Effects of Irrigation, Nitrogen Levels, and Plant Population on Corn Yields in Lajas Valley, P. R.[1]

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INTRODUCTION

There are a number of factors that influence crop yields. Among the most important are soil moisture, soil fertility, and plant population. The optimum level of moisture for plant growth is very important in irrigation agriculture, because it is fundamental in determining the time for, and the amount of, irrigation.

Little is known of the relationship between water used by corn and the corresponding growth and yield on soils and under climatic conditions of Puerto Rico. Some studies have been made in the United States by Boswell, Anderson, and Stacey (*2*)[3] who found a response to nitrogen and plant population when irrigation was applied. However, data of this kind are greatly affected by climatic and soil conditions and can only be applied to closely similar areas.

A response of corn to irrigation was observed in previous limited studies at Lajas Substation. However, in view of the impending development of additional water supply for the Lajas Valley, it was decided to undertake a series of experiments at the Lajas Substation to evaluate more thoroughly the effect of irrigation in combination with nitrogen fertilizer and different plant populations on the production of field corn.

EXPERIMENTAL PROCEDURE

Three experiments were conducted at Lajas Substation farm. The first experiment was planted July 12, 1956 and harvested November 5, 1956; the second was planted March 14, 1957 and harvested July 23, 1957; the third was planted April 17, 1958 and harvested August 17, 1958. The experiments were located in different sites of the farm and a simple lattice design was used throughout. The treatments included a combination of 3

[1] This research was done as part of the work of a contributing project of Southern Regional Project S-24.

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[3] Italic numbers in parentheses refer to Literature Cited, p. 137.

irrigation levels, 3 nitrogen levels, and 3 plant-population levels, with 4 replications, there being a total of 108 plots. The plant-population fertilizer-treatment combinations were grouped in blocks of 9 plots under each irrigation treatment, there being 3 blocks within each replication. The plots were 6 rows, 18 feet wide and 18 feet long. Six guard rows were left on each side of the experiment. The entire experiment covered an area of about 240 feet wide by 200 feet long.

The soil in the different sites was classified as Santa Isabel clay. This is one of the predominant soil types in Lajas Valley. No crops had been planted in these sites during the last few years. The soil moisture retained at different tensions and other physical properties were determined (table 1).

TABLE 1.—*Moisture-release data (percentage by weight) for Santa Isabel clay soil, Lajas, P. R.*

Moisture tension (atmospheres)	Soil moisture at—			
	Site No. 1 at—		Site No. 2 at—	
	Soil depth of 3-6 inches	Soil depth of 18-21 inches	Soil depth of 3-6 inches	Soil depth of 18-21 inches
0.1	41.3	43.7	31.2	31.4
.3	38.3	39.7	30.5	30.4
.6	37.2	37.3	28.5	30.0
1.0	35.8	35.2	26.8	29.8
2.0	34.3	34.0	26.1	29.6
15.0	21.4	22.7	16.2	16.1
Bulk density[1]	1.03	1.24	1.33	1.48

[1] Grams per cubic centimeter.

IRRIGATION

The three following irrigation treatments were tried: Frequent, irrigated when 20 percent of the available moisture had been depleted from the active root zone; intermediate, irrigated when 60 percent of the available moisture had been depleted from the active root zone; no irrigation, not irrigated after the crop was established.

The soil was plowed and harrowed several times until a good seedbed was obtained. Furrows about 4 inches deep and 3 feet apart were made in the whole experiment for the purpose of irrigation. Feeding ditches were made at the head of each irrigation block and used as equalizing bays by means of plastic dams placed at the end of each block. Plastic siphon tubes were used as flow controls for each furrow. A heavy irrigation was applied to the whole area after being planted in each experiment except in experiment No. 3 in which there was enough soil moisture to establish the plants. Subsequent irrigations were made according to the treatments involved.

PLANT POPULATION

The 3 plant-population levels tried were 9,600, 14,500, and 19,400 plants per acre. In experiment No. 3 the plant-population treatment of 9,600 was substituted with 24,900 plants per acre. A field-corn variety, Mayorbela, was planted in the top of the furrows at a 3-foot distance between furrows, with 9, 12, and 18 inches between plants. In experiment No. 3 the 18-inch distance was changed to a 7-inch one, corresponding to the 24,900 plant-population treatment. Two seed were placed in each hill; thinning to one plant per hill was done after the plants emerged.

FERTILIZER

The nitrogen-fertilizer treatments used were 0, 80, and 160 pounds per acre and were applied when the corn plants were about 8 inches high. Nitrogen in the form of ammonium sulfate (20.5 percent of N) was applied at the rates of 80 and 160 pounds per acre. Phosphorus and potassium in the form of superphosphate (20.5 percent of P_2O_5), and muriate of potash (61 percent K_2O), respectively, were applied to the whole experiment at the rate of 200 pounds each of P_2O_5 and K_2O per acre. All the fertilizer was placed in a small furrow opened about 3 inches at both sides of the corn plant.

SOIL-MOISTURE CONTROL

Disturbed and undisturbed soil samples were taken from 3 to 6 inches and from 18 to 21 inches deep at both sites where the experiments were conducted. The soil moisture retained by the undisturbed soil samples at different tensions in the low-tension range was determined in the pressure plate. The moisture retained at higher tensions by the disturbed soil samples was determined in the pressure membrane apparatus (*5*). Bulk-density determinations were made at both sites at each depth.

Tensiometers (*4*) were installed in the highest fertility and plant-population plots of the frequently irrigated blocks at 6-, 12-, 18-, and 24-inch depths. Two groups of tensiometers were placed on the top of the forrow, close to the corn plants. Readings of the instruments were taken every day. Irrigation of the frequently irrigated plots were made when the average soil-moisture tensions in the active root zone became 750 cm. of water. Gypsum resistance-blocks of the Bouyoucos type (*1*) and home-made models were installed in experiment No. 3 at 6-, 12-, 18-, 24-, and 30-inch depths in the frequently, intermediately, and nonirrigated plots.

The irrigations of the intermediately irrigated plots were made when the average available soil moisture in the active root zone dropped to 28.8 percent in experiments Nos. 1 and 2. In experiment No. 3 the soil was a little different, having a different soil-moisture retention; the average percentage was found to be 22.2 for irrigation of the intermediately irrigated plots. About 2 inches of water were applied whenever an irrigation was carried out (table 2). Soil samples for moisture determination were taken during

TABLE 2.—*Irrigation frequencies used in the corn experiment at Lajas Substation*

Moisture treatment	Dates of irrigation for—		
	Experiment No. 1, 1956	Experiment No. 2, 1957	Experiment No. 3, 1958
No irrigation	July 16–17	Mar. 19	—
Intermediate irrigation	July 16–17 Aug. 24 Sept. 11	Mar. 19 Apr. 5 Apr. 20 May 10–11 May 27–28 June 13 July 5–6	May 19
Frequent irrigation	July 16–17 Aug. 11 Aug. 24 Sept. 3 Sept. 11 Sept. 27	Mar. 19 Apr. 5 Apr. 20 Apr. 30 May 10–11 May 17 May 27–28 June 13 June 22 July 5–6	May 16 May 27 June 20 July 18

the whole growing season to indicate the irrigation of the intermediately irrigated plots and to calculate the moisture extracted from the root zone in each moisture treatment.

In experiment No. 1 the soil samples were taken with an Uhland soil sampler at the following depths: 0 to 9, 9 to 15, 15 to 21, 21 to 27, 27 to 33, and 33 to 39 inches. In experiments Nos. 2 and 3 duplicate soil samples were taken with a soil auger at 3 depths: 3 to 9, 15 to 21, and 27 to 33 inches. The soil samples were taken twice a week in the plots having a combination of 9,400 plants and no nitrogen; 14,500 plants and 160 pounds of nitrogen; and 19,400 plants with 160 pounds of nitrogen per acre under each irrigation treatment. In experiment No. 3 the soil samples were taken in the plots having 14,500, 19,400 and 24,900 plants per acre, respectively.

All samples were weighed and placed in an oven for 24 hours at 105°C. and the percentage of moisture on an oven-dry weight basis was determined. The water extracted from the top 3 feet of soil in the frequently and intermediately irrigated, and in the nonirrigated plots, was calculated for short periods throughout the whole growing season. A total of six samples at each moisture treatment was used to calculate the water extracted in those short periods and the whole growing season. The consumptive use of water was calculated by adding to the water extracted the rainfall during those periods.

CULTURAL PRACTICES

Weedings were made as was necessary to maintain the plots free of weeds. Every 10 days the whole experiment was sprayed with DDT (50-percent wettable) at the rate of 4 pounds per 100 gallons of water to control worm attack. When the kernels were dry, the central 12-foot-long sections of the central four rows of each plot were harvested. Percentage moisture of the kernel was determined.

EXPERIMENTAL RESULTS

An evaluation was made of the soil-moisture data and the effects of irrigation, nitrogen, and plant population on corn yields.

SOIL MOISTURE

As shown in table 1 there was a difference in the soil moisture retained at different tensions between the soil samples taken at sites Nos. 1 and 2. There was a difference in the soil moisture retained between the samples taken at 3-, to 6-, and 18- to 21-inch depths at each site.

Table 3 shows the rainfall data by days and months during the years 1956, 1957, and 1958, and the 10-year monthly average at Lajas Substation. As can be seen, 1957 was very dry, while 1958 had an abnormal rainfall distribution. Because of frequent rainfall it was not possible to calculate the water extracted from the root zone during the growing period of experiment No. 1. In some instances in experiment No. 2 the irrigations could not be performed as indicated by the soil-moisture measuring devices because of scarce irrigation water.

The consumptive use of water during short periods and throughout the whole growing season under each moisture treatment for experiments Nos. 2 and 3 is presented in tables 4 to 9. As shown in tables 4, 5, and 6, the total consumptive use in 125 days under experiment No. 2 varied from 19.99 inches in the frequently irrigated plots to 18.51 and 8.91 inches in

TABLE 3.—*Inches of daily rainfall during the growth period of each corn-yield experiment at Lajas, P. R., 1956–58*

Date	1956					1957					1958				
	Jul.	Aug.	Sept.	Oct.	Nov.	Mar.	Apr.	May	June	Jul.	Apr.	May	June	Jul.	Aug.
1		0.23		1.47		0.01							0.35	0.76	
2			0.17	.70	0.90	.12	0.08					0.05	.13	1.00	1.23
3			.45	.46	3.87				0.01			.28	.65		.35
4				.79					.02	0.02		.46			
5				.06								.11	.21	.26	2.49
6										.02	0.07	.26	.08	.26	.01
7												.02	1.42	.89	
8		.15					.03								.07
9	0.08	.04		.17								.24	.08	.49	.11
10				.41	.22	.01					.22		.01		.23
11			.02								.07				.21
12		.91	.02					0.26	.21			.03	.80		.07
13		.02	.10			.01		.02			.06	.04			.07
14					.09		.09				.02				
15		.03					.01				.07		.06		
16	.05		.65				.03	.22	.04					.15	.21
17				.78		.15									.05
18	.06		.08	.12					.17		.59	.02			
19	.12	.48	.45	.55			.11		.13		1.25	.10			
20	.45						.63				1.22		.61	.27	.02
21	2.65		.01	.65				.08						1.68	
22		.05		1.61				.18			.23		.04	.03	
23			.23								.12				
24		1.31	.03				.07	.03	.25	.06	.02		.07	.69	.02
25	.07			.03			.13	.38	.03		.68		.01		
26		.23	.44	.18	.19		.01								
27	.05				.62									.10	
28			.77	.85	.10	.01		.20				.36		.07	.56
29		.06		.11			.01	.01						.01	
30			1.43	1.18				.02	.05	.21	.15	.67	.15		.10
31	.35	.07		.06											2.31
Total	3.88	3.58	4.85	10.18	5.99	0.31	1.20	1.40	0.91	0.31	4.77	2.64	4.67	6.66	8.11
Average (10 years)	4.93	5.60	6.61	5.69	4.09	2.91	2.19	2.81	2.43	4.93	2.91	2.81	2.43	4.93	5.60

the intermediately irrigated and nonirrigated plots. Tables 7, 8, and 9 show the consumptive use of water in 123 days under experiment No. 3. It was 27.91 inches in the frequently irrigated plots, 22.70 in the intermediately irrigated, and 18.24 in the nonirrigated plots. Table 10 shows the variation in water used according to the corn growth stage. An average of 0.144 inch daily was consumed in the first 30 days after planting; this increased to an average of 0.208 inch per day at 56 days from planting, but decreased to 0.114 inch per day during the last 41 days of the growing season. The average total consumptive use in 125 days was 18.48 inches.

TABLE 4.—*Consumptive use of water by field corn in the frequently irrigated plots of experiment No. 2, by periods, March 19 to July 21, 1957*

Period	Consumptive-use interval	Total consumptive use	Average daily consumptive use
	Days	*In.*	*In.*
Mar. 19 to Mar. 24[1]	6	0.492	0.082
Mar 25 to Apr. 3	10	1.052	.105
Apr. 4 to Apr. 7[1]	4	.504	.126
Apr. 8 to Apr. 17	10	1.465	.146
Apr. 18 to Apr. 21[1]	4	.880	.220
Apr. 22 to Apr. 24	3	.756	.252
Apr. 25 to May 1[1]	7	1.456	.208
May 2 to May 8	7	1.035	.148
May 9 to May 12[1]	4	.604	.151
May 13 to May 15	3	.459	.153
May 16 to May 19[1]	4	.740	.185
May 20 to May 26	7	1.625	.232
May 27 to May 29[1]	3	.792	.264
May 30 to June 2	4	1.152	.288
June 3 to June 5[1]	3	.780	.260
June 6 to June 12	7	1.526	.218
June 13 to June 16[1]	4	.896	.224
June 17 to June 19	3	.688	.229
June 20 to June 23[1]	4	.808	.202
June 24 to July 4	11	1.328	.121
July 5 to July 10	6	.468	.078
July 11 to July 21	11	.486	.044
Total	125	19.992	

[1] Consumptive-use data calculated by interpolation.

EFFECTS OF IRRIGATION

In experiments Nos. 1 and 3 there was no statistically significant difference in production due to irrigation (table 11). In experiment No. 2 there was a highly significant irrigation effect on production (table 11 and figure 1). As shown in table 11, there was no statistical difference in production between the frequently and the intermediately irrigated plots. However, there was a highly significant difference in production between the irrigated (both frequently and intermediately) and the nonirrigated plots. There was an average increase in production due to irrigation of 25.03, 34.48, and 36.01

TABLE 5.—*Consumptive use of water by field corn in the intermediately irrigated plots of experiment No. 2, by periods, March 19 to July 21, 1957*[1]

Period	Consumptive-use interval	Total consumptive use	Average daily consumptive use
	Days	*In.*	*In.*
Mar. 19 to Mar. 24[2]	6	0.492	0.082
Mar. 25 to Apr. 3	10	1.052	.105
Apr. 4 to Apr. 7[2]	4	.504	.126
Apr. 8 to Apr. 17	10	1.465	.146
Apr. 18 to Apr. 21[2]	4	.564	.141
Apr. 22 to May 1	10	1.354	.135
May 2 to May 8	7	.951	.136
May 9 to May 12[2]	4	.772	.193
May 13 to May 19	7	1.734	.248
May 20 to May 26	7	1.412	.202
May 27 to May 29[2]	3	.666	.222
May 30 to June 5	7	1.677	.240
June 6 to June 9	4	.839	.210
June 10 to June 12[2]	3	.609	.203
June 13 to June 19	7	1.348	.192
June 20 to June 26	7	1.265	.181
June 27 to July 4	8	.767	.096
July 5 to July 10	6	.456	.076
July 11 to July 21	11	.583	.053
Total	125	18.510	

[1] Consumptive-use data from Mar. 19 to Apr. 17 are the same as for the frequently irrigated plots. All soil-moisture samples taken under each moisture treatment were combined to calculate the moisture extracted during that period.

[2] Consumptive-use data calculated by interpolation.

TABLE 6.—*Consumptive use of water by field corn in the nonirrigated plots of experiment No. 2, by periods, March 19 to July 21, 1957*[1]

Period	Consumptive-use interval	Total consumptive use.	Average daily consumptive use
	Days	*In.*	*In.*
Mar. 19 to Mar. 24[2]	6	0.492	0.082
Mar. 25 to Apr. 3	10	1.052	.105
Apr. 4 to Apr. 17	14	1.705	.122
Apr. 18 to May 1	14	1.245	.089
May 2 to May 15	14	1.576	.112
May 16 to May 26	11	.512	.046
May 27 to June 9	14	.337	.024
June 10 to June 26	17	1.758	.103
June 27 to July 21	25	.236	.010
Total	125	8.913	

[1] Consumptive use from March 19 to April 3 is the same as for the frequently and intermediately irrigated plots. All soil-moisture samples taken under each moisture treatment were combined to calculate the moisture extracted during that period.

[2] Consumptive-use data calculated by extrapolation.

hundredweights per acre under the 0, 80, and 160 pounds of nitrogen applied per acre, respectively, (derived from averages of data in table 11).

EFFECTS OF NITROGEN FERTILIZATION

In all the experiments conducted nitrogen had a highly significant effect on yield at all irrigation levels, with the exception of the nonirrigated plots

TABLE 7.—*Consumptive use of water by field corn in the frequently irrigated plots of experiment No. 3, by periods, April 17 to August 17, 1958*

Period	Consumptive-use interval	Total consumptive use	Average daily consumptive use
	Days	*In.*	*In.*
Apr. 17 to Apr. 24[1]	8	1.424	0.178
Apr. 25 to May 1	7	1.452	.207
May 2 to May 13	12	2.077	.173
May 14 to May 18[1]	5	1.230	.246
May 19 to May 25	7	2.083	.298
May 26 to May 27[1]	2	.640	.320
May 28 to June 5	9	3.156	.351
June 6 to June 12	7	1.520	.217
June 13 to June 19	7	1.575	.225
June 20 to June 22[1]	3	.888	.296
June 23 to July 1	9	3.376	.375
July 2 to July 14	13	2.075	.160
July 15 to July 18[1]	4	.904	.226
July 19 to July 22	4	1.026	.256
July 23 to July 28	6	1.278	.213
July 29 to Aug. 3	6	.918	.153
Aug. 4 to Aug. 10	7	1.120	.160
Aug. 11 to Aug. 17	7	1.170	.167
Total	123	27.912	

[1] Consumptive-use data calculated by interpolation.

of experiment No. 2. However, the difference in production between the plots receiving 80 and 160 pounds of nitrogen per acre under all irrigation treatments was not statistically significant (table 11 and figure 2). In other words, the effect of nitrogen on yield follows the law of diminishing returns (figure 3). There was an average increase in production of 11.95, 6.20, and 10.47 hundredweights per acre with the application of 80 pounds of nitrogen per acre in experiments Nos. 1, 2, and 3 (derived from averages of data in table 11). As shown in table 11, the increase in production under frequent irrigation with 80 pounds of nitrogen applied per acre in experiment No. 2

TABLE 8.—*Consumptive use of water by field corn in the intermediately irrigated plots of experiment No. 3, by periods, April 17 to August 17, 1958*[1]

Period	Consumptive-use interval	Total consumptive use	Average daily consumptive use
	Days	*In.*	*In.*
Apr. 17 to Apr. 24[2]	8	1.424	0.178
Apr. 25 to May 1	7	1.452	.207
May 2 to May 13	12	2.077	.173
May 14 to May 20[2]	7	1.526	.218
May 21 to June 1	12	3.140	.262
June 2 to June 5	4	.942	.236
June 6 to June 12	7	1.902	.272
June 13 to June 19	7	2.013	.288
June 20 to July 1	12	4.032	.336
July 2 to July 14	13	1.075	.083
July 15 to July 28	14	1.006	.072
July 29 to Aug. 3	6	.437	.073
Aug. 4 to Aug. 10	7	.721	.103
Aug. 11 to Aug. 17	7	.954	.136
Total	123	22.701	

[1] Consumptive-use data from April 17 to May 13 were calculated from those representing a combination of all the soil-moisture samples taken under the 3 moisture levels.

[2] Consumptive-use data calculated by interpolation.

TABLE 9.—*Consumptive use of water by field corn in the nonirrigated plots of experiment No. 3, by periods, April 17 to August 17, 1958*[1]

Period	Consumptive-use interval	Total consumptive use	Average daily consumptive use
	Days	*In.*	*In.*
Apr. 17 to Apr. 24[2]	8	1.424	0.178
Apr. 25 to May 1	7	1.452	.207
May 2 to May 13	12	2.077	.173
May 14 to June 1	19	1.376	.072
June 2 to June 5	4	1.233	.308
June 6 to June 12	7	1.222	.174
June 13 to June 19	7	1.184	.169
June 20 to July 1	12	3.267	.272
July 2 to July 14	13	1.268	.098
July 15 to July 28	14	1.187	.085
July 29 to Aug. 3	6	.733	.122
Aug. 4 to Aug. 10	7	.868	.124
Aug. 11 to Aug. 17	7	.944	.135
Total	123	18.235	

[1] Consumptive-use data from April 17 to May 13 were calculated from those representing a combination of all the soil-moisture samples taken under the 3 moisture levels.

[2] Consumptive-use data calculated by extrapolation.

TABLE 10.—*Average consumptive use of water (inches) by field corn at different growth stages in the intermediately irrigated and nonirrigated plots of experiments Nos. 2 and 3*

Growth stage (days after planting)	Average daily consumptive use for—		Average daily consumptive use for Nos. 2 and 3	Total consumptive use for period of growth
	No. 2	No. 3		
0 to 30	0.117	0.172	0.144	4.320
31 to 55	.146	.130	.138	3.450
56 to 84	.225	.192	.208	6.032
85 to 125	.118	.109	.114	4.674
Total	—	—	—	18.476

TABLE 11.—*Effect of irrigation and nitrogen fertilizer on the yield per acre (hundred weights) of 15-percent-moisture shelled corn grown during 3 experiments in Santa Isabel clay at Lajas, P. R., 1956–58*

Irrigation treatment[1]	Effects of indicated pounds of nitrogen applied per acre in experiment—									Mean
	No. 1			No. 2			No. 3			
	0	80	160	0	80	160	0	80	160	
Frequent	22.91	37.38	37.06	29.72	40.97	42.40	20.54	33.97	39.06	33.78
Intermediate	25.54	37.02	38.45	31.14	38.60	41.05	21.07	33.46	35.08	33.49
No irrigation	26.52	36.43	37.23	5.40	5.30	5.71	22.10	27.69	29.46	21.76
Mean	24.99	36.94	37.58	22.09	28.29	29.72	21.24	31.71	34.53	29.68

[1] 1 irrigation applied to the plots with the nonirrigation treatment in experiments Nos. 1 and 2 to establish the crop.

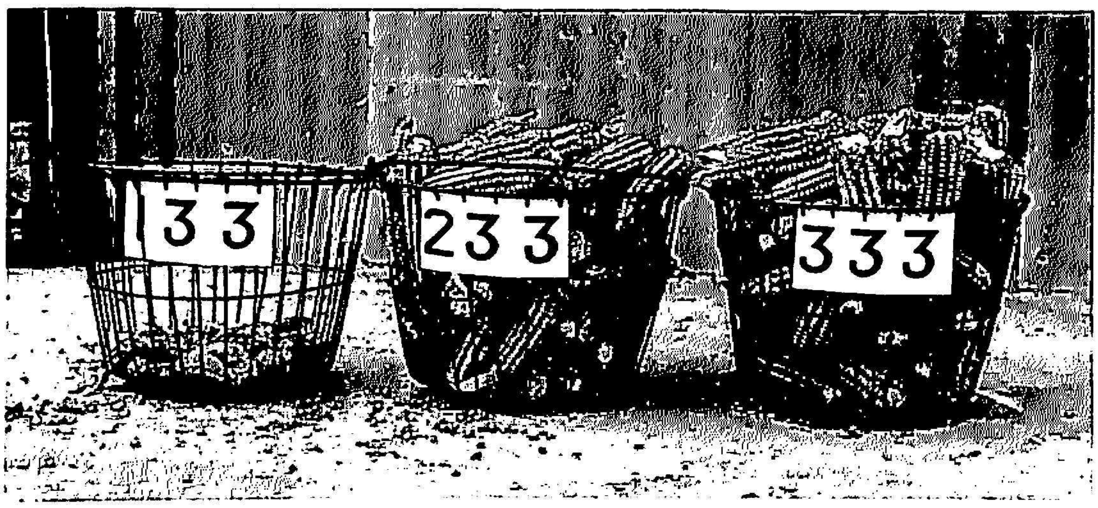

FIG. 1.—Response of corn to irrigation when grown at a rate of 19,400 plants per acre and fertilized at a rate of 160 pounds of nitrogen per acre in experiment No. 2: 133, nonirrigated; 233, intermediate irrigation; 333, frequent irrigation.

was of 11.25 hundredweights per acre. It can be also observed in table 11 that the production in the plots receiving no nitrogen was larger when they were not irrigated, except in experiment No. 2 in which the nonirrigated plots did not receive enough rainfall for normal crop growth.

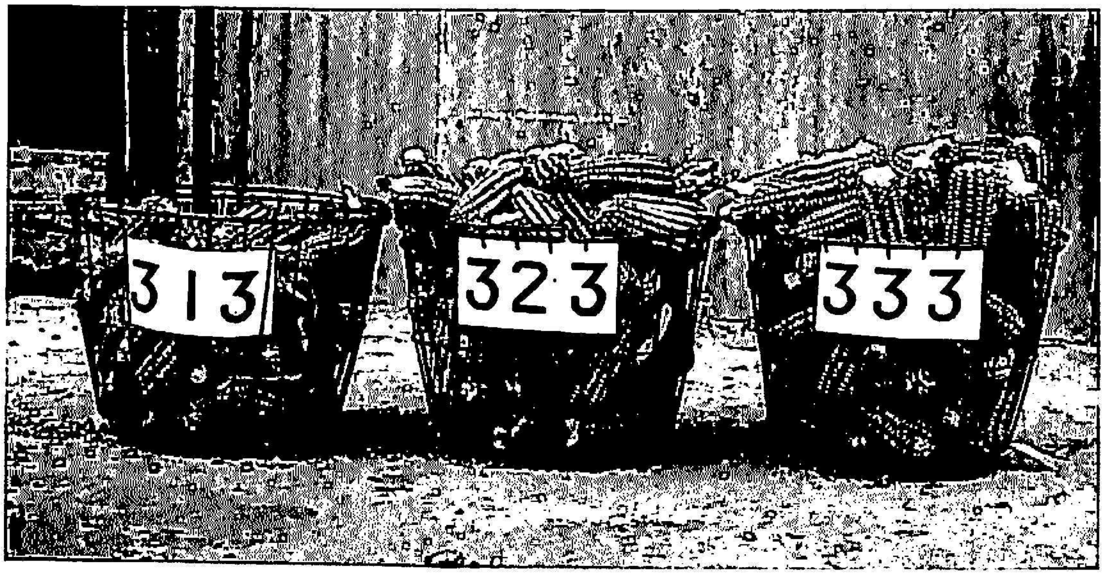

FIG. 2.—Response of corn to nitrogen when grown at a rate of 19,400 plants per acre under frequent irrigation in experiment No. 2: 313, no nitrogen applied; 323, 80 pounds of nitrogen applied per acre; 333, 160 pounds of nitrogen applied per acre.

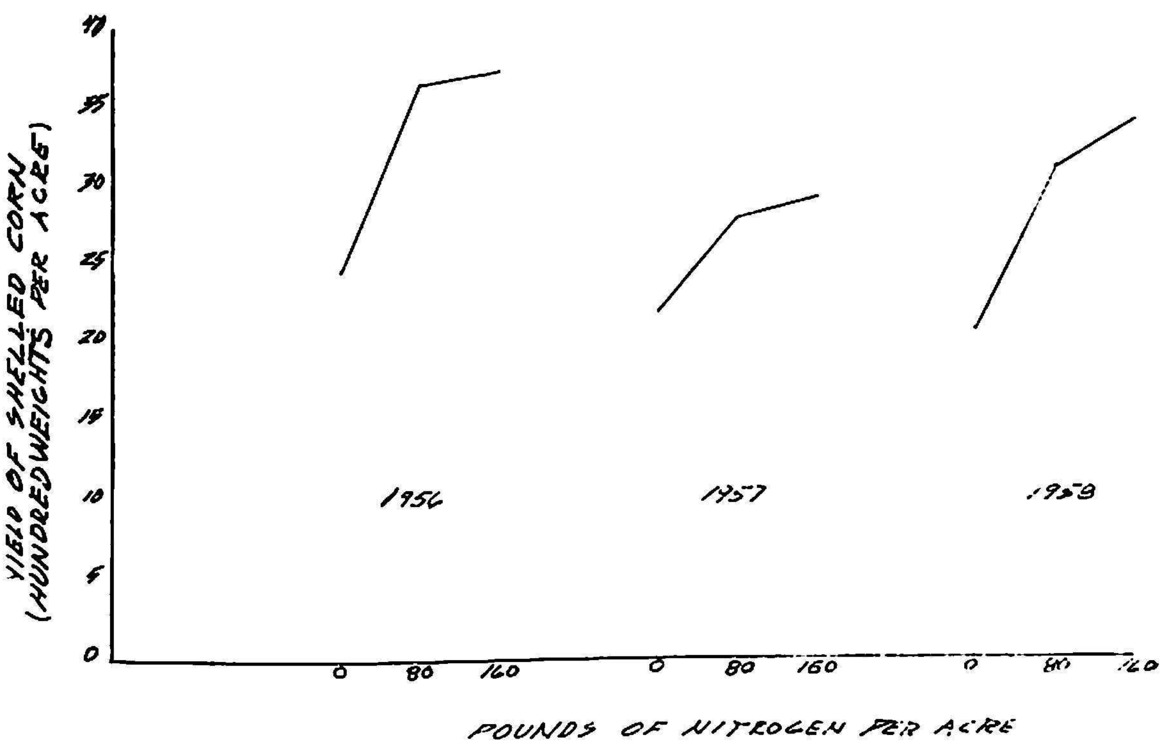

FIG. 3.—Effects of 3 different levels of nitrogen on yields of corn grown under irrigation and nonirrigated in Santa Isabel clay at Lajas, P. R., 1956–58.

EFFECT OF PLANT POPULATION

In the first two experiments conducted there was a highly significant effect of plant population on yields at all irrigation levels, except in the nonirrigated plots in experiment No. 2 (table 12). As shown in table 12, in experiment No. 2 there was an average increase in production of 5.86 and 12.07 hundredweights per acre with an increase in population from

TABLE 12.—*Effect of irrigation and plant population on the yield per acre (hundredweights) of 15-percent-moisture shelled corn grown during 3 experiments in Santa Isabel clay at Lajas, P. R., 1956–58*

Irrigation treatment[1]	Effects of indicated number of plants per acre in experiment—									Mean
	No. 1			No. 2			No. 3			
	9,600	14,500	19,400	9,600	14,500	19,400	14,500	19,400	24,900	
Frequent	28.05	31.59	37.71	32.92	37.48	42.67	30.09	30.52	32.96	33.78
Intermediate	26.76	34.39	37.86	30.77	39.20	40.82	28.75	32.20	30.70	33.49
No irrigation	26.10	32.51	41.56	6.91	5.30	4.20	26.48	26.54	26.23	21.76
Mean	26.97	32.83	39.04	23.53	27.33	29.23	28.44	29.75	29.96	29.68

[1] 1 irrigation applied to the plots with the nonirrigation treatment in experiments Nos. 1 and 2 to establish the crop.

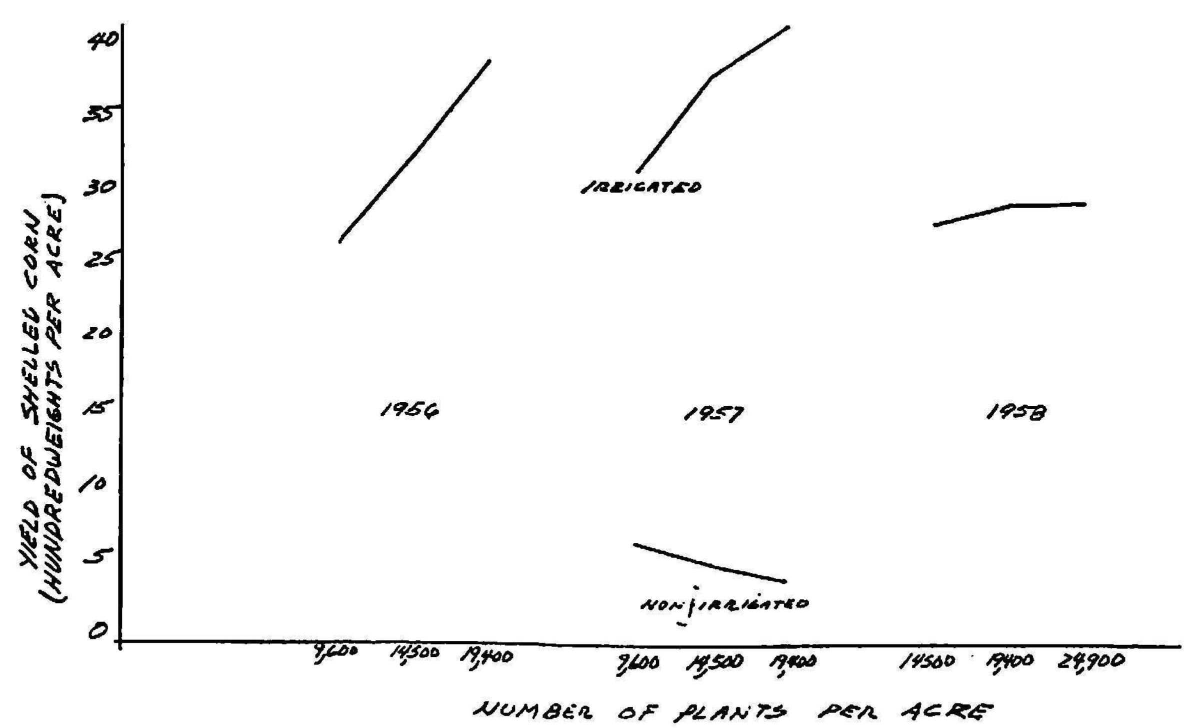

FIG. 4.—Effects of 3 different levels of plant population per acre on yields of corn grown under irrigation and nonirrigated in Santa Isabel clay at Lajas, P. R., 1956–58.

9,600 to 14,500 and from 9,600 to 19,400 plants per acre, respectively. In experiment No. 2, in the irrigated plots, the corresponding average increase in production with an increase in population from 9,600 to 14,500 plants per acre was 6.40 hundredweights per acre, and with an increase from 9,600 to 19,400 plants, was 9.80 hundredweights per acre. On the other hand, in the nonirrigated plots there was a decrease in production of 1.61 and 2.71 hundredweights per acre with an increase in population from 9,600 to 14,500 and from 9,600 to 19,400 plants per acre, respectively. As shown in figure 4, there was a linear increase in yield with an increase in plant population in the irrigated plots of experiments Nos. 1 and 2; however, in the nonirrigated plots of experiment No. 2 there was a linear decrease in yield with an increase in plant population. In experiment No. 3 there was no significant effect of plant population treatments on production (table 12).

DISCUSSION

Irrigation, nitrogen application, and increases in plant population definitely influenced corn yields. However, irrigation did not, whenever there were 20 inches of well-distributed rainfall throughout the growing season. The data obtained show that when rainfall distribution is normal (table 3), there is enough rainfall from July to November for normal growth of corn. Probably an initial heavy irrigation would be necessary at planting time. Supplemental irrigation should be applied from March to June.

Because there was no significant difference in corn yields between the frequently and the intermediately irrigated plots in experiment No. 2, or between the frequently and the intermediately irrigated, and the nonirrigated plots in experiment No. 3, the consumptive-use data from the intermediately irrigated plots of experiment No. 2, and the nonirrigated plots in No. 3 were selected as representing the normal consumptive water use of growing corn.

The growth stage of the corn plant is one of the main factors that affects the consumptive use of water. The maximum consumptive use was during the tasseling to hard-dough stage, decreasing in the last month of the growing season. In table 10 a higher consumptive use can be observed during 0- to 30-day period after planting in experiment No. 3 than in experiment No. 2. This was attributable to frequent rainfall and the impossibility of weeding during that period in experiment No. 3. Other factors like climate affect the consumptive use of water. The data need further analysis to correlate the consumptive-use data with climatic factors. Fuhriman (*3*) found that the consumptive use of water by sugarcane varied according to the growth stage of the plant and the soil-moisture levels; however, he pointed out that some climatic factors like wind movement, seasonal temperature, and hours of sunshine should be taken into consideration.

The nitrogen effect on yield follows the law of diminishing returns, *i.e.*, there was a high increase in production with the application of the first 80 pounds of nitrogen per acre, while, the difference in production when 80 and 160 pounds of nitrogen were applied per acre was not statistically significant. There was a highly significant interaction between nitrogen and irrigation. The data show that yields were increased with the same irrigation treatment when nitrogen was applied. In other words, irrigation alone does not increase yields.

A linear increase in yield was observed with an increase in plant population in experiments Nos. 1 and 2. Late weeding and fertilizing in experiment No. 3 apparently affected the plant-population effects. In experiments Nos. 1 and 2 there was a highly significant interaction between irrigation and plant population; and between plant population and nitrogen. The interaction between irrigation, plant population, and nitrogen was not statistically significant. Further work is still needed, especially on plant population and different moisture levels throughout the available moisture range.

SUMMARY

Three field experiments using three irrigation, three nitrogen, and three plant-population levels were conducted at Lajas Substation in order to determine the effect of irrigation in combination with nitrogen fertilizer and different plant populations on the production of field corn. "Frequently irrigated" plots were irrigated when 20 percent of the available moisture had been depleted from the active root zone, "intermediately irrigated" plots when the depletion was 60 percent, and "nonirrigated" plots were used as a check. The nitrogen levels tested were 0, 80, and 160 pounds per acre, and the plant-population levels were 9,600, 14,500, and 19,400 plants per acre. The data indicate that:

1. Irrigation does not influence corn yields whenever there are 20 inches of well-distributed rainfall throughout the growing season.
2. There was no significant difference in production between the frequently and the intermediately irrigated plots.
3. The average total consumptive use of water by field corn in 125 days was 18.48 inches.
4. The growth stage of the corn plant is one of the main factors that affects the consumptive use of water. During the first 30 days after planting, the corn plant consumed an average of 0.144 inches per day, increasing to an average of 0.208 inches per day during the tasseling to hard-dough stage (56 to 84 days after planting), and decreasing to an average of 0.114 inch daily in the last 41 days of the growing season.
5. There was a highly significant increase in corn yields with the application of 80 pounds of nitrogen per acre at all irrigation levels. However,

the difference in production between the plots receiving 80 and 160 pounds of nitrogen per acre was not statistically significant.

6. There was a highly significant interaction between nitrogen and irrigation.

7. There was a highly significant increase in yield with an increase in plant population from 9,600 to 19,400 plants per acre in the irrigated plots of experiments Nos. 1 and 2; however, in the nonirrigated plots of experiment No. 2, there was a decrease with an increase in plant population.

8. There was highly significant interaction between irrigation and plant population; and between plant population and nitrogen.

RESUMEN

Tres experimentos de campo para estudiar el efecto de tres niveles de riego en combinación con tres niveles de nitrógeno y población de plantas en la producción de maíz fueron llevados a cabo en la Subestación de Lajas. Los resultados fueron los siguientes: Se usaron los siguientes niveles de riego: Frecuente, cuando el 20 por ciento del agua asimilable fuera usada; intermedio, cuando el 60 por ciento del agua asimilable fuera usada; y testigo parcelas sin riego. Se estudiaron tres niveles de nitrógeno, a saber: 0, 80 y 160 libras por acre. Las poblaciónes estudiadas füeron 9,600, 14,500 y 19,400 plantas por acre.

1. La aplicación de riego no influyó sobre la producción de maíz cuando la lluvia llegó a 20 pulgadas bien distribuídas durante el período de crecimiento.

2. No hubo diferencia significativa entre la producción de las parcelas regadas frecuentemente y las regadas con menos frecuencia.

3. El promedio de consumo de agua total del maíz en un período de 125 días fué 18.48 pulgadas.

4. La etapa de crecimiento de la planta del maíz es uno de los factores más importantes que afecta el consumo de agua. Durante los primeros 30 días de crecimiento la planta de maíz consumió un promedio de 0.144 pulgadas por día, aumentando a un promedio de .208 pulgadas diarias durante el período de espigamiento hasta que el grano estuvo formado y duro (de los 56 a 84 días de sembrados), disminