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ON-FARM WATER MANAGEMENT RESEARCH IN THE ACONCAGUA VALLEY, CHILE

Third Annual Report

1971-1972

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PART I

FERTILIZER NITROGEN, PLANT POPULATION, CORN VARIETIES, AND SOIL MOISTURE

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Part I

Fertilizer Nitrogen, Plant Population, Corn Varieties, and Soil Moisture

Introduction

This research report for the 1971-72 growing season is the third and final report dealing with soil moisture-fertility investigations in Chile.

The same objectives were pursued throughout the three-year program. That is, to research and demonstrate crop management techniques aimed at maximum production under intensive irrigation agriculture. Given sufficient time the program would have generated information that would be adaptable to economic analysis. The ultimate objective is to obtain crop yield functions of water worth so that the value of a unit depth of irrigation water can be determined based on the intrinsic value of the crops produced. This kind of information is needed in order to be able to optimize the allocation of land and water resources and to maximize irrigation crop production within a river basin.

Research design in this series has involved a limited number of crop growth factors. The main emphasis has been on soil fertility, irrigation frequency and plant population density. Somewhat conflicting or indeterminate results were obtained the first two years because different hybrid corn varieties were used and nitrogen carry-over in the experi-

mental fields obscured the soil fertility-soil-moisture interaction. Other factors affecting yield were encountered and these will be amplified in this report.

In 1970-71 experiments were conducted on two farms, El Castillo and Condoroma. El Castillo was not avai lable in 1971-72 so all the research was done at Condoroma. The experiments reported here were designed to augment and expand the results obtained previously.

Materials and Methods

Farm Condoroma is in the upper Aconcagua valley near Los Andes, Chile. The soil is very fine sandy loam to silt loam. The experimental field has a slope of about 1.5 percent and is very well drained. Soil samples were obtained from the site before the experiment was established. These were analyzed by the soils laboratory at La Platina using their standard procedures. Average results for the top 30 cm of soil were as follows: pH, 7.1; organic matter, 2.00 percent; available phosphorus, 5.7 ppm; and available potassium, 89.2 ppm. Average electrical conductivity of the saturation extract on successive 30 cm depths to 120 cm were .84, .77, .65 and .62 mmohs/cm, respectively.

Extractable mineral nitrogen (nitrate plus ammonium) was determined in 30 cm depth increments to 120 cm. Soil test results are given in Table 1.1 by depth and field location. The data show the distribution of soil residual nitrogen both vertically and horizontally in the field. It

Table 1.1. Extractable Nitrogen (ppm) by Depth and Field Location. (Data shown are averages within replications.)

Depths	Replication 1	2	3	4	Average
1	6.6	13.0	11.2	13.8	11.15
2	5.0	7.6	12.2	11.4	9.05
3	4.4	6.4	8.4	9.4	7.15
4	4.0	7.6	7.2	7.4	6.55
Total	20.0	34.6	39.0	42.0	33.90

will be noted that soil nitrogen increased from the upper to the lower end of the field (replication 1 through 4) and that it decreased from the 30 cm to the 120 cm depth.

In the previous season onions were produced on the experimental site. This crop was followed by winter wheat which was removed for forage before spring operations were initiated.

The experimental variables were fertilizer nitrogen, plant population density, and corn variety. There were five nitrogen rates: zero, 100, 200, 300, and 400 kgms of nitrogen per hectare in the form of urea (These treatments will be designated throughout the text as N-0, N-100, etc.). Plant populations ranged from 50 to 110 thousand in five-fifteen thousand increments (P-50, P-65, etc.). These populations were attained by planting uniformly then thinning back to the desired stand in each plot after germination. The corn varieties used were Chilean

hybrid MA-7, and Tracy hybrid T-133. Both varieties are in general use in the country.

The nitrogen (N) and population (P) were put out in complete factorial combination, giving 25 combinations. The varieties (V) constituted a split plot in each N-P whole plot. Each variety was planted in alternate six-row strips across the plot area. Thus, varieties were not truly randomized. The overall experimental design was a randomized complete block in four replications. The whole plot size was 10.4 meters wide by 10 meters long.

The nitrogen fertilizer treatments were hand broadcast before plowing. At the same time, fertilizer phosphorus was uniformly applied using a mechanical spreader. Phosphorus was in the form of treble-superphosphate and went on at the rate of 67 kilos of the element per hectare.

The site was disc plowed after the fertilizer was applied. After furrowing, the land was pre-irrigated. The seed bed was then prepared by making two passes over the field with a disc harrow, roller-packer, and spike tooth harrow hooked in tandem.

The corn was planted on October 22 and harvested during the two-week period beginning April 10. At harvest, all the ears from the center four rows of each plot were taken, leaving one meter of row on either end of the plot to avoid border effects. The weight and number of ears per row were recorded. Five ears from each row were selected at

random and the moisture content of grain determined using a Delmhorst moisture meter.

The corn yield data were averaged across the four yield rows in each plot and adjusted to the standard 15 percent moisture content. Results are given in terms of quintales per hectare (1 quintal/hectare = 1.46 bushels per acre).

Soil Sampling and Analysis

After harvest soil samples were taken from all the P-80 plots. Sampling technique consisted of two, three-core groups from each plot. A sampling point was selected at random in the irrigation furrow. Another point was then sampled adjacent to the first in the corn row. A third point was sampled mid-way between the first two. Thus, the samples were oriented in a straight line at right angles to the rows and were taken in such a way as to represent the high and low soil nitrogen concentrations that develop in soil with furrow-applied water. The samples were taken to the 120 cm depth in 30 cm increments. All the cores for each depth increment (total of six per plot) were composited. There were thus four samples per plot prepared for analysis. The soils were analyzed for extractable nitrate and ammonia nitrogen. Results are reported as parts per million (ppm) of nitrogen.

Leaf Analysis

Leaf samples were taken from the P-80 plots for T-133 at silking time (January 27). Fifteen plants were sampled at random in each such

plot by taking the whole leaf blade from the node opposite and below the ear node. Total nitrogen was determined by the La Platina soils laboratory using their standard procedures. Results are given as percentage dry weight of total nitrogen in the leaf tissue.

Irrigation

Water was applied uniformly to all plots as required. Water was measured on and off each replication using V-notch weirs. Plastic siphon tubes were used to transfer the water from the head ditch to each furrow.

Experience in the two previous seasons indicated that the soil at Fundo Condoroma had a slow water intake rate. In order to minimize this problem the site was surveyed for slope and the rows were layed out in such a way as to allow minimum slope in the direction of water flow.

Results and Discussion

During the entire growing season the N-0 plots were visibly different from the other nitrogen treatments, displaying typical nitrogen deficiency symptoms. By mid-summer some of the N-100 treatments appeared nitrogen deficient and some of the higher nitrogen rates on plots with P-95 and P-100 stands began to appear nitrogen deficient. These differences were both interesting and informative to the many visitors that toured the plots during the season.

Yield

Table 1.2 contains the corn yield results. Statistical analysis of the data, given in Table 1.3, indicates that yield differences among fertilizer rates and between varieties were highly significant. The only significant interaction was the three-way V x P x N effect.

The average results from varieties and nitrogen are presented graphically in Figure 1.1. The figure illustrates the superiority of variety T-133 over MA-7. Average overall yields were: T-133, 67.75 quintales per hectare and MA-7, 58.57 quintales per hectare. Figure 1.1 also demonstrates that the fertilizer response in the two varieties was very similar. Yield increased from 56.69 (T-133) and 41.08 (MA-7) at treatment N-0 to 79.29 (T-133) and 62.61 (MA-7) quintales per hectare at N-300. Yield decreased in both varieties at the N-400 rate to approximately the same level as was measured at the N-200 rate.

Although there was no significant effect from population density (Table 1.3), the population results are graphed in Figure 1.2 to illustrate the trends. It is apparent from Figure 1.2 that the optimum density of corn was 65,000 plants per hectare for both varieties.

It became apparent during the growing season that soil moisture varied among plots despite the fact that water was applied uniformly. This difference was attributed to the variation in slope in the field. After the crop was harvested the field was surveyed and percentage slope was obtained from each whole plot. The survey results are given in Table 1.4.

Table 1.2. Corn Yield Results. (Plot data were converted to quintales per hectare of shelled corn at standard 15% moisture content.)

