WR 93-483-381

Final Report

Water Conservation and Quality Enhancement Using Shallow Reservoirs to Collect Runoff and Rain for Rice Production

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between

Texas Water Development Board
and
Texas Agricultural Experiment Station

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Executive Summary

Inefficient water and land use is evident in Upper Texas Coast rice production. An example of inefficient water resource use is based on the fact that about 80% of the 17 to 32 inches of rainfall during the rice growing season is lost in runoff from rice fields. This loss approximates the 22 inch irrigation water requirement of a rice crop. Examples of inefficient land use is 1) high rainfall and poorly-drained soils essentially eliminate economical alternative crop production and the opportunity to spread fixed cost across other crops; 2) inclimate weather and red rice induced rotations result in three to four acres of uncropped land for each acre of rice production.

Our primary research objective was to test alternative methods for growing rice which conserve water resources and reduce land requirement. We tested the use of shallow reservoirs to collect rain water and store surface runoff from adjacent crop land. Pumping the surface water from non-rice crops into reservoirs should improve land productivity and conserve water resources for reuse on rice. With 1/3 of the land in reservoir, 1/3 in soybean and 1/3 in rice, minimum tillage techniques were employed to improve continuous and rotating crop production efficiencies as well as land use efficiency.

Identified advantages and positive findings

1. Results illustrate the strong possibilities to conserve Texas water resources by using rain and runoff water to meet rice production water requirements.

2. The land allocation ratio of 1/3 rice, 1/3 row crop (also serves as a source of runoff water), and 1/3 shallow reservoir provided 100% and 70% of the rice water requirement in 1994 and 1995, respectively.

3. Our field-based studies provided insight into practical constraints to storing rain water (land requirement, leaking levees, pumping cost) and will be very helpful in designing additional studies to improve efficient use of land and water resources.

4. Rice grown continuously or in rotation with reservoir and soybean did not produce apparent differences in soil chemistry or disease pressure during the study. We expected the rotation cropping system to reduce weed and disease pressure. Possibly the two-year period was not long enough or possibly suppressed yields prevented treatments from influencing weed and disease pressure. We expected a slight accumulation of salts in the closed water system but there was no evidence of salt build-up.

5. Storage of water in a shallow reservoir with aquatic plants improved water turbidity and removed inorganic nutrients.

6. Rice fields serve as temporary wetlands providing shallow floodwater for about 90 days/year (180 days when ratoon rice is grown). Shallow reservoirs used in this study provided wetland 270 to 300 days per year. Although rice production probably

provides more waterfowl food than the shallow water storage reservoirs, the reservoirs provided more available water surface than rice fields for waterfowl. In this study the rotating reservoir had less aquatic weeds and more open water than the stationary or continuous reservoir. The shallow reservoirs used in this study occupied more land area than deep reservoirs of equal water holding capacity but were cheaper to construct and provided the shallow water (less than 12 inches deep) preferred by most waterfowl. The reservoir definitely attracted more waterfowl than the rice fields.

7. The evaluated land use allocation of 1/3 rice, 1/3 reservoir, and 1/3 alternative crop utilized land more efficiently than the typical current upper Texas coast rice production system which typically have 1/3 of the land in rice and 2/3 of the area non-cropped.

Identified disadvantages or concerns discovered

1. Minimum tillage techniques may not be effective for production of continuous rice in areas where winters are not cold enough to kill rice stubble. We found overwintering rice stubble is not easily killed with Roundup herbicide prior to planting rice. The overwintering rice reduced yield by competing with rice seedlings for sunlight and nutrients and thereby reduces grain quality by maturing earlier than the seedlings.

2. Soil moisture conservation due to reduced tillage may be a disadvantage in high rainfall areas. Our experience with this study suggests that the reduced tillage crop residue, beneficial in reducing evaporative water losses in dry land farming, may prolong periods of water saturation and actually reduce the time that soil conditions are dry enough for planting in these poorly-drained soils. The increased vegetative residue associated with reduced tillage can reduce evaporative water loss and increase the duration of water saturation, negatively influencing crop yield.

3. The two years of crop production data on poorly-drained soils suggest that reduced tillage will lengthen the life of tillage equipment (disc, land planes, harrows, and tractors). However, the reduced tillage production systems require the purchase of a minimum till drill to plant in a vegetated seedbed and added herbicide cost for weed control.

4. The water conservation and water recycling practices tested in this study may have two negative implications:
   a) Salts should eventually accumulate as more salts are added than removed by limited water infiltration in poorly drained soils and runoff is returned to the reservoir.
   b) Large acreage in a no runoff, water conservation, cropping system could reduce surface water flow to coastal marshes and estuaries, potentially reducing their productivity.

5. Our findings suggest that simple removal of surface water by pumping it off the crop land and into the water storage reservoir will not sufficiently and quickly aerate the

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   b) Large acreage in a no runoff, water conservation, cropping system could reduce surface water flow to coastal marshes and estuaries, potentially reducing their productivity.

5. Our findings suggest that simple removal of surface water by pumping it off the crop land and into the water storage reservoir will not sufficiently and quickly aerate the

water saturated root zones which limit seedling and crop survival in flat, clayey soils with poor internal drainage.

6. The water collection and storage in shallow reservoir did conserve rain and runoff water. But this water conservation practice may not be cost effective considering the relatively cheap, readily available canal water in the eastern rice belt which is supplied to the rice fields by gravity flow.

7. Critics of the shallow reservoirs for water storage predict reservoirs will not function over large surface areas because the cross-levees (needed on all but totally flat land) will be destroyed by wave action. Once one levee breaks there will likely be a domino effect and reservoir water will be lost.

8. A rotation cropping system using shallow water storage reservoirs as part of the rotation can present stand establishment problems (delayed planting, oxygen deficiency) for the crop planted into the previous year's reservoir land using minimum tillage practices. The thick aquatic vegetation in the previous year's reservoir land keeps the soil too wet for good seedbed preparation. Conventional tillagemay help crop establishment in land that was used as a reservoir the previous year.

9. Although an economical assessment was not part of this proposal, we can make inferences about the relative cost of the water conservation practices used in this study. The shallow reservoirs, prepared by constructing 12- to 18-inch-high levees, are less expensive to construct than deep water reservoirs. However, shallow reservoirs occupy more crop land area than similar capacity deep reservoirs. The shallow reservoirs greater surface area causes greater evaporative loss than deep reservoirs with less surface area. Pumps and labor were required to pump runoff water into the reservoir and remove water from the reservoir. By comparison, canal water sources in the eastern rice belt are readily available, provide water by gravity flow, and are relatively cheap (≈$20/acre ft). Therefore, even though the shallow reservoirs effectively conserved natural water resources and served as wetlands, their cost effectiveness needs to be addressed.

Conclusion:

This research illustrates that shallow reservoirs help use upper Gulf Coast water and land more efficiently than the current rice production methods. The research provides needed information useful in our effort to find cheaper ways to produce rice. Cost studies are needed to determine the economics of collection and storage of rainwater in shallow reservoirs.

I. Research Justification

Uncertainty of U.S. Government rice support price, low world-market rice prices (≈$5/cwt), 50 cwt yields in the Upper Texas Coast, and rice production cost exceeding $500 an acre speak harshly about the future of the Upper Texas Coast rice industry. Our research goal is to reduce rice production constraints by environmentally sound use of water and land resources.

Reducing irrigation water cost could brighten the future of the rice industry since water represents up to 25% of the variable production cost. Possibly the 25 to 30 acre inches of irrigation water required to produce rice could be supplied by the ≈15 inches of rainfall during the 120 days required to grow rice plus the run-off from adjacent land. Capturing the rain and runoff in a shallow reservoir for later use could reduce or eliminate the need for canal or well water to produce rice.

Current rice production systems in the upper Texas coast consist of one year in rice followed by two to four years out of rice. Thus, upper Texas coast rice production requires three to four acres of land for each acre in rice. For the heavy clay soil areas, the land not in rice any given year will either be used for cattle or more commonly left idle or fallow. The fixed land cost associated with rice production can be inflated due to idle land. The proposed tailwater recovery system could improve surface drainage and soybean production potential on idle land thereby reducing the fixed cost. The proposed on-farm reservoir system will also provide a wetland habitat for water fowl and wildlife and will test environmentally sound methods to reduce land, equipment, and water resources needed to produce rice in Texas. The cropping system being evaluated differs from other water storage reservoir systems in that the reservoirs are shallow and inexpensive to construct, plus the fact that continuous rice, soybean, and reservoir are compared with a rotating rice, soybeans and reservoir. If the proposed rice cropping production system can sustain production, then it will improve land utilization, reduce production costs, and conserve natural resources -- the primary constraints to economical rice farming.

II. Research Objectives

A. Develop water retention systems to capture, store, and recycle rainfall and run-off from soybean and rice fields.

B. Determine if seedling survival and crop yield can be improved by pumping excess water into a reservoir.

C. Monitor changes in quality of recycled water.

D. Evaluate reduced tillage practices as a method for fuel and equipment conservation.

E. Monitor changes in soil chemistry and pests as influenced by continuous rice versus rice rotation.

III. Research Methods

A. Experimental Design

We used six, two-acre fields of typical, poorly drained clayey rice soil in this study. Three fields served as the continuous rice, soybean, or reservoir and three fields were rotated with rice, soybean, or reservoir. This crop rotation order was chosen 1) to prevent aerial blight of soybean from carrying over into the primary rice crop as sheath blight, and 2) to use the reservoir rotation to minimize constraints associated with continuous single cropping. The fields were managed using various degrees of reduced tillage depending on vegetation cover and soil moisture. The shallow reservoir for collection of rain and run-off from the fields provided a water reserve and allowed for removal of excess surface water from soybean land. All six fields were drained and irrigated from a single central lateral. When the reservoirs were depleted, supplemental irrigation water was obtained from the Lower Neches Valley River Authority canals. Soybean and rice run-off was recovered via a pump system that lifts water from the lateral into the reservoir. See Figure IIIA and IIIB for diagram of 1994 and 1995 fields and irrigation system. Water balance sheets were maintained to determine the amount of rain water recovered, supplemental irrigation water requirements, and total water lost. Other parameters measured were rice, soybean, and wheat yields, water quality, water use, soil nutrient levels, and pesticide levels.

B. Physical Design for water collection, storage, and pumping for the six, 2-acre fields. (See Fig IIIA and IIIB)

1. Year One (1994)

May 1993 funding approval spurred mid-summer earth moving for the 12-acre site. Construction of the six fields, pumping system for irrigation, water collection, and storage reservoirs (two, 2-acre reservoirs with capacity to hold 12 inches of water each) was on typical clay soil at the Research and Extension Center near Beaumont. Figure IIIA shows the positioning of the 2 acre fields F-1, -2, and -3 for the continuous rice, soybean and reservoir, respectively. Fields F-4, -5, and -6 represent the rice, soybean, and reservoir rotation, respectively. One 4-in.-dia. pump served the continuous cropping and another for the annual rotation cropping system.

After constructing the six, 2-acre fields and the water control system, rice was planted in F-2 and F-4 fields and soybean in fields F-1 and F-6 to provide crop stubble for minimum tillage planting in the spring of 1994. It was too late (September) to expect the crops to produce significant biomass or seed prior to frost. Water was collected in shallow reservoirs beginning in the Fall of 1993 for use in the 1994 crop.

