RESEARCH PROGRESS REPORT FOR 1993

Submitted to: SLV Research Committee
and
The Colorado Potato Administrative Comittee (Area II)

Title: Efficacy of Ozone for enhancing potato production and storage.

Project Leaders: Richard T. Zink and Robert D. Davidson, SLV,Research Center

OBJECTIVE:

Numerous reports exist of the benefits of supplemental ozone in potato production. Several ozone generators are in operation in the San Luis Valley and growers have made a range of observations as to the effects of these applications. Observations have included reduced water usage, increased plant vigor, increased yields and improved soil texture.

This study was conducted to determine, in the most objective manor, the effects of ozone enriched irrigation water on potato production. This study was limited to the field growing aspects of potato production. An attempt was made to measure all possible parameters associated with large scale production of potatoes under center pivot sprinkler.

MATERIALS AND METHODS:

An ozone unit was installed and electronically integrated into the controls of a Valley center pivot sprinkler system on May 19,1993 on Kehler Ranches, Inc. field 11-12. The entire 145 acres irrigated by the system was planted on May 17 with the potato variety Russet Norkotah. Generation 5 Colorado certified seed was used and the field was entered into the Colorado seed certification program for the 1993 growing season. The first irrigation occurred on May 20. This study included the full east half of the 145 acre field. The north half of the study area received ozone enriched water at each irrigation and the south half unenriched water. The south half of the study area was the control (see plot diagram). Irrigation water was a mixture of well water and Rio Grande River water. During irrigations when a herbicide, insecticide or fertilizer were applied, ozone enrichment was not used.

Tensiometers were installed at the start of the season in both halves of the study at 6,12 and 18 inches. Soil moisture readings were taken on a regular basis. Soil samples were taken down to 18 inches before planting and after harvest. Yield and grade were determined by hand harvesting ten foot of row replicated five time per treatment and by machine harvesting three 250 cwt truck loads per treatment.

Water samples were collected at the second sprinkler tower before and during fertilizer injection to determine the effect of ozone enrichment on nutrient levels in irrigation water.

Following harvest tuber samples from treated and untreated areas of the study were tested for Fusarium dry rot potential using the "bag test".

For a breakdown of cultural practices and types of data collected, see protocol outline.

RESULTS:

No significant differences in stand, number of stems per plant or plant vigor were observed between ozone treated and untreated areas of the study. Similarly, no differences were observed in the incidence of seed piece decay or Rizoctonia stem canker due to treatment. The development of early blight symptoms were greatly delayed due to growing conditions and cultural practices. When symptoms did develop, however severity and incidence were uniform across the study. (Table 1)

Tubers from treated and untreated areas of the study were cut and subjected to the "bag test" to measure Fusarium dry rot potential. After four weeks of incubation all samples showed good suberization and no development of Fusarium dry rot.

Irrigation water was analyzed before and during injection of calcium nitrate fertilizer. Ozone enrichment of the water during fertilizer injection did not substantially alter the concentration of nitrate leaving the sprinkler system or adversely affect water quality. (See water analysis reports).

Soil samples taken before planting and after harvest, showed upon analysis that residual levels of macro and micro nutrients and pH were unaffected by applications of ozone enriched irrigation water. (See soil analysis reports). Likewise,mid-season testing of leaf petiolules revealed no differences among nutrient levels between ozone treated and untreated areas of the study. (See petiolule analysis reports).

Measurements of tuber yield varied depending on the harvest technique. Yields determined by hand digging of 10 feet sections of row were the same, 447 cwt/A for ozone treated and untreated areas of the study. While mechanical harvesting of large blocks of the study indicated that the average yield within treated areas was 391 cwt/A compared to an average yield of 418 cwt/A in untreated areas. This yield discrepancy between harvesting methods is likely due to sampling error. Yield estimate based on truck load samples were not random and were restricted to certain areas of the field. (Table 1)

In hand harvested samples there was a 6% increase in the percent U.S. No. 1 potatoes from ozone treated areas over untreated areas (Table 1). The variation between hand and machine harvested samples is due to picking up more under size tubers by hand harvesting.

Measurements of specific gravity indicated an increase in the percent dry matter in tubers produced under ozone enriched irrigation water. On the average, tubers from ozone treated areas had a specific gravity of 1.090 while tubers from non-treated areas had a specific gravity of 1.071.

Over the growing season soil moisture was monitored using tensiometer placed at 6,11 and 18 inches deep in treated and untreated areas. Moisture reading varied between irrigations at the 6 inch depth but remained constant at the 12 and 18 inch depths. All readings were uniform across the study over the growing season. Color and infrared aerial photographs of the field revealed no visible differences between treated and untreated areas of the study (see photographs).

DISCUSSION:

The data collected in this study indicated that ozone enrichment of irrigation has potential for increasing yields and quality when utilized in a comprehensive potato production scheme. Increasing the percentage of number one grade potatoes by five percent or more combined with an increase in percent dry matter on a tuber basis can be beneficial. Another factor in this study that became evident only at harvest was an apparent improvement in soil texture. While this was not measured objectively, the driver of the potato harvester stated that he could increase tractor speed by two gears when digging on ozone treated ground with no increase in the volume of soil clods going over the harvester. A reduction in soil clods on the harvester can result in less mechanical damage to the tubers, less soil being transported into the bin and less potential for problems in storage due to dry rot and soft rot.

The lack of an effect of zone treatment on stand, vigor, seed piece decay, Rizoctonia stem canker, early blight and Fusarium dry rot is not surprising, given cultural practices and growing conditions during 1993 in the San Luis Valley.

The field this study was located on had been a barley rotation and was planted with high quality certified seed, of which half was uncut. Throughout the growing season the crop was managed very closely, the soil was never too wet or allowed to dry out. Fertility was also managed closely keeping nutrient levels optimal for ideal plant development. Early blight was not a major problem in this field during 1993 due to under high fertility and timely fungicide applications.

On July 12 a major hail storm passed through the area. The quarter section where this study was located suffered substantial levels of hail damage. The damage is evident in the July 24 aerial photograph of the field. The degree of hail damage as measured by yield, ranged from 503 cwt/A in area of no damage to 346/A in area of high damage. Most of the ozone treated area of the study received high levels of hail damage. Therefore, additional efficacy studies need to be conducted to substantiate these data.

Table 1. Effect of Oxion treatment on growth disease and yield of potato

Parameter	Oxion	Control
Stand[a]	41.3	40.8
Stems[b]	4.7	4.9
Vigor[c]	3.8	3.8
Seed piece decay[d]	0.1	0.0
Rizoctonia[e]	0.9	0.6
Early Blight[f]	0.3	0.4
Yield (hand)[g]	447	447
Yield (machine)[h]	391	418
%U.S. No. 1 (hand)[i]	63	57
%&.S. No. 1 (machine)[j]	87	83
Specific gravity[k]	1.090	1.071

[a]Number of plants emerged 32 days after planting; mean of 6 replicates

[b]Number of stems per plant; mean of ten seed pieces per treatment from six replicates

[c]Rated 1-4; 1 = poor and 4 = good; mean of ten plants per treatment from six replicates

[d]Percentage of the seed tuber decayed; mean of ten seed tubers per treatment from six replicates

[e]Percentage of stems infected; mean of ten plants per treatment from six replicates

[f]Percentage of leaflets infected 88 days after planting; mean from six replicates

[g]Hundred weight per acre; mean from ten foot of row per treatment from five replicates

[h]Hundred weight per acre; mean of three truck loads per treatment

[i]Mean of ten foot of row per treatment from five replicates

[j]Mean of three truck loads per treatment

[k]Mean of five replicates per treatment

PROTOCOL FOR EVALUATION OF OXION ENRICHED IRRIGATION WATER ON POTATOES

Location: San Luis Valley, Colorado

Cooperator: Kehler Ranches, Inc.
8204 North Road 3 East
Center, CO 81125
Contact person: Rod Kehler

Plot Size: 60 acres

Sample replications: Six/treatment

Sample size: 50 ft. of row/treatment/replication

Cultivar: Russet Norkotah. The plot will be planted with certified seed and entered into the Colorado Seed Certification Program for inspection.

Treatments: 30 acres oxion enriched water throughout the entire growing season.
30 acres non-enriched water

Irrigation: Center pivot, rate based on ET and tensiometer readings.

