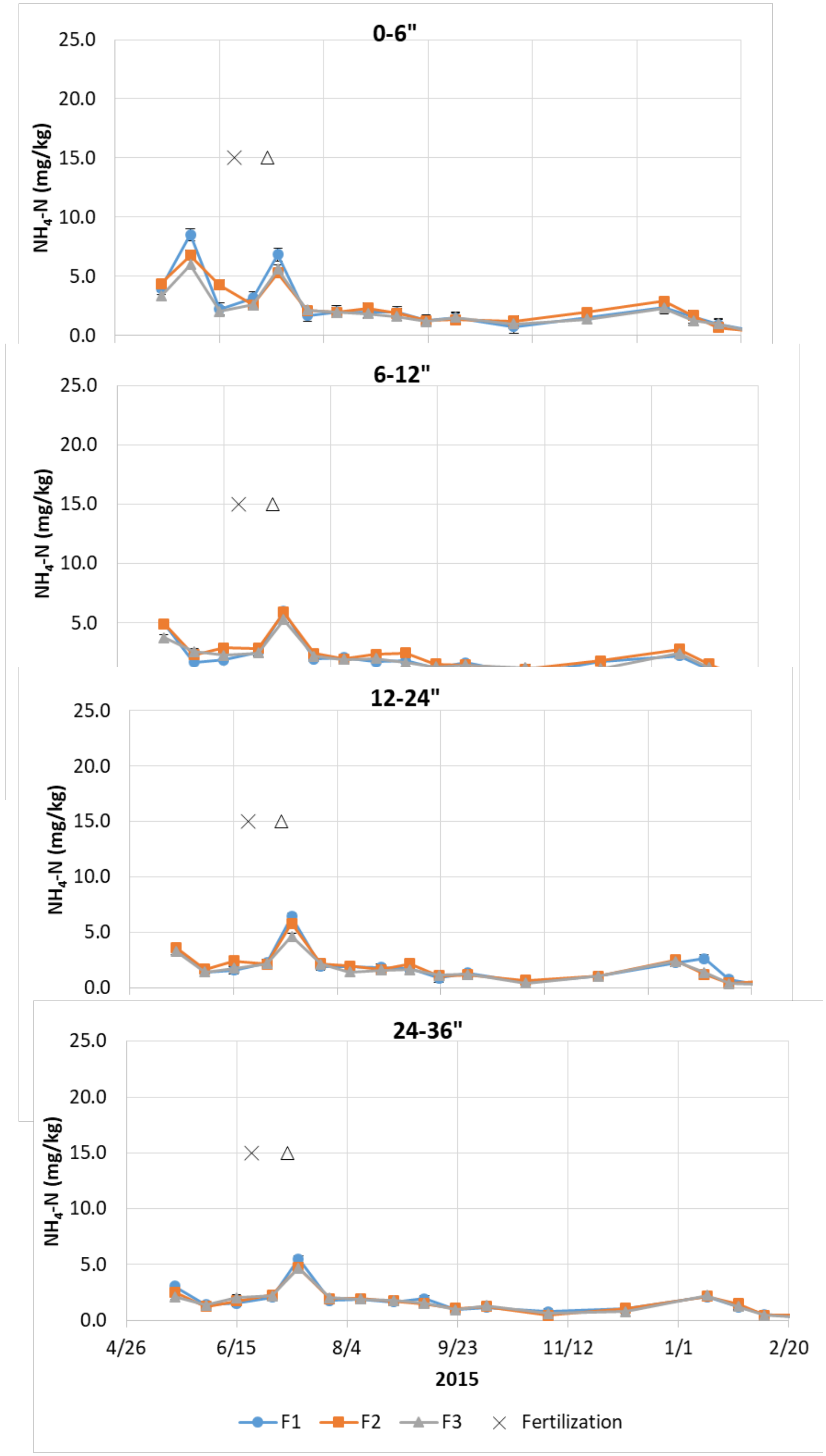


Figure 11. Average soil water NH_4-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in, 6-12 in, 12-24 in and 24-36 in for peanut 2015. Symbol (**X**) represent granular (3-7-28) and gypsum applications. Error bars show SE of NH_4-N means.

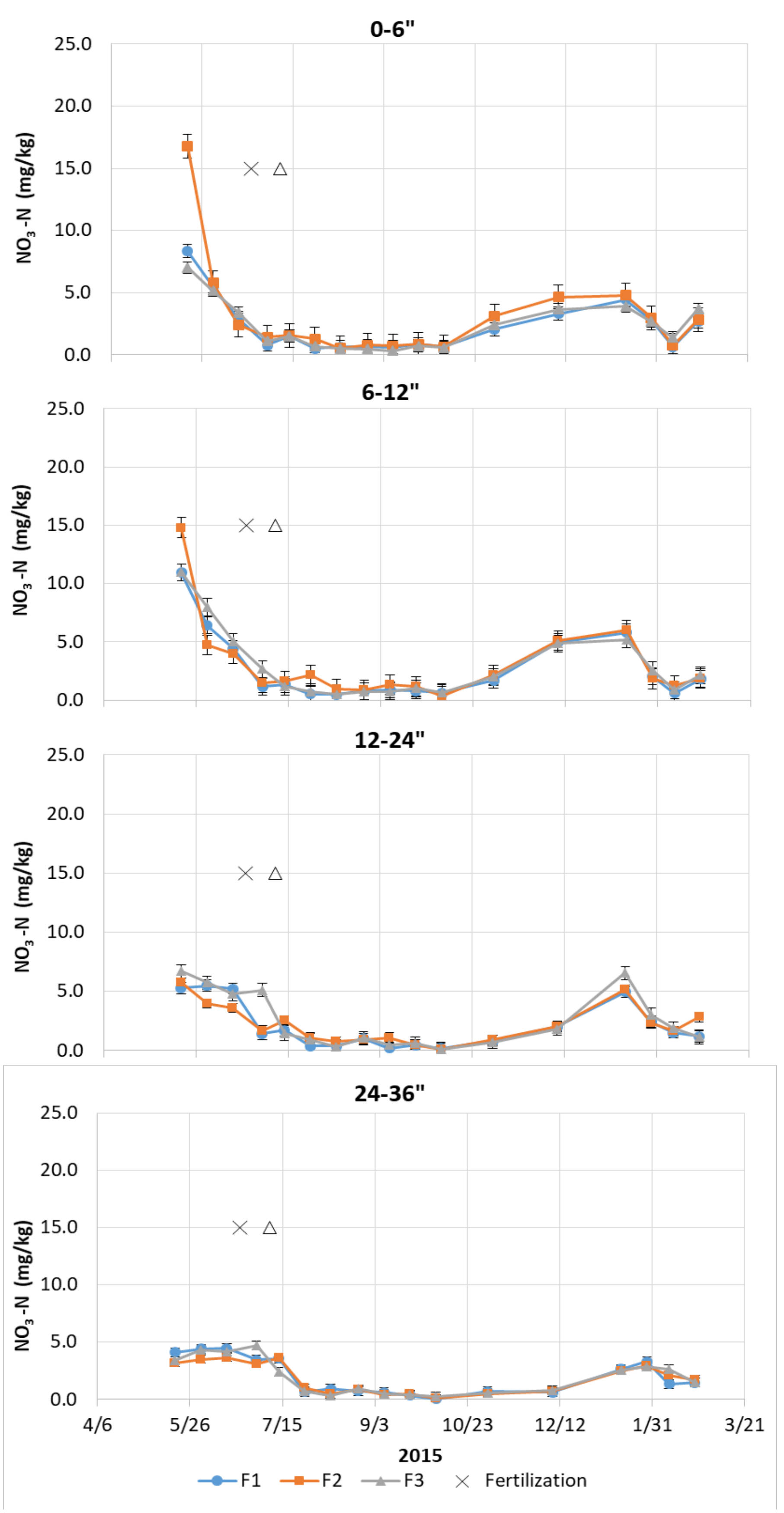


Figure 12. Average soil NO_3-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in, 6-12 in, 12-24 in and 24-36 in for peanut 2015. Symbols represent granular (3-7-28) (**X**) and gypsum (Δ) applications. Error bars show SE of NO_3-N means.

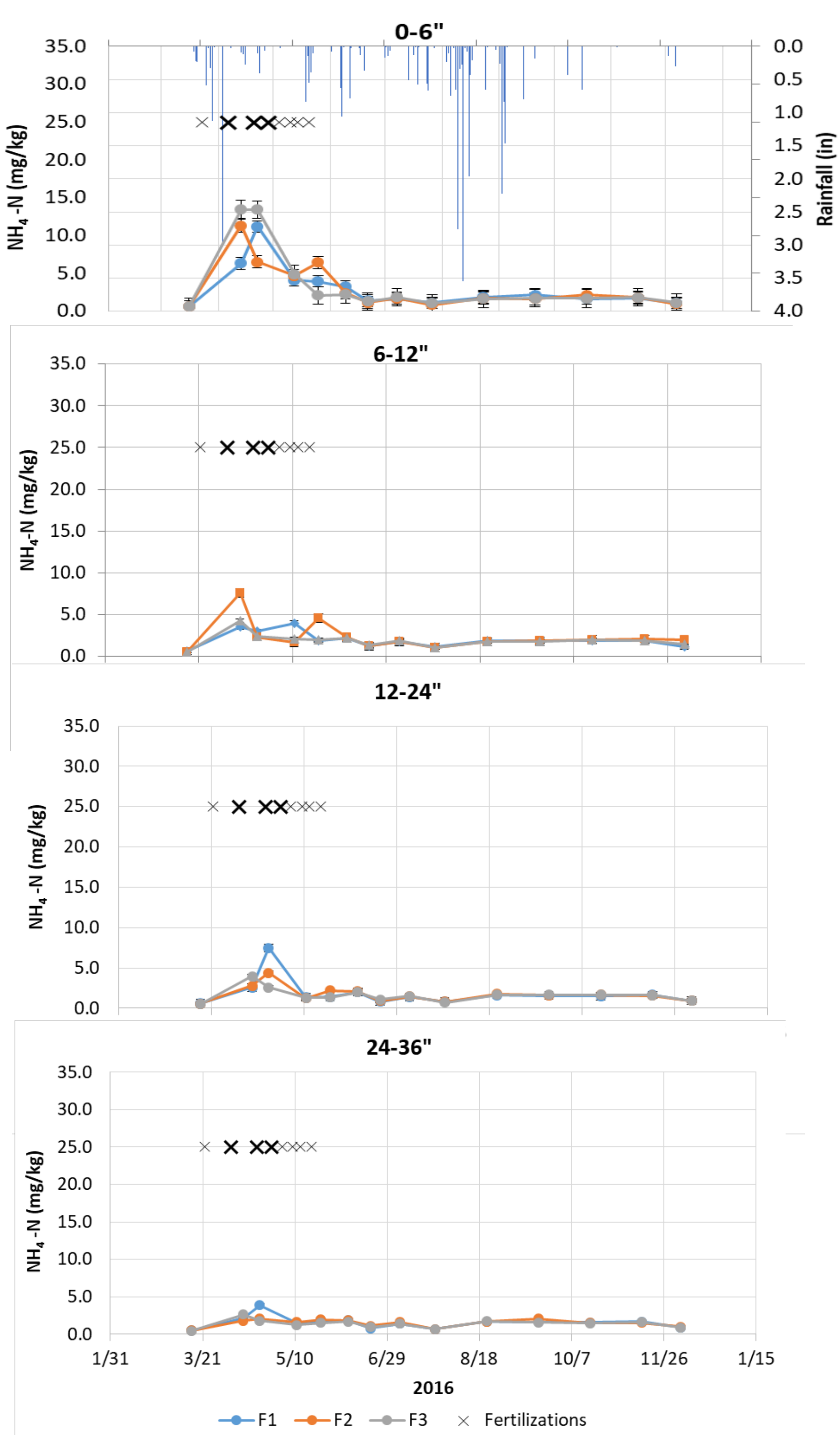


Figure 13. Average soil NH_4-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in, 6-12 in, 12-24 in and 24-36 in for corn 2016. Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NH_4-N means.

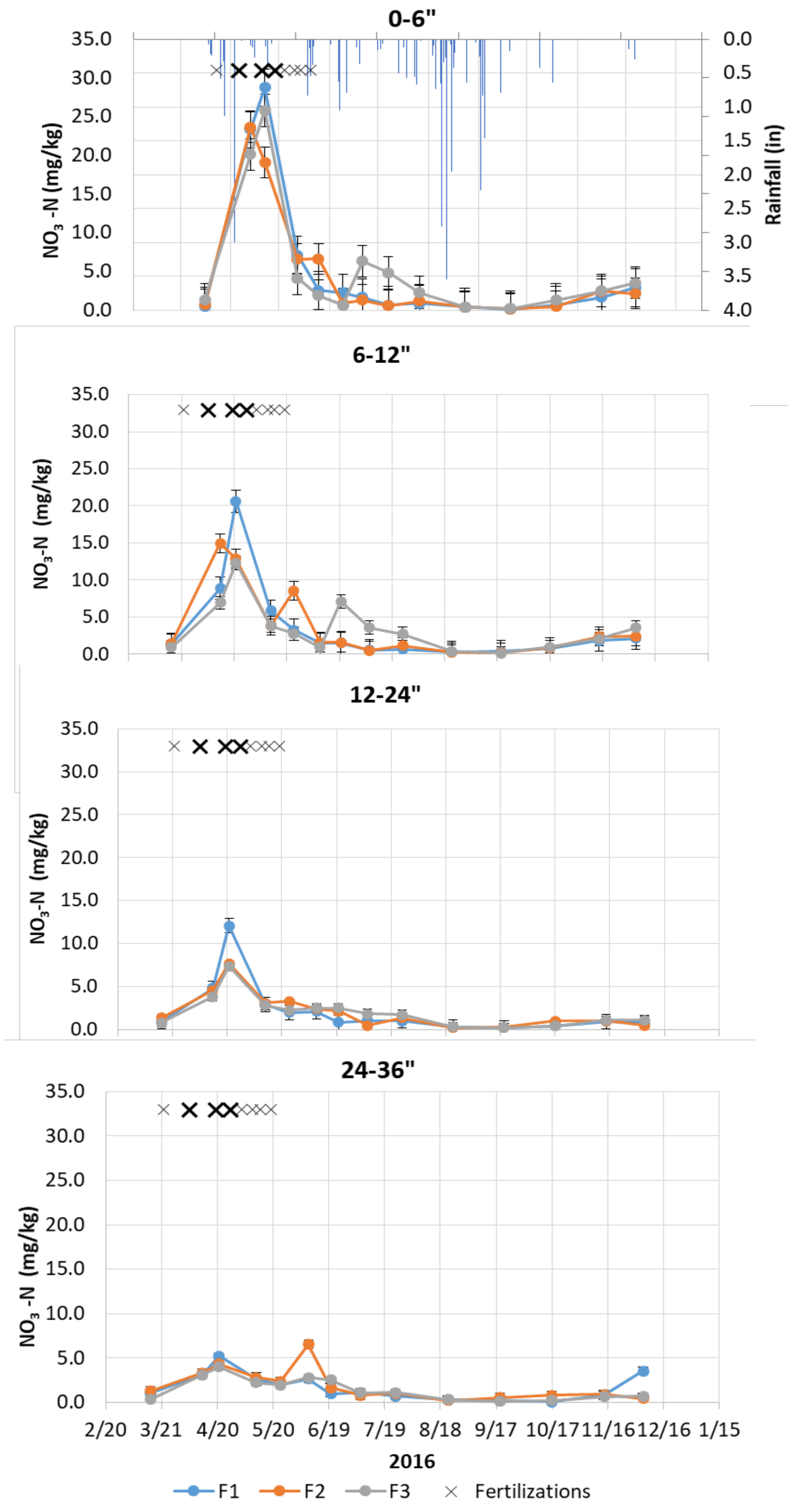


Figure 14. Average soil NO_3-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in, 6-12 in, 12-24 in and 24-36 in for corn 2016. Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NO_3-N means.

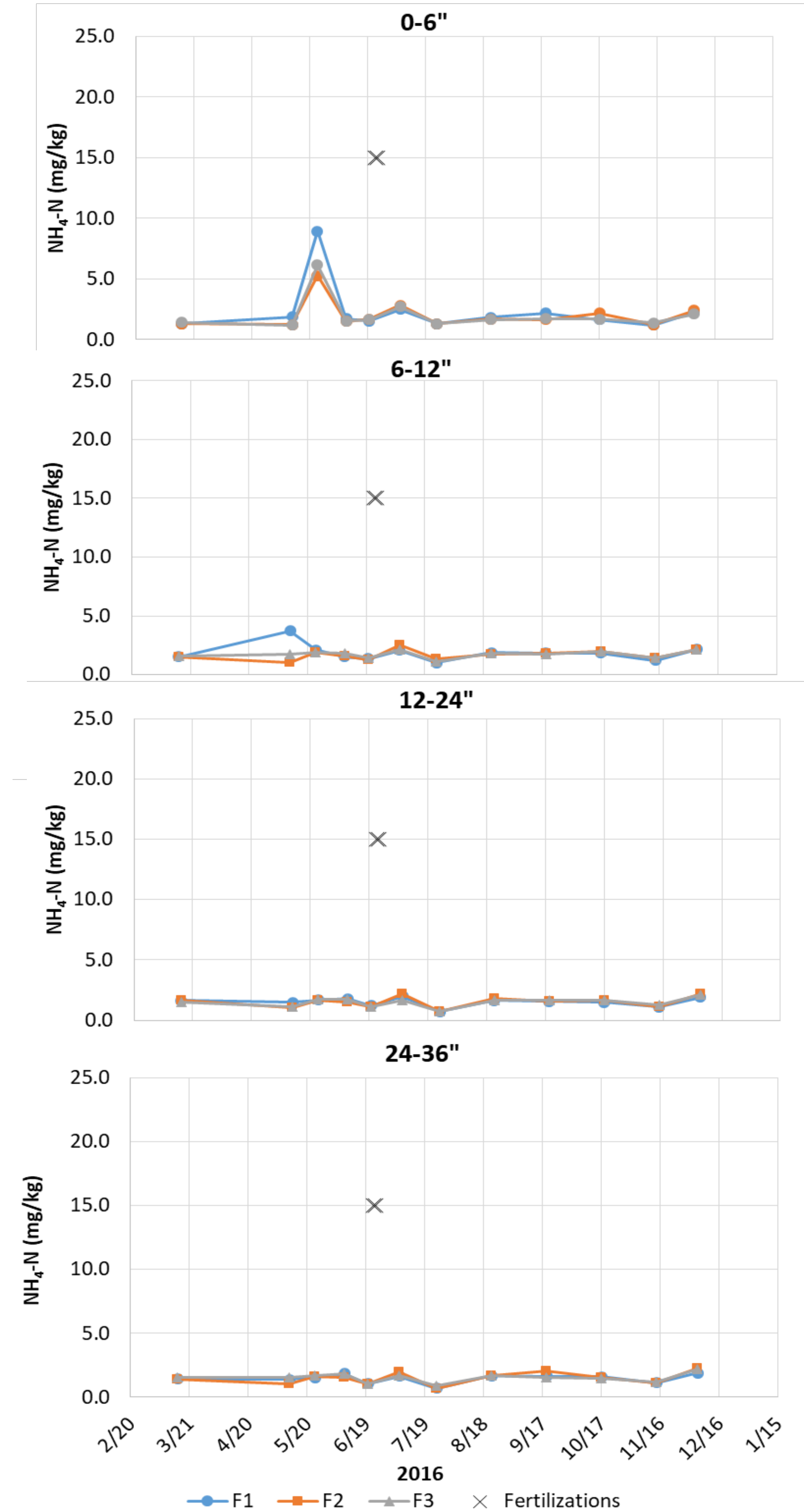


Figure 15. Average soil water NH_4-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in, 6-12 in, 12-24 in and 24-36 in for peanut 2016. Symbol (**X**) represent granular (8-0-39) and gypsum applications. Error bars show SE of NH_4-N means.

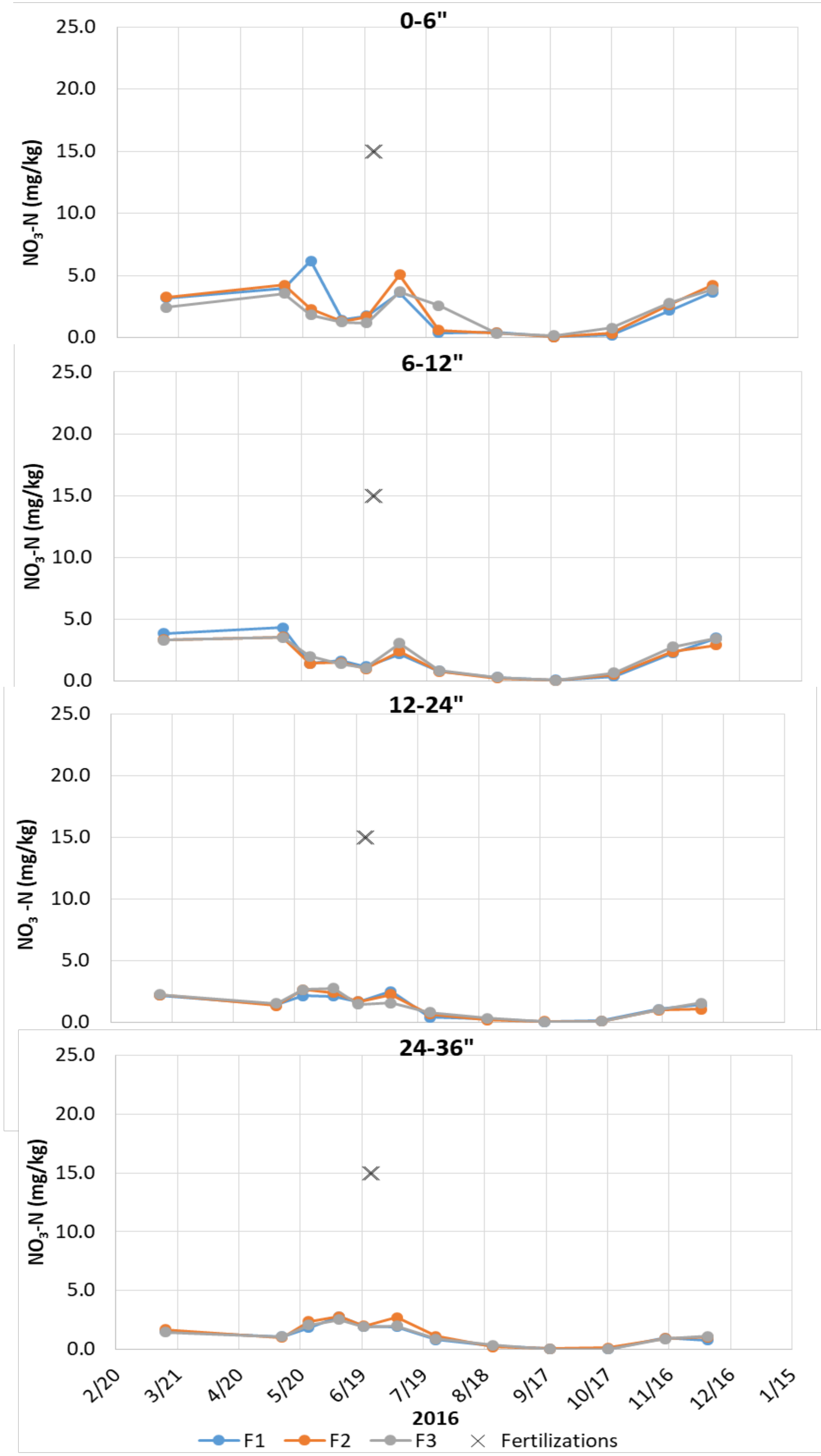


Figure 16. Average soil water NO_3-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in and 6-12 in, 12-24 in and 24-36 in for peanut 2016. Symbol (**X**) represent granular (8-0-39) and gypsum applications. Error bars show SE of NO_3-N means.

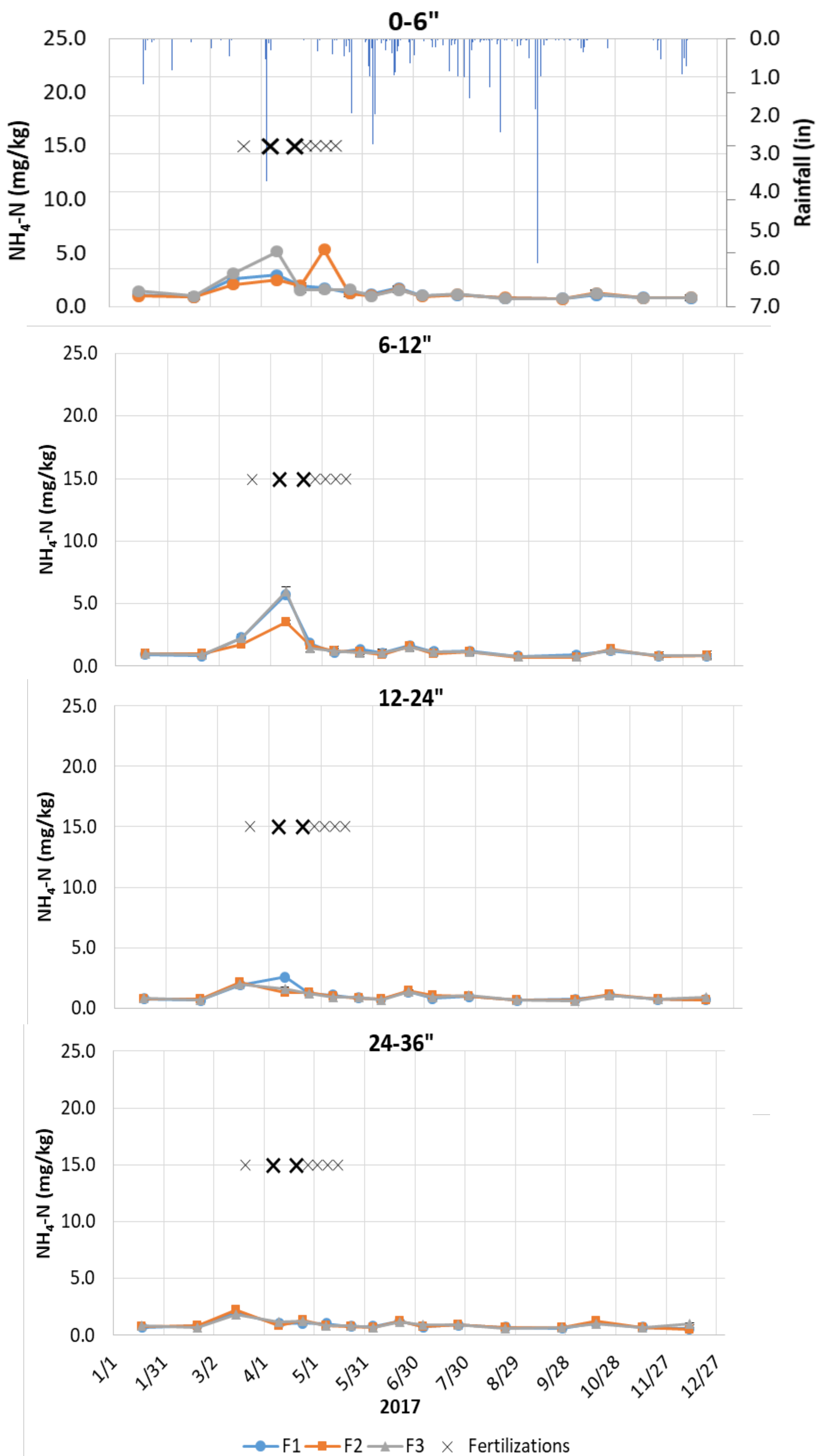


Figure 17. Average soil NH_4-N results from fertility levels (F1, F2 and F3) obtained at 0-6" and at 0-6 in, 6-12 in, 12-24 in and 24-36 in for corn 2017 Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NH_4-N means.

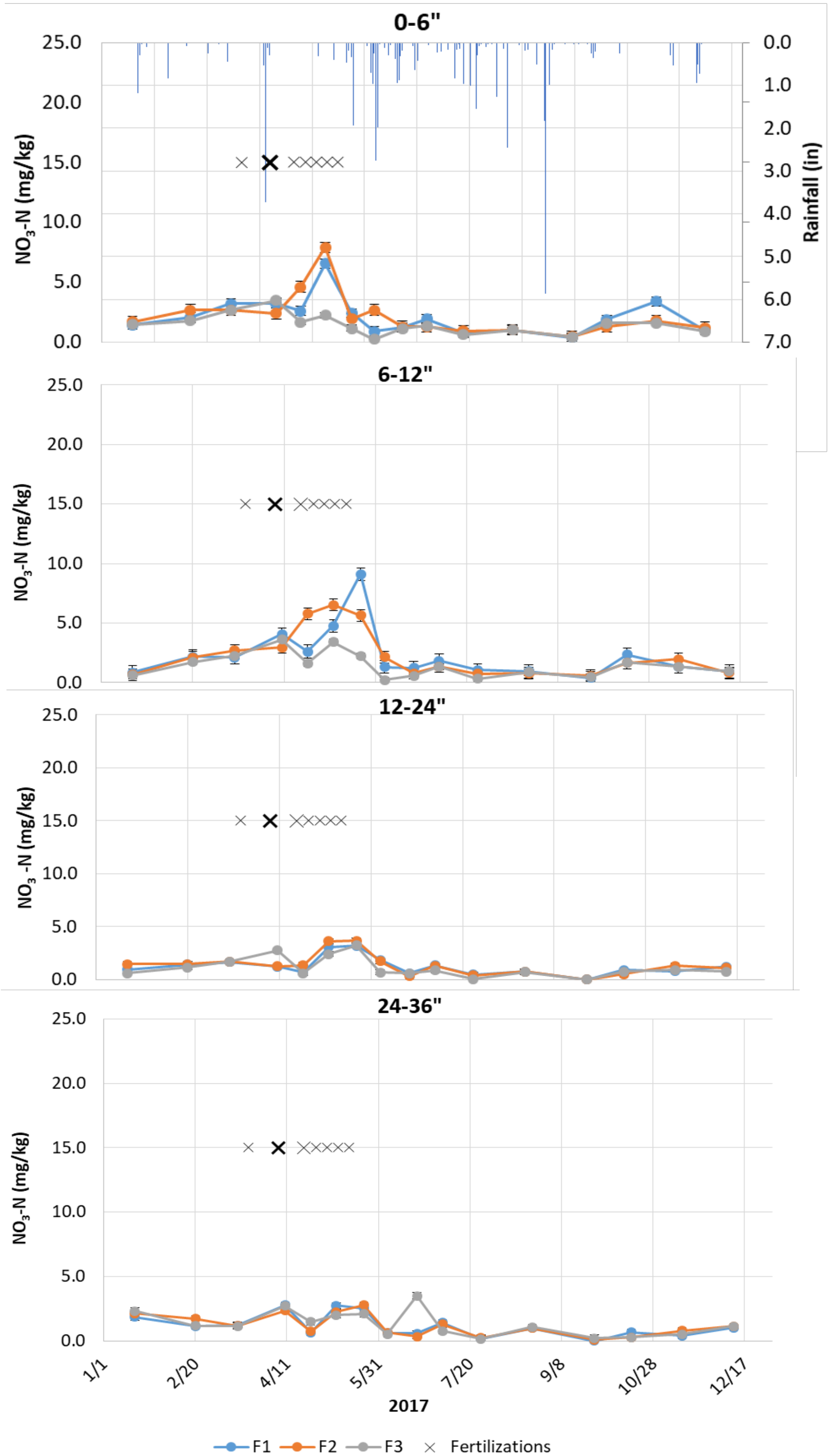


Figure 18. Average soil NO_3-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in and 6-12 in, 12-24 in and 24-36 in for corn 2017. Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NO_3-N means.

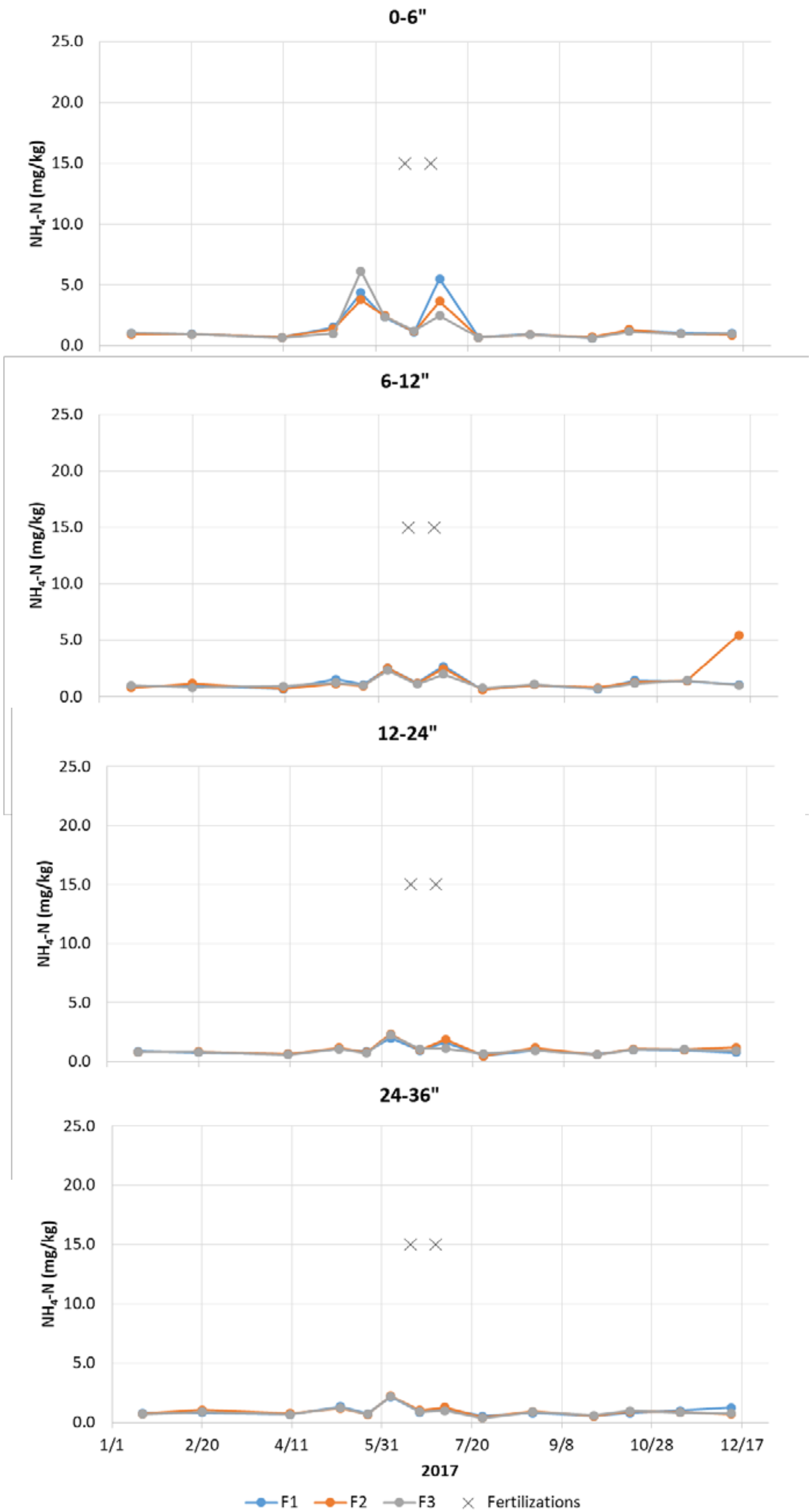


Figure 19. Average soil water NH_4-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in and 6-12 in, 12-24 in and 24-36 in for peanut 2017. Symbols (**X**) represent granular (8-0-39) and gypsum applications, respectively. Error bars show SE of NH_4-N means.

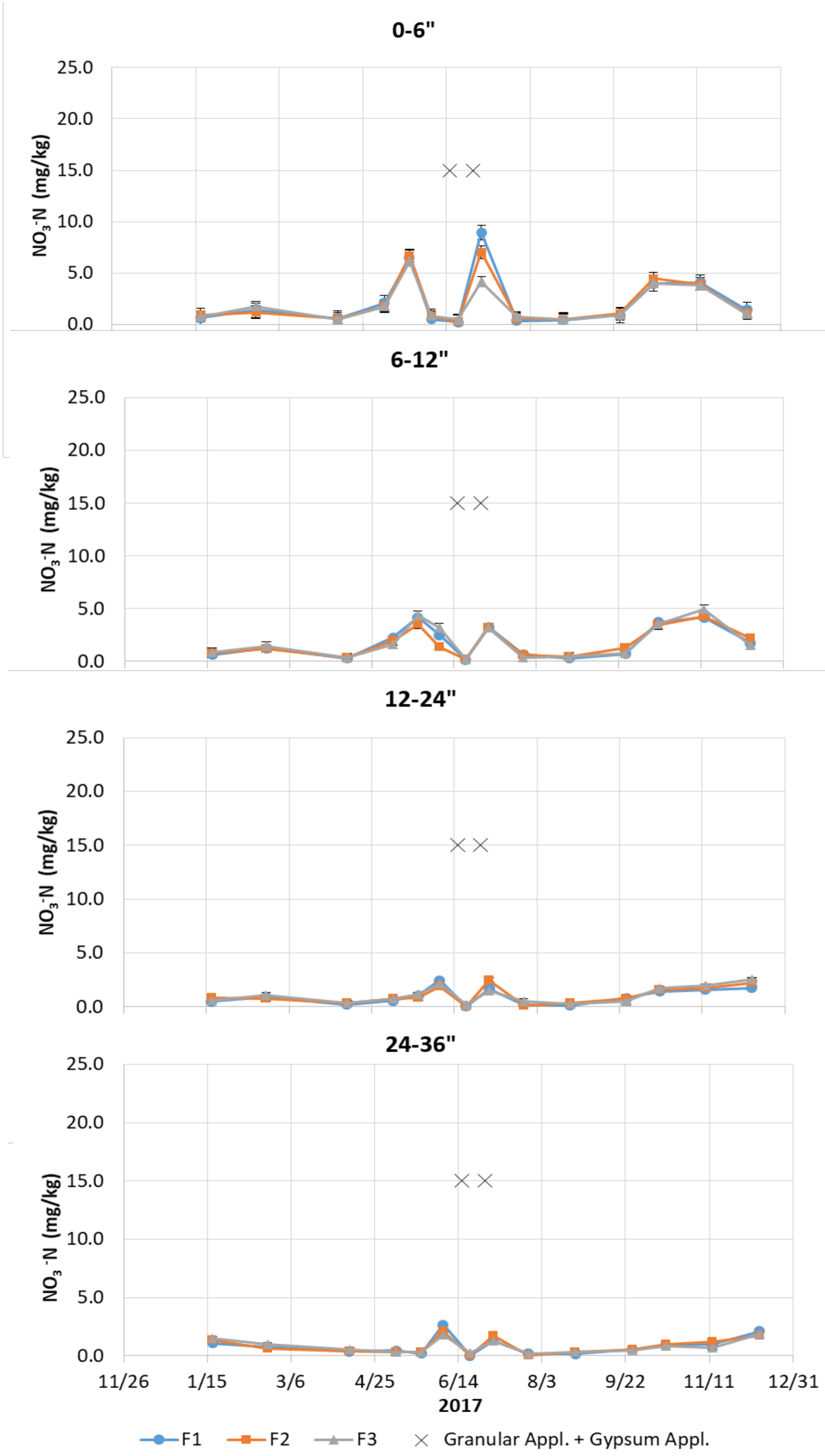


Figure 20. Average soil water NO_3-N results from fertility levels (F1, F2 and F3) obtained at 0-6 in and 6-12 in, 12-24 in and 24-36 in for peanut 2017. Symbols (**X**) represent granular (8-0-39) and gypsum application. Error bars show SE of NO_3-N means.

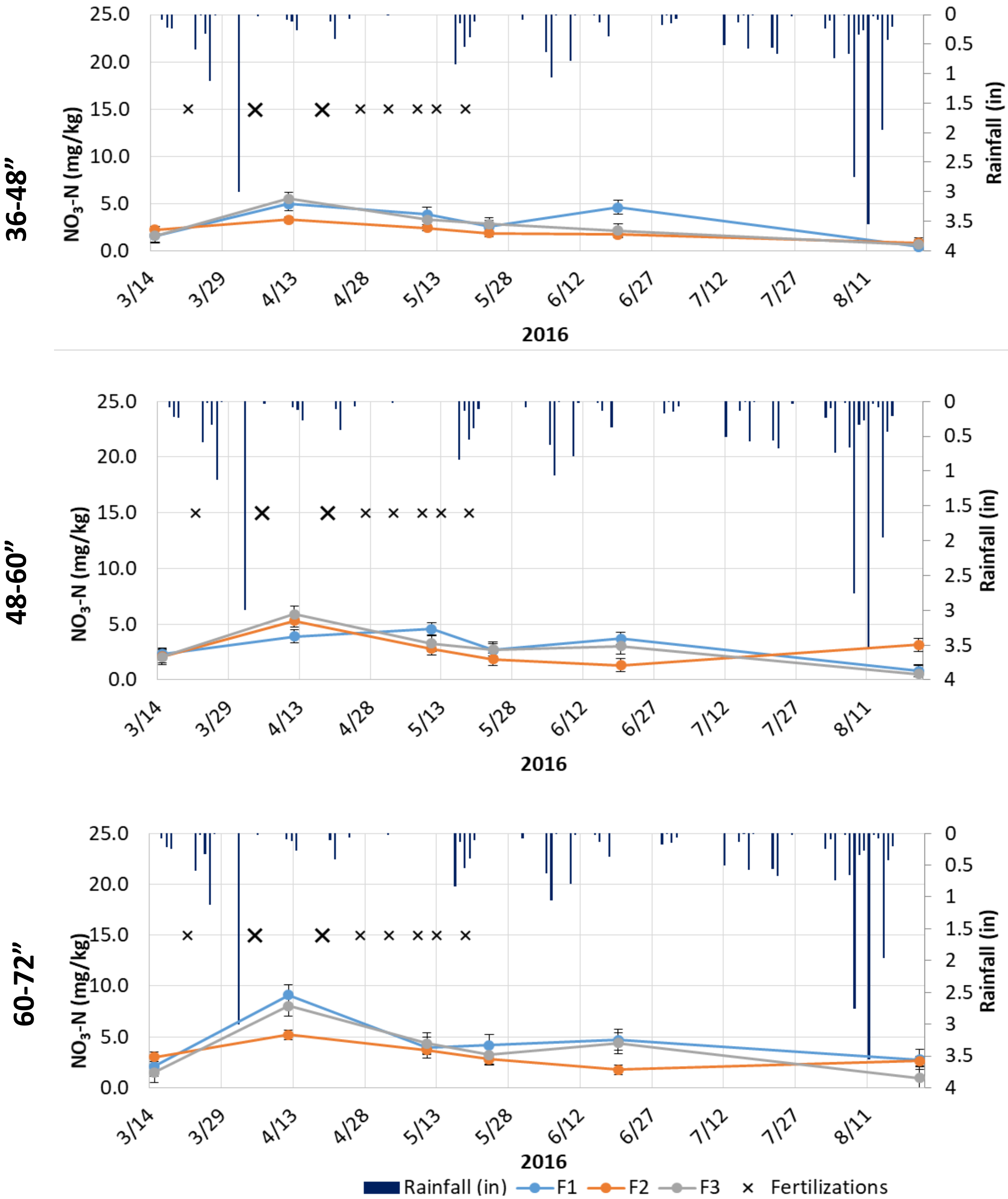


Figure 21. Average soil water NO_3-N results from fertility levels (F1, F2 and F3) obtained at 36-48 in, 48-60 in and 60-72 in for corn 2016. Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NO_3-N means.

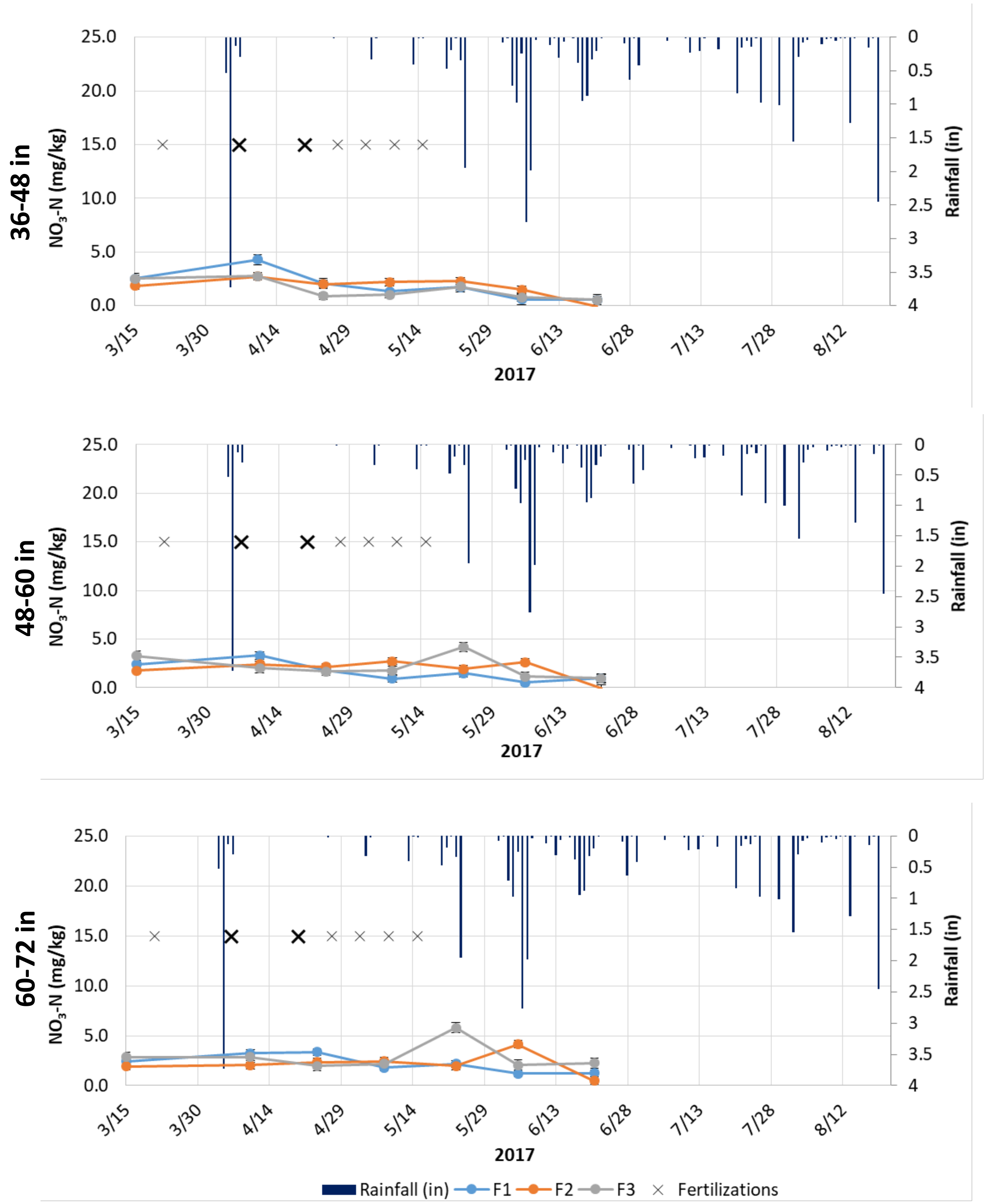
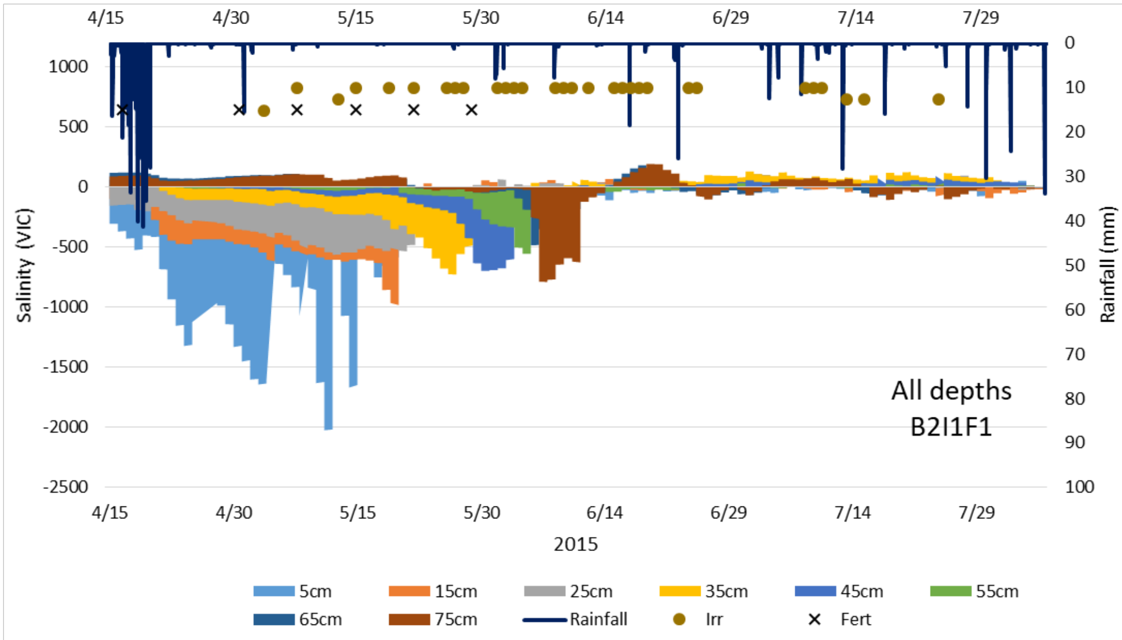


Figure 22. Average soil water NO_3-N results from fertility levels (F1, F2 and F3) obtained at 36-48 in, 48-60 in and 60-72 in for corn 2017. Large symbols (**X**) represent granular applications and small symbols (x) represent the starter fertilizer and the liquid side-dress applications. Error bars show SE of NO_3-N means.

Salinity

Corn 2015



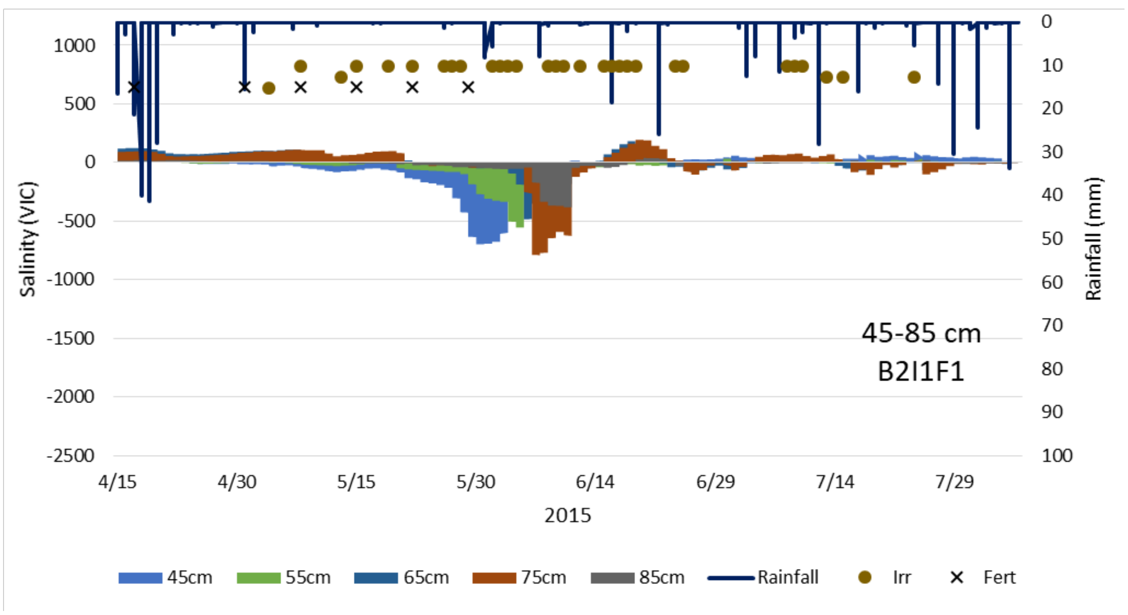
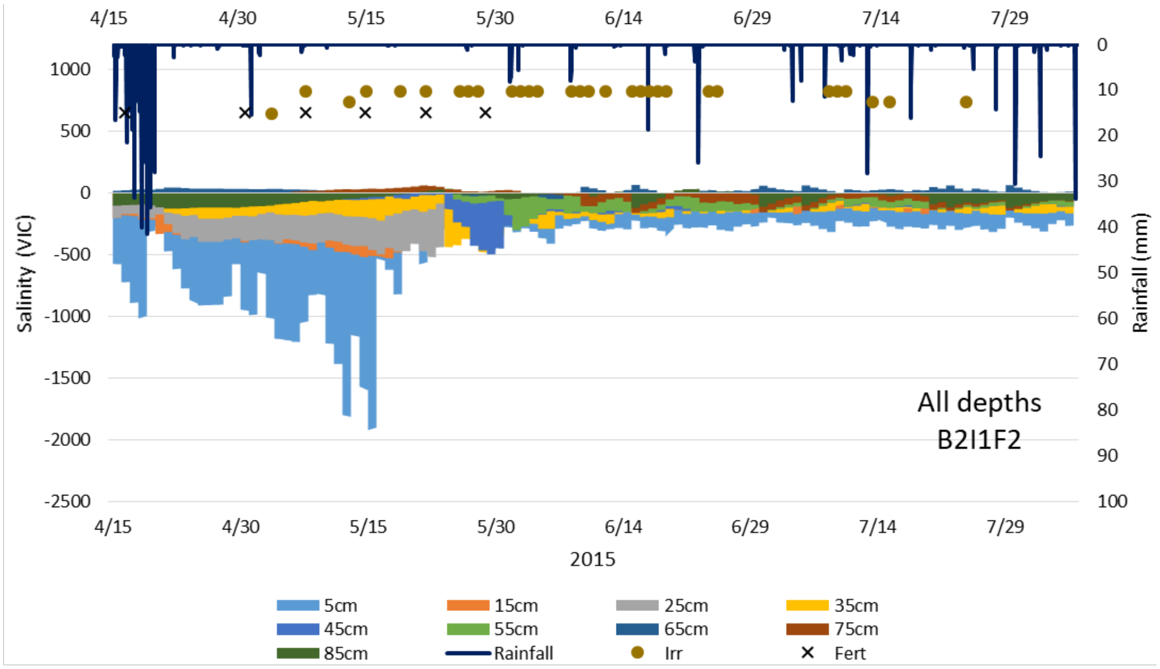


Figure 23. B2I1F1 (GROW-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.



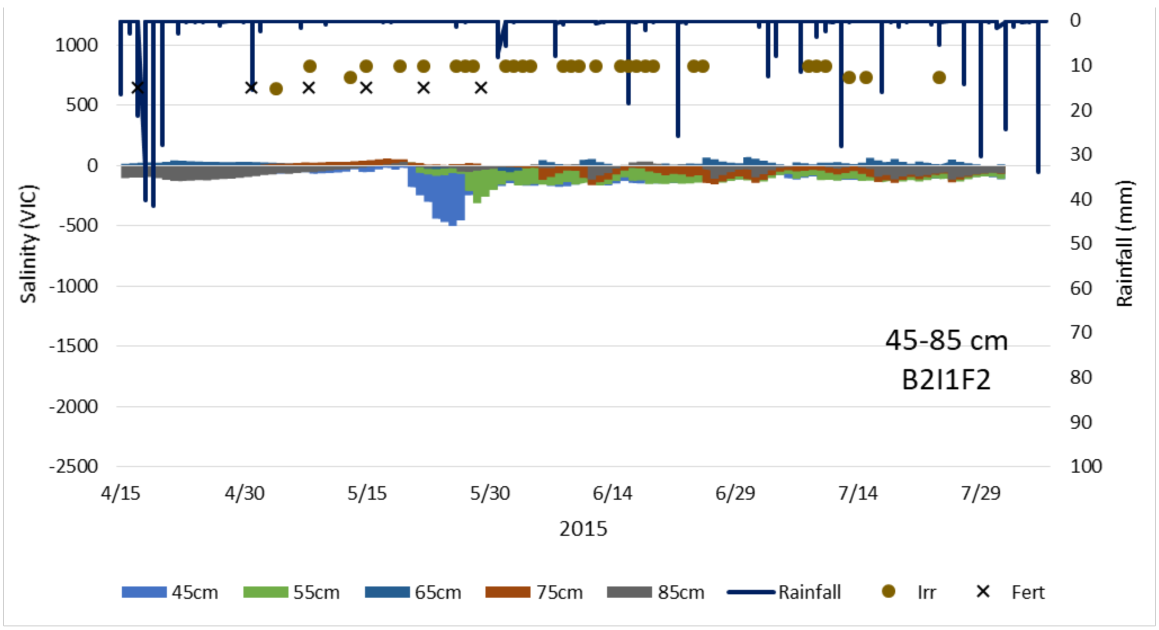


Figure 24. B2I1F2 (GROW-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.

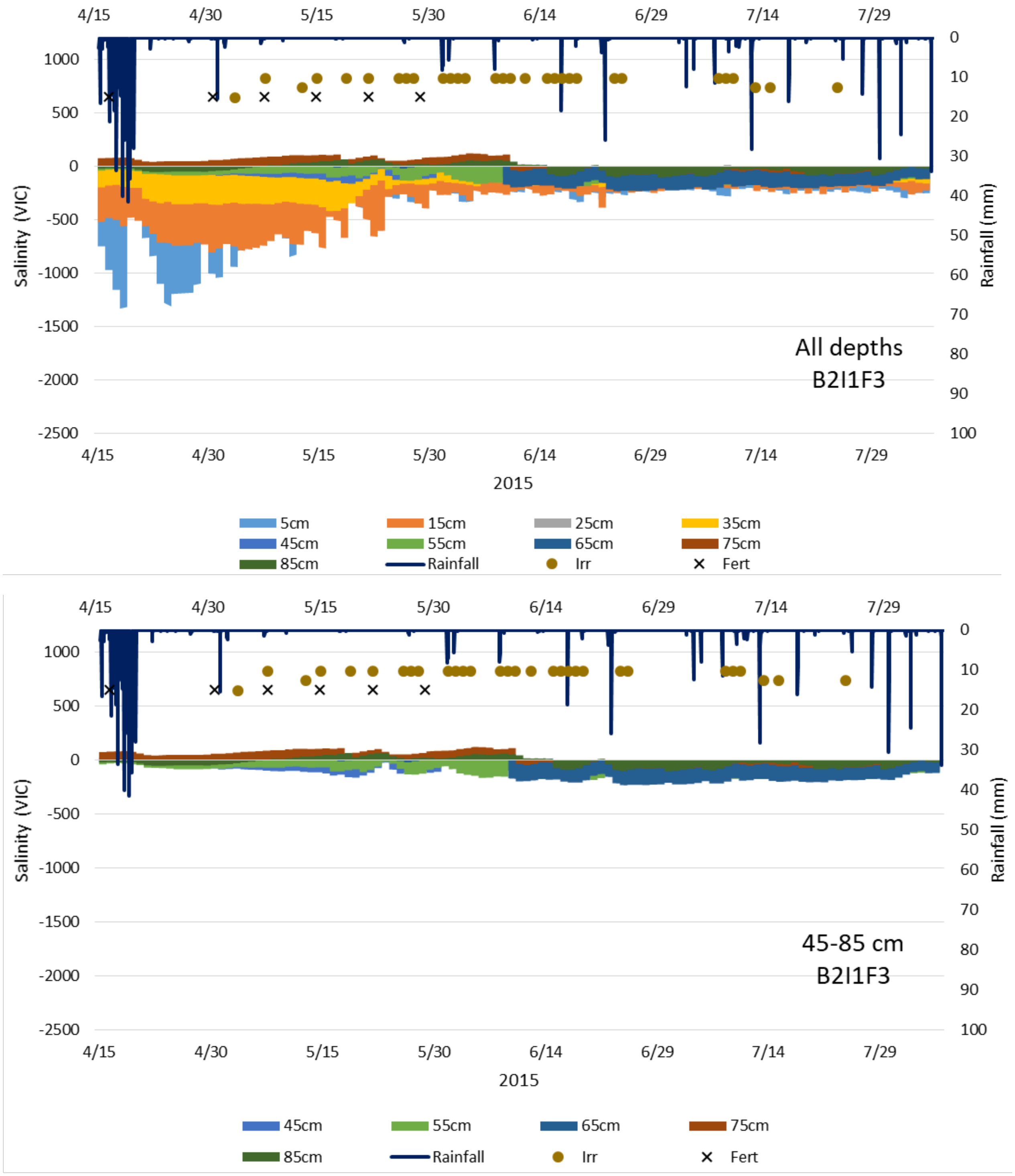
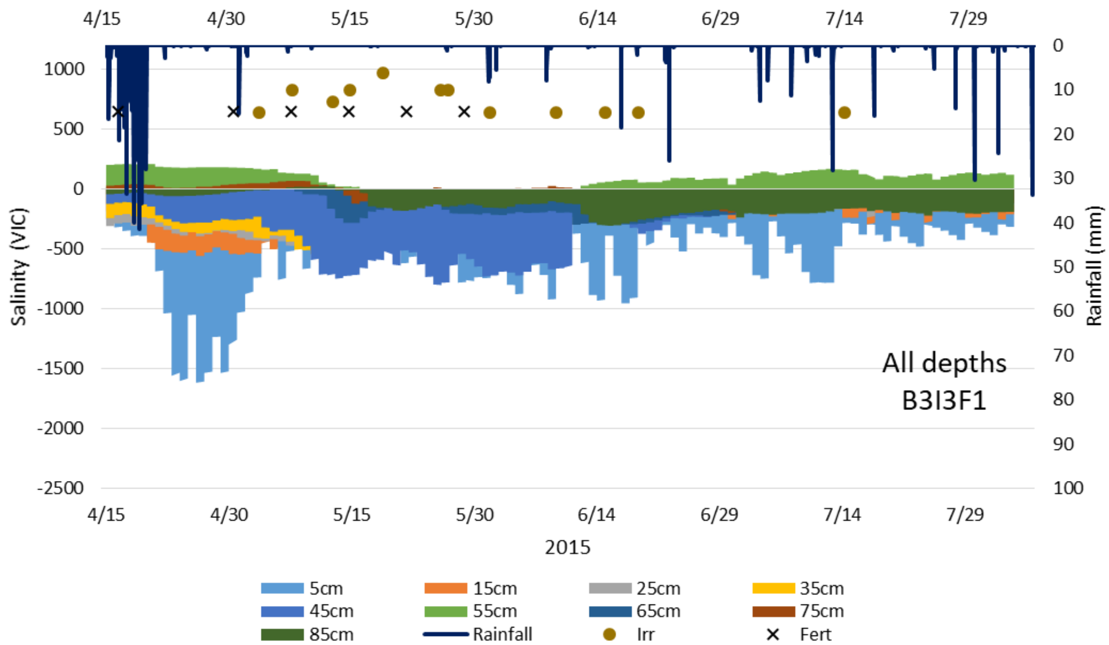


Figure 25. B2I1F3 (GROW-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.



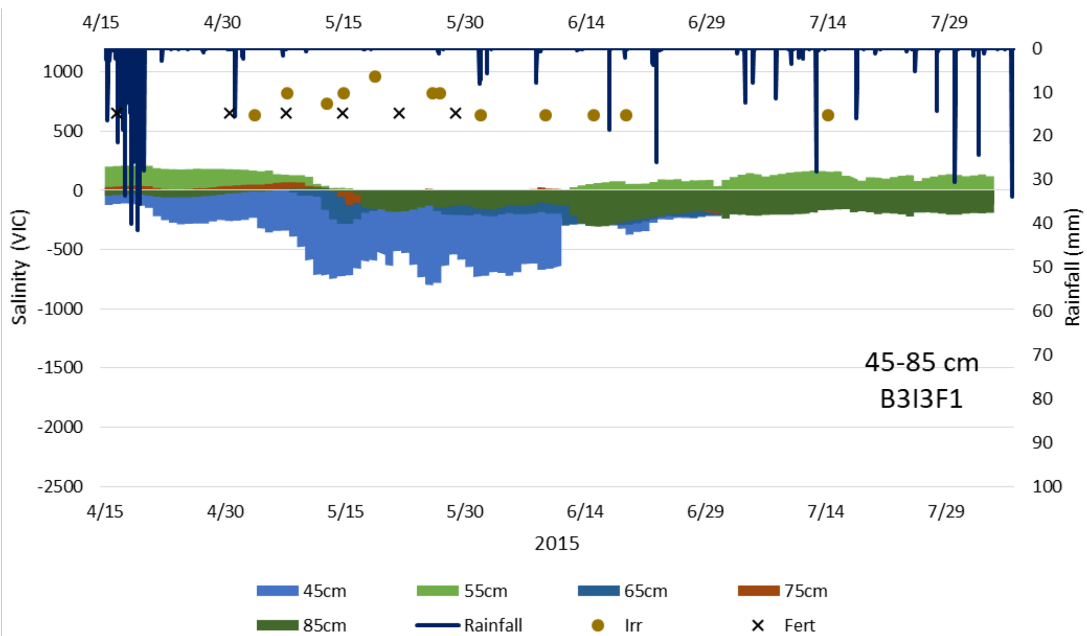
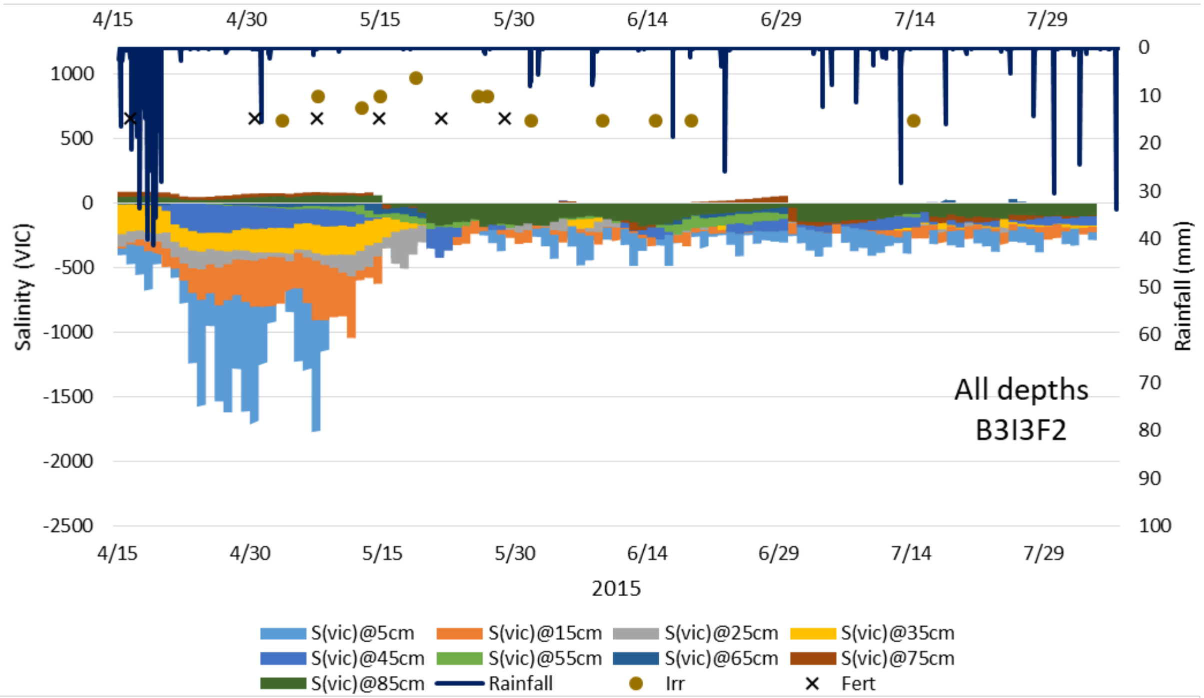


Figure 26. B3I3F1 (SMS-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.



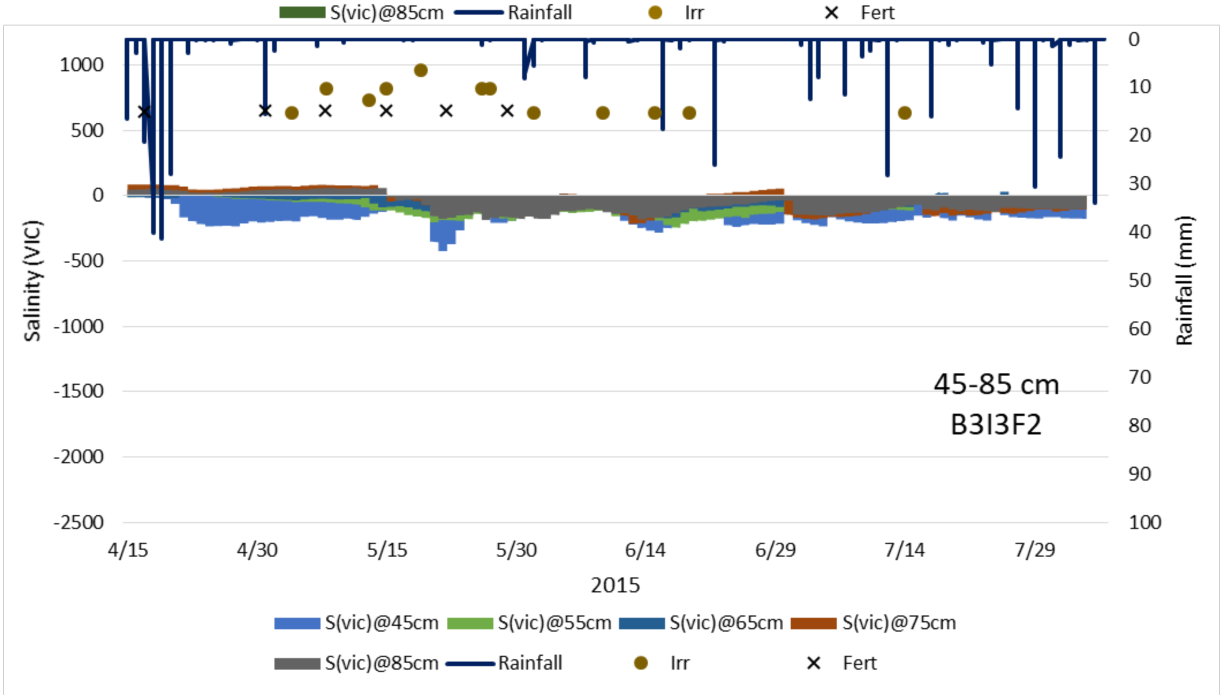
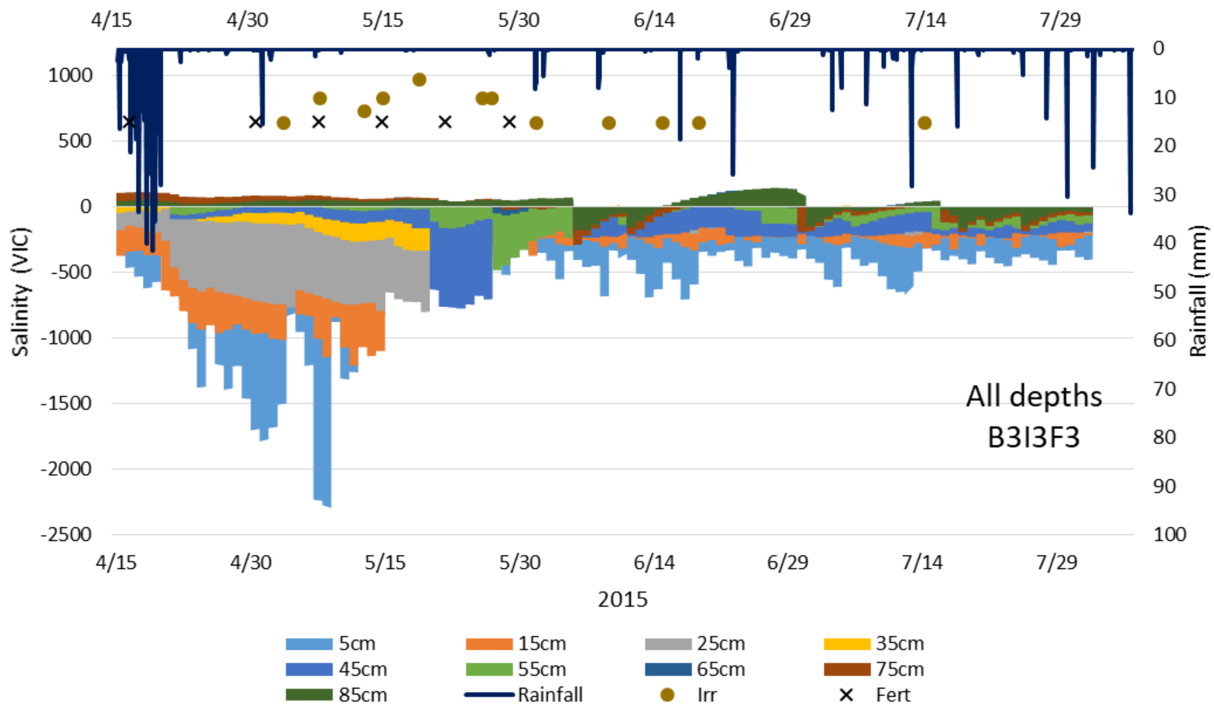


Figure 27. B3I3F2 (SMS-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.



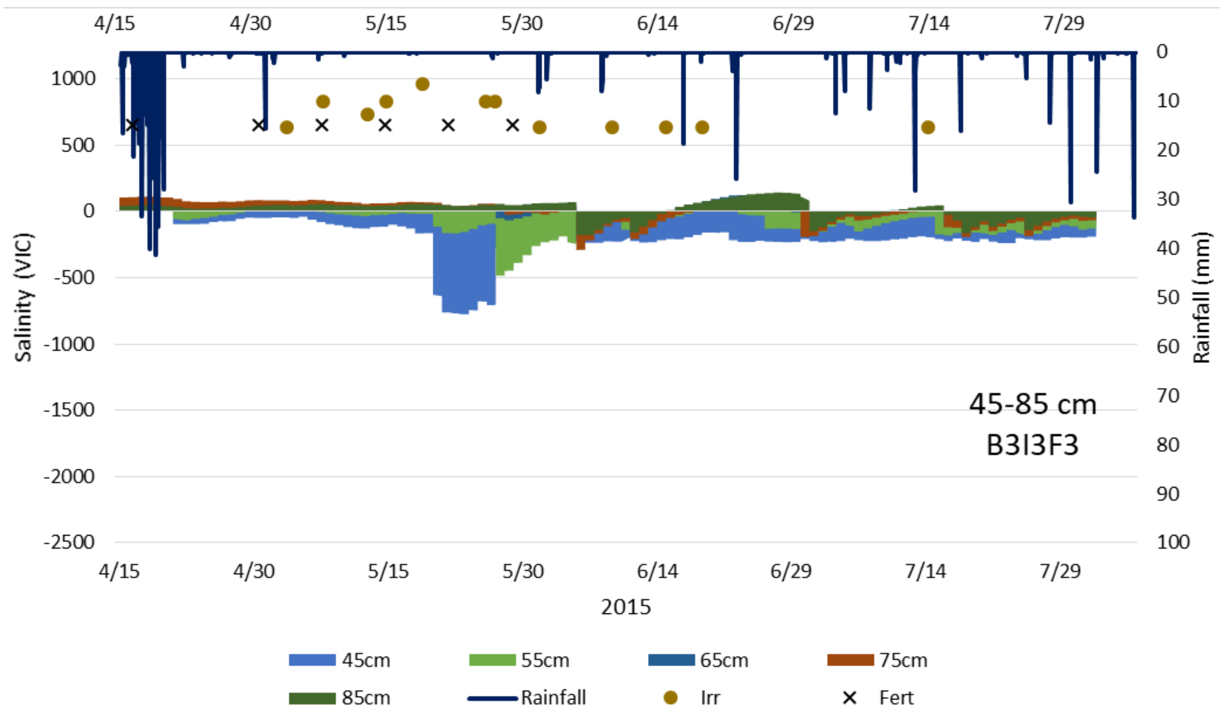
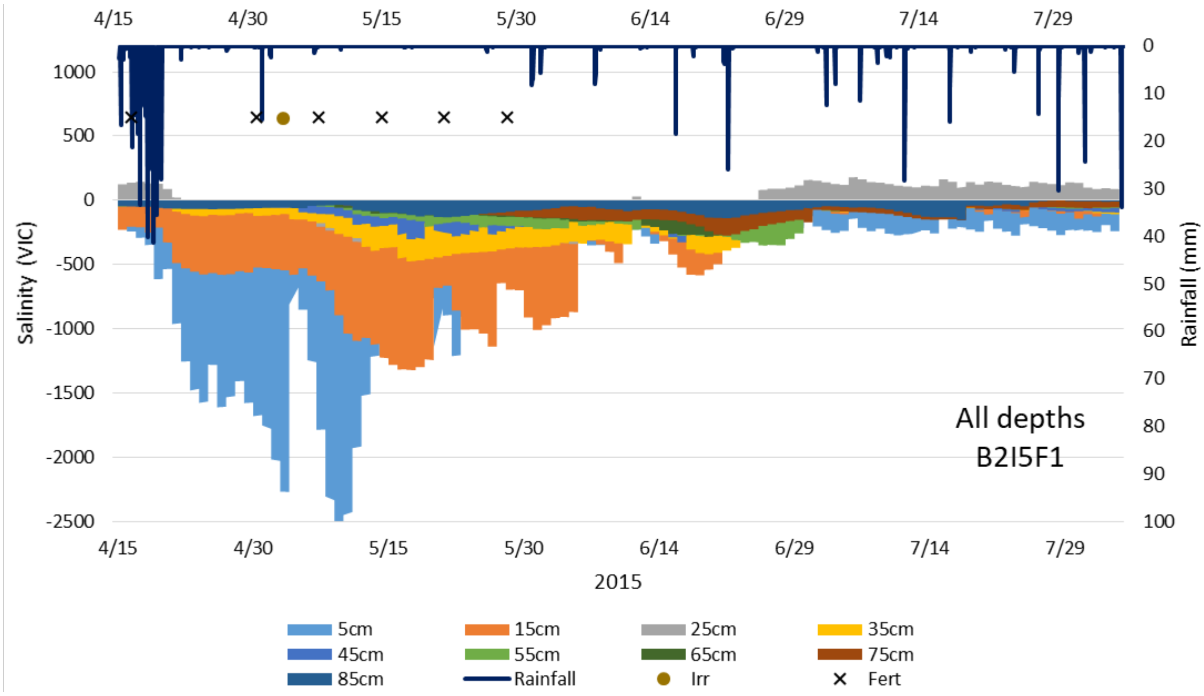


Figure 28. B3I3F3 (SMS-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.



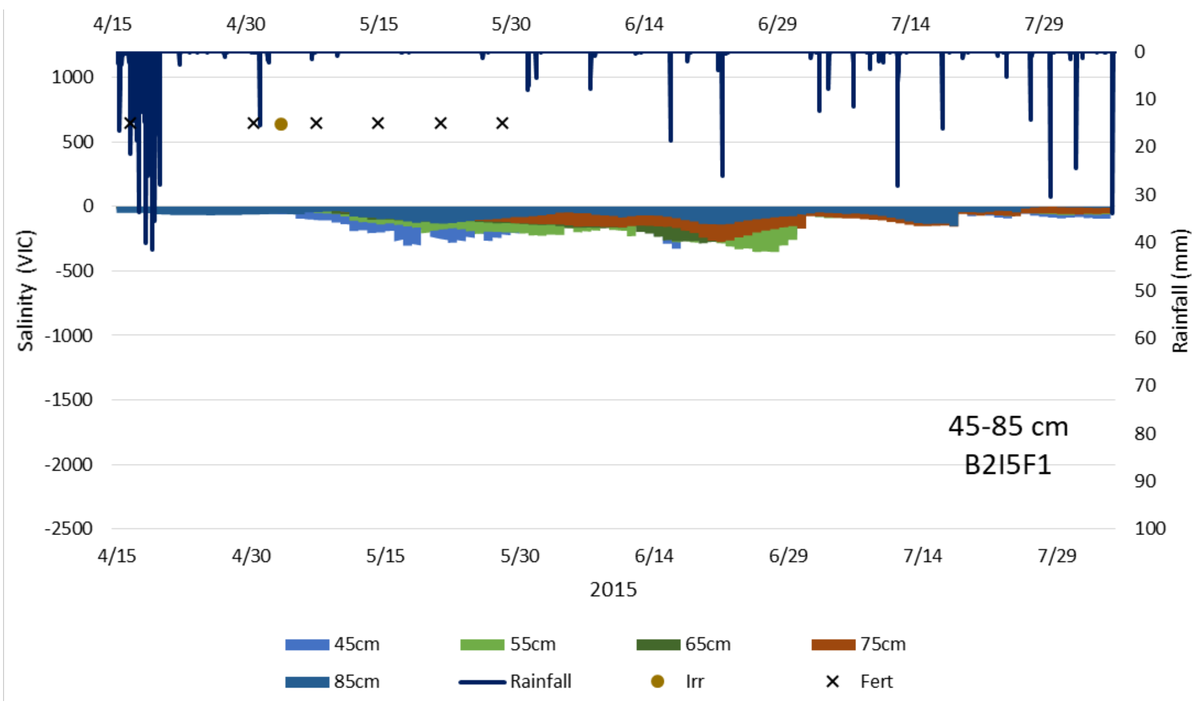
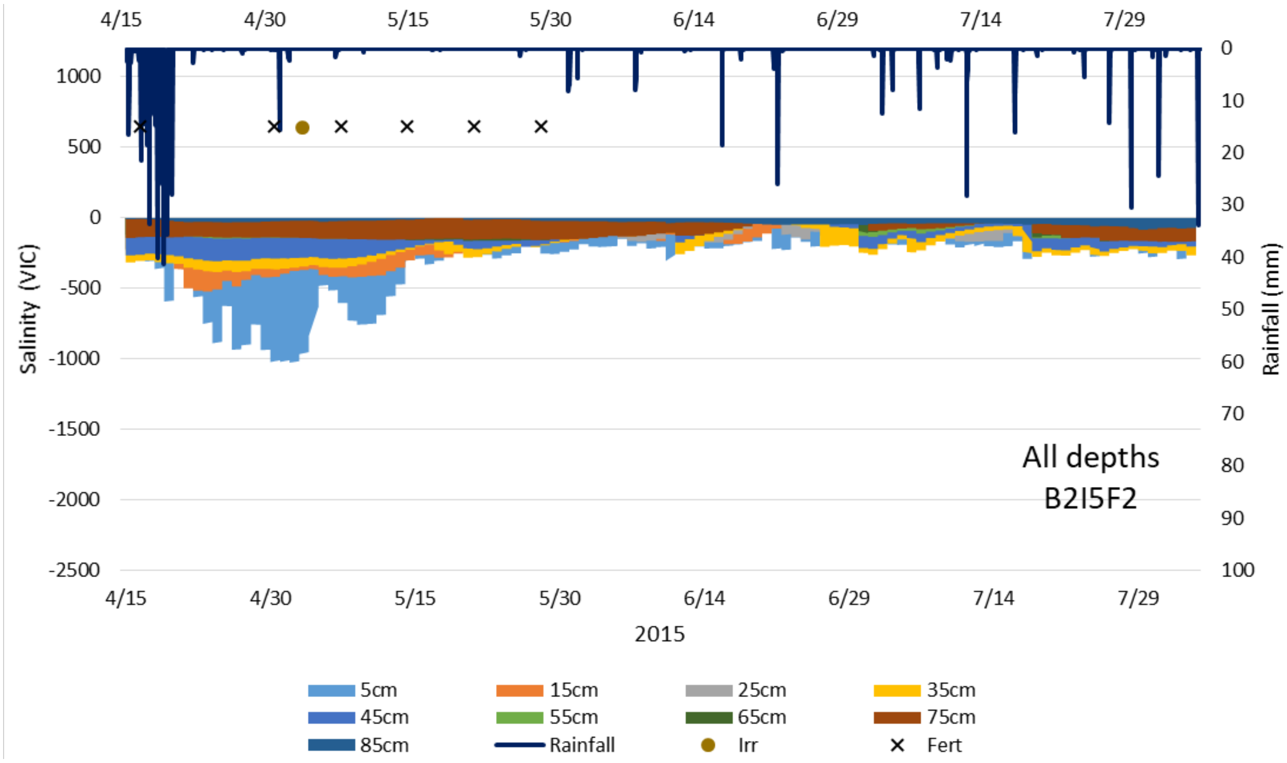


Figure 29. B2I5F1 (NON-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.



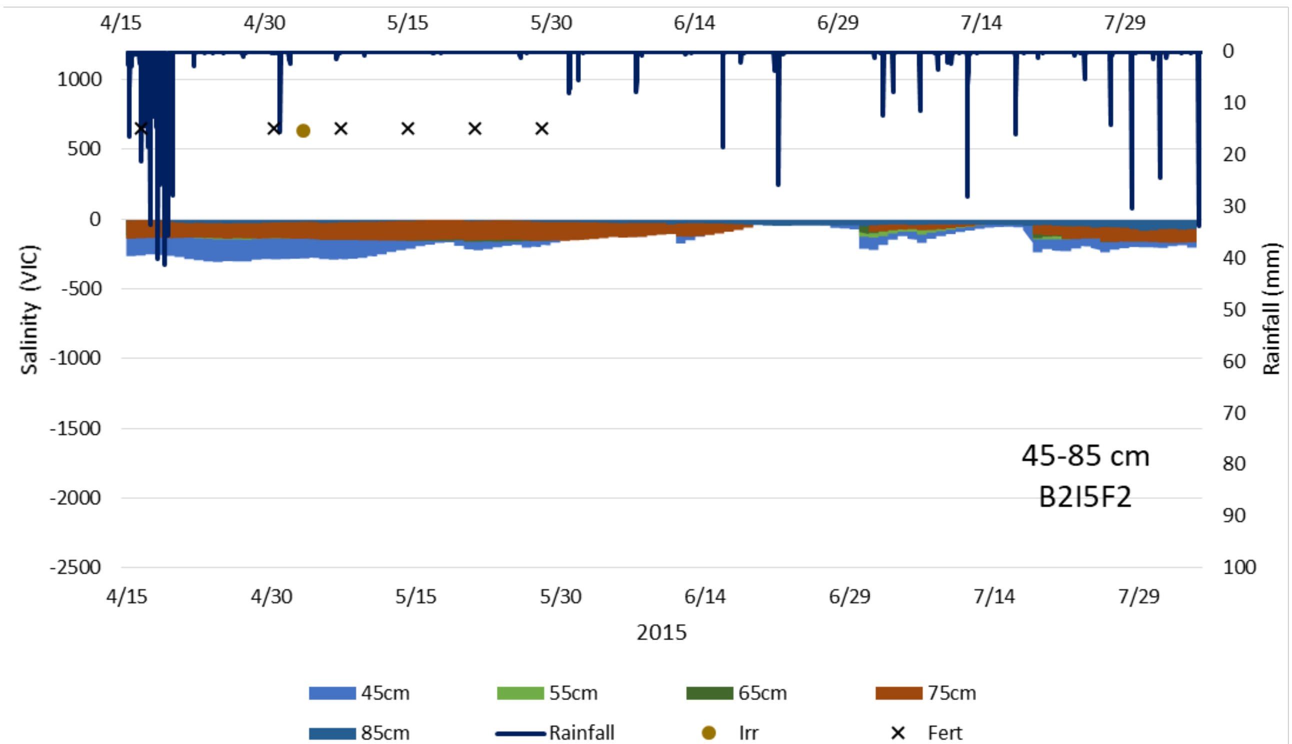
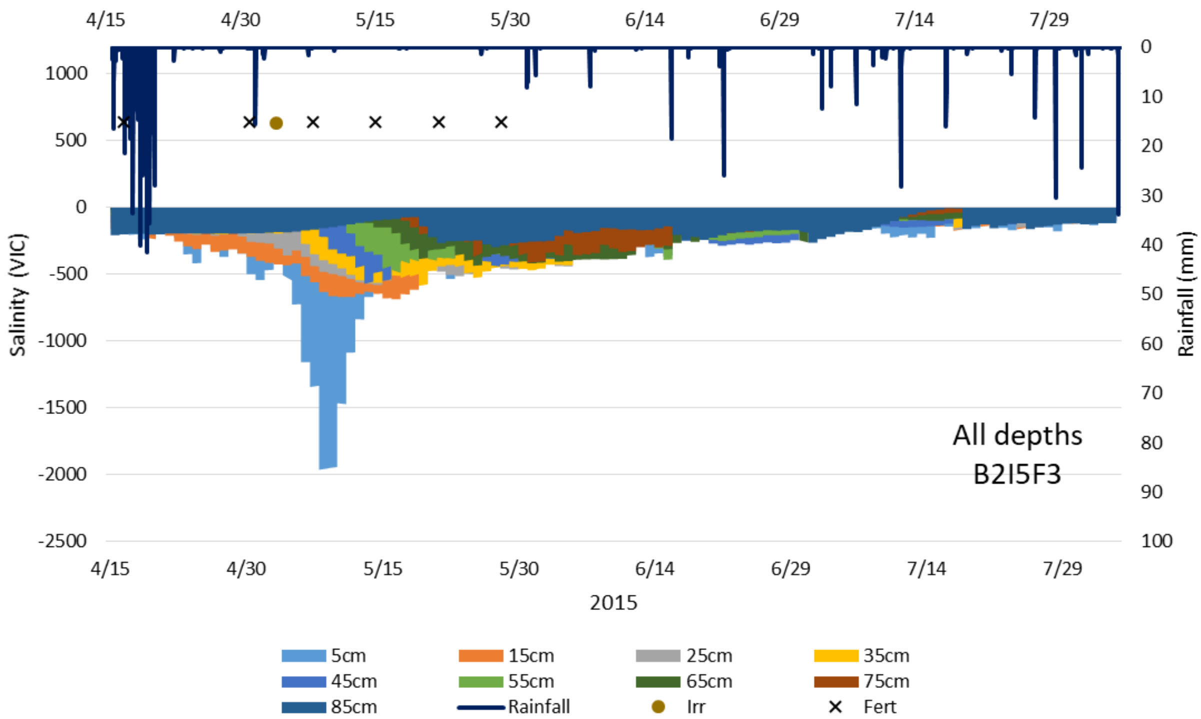


Figure 30. B2I5F2 (NON -220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.



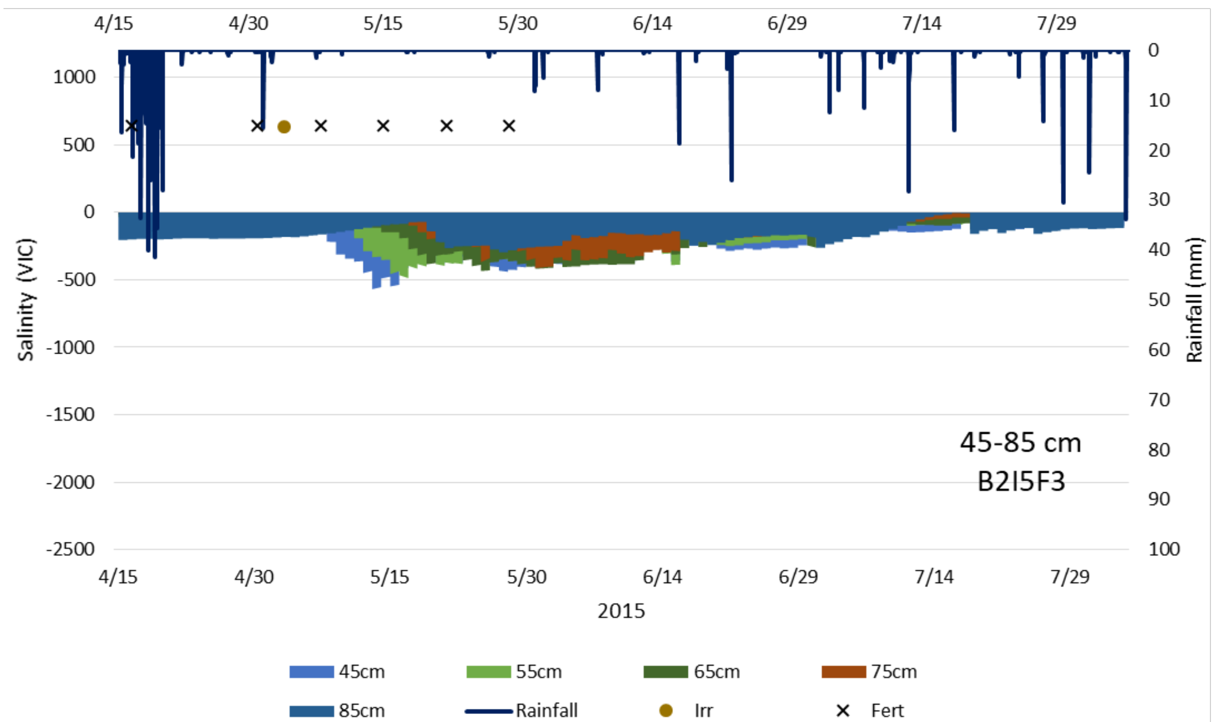
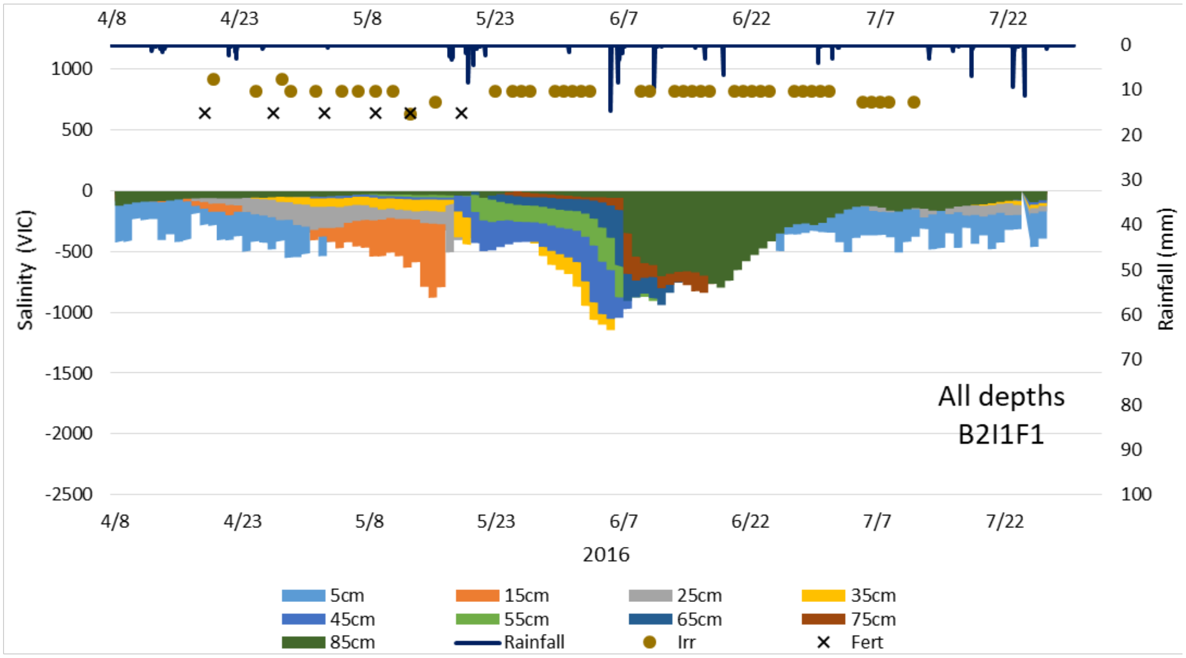


Figure 31. B3I5F3 (NO -140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2015 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 17 April until 29 May, 2015.

Corn 2016



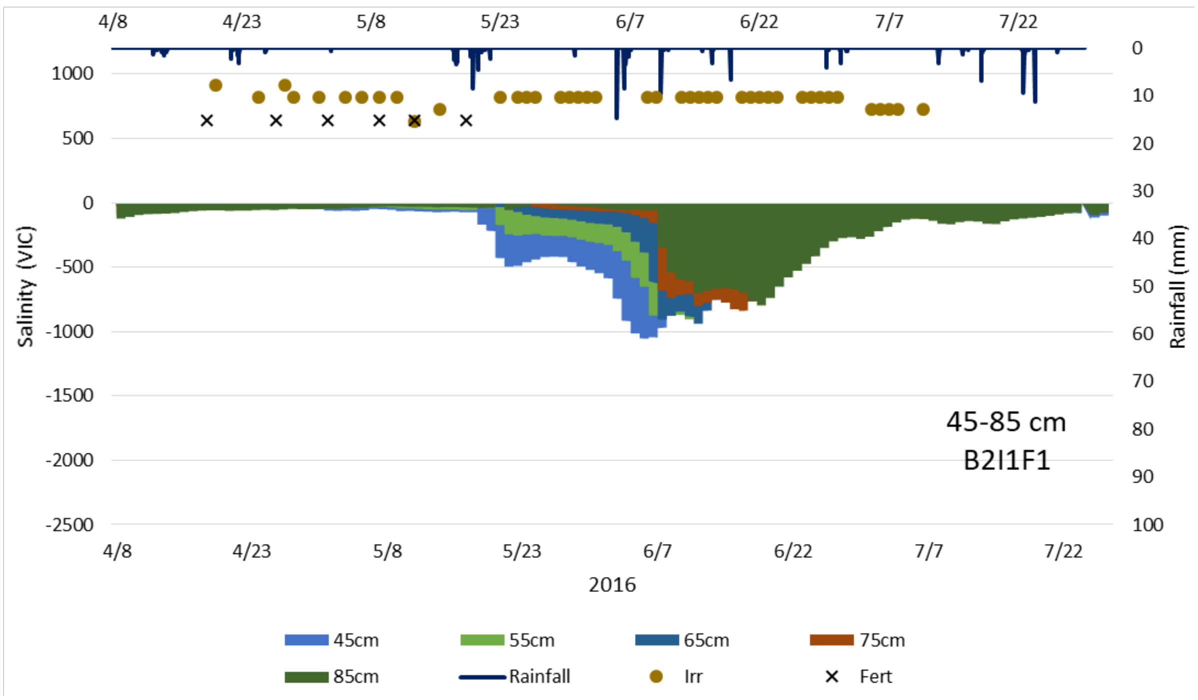
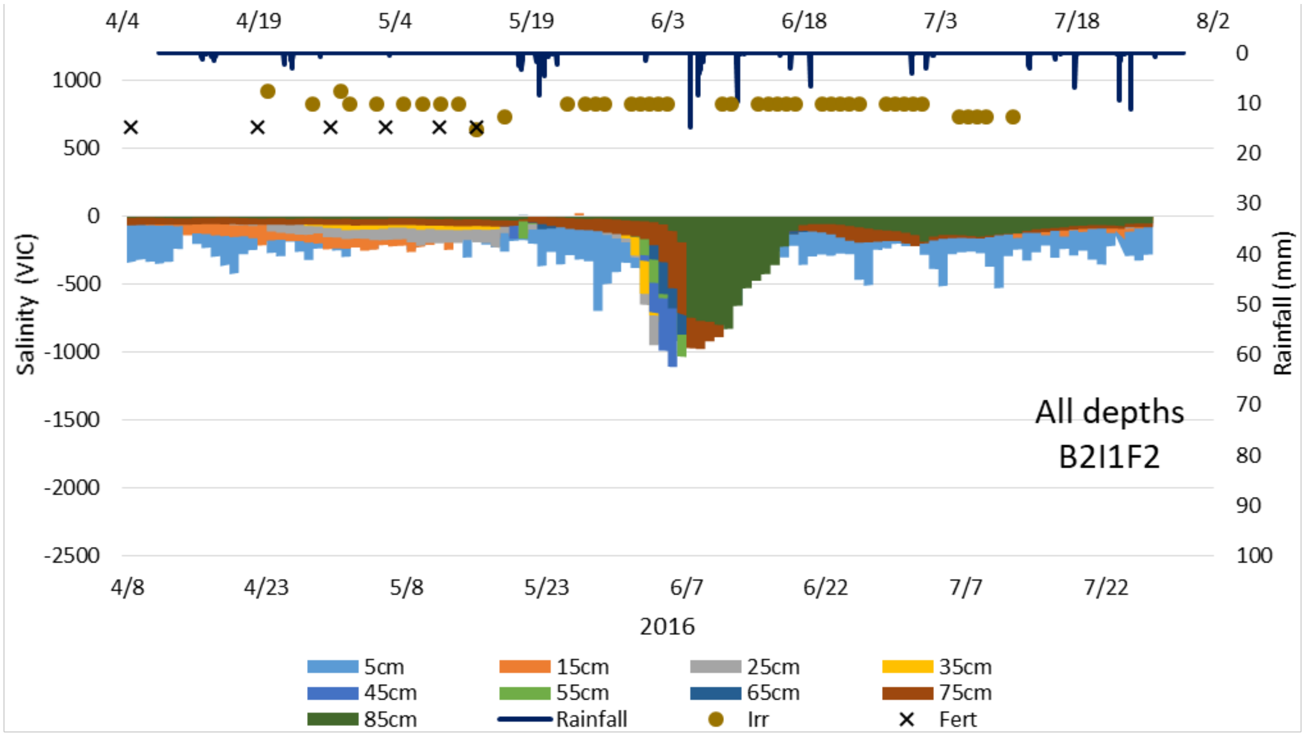


Figure 32. B2I1F1 (GROW-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



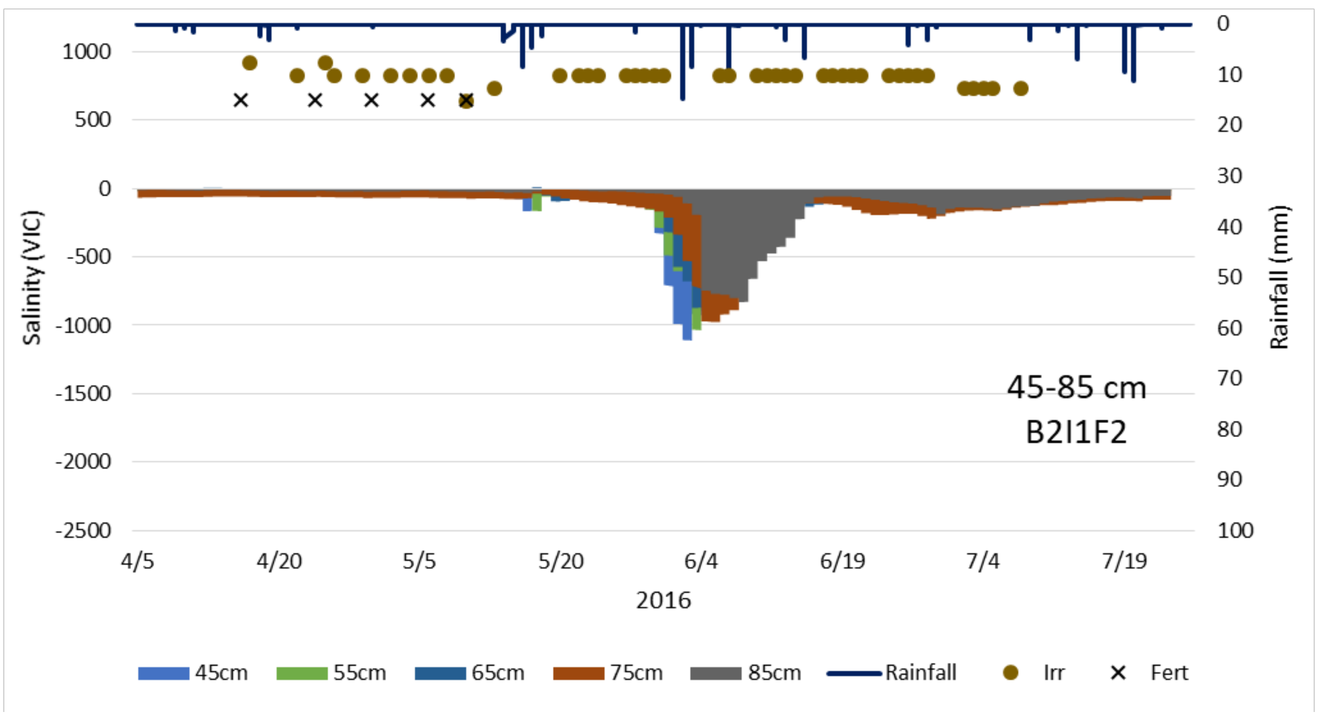
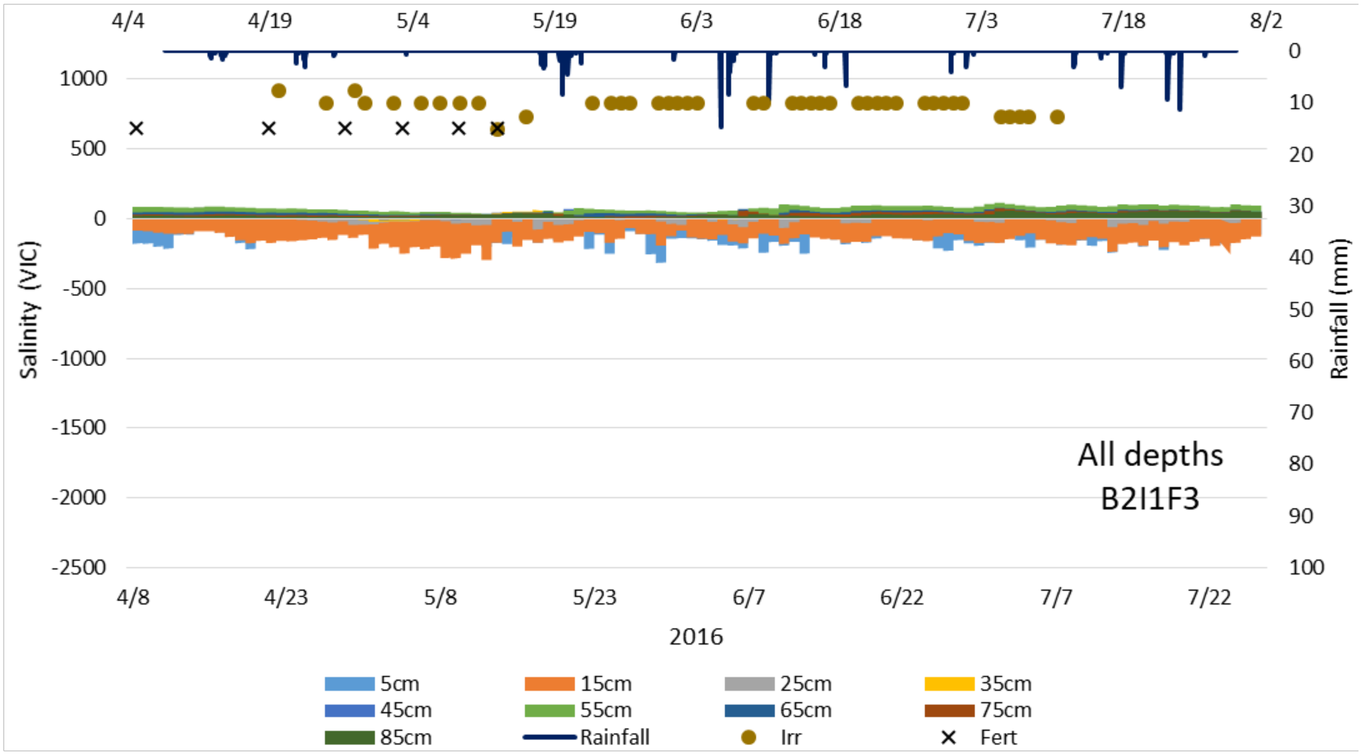


Figure 33. B2I1F1 (GROW-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



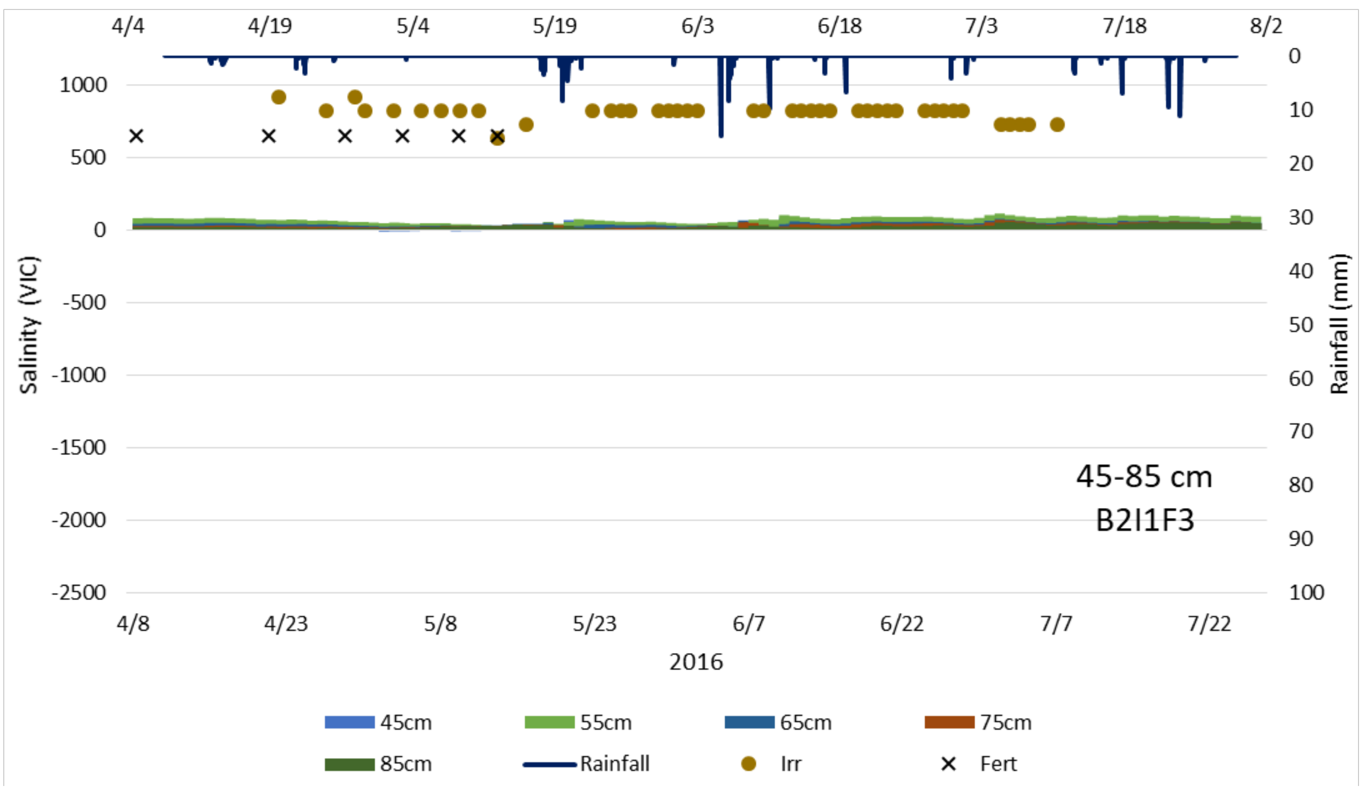
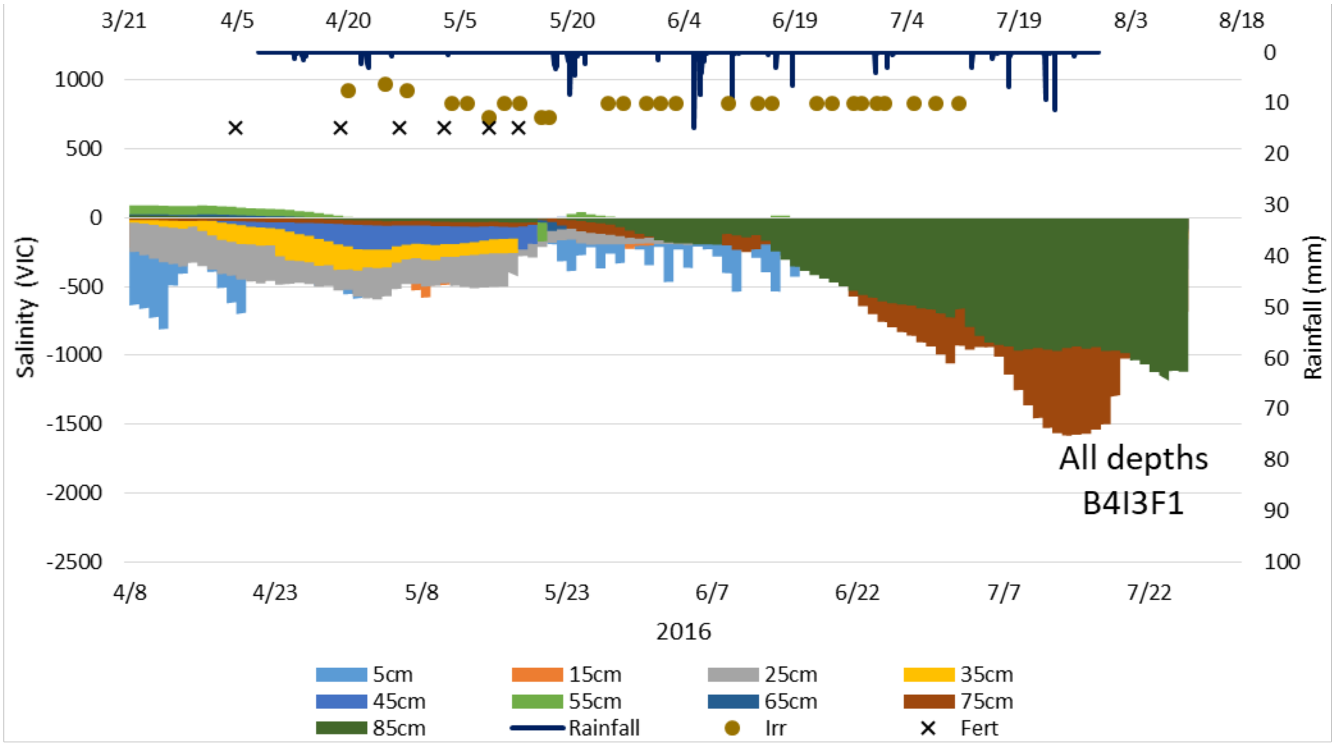