Crucial to having enough rainwater for irrigating the rice is the ratio of reservoir to crop land. In this experiment one-third of the land area within each cropping system was used for a reservoir. There were 2 acres each of rice, soybean, and reservoir for both the continuous cropping and rotating cropping systems.

2. *Year Two (1995)*

Levees were built higher where needed prior to the 1995 season. No other construction was necessary for 1995. (See Figure IIIB showing crop positions.)

IV. Results

A. Crop production and yields for the continuous and/or rotating rice, soybean, and wheat.

Table of crop yields

		Rotation	
Crop	Year	continuous	rotating
Rice	1994	5300 lbs/A (no ratoon crop attempted)*	4000 lbs/A (ratoon destroyed by birds on Nov 30)
	1995	3050 lbs/A (no ratoon attempted)**	3900 lbs/A (no ratoon attempted)**
Soybean	1994	29 bu/A	29 bu/A
	1995	25 bu/A	17 bu/A
Wheat	1994-95	27 bu/A	(not planted)***

--- Continued on next page ---

* No ratoon crop attempted because ratoon harvest ruts would remain too wet for reduced tillage planting of the continuous rice but not soybean planting which occurs 30 to 45 days later than rice.

** No ratoon attempted in 1995 because of later planted rice and May 95 Grant Termination date.

*** Wheat production not compatible in rotation between rice and soybean because of the plan to ratoon rice.

1. Rice Production

Specific cultural practices used to produce each crop are shown in the Appendix tables (IVA 1994 and IVA 1995).

The differences in 1994 rice yields in the continuous and rotation cropping system cannot be attributed to cropping system. No cropping effect had been established since both land areas were treated the same prior to the 1994 rice crop. Close observation of fields indicated that lower rice yields in the rotating cropping system were due to random variation (weed pressure, stand establishment, etc.) rather than cropping system.

Although the significantly lower 1995 rice yields were typical of on-farm yields (because of high disease pressure and extended periods of 95°F or more during critical growth stages), cropping system treatment effects were evident and identified as:

a. A significant amount of the continuous rice survived the mild winter and was resistant to repeated herbicide [Roundup (glyphosate)] application because of limited active leaf surface and an extensive root system. The overwintering rice competed with and matured earlier than the planted rice in the continuous cropping system. The rotating system rice was planted in the 1994 reservoir field without overwintering rice.

b. The overwintering, aquatic vegetation in the 1994 reservoir field was killed by the herbicide Roundup but the decaying root mat and above ground vegetation kept the wet, poorly-drained soil from drying. Consequently, the minimum tillage drill did not plant properly. Rains following delayed planting caused additional emergence problems.

Therefore, both the continuous and rotation cropping systems created rice establishment constraints using minimum tillage equipment. Aerial application of seed in the reservoir field may have provided a better stand. Also, conventional tillage seedbed preparation may have resulted a better stand.

2. *Soybean Production*

Soybean yields were typical of the region's 1994 crop yields. However, the 1995 yields were suppressed due to poor stand establishment in the poorly drained soil. This was especially the case for the beans that followed rice (Field F-4) because of an inferior seed bed (ruts in soil from combing harvesting rice keep soil wet) relative to the continuous soybean. The field had to be conventionally tilled prior to planting soybean.

Even though the excess surface water was removed and stored in the reservoir, the poorly drain clayey soil remained saturated for extended periods and interfered with conventional or minimum tillage techniques for establishing soybean on flat seed beds.

3. *Wheat Production*

Cropping system definitely influenced wheat production possibilities. The continuous soybean cropping system is the only cropping system that would allow wheat production because wheat matures after the optimum planting date for rice or interferes with the reservoir rotation.

More than two crop seasons are needed to adequately evaluate cropping systems but these limited data do provide insight into constraints to minimum tillage in both the continuous and rotating rice cropping in poorly drain soil in high rainfall areas.

B. Environmental Assessment

1. Water Use for 1994

1994 (see Appendix for Table IVB 1995 details)

Water added to rice in both continuous (F-2) or rotating (F-4) cropping systems

Rain	+	Pumped from each reservoir	=	Total
17.48	+	7.65*	=	25.13

*9.15 inches actually pumped from each reservoir to rice but 1.5 inches returned to each reservoir when rice was ready to harvest.

Potential evapotranspiration after flooding rice was estimated at 0.22 in. per day between flooding May 4 to August 12 drain (89 days) or a total of 19.56 inches of potential evapotranspiration. Previous research shows an almost insignificant 0.02 inches per day percolation rate for these clay soils.

		Inches			
Rain water used directly	=	17.48	=	70%	of applied water was unpumped rainwater.
Water from reservoir	=	7.65	=	30%	of applied water was impounded in reservoir and pumped onto rice.
Total water applied	=	25.13	=		water use per acre
Estimated evapotranspiration	=	(19.56)	=	78%	of applied lost to evapotranspiration.
Estimated levee leakage + percolation	=	4.87	=	22%	of applied lost to leakage through levee and infiltration. Infiltration amounts to 1.8 inches for 89 days. This equals 37% of 4.87 inches.

No canal or ground water was used to produce the main crop in 1994. Four inches of canal water was needed to establish the rice ratoon crop flood in field F-4. The ratoon rice was destroyed by blackbirds on November 30 before it could be harvested. No ratoon rice was established in F-2 because the potential for the soil surface to have excessive ruts for minimum tillage rice in early 1995. F-4 could be ratoon cropped because soybean follows rice in that field and is planted later than rice.

Summary of 1995 Water Use (See Appendix Table IVB 1995 for details)

Water added to rice in the continuous (F-2) and the rotating (F-5) fields in 1995 differed because of differences in leakage from the two rice fields. Therefore, water use in the two fields is shown separately. The following table shows the amount of water contributed from each source.

	Continuous (F-2)	Rotating (F-5)
	--------------------inches--------------------	
Rainfall	25.36	25.36
Reservoir	9.00	9.25
Canal	10.00	12.00
Total	44.36	46.61

Potential evapotranspiration after flooding rice was estimated at 0.22 inches per day between flooding rice fields on May 30 and draining on Aug 23 (85 days), or about 18.7 inches of potential evapotranspiration for the season. The following table shows the amount and percent of water in each category averaged for the two cropping systems for 1995.

		Avg for F-2 and F-5 (inches)	
Rainwater used directly	=	25.36	56% of applied water was unpumped rainwater
Water from reservoir	=	9.12	20% of applied water supplied by reservoir
Water from canal	=	11.00	24% of applied water supplied by canal
Total water applied	=	45.48	water use/acre
Estimated evapotranspiration	=	18.7	41% of applied lost to evapotranspiration
Estimated leakage plus percolation	=	26.78	59% of applied lost to levee leakage and percolation (1.7 inches)

The two years of water use data by upper Texas coast rice, show rainfall during the growing season approaches or exceeds evapotranspiration and illustrates the great potential for rainwater to meet the water requirement of upper Texas coast rice. For 1994, 70% (17.48 inches) of the water applied to main crop rice was met by rainfall and 30% (7.65 inches) by rainfall stored in reservoir. A key factor in the adequacy of the rainfall to supply the requirement was the 1/3:1/3:1/3 ratio of the rice land area to the run-off crop land to reservoir. Less area in run-off or reservoir land would not have supplied sufficient water.

The same 1/3:1/3:1/3 land allocation ratio was insufficient to supply the 1995 main crop rice water requirement. Even though the 1995 crop season rainfall (25.36) exceeded the 1994 rainfall by 7.88 inches and evapotranspiration was similar both years, the excess 1995 levee leakage (increase from 4.87 inches in 1994 to 26.78 in 1995) prevented us from being able to supply the main crop water requirement with rainfall and rainfall stored in reservoir. Canal water (11 inches) was required to supplement rainfall for the 1995 rice crop. Levee leakage was due mainly to increased crawfish populations during 1995. Reservoirs served as a habitat for the crawfish.

These data illustrate the potential to conserve Texas water resources through better use of rainwater for rice as well as the difficulty of stopping leakage through levees.

2. *Water quality monitoring*

a. Water samples were collected (where possible) at 0, 1, 2, 4, 8, 16, and 32 days after nitrogen applications to rice fields and periodically during the season. Water samples were also periodically taken from the supply reservoirs and main supply canal. Sub-samples were filtered, acidified, and stored at 4°C for analysis for nitrate and ammonium nitrogen. These sub-samples were analyzed for nitrates according to EPA method 353.2 and for ammonium according to EPA method 350.2. A second sub-sample was digested and analyzed for total Kjeldahl nitrogen according to EPA method 351.2. Analysis was performed utilizing an Auto Analyzer II equipped with GTpc computerized controller and GTpc controlling software.

Nitrogen levels were monitored periodically in the irrigation water: i.e. main supply canal, continuous reservoir, and rotational reservoir. These data are presented in Figures IV.B2-1 through IV.B2-6. Nitrogen forms never exceeded 2 ppm in any of the inflow sources. Nitrate and ammonium nitrogen showed slight season variations but were generally less than 1 ppm. Organic Kjeldahl nitrogen (OKN) varied from about 0.5 to 2 ppm. Organic nitrogen was highest early then declined below 1 ppm during the mid-season. The level increased late in the season in the water reservoirs in 1994 but not in 1995. Possibly because of higher waterfowl populations in 1994. These year to year variations were not significant nor did rice rotation influence N content of reservoir water.

Flood water nitrogen levels for the rice fields are shown Figures IV.B2-7 through IV.B2-10. Nitrogen management and concentration patterns between years were distinctly different. In 1994, the first nitrogen application was made the day after the rice emerged and a flood was established four days later via a 3.8 inch rain. The rice was flooded very young, about five days after emergence. The panicle differentiation nitrogen was dropped into the flood 31 days later. In 1995, the first nitrogen was applied about two days after emergence. Fields were flushed ten days later. A flood was established five days after that. The delay of the peaks after flood establishment are assumed due to the 15 day delay and the earlier flush incorporation of N fertilizer. The nitrogen peaks following the panicle differentiation application were vastly different between 1994 and 1995. Assuming the growth stage was the same, the only apparent explanation is warmer temperatures during the 1995 application. The 1994 application was made on 10 June and the 1995 application was on 3 July. The day and night temperatures were well above average in July and August 1995.

b. Roundup was used as the burn down herbicide for reduced tillage planting of rice and soybean. Roundup was applied 6-10 days prior to planting. The rice was planted using a minimum till drill. No water was added during the planting process. In 1994, the first irrigation water applied to the field was the flood at 16 days after Roundup application. In 1995, Roundup was applied to the plots on April 11. Fields were briefly flushed on May 6 and flooded on May 10. The flush was 17 days after application and the flood was 40 days after application. Roundup concentrations were not monitored due to the prolonged dry period after application and neutralization by soil.

c. Stam M-4 (propanil), a rice herbicide, was not used in 1994. It was applied 5 days prior to a flush and 10 days prior to flood establishment in 1995. Stam must be absorbed into the weeds with 6 hours to be effective and has been shown nondetectable in floodwater 24 hours after application. Stam concentrations were not monitored due to the prolonged dry period after application and its rapid dissipation.

d. Furadan 3G (carbofuran) was used in both years for rice water weevil control.

Furadan was applied about 10 days after flood establishment. Water samples were collected at 0, 1, 2, 4, 8, 16, and 32 days after application. Samples were filtered and stored for analysis after the 32-day sample. Samples were analyzed according to Method 531.1 using a Gilson HPLC equipped with a Pichering PCX5100 Post Column Reaction module and a Gilson Flourometric detection unit. The dissipation patterns are shown in Figure IV.B2-11 through IV.B2-14. Furadan concentration patterns showed little variation between treatments or years. The slight variations were probably due to variations in water depth. Maximum concentrations of about 400 ppb occurred 24 hours after application. Concentrations were at or near 100 ppb 4 days after application. Concentrations were still detectable at 32 days after application. Spot checks showed no evidence of Furadan in reservoir water.

e. Non-point source loading was to be estimated from flood water concentrations and tailwater volumes. The project design is shown in Figure IIIA and B. Drop pipes and flash board risers were installed at each of the road crossing (shown by 'X' in Figure IIIA and B). Flow was controlled by inserting or removing tongue and grooved boards in the flash board risers. Water stage recorders were installed upstream from each drop pipe.

During the 1994 rice season significant runoff from rice fields did not occur. Several rainfall events caused problems in October, November, and February. Runoff problems occurred several times during the 1995 season and chemical loss in runoff could have occurred. About 27 acre inches of water was lost from the rice fields by leakage through levees. This is about average for runoff from water seeded rice in

3. Phosphorus was applied only to 1995 rice (Fields F-2 and F-5) at 40 lbs P_2O_5/A. Only the Field F-4 showed a consistent increase for all subsamples. Soil test P levels did not reflect the P application because of plant uptake and soil reactions with the fertilizer P. Some fields showed an average increase of up to 4 ppm but changes were inconsistent with P treatments or rotation and within the variability of soil P testing.
4. No potassium fertilizer was applied. Soil test potassium levels generally declined in continuous soybean and rice fields. Declines for individual subsamples ranged from 0 to 36%. Changes in soil potassium appeared to be due to sampling and random variability.
5. Calcium levels increased in all fields after the first year of cropping or reservoir. Levels increased from 30 to 50% even though no calcium was added to any of the fields. The change may be related to the change from several years of clean till fallow to cropped or reservoir. Or possibly the added ammonium fertilizer was fixed by the clay colloids reducing the intensity by which the calcium ions were held on the cation exchange sites making the calcium cations more extractable by the soil test extractant.
6. Field F-6 experienced no significant change in magnesium. Magnesium decreased by 16 to 100 ppm in all other fields. The decline in these fields was generally consistent among subsamples. The authors can offer no clear reason for the decrease. The changes should have no environmental implications.
7. Initial salinity levels ranged from 150 to 650 ppm. Levels may have been

abnormally elevated as the fields had been clean fallowed and initial sample collection was during a dry period. Wicking may have concentrated salts near the surface. Salinity decreased in each year of the study in all fields. The decrease ranged from 30 to 80% with the largest decrease occurring with rice production and reservoir storage. There was no evidence to suggest that water recycling increased soil salinity over the two year sampling period.

8. Sodium decreased in all fields from 25 to 40%. No relation between decrease and cropping system was oblivious to the authors. The decrease was probably related to the decrease in salinity and generally followed the same pattern.
9. Sulphur levels decreased about 65 to 85%. No relation between the decrease and cropping system was obivious to the authors. It can only be assumed that this is related to the transition from several years of clean fallow to cropping and reservoir storage.

b. Pesticide

Soil samples were taken at the end of the season to assess pesticide residues and nutrient accumulations. A sample was also taken from an area that had been clean fallowed for the past five years. Samples were air dried, ground, and sieved.

1. Stam - A sample from the clean fallowed field was spiked with 1 ppm by soil weight. Samples were extracted using a DIONEX SFE unit equipped with a co-solvent injection unit set to meter 10% (on a molecular weight basis) of 10:90 acetone:water mixture containing 1% triethylamine. Samples were placed into extraction tubes in random order for each run. Three replications were extracted

and analyzed for propanil content. Each sample was concentrated to approximately 2 ml and brought up to a final volume of 5 ml with LC carrier solvent. Samples were analyzed using a Waters HPLC equipped with a photodiode array detector at a wavelength of 250 nm. Except for the spikes, no propanil was detected in any samples. The extraction recovery from the spikes was 101.8%, well within limits of variability.

2. Furadan - Samples were extracted by mixing the soil with 100 ml of a 5:95 solution of acetonitrile and methylene chloride, sonicating for three minutes, then decanting and filtering the extract. This process was repeated three times. After the last extraction, the soil was rinsed and filtered with the extraction solution. The extract was condensed to about 3 ml then diluted to 10 ml using LC carrier solvent. Samples were analyzed according to Method 531.1 using a Gilson HPLC equipped with a post column reaction unit and a Gilson Flourometric detection unit. A blank sample was spiked with 1 ppm Furadan by soil weight. The extraction recovery was 97.6%. Furadan was not detected in any samples except the spikes.

4. Wetlands contribution

A wetland's value to the human environment as a "source", "sink" and transformer of chemical and biological materials is so great that our government protects wetlands. Wetlands are so effective in removing organic matter, suspended sediments and nutrients from waste water that municipalities are constructing wetlands to purify their wastewater. While purifying water, wetlands provide food and habitat for fish and waterfowl.

Rice fields serve as temporary wetlands providing shallow floodwater for about 90 days/year (180 days when ratoon rice is grown). Shallow reservoirs used in this study provide wetland 270 to 300 days per year. Although rice production probably provides more waterfowl food than the shallow water storage reservoirs, the reservoirs provided more available water surface than rice fields. In this study the rotating reservoir had less aquatic weeds and more open water than the stationary or continuous reservoir. The shallow reservoirs used in this study occupied more land area than deep reservoirs of equal water holding capacity but were cheaper to construct and provide the shallow water (less than 12 inches deep) preferred by most water fowl. The reservoir definitely attracted more waterfowl than the rice fields. The type of waterfowl varied throughout the year. The dominant species were Black-necked stilt (Himantopus mexicanus), Fulvous Whistling-Duck (Dendrocygna bicolar) appeared two different times during 1994 off springs were seen, Mottled Duck (Anas fulvigula), White-faced Ibis (Plegadis chihi) and White Ibis (Eudocimus albus) of various stages of maturity, Snowy Egret (Egretta thula) and Great Egret (Casmerodius albus), Blue-winged Teal (Anas discors), and Little Blue Heron (Egretta caerula) and Great Blue Heron (Ardea herodias). In addition, the shallow reservoirs provided habitat for crawfish, racoons, and mink.

V. Summary and conclusions

A. Regarding each objective:

Objective 1) Develop water retention systems to store and recycle high rainfall run-off from soybean and rice fields.

The results illustrate the strong possibilities to conserve Texas water resources by using rain and run-off water to supply rice production water requirements. The research also provides insight into practical constraints to storing rain water (land requirement, leaking levees, pumping cost). The data base has been developed towards accomplishing Objective 1.

Objective 2) Determine if seedling survival and crop yield can be improved by pumping excess surface water into a reservoir for later use.

The results suggest that simple removal of surface water helps but will not sufficiently and quickly improve the water saturated root zones which limit seedling and crop survival in flat, clayey soils with poor internal drainage.

Objective 3) Monitor changes in quality of recycled water.

Storage of water in a shallow reservoir with aquatic plants will improve water turbidity and remove inorganic nutrients. Soil or water salinity did not increase when water was recycled during the duration of the experiment.

Objective 4) Evaluate reduced tillage practices as a method for fuel and equipment conservation.

The two years of crop production data on poorly drained soils shows that reduced tillage will lengthen the life of equipment (disc, land planes, harrows, and tractors). However, the production system requires the purchase of a minimum till drill to plant in a vegetated seedbed, and increases the cost of herbicide to control weeds not killed by mechanical cultivation is increased. See comments about reduced tillage under V-B. Other Significant Findings, Section 1 on next page.

Objective 5) Monitor changes in soil chemistry as influenced by continuous rice versus rice in rotation.

Rice grown continuously or in rotation with reservoir and soybean did not produce apparent differences in soil chemistry. We expected a slight accumulation of salts in the closed water system but there was no evidence of salt build-up.

B. Other Significant Findings

1. Soil moisture conservation effects of reduced tillage may be a disadvantage in high rainfall areas.

Our experience with this study suggests that the reduced tillage crop residue, beneficial in reducing evaporative water losses in dry land farming, may prolong periods of water saturation and actually reduce the time that soil conditions are dry enough for planting in these poorly drained soils. Standing vegetative residue associated with reduced tillage can reduce evaporative water loss and increase periods of water saturation, thereby delaying planting and reducing yield of established crops. Therefore, surface residue attributed to reduced tillage can be a negative aspect of reduced tillage for high rainfall areas. This problem was most evident when planting rice after land was in reservoir for one year. Possibly conventional tillage practices should have been used to plant crops after the land was used for a reservoir.

2. The water collection and storage in shallow reservoir did conserve rain and runoff water and appears agronomically feasible. Cost studies are needed to determine the economics of the shallow reservoirs as a water supplement for rice.

The water collection and storage in shallow reservoirs did conserve rain and runoff water. The concept appears too agronomically sound for both continuous and rotational management systems. Modifications of the infrastructure and economics will require further evaluation.

Inferences from this study would raise concerns. A major portion of the rice in Texas involves absentee land owners and tenants. The benefit of this management system to both parties will require further evaluation. The shallow reservoirs, prepared by constructing 12 to 18 inch high levees, are less expensive to construct than deep water reservoirs. However, shallow reservoirs occupy more land area than similar capacity deep water reservoirs. The advantages of a land owner 1) investing in reservoir construction and a pumping system and 2) tying-up more land for each rice crop must be demonstrated. Water for most tenant arrangements is furnished by the land owner by gravity flow from canals at relatively low per acre cost (approximately $20 per acre-foot in most areas with about 2 acre feet required). All labor is typically the responsiblity of the tenant. The shallow reservoir system requires a significant increase in labor to recover the rainfall and runoff and to irrigate a rice crop. The benefits of these added cost must be demonstrated to the tenant.

The shallow reservoir system can conserve natural land and water resources and serve as wetlands. The benefits to both the land owner and tenant must be identified before the system would appear adaptable to the Texas rice areas.

3. The land allocation ration of 1/3 rice, 1/3 row crop (as a source of runoff water), and 1/3 shallow reservoir provide 100% and 75% of the rice water requirement in 1994 and 1995, respectively. If water loss due to leakage had not been so great in 1995, rice water requirements might have been met by rainfall.

4. The water conservation and water recycling practices tested in this study may have two negative implications when perfectly managed:

   a. Soils would eventually accumulate as more salts were added than removed by water infiltration.
   b. Large acreage in this no runoff water conservation cropping system could reduce surface water flow to coastal marshes and estuaries potentially reducing their productivity.

5. Minimum tillage techniques may not be effective for production of continuous rice in areas where winters are not cold enough to kill rice stubble. Overwinter rice stubble is not easily killed with Round-Up herbicide prior to planting rice and competes with rice seedling sunlight and nutrients reducing rice quality and yield.
6. Rice fields are flooded about 90 days for main crop production and about 180 days when a ratoon crop is produced. Whereas the shallow reservoirs provide wetlands for 270 to 300 days per year.

Appendix

FIG IIIA

WATER RECYCLING PROJECT
1994 FIELD DIAGRAM

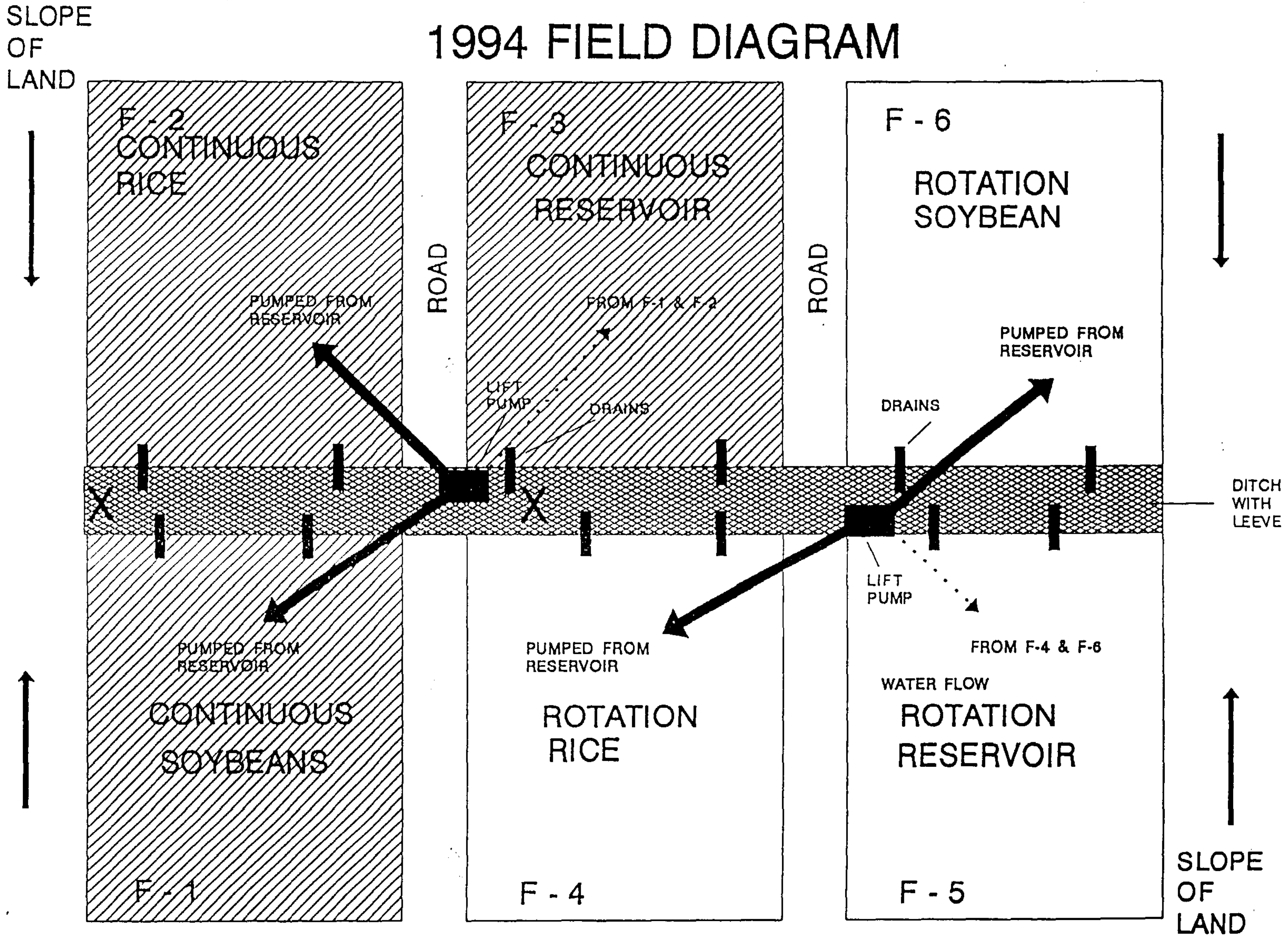


FIG IIIB

WATER RECYCLING PROJECT

1995 FIELD DIAGRAM

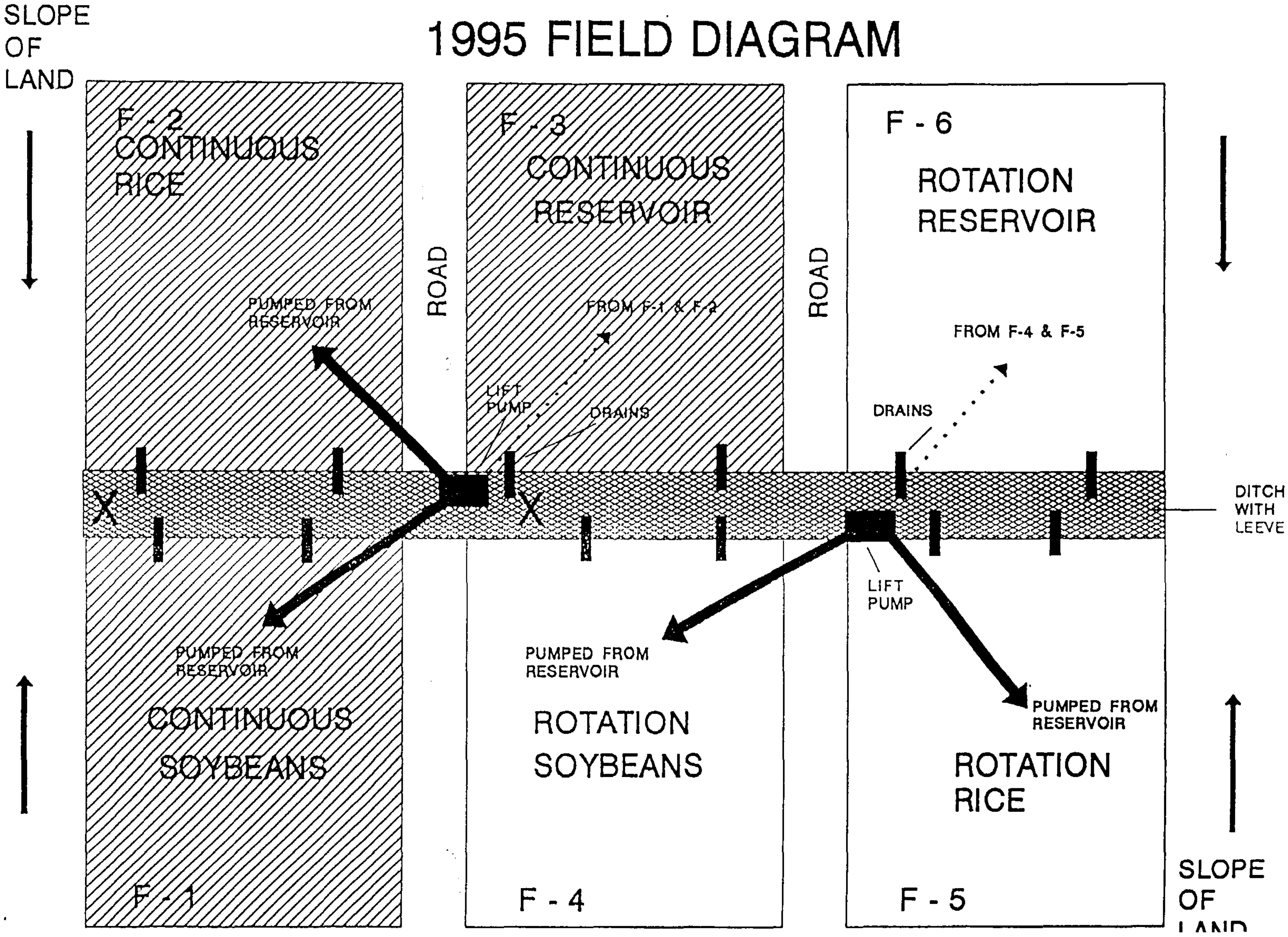


Table IVA-1994 1994 Cultural Practices

4-19-94	Sprayed Roundup at 2 qt/acre
4-28-94	Using minimum tillage drill rice of Gulfmont variety was planted at 100 lbs seed/acre in fields F-2 and F-4
5-9-94	Rice emergence
5-10-94	70 lbs N/acre applied as urea on dry soil
5-14-94	Started flood early because of 3.8" rainfall
5-24-94	Furadan applied to control water weevil
6-10-94	Panicle differentiation N applied 45 lbs N
8-12-94	1.5 inches of water pumped from field into reservoir in preparation for harvest
8-24-94	Harvest

Table IVA-1995 1995 Cultural Practices

May 1	Planted F-2 (continuous rice) using the variety Gulfmont at a seeding rate of 100 lbs per acre. This was planted as no-till.
May 4	Planted F-5 (rotation) using Gulfmont. About half of the field was wet which lead to a poor stand in this area.
May 5	Flushed both F-2 and F-5. There was not enough water in F-3 reservoir to complete flush so about the lower 1/4 of F-2 was watered from reservoir and the remainder of the field received 1/2 to 3/4 inch canal water. All of F-5 was flushed with canal water.
May 6	All water from flushing on 5/6 was pumped back into respective reservoirs.
May 8	About 1.6 inches of rainwater was pumped into reservoirs F6 and F-3. This returned reservoir levels to about 6 inches.
May 13	Emergence of F-2
May 15	Applied 70 lbs N and 40 lbs P by airplane to F-2 and F-5 Emergence of F-5
May 20	Applied 4 lbs of propanil to F-2 and F-5
May 25	Flushed both F-2 and F-5 using canal water since reservoirs were too low. Used about 2 inches to cover fields. Water was returned to reservoir.
May 30	Permanent flood
May 31	Pumped water from F-1 and F-4 into reservoirs after heavy rain.
June 1	Due to heavy rains the previous night water was released to drainage ditch from fields F-2 and F-4. Reservoirs were full at this time. Also water was released from F-5 because water depth was too great for young rice.
June 5	Lost nearly all water from F-6 reservoir due to leak in tile over weekend. Most of the water leaked into F-1 and F-4 and was recovered from these two fields over the next two days. May have 20% of the original volume.
June 8	Added 2 to 3 inches of water from reservoirs to F-2 and F-5. Water had leaked from F-2 the previous night and it was also returned to F-2.
June 9	Added another 3/4 to 1 inch of water to F-2. Mo Way checked for water weevil and recommended applying 17 lbs Furadan.

June 12	Applied 17 lbs Furadan to F-2 and F-5. Also applied 50 lbs of N as urea.
June 14	Added .8 ft (9.6 in.) water from canal to F-3 reservoir.
June 15	Added water to F-2 and F-5. Planted soybeans in F-1. Sprayed with Roundup, Dual, and Sencor before planting.
June 16	Planted soybeans in F-4 and sprayed with Dual and Sencor after planting.
June 20	Added water to F-3 reservoir
June 28	Added 6 in of water from canal to F-3 and F-6 reservoirs. Had rain that afternoon.
June 29	Pumped rainwater from soybeans into reservoirs.
July 3	Lost some water from F-5 over weekend due to leak. Had to add water from F-6 before applying 50 lbs of urea. Plants at PD.
July 5	Another leak in F-5. Added water.
July 10	Added water to F-2 and F-5.
July 28	Heading
August 23	Drain

Table IVB-1994

1994 Water Use Summary

	Total Rain	Water From Reservoir			Total Water	Potential *
	(Inches)	Date	Source	Inches	Added (Inches)	Evapotranspiration
		May 20	Soybean	1.00		
		May 24	Reservoir	1.00		
		May 27	Reservoir	0.75		
		May 31	Soybean	1.00		
	5.84 (May 14–31)			3.75	9.62	3.52
		June 13	Soybean	0.70		
		June 13	Reservoir	0.50		
	5.24 (June)			1.20	6.44	6.60
		July 1	Reservoir	2.50		
		July 5	Reservoir	0.70		
		July 8	Reservoir	1.00		
	3.77 (July)			4.20	7.97	6.80
	2.6 (August 1–12)			0.00	2.60	2.64
Total	17.48			9.15	26.63	19.56
Minus water drained at harvest				1.50	1.50	
Total	**17.48**			**7.65**	**25.13**	**19.56**

* Potential Evapotranspiration = 0.22 inches/day x number of days

Table IVB-1995

1995 Water Use Summary

	Field F-2 Continuous Rice				Field F-5 Rotation Rice			
	Water Source (inches)				Water Source (inches)			
	Rainfall	Reservoir	Canal	Total	Rainfall	Reservoir	Canal	Total
May 1-31	10.02	1	3	14.02	10.02	0	4	14.02
June 1-30	5.53	4	4	13.53	5.53	1.25	5	11.78
July 1-30	4.76	2	3	9.76	4.76	6	3	13.76
Aug. 1-23	5.05	2	0	7.05	5.05	2	0	7.05
Total	25.36	9	10	44.36	25.36	9.25	12	46.61
% of Total	57.2	20.3	22.5		54.4	19.8	25.7	

Figure IV.B2-1 Nitorgen Concentrations in supply canal by N form in 1994.

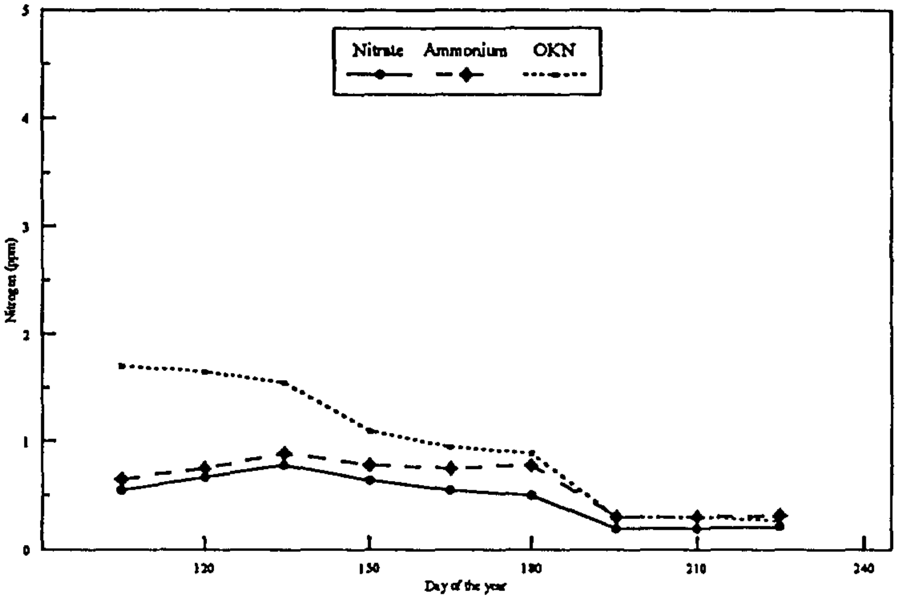


Figure IV.B2-2. Nitorgen concentrations in supply canal by N form in 1995.

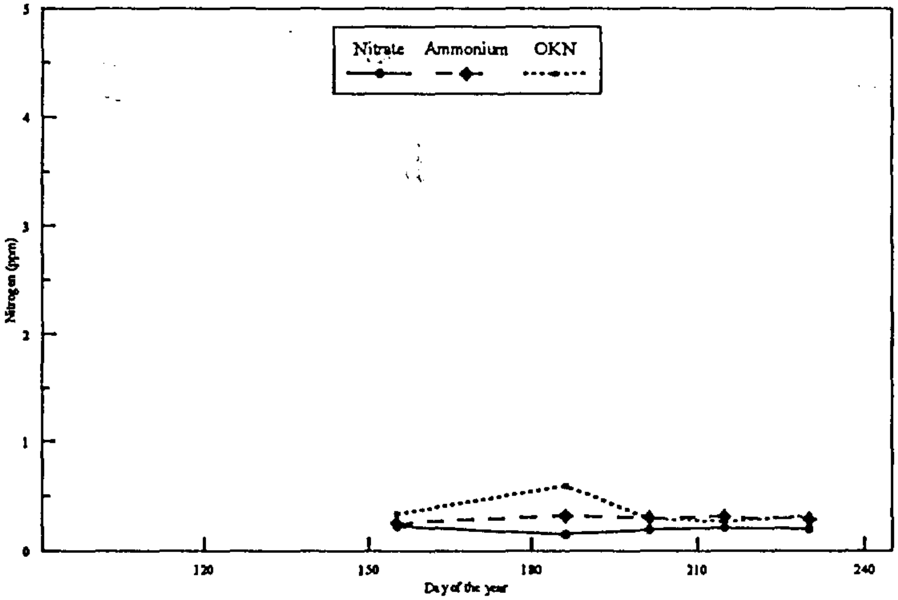


Figure IV.B2-3. Nitorgen concentrations in continuous supply reservoir (Field F-3) by N form in 1994.

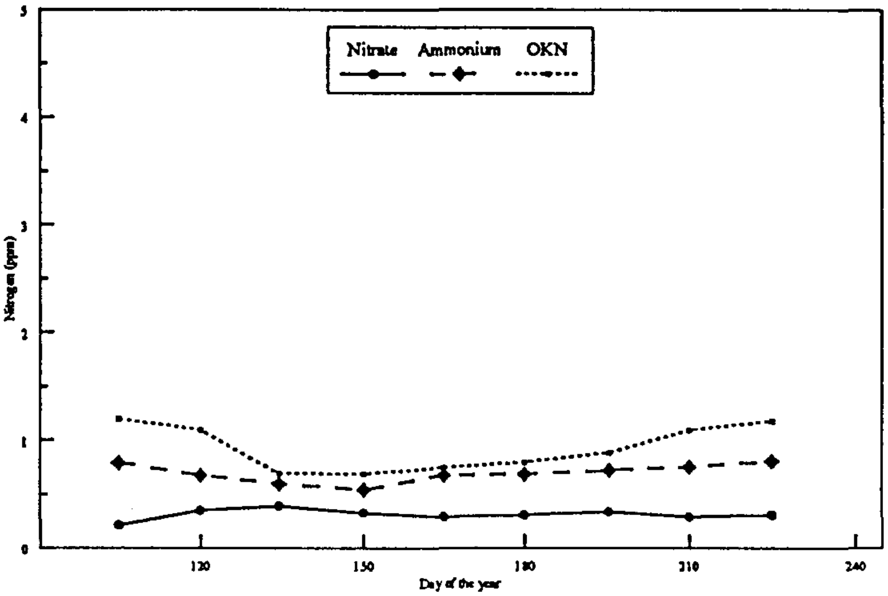


Figure IV.B2-4. Nitorgen concentrations in continuous supply reservoir (Field F-3) by N form in 1995.

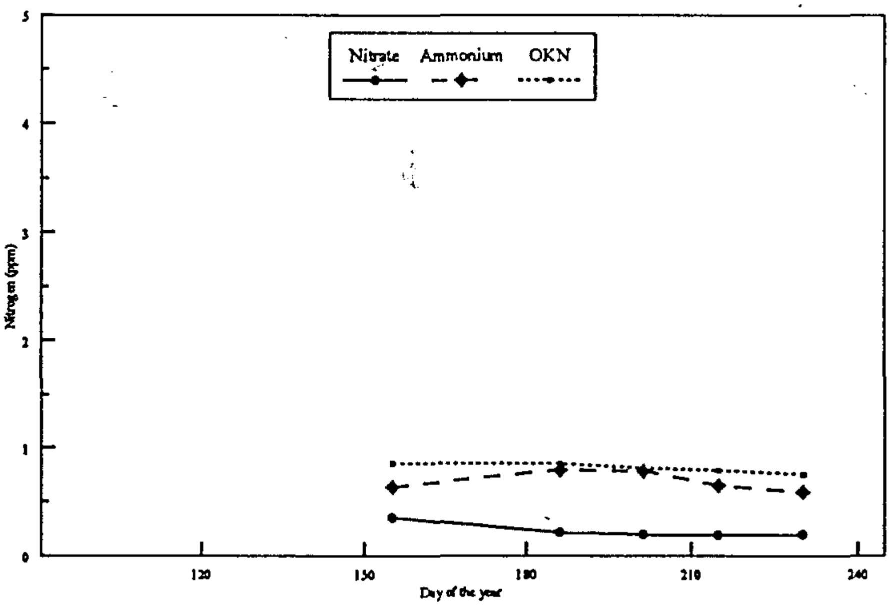


Figure IV.B2-5. Nitorgen concentrations in rotational supply reservoir (Field F-5) by form in 1994.

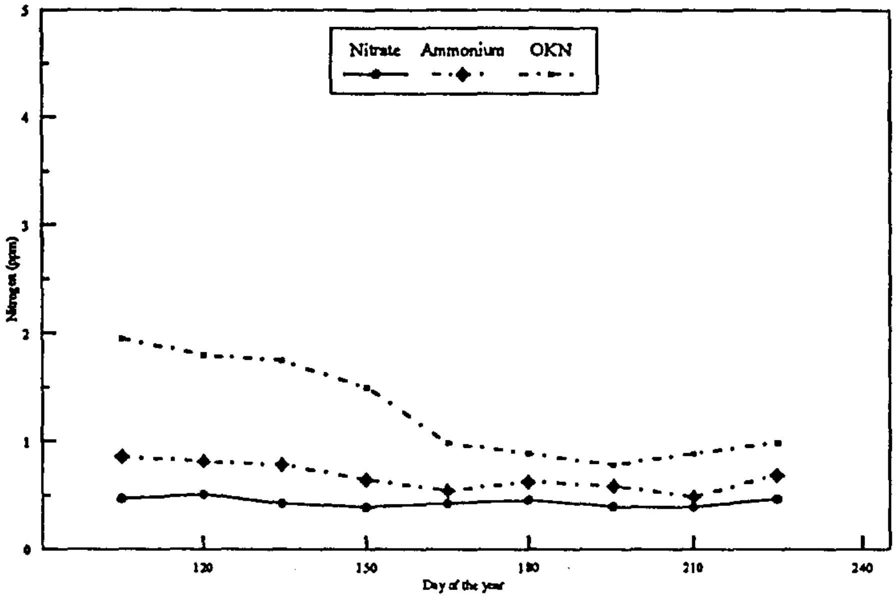


Figure IV.B2-6. Nitorgen concentrations in rotational supply reservoir (Field F-6) by N form in 1995.

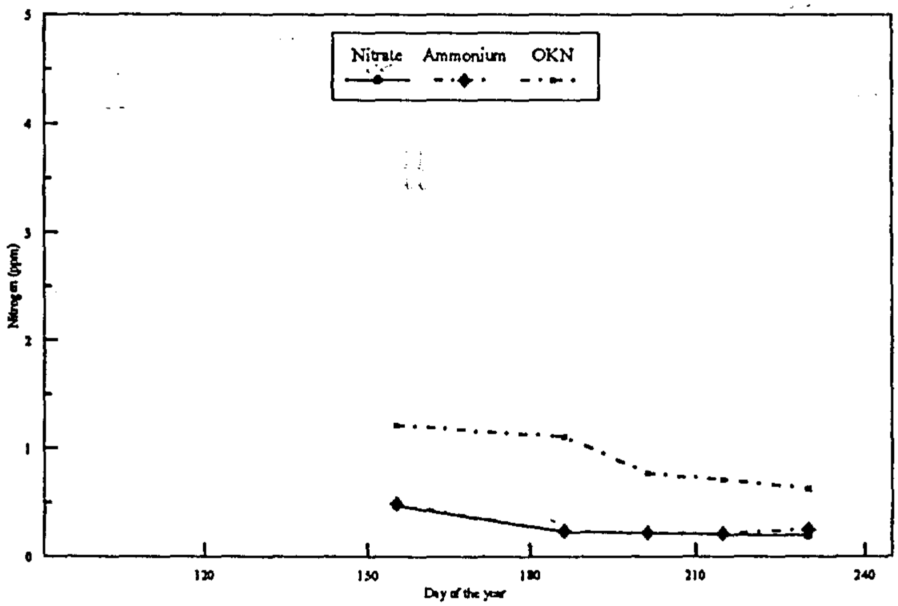


Figure IV.B2-7. Nitorgen concentrations in continuous rice (Plot F-2) by form in 1994.

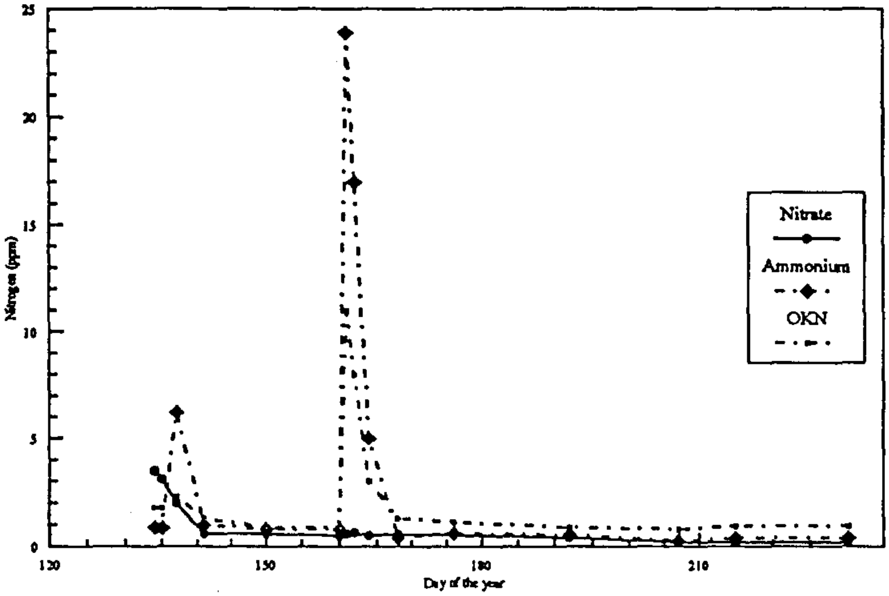


Figure IV.B2-8. Nitorgen concentrations in continuous rice (Field F-3) by N form in 1995.

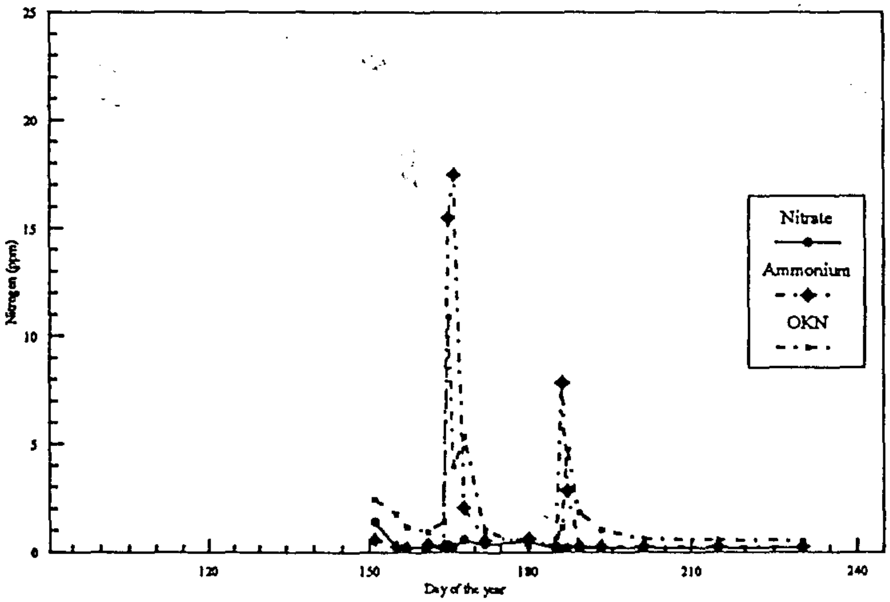


Figure IV.B2-9. Nitorgen concentrations in rotational rice (Plot F-4) by form in 1994.

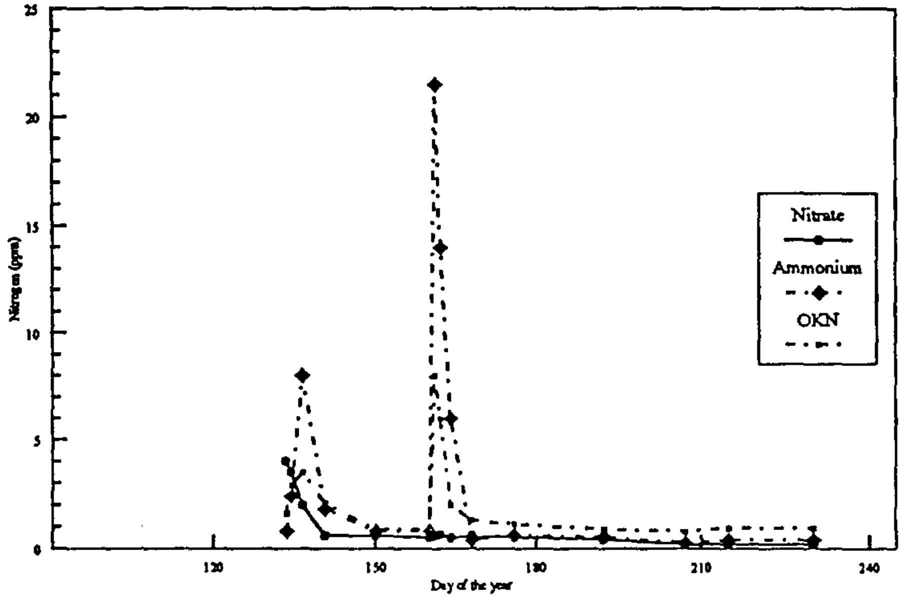


Figure IV.B2-10. Nitorgen concentrations in rotational rice (Plot F-4) by form in 1995.

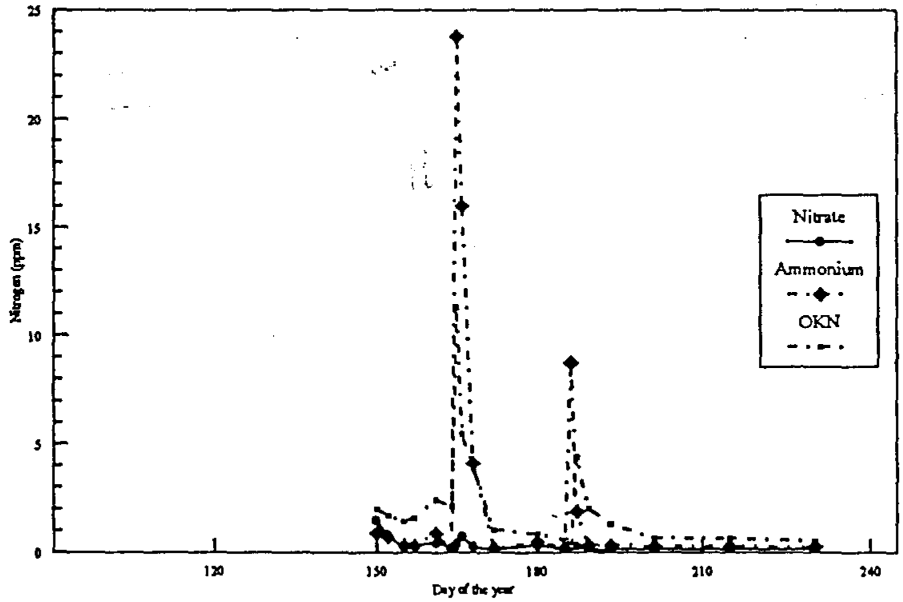


Figure IV.B2-11. Carbofuran levels in continuous rice field flood water (Plot F2) for the 1994.

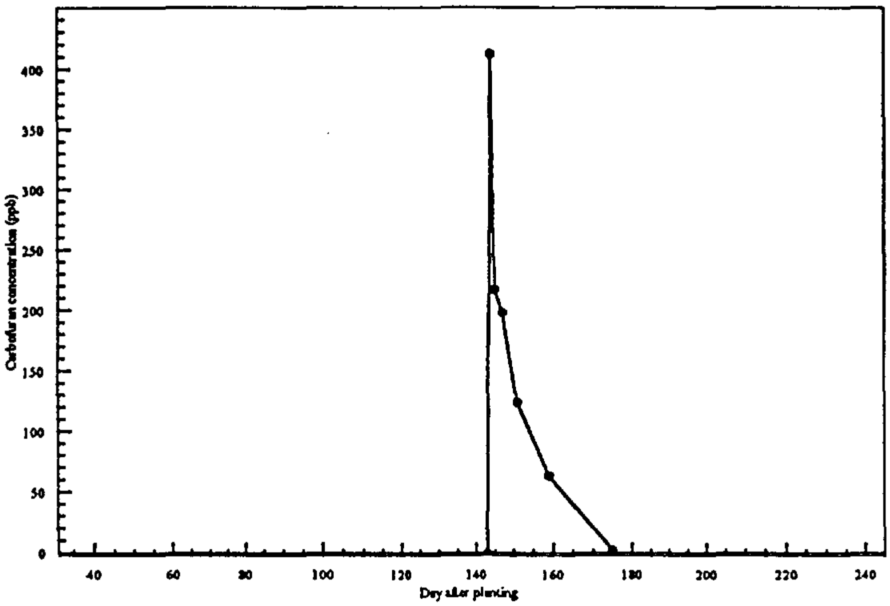


Figure IV.B2-12. Carbofuran levels in continuous rice field flood water (Plot F-2) for the 1995.

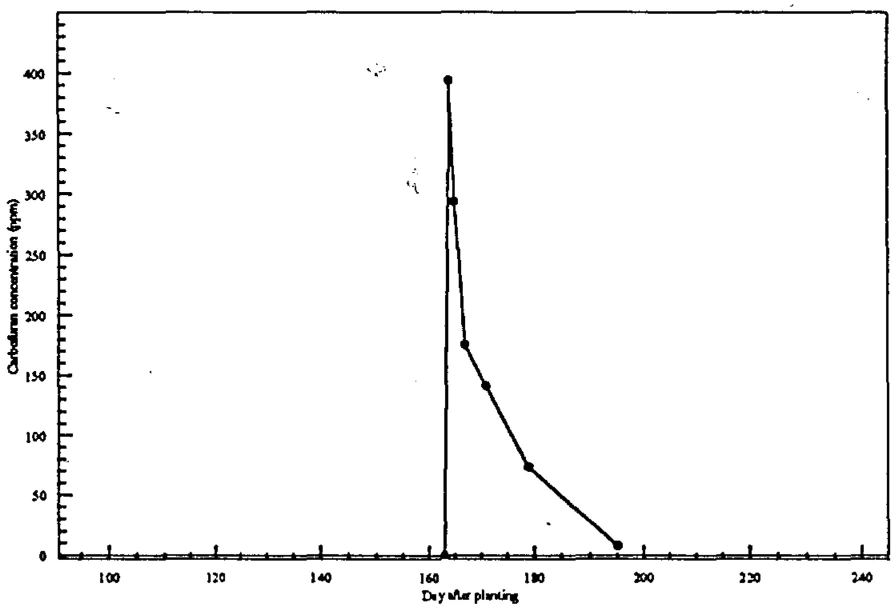


Figure IV.B2-13. Carbofuran levels in rotational rice field flood water (Plot F-4) for the 1994.

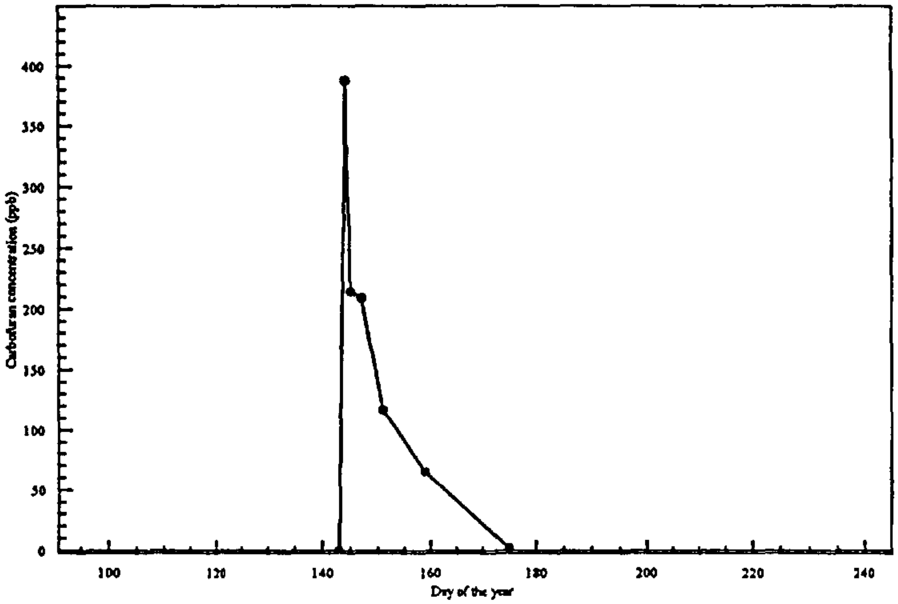


Figure IV.B2-14. Carbofuran levels in rotational rice field flood water (Plot F-5) for the 1995.

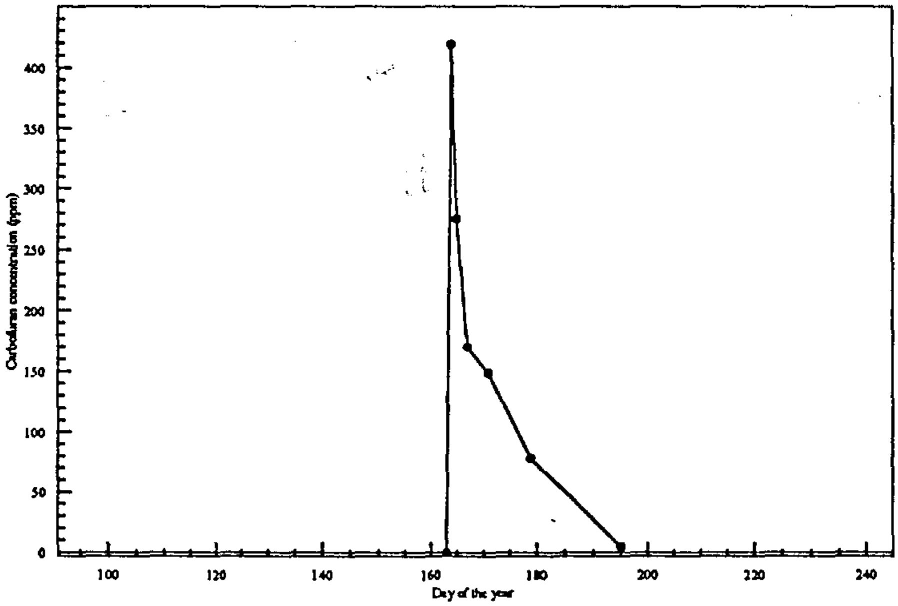


Figure IV.B2-.16. Rainfall at the Texas A&M Research and Extension Center near Beaumont, Texas for 1994.

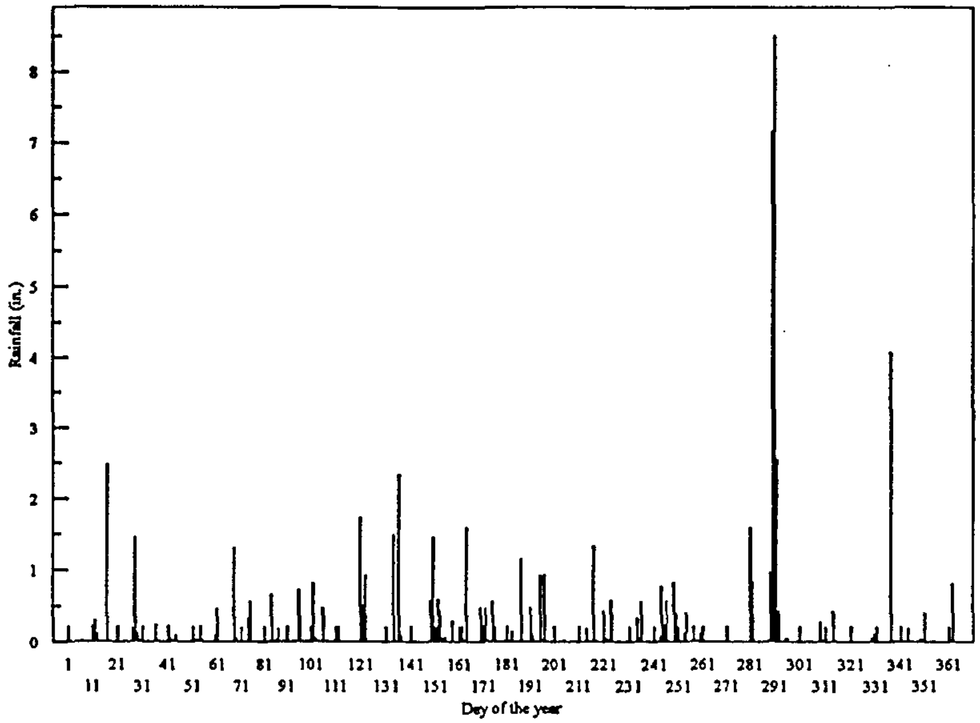
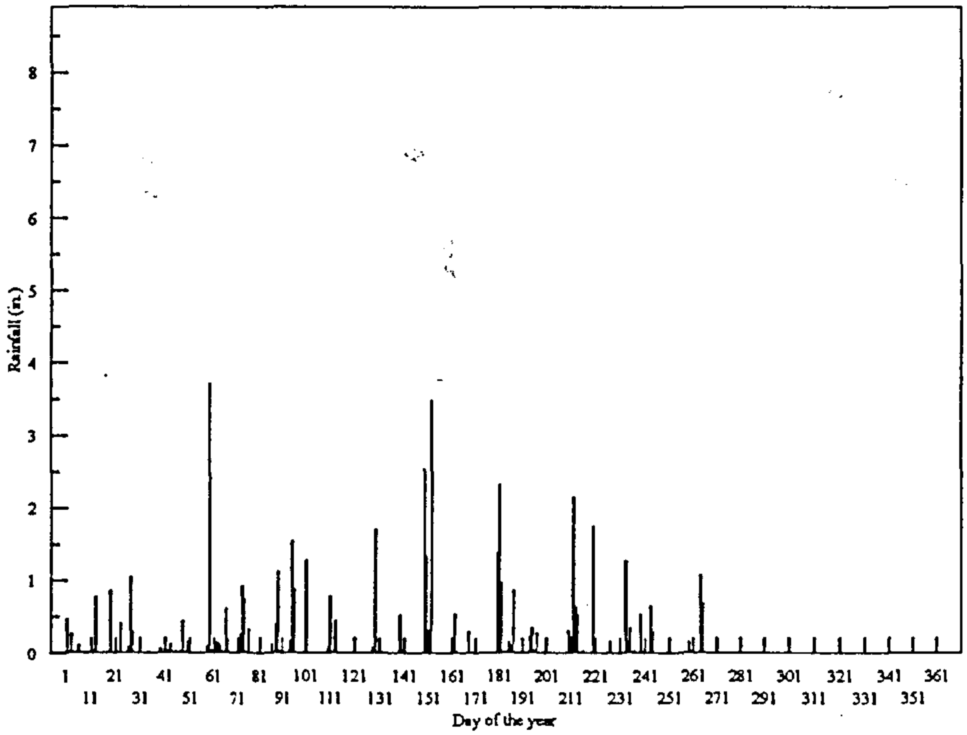


Figure IV.B2-17. Rainfall at the Texas A&M Research and Extension Center near Beaumont, Texas for 1995.



SOIL TEST

Field F-1, Continuous Soybeans

Sample I. D.	Date	pH	Nitrogen	Phosphorus	Potassium	Calcium	Magnlesium	Salinity	Sodium	Sulphur
EA-1	8-31-93	5.80	14	8	151	2328	552	390	124	54
EA-1	Preplant 95	5.90	1	10	124	3979	394	169	87	26
EA-1	9-29-95	6.40	1	9	96	3809	376	79	78	18
EA-2	8-31-93	5.90	12	10	129	2527	491	260	125	57
EA-2	Preplant 95	5.70	1	12	157	4282	443	169	136	22
EA-2	9-29-95	6.10	1	10	113	3739	392	50	86	12
EA-3	8-31-93	5.90	15	11	133	2285	489	325	126	60
EA-3	Preplant 95	5.50	1	11	122	3980	421	156	90	21
EA-3	9-29-95	6.00	1	10	176	3967	437	51	82	18
EA-4	8-31-93	5.90	14	10	133	2337	474	325	119	61
EA-4	Preplant 95	6.10	1	12	142	4077	399	123	100	21
EA-4	9-29-95	5.80	1	10	132	4113	412	80	86	21
EA-5	8-31-93	5.90	15	9	134	2190	458	325	103	53
EA-5	Preplant 95	5.90	1	11	135	3905	390	188	93	20
EA-5	9-29-95	6.30	1	10	101	3514	356	51	87	19
EA-6	8-31-93	6.40	12	9	151	2661	518	260	131	64
EA-6	Preplant 95	5.70	1	11	133	4123	411	169	110	24
EA-6	9-29-95	6.40	1	9	114	3737	369	40	85	18
Avg.	8-31-93	5.97	14	10	139	2388	497	314	121	58
Avg.	Preplant 95	5.80	1	11	136	4058	410	162	103	22
Avg.	9-29-95	6.17	1	10	122	3813	390	59	84	18

SOIL TEST

Field F-2, Continuous Rice

Sample I. D.	Date	pH	Nitrogen	Phosphorus	Potassium	Calcium	Magniesium	Salinity	Sodium	Sulphur
WA-1	8-31-93	5.60	20	17	137	2193	430	260	96	53
WA-1	Preplant 95	5.30	1	16	142	3749	397	130	74	26
WA-1	9-29-95	5.60	1	16	135	3955	406	110	79	17
WA-2	8-31-93	5.50	17	19	142	2084	410	520	89	53
WA-2	Preplant 95	5.30	1	16	99	3589	370	130	73	29
WA-2	9-29-95	5.70	1	19	164	3799	404	92	74	19
WA-3	8-31-93	5.50	18	20	118	2090	407	455	87	58
WA-3	Preplant 95	5.30	1	17	116	3394	359	143	67	23
WA-3	9-29-95	5.70	1	19	89	3427	376	78	64	18
WA-4	8-31-93	5.50	15	14	124	2165	423	390	100	56
WA-4	Preplant 95	5.20	1	11	108	3494	363	208	94	26
WA-4	9-29-95	5.80	1	17	101	3748	397	74	84.00	15
WA-5	8-31-93	5.50	17	16	144	2109	427	390	95	57
WA-5	Preplant 95	5.20	1	12	100	3440	351	175	79	27
WA-5	9-29-95	5.80	1	15	136	4046	425	68	95	18
WA-6	8-31-93	5.60	15	12	110	2035	391	455	89	52
WA-6	Preplant 95	5.30	1	14	142	3643	382	182	75	23
WA-6	9-29-95	5.80	1	13	81	3914	366	68	92	24
Avg.	8-31-93	5.53	17	16	129	2113	415	412	93	55
Avg.	Preplant 95	5.27	1	14	118	3552	370	161	77	26
Avg.	9-29-95	5.73	1	17	118	3815	399	85	70	16

SOIL TEST

Field F-3, Continuous Reservoir

Sample I. D.	Date	pH	Nitrogen	Phosphorus	Potassium	Calcium	Magnlesium	Salinity	Sodium	Sulphur
WB-1	8-31-93	5.80	15	11	104	1965	399	455	92	54
WB-1	Preplant 95	5.50	1	12	130	3759	362	169	75	18
WB-1	9-29-95	6.50	1	11	90	4002	367	68	93	8
WB-2	8-31-93	5.70	15	9	101	1812	386	455	87	47
WB-2	Preplant 95	5.40	1	12	122	3520	363	136	74	19
WB-2	9-29-95	6.10	1	13	130	3864	358	90	87	14
WB-3	8-31-93	5.70	13	8	109	2089	403	520	101	49
WB-3	Preplant 95	5.40	1	11	154	3299	344	143	58	19
WB-3	9-29-95	6.10	1	12	113	3518	351	74	77	18
WB-4	8-31-93	5.80	15	7	114	1961	380	390	95	43
WB-4	Preplant 95	5.50	1	9	131	3310	349	156	54	16
WB-4	9-29-95	6.30	1	12	126	3898	350	70	84	12
WB-5	8-31-93	5.80	13	7	118	1995	378	455	98	53
WB-5	Preplant 95	5.40	1	12	140	3732	373	143	67	19
WB-5	9-29-95	6.00	1	11	111	3515	347	82	85	18
WB-6	8-31-93	5.70	16	11	102	1958	381	520	98	61
WB-6	Preplant 95	5.40	1	12	124	3293	336	149	77	21
WB-6	9-29-95	6.10	1	10	74	3207	306	59	72	9
Avg.	8-31-93	5.75	15	9	108	1963	388	466	95	51
Avg.	Preplant 95	5.43	1	11	134	3486	355	149	68	19
Avg.	9-29-95	6.18	1	12	107	3667	347	74	83	13

SOIL TEST

Field F-4, Rice 1994, Soybeans 1995

Sample I. D.	Date	pH	Nitrogen	Phosphorus	Potassium	Calcium	Magniesium	Salinity	Sodium	Sulphur
EB-1	8-31-93	5.90	15	3	123	2410	460	227	112	53
EB-1	Preplant 95	5.80	1	11	112	3647	357	130	75	12
EB-1	9-29-95	6.40	1	12	150	4045	384	82	85	9
EB-2	8-31-93	6.30	14	3	141	2647	480	182	146	57
EB-2	Preplant 95	5.60	1	11	146	3633	349	136	71	14
EB-2	9-29-95	6.30	1	11	133	3902	363	72	84	19
EB-3	8-31-93	6.30	12	3	125	2443	456	156	121	52
EB-3	Preplant 95	5.50	1	12	143	3596	359	156	73	22
EB-3	9-29-95	6.10	1	12	152	3963	378	80	88	18
EB-4	8-31-93	6.30	13	2	136	2366	450	195	129	52
EB-4	Preplant 95	5.80	1	10	129	3267	337	149	86	19
EB-4	9-29-95	6.20	1	12	118	4295	408	70	101	13
EB-5	8-31-93	6.20	15	6	124	2090	395	325	111	47
EB-5	Preplant 95	5.80	1	9	129	3344	344	182	76	15
EB-5	9-29-95	6.50	1	11	148	3938	377	67	93	9
EB-6	8-31-93	6.60	11	6	123	2270	434	214	141	48
EB-6	Preplant 95	5.60	1	10	140	3634	354	162	87	21
EB-6	9-29-95	6.60	1	10	108	3904	374	51	100	23
Avg.	8-31-93	6.27	13	4	129	2371	446	217	127	52
Avg.	Preplant 95	5.68	1	11	133	3520	350	153	78	17
Avg.	9-29-95	6.35	1	11	135	4011	381	70	92	15

SOIL TEST

Field F-5, Reservoir 1994, Rice 1995

Sample I. D.	Date	pH	Nitrogen	Phosphorus	Potassium	Calcium	Magniesium	Salinity	Sodium	Sulphur
EC-1	8-31-93	6.10	22	8	87	1621	309	182	117	46
EC-1	Preplant 95	5.70	1	12	95	3007	308	208	77	22
EC-1	9-29-95	6.60	1	10	92	3088	308	86	110	12
EC-2	8-31-93	6.30	16	3	84	1643	278	201	115	42
EC-2	Preplant 95	5.60	1	10	129	3306	342	175	90	23
EC-2	9-29-95	6.30	1	9	80	3005	302	83	97	14
EC-3	8-31-93	6.30	20	7	97	1729	322	240	139	39
EC-3	Preplant 95	5.50	1	11	111	3121	309	136	82	16
EC-3	9-29-95	6.00	1	10	127	3130	315	93	85	25
EC-4	8-31-93	6.60	16	3	86	1849	327	260	130	45
EC-4	Preplant 95	6.10	1	9	106	3099	299	201	69	13
EC-4	9-29-95	6.40	1	9	83	2879	267	64	82	12
EC-5	8-31-93	6.40	19	8	111	1895	364	325	136	44
EC-5	Preplant 95	6.30	1	10	130	3302	324	240	84	12
EC-5	9-29-95	6.80	1	8	95	3348	314	77	94	10
EC-6	8-31-93	6.90	12	3	102	2034	364	260	140	49
EC-6	Preplant 95	5.80	1	10	118	3290	309	182	85	16
EC-6	9-29-95	6.80	1	9	118	3363	324	102	99	11
Avg.	8-31-93	6.43	18	5	95	1795	327	245	130	44
Avg.	Preplant 95	5.83	1	10	115	3188	315	190	81	17
Avg.	9-29-95	6.48	1	9	99	3136	305	84	95	14

SOIL TEST

Field F-6, Soybeans 1994, Reservoir 1995

Sample I. D.	Date	pH	Nitrogen	Phosphorus	Potassium	Calcium	Magniesium	Salinity	Sodium	Sulphur
WC-1	8-31-93	6.10	16	10	85	1529	309	650	133	53
WC-1	Preplant 95	5.40	1	13	127	2926	304	156	71	21
WC-1	9-29-95	6.40	1	11	85	3180	292	67	104	12
WC-2	8-31-93	6.30	15	7	81	1615	310	650	144	43
WC-2	Preplant 95	5.30	1	13	112	2754	287	208	72	19
WC-2	9-29-95	6.30	1	11	80	3321	338	72	102	10
WC-3	8-31-93	5.90	21	11	93	1545	330	650	117	43
WC-3	Preplant 95	5.50	1	10	73	2676	307	156	72	20
WC-3	9-29-95	6.30	1	9	77	3098	323	93	113	21
WC-4	8-31-93	6.20	14	5	80	1705	307	650	136	51
WC-4	Preplant 95	5.70	1	8	98	2594	236	201	77	16
WC-4	9-29-95	6.50	1	10	56	3144	307	61	130	18
WC-5	8-31-93	5.80	16	9	84	1580	314	520	119	46
WC-5	Preplant 95	5.70	1	8	87	2735	275	169	86	27
WC-5	9-29-95	6.60	1	11	88	3497	311	67	144	17
WC-6	8-31-93	6.30	15	6	88	1659	280	585	129	42
WC-6	Preplant 95	5.60	1	9	94	2920	305	149	90	24
WC-6	9-29-95	6.40	1	9	102	3224	274	76	130	17
Avg.	8-31-93	6.10	16	8	85	1606	308	618	130	46
Avg.	Preplant 95	5.53	1	10	99	2768	286	173	78	21
Avg.	9-29-95	6.42	1	10	81	3244	308	73	121	16