Fertilizer: 110 lb/A N; 180 lb/A P_2O_5; 30 lb/A S preplant; 110 lb/A N postplant

Herbicide: Eptam + Sencor

Insecticide: Thiodan

Fungicide: Super Tin by chemigation, non-enriched water

Vine killer: Diquat

Harvest: Mid-September

DATA

Aerial photography: Color and infared at 14 day intervals

Petiolule testing: Complete nutrient analysis at 14 day intervals

Stand: 1-50 ft. row/treatment/replication, readings taken on three dates

Seed piece decay: soft-rot and dry-rot rated 1-100, 0 = no decay and 100 = complete decay; 10 seed pieces/treatment/replication

Rhizoctonia stem canker: percent stems infected; 10 plants/treatment/replication

Plant vigor: Rated 1-4; 1 = poor and 4 = good; 10 plants/treatment/replication

Stems: Average number of stems/plant; 10 plants/treatment/replication

Early Blight: Field; disease incidence determined using the Horsfall-Barratt grading system; 50 ft. of row/treatment/replication

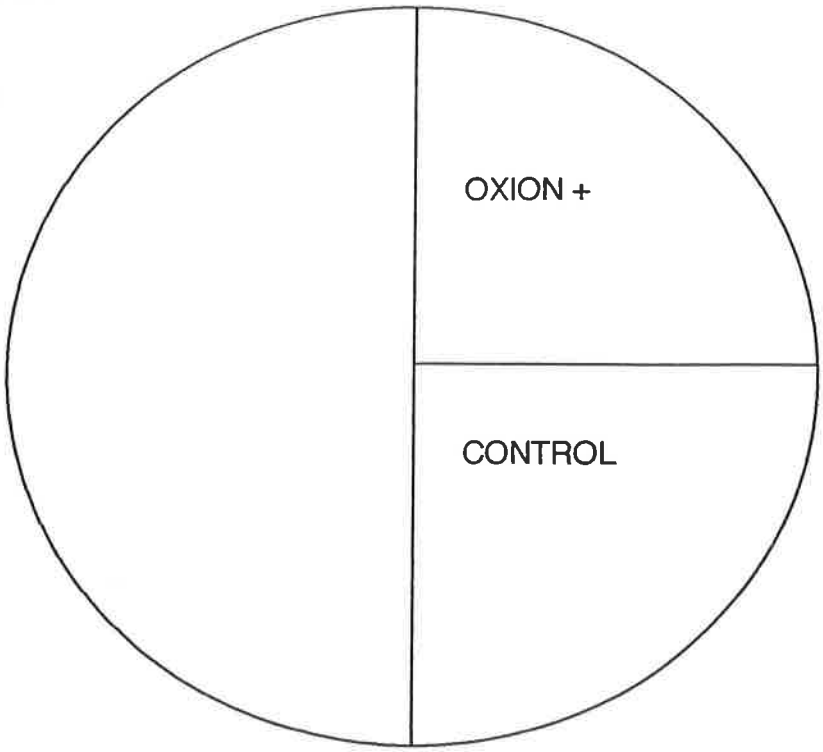
Storage; tuber samples will be collected and scored for early blight infection on two dates during storage

Silver scurf: Tuber samples will be collected and scored for silver scurf infection on tow dates during storage

Yield and grade: Calculated on 30 acres/treatment

KEHIER
RANCHES 11/12
145 ACERS
RUSSET
NORKOTAH

NORTH

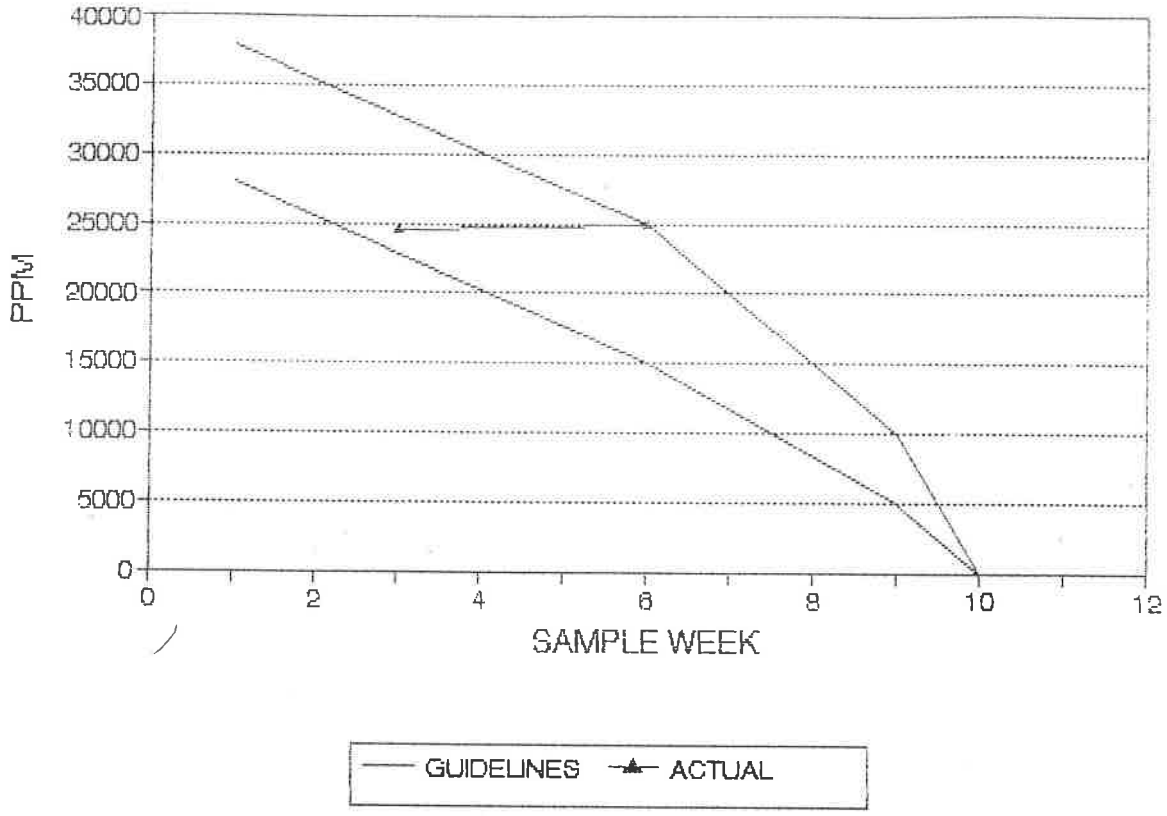


OXION TEST PLOT
CENTER, CO ,1993

Field 11-12-NE Orion +

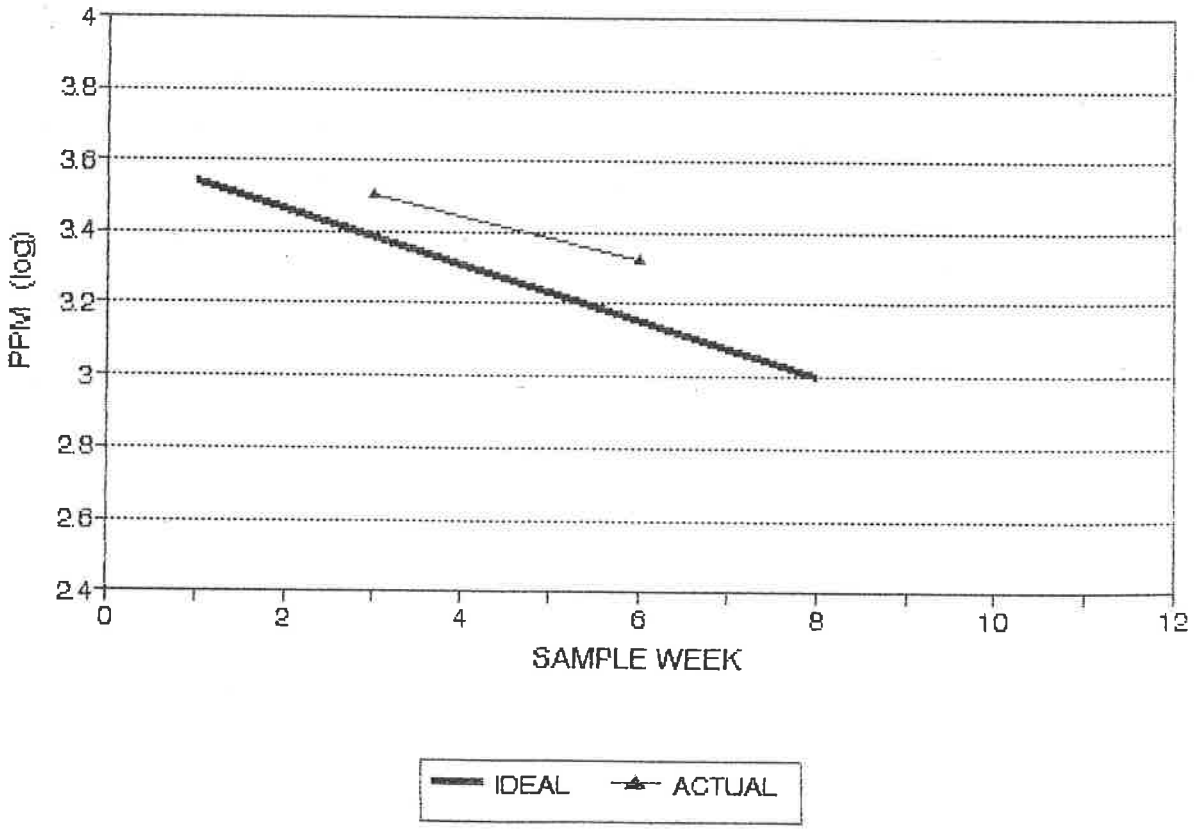
KEHLER [T3] - NORKOTA

PETIOLE NITRATES



First Sample: 07/20/93 Current Sample: 08/10/93

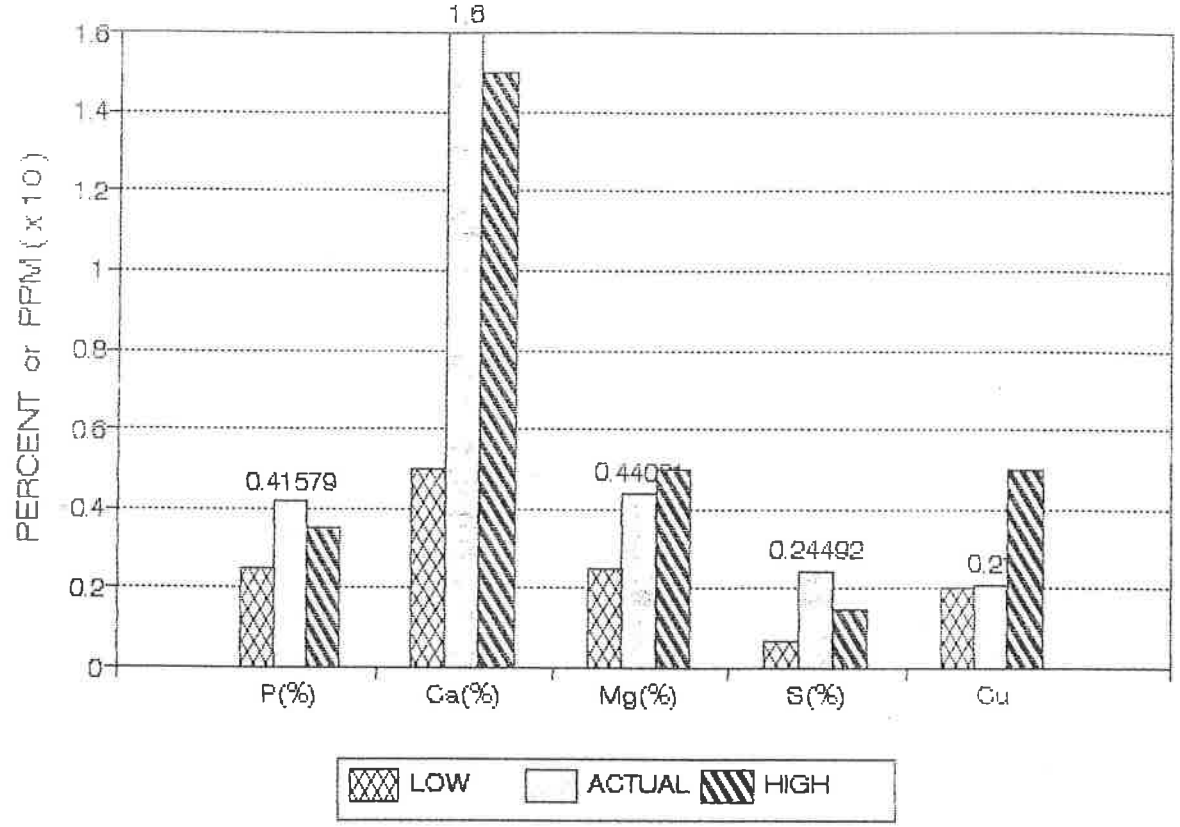
PETIOLE PHOSPHATES



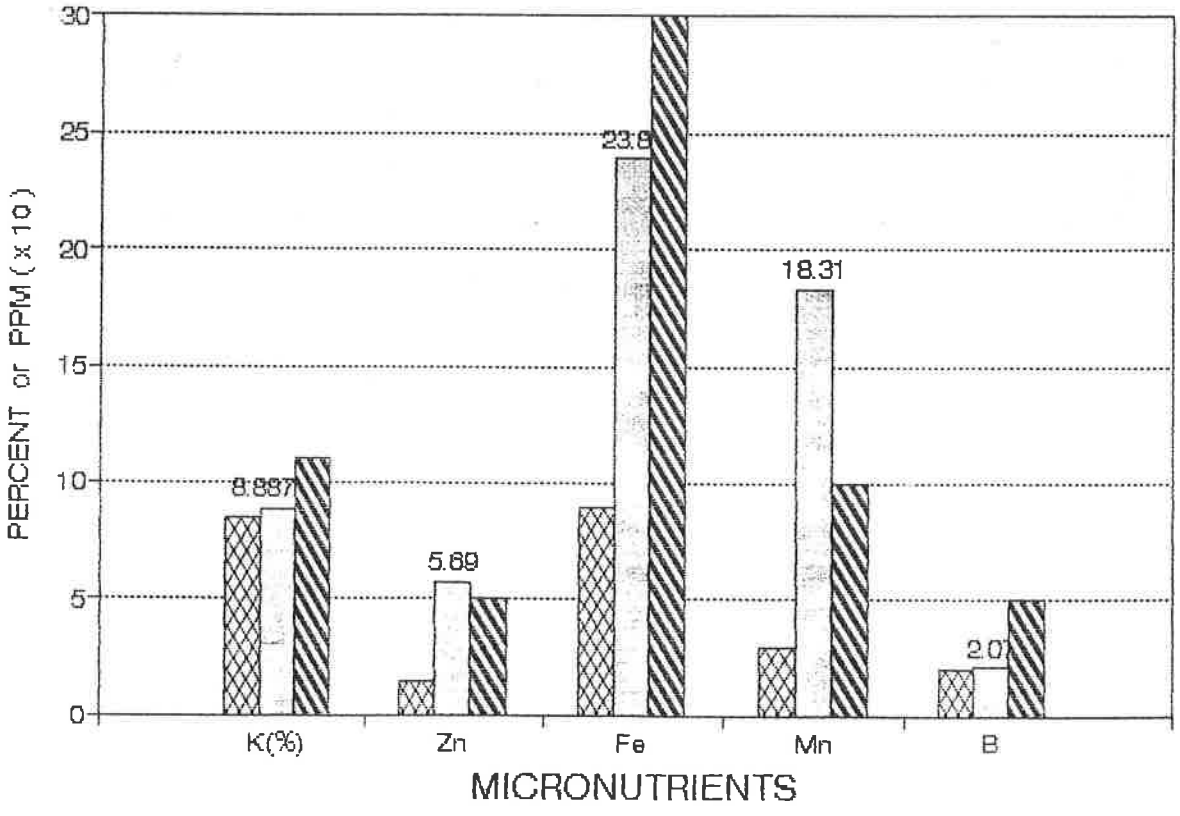
Field 11-12-NE Orion +

KEHLER [T3] - NORKOTA

MID SEASON PETIOLE REPORT



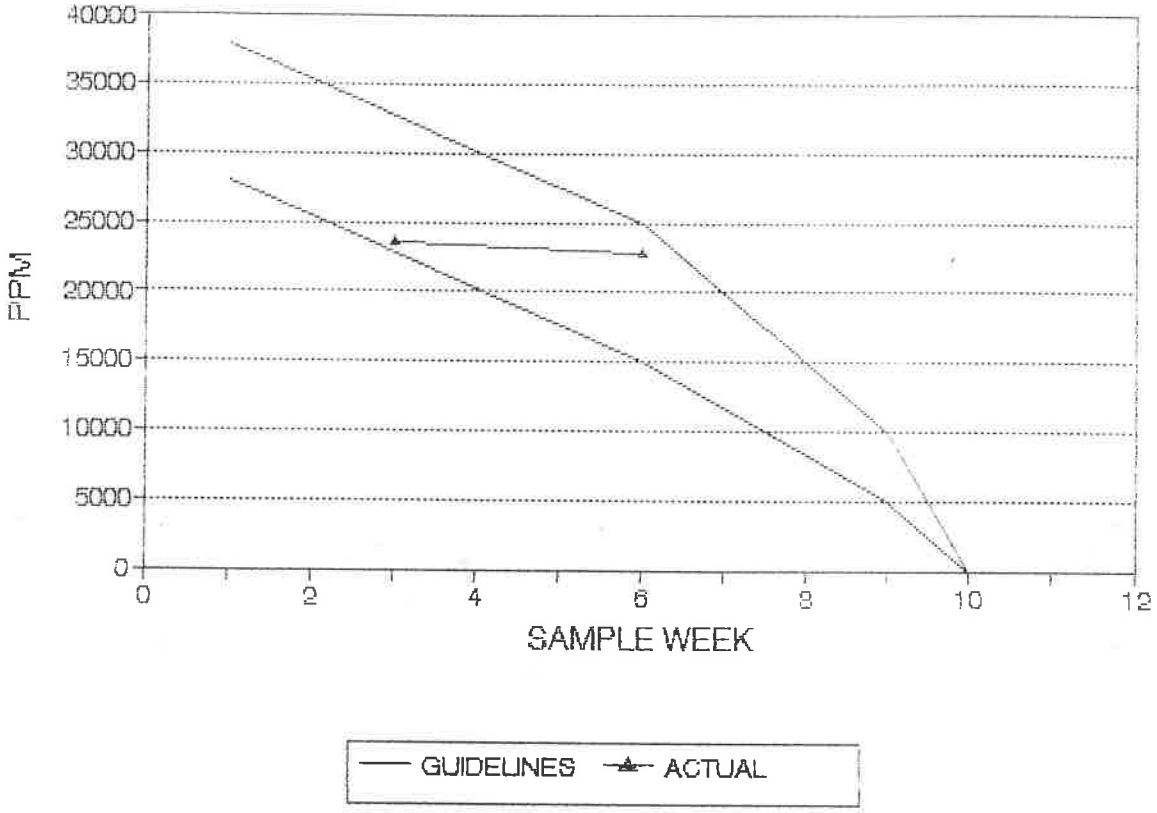
07/20/93
SAMPLE DATE



Field 11-12 - SE Orion - Control

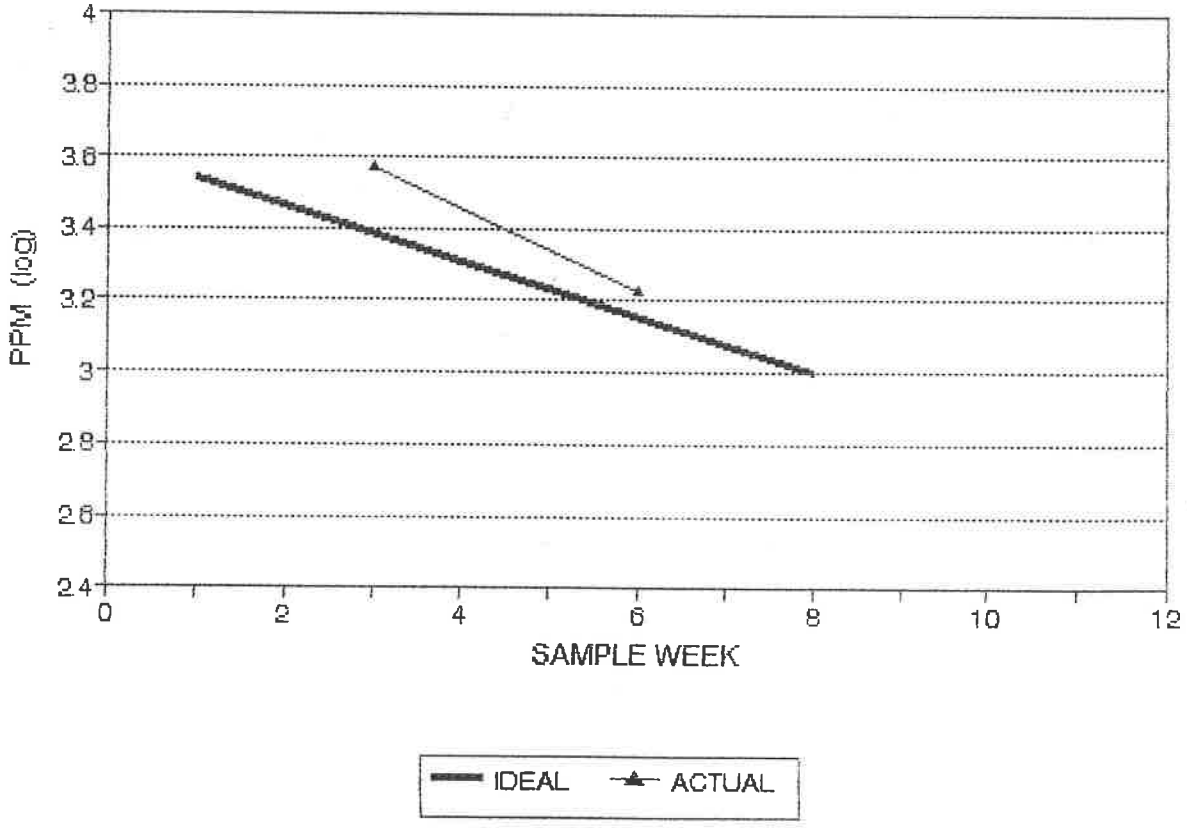
KEHLER [T2] - NORKOTA

PETIOLE NITRATES



First Sample: 07/20/93 Current Sample: 08/10/93

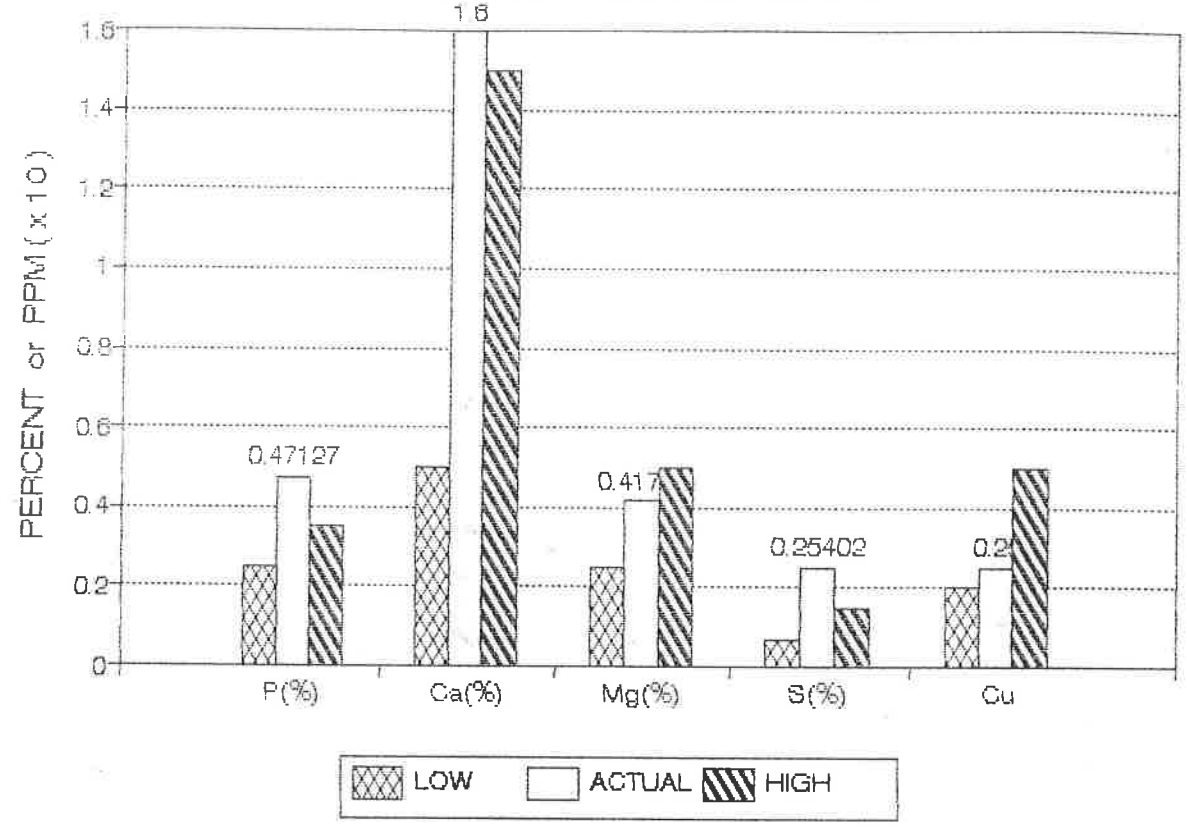
PETIOLE PHOSPHATES



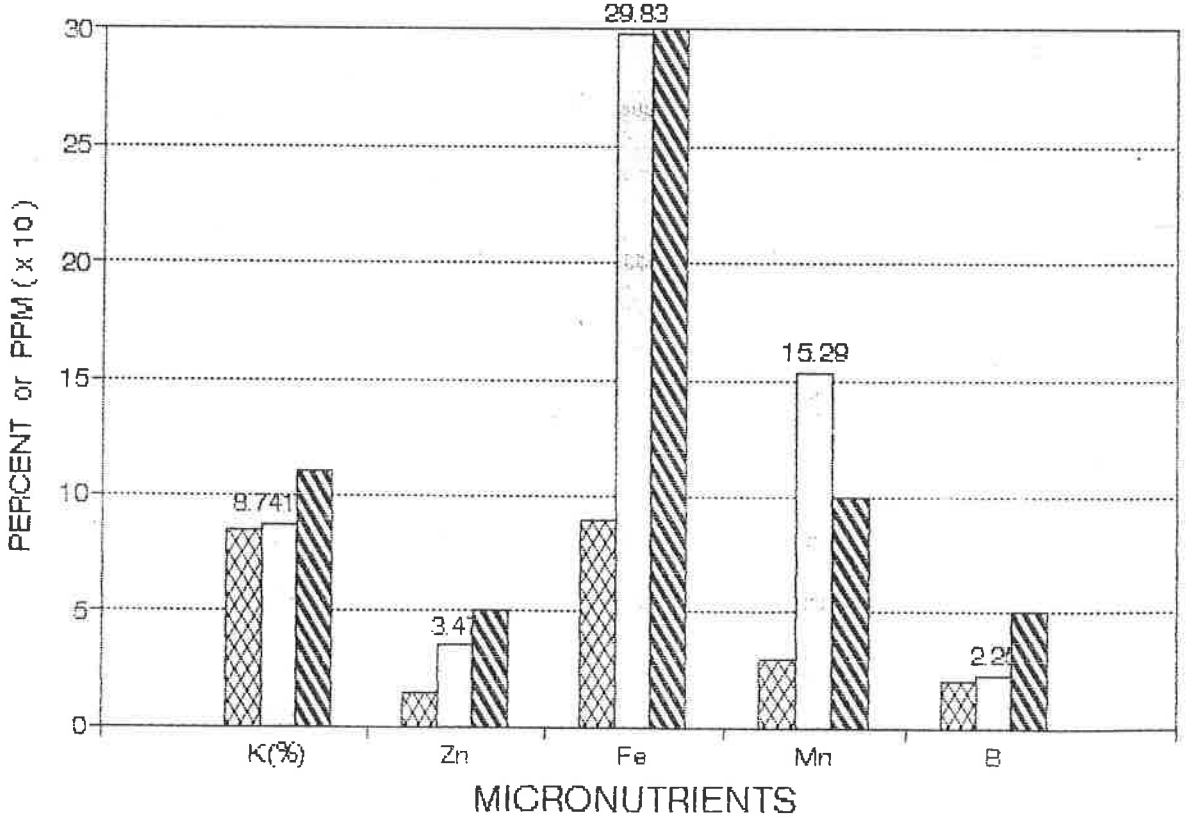
Field 11-12-SE Orion - Central

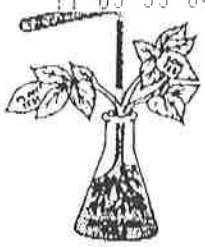
KEHLER [T2] - NORKOTA

MID SEASON PETIOLE REPORT



07/20/93
SAMPLE DATE





WESTERN LABORATORIES
P.O. Box 1020 208/722-6564
Parma, ID 83660 1-800-658-3858

MONTE VISTA CO-OP

P.O. BOX 111
1901 EAST HWY 160
MONTE VISTA, CO 81144

SOIL REPORT

LAB NUMBER: 09456

GROWER: KEHLER RANCHES

FIELD ID: #11 SE 1/4 Oxign - Control

RECEIVED: 11-08-1993 REPORTED: 11-08-1993