Figure 34. B2I1F1 (GROW-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



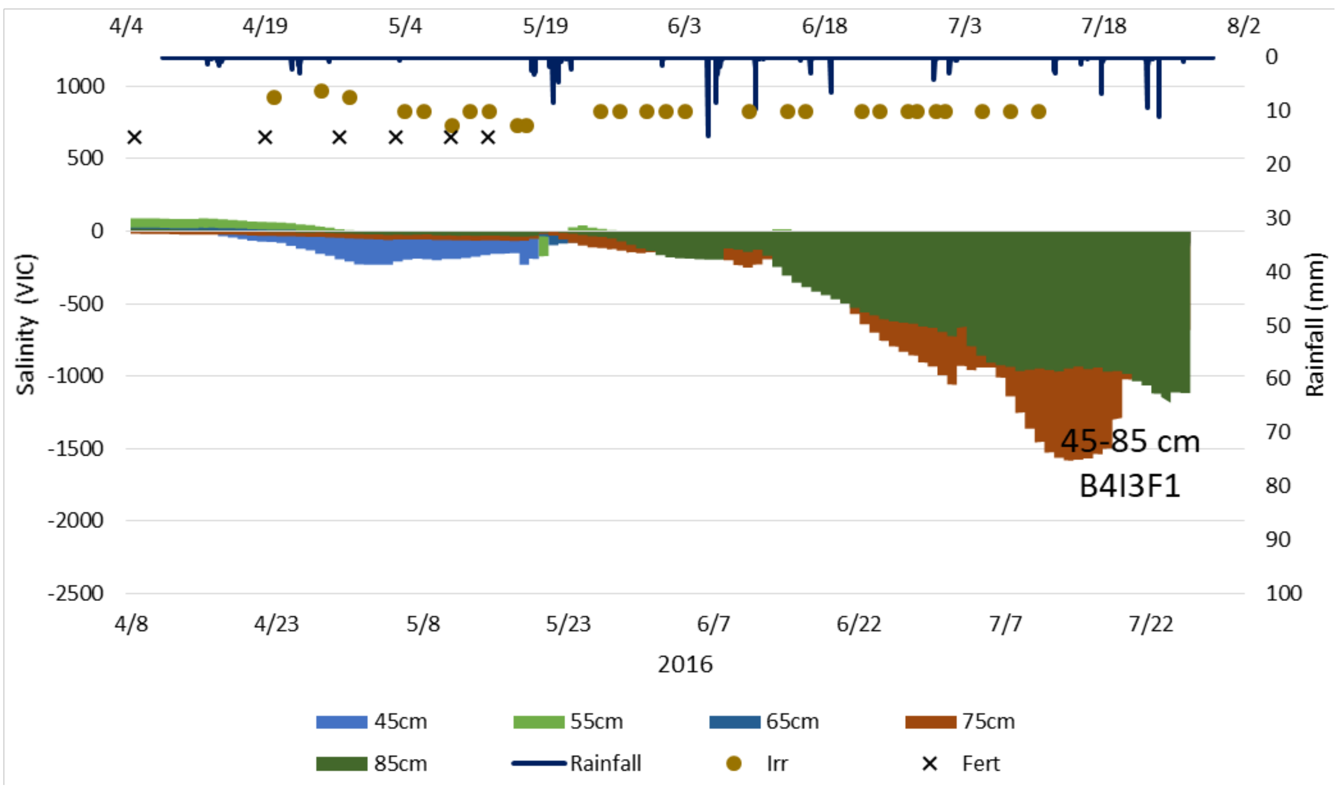
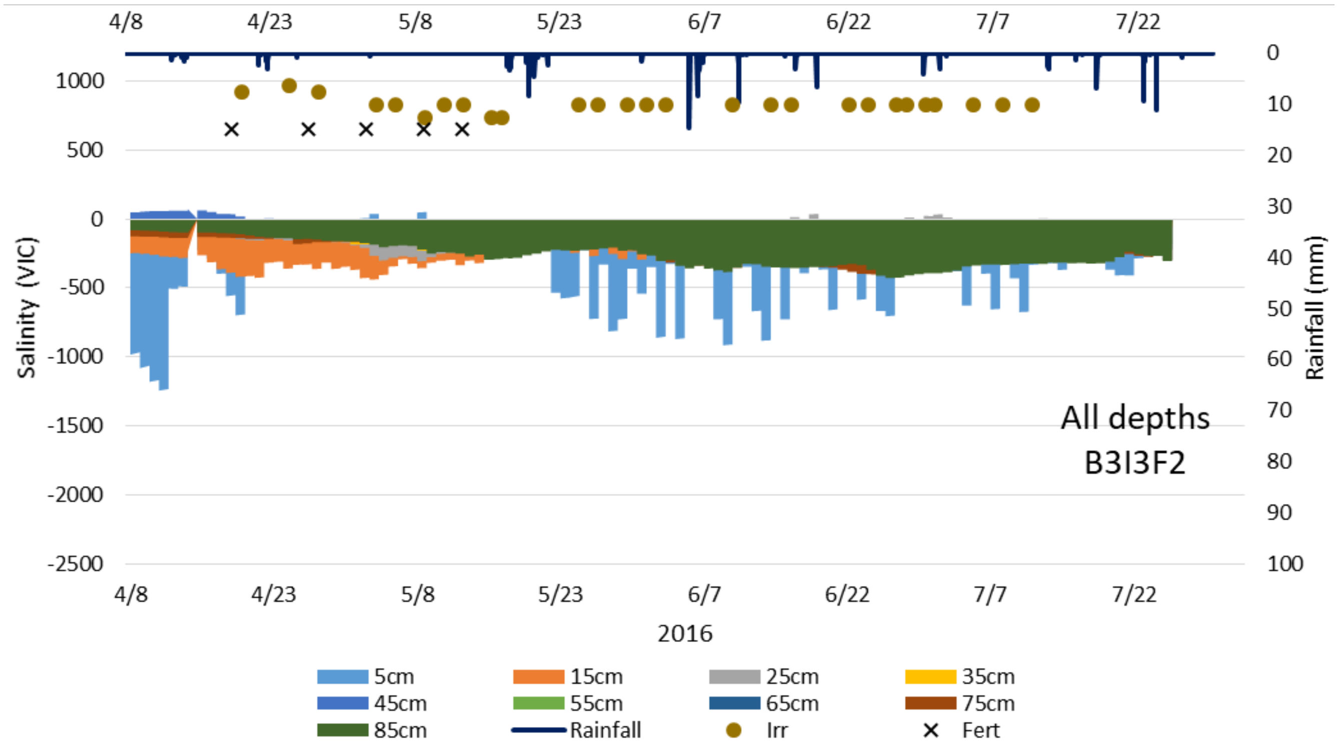


Figure 35. B4I3F1 (SMS-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



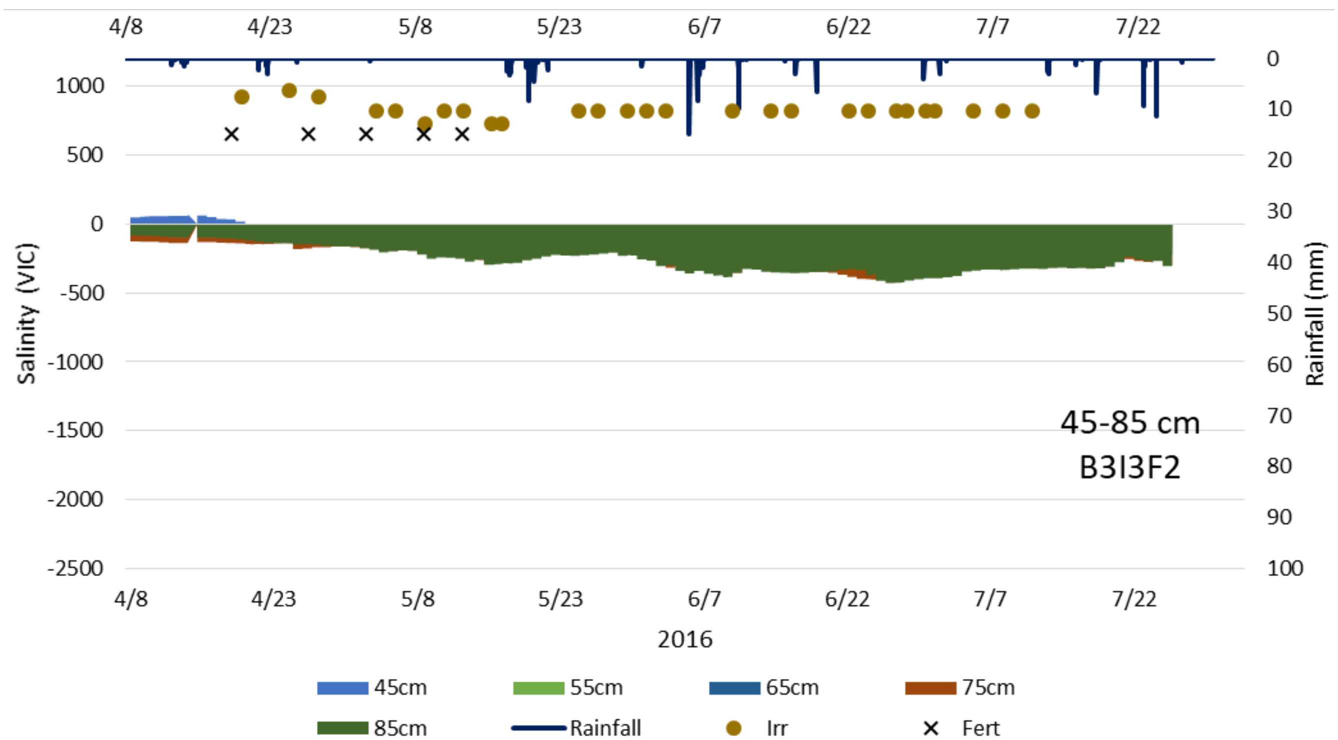
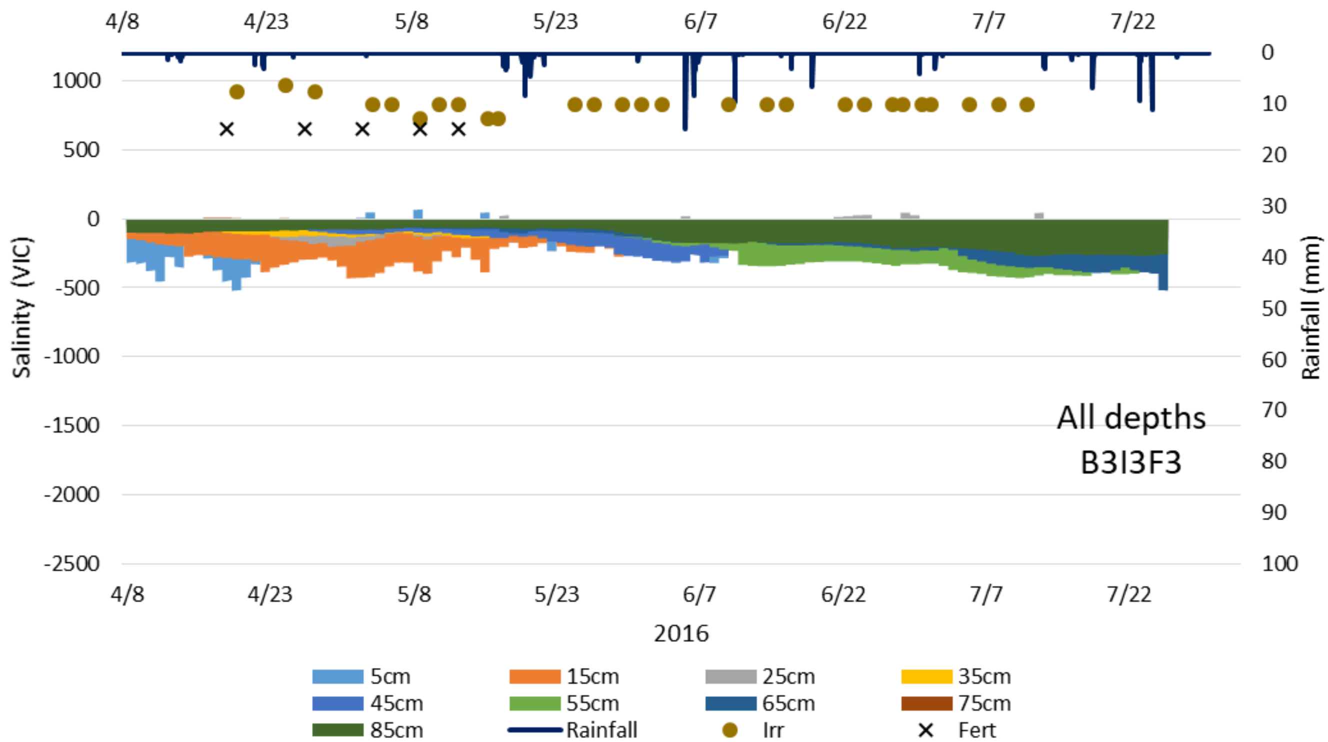


Figure 36. B3I3F2 (SMS-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



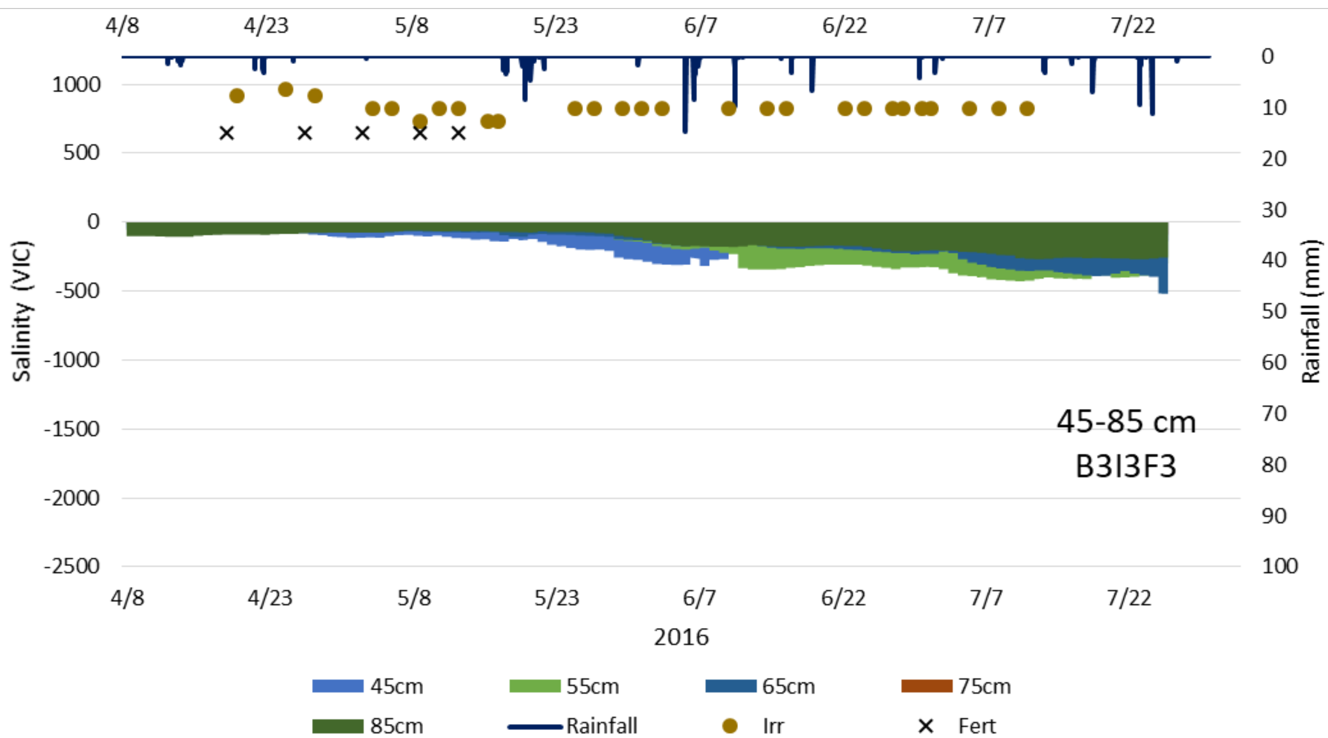
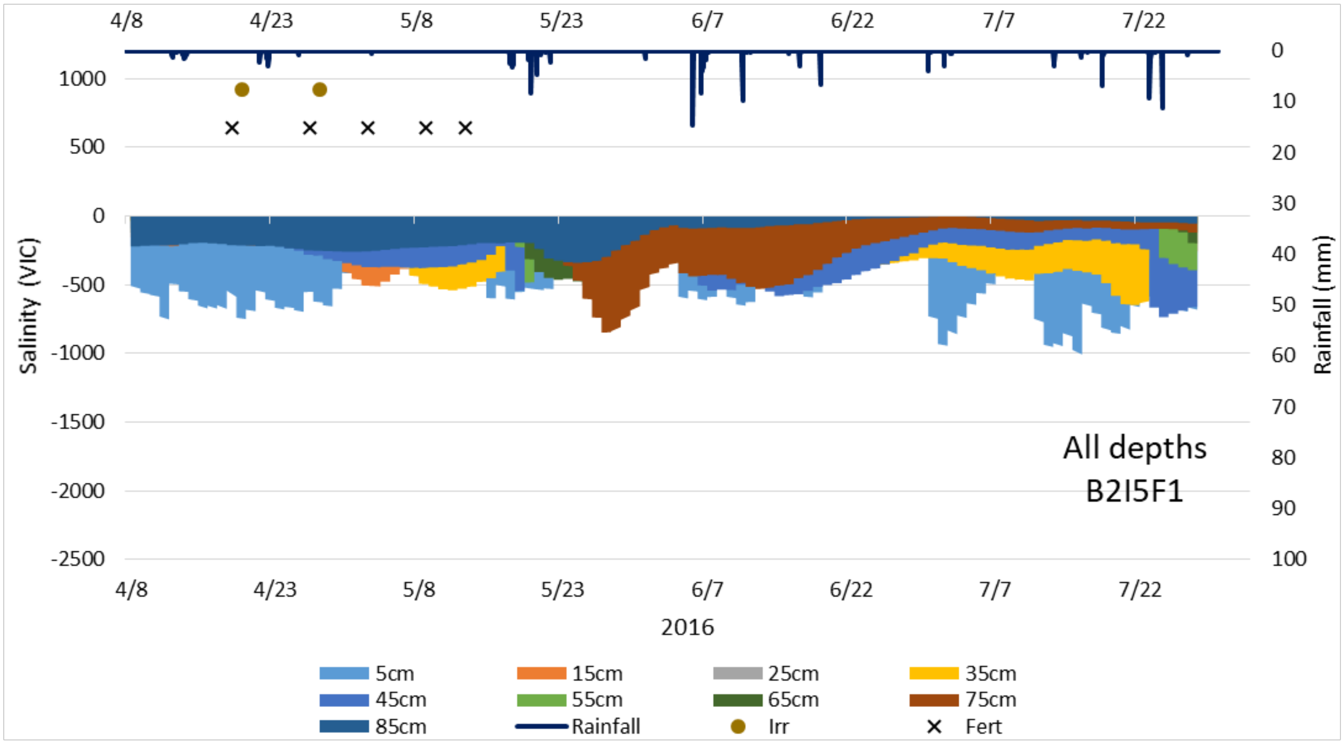


Figure 37. B3I3F3 (SMS-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



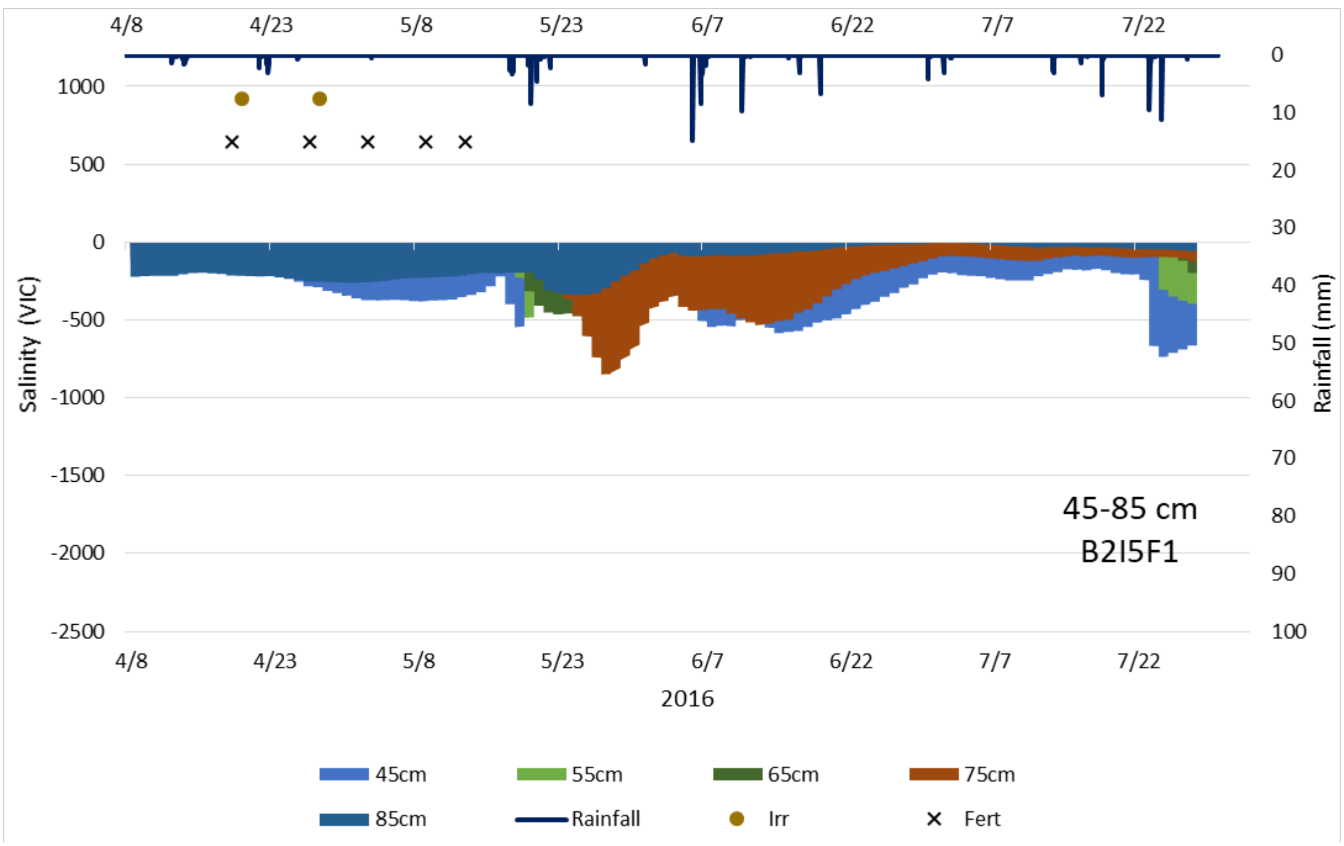
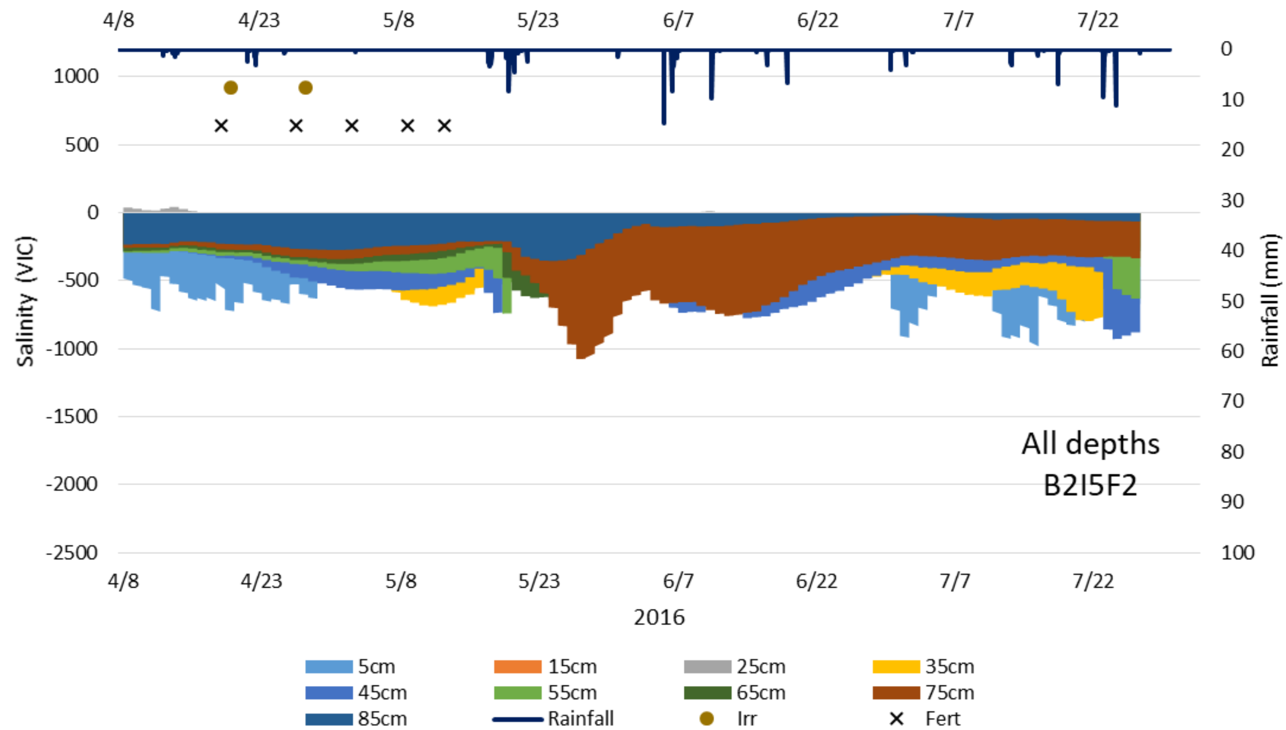


Figure 38. B2I5F1 (NON-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



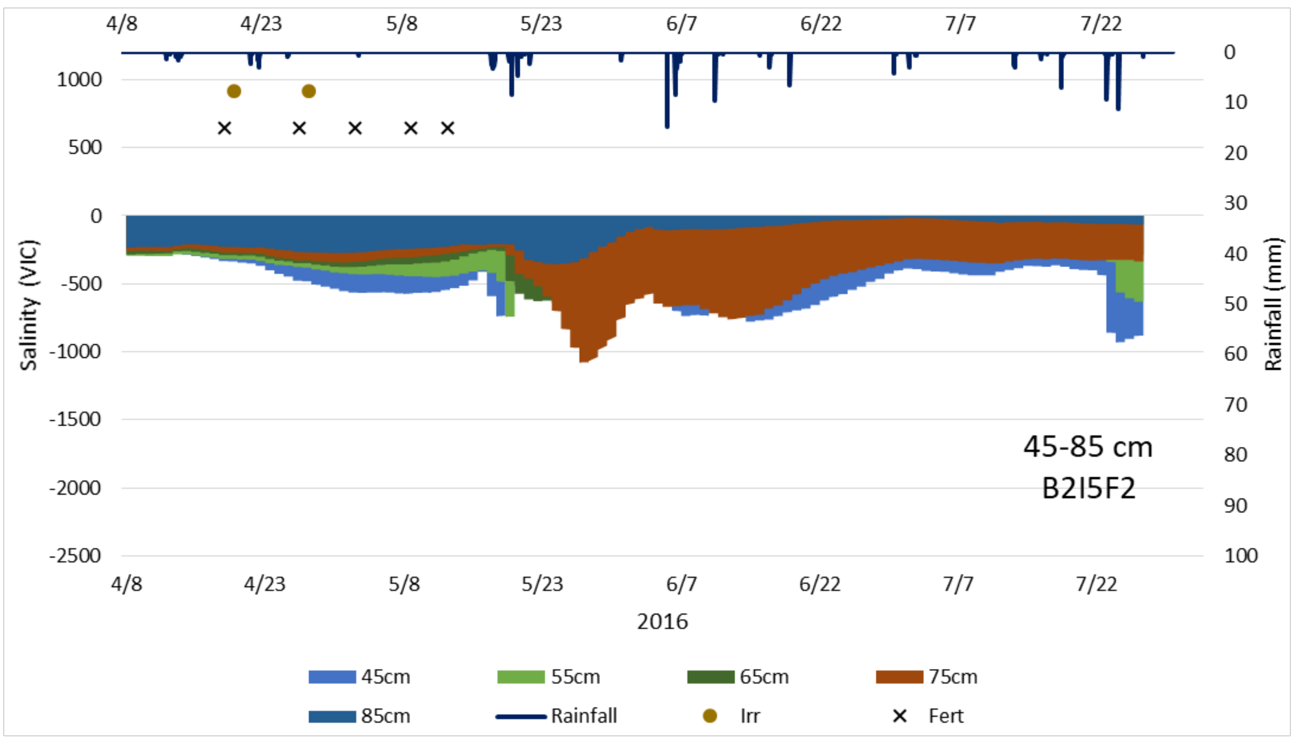
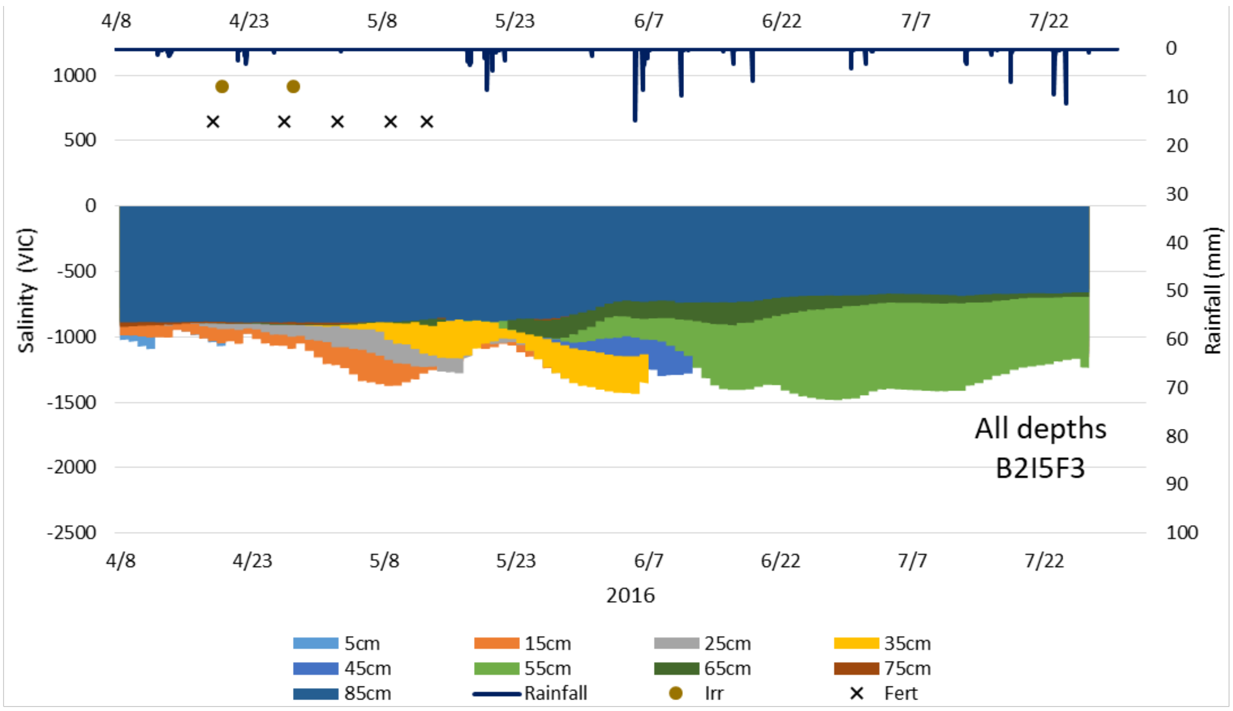


Figure 39. B2I5F2 (NO-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.



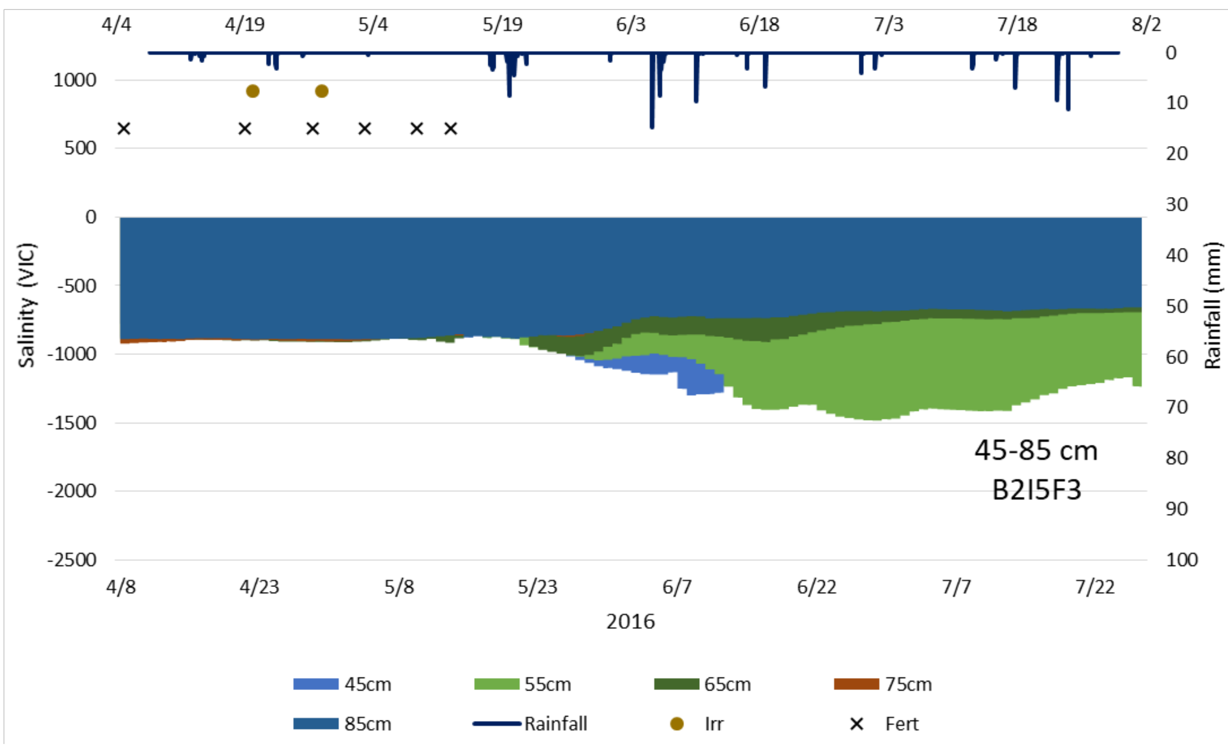
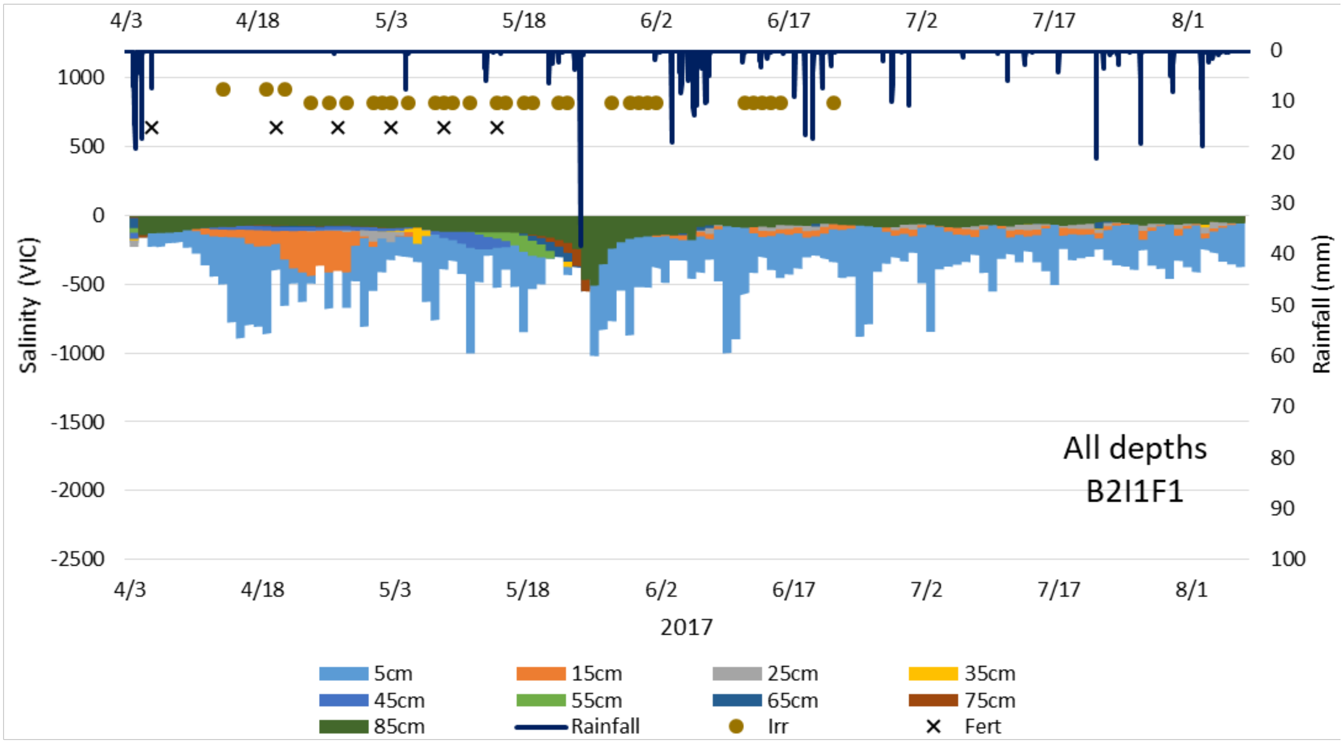


Figure 40. B2I5F3 (NON-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2016 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 5 April until 19 May, 2016.

Corn 2017



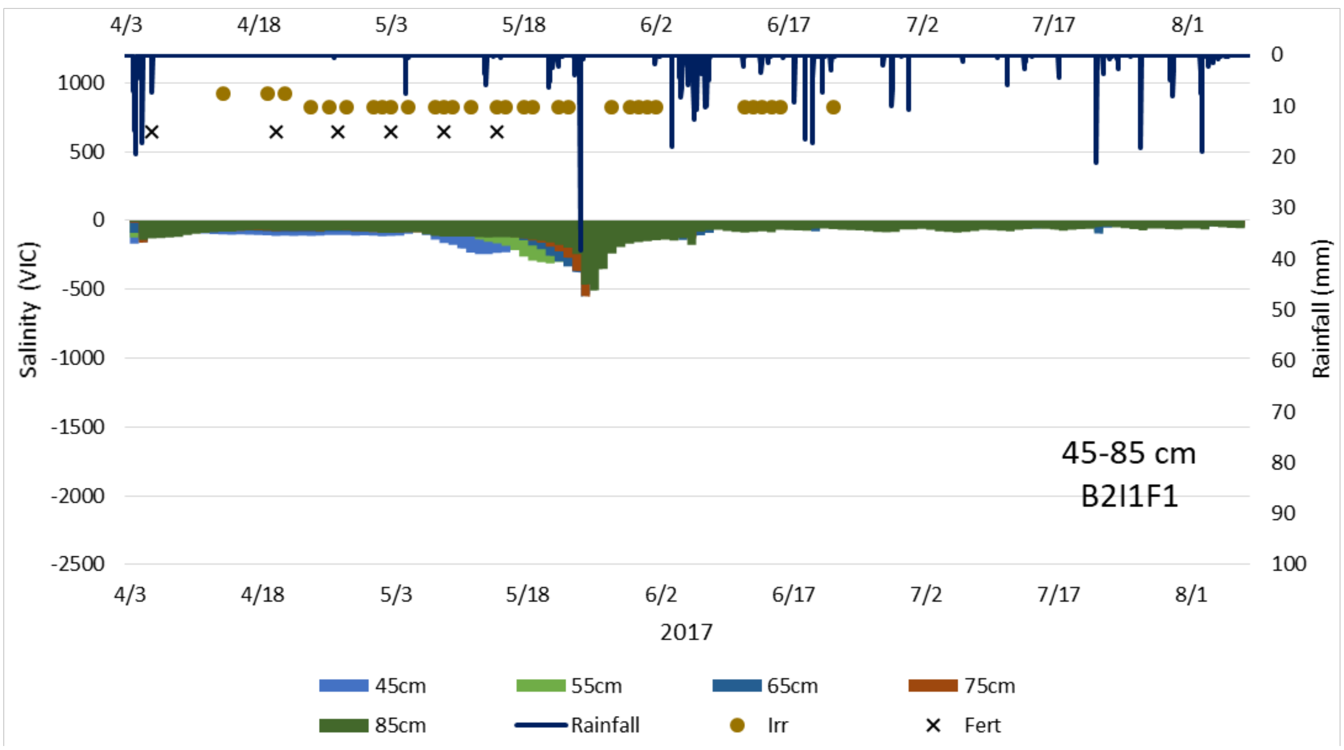
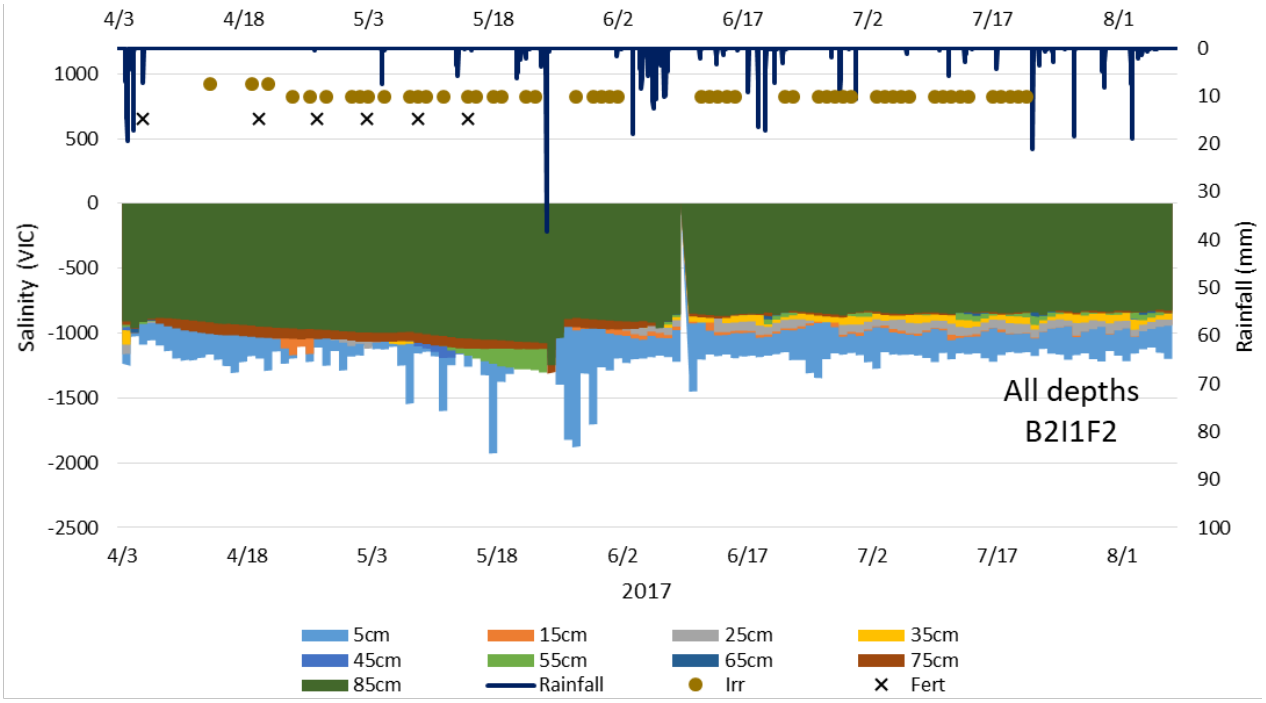


Figure 41. B2I1F1 (GROW-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



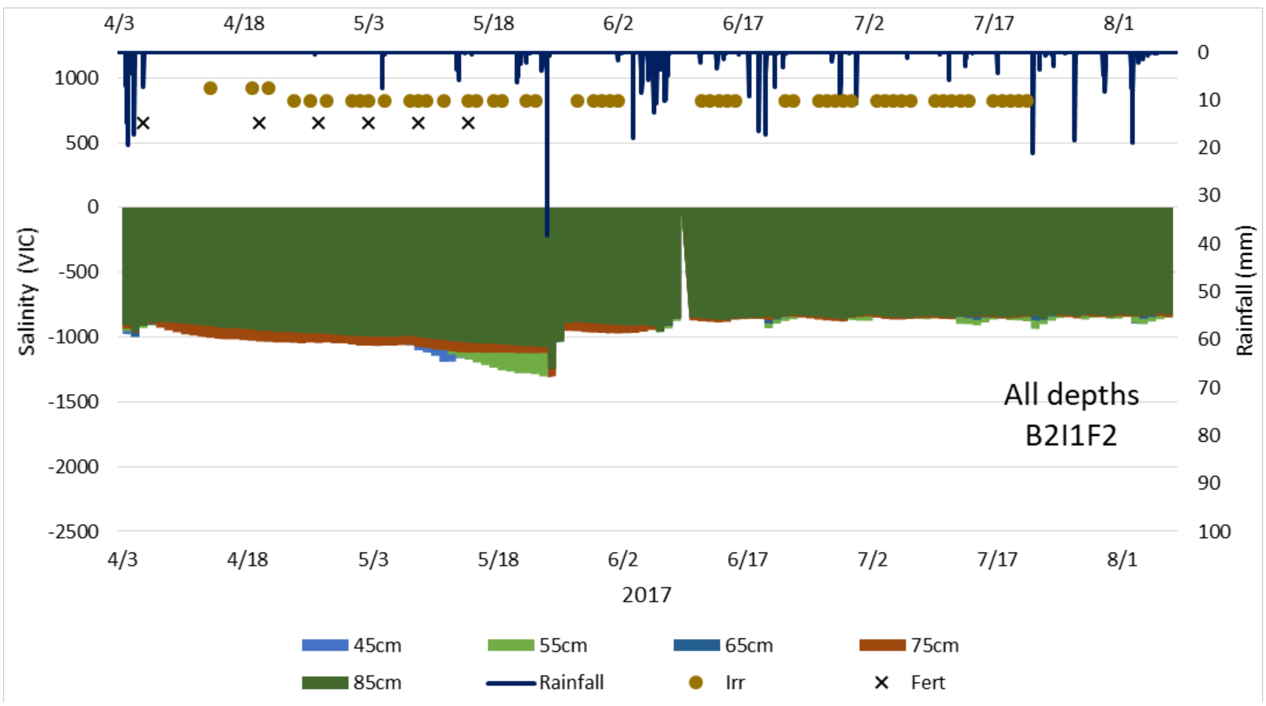
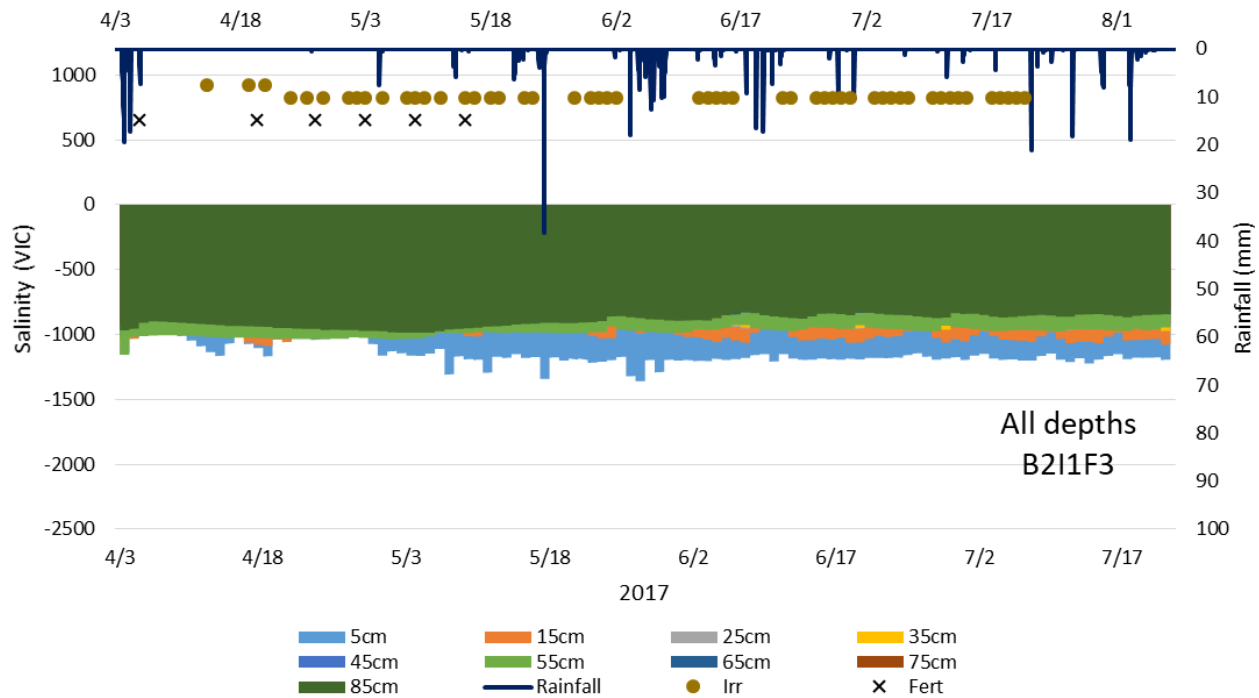


Figure 42. B2I1F2 (GROW-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



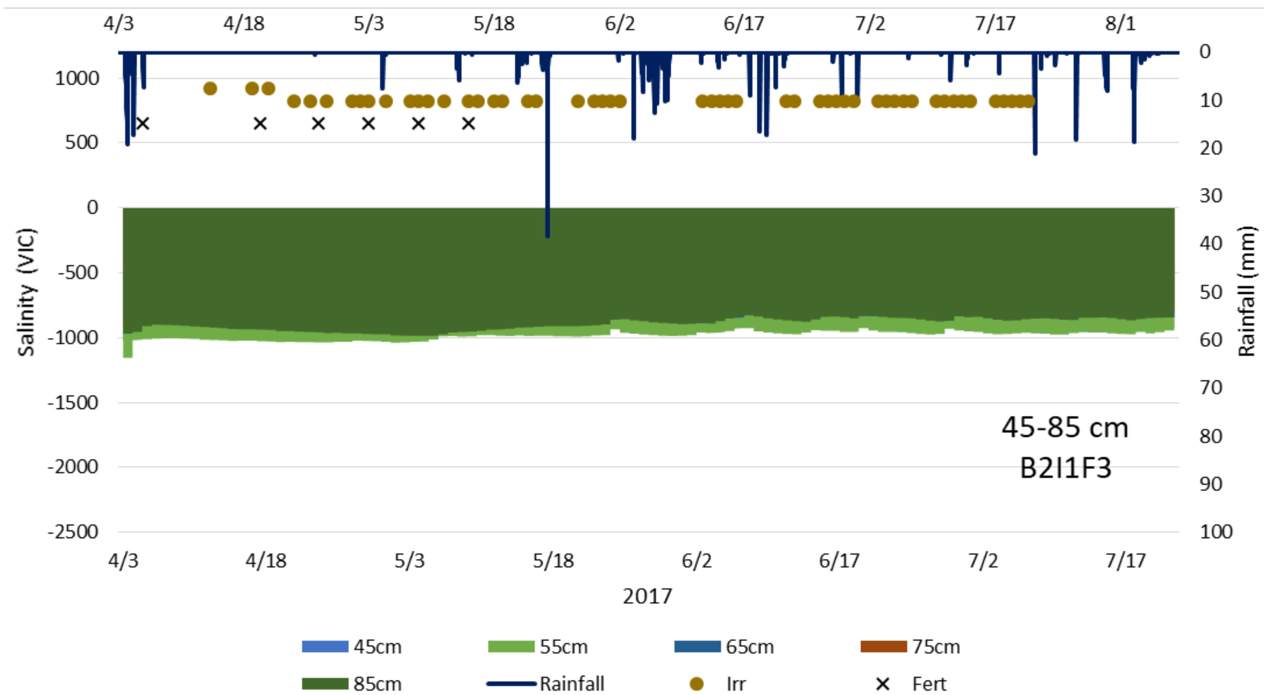
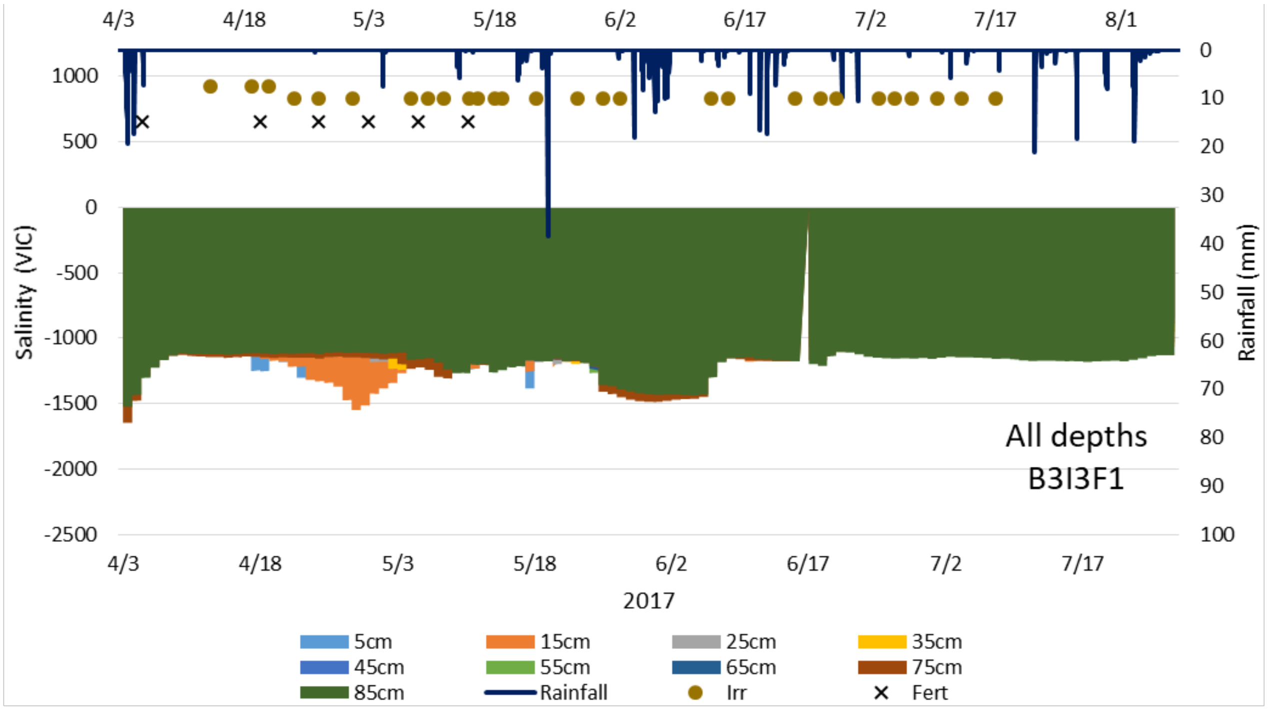


Figure 43. B2I1F3 (GROW-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



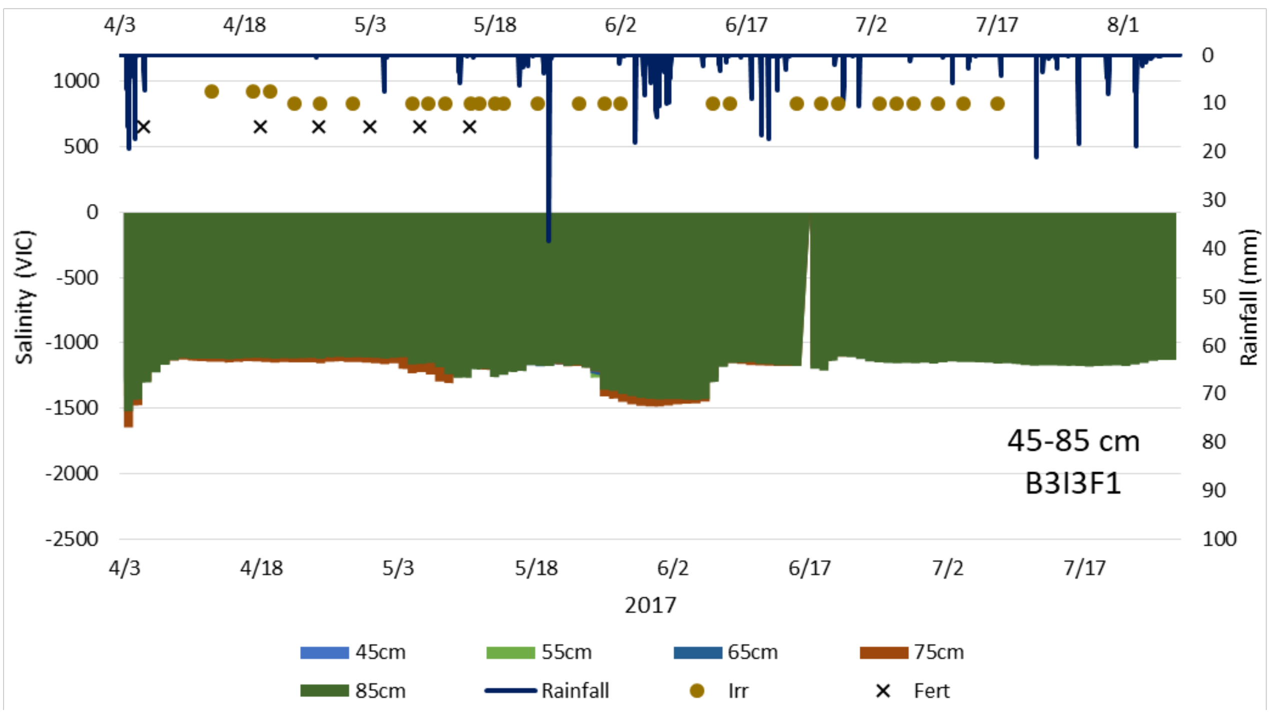
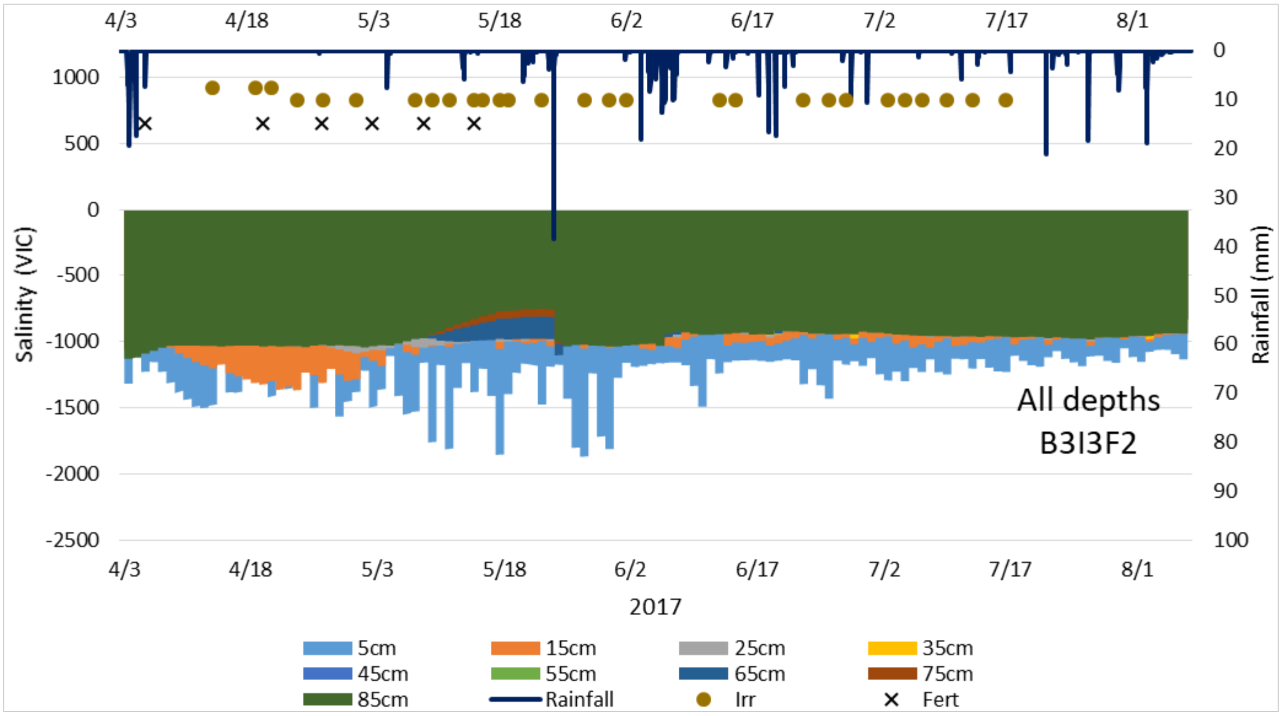


Figure 44. B3I3F1 (SMS-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



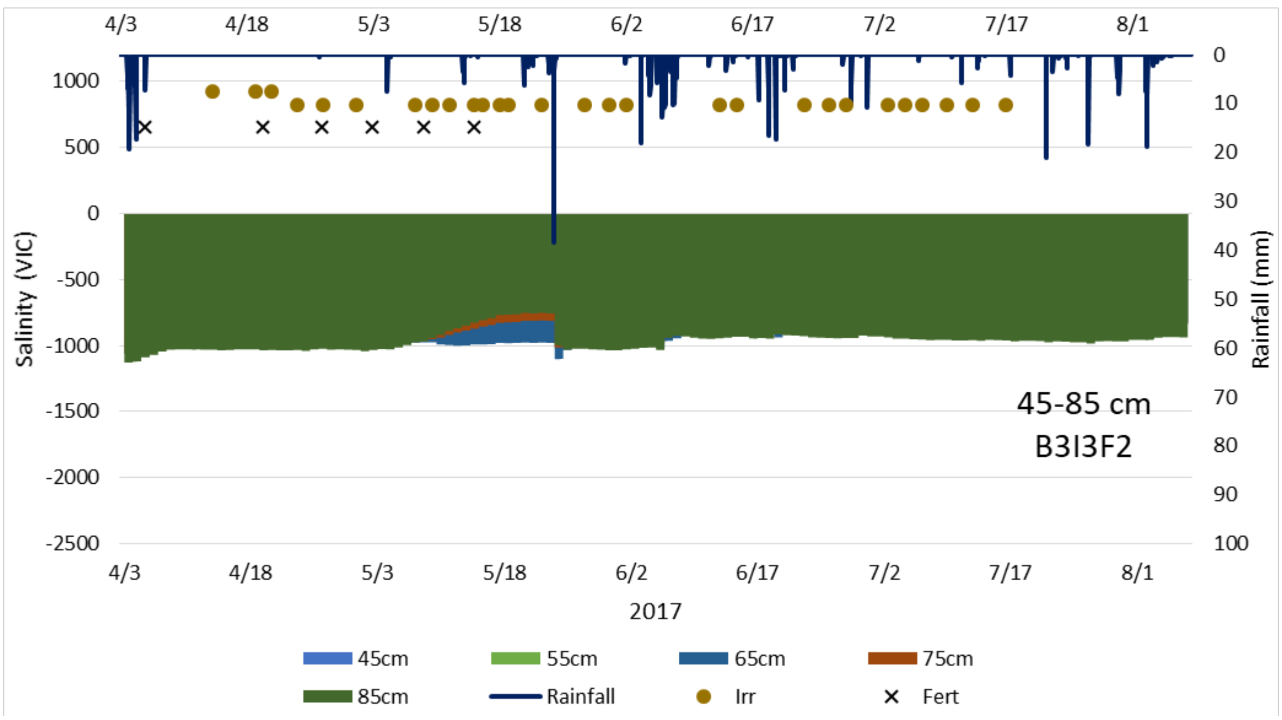
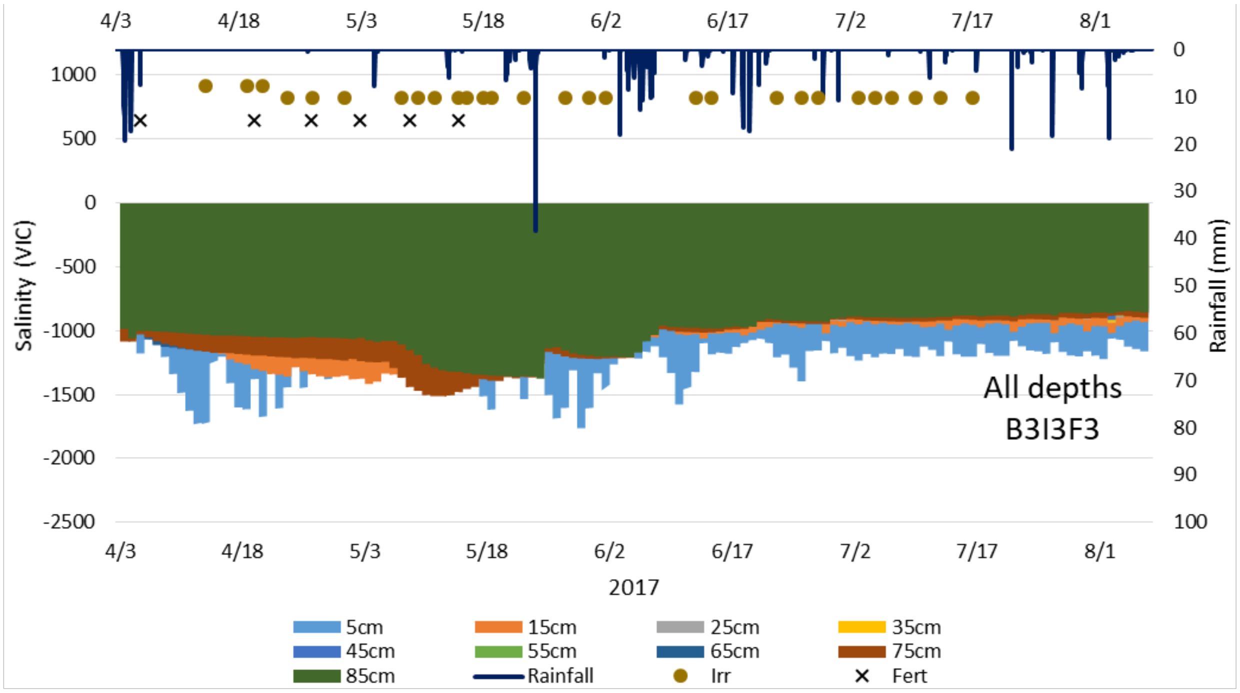


Figure 45. B3I3F2 (SMS-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



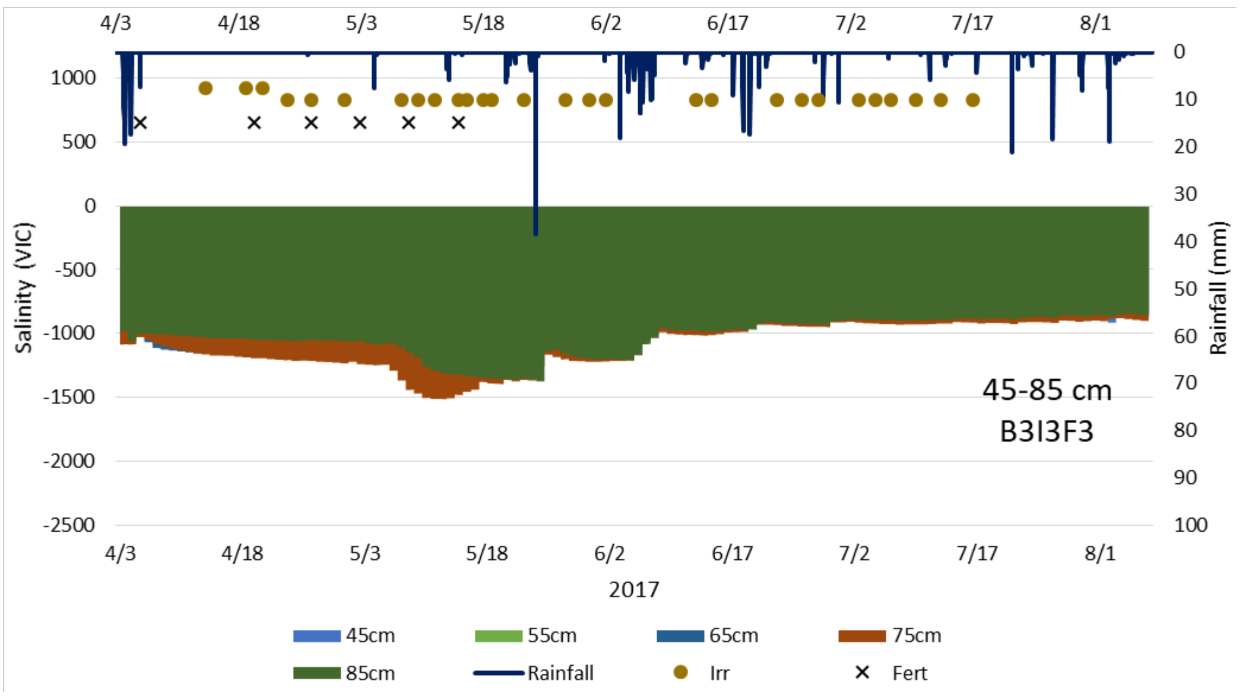
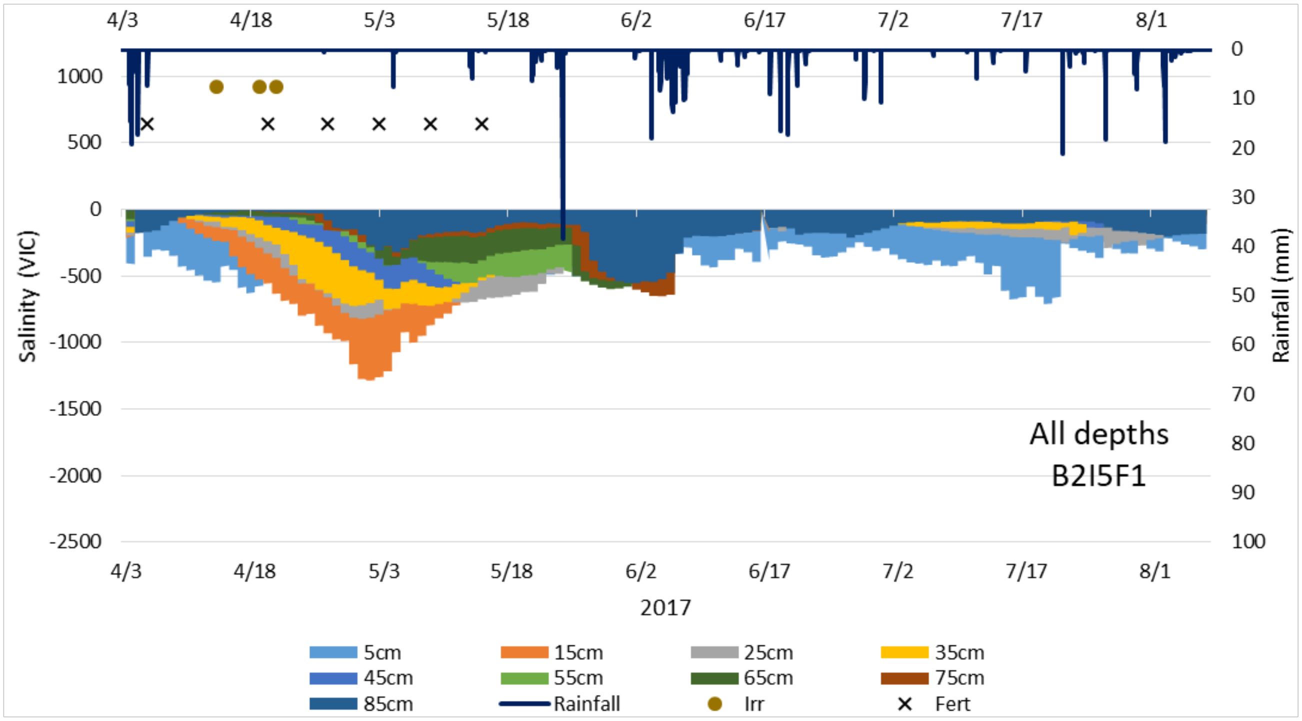


Figure 46. B3I3F3 (SMS-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



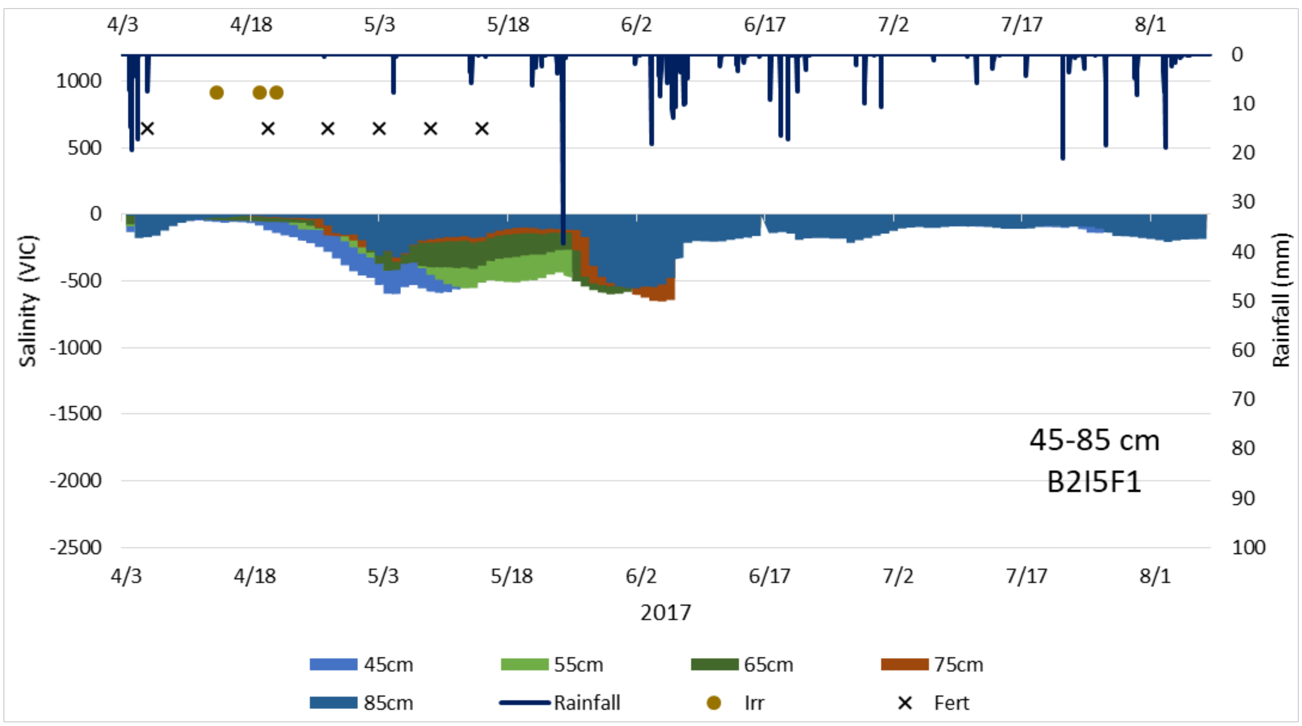
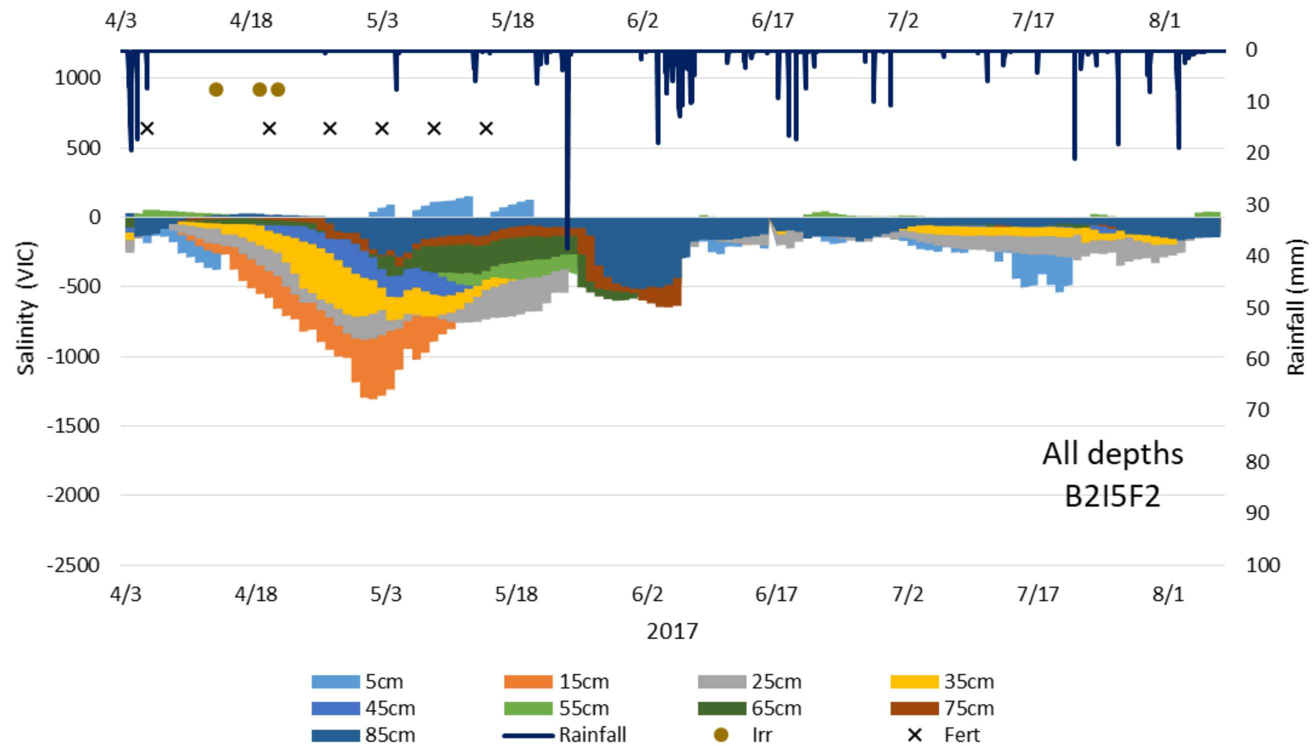


Figure 47. B2I5F1 (NON-300 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



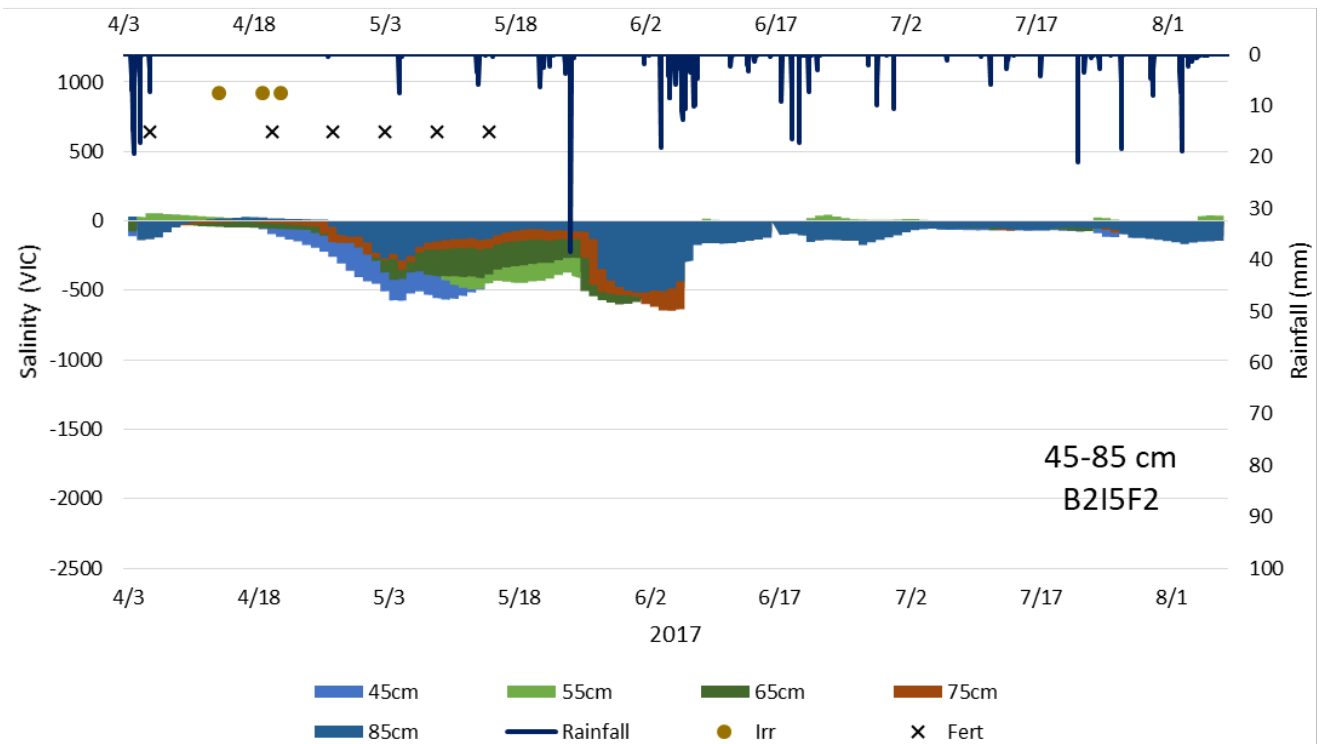
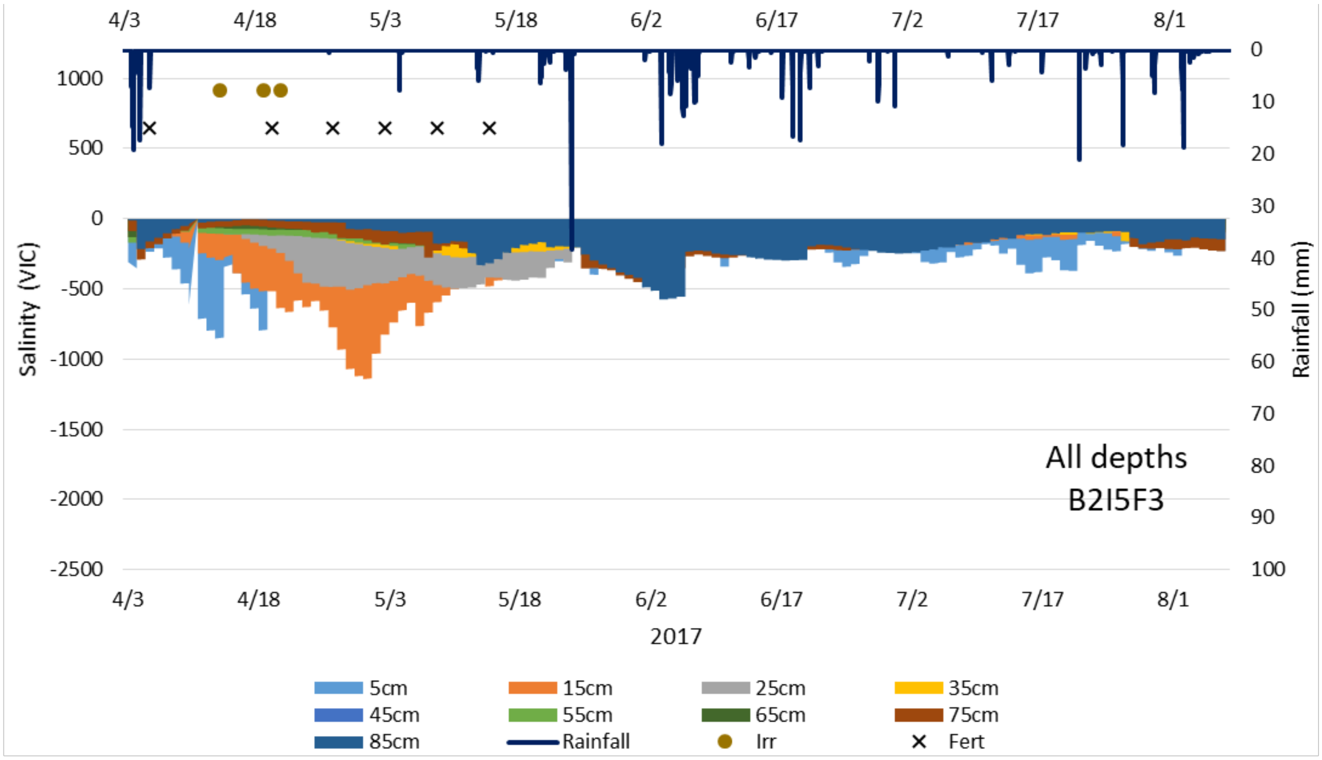


Figure 48. B2I5F2 (NON-220 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.



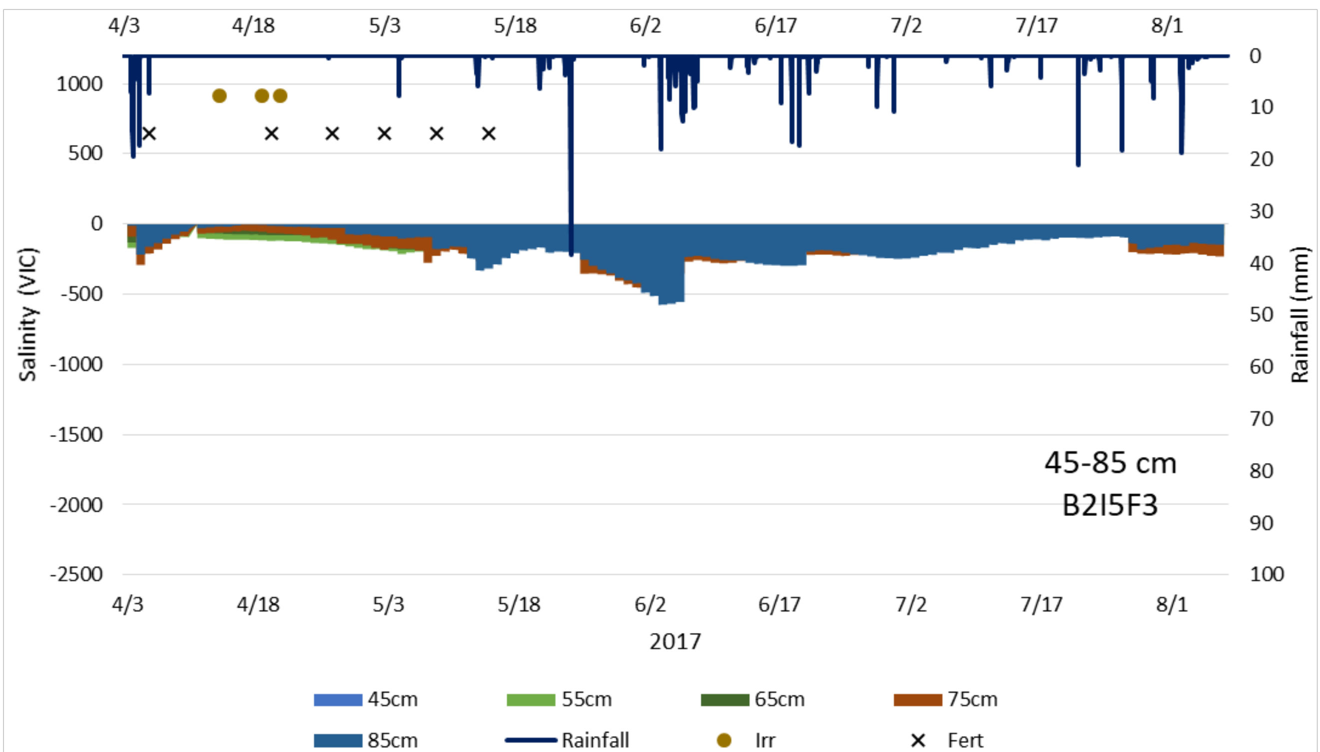
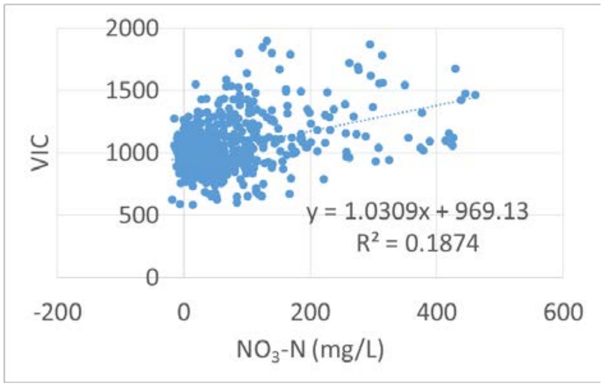
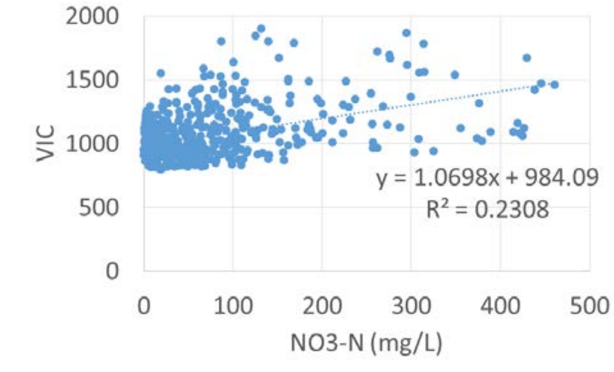


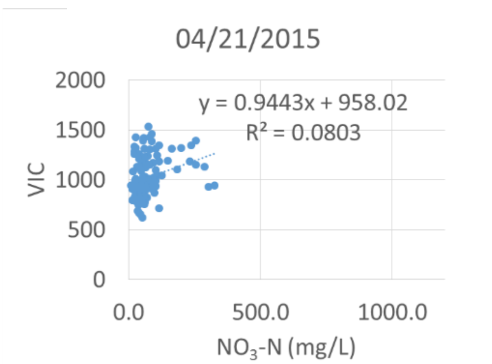
Figure 49. B2I5F3 (NON-140 lb N/ac) salinity data (VIC) (color areas) measured throughout the corn 2017 growing season at all depths (5-85 cm, top) and at the deepest layers (45-85 cm, bottom). Bars and dots denote daily rainfall and irrigation applied during the season. Symbols (X) denote granular and sidedress applications performed from 6 April until 15 May, 2017.

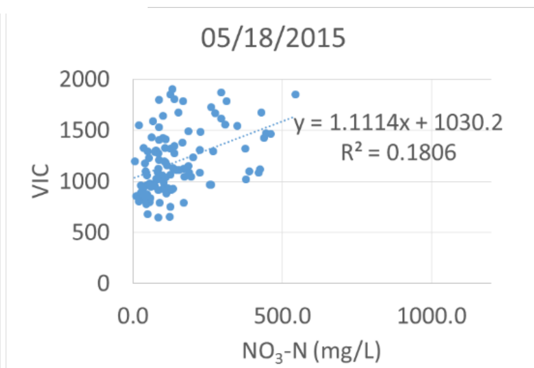
All data **Values >800VIC**

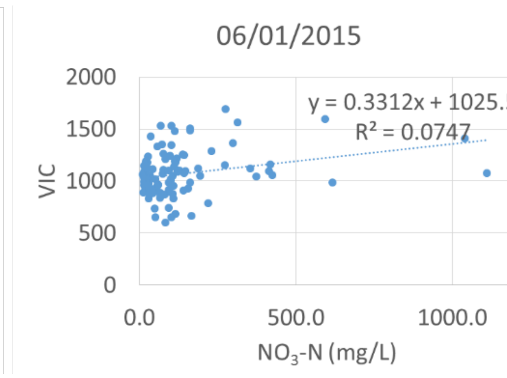




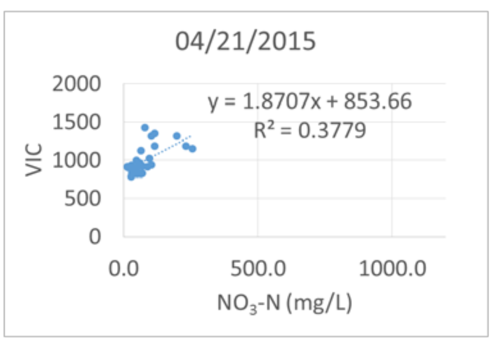
By sampling date

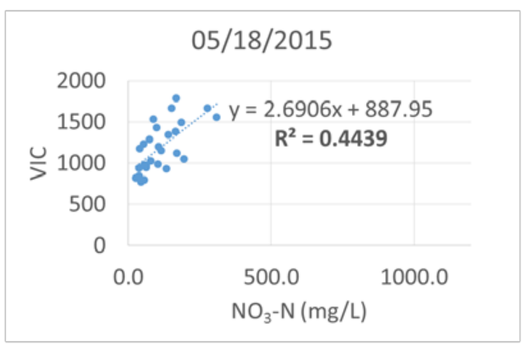






By fertility rate (F1) and depth 15-36 in





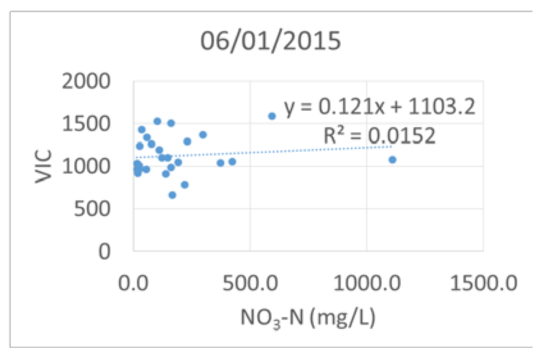


Figure 50. Correlation results between soil NO_3-N and salinity data (VIC) in corn 2015. Top left: all data, top right: values >800 VIC. Data segregation by sampling date and further by fertility and depth.

Leachate-N

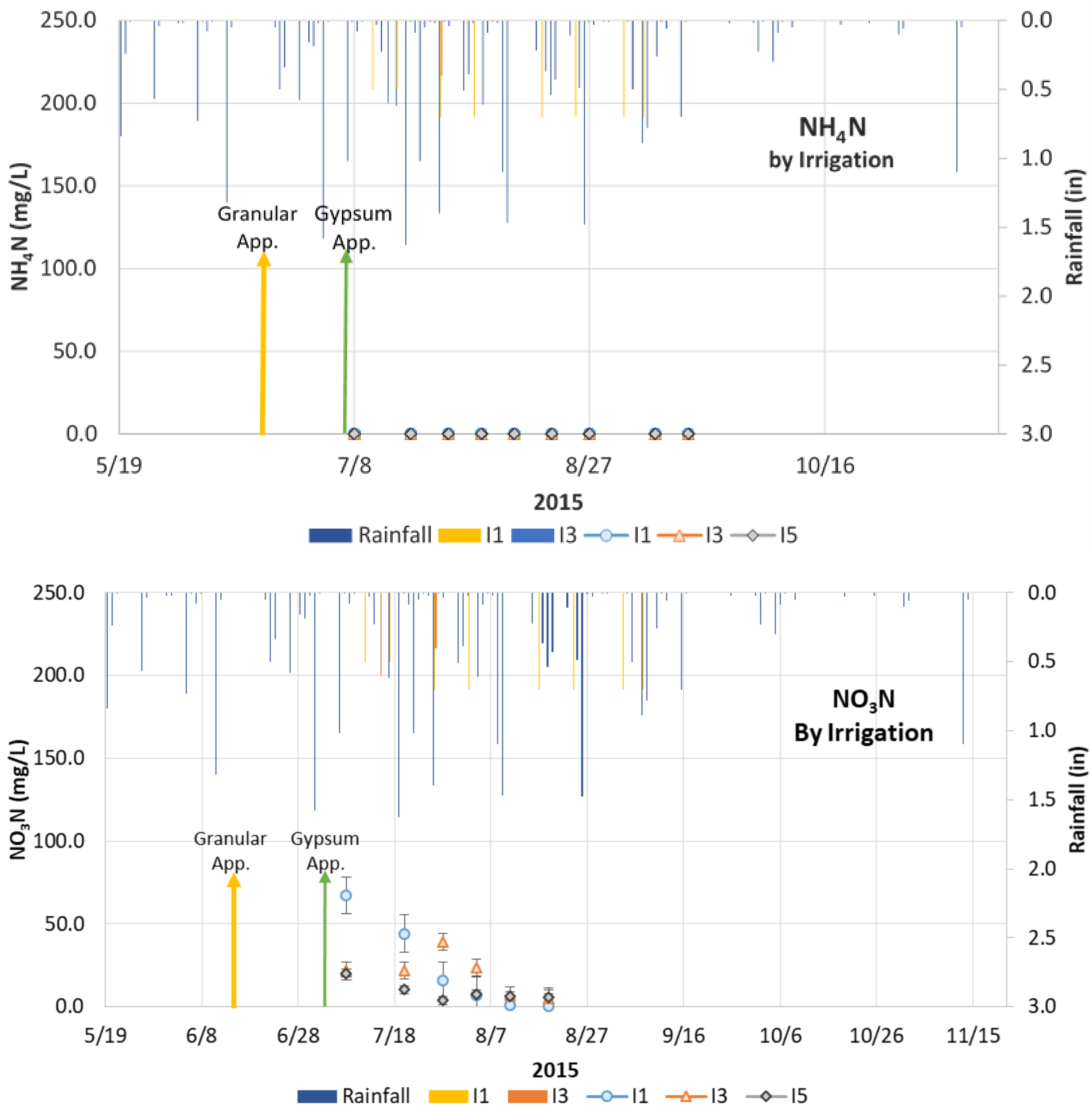


Figure 51. Average lysimeter leachate NH_4-N and NO_3-N concentrations (top and bottom) per irrigation obtained in peanut, 2015. Bars show daily rainfall and irrigation events per treatment. Dots are NH_4-N and NO_3-N results from each irrigation treatment. Green and yellow arrows represent the granular application (3-7-28 @ 500 lb/ac) and gypsum application (@ 2000 lb/ac). Error bars show SE of NH_4-N means.

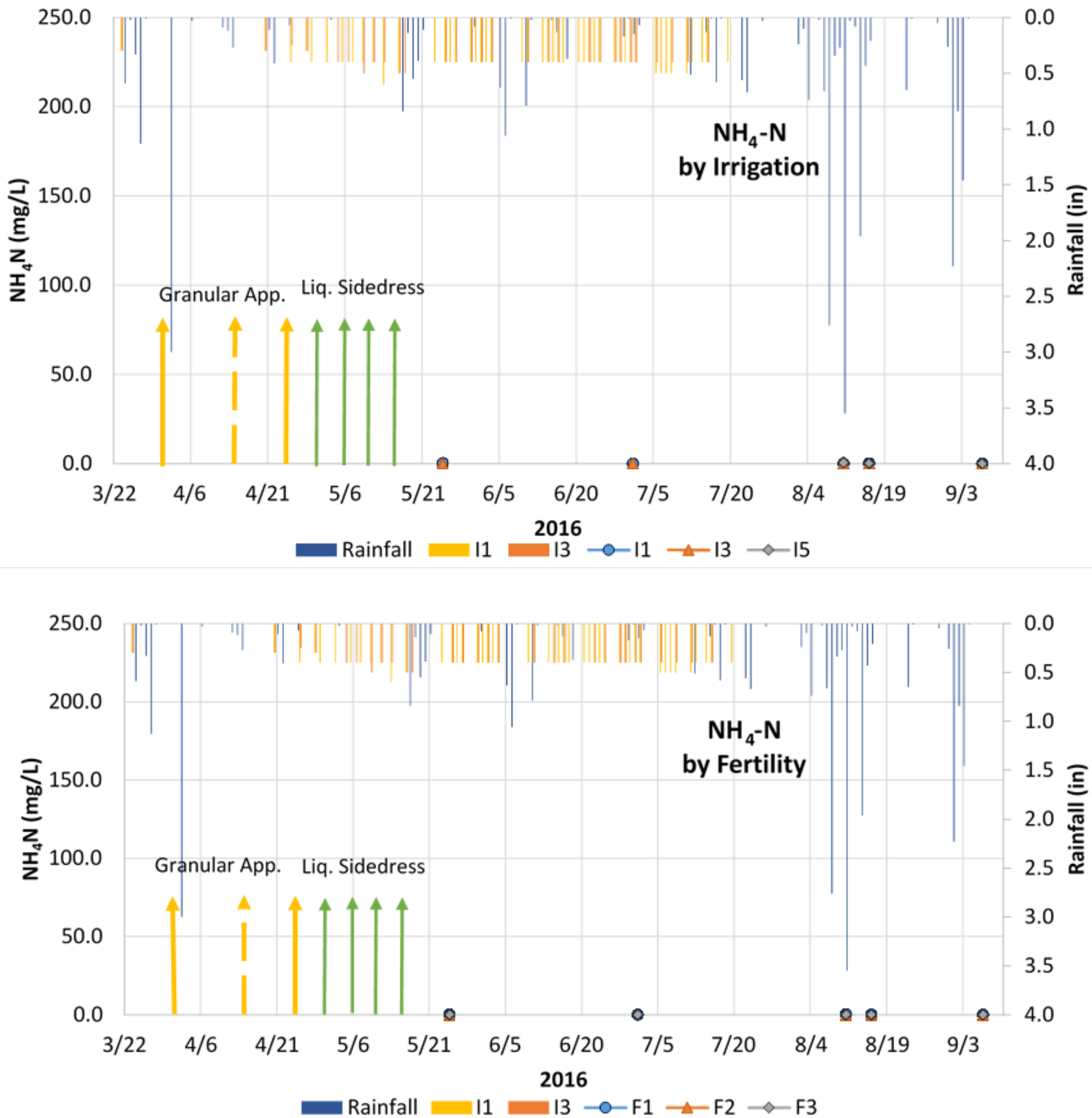
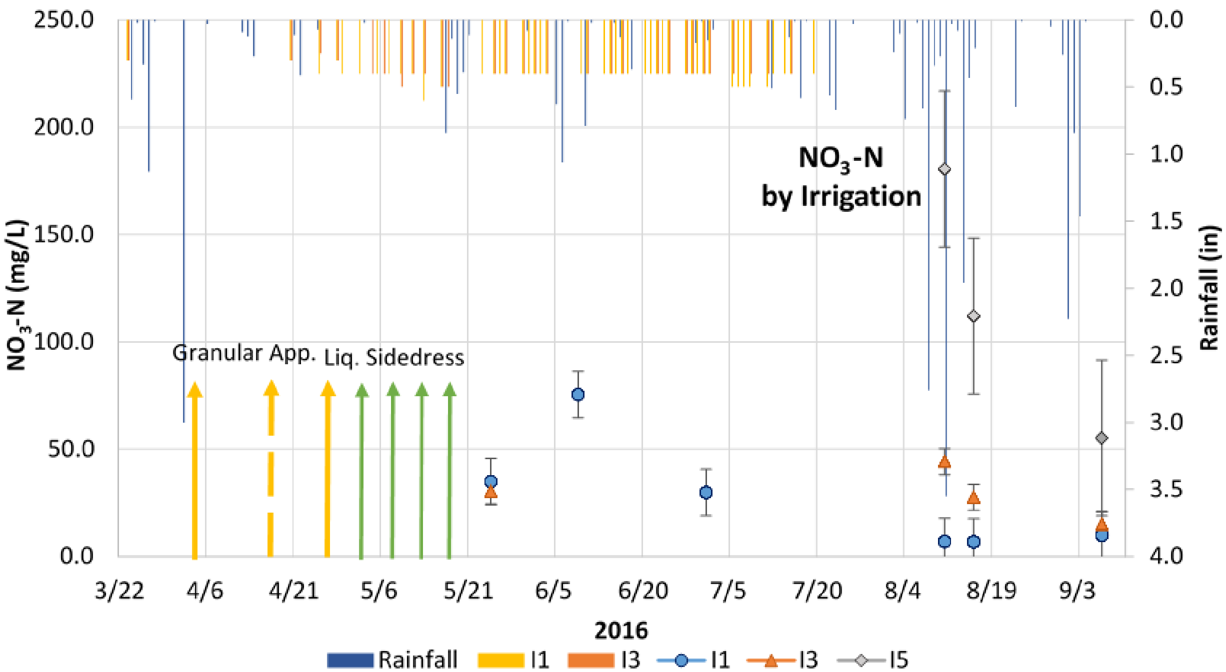


Figure 52. Average lysimeter leachate NH_4-N concentrations per irrigation (top) and per N fertility rate (bottom) obtained in corn, 2016. Bars show daily rainfall and irrigation events per treatment. Dots are NH_4-N results from each irrigation or fertility treatment. Green and yellow arrows represent the granular and liquid side-dress applications. Error bars show SE of NH_4-N means.



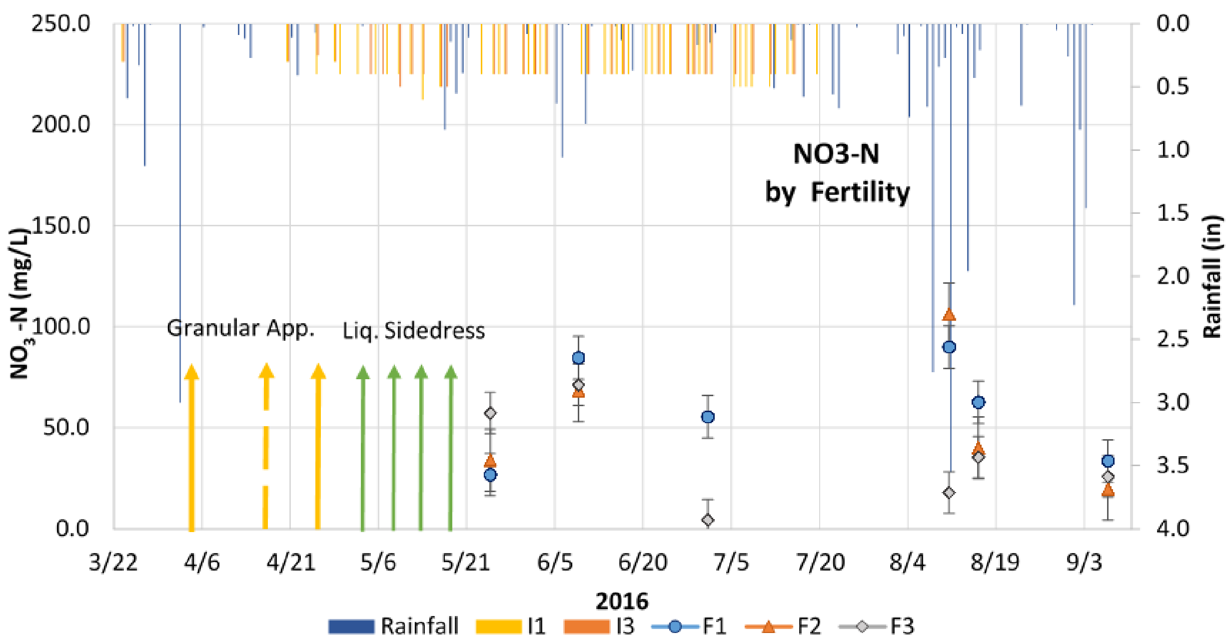


Figure 53. Average lysimeter leachate NO_3-N concentrations per irrigation (top) and per N fertility rate (bottom) obtained in corn, 2016. Bars show daily rainfall and irrigation events per treatment. Dots are NO_3-N results from each irrigation or fertility treatment. Green and yellow arrows represent the granular and liquid side-dress applications. Error bars show SE of NO_3-N means.

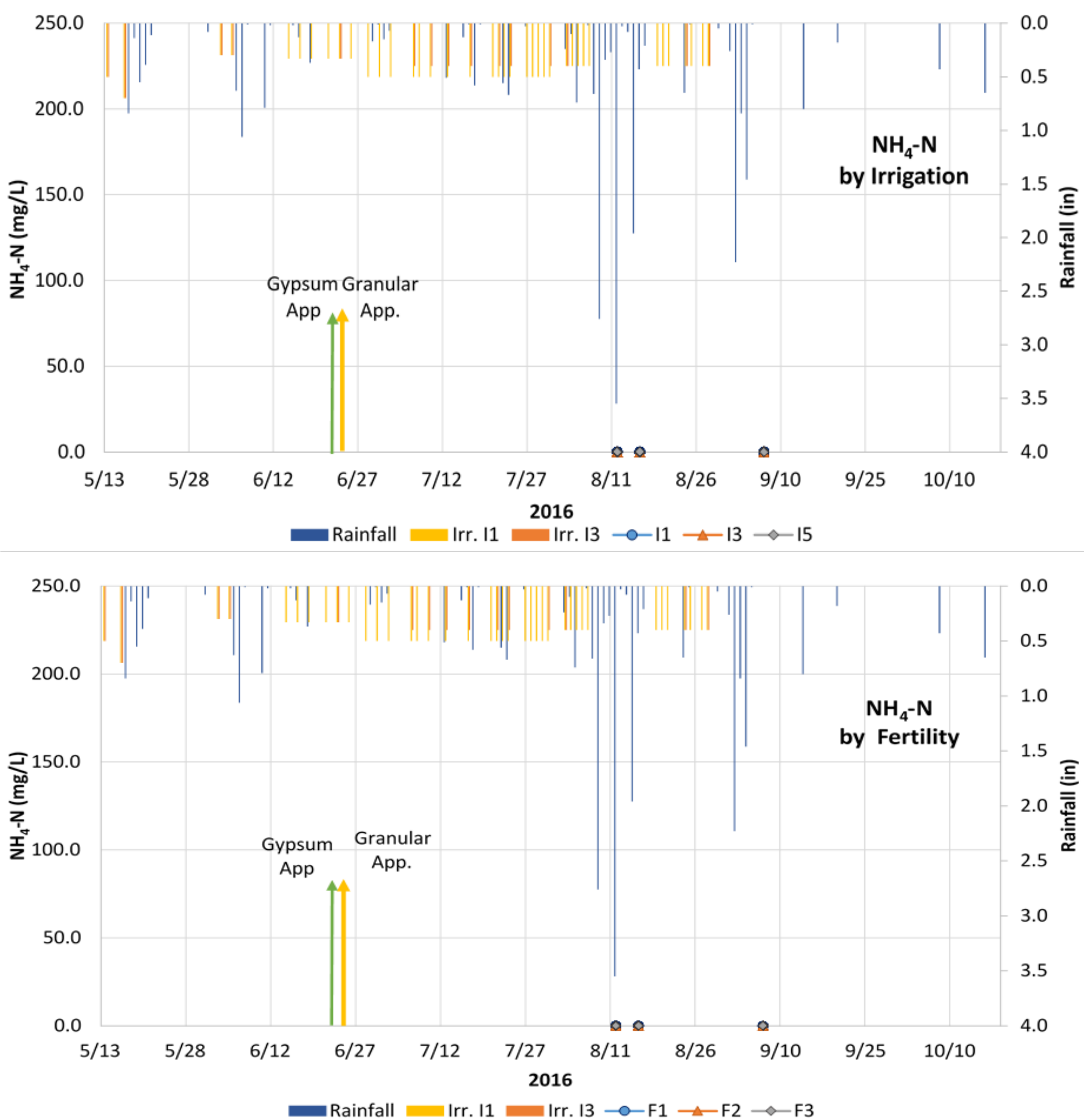
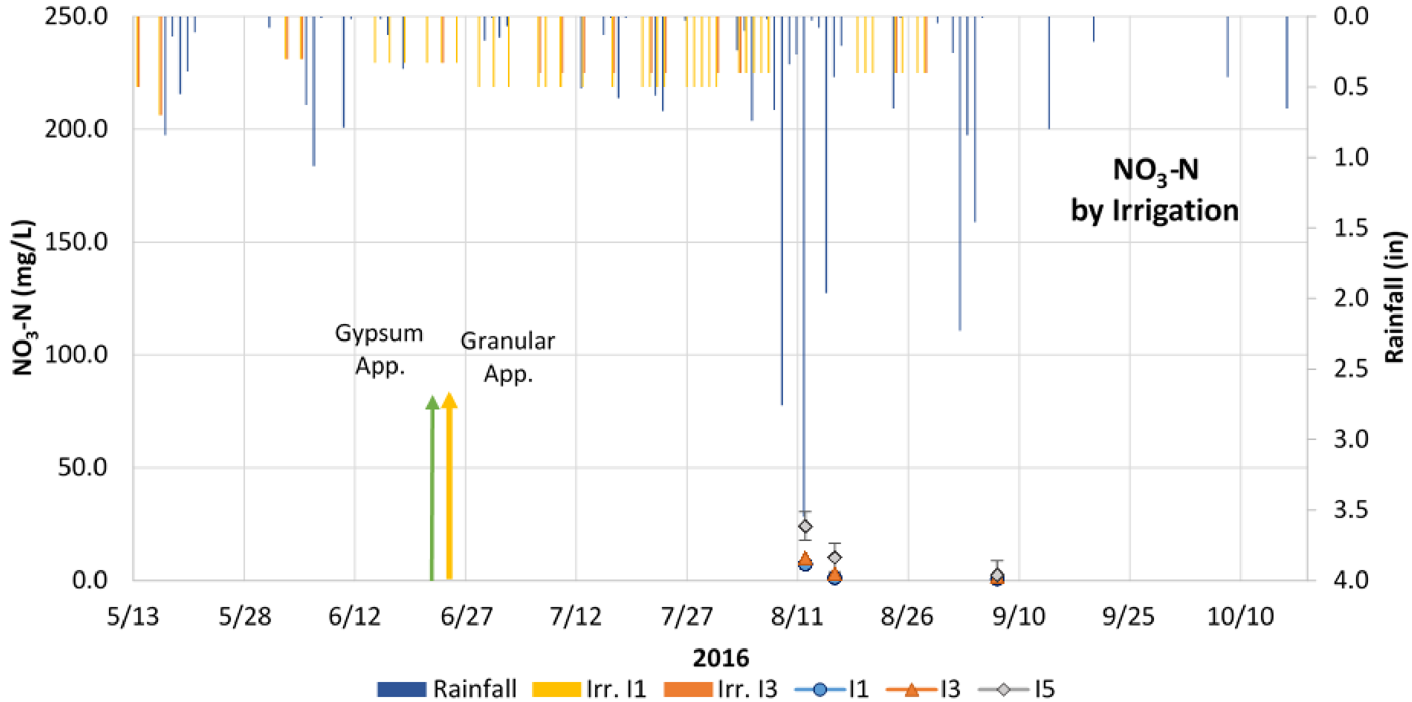


Figure 54. Average lysimeter NH_4-N leachate concentrations per irrigation (top) and per N fertility rate (bottom) obtained in peanut, 2016. Bars show daily rainfall and irrigation events per treatment. Dots are NH_4-N results from each irrigation treatment. Green and yellow arrows represent the granular application (3-7-28 @ 500 lb/ac) and gypsum application (@ 2000 lb/ac). Error bars show SE of NH_4-N means.



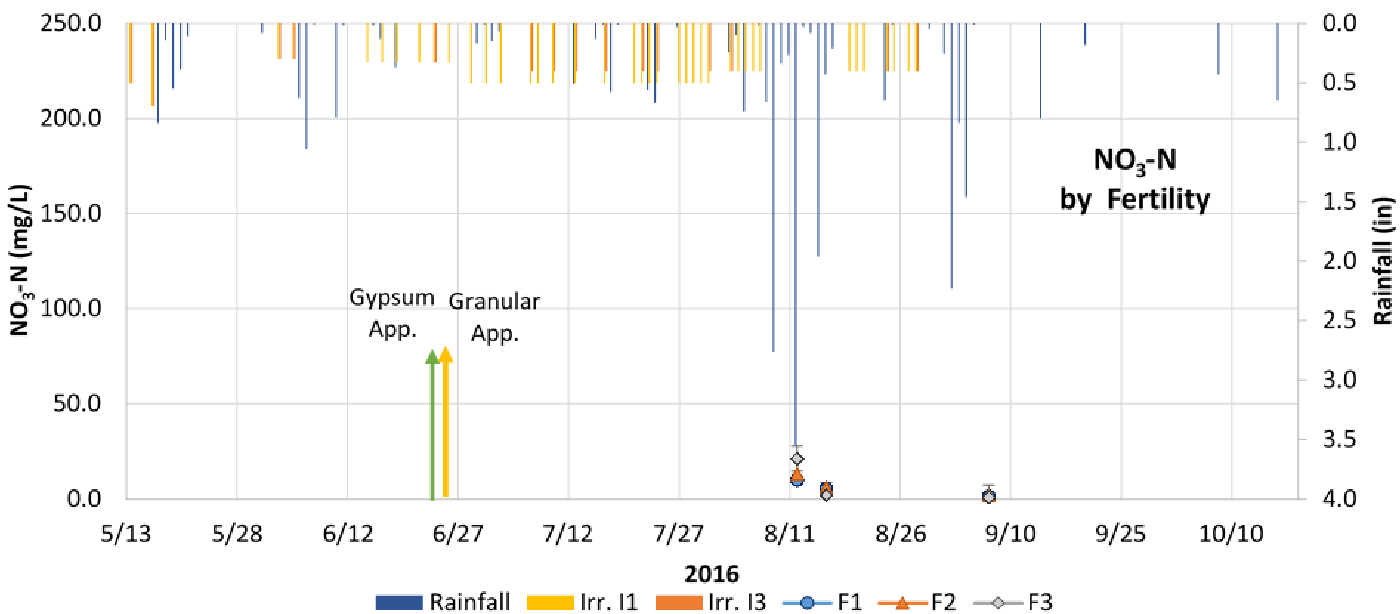


Figure 55. Average lysimeter leachate NO_3-N concentrations per irrigation (top) and per N fertility rate (bottom) obtained in peanut, 2016. Bars show daily rainfall and irrigation events per treatment. Dots are NO_3-N results from each irrigation or fertility treatment. Green and yellow arrows represent the granular application (3-7-28 @ 500 lb/ac) and gypsum application (@ 2000 lb/ac). Error bars show SE of NO_3-N means.

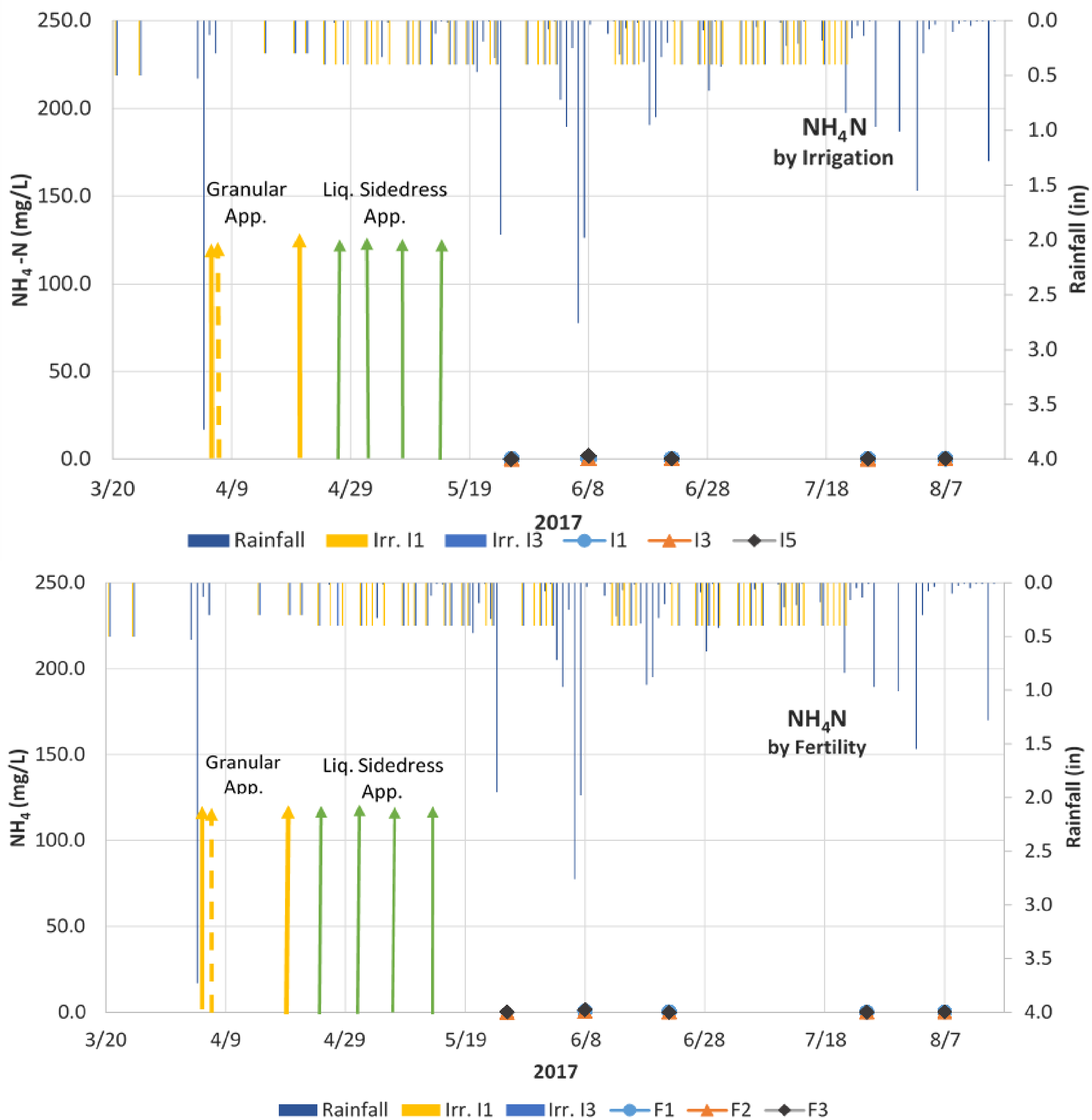


Figure 56. Average lysimeter leachate NH_4-N concentrations per irrigation (top) and per N fertility rate (bottom) obtained in corn, 2017. Bars show daily rainfall and irrigation events per treatment. Dots are NH_4-N results from each irrigation or fertility treatment. Green and yellow arrows represent the granular and liquid side-dress applications. Error bars show SE of NH_4-N means.

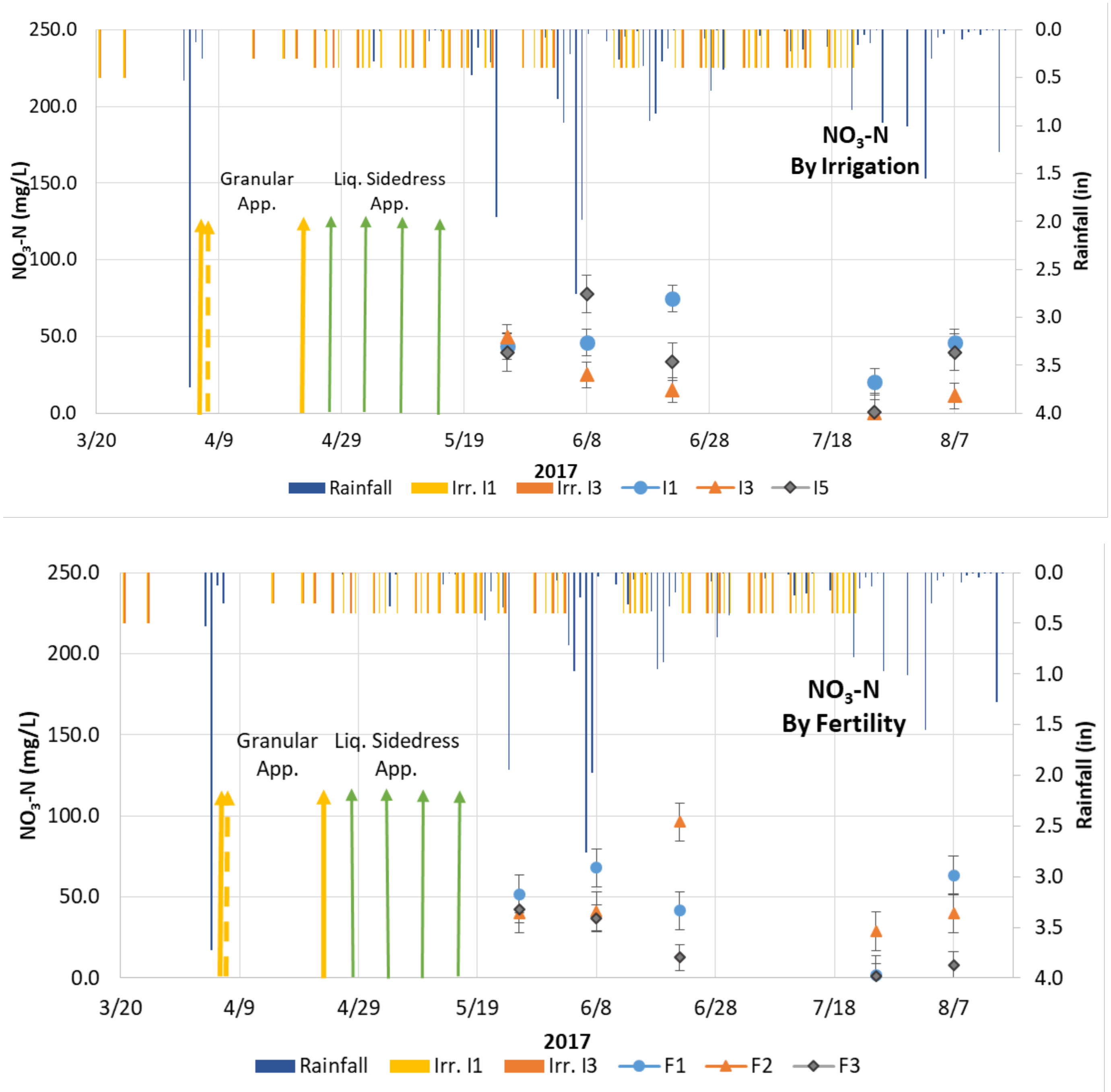


Figure 57. Average lysimeter leachate NO_3-N concentrations per irrigation (top) and per N fertility rate (bottom) obtained in corn, 2017. Bars show daily rainfall and irrigation events per treatment. Dots are NO_3-N results from each irrigation treatment. Green and yellow lines represent the granular and liquid side-dress applications. Error bars show SE of NO_3-N means.

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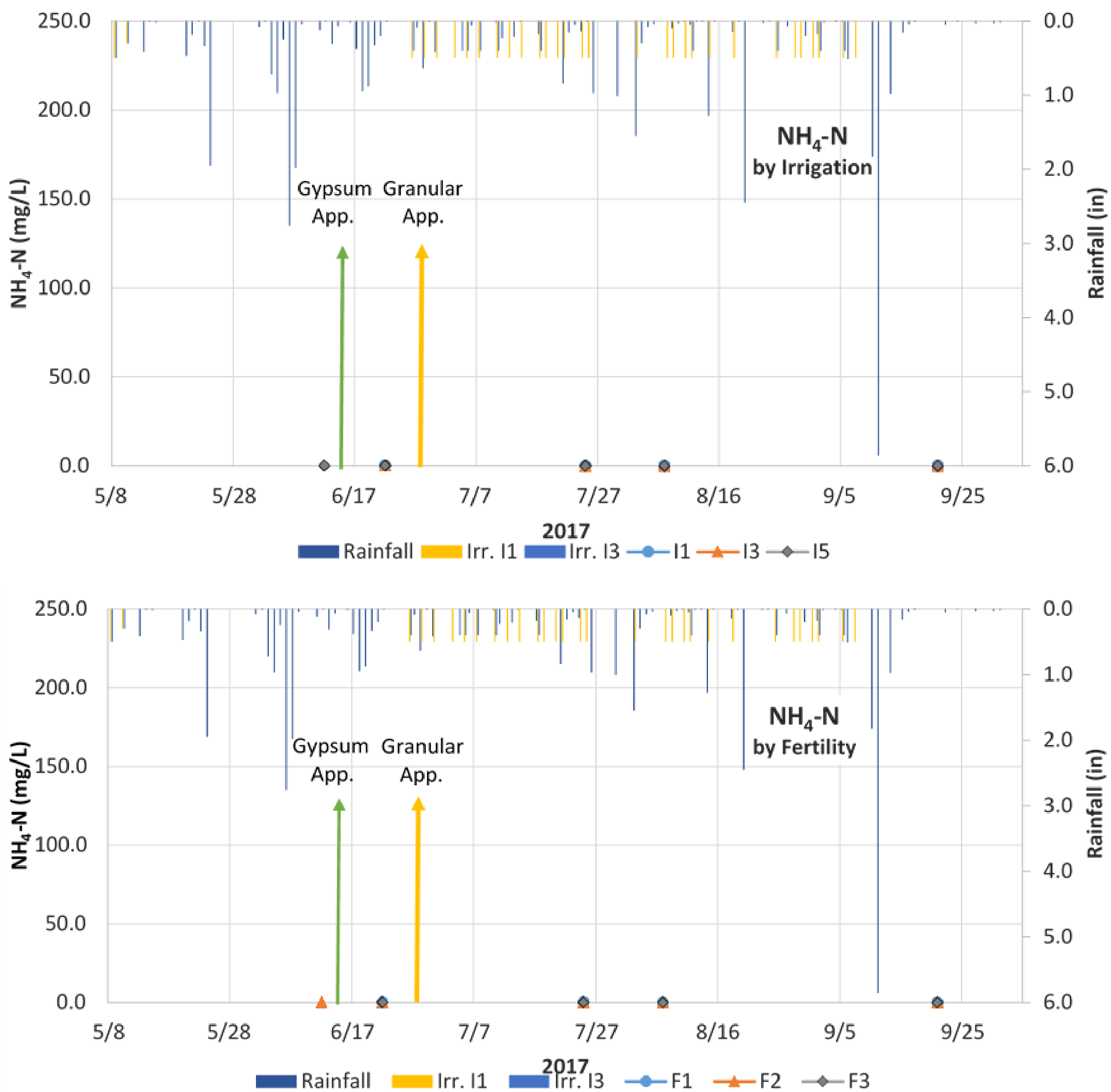

Figure 58. Average lysimeter leachate NH_4-N concentrations per irrigation (top) and per N fertility rate (bottom) obtained in peanut, 2017. Bars show daily rainfall and irrigation events per treatment. Bars show daily rainfall and irrigation events per treatment. Dots are NH_4-N results from each irrigation treatment. Green and yellow arrows represent the gypsum application (1500 lb/ac) and granular applications (350 lb/ac of 8-0-39). Error bars show SE of NH_4-N means.

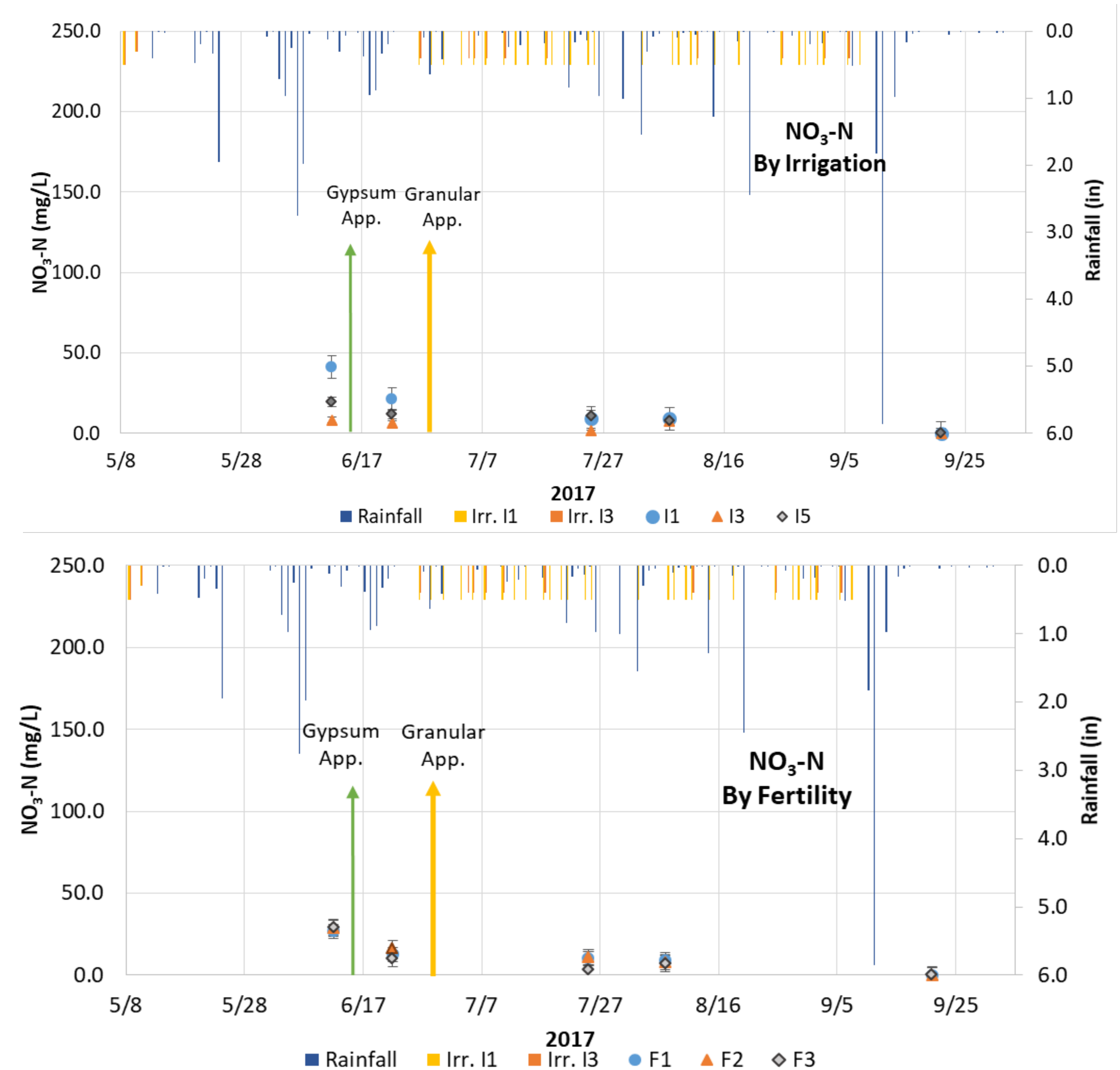

Figure 59. Average lysimeter leachate NO_3-N concentrations per irrigation (top) and per N fertility rate (bottom) obtained in peanut, 2017. Bars show daily rainfall and irrigation events per treatment. Dots are NO_3-N results from each irrigation or fertility treatment. Green and yellow arrows represent the gypsum application (1500 lb/ac) and granular applications (350 lb/ac of 8-0-39). Error bars show SE of NO_3-N means.

Biomass and N(%)

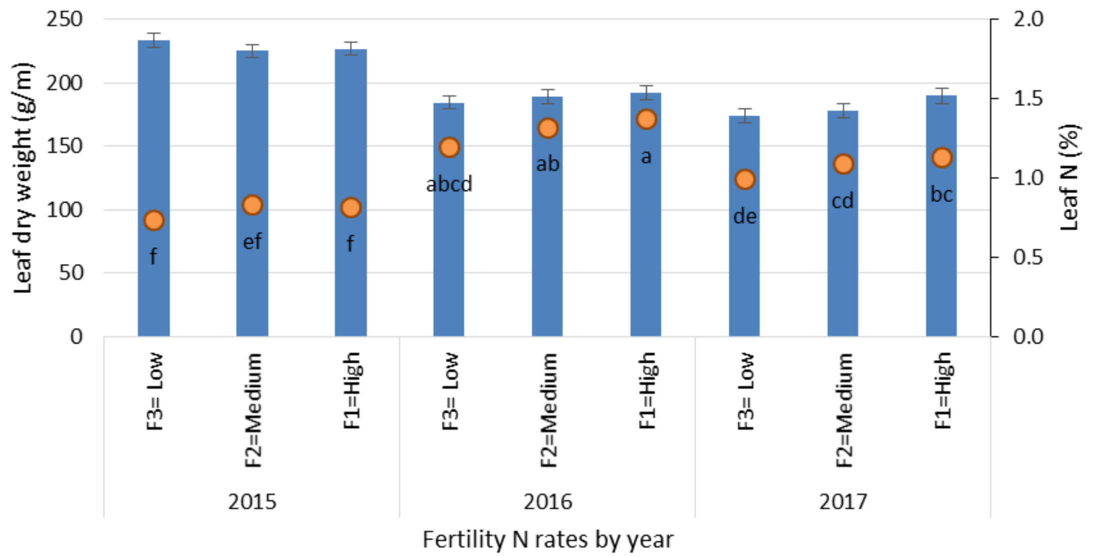

Figure 60. Final corn leaf dry weight (g/m) (bars) and N (%) content (dots) across irrigation treatments in 2015-17 seasons. Different letters denote statistical differences in N content among treatments in corn seasons 2015-17. No statistical differences in leaf dry weight were found between N rates. Error bars show SE of dry weight means.

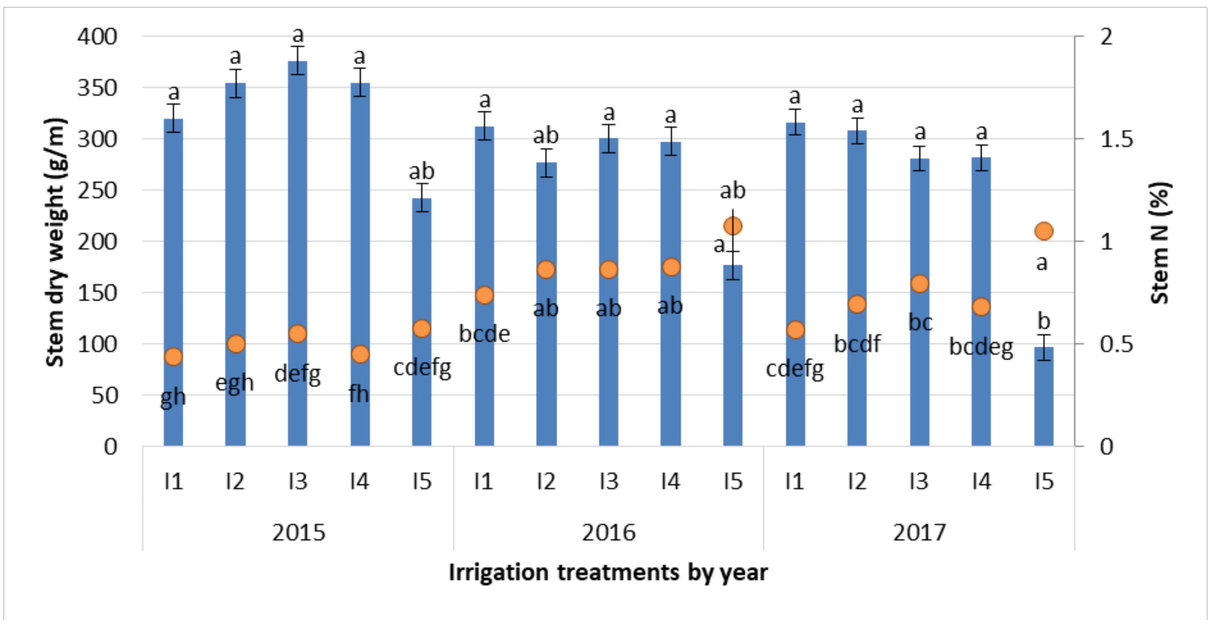

Figure 61. Final corn stem dry weight (g/m) (bars) and N (%) content (dots) across irrigation treatments in 2015-17 seasons. Different letters denote statistical differences among treatments in corn seasons 2015-17. Error bars show SE of dry weight means.

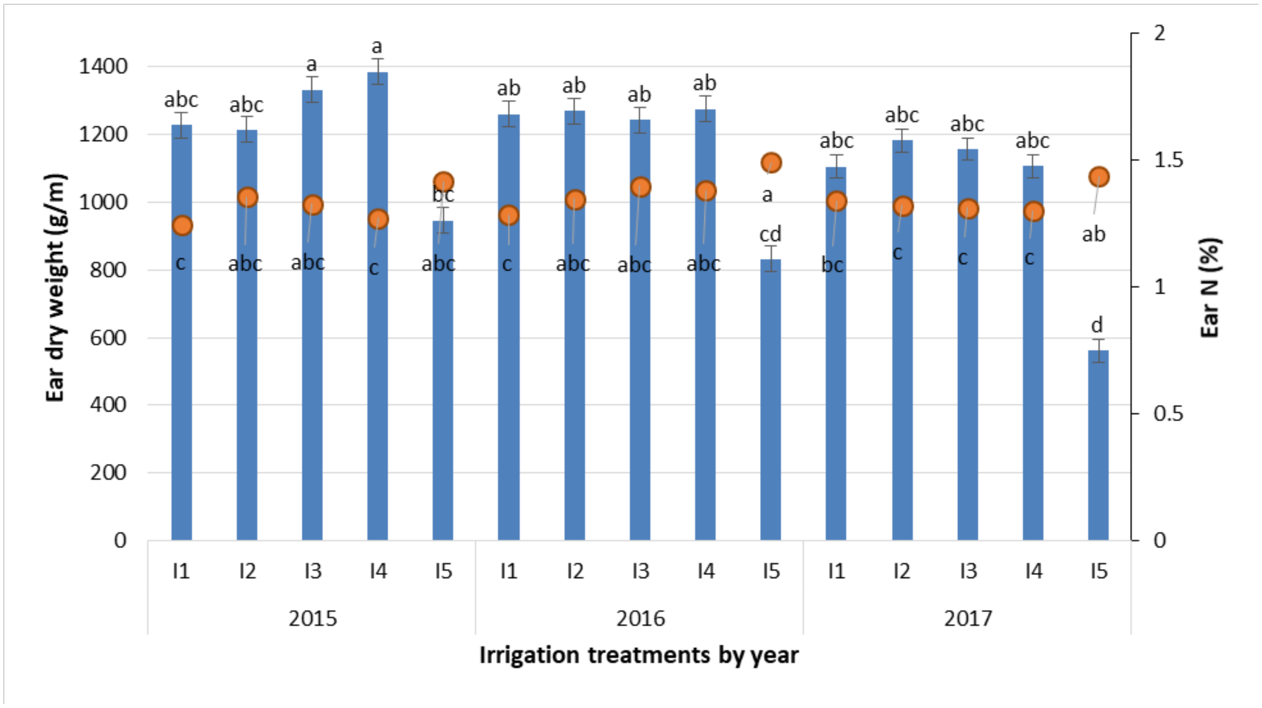

Figure 62. Final corn ear dry weight (g/m) (bars) and N (%) content (dots) across irrigation treatments in 2015-17 seasons. Different letters denote statistical differences among treatments in corn seasons 2015-17. Error bars show SE of dry weight means.

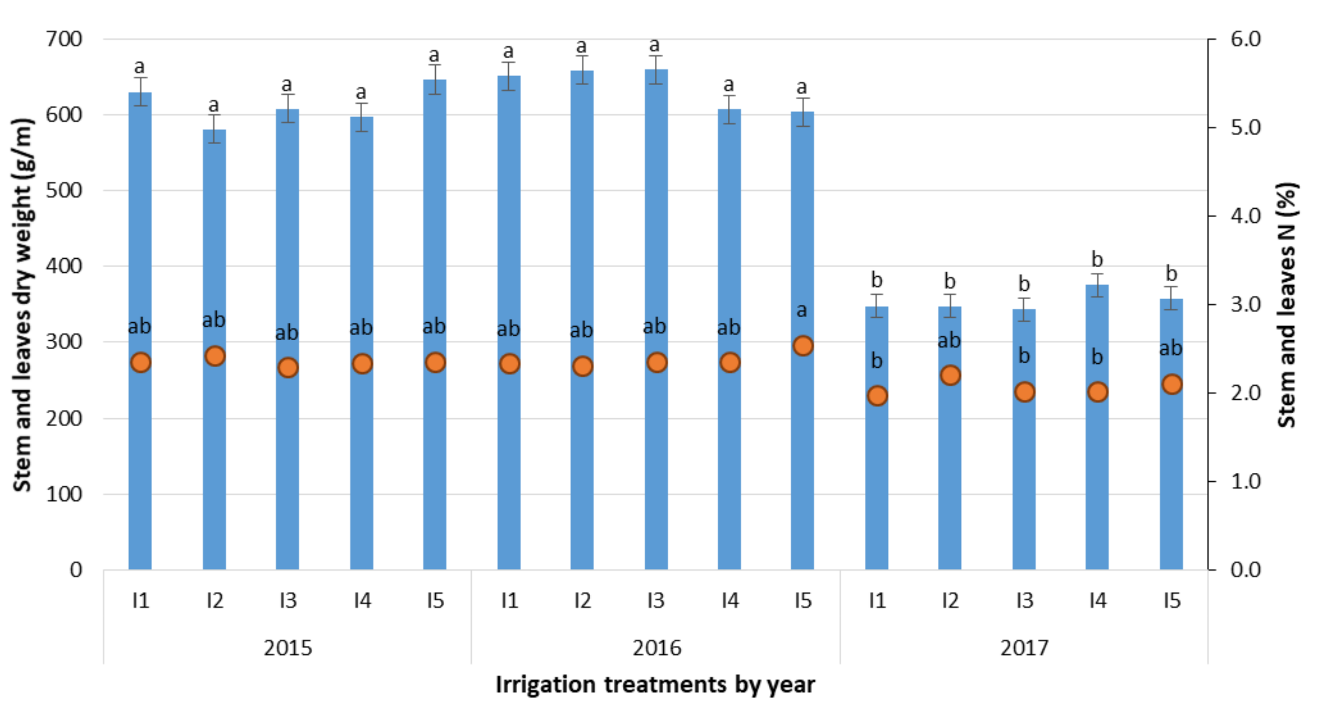

Figure 63. Final peanut stems and leaves dry weight (g/m) (bars) and N (%) content (dots) across irrigation treatments in 2015-17 seasons. Different letters denote statistical differences among treatments in peanut seasons 2015-17. Error bars show SE of dry weight means.

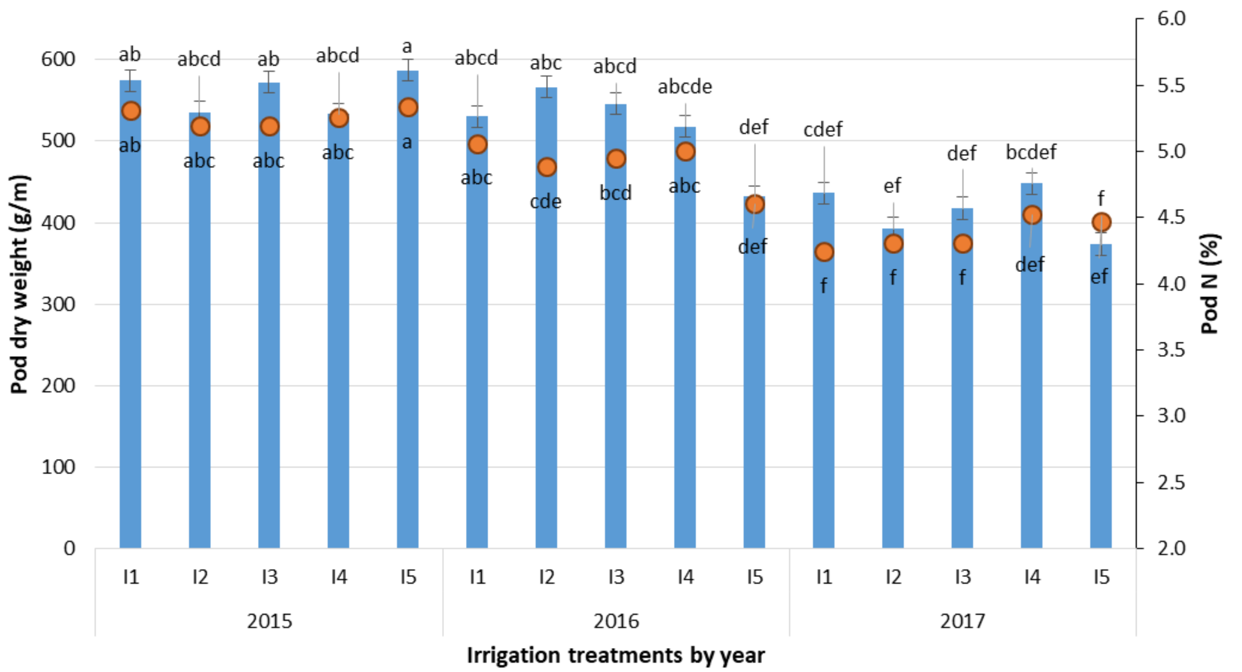

Figure 64. Final peanut pod dry weight (g/m) (bars) and N (%) content (dots) across irrigation treatments in 2015-17 seasons. Different letters denote statistical differences among treatments in peanut seasons 2015-17. Error bars show SE of dry weight means.

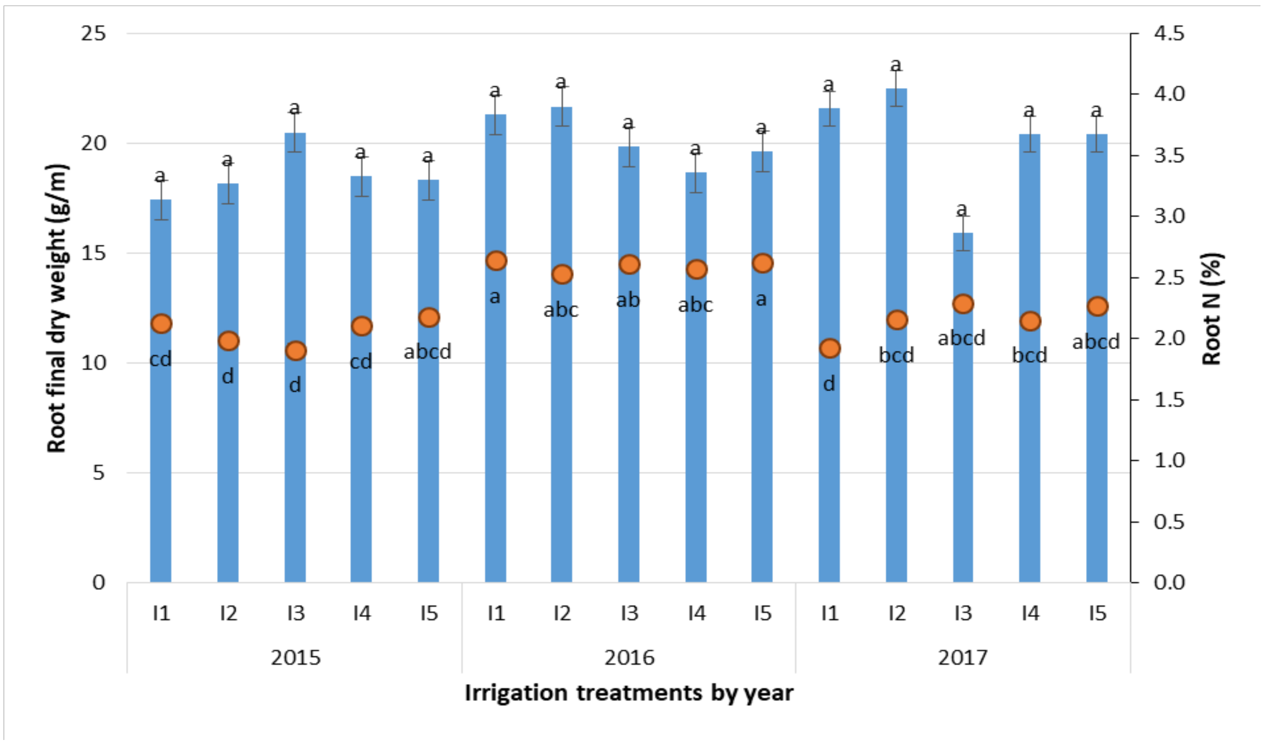

Figure 65. Final peanut root dry weight (g/m) (bars) and N (%) content (dots) across irrigation treatments in 2015-17 seasons. Different letters denote statistical differences among treatments in peanut seasons 2015-17. Error bars show SE of dry weight means.

Yield

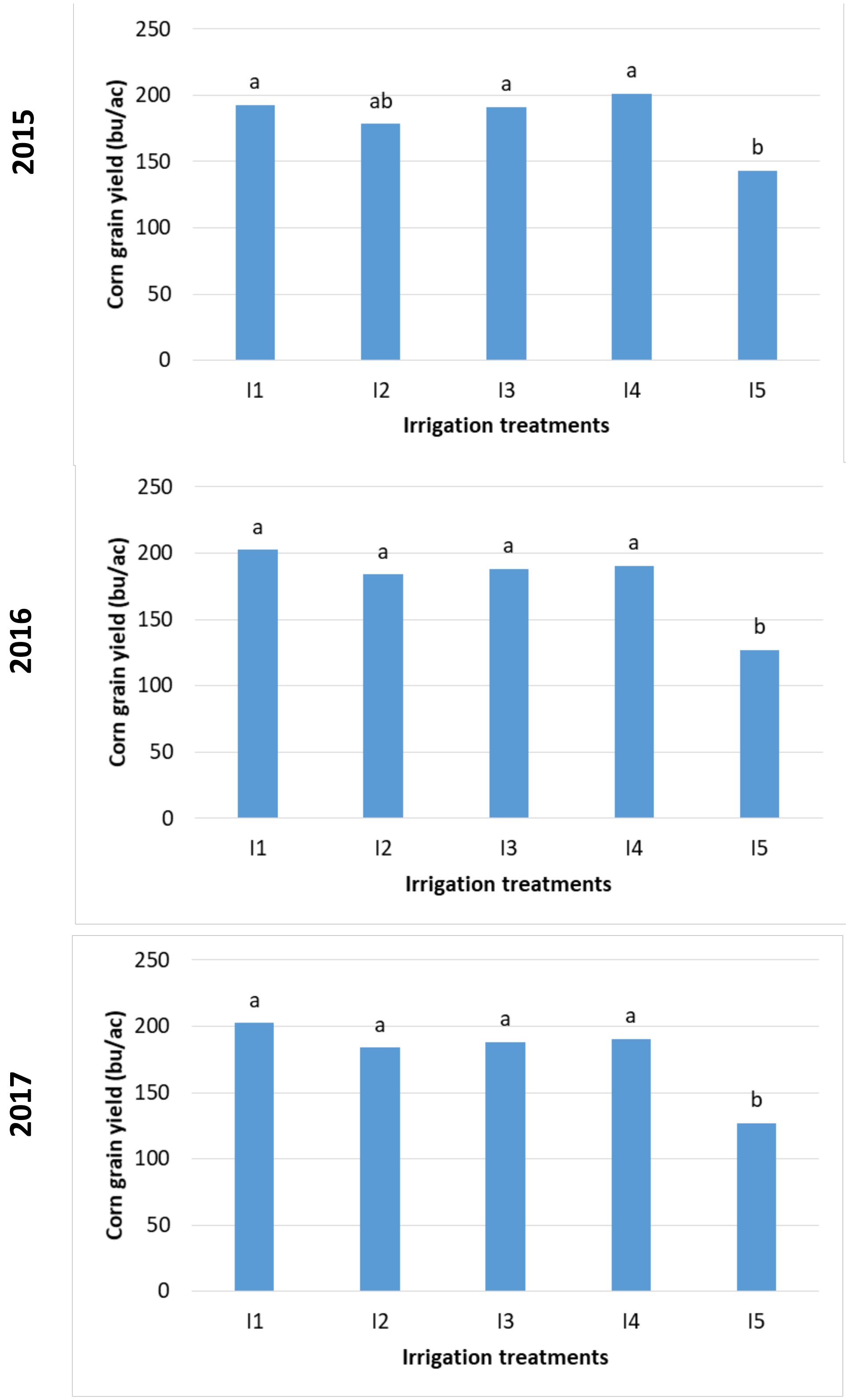

Figure 66. Average corn grain yield means across irrigation treatments in 2015-17 seasons (top to bottom). Data standardized for 15.5% market moisture. Different letters indicate differences at the 95% CI for irrigation treatment means.

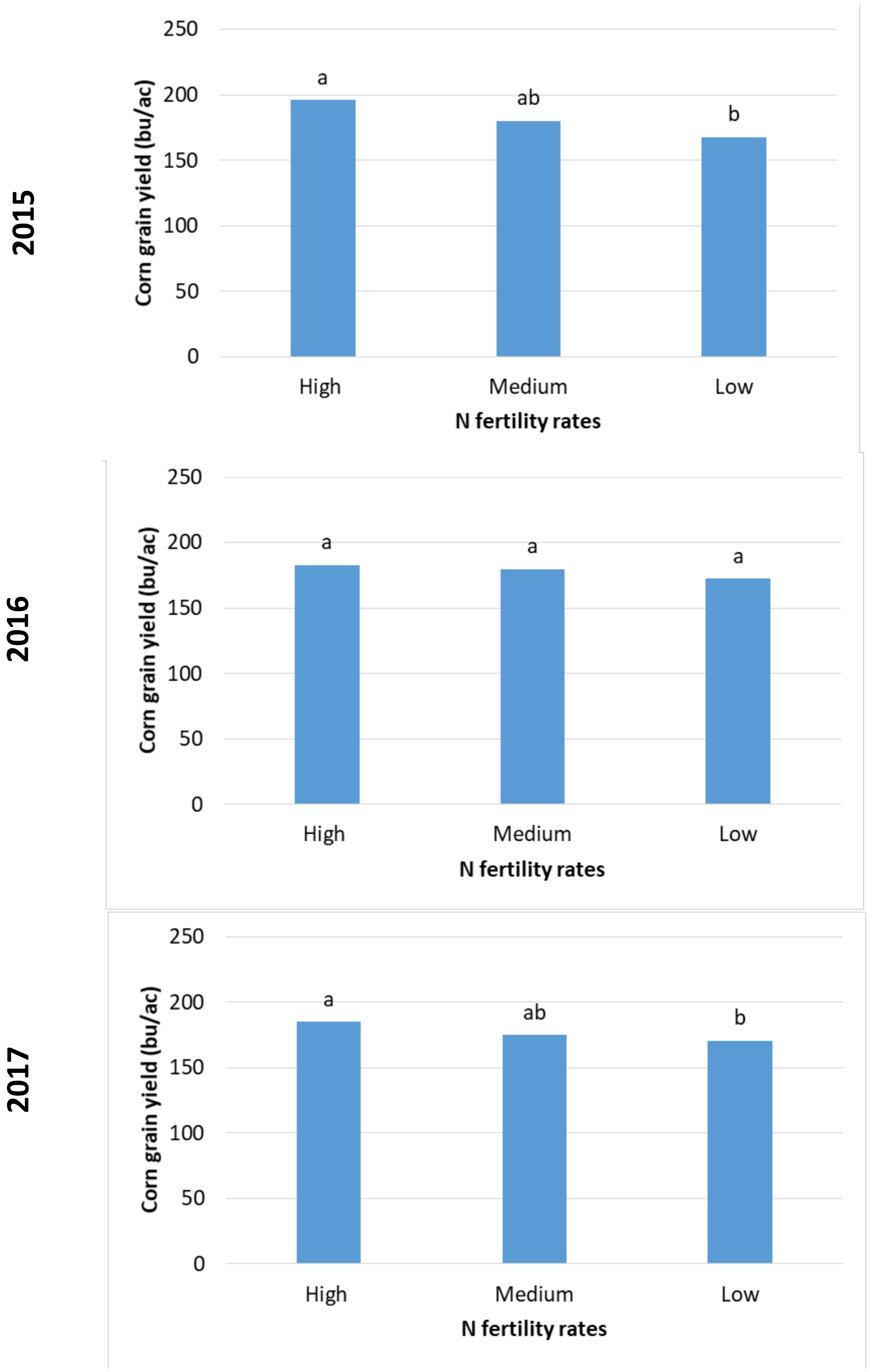

Figure 67. Average corn grain yield means across N fertility rates applied in 2015-17 seasons where F1 is “high” and F3 is “low”. Data standardized for 15.5% market moisture. Different letters indicate differences at the 95% CI for N rate means.

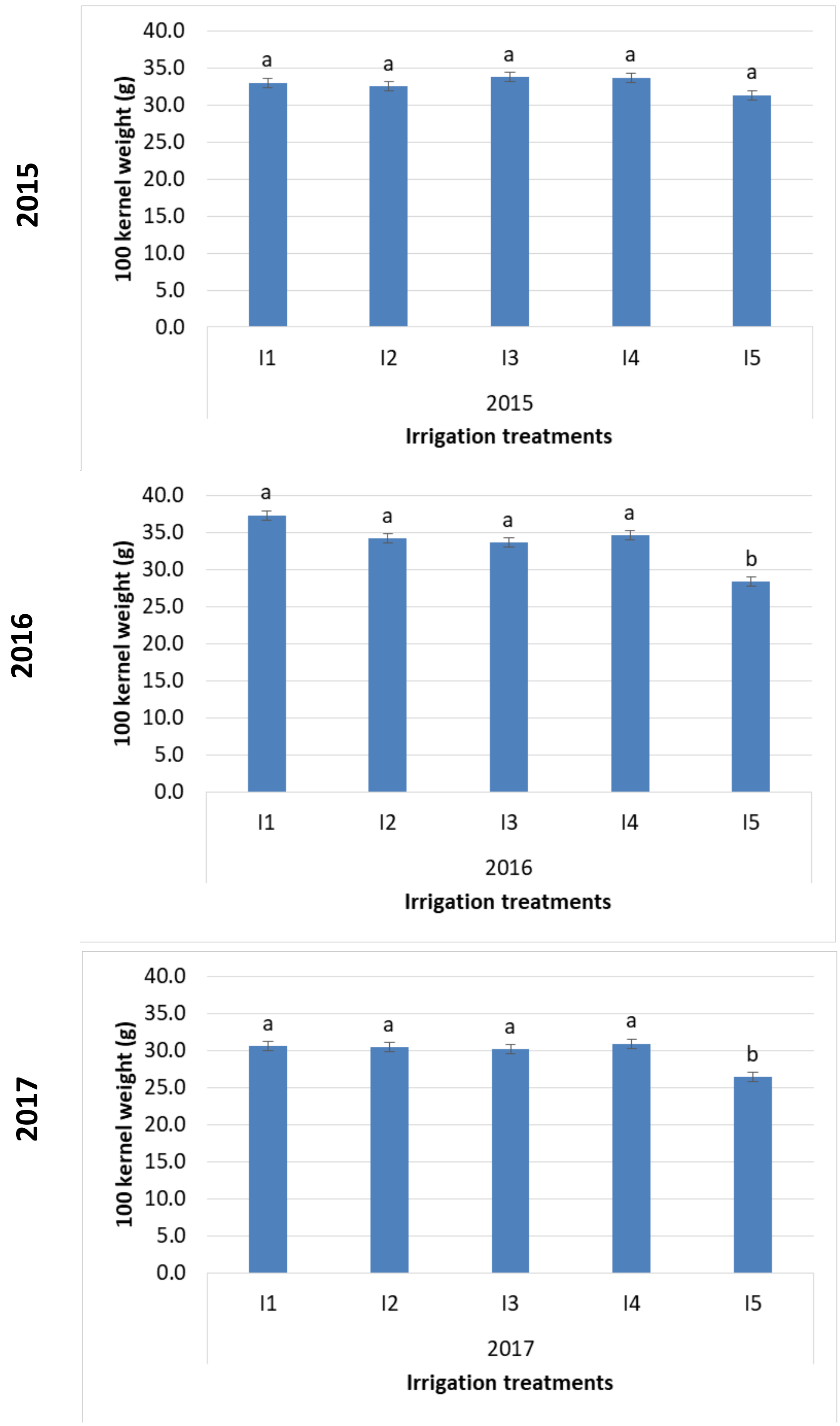

Figure 68. Weight of 100 kernels across irrigation treatments during corn seasons 2015-17. Different letters indicate differences at the 95% CI for irrigation means per season. Error bars show SE of kernel weight across means.

Figure 69. Weight of 100 kernels across fertility rates during corn seasons 2015-17. Different letters indicate differences at the 95% CI for irrigation means per season

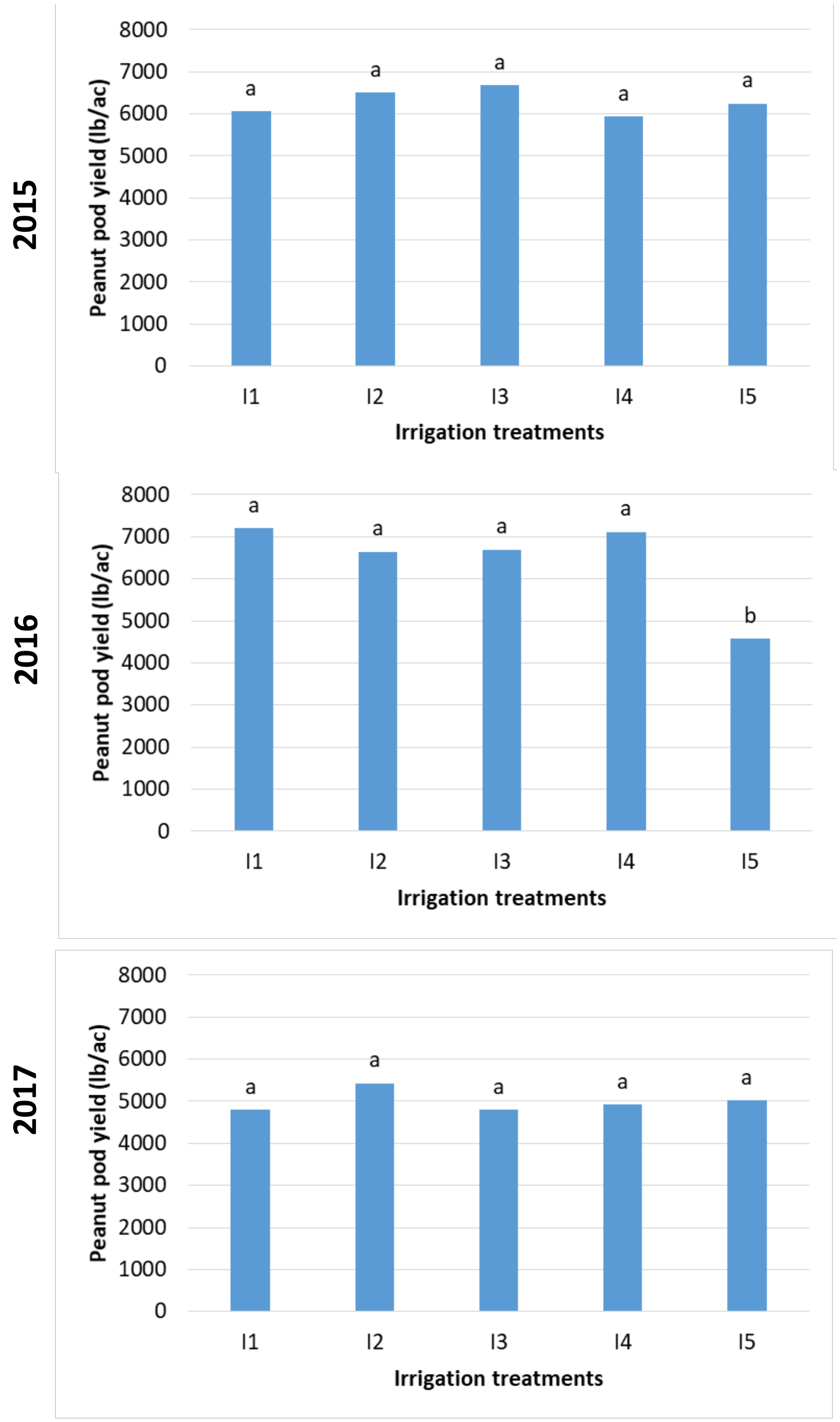

Figure 70. Peanut yield means across irrigation treatments in 2015-17 seasons (top to bottom). Data standardized for 10.5% moisture. Different letters indicate differences at the 95% CI for irrigation treatment means.

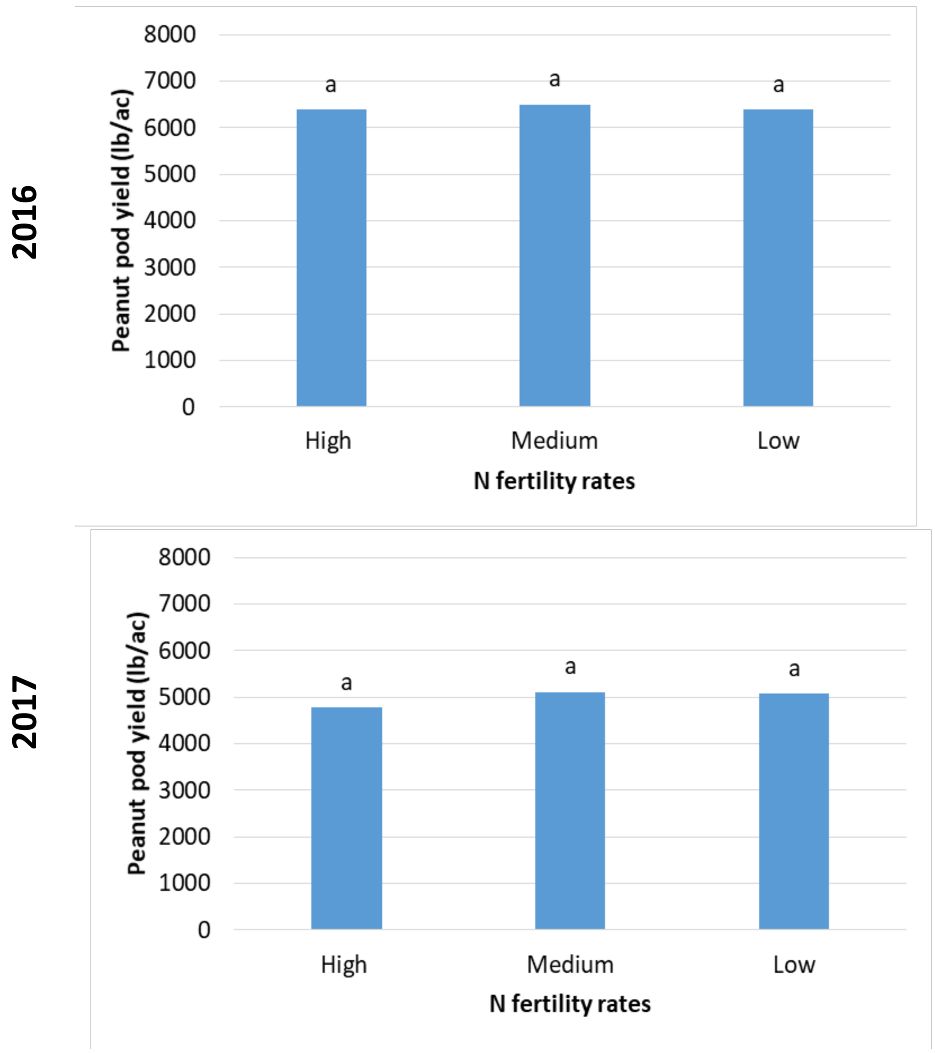

Figure 71. Peanut yield means across previous year corn fertility treatments (where F1 is “high” and F3 is “low”). Data not shown for 2015 since corn seasons started in 2015. Data standardized for 10.5% moisture. Different letters indicate differences at 95% CI for N rate means.

Appendix

A-1

Soil Sampling Protocol

Soil sampling technique:

- Collect soil samples from 0-6 in, 6-12 in, 12-24 in, and 24-36 in depth using a hand auger.
- Stir samples in a bucket and take a subsample (200-300 g).
- Put it in a tightly sealed plastic bag properly identified and store it in coolers for transportation.
  Note: If a scale is available in the field, the total fresh weight can be recorded; otherwise, samples have to be transported over ice to prevent moisture loss.
- Aluminum pans were used to dry soil samples. After returning from the field, transfer soil samples from the field plastic sampling bags to aluminum pans for the drying process.

NOTES:

- Each sample must be properly identified (i.e. plot ID, depth, field ID and date of collection).

-If samples can't be processed immediately and are required to be held for a day or two, samples should be kept under refrigeration.

-Soil samples should be dried within 12 to 48 hours of collecting, especially for nitrate analyses. Samples should not be dried for longer than needed or at excessive temperatures. This will lead to a change in the original N species profile. Further, dried samples must not be "stored" in the drying facility.

Soil drying:

- Weigh the total soil sample fresh from the field (before any drying).
- Mix the soil uniformly.
- Divide the sample into two portions, about half each. Record the fresh wt. of each portion.
- Dry one sample at room temperature (temperature ≤105 °F or 40 °C (call this one "air-dried") for 48 hours.
- Dry one sample at 221 °F or 105 °C (call this one "oven-dried") for 48 hours.
- Weigh the air-dried sample immediately after drying.
- Weigh the oven-dried sample immediately after drying, using a desiccator to cool the sample (about 20 minutes) before weighing.
- Using the initial fresh weight and dry weight of the oven-dry sample, calculate the gravimetric water content for each soil layer.
- Sieve air-dry subsamples with a 2 mm sieve. Store them in paper bags and submit samples to ARL for analysis (nitrate-N and ammonium-N). The air dried samples can also be used for other analytes such as soil organic carbon, pH, Mehlich-1.

Analysis from soil sub-samples:

1. Air dried soil samples: nitrate-N, ammonium-N.
2. Oven dried samples: gravimetric water content.

A-2

Leachate Sampling Protocol

The protocol described below is meant for NO_3-N and NH_4-N only.

Pre-sampling:

- ✓ Submit sample form to the Anserv Lab, Gainesville (ARL) to get your submission date
- ✓ Submittal forms are on the web. http://arl.ifas.ufl.edu/UserInput.asp
- ✓ Develop a field collection activity plan
- ✓ Prepare field record form and your chain-of-custody form
- ✓ Number vials and caps

Equipment:

1. Cooler, with ice
2. Sampling vials
3. Dropper bottle of sulfuric acid (9 molar) with dropper
4. Field notebook
5. Marker/pen
6. Scale (to weight leachate volumes)
7. DI water (for Equipment blanks and for rinsing the collection bottles after sampling)

Field record sheet

Before going for leachate sample collection, label the vials with your serial numbers and if possible ARL lab numbers. ARL lab numbers have to be requested in advance from the lab. Every information in the field print out should be noted right in the field.

Example of Field sheet

LEACHATE DATA

Date of collection: 08/16/2016 **Set number:** R3479 **ARL** R170693

Crop	IRR	FER	Block	Plot name	When to take it	Lysimeter bottle #	Vial #	Vial # corresponds to:	Total Weight (kg)
Equipment blanks, duplicate and lab samples						1	1	E-1	Done
						9	2	E-9	
						10	3	E-10	
						18	4	E-18	
						19	5	E-19	
						27	6	E-30	
						28	7	E-25	
						36	8	E-36	
							9	DUP-10	
							10	DUP-20	
							11	DUP-30	
							12	LAB	
Corn	B1	I1	F2	B1I1F2	E	1	13	1	12.06
Corn	B1	I1	F1	B1I1F1		2	14	2	13.42
Corn	B1	I1	F3	B1I1F3		3	15	3	10.14
Corn	B2	I5	F2	B2I5F2		4	16	4	9.4

Important terms:

Lab blank: In the lab, pour some distilled water into one or two sample vials. Two vials will give you a duplicate. This checks on the possibility of contamination of the water source. (Required by FDEP).

Equipment blank: Use pump to dispense distilled water from a 1-L bottle into a vial. Start the pump, let it dispense about one-half of the bottle of water, and then collect a sample. One vial per pump will give you equipment blank. First equipment blank collection should be made prior to starting the field sampling. This checks on the possibility of contamination from the use of equipment. (Required by FDEP).

Field Duplicate samples: These are simply duplicate samples collected in the same manner as the field samples with the same equipment. Collect duplicate samples every 10 lysimeters.

Sample collection procedure:

1. Hook up the pump with distilled water carboy and collect equipment blank sample (1 vial per pump).
2. Hook up the pump with lysimeter and pump the leachate into the Nalgene bottles for 30 minutes or till the lysimeters are empty.
3. Weigh (battery operated scales) the Nalgene bottles of collected leachate and record the weight. Be sure that you have accounted for the tare weight of the Nalgene bottle.
4. Mix the Nalgene bottle and pull one sample into the vial.
5. Add a drop of half-strength sulfuric acid (9M sulphuric acid) to each vial of sample and cap the vial. Rotate vial a few times to mix acid and sample. Put the vials into cooler over the ice.
6. Some lysimeters will be dry. Those vials are marked “no sample”. Invert the vials upside down and label ‘NS.’
7. Once the sample collection is done, rinse all the Nalgene bottles with DI water.

Transport: Once all samples have been collected, transport back to the lab with “wet” ice (ice that has some free water), and keep them in cooler (< 4°C) until taken to the Lab.

Chain of custody and sample submission: Your sample tray will comprise of field equipment blanks, lab blanks, samples, and duplicate samples. Before submitting the samples to the lab, identify your samples and record them in an excel sheet since you will blind the samples by assigning only consecutive numbers to the vials.

On the day of submitting the samples to the ARL lab, bring the chain of custody sheet properly filled along with lab submission form. Get the initials and date from the lab manager or the person collecting your sample on the chain of custody sheet. Ask for a copy of the lab submission form for your records. Preserve both the chain of custody sheet and the sample submission form.

Chain of custody

CHAIN OF CUSTODY

Project Number: 121976
Sample Collection Team: M. Zamora, M. Gutierrez, D. Hansley, S. Rider, Sienna
Site Location: Live Oak, Florida (Corn)
Sample Types: Leachates
08/16/2016

Number	Site	Project	Sample Type	Sample ID	ARL Set No.	ARL Lab Set No.	Time Collected	Acidification	Cooling	Required analysis (ppm)	Notes
1	Live Oak, FL	SVAEC	Water	1	R3479	R170693	8:00	Yes	Yes	NH_4-N, NO_3-N	E-1
2	Live Oak, FL	SVAEC	Water	2	R3479	R170694	8:10	Yes	Yes	NH_4-N, NO_3-N	E-9
3	Live Oak, FL	SVAEC	Water	3	R3479	R170695	8:20	Yes	Yes	NH_4-N, NO_3-N	E-10
4	Live Oak, FL	SVAEC	Water	4	R3479	R170696	8:30	Yes	Yes	NH_4-N, NO_3-N	E-18
5	Live Oak, FL	SVAEC	Water	5	R3479	R170697	8:40	Yes	Yes	NH_4-N, NO_3-N	E-19
6	Live Oak, FL	SVAEC	Water	6	R3479	R170698	8:50	Yes	Yes	NH_4-N, NO_3-N	E-30

Custody Transfer

Date of Delivery:	08/16/2016	**Date Received:**	08/16/2016
Time of Delivery:	1:30 PM	**Time Received:**	
Departing Temp (C):		**Received Temp (C):**	
Delivered by:	Maria Zamora	**Received by:**	
Signature:		**Signature:**	

Notes:

Report Results to:
mzamorare@gmail.com

Requested Tests:
NH_4-N, NO_3-N

Comments

All samples were preserved w/H_2SO_4 to <2oh and cooled with wet ice to < 4°C.
All samples were taken for research purposes, so individual sample identificantion and location are coded in the Custody form to prevent blasness with the samples results.

A-3

Tissue Sampling Protocol

Tools and supplies needed: Clippers, spade, measuring tape, paper bags or cloth bags numbered, Ziploc bags, bucket to wash roots, Plastic baskets to transport the samples to the drying facility.

Parameters to be analyzed: Total Kjeldahl Nitrogen.

Sampling procedure (corn):

- Sample plants were collected in a section of row (1m). Numbers of plants in the 1 meter section were counted.
- Plants parts were separated into stalks, leaves, and ears.
- Total numbers of leaves per plant were counted and recorded.
- Total numbers of ears and fresh weight of ear in 1 meter sections were also recorded in the field.
- Plant samples were dried in 60°C for 72 hours or until thoroughly dries. Dry weights were recorded.
- Dried plant parts leaves, stalks and ears were chopped with a chipper /using a shredder machine prior to grinding.
- Chopped plant samples were ground in a Wiley mill using 2mm screen and sample were mixed well before taking a subsample for the lab analysis.

Sampling procedure (peanut):

- Plants sample were collected in a section of row (1m).
- Numbers of plants in the 1 meter section were counted.
- Plants parts were separated into stems, roots, and pods.
- Total numbers of pods in 1 meter sections were also recorded in the field.
- Plant samples were dried in 60°C for 72 hours or until thoroughly dries. Dry weights were recorded.
- Dried plant parts stems, and roots were chopped with a chipper /using a shredder machine prior to grinding.
- Pods, roots and stems were grind using a Wiley mill, passed through a 2mm screen and were subsampled for the lab analysis.

A-4

IFAS University of Florida VRI Linear

cycle setting: 10							
prescription:	90%	80%	70%	60%	50%	40%	30%
Percent Timer	Valve Off Time (secs)						
100%	n/a	n/a	n/a	n/a	n/a	n/a	n/a
95%	1	2	3	4	5	6	7
90%	1	2	3	4	6	7	8
85%	1	2	4	5	6	7	8
75%	1	3	4	5	7	8	9
70%	1	3	4	6	7	9	10
65%	2	3	5	6	8	9	11
60%	2	3	5	7	8	10	12
55%	2	4	5	7	9	11	13
50%	2	4	6	8	10	12	14
45%	2	4	7	9	11	13	16
40%	3	5	8	10	13	15	18
35%	3	6	9	11	14	17	20
30%	3	7	10	13	17	20	23
25%	4	8	12	16	20	24	28
20%	5	10	15	20	25	30	35
15%	7	13	20	27	33	40	47
10%	10	20	30	40	50	60	70

cycle setting: 20							
prescription:	90%	80%	70%	60%	50%	40%	30%
Percent Timer	Valve Off Time (secs)						
100%	n/a	n/a	n/a	n/a	n/a	n/a	n/a
95%	2	4	6	8	11	13	15
90%	2	4	7	9	11	13	16
85%	2	5	7	9	12	14	16
75%	3	5	8	11	13	16	19
70%	3	6	9	11	14	17	20
65%	3	6	9	12	15	18	22
60%	3	7	10	13	17	20	23
55%	4	7	11	15	18	22	25
50%	4	8	12	16	20	24	28
45%	4	9	13	18	22	27	31
40%	5	10	15	20	25	30	35
35%	6	11	17	23	29	34	40
30%	7	13	20	27	33	40	47
25%	8	16	24	32	40	48	56
20%	10	20	30	40	50	60	70
15%	13	27	40	53	67	80	93
10%	20	40	60	80	100	120	140

cycle setting: 30							
prescription:	90%	80%	70%	60%	50%	40%	30%
Percent Timer	Valve Off Time (secs)						
100%	n/a	n/a	n/a	n/a	n/a	n/a	n/a
95%	3	6	9	13	16	19	22
90%	3	7	10	13	17	20	23
85%	4	7	11	14	18	21	25
75%	4	8	12	16	20	24	28
70%	4	9	13	17	21	26	30
65%	5	9	14	18	23	28	32
60%	5	10	15	20	25	30	35
55%	5	11	16	22	27	33	38
50%	6	12	18	24	30	36	42
45%	7	13	20	27	33	40	47
40%	8	15	23	30	38	45	53
35%	9	17	26	34	43	51	60
30%	10	20	30	40	50	60	70
25%	12	24	36	48	60	72	84
20%	15	30	45	60	75	90	105
15%	20	40	60	80	100	120	140
10%	30	60	90	120	150	180	210

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