Replication	Population (in thousands)	Variety	N Rate - kgsm/ha (corn qq/ha)					
			0	100	200	300	400	Total
1	50	1. T-133	61.15	68.00	87.73	78.27	79.63	374.78
		2. MA-7	55.68	56.55	64.25	66.52	68.51	311.51
		Total	116.83	124.55	151.98	144.79	148.14	686.29
	65	1	39.25	78.32	74.75	72.84	74.08	339.24
		2	26.06	62.64	64.78	68.77	84.39	306.64
		Total	65.31	140.96	139.53	141.61	158.47	645.88
	80	1	55.96	59.19	65.65	74.78	47.65	303.23
		2	49.12	48.68	68.61	57.42	39.84	263.87
		Total	105.08	107.87	134.26	132.20	87.20	566.90
	95	1	36.08	46.66	60.17	44.72	91.24	278.87
		2	29.62	41.15	68.79	37.67	72.72	249.95
		Total	65.70	87.81	128.96	82.39	163.96	528.82
	110	1	30.78	61.29	64.96	91.59	58.43	307.05
		2	10.72	46.88	58.41	92.82	48.48	257.31
		Total	41.50	108.17	123.37	184.41	106.91	564.36
		Replication Total	394.42	569.36	678.10	685.40	664.97	2,992.25
2	50	1	57.30	61.93	80.29	61.95	70.12	331.59
		2	41.05	48.49	74.03	53.67	67.10	284.34
		Total	98.35	110.42	154.32	115.62	137.22	615.93
	65	1	52.74	67.40	64.19	80.37	79.48	344.18
		2	42.33	53.48	53.84	62.14	55.49	267.28
		Total	95.07	120.88	118.03	142.51	134.97	611.46
	80	1	59.94	67.40	56.52	86.86	67.22	337.94
		2	39.97	41.15	51.82	65.71	47.57	246.22
		Total	99.91	108.55	108.34	152.57	114.79	584.16
	95	1	42.72	75.99	66.15	85.17	54.79	324.82
		2	35.13	54.89	54.89	72.26	39.31	256.48
		Total	77.85	130.88	121.04	157.43	94.10	581.30
	110	1	61.24	75.10	57.83	57.16	81.95	333.28
		2	42.80	55.29	36.70	61.54	63.08	259.41
		Total	104.04	130.39	94.53	118.70	145.03	592.69
		Replication Total	475.22	601.12	596.25	686.83	626.11	2,985.54

Table 1.2. (Continued)

Replication	Population (in thousands)	Variety	N Rate - kgsm/ha (corn qq/ha)					
			0	100	200	300	400	Total
3	50	1	42.26	60.94	77.73	76.23	49.11	306.27
		2	39.98	42.32	63.71	69.95	35.48	251.44
		Total	82.24	103.26	141.44	146.18	84.59	557.71
	65	1	49.94	57.59	76.91	92.63	64.09	341.16
		2	41.20	54.93	73.73	92.03	64.62	326.51
		Total	91.14	112.52	150.64	184.66	128.71	667.67
	80	1	56.82	60.81	74.59	73.98	94.45	360.65
		2	55.69	54.61	68.81	6 3.81	91.15	334.07
		Total	112.61	115.42	143.40	137.79	185.60	694.72
	95	1	60.64	85.12	21.59	89.47	71.04	327.86
		2	44.70	68.53	40.56	93.76	60.42	307.97
		Total	105.34	153.65	62.15	183.23	131.46	635.83
	110	1	52.40	37.53	86.04	60.60	62.46	299.03
		2	36.21	39.97	75.60	65.46	64.35	281.59
		Total	88.61	77.50	161.64	126.06	126.81	580.62
		Replication Total	479.84	562.35	659.27	777.92	657.17	3,136.55
	50	1	62.73	63.89	83.44	78.42	77.87	366.35
		2	45.92	57.16	63.35	81.72	62.52	310.67
		Total	108.65	121.05	146.79	160.14	140.39	677.02
	65	1	66.22	80.81	103.13	87.25	86.15	419.56
		2	61.34	69.86	77.59	84.46	102.77	396.02
		Total	123.56	150.67	180.72	171.71	188.92	815.58
	80	1	44.19	75.80	80.75	86.17	48.72	335.63
		2	35.80	65.67	71.80	79.03	37.34	289.64
		Total	79.99	141.47	152.55	165.20	86.06	625.27
	95	1	61.51	87.40	63.55	100.24	74.55	387.25
		2	40.83	82.31	54.15	92.44	63.22	332.95
		Total	102.34	169.71	117.70	192.68	137.77	720.20
	110	1	63.96	76.85	32.25	107.06	75.79	355.91
		2	47.50	65.37	51.83	91.05	67.48	323.23
		Total	111.46	142.22	84.08	198.11	143.27	679.14
		Replication Total	526.00	725.12	681.84	887.84	696.41	3,517.21

Table 1.3. Analysis of Variance - Corn Yield Data

Source of Variation	df	SS	MS	F
Total	199	59,239.17		
Replication (R)	3	3,734.14	1,244.71	2.51
Nitrogen (N)	4	17,800.63	4,450.16	8.96**
Population (P)	4	1,617.30	404.32	.81
N x P	16	3,973.32	248.33	.50
Error (a)	48	23,840.88	496.69	
Variety (V)	1	4,211.32	4,211.32	145.02**
V x N	4	244.17	61.04	2.10
V x P	4	83.65	20.91	.72
V x P x N	16	859.16	53.70	1.85*
Error (b)	99	2,874.71	29.04	

*Significant at 5% level.
**Significant at 1% level.

$$CV - (N + P) = \frac{\sqrt{496.69}}{63.16} = .35$$

$$CV\ (V\ only) = \frac{\sqrt{29.04}}{63.16} = .09$$

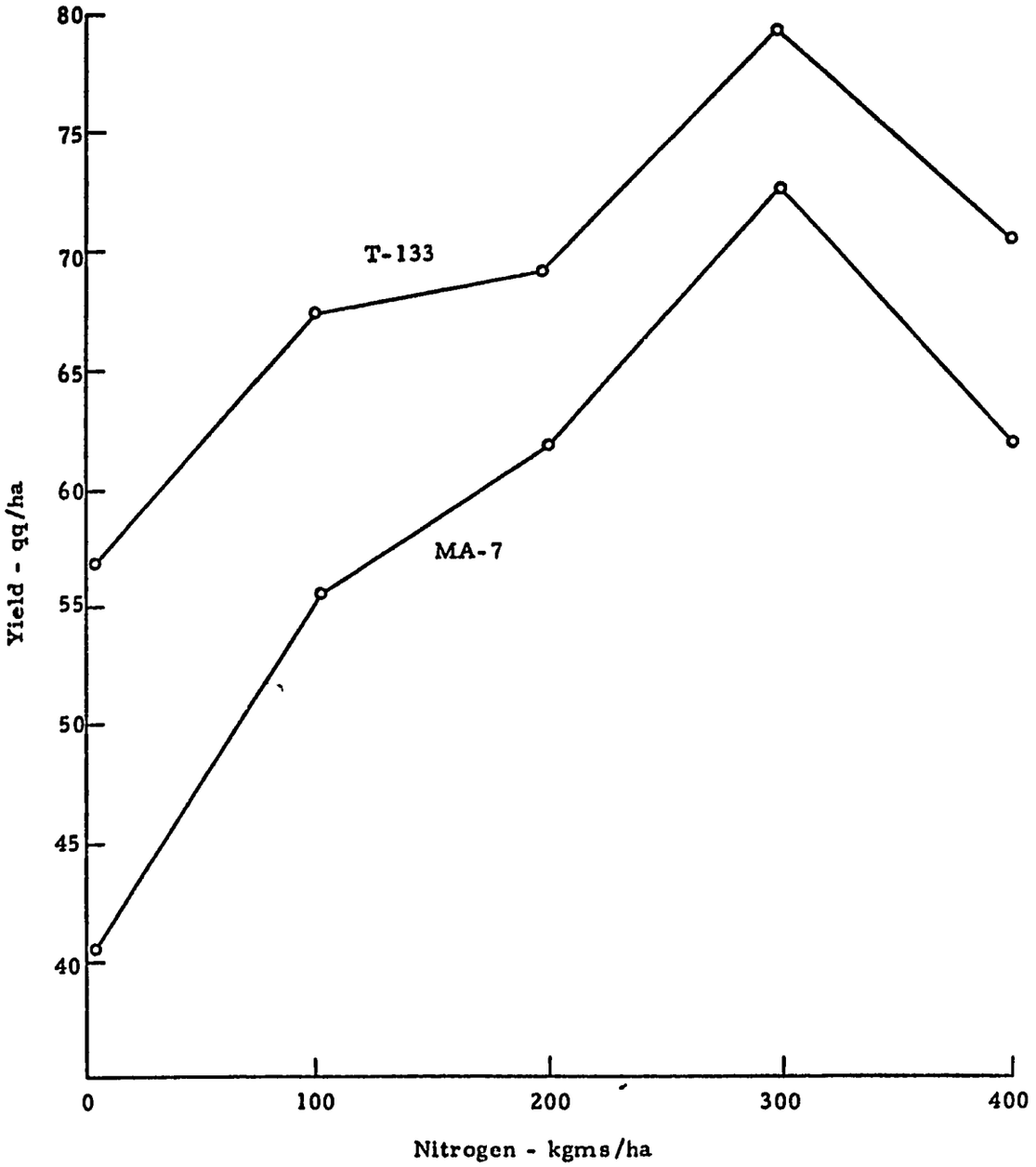


Figure 1.1. Yield of Corn as Influenced by Nitrogen Rates and Varieties. (Each point is the mean of twenty observations---four replications and five populations.)