pH	TEXTURE	SALTS	CEC	% LIME	% OM	% BASE SATURATION	% Ca of CEC	% Mg of CEC	% K of CEC	% Na of CEC
7.5	SAND	0.7	6.0	0.5	1.4	443.0	391.7	41.1	6.6	3.3

PARTS PER MILLION - PPM

NITRATE NO_3-N	AMMONIUM NH_4-N	PHOSPHORUS P	POTASSIUM K
8	3	14 M	155 L

TEST	NO_3	NH_4
1st FT	8	3
2nd FT	0	0
3rd FT	0	0
TOTAL	8	3

CALCIUM Ca	MAGNESIUM Mg	SODIUM Na	ZINC Zn	IRON Fe	MANGANESE Mn	COPPER Cu	SULFATE SO_4-S	BORON B
4700 VH	296 L	45 L	0.5 L	2.2 L	2.2 L	0.1 VL	13.0L	0.3 VL

NUTRIENTS IN POUNDS/ACRE

CROP	BARLEY	
YIELD GOAL	190	
PAST CROP	R. BURBANK	
ACRES	30	
NITROGEN	207	
P_2O_5	135	
K_2O	244	
SULFATE-S	41	
ELEMENTAL-S	35	
GYPSUM		
MAGNESIUM		
ZINC	7	
IRON		
MANGANESE	3	
COPPER	4	
BORON	2.0	

% BASES FROM SUM OF CATIONS

BASES	IDEAL	YOURS
CALCIUM	65 - 80%	88.4
MAGNESIUM	10 - 20%	9.3
POTASSIUM	2 - 6%	1.5
SODIUM	< 5%	.74

IDEAL NUTRIENT RATIO

MICRO	IDEAL	YOURS
ZINC	1.5	0.5
MANGANESE	5.0	2.2
COPPER	1.0	0.1
IRON	5.0	2.2

IDEAL CALCIUM: PHOSPHORUS RATIO

150: 1

YOURS 336 :1 - Unfavorable

IDEAL PHOSPHORUS: ZINC RATIO

15: 1

YOURS 28 :1 - Unfavorable

USEFUL CONVERSIONS

PPM X 3.6 = lbs. / acre Ft.
Meq Ca X 200 = ppm ÷ 200 = Meq
Meq Mg X 120 = ppm ÷ 120 = Meq
Meq Na X 230 = ppm ÷ 230 = Meq
Meq K X 390 = ppm ÷ 390 = Meq

RATING

VL - VERY LOW
L - LOW
M - MEDIUM
H - HIGH
VH - VERY HIGH

TEXTURE

SN - SAND
SI - SILT
LO - LOAM
CL - CLAY

PAST CROP

GRAIN + 20# N/T
CORN + 10# N/T
LEGUME - 50# N

FROM RECOMMENDATIONS

Ca: Mg RATIO

16:1

1. SPLIT APPLY N
2. DO NOT EXCEED 80 LBS NH_4 ON YOUNG SEEDLINGS

FERTILIZER RECOMMENDATIONS ARE GUIDELINES ONLY.
CONTACT YOUR FIELDMAN, ADVISOR OR CONSULTANT FOR A SPECIFIC PROGRAM

ALWAYS PRACTICE THE LAWS OF AGRONOMY

John P. Taberna
Soil Scientist

WESTERN LABORATORIES
P.O. Box 1020 208/722-6564
Parma, ID 83660 1-800-658-3858

SOIL REPORT

MONTE VISTA CO-OP

P. O. BOX 111
1901 EAST HWY 160
MONTE VISTA, CO 81144

LAB NUMBER: 09457

GROWER: KEHLER RANCHES

FIELD ID: N.E. #11 Oxion +

RECEIVED: 11-08-1993 REPORTED: 11-08-1993

pH	TEXTURE	SALTS	CEC	% LIME	% OM	% BASE SATURATION	% Ca of CEC	% Mg of CEC	%K of CEC	% Na of CEC
7.3	SAND	0.8	6.0	0.5	1.4	99.0	62.9	18.5	8.5	8.8

PARTS PER MILLION - PPM

NITRATE NO_3-N	AMMONIUM NH_4-N	PHOSPHORUS P	POTASSIUM K
11	4	17 M	199 L

TEST	NO_3	NH_4
1st FT	11	4
2nd FT	0	0
3rd FT	0	0
TOTAL	11	4

CALCIUM Ca	MAGNESIUM Mg	SODIUM Na	ZINC Zn	IRON Fe	MANGANESE Mn	COPPER Cu	SULFATE SO_4-S	BORON B
755 VL	133 VL	121 M	2.2 VH	9.5 M	3.2 L	0.6 M	17.0M	0.4 VL

NUTRIENTS IN POUNDS/ACRE

CROP	BARLEY	
YIELD GOAL	190	
PAST CROP	R. BURBANK	
ACRES	30	
NITROGEN	193	
P_2O_5	111	
K_2O	200	
SULFATE-S	37	
ELEMENTAL-S		
GYPSUM		
MAGNESIUM		
ZINC	1	
IRON		
MANGANESE	1	
COPPER	1	
BORON	2.0	

% BASES FROM SUM OF CATIONS

BASES	IDEAL	YOURS
CALCIUM	65 - 80%	63.5
MAGNESIUM	10 - 20%	18.7
POTASSIUM	2 - 6%	8.6
SODIUM	< 5%	8.8

IDEAL NUTRIENT RATIO

MICRO	IDEAL	YOURS
ZINC	1.5	2.2
MANGANESE	5.0	3.2
COPPER	1.0	0.6
IRON	5.0	9.5

IDEAL CALCIUM: PHOSPHORUS RATIO

150: 1
YOURS 44 :1 - Favorable

IDEAL PHOSPHORUS: ZINC RATIO

15: 1
YOURS 8 :1 - Favorable

USEFUL CONVERSIONS

PPM X 3.6 = lbs. / acre Ft.
Meq Ca X 200 = ppm ÷ 200 = Meq
Meq Mg X 120 = ppm ÷ 120 = Meq
Meq Na X 230 = ppm ÷ 230 = Meq
Meq K X 390 = ppm ÷ 390 = Meq

RATING

VL - VERY LOW
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M - MEDIUM
H - HIGH
VH - VERY HIGH

TEXTURE

SN - SAND
SI - SILT
LO - LOAM
CL - CLAY

PAST CROP

GRAIN + 20# N/T
CORN + 10# N/T
LEGUME - 50# N
FROM RECOMMENDATIONS

Ca: Mg RATIO

6:1

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ALWAYS PRACTICE THE LAWS OF AGRONOMY

John P. Taberna
Soil Scientist

SOIL ANALYSIS REPORT

Onion test Preplant

SENT TO:	
4703	AGRO ENGINEERING 0210 RD 2 SOUTH ALAMOSA, CO 81101

Servi-Tech Laboratories
1816 East Wyatt Earp
Dodge City, Kansas 67801
Phone: (316) 227-7123

LAB NO:	27088
INVOICE NO:	D93610
DATE RECEIVED:	05-17-93
DATE REPORTED:	05-18-93

SOIL ANALYSIS RESULTS FOR: KEHLER RANCHES

Lab No.	Sample ID	Sample Depth, Inches	Soil pH	Buffer pH	Soluble Salts mmho/cm	Excess Lime	Organic Matter % OM	Nitrate Nitrogen ppm	Nitrate Nitrogen lb. N/A	Phosphorus ppm P	Potassium ppm K	Zinc ppm Zn	Iron ppm Fe	Manganese ppm Mn	Copper ppm Cu	Sulfur ppm	Sulfur lb. S/A	Calcium ppm Ca	Magnesium ppm Mg	Sodium ppm Na
27088	11-12	0-12	7.5		0.25	No	1.4	10	36	92	251	4.0	14.1	10.4	1.1	17	61	2381	210	30

SOIL SAMPLES ARE KEPT A MINIMUM OF 30 DAYS

FERTILIZER RECOMMENDATIONS — POUNDS ACTUAL NUTRIENT PER ACRE

Lab No.	Sample ID	Crop to be Grown	Yield Goal	Lime, ECC Tons/A	Nitrogen N	Phosphorus P_2O_5	Potassium K_2O	Zinc Zn	Sulfur S	Magnesium MgO	Copper Cu	Manganese Mn
27088	11-12											

Cation Exchange Capacity

CEC	%H	%K	%Ca	%Mg	%N
14	0	4	83	12	1

SPECIAL COMMENTS AND SUGGESTIONS

Sample ID: 11-12 NH4-N 6 ppm 22 lbs/A

SAMPLE(S): 11-12
Servi-Tech Laboratory fertilizer recommendations were not requested.

Explanations of soil analysis terms are given on the back of the yellow copy.

Colorado State University
Soil, Water, & Plant Testing Laboratory
Irrigation Water Analysis Report

Date Received: 10-12-93 **Date Reported:** 10-21-93 **Lab NO.** W 984

NAME	Richard T. Zink
ADDRESS	0249 E. Rd. 9 North
	Center, CO 81125
LOCATION	Rio Grand County, Well (H2O)

Conductivity 97.2 µmhos/cm (E.C. x 1,000,000) **pH** 9.0

	Result (mg/l)	meq/l
Calcium	17.8	0.9
Magnesium	1.4	0.1
Sodium	4.4	0.2
Potassium	0.9	0.02
SAR	0.2	
Salinity Hazard	Low	
Sodium Hazard	Low	

	Result (mg/l)	meq/l
Carbonate	22.1	0.7
Bicarbonate	18.7	0.3
Chloride	4.4	0.1
Sulfate	8.6	0.2
Nitrate	7.2	0.1
Nitrate as N	1.6	0.1
lbs of SO4 per acre foot	8	
lbs of NO3 per acre foot	4	

Additional Tests:

	(mg/l)
Boron	<0.01

COMMENTS:

This is good quality water for irrigation use.

Colorado State University
Soil, Water, & Plant Testing Laboratory
Irrigation Water Analysis Report

Date Received: 10-12-93 **Date Reported:** 10-21-93 **Lab NO.** W 985

NAME	Richard T. Zink
ADDRESS	0249 E. Rd. 9 North
	Center, CO 81125
LOCATION	Rio Grand County, Well (N +)

Conductivity 598 µmhos/cm (E.C. x 1,000,000) **pH** 8.7

	Result (mg/l)	meq/l
Calcium	77.4	3.9
Magnesium	15.4	1.3
Sodium	38.1	1.7
Potassium	12.2	0.3
SAR	0.8	
Salinity Hazard	Low	
Sodium Hazard	Low	

	Result (mg/l)	meq/l
Carbonate	<0.1	<0.1
Bicarbonate	152.6	2.5
Chloride	33.9	1.0
Sulfate	89.3	1.9
Nitrate	142.1	2.3
Nitrate as N	32.1	2.3
lbs of SO4 per acre foot	79	
lbs of NO3 per acre foot	87	

Additional Tests:

	(mg/l)
Boron	0.05

COMMENTS:

This is good quality water for irrigation use.

Colorado State University
Soil, Water, & Plant Testing Laboratory
Irrigation Water Analysis Report

Date Received: 10-12-93 **Date Reported:** 10-21-93 **Lab NO.** W 987

NAME	Richard T. Zink
ADDRESS	0249 E. Rd. 9 North
	Center, CO 81125
LOCATION	Rio Grand County, Well (N + O x)

Conductivity 870 µmhos/cm (E.C. x 1,000,000) **pH** 8.5

	Result (mg/l)	meq/l
Calcium	105.5	5.3
Magnesium	21.5	1.8
Sodium	56.6	2.5
Potassium	18.5	0.5
SAR	1.0	
Salinity Hazard	Medium	
Sodium Hazard	Low	

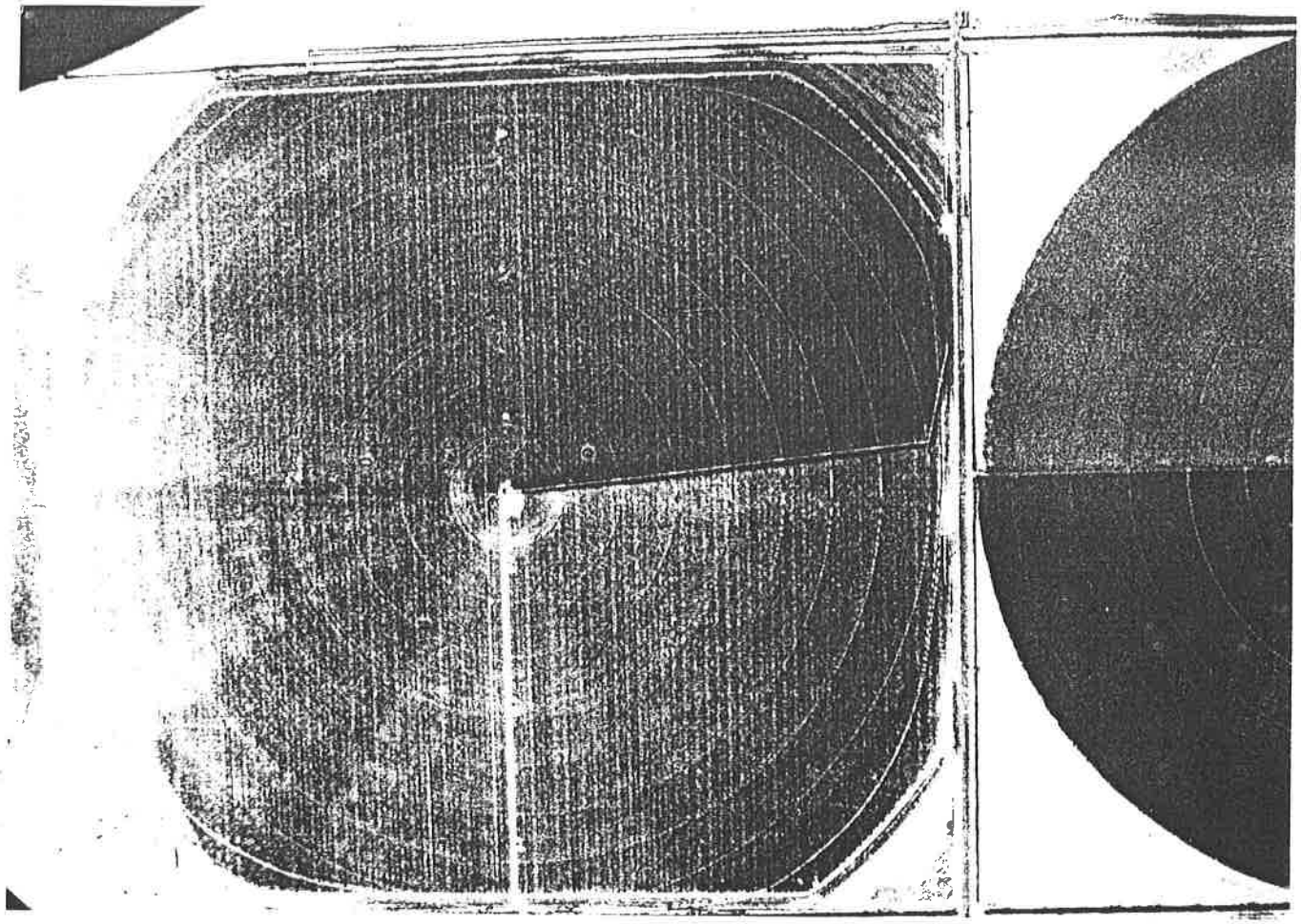
	Result (mg/l)	meq/l
Carbonate	<0.1	<0.1
Bicarbonate	217.1	3.6
Chloride	31.6	0.9
Sulfate	126.2	2.6
Nitrate	136.3	2.2
Nitrate as N	30.8	2.2
lbs of SO4 per acre foot	112	
lbs of NO3 per acre foot	84	

Additional Tests:

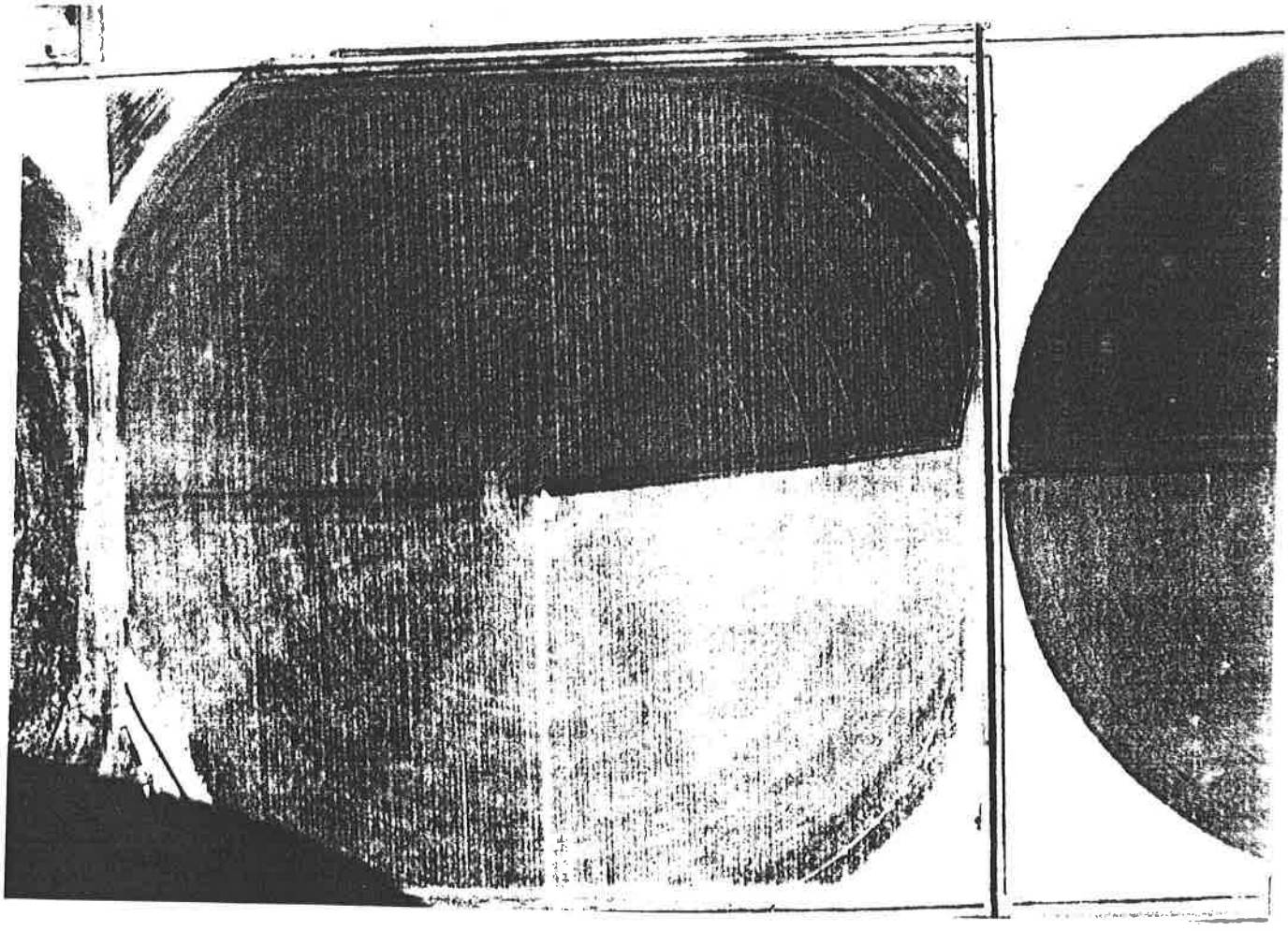
	(mg/l)
Boron	0.09

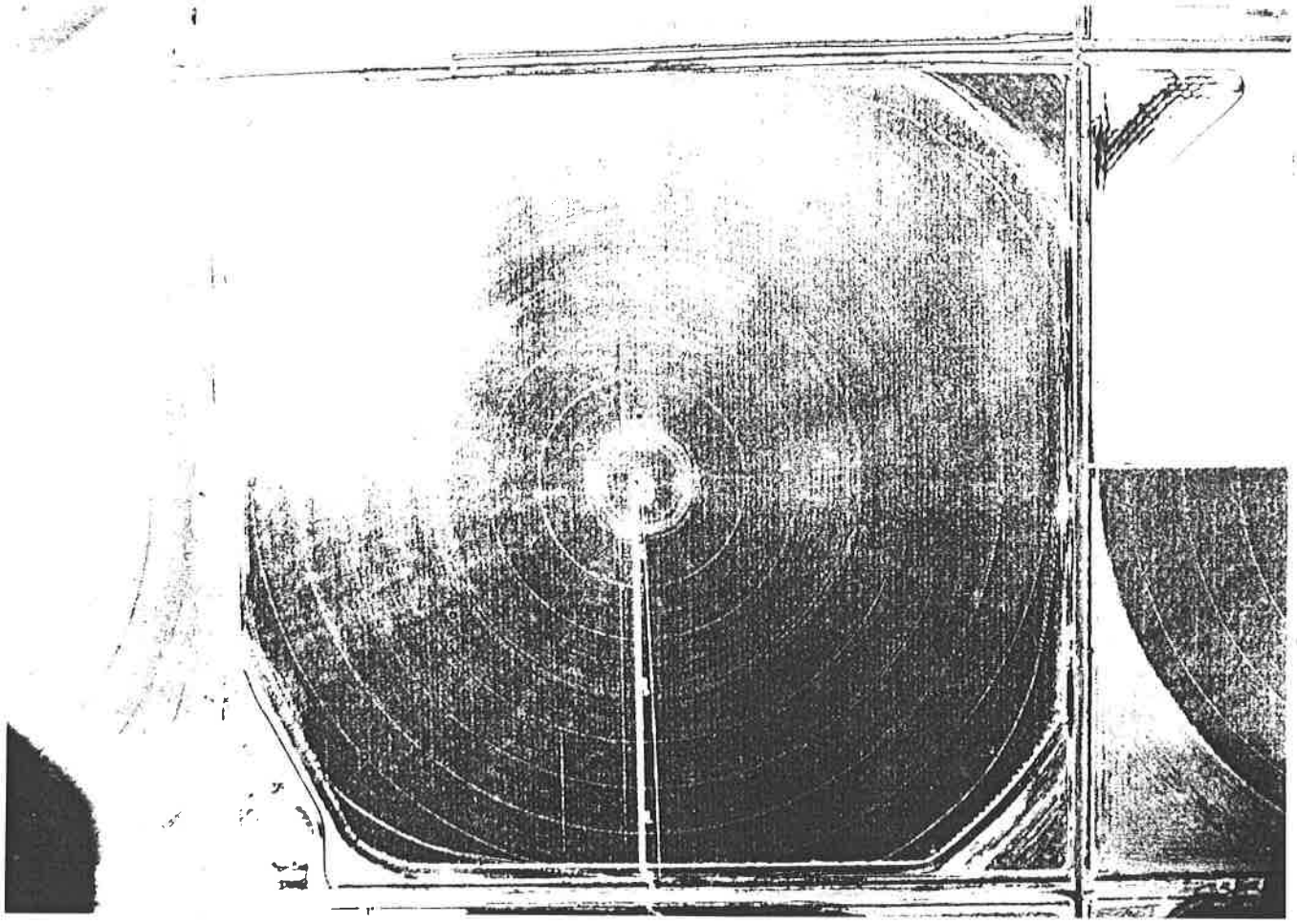
COMMENTS:

This water is classified as a medium salinity hazard irrigation water. It should not cause problems due to salt accumulation in the soil if a moderate amount of leaching occurs and soil drainage is adequate.



KEHLER 11-12 7-8-93





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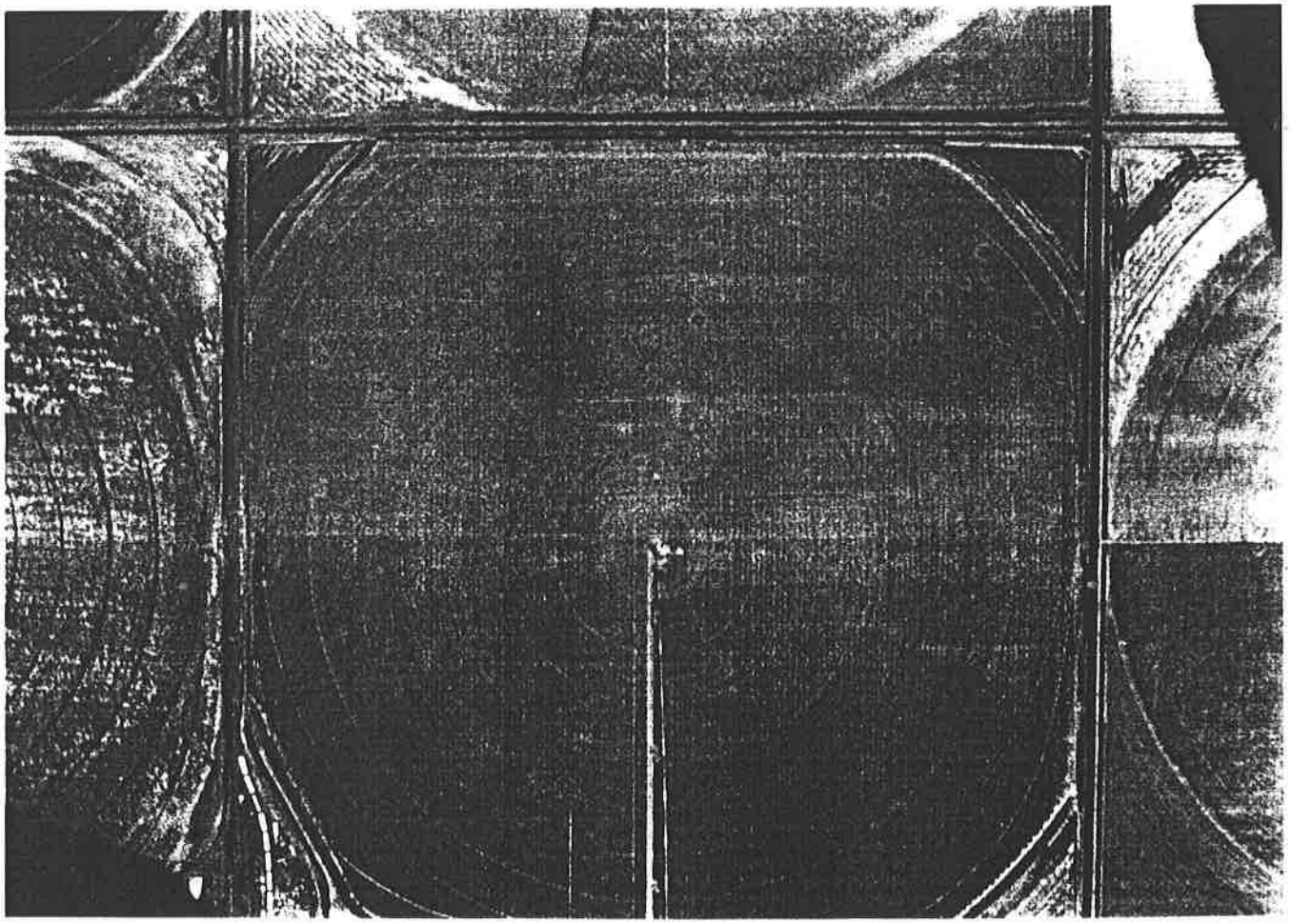

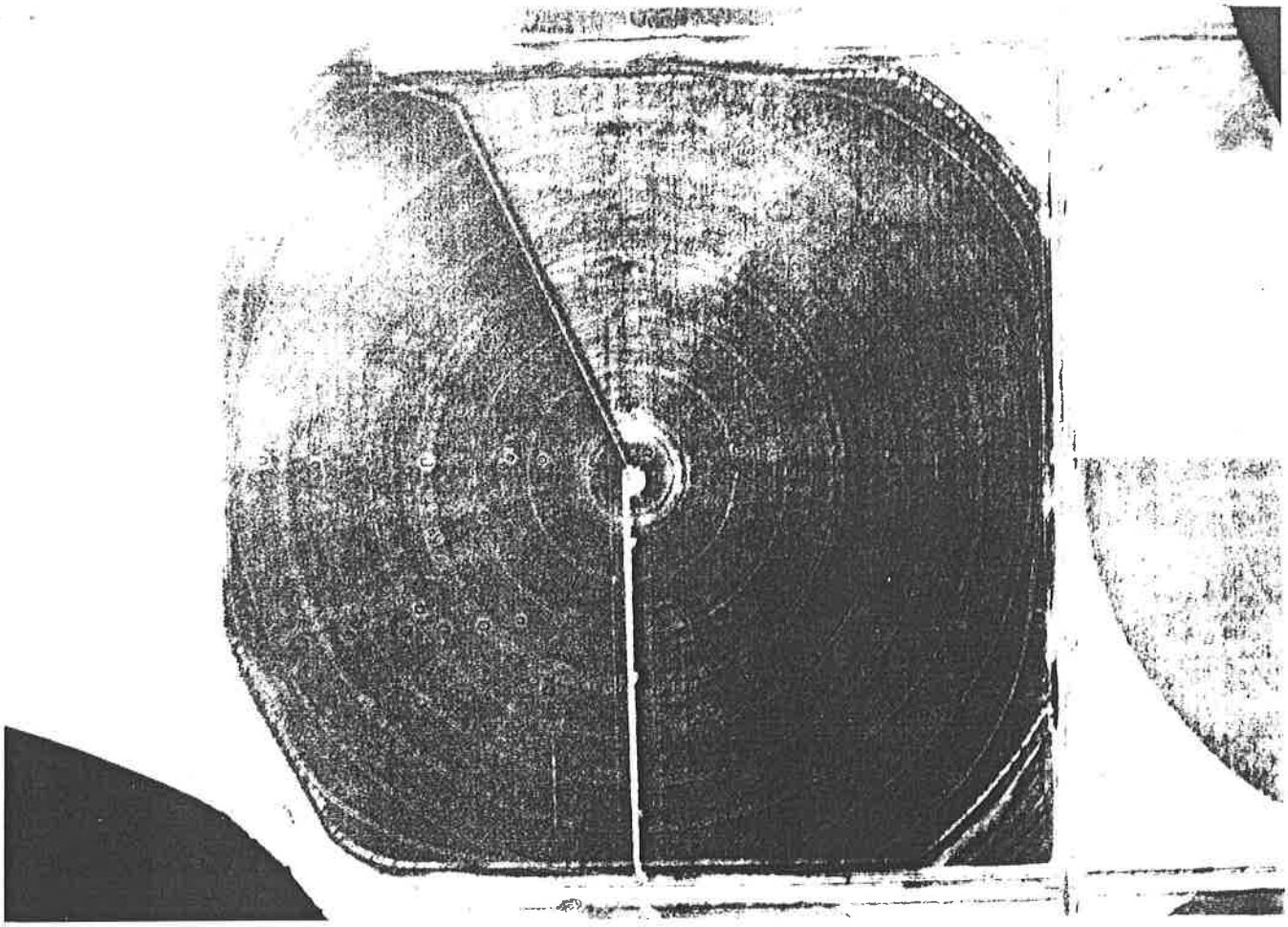

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