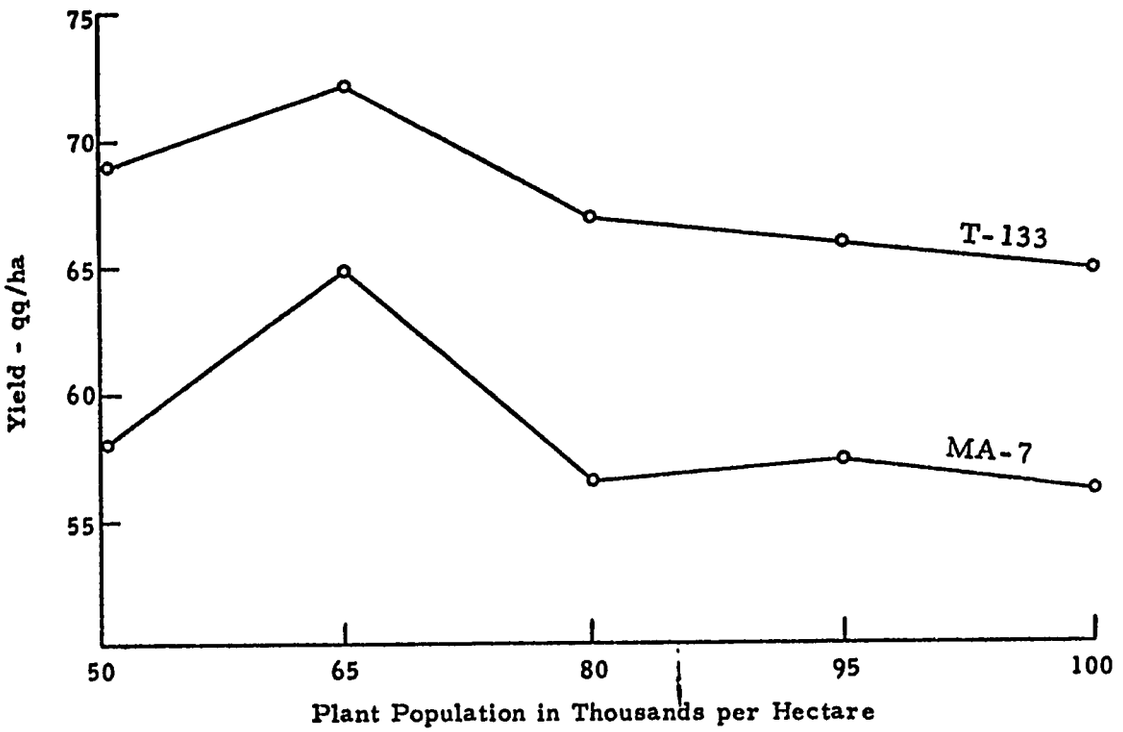


Figure 1.2. Yield of Corn as Influenced by Populations and Varieties. (Each point is the mean of twenty observations---four replications and five nitrogen rates.)

Table 1.4. Slope Percentages for Each Whole Plot. (Data are presented in the same relative position as they occurred in the field. Direction of irrigation flow was from left to right. The highest elevation was in the upper left hand corner and the lowest was in the lower right hand corner.)

Replication	Plot No.	Plot Number					Mean
		1	2	3	4	5	
1	1	1.00	.45	.90	.90	.85	.82
	2	1.05	.65	.65	.95	.85	.83
	3	1.00	.55	.90	.60	.90	.79
	4	.85	.40	1.10	.40	1.00	.75
	5	.85	.65	.80	.40	.70	.68
	Mean	.95	.54	.87	.65	.86	.77
2	1	.95	.50	.55	.85	.35	.64
	2	.95	.60	.75	.65	.40	.67
	3	.90	.90	.55	.70	.40	.69
	4	.85	1.00	.60	.75	.20	.68
	5	.65	1.05	.85	.60	.20	.67
	Mean	.86	.81	.66	.71	.31	.67
3	1	1.05	.85	.65	.30	.55	.68
	2	.95	.85	.65	.25	.35	.61
	3	.90	.70	.70	.30	.15	.55
	4	.90	.55	.70	.40	.00	.51
	5	.75	.60	.65	.35	.00	.47
	Mean	.91	.71	.67	.32	.21	.56
4	1	.90	.55	.45	.30	.10	.48
	2	1.05	.60	.40	.25	.10	.48
	3	1.00	.65	.60	.10	.00	.47
	4	.85	.65	.65	.10	.10	.47
	5	.90	.45	.50	.30	.00	.43
	Mean	.94	.58	.52	.21	.06	.46

Value for slope percentage (parallel to the furrows) are given. Table 1.4 shows that slope varied from 1.05 % to 0.0% in the experimental area. The field slope at right angles to the furrows (not shown in the table) varied from 1.2 to 1.7%.

It was observed during crop growth that corn growing in the flatter plots was, in general, more vigorous than corn growing in other areas. In order to evaluate this effect, yield data were averaged across varieties and populations and then averaged among nitrogen rates and slope categories. The results of this comparison are given in Table 1.5. Correlation and regression analyses were done on these data, and the results are given in Figure 1.3. Figure 1.3 shows that the yield decreased with increasing slope and increased among slope groups with nitrogen rates. Average yields varied from about 94 quintales per hectare at zero slope and N-400 to about 36 quintales per hectare at 1% slope and N-0.

The differences in corn performance, as related to field slope, are interpreted entirely in terms of moisture availability. That is, moisture penetration increased as the field became flatter. The fact that water infiltration problems occur in the soils of this area is well illustrated in Part II of this report.

It is apparent from the results of this experiment that limitations imposed on the crop by soil moisture stress prevented a full expression of the controlled variables (i.e., N, V, and P). The average yields from

Table 1.5. Relationship Between Corn Yield, Slope of the Land, and Nitrogen Fertilizer Rate

Slope Percent	Nitrogen Rate - kgms/ha					
	0	100	200	300	400	Average
	Corn Yield - qq/ha (see Table 1.2)					
.0	54.30	76.82	-	-	93.63	74.93
.1	-*	75.34	81.88	92.25	-	82.49
.2	48.36	-	-	84.72	-	66.54
.3	56.26	68.61	78.07	92.33	-	73.82
.4	58.42	65.32	71.70	82.40	66.04	68.78
.5	53.64	71.11	-	68.90	62.73	64.10
.6	50.67	70.74	69.12	73.99	64.50	65.80
.7	42.71	57.71	73.94	78.72	68.32	64.28
.8	45.57	55.17	58.85	56.11	61.71	55.48
.9	34.86	52.09	51.50	72.26	42.65	50.67
1.0	36.42	55.53	52.63	-	81.98	56.64

*Where no data are shown, no slope-N combinations existed. All datum points are means of from two to ten observations per cell.

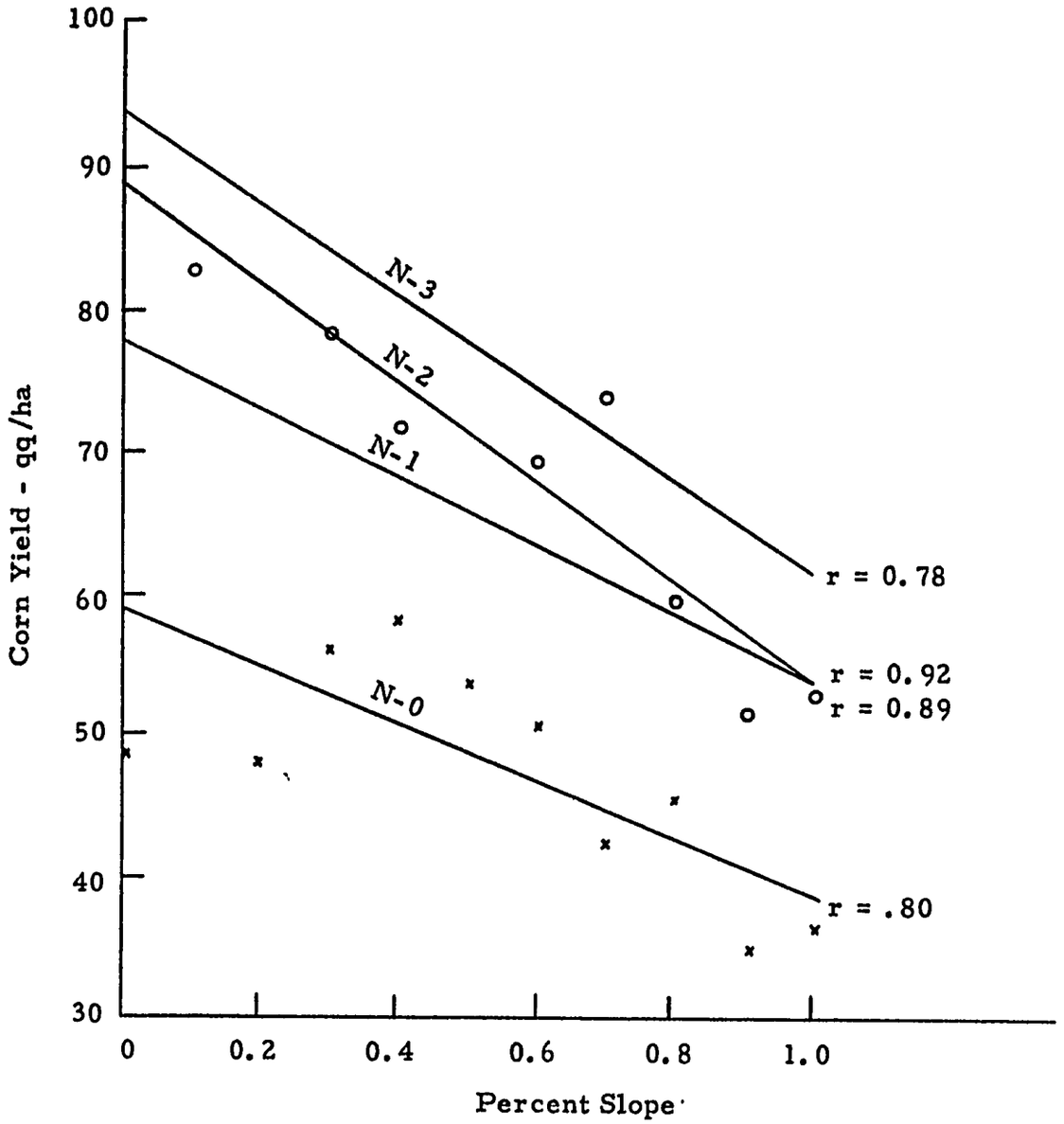


Figure 1.3. Yield of Corn as Influenced by Slope of Plots and Nitrogen Rate. (Points are shown only for N-0 and N-200 plots. Other points were not included because of overlap. Regression line for N-400 lies across the N-100 and N-300 lines and is not shown. The number of plots in each point (replications plus populations plus varieties) ranged from 2 to as high as 10. The regression lines were calculated using only the mean of all points in each N rate and slope group.)

this experiment were considerably below the demonstrated potential for this area as discussed later in this report and in previous reports. If soil moisture had not been limiting, differences between varieties probably would have been accentuated. In addition, competition from increased growth vigor would have resulted in a more clear definition of the population effects.

The pattern of response to nitrogen fertilizer would have been quite different if moisture penetration, and therefore effective rooting depth, had been better. The results of soil analyses at the beginning of the season (Table 1.1) indicate that appreciable amounts of nitrogen were carried over in the soil from previous seasons. Since the pre-irrigation was done after plow-down of the fertilizer treatments, it is reasonable to assume that some of the nitrogen was moved out of the root zone and was thus positionally unavailable to the crop. Certainly 300 kgm of nitrogen per hectare is excessive as an optimum rate (Figure 1.1), and these data should not be construed to indicate that that much nitrogen is required by corn.

The decrease in yield from N-300 to N-400 (Figure 1.1) is not normal behavior for corn, all other things being adequate and equal. This phenomenon is interpreted as being an example of the soil moisture-soil fertility interaction. Treatment N-400 probably induced very succulent and rapid growth early in the season. This would lead to greater

drouth susceptibility, which would occur cyclically between irrigations. As will be pointed out later, as the season progressed, water intake rate decreased. Therefore, drouth stress was most pronounced during the time of maximum moisture demand by the crop.

The average yield in this experiment (63.16 quintales per hectare) was 50% less than that obtained in the previous season and on different sites in this season (see below). Whereas the crop yield in this experiment was considerably less than the proven potential for the area, the results do fulfill one of the major objectives of this research program, that is, to discover growth-limiting factors and to evaluate methods for improving on-farm water management to bring about more efficient utilization of the irrigation water resources. In the Aconcagua valley low soil permeability (a characteristic arising from poor soil structure) is a factor that requires major effort to achieve maximum production. Section II of this report demonstrates that water infiltration is in fact subject to management control.

Irrigation Frequency and Depth

Irrigation dates and the depth of application for each replication block are shown in Table 1.6. Uniform water application to all of the blocks was attempted by keeping the irrigation frequency and time the same. The differences in net water application among replications thus reflect the differences in the average infiltration rate over the whole block.

Table 1.6. Net Water Applied as Related to Date of Irrigation and Replication Block

Irrigation Date	Water Applied - cm Block				
	1	2	3	4	Average
Nov 23 - 26	12.83	12.70	9.59	12.28	11.85
Dec 13 - 16	8.70	9.66	8.35	10.74	9.36
Jan 3 - 6	6.91	9.16	7.47	8.52	8.01
Jan 17 - 20	5.04	6.14	7.07	8.62	6.72
Jan 25 - 28	4.35	7.80	6.44	5.50	6.02
Feb 7 - 10	4.70	5.34	6.39	6.19	5.66
Feb 22 - 25	3.72	4.86	7.11	7.19	5.72
Total	46.27	55.66	59.04	59.04	53.34

Accordingly, the yield results already discussed correspond to the net water application results.

The depth of water applied was inversely related to the average slope of the whole block. Block I, for example, with the highest average slope (0.77%) had the least total depth of water application (46.27 cm). Compare this to Block IV which had the least average slope (0.46%) and the greatest net water application (59.04 cm). These water application depths do not include the pre-planting irrigation which was estimated to be 12 cm over the entire field.

Since the furrow length was very short, the water generally reached the end of the block within 30 minutes. There was thus essentially no difference in opportunity time for infiltration over the whole block. The

increase in infiltration with decreasing slope was apparently the result of decreased velocity which required a larger cross section in the furrow and greater wetted perimeter. Thus, there was a larger area of water-soil interface and greater opportunity for infiltration to occur.

Table 1.6 gives the evaporation pan data for the periods between irrigations. The average net water application for the same period is also given in Table 1.7. In nearly all cases the evaporation was appreciably greater than the application depth. This indicates that the crop was probably extracting more water from the soil than was being replaced by irrigation and that the soil was gradually drying out. This would explain why the overall average yield was considerably below that observed in other fields in this valley (see Part III below). If the ratio of consumtive use to evaporation is assumed to be 0.9 for the period November 3 through February 25, then the estimated consumptive use would be about 75 cm, or 22 cm more than the total net depth of irrigation applied during the same period.

Plant Tissue Analysis

As indicated in the procedure, only the P-80 plots from variety T-133 were sampled for tissue analysis. This represents one-tenth of the total number of plots in the experiment. The limited data that were obtained are given in Table 1.8. Total (protein) nitrogen followed the fertilizer rates rather well. Because of the soil moisture problems already

Table 1.7. Evaporation from the "Class A" pan in Relation to the Net Water Application

Period	Evaporation cm	Net Water Applied cm
Nov 3 - Nov 26	17.05	11.85
Nov 27 - Dec 16	14.01	10.21
Dec 17 - Jan 6	16.29	8.01
Jan 7 - Jan 20	10.24	6.71
Jan 21 - Jan 28	6.00	6.02
Jan 29 - Feb 10	9.72	5.66
Feb 11 - Feb 25	9.34	5.72
Total	82.65	53.34

Table 1.8. Total Nitrogen Composition of Corn Leaves - Percentage Dry Weight

Replication	Nitrogen Rate - kgm/ha					
	0	100	200	300	400	Total
1	0.94	1.29	1.12	1.93	1.79	7.07
2	0.95	1.25	1.44	1.68	1.83	7.16
3	1.01	1.40	1.76	1.79	2.25	8.21
4	0.85	1.40	1.43	1.75	1.54	6.97
Total	3.75	5.35	5.75	7.15	7.41	29.41
Average	0.94	1.34	1.43	1.78	1.85	

	df	SS	MS	F
Total	19	2.68		
Replication	3	0.20	0.07	
Treat	4	2.00	0.50	12.5*
Error	12	0.48	0.04	

*Significant at 1% level.

$$CV = \frac{.2}{1.47} = 14\%$$

discussed, no conclusions can be drawn regarding the optimum concentration of nitrogen in the plants. More data should be obtained in subsequent years to correlate nitrogen uptake with plant yield and quality. Tissue analysis is justified because of its value to research and extension workers in diagnosing crop growth problems in the field.

Post-season Soil Nitrogen

The fall soil sample results are included in Table 1.9. These data indicate that there was very little influence of fertilization on nitrates in the soil profile below 30 cm. The changes with fertilization in the profile totals were essentially identical to the 30 cm layer alone.

Although fertilization increased residual nitrogen, there was no consistency in the residual levels as compared to the applied levels. This is probably related to the problem of sampling a highly mobile element such as nitrate-nitrogen. Sampling technique in this type of soil should be carefully evaluated.

The restricted vertical mobility of the applied nitrogen is related to the restricted penetration of the irrigation water. Based on the low winter precipitation typical in this area, it can be assumed that the residual nitrogen will remain in the same position and be available for subsequent crops. As stated in the report for 1970-71, residual nitrogen can have an over-riding influence on the response of crops to fertilizer in the season of application.

Table 19. Post-season Nitrogen Composition of the Field Plots. (Data represent P-80 plots only; concentrations are in terms of parts per million of nitrate plus ammonium nitrogen in the soil.)

Depth cm	Nitrogen Fertilizer Rate - kgm/ha						
	0	100	200	300	400	Total	Mean
0 - 30	33.50	64.00	52.50	40.25	93.50	283.75	56.75
30 - 60	8.25	8.25	10.00	8.00	15.50	50.00	10.00
60 - 90	6.00	7.75	7.50	9.00	10.00	40.25	8.05
90 - 120	9.00	8.50	9.25	6.25	9.75	42.75	8.55
Total	56.75	88.50	79.25	63.50	128.75	416.75	83.35

Summary and Conclusions

This experiment was conducted to evaluate nitrogen fertilizer rates, plant density, and crop variety in production of shelled corn in the Aconcagua valley of Chile. The results show that yield of corn increased with fertilization to 300 kgs N/ha. With 400 kgs N/ha, yield decreased to the same level that was obtained with 200 kgs N/ha. Differences in yield associated with plant populations were not significant but the trend favored the density of 65,000 plants/ha. Hybrid variety T-133 was superior to hybrid MA-7.

Although irrigation was not a controlled variable, differences in yield were obtained that were related to differences in soil moisture. Irrigation water intake rate was limited in general by poor soil structure. But water intake was greater in those parts of the field that had

about zero percent slope and considerably less in those parts that had near one percent of slope. Limited water penetration also influenced residual fertilizer and soil nitrogen; this was localized within the top 30 cm of soil.

Limitations imposed on the crop by soil moisture stress prevented a full expression of the controlled variables. Fertilizer rates and plant population will have to be studied further under conditions of good moisture availability. It is believed, however, that hybrid T-133 would be superior to MA-7 under intensive irrigated corn production. This aspect of the results points to the need for continued hybrid corn development, particularly of varieties that are designed specifically for high yield potential under conditions of intensive irrigation agriculture.

While the results do not fully satisfy the original objectives of this experiment, they do emphasize that many factors must be controlled if maximum water use efficiency is to be attained. None of the problems encountered in this research are considered to be insurmountable as efforts are continued toward the long term goals of this research program.

PART II

IRRIGATION WATER INFILTRATION EXPERIMENT

Personnel: Same as indicated under Part I

Part II

Irrigation Water Infiltration Experiment

Introduction

Experiences gained during the past two years on many soils in the Aconcagua valley, especially those at Condoroma, indicate a serious problem related to irrigation water intake rate in the area. The limiting effect of water intake is evident from corn yields obtained at two different sites. At El Castillo in 1969-70 the average corn yield was 100 qq/ha, while at Condoroma it was 86 qq/ha. For 1970-71 the same comparison shows that corn yielded 116 qq/ha at El Castillo and 80 qq/ha at Condoroma. Water application depths and frequencies largely explained the difference in yield at the two sites. For example, in 1970-71 at El Castillo, a total of 92 cm of water were applied during eight irrigations in one of the soil moisture treatments, while at Condoroma a total of 74 cm of water were applied during 14 irrigations.

The operational problems, inconveniences, and lower efficiencies connected with light, frequent irrigations (together with the lower yields) suggested the need to improve or eliminate the water intake problem. The experiment reported here was designed specifically to determine whether water intake could be improved through management of the soil.

One possibility was obvious at the outset. It is a general habit in this area to remove crop residues either by pasturing, burning, mechanical removal, or a combination of these practices. It appeared that proper utilization of the crop residues would improve the soil moisture situation through facilitating structure development and channels for moisture flow. In addition, observations made on soil cores in the laboratory suggested that gypsum might be a useful amendment to aid in soil structure development. This, of course, implies that sodium was part of the problem.

Materials and Methods

The experiment was located at Condoroma about 200 meters from that described in Part I of this report. Again, the soil texture was silt loam to fine sandy loam. The site was well-drained; average slope was about one percent. The previous crop had been corn. At the time the experimental work was initiated the field was typically littered with corn stalks that remained from the previous crop which had been trampled by livestock during the winter.

Two experimental variables were imposed on the soil. The first consisted of three levels of corn crop residue. These were developed as follows. One plot had all the litter completely removed---this was the check or control plot. The second residue level consisted of the application of 55 quintales per hectare of corn residue---this approximated the indigeneous level of residue. The third treatment was the application

of 110 quintales per hectare of the corn residue. The second variable (treatment number four) consisted of gypsum applied at the rate of 40 quintales per hectare. The latter treatment was done on a plot that had had all the litter removed.

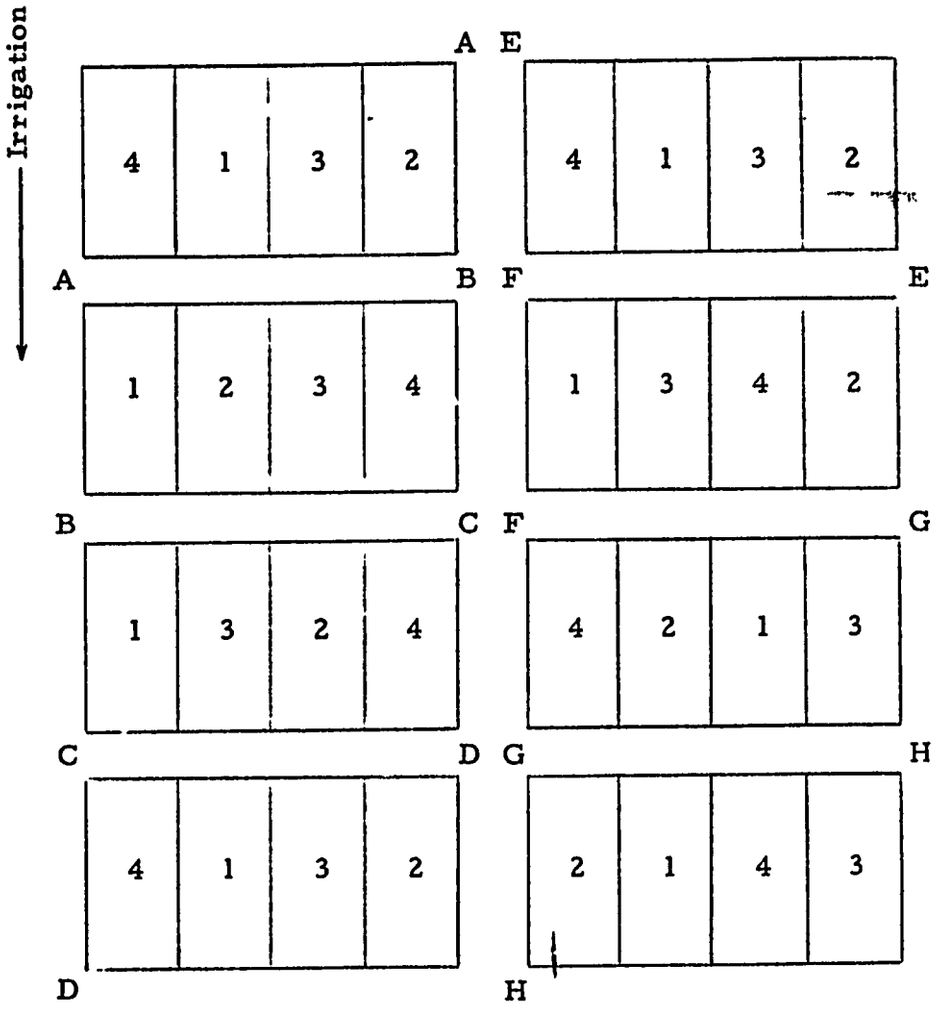
The treatments were applied in plots 8.7 meters wide (10 corn rows wide) by 27 meters long. The four treatments were put out in randomized complete blocks in eight replications. Details of the field layout are given in Figure 2.1.

After applying the crop residue the field was disced. This served to break up the stalks. After this the gypsum treatments were applied and the field was disc plowed. Because the soil was dry and very hard, the plowing was poorly done. The field was then furrowed, irrigated and plowed again. Another light irrigation was applied by surface flooding prior to seed bed preparation.

Nitrogen fertilizer in the form of urea was applied uniformly over the field with a mechanical spreader at the rate of 150 kgs of nitrogen per hectare. Phosphorus fertilizer in the form of treble super-phosphate was applied uniformly at the rate of 60 kgm of the element per hectare.

Seed bed preparation involved discing in the fertilizer with the disc plow and then making two passes with the disc harrow, roller, and spike tooth harrow described in Part I.

The plots were planted on October 26 to a population of approximately 70,000 plants per hectare using variety T-133.



A - measuring orifice locations

Treatments: 1 control plot
2 single residue, 55 qq/ha
3 double residue, 110 qq/ha
4 clean plot plus gypsum

Figure 2.1. Field Layout of Infiltration Experiment Showing Location of Inflow and Outflow Measuring Devices

Boyoucous soil moisture blocks were installed at depths of 30, 60, and 90 cm at the approximate centers of each plot. In addition, tensiometers were installed at 40 cm depth in the four central blocks (B, C, E, and F, Figure 2.1).

The plots were irrigated by furrows using 1/2-inch diameter plastic siphon tubes to distribute the water. Water applied to each plot was measured using submerged orifices installed in wooden structures; a two-inch diameter orifice at the inlet corner of each block and a one-inch diameter orifice and a 1-3/8-inch diameter orifice (either one or both could be used depending on quantity of flow) at the outlet corner of each block. With the exception of the first irrigation after planting, the same treatment in all of the eight replication blocks was irrigated at the same time.

A standard U.S. Weather Bureau evaporation pan was installed in an alfalfa field close to the experiment. An area of 5 x 5 meters was fenced around the pan. It was located to avoid shading from trees. Readings were taken at approximately one-week intervals on water level in the pan from November 3 through March 14.

Harvest data were collected in the same manner as described in Part I. In this case the six center rows in each plot were harvested with proper regard for border effects. Yield results are expressed in quintales per hectare of shelled corn at 15 percent moisture content.

During the growing season differences in crop appearance developed that were associated with the treatments. In replication blocks F and G, where the contrast in crop appearance was greatest, soil samples were taken from each treatment for laboratory analysis. The samples were taken on February 17, during the silking stage of the corn. One composite was made of each plot from ten samples which were taken at random over the plots. The composite represented the top 10 inches of soil taken in the bottom of the irrigation furrows.

On February 18 bulk density samples were taken at a four-inch depth in the bottom of the furrows in blocks B, C, F, and G. Two sets of samples were taken from each plot; one set of three samples was taken from the furrow where tractor wheel compaction had occurred during planting and tillage operations. The second set of three samples was taken from the furrows where there had been no tractor wheel traffic.

Results and Discussion

Yield

The yield results by treatment and replication are given in Table 2.1. The analysis of variance for these data, shown in Table 2.2, indicates that there was a significant difference in yield due to the effects of treatment 3, which was the double rate of crop residue incorporation. The yields from treatments 2 and 4 were essentially the same as that from the control. These results indicate that the addition of substantial

Table 2.1. Corn Yield in Terms of qq/ha of Shelled Corn at Standard 15% Moisture Content

Replication Blocks	Treatment				Average
	Control*	Residue 1	Residue 2	Gypsum	
A	47.53	40.24	69.94	44.29	50.50
B	36.97	48.91	61.52	55.50	50.72
C	58.18	48.20	78.44	26.44	52.81
D	70.72	29.08	71.51	78.14	62.36
E	21.53	48.02	30.66	22.05	30.56
F	13.19	24.50	32.22	18.70	22.15
G	31.98	46.97	38.95	41.37	39.82
H	40.34	46.26	60.55	30.56	44.43
Totals	320.44	332.18	443.79	317.05	
Average	40.06	41.52	55.47	39.63	44.17

Table 2.2. Analysis of Variance

Source of Variation		SS	MS	F
Total	31	9,731.39		
Replication	7	4,709.36	672.77	3.88
Treatments	3	1,378.54	459.51	2.65
Residue 2 vs Rest	(1)	1,362.79	1,362.79	7.85 **
Residue 2 vs Control	(1)	920.48	920.95	5.48 **
Error	21	3,643.49	173.5	

**Significant at 1% level.

CV - 30%

amounts of gypsum had no effect on soil moisture availability. Neither did the treatment that used only the normal level of indigeneous crop residue.

The yield from treatment 3 represents an increase of 15.4 qq/ha of shelled corn, or 38 percent more than the control plot. This increase in yield reflects the increased water availability which resulted from the improvement in soil moisture infiltration. This result shows that the problem of low moisture availability under irrigation can be overcome, at least in part, by managing the soils and crops specifically toward this end. The problem needs further analysis, but it is evident that crop residue incorporation, including that of corn, wheat and many other crops grown in the area, should become a standard practice. The added management costs with this practice would be insignificant compared to the benefits that would accrue.

It is likely that a permanent adoption of this practice would have accumulative effects, not only from the direct residue carryover but also because as root and top growth are increased by improved soil conditions, more residue would be available for incorporation in subsequent seasons.

Soil Moisture Conditions

The net amount of water applied by treatments and replications is given in Table 2.3. The totals and averages (converted to application depths in cm) are also shown. The irrigation schedule is given in Table 2.4.

Table 2.3. Net Water Application to Replication Blocks. (Data are in terms of volume (cubic meters). Total volume is converted to depth (cm).)

Replication Block	Treatment			
	1	2	3	4
A	26.49	20.00	27.54	13.66
	9.43	9.22	9.75	11.38
	11.72	11.01	10.26	14.73
	11.48	8.84	9.43	13.57
	7.33	6.80	8.22	11.21
	8.39	6.48	8.31	12.89
	2.18	6.44	5.25	20.47
Total m^3	77.02	68.79	78.76	97.91
Total cm	33 cm	29.2	33.5	41.6
B	1 .14	30.29	22.83	23.00
	14.65	16.90	15.42	17.20
	15.79	15.31	17.14	13.91
	18.57	16.99	15.44	16.67
	11.36	12.89	13.86	13.49
	16.43	16.13	17.62	14.07
	15.29	13.88	12.73	12.50
Total m^3	107.23	122.39	115.04	110.84
Total cm	45.6	52.1	48.9	47.2
C	27.20	20.00	23.50	17.00
	17.00	18.42	17.67	14.55
	14.27	15.28	21.95	20.17
	15.64	14.53	17.00	18.12
	8.74	13.11	14.51	13.61
	11.52	14.93	15.03	14.14
	12.53	15.16	14.91	13.82
Total m^3	106.90	111.43	124.57	111.41
Total cm	45.5	47.4	53.0	47.4

Table 2.3. (Continued)

Replication Block	Treatment			
	1	2	3	4
D	26.06	20.31	21.62	30.56
	18.02	16.68	21.98	18.68
	15.09	12.04	16.98	21.73
	17.02	13.22	26.44	22.04
	10.14	12.56	15.84	15.74
	14.28	10.81	17.49	20.04
	14.02	11.58	15.72	17.35
Total m^3	114.63	97.20	136.07	146.14
Total cm	48.8	41.3	57.9	62.2
E	22.92	18.61	21.57	18.93
	11.64	15.58	10.88	13.40
	14.29	18.34	8.03	12.47
	12.69	12.71	11.43	8.78
	5.67	9.69	11.04	9.05
	10.92	12.24	12.27	8.25
	8.02	9.09	11.35	7.04
Total m^3	86.15	96.26	86.57	77.92
Total cm	36.6	40.9	36.8	33.1
F	17.43	15.34	22.64	18.77
	11.09	11.78	15.15	11.78
	11.28	12.46	13.63	14.06
	10.82	12.54	14.92	13.91
	9.07	10.82	12.57	13.72
	11.38	14.01	11.88	14.61
	8.56	20.96	11.37	11.99
Total m^3	79.63	97.91	102.16	98.84
Total cm	33.9	41.7	43.5	42.1
G	19.52	21.03	20.05	17.77
	21.44	15.96	16.53	23.32
	24.64	28.14	17.75	23.56
	18.94	25.49	15.98	17.12
	14.16	15.49	16.11	5.79
	17.77	16.66	16.94	18.67
	14.55	15.35	17.82	15.82
Total m^3	131.02	138.12	121.18	122.05
Total cm	55.7	58.8	51.6	51.9

Table 2.3. (Continued)

Replication Block	Treatment 1	2	3	4	
H	21.18	17.06	18.35	20.64	
	15.25	16.20	16.99	12.59	
	14.62	16.81	10.59	13.77	
	16.13	13.57	10.18	10.68	
	8.30	15.26	0.79	10.01	
	13.48	11.91	9.85	10.71	
	6.32	10.67	10.07	10.16	
Total m^3	95.28	101.48	85.82	88.56	
Total cm	40.5	43.2	36.5	37.7	
Overall Totals	797.86	833.58	850.17	853.67	
Averages m^3	99.73	104.20	106.27	106.71	
Averages cm	42.4	44.3	45.2	45.4	44.3

Table 2.4. Irrigation Schedule

Treatment	December	January	February
1	1-6 20	5 18 25	8 15
2	1-6 22	7 20 27	10 17
3	1-6 23	6 19 26	9 16
4	1-6 21	4 17 24	7 14

Except for the first irrigation (December 1-6), all replications of the same treatment were irrigated the same day.

No appreciable differences in water applied are indicated by the data; there seems to have been no treatment effect on net water application. This result is not in line with the yield results just discussed, or more particularly, with observed differences in crop appearances among treatments during the growing season.

With the exception of block D, there were obvious differences in corn appearance among treatments, especially in blocks E through H. The control plots showed clear signs of moisture stress in the plants and retarded crop development. In general, the plots receiving the double crop residue treatment showed the greatest plant development and least sign of moisture stress, although at times there were slight signs of wilting in these plots.

The observations during the growing season and yield results indicate a difference in available moisture related to treatments, even though a difference in water applied was not measured. This can be explained at least in part by the following: (1) The first irrigation was applied uniformly over the field and was not measured on the individual blocks. At this time the crop residue on treatments two and three was at or near the surface where it had maximum effect in holding the soil open for greater moisture penetration. This effect was in fact observed during the first irrigation in terms of the rate of advance of the water across the plots. This allowed the root zone in these treatments to be more nearly filled to field capacity. As indicated previously, following the first irrigation

the field was replowed and the residue was incorporated to such a depth that its influence on infiltration may have been reduced.

(2) Following planting, the inflow of water was measured through a submerged orifice and then delivered in unlined earth canals along the upper end of the furrows in each block. Then water was distributed to the individual furrows by means of siphon tubes. The outflow from the plots was collected in a small ditch at the lower end of the plots and measured at the end of this ditch. Because of this arrangement the water losses due to seepage in the canals were measured as water applied to the plot. This over-estimation of net water application to the plot was greatest for treatment number four which was the first to receive water during each irrigation cycle. At this time the seepage loss was greatest, the canals being relatively dry after periods of from three to ten days without water. Evidently, the system used for measuring net water application was too gross to be able to distinguish effects from the treatments.

Considering the 10 cm depth of water applied in the pre-plant irrigation, the average total net water applied was 54.47 cm. This compares with 78.11 cm of evaporation from the evaporation pan. If this applied water is taken as a measure of consumptive use, then the ratio of consumptive use to pan evaporation for the period November 3 to February 17 would be approximately 0.7 (as compared with a ratio of 0.9 that would have been predicted based on results obtained elsewhere). This would indicate that the water transpired by the crop was not being replaced by

irrigation, and that the soil in the root zone was gradually drying out during the growing season. This is supported by the soil moisture block data summarized in Table 2.5. These are the average conductivity readings for the eight replications. While some of the blocks at the 30 cm depth responded to the irrigation, the blocks at 60 and 90 cm depths became progressively drier with time.

Cumulative data from the evaporation pan, along with daily averages for periods between readings, are given in Table 2.6 The evaporation for the periods between irrigations is shown in Table 2.7 in relation to the water applied at the end of each period.

The water holding capacity of the 120 cm root zone was estimated to be 25 cm of water. If irrigation was applied when 40 percent of this had been removed, the net application would have been 10 cm and the average frequency 2 weeks (providing the irrigation time could be long enough to apply the 10 cm depth each time). In this experiment a 9-hour irrigation period applied an average of about 5 cm of water. Where a 7-day interval was possible, this replaced approximately the same amount of water as was evaporated from the pan.

A reliable estimate of consumptive use cannot be made from this study because soil moisture availability limited crop growth and development. In the results given in Part I of this report, the overall average yield for variety T-133 was 67.75 qq/ha, and there was a total of 66.34 cm of water applied. In this experiment the overall average depth was 54.47 cm of water and yield averaged 44.16 qq/ha.

Table 2.5. Average of Boyoucous Soil Moisture Block Readings in Terms of Electrical Conductivity by Treatment and Depth in Relation to Irrigation Dates

Reading Dates	Treatment 1			Treatment 2			Treatment 3			Treatment 4			Dates of Irrigations*
	Depth in Centimeters												
	30	60	90	30	60	90	30	60	90	30	60	90	
Dec 22	164	95	155	56	31	157	13	85	180	118	67	133	Dec 1-6
Dec 28	21	69	108	28	24	106	105	73	111	14	45	96	Dec 20-23
Jan 4-7	8	11	37	5	8	11	45	15	9	26	17	13	Jan 5-7
Jan 12	10	4	12	6	4	6	5	10	6	4	7	7	
Jan 18	7	7	8	4	5	4	3	7	4	66	5	5	Jan 17-20
Jan 21	22	7	8	53	5	3	33	8	3	23	7	5	
Jan 24	9	6	4	32	5	3	10	8	3	5	5	5	Jan 24-27
Jan 28	11	7	7	56	5	3	30	10	3	20	7	5	Feb 7-9
Feb 18	44	6	6	74	9	3	43	6	3	51	5	4	Feb 14-17

*Irrigations were applied to the treatments in the following order: 4, 1, 2, 3.

Table 2.6. Cumulative and Average Daily Evaporation from Standard U.S. Weather Bureau Pan

Period	Average Daily Evaporation mm	Accumulated Evaporation mm
Nov 3-4	7.5	15.0
Nov 5-9	6.4	47.0
Nov 10-15	7.0	89.0
Nov 16	7.3*	96.3
Nov 17-22	7.7	142.3
Nov 23-25	7.0	163.3
Nov 26 - Dec 1	7.2	206.3
Dec 2-9	7.1	263.3
Dec 10-12	7.7	286.3
Dec 13-15	6.0	304.3
Dec 16-19	6.2	329.3
Dec 20-21	6.5	342.3
Dec 22	8.0	350.3
No readings	8.2*	
		448.7
Jan 4-6	8.3	473.7
Jan 7-13	7.6	526.7
Jan 14-18	7.2	562.7
Jan 19-26	6.7	616.7
Jan 27	6.6	623.3
Jan 28-30	6.5	642.8
Jan 31 - Feb 6	7.8	697.3
Feb 7-9	7.7	720.3
Feb 10	6.5	726.8
Feb 11-13	6.3	745.8
Feb 14-18	6.9	780.3
Feb 19-29	5.7	843.3
Mar 1-8	5.0	883.0
Mar 9-13	4.9	907.3

*No data-average of preceeding and following period used.

Table 2.7. Evaporation from U.S. Weather Bureau Pan in Relation to Net Water Applied

Period	Evaporation for Period	Net Water Applied at End of Period by Treatments, cm				Average
	cm	1	2	3	4	
Nov 3 - Dec 7	25.71	9.36	8.65	9.47	8.53	9.00
Dec 8-23	10.93	6.30	6.42	6.62	6.54	6.47
Dec 24 - Jan 7	12.27	6.47	6.88	6.19	7.15	6.67
Jan 8-20	9.50	6.45	6.27	6.43	6.43	6.39
Jan 21-27	4.68	3.97	5.14	5.42	4.93	4.86
Jan 28 - Feb 10	10.37	5.54	5.49	5.82	6.03	5.72
Feb 11-17	4.65	4.33	5.49	5.28	5.80	5.36
Totals	78.11	42.42	44.34	45.23	45.41	44.47

Pre-irrigation was estimated to be 10 cm over the entire field.

Soil Analysis

The results of the bulk density samplings from blocks B, C, F, and G are given in Table 2.8. No differences were observed in the bulk density values with and without tractor wheel traffic in the row. Nor were there differences in treatments or replications blocks.

The results of soil chemical analysis taken from blocks F and G are given in Table 2.9. The yield results are included for comparison. The high residual nitrogen in the bottom of the furrow after the sixth irrigation indicates that there was definitely limited infiltration. In general, where higher infiltration rates and water availability are indicated by increased yields, the nitrogen is lower as also is the total soluble salts. These observations support the conclusion that water infiltration was severely inhibited.

Summary and Conclusions

Experiments conducted during two growing seasons---1969 through 1971---in the Aconcagua valley near Los Andes, Chile demonstrated that irrigation water infiltration in many soils of the area placed severe limitations on soil moisture availability and crop production. An experiment was designed in 1971-72 to determine whether the problem was subject to management control through incorporation of crop residues and other soil amendments.

Table 2.8. Bulk Density at 10 cm Depth in the Furrow Bottom in Blocks B, C, F, G

Plot	Bulk Density - gm/cc		Average
	Wheel Furrow	Non-wheel Furrow	
F1	1.35	1.31	1.33
F2	1.58	1.43	1.50
F3	1.50	1.32	1.41
F4	1.47	1.51	1.49
Block Average			1.43
G1	1.42	1.30	1.36
G2	1.52	1.53	1.52
G3	1.51	1.46	1.48
G4	1.35	1.38	1.36
Block Average			1.43
B1	1.40	1.47	1.43
B2	1.44	1.38	1.41
B3	1.29	1.31	1.30
B4	1.37	1.49	1.43
Block Average			1.39
C1	1.49	1.36	1.42
C2	1.41	1.33	1.37
C3	1.34	1.39	1.36
C4	1.33	1.48	1.40
Block Average			1.39
Average	1.42	1.40	1.41

Treatment Averages: Treatment 1 1.38
2 1.45
3 1.39
4 1.41

Table 2.9. Soil Chemical Data for 25 cm Depth in Furrow Bottom from Blocks F and G, Compared with Net Water Application and Yield

Sample	O.M. %	Nitrogen ppm	Nitrogen pH	Conductivity mmhos	Total Irrigation Depth cm	Yield qq/ha
F1	1.5	32	8.2	1.4	33.9	13.19
F2	1.6	22	7.9	1.5	41.7	24.50
F3	1.6	18	8.0	1.0	43.5	32.22
F4	1.5	39	7.8	2.6	42.1	18.70
G1	1.7	41	8.0	1.9	55.7	31.98
G2	2.0	23	8.0	1.4	58.8	46.97
G3	1.8	18	8.0	1.0	51.6	38.95
G4	2.1	16	7.8	1.6	51.9	41.37

Experimental variables included three levels of indigenous corn crop residue---zero, single, and double the normal residue levels---and one level (40 qq/ha) of gypsum. The four treatments were put out a. Condoroma farm in eight replications of randomized complete blocks.

Data collected during the season included net irrigation water applied, daily loss of water from a standard U.S. Weather Bureau evaporation pan, and yield of shelled corn.

Corn yield results showed that there was an increase of 38 percent in shelled corn on plots receiving the double crop residue treatment. The single residue rate and the gypsum treatment results were not different from the control plots. Drouth symptoms in the corn during the season indicated severe moisture stress in most plots between irrigations, especially on plots having no incorporated residue.

There was no difference among treatments in terms of net water application over the season. The method of water measurement would need to be refined, and the differences in water absorbed would need to be enlarged in order to observe distinct differences in water intake. In this experiment even the best yielding plots had some limitations from poor water infiltration.

Loss of water from the evaporation pan amounted to 78.1 cm of water during the period November 3 to February 17.

It was concluded that the slow water infiltration was related to poor soil structure. The problem has developed over the years as a result

of total elimination of crop residues. It was concluded that water infiltration can be improved, if not entirely eliminated, as a crop growth retarding factor. This will be possible with the resources available to farmers in the area and with no significant changes in cost of production.

The problem should be investigated further to determine optimum amounts of crop residue, best methods of incorporation, and longevity of the treatments.

PART III

FARMER COOPERATOR EXPERIMENTS DEMONSTRATING PRODUCTION MANAGEMENT TECHNIQUES FOR IMPROVED CORN PRODUCTION ON COMMERCIAL FARMS

Personnel: In addition to Don C. Kidman and R. Kern Stutler, Utah State University, the following people were involved in the execution of this work. Jorge Tondreau and Hector Silva, Chilean Agriculture Research Institute; Armando Heilbraum and Victor Gonzalez, La Platina Regional Unit of the Agriculture and Livestock Service of Chile.

Nelda Gonzalez, Sleman Sabaj, Conrado Grau, and Jose Zapata, San Felipe Office of the Agriculture and Livestock Service of Chile. Eduardo Castellani and Guillermo Osorio and Guido Krueger, Quillota Office of the Agriculture and Livestock Service of Chile.

Jaime Bahamondes, Ernesto Paez and Luis Campos of the La Ligua Office of the Agriculture and Livestock Service of Chile.

Part III

Farmer Cooperator Experiments Demonstrating Production Management Techniques for Improved Corn Production on Commercial Farms

Introduction

A demonstrative experiment was designed and used as a cooperative effort between INIA (Instituto Nacional de Investigaciones Agropecuarias), SAG (Servicio Agricola y Ganadero), and Utah State University, to fulfill the following objectives: (1) to demonstrate to the farmers within the area of SAG Zone 3, soil, water and crop management techniques that are proven by the intensive experiments; (2) to train extension personnel in designing, conducting and in applying field demonstration type experiments; and (3) to obtain supplemental information from which production management recommendations might be more clearly defined within the area.

Materials and Methods

Ten locations were selected in Zone 3 of SAG. Nine of the locations were in the Aconcagua valley: one near Llay-Llay, one near Catemu, seven in the area of Los Andes and San Felipe. One was located in the area of La Ligua. All of the experimental sites were located on cooperative farms (asentamientos). The locations were:

Cristo Redentor - Los Andes

Vencederoes Unidos - Los Andes

Manuel Rodriguez - Los Andes

Nueve de Julio - Los Andes

El Maiten - San Felipe

Tartaro de la Vicuna - San Felipe

Piguchen - San Felipe

San Lorenzo - La Ligua

San Jesus - Llay Llay

San Jose - Catemu

Variables in this project were four nitrogen fertilizer rates and four plant population densities. The design was a completely randomized complete factorial with one replication at each location of the sixteen treatments.

The nitrogen source was urea and was applied in rates of 0, 100, 200, and 300 kilograms of the element per hectare, hand broadcast at time of seed bed preparation. Treble super-phosphate was applied at the rate of 67 kilos of the element per hectare, broadcast uniformly over all plots.

Plant population densities were established by seeding at a very high rate and thinning back to populations of 50,000, 65,000, 80,000 and 95,000 plants per hectare. Field layouts were as shown in Figure 3.1. The individual plot size was 25 meters long by 8 meters wide.

N3 P4	N1 P1	N1 P3	N0 P4
N0 P3	N1 P4	N3 P1	N0 P1
N3 P3	N0 P2	N2 P1	N3 P2
N2 P2	N1 P2	N2 P4	N2 P3

Nitrogen Rates:

N0 - 0
N1 - 100 kg/ha
N2 - 200 kg/ha
N3 - 300 kg/ha

Plant Populations:

P1 - 50,000 plts/ha
P2 - 65,000 plts/ha
P3 - 80,000 plts/ha
P4 - 95,000 plts/ha

Figure 3.1. Field Layout of Demonstration Experiments

In general the seed bed for each site was prepared in the following manner:

1. Plowing by disc-plow.

2. Irrigation by furrows using siphon tubes for water distribution.

3. Harrowing with a disc harrow coupled with a spike-tooth harrow twice over to prepare for planting.

The corn variety used was Tracy Seed Company's T-133.

In general, subsequent irrigations were applied by furrow using siphon tubes to distribute the water to the furrows.

Harvesting was accomplished by selecting five rows, fifteen meters in length from the center of the plots with some modifications for stand uniformity. The corn from each harvested row was weighed, the ears counted, and five ears from each row were selected at random to determine the moisture content of the grain. Yields were then converted to quintales per hectare of shelled corn at standard fifteen percent moisture content.

Results and Discussion

Yield

There were ten asentamientos cooperating in these experiments, but for reasons of (1) bird damage to maturing corn, (2) faulty irrigation, and (3) insufficient plant emergence, there were only five locations from which measurable data could be taken. From the five locations, complete

harvest data were taken from three, leaving asentamientos Vencedores Unidos and Nueve de Julio with some of the plots unharvested due to one of the reasons listed above.

Table 3.1 shows the yield from the nitrogen treatments averaged across plant population. There was an increase in yield up to 200 kgm/ha.

The results indicated an increase in corn production of about forty percent between the 0 and 200 kilos per hectare rate. The average of the zero nitrogen plots, 64.52 quintales per ha, is approximately twenty quintales per hectare over the area average of about forty-five quintales per hectare. This indicates that other management factors besides fertilization are important in increasing corn production in this area. The differences in yield between the area average yield and the 200 kgm N/ha average yield is about forty-six quintales per hectare, or an increase of one hundred percent. This is consistent with percentage yield increases obtained from the demonstration experiments of 1970-71.

Table 3.2 shows the yields from the population treatments averaged across nitrogen rates. The differences in yield are not felt to be significant.

In general, the experimental results of work conducted in the Aconcagua valley indicate that the varieties studied have a fairly wide range of plant population tolerance with perhaps a trend toward higher economical returns from populations in the area of 60,000 plants per hectare.

Table 3.1. Nitrogen Treatment Yields in Quintales per Hectare of Shelled Corn at 15% Moisture Content

Asentamiento	Nitrogen Applied kg/ha					Average
	0	100	200	300	Total	
San Jose	80.75	120.25	167.13	156.84	525.07	131.27
9 de Julio	74.40	82.90	86.25	90.70	334.25	83.56
Vicuna	73.73	92.66	96.02	90.88	353.29	88.32
El Maiten	58.63	58.56	73.68	77.71	267.58	67.15
Vencedoras Unidos	35.10	49.37	32.71	48.86	166.04	41.51
Total	322.61	403.74	455.89	464.99	1,647.23	-
Average	64.52	82.75	91.18	93.00	-	82.36

Table 3.2. Population Treatment Yields in Quintales per Hectare of Shelled of Corn at 15% Moisture Content

Asentamiento	Plant Densities					Average
	50,000	65,000	80,000	95,000	Total	
San Jose	120.59	120.03	148.22	136.25	525.09	131.27
9 de Julio	80.49	93.54	73.86	87.12	335.01	83.75
Vicuna	92.46	99.75	73.63	87.45	353.29	88.32
El Maiten	78.40	72.74	61.63	55.82	268.59	67.15
Vencedores Unidos	56.28	26.24	-	-	82.52	41.26
Total	428.22	412.30	357.34	366.64	1,564.50	-
Average	85.64	82.46	89.34	91.66	-	86.92

Demonstration

One of the more important aspects of these demonstration experiments was the interest created among the members of the cooperative farms on which the experiments were located. Even though for various reasons it was difficult at times to maintain the active participation of the farmers during the season, they were aware of the importance of the techniques demonstrated.

One of the techniques of greatest interest was the use of the spike-tooth harrow for seed bed preparation and early weed control. The committee members of several of the cooperative farms involved want to continue the use of this implement on their farms and have started negotiations with a manufacturing company to make and sell these harrows to the farms.

In order to extend the benefits of these experiments beyond the farms on which they were conducted, four tours were organized by the San Felipe SAG office to visit some of the locations and also the interaction and infiltration experiments on Fundo Condoroma. Forty farmers from twenty-five different farms participated in these tours along with ten government officials from Quillota and La Ligua. The visitors showed a real interest in all of the experiments and many expressed a desire to apply on their farms some of the observed practices and to adopt the recommendations given to them during the short talks at the different sites.

Several of the farms on which these experiments were carried out have requested technical assistance from SAG offices in applying these practices on a larger scale in the coming crop year.

It is of interest to note here that some of the farms involved in the demonstration experiments conducted last year have adopted some of the practices and applied them on a larger scale to increase their corn production. For example, on Cristo Redentor, the corn harvest this year is approximately double that of the previous year on the same area. On Vicuna and Tartaro the yields from some of the fields this year are in the neighborhood of one hundred quintales per hectare, which represents more than a one hundred percent increase over the average corn yield of the farm in past years.

Training

These experiments have also served to train the SAG personnel, professionals and technicians, and to provide them with experience in laying out and executing these demonstrations. For the personnel in San Felipe this was the second year of this type of experience for the professional agronomist and three technicians located there. In addition, to those in the area of Quillota and La Ligua, two professionals and five technicians were involved in the experiments, along with two professionals stations at La Platina, one from INIA and one from SAG.

In total, five professionals and nine technicians actively participated in conducting the experiments. The experience gained by them included

experimental plot layout, fertilizer application, improved seed bed preparation, calibration and adjustment of planting equipment, furrow irrigation using siphon tubes and harvest of experimental plots using sampling techniques.

With the experience acquired from this year's work, the personnel should be able to continue this type of program of demonstration and be better able to provide technical assistance to the farmers in crop production. They will be able to communicate with the farmers and convince them of the advantages of these new and better practices because they have seen them carried out and observed the resulting benefits.

Summary and Conclusions

In the areas of SAG Zone 3, San Felipe, Los Andes, Llay Llay and La Ligua, demonstration experiments with four nitrogen levels and four plant population densities were conducted at ten locations using corn variety T-133.

It is evident from the overall results of these experiments (in agreement with the similar results of the previous year) that the extension of the practices demonstrated is of profound importance in increasing corn production in the area. Based on these two years of experience from this type of program in the Zone 3, it appears that it should be continued, but with some modifications. Instead of demonstrating on a plot basis, the concept should be enlarged to a field basis (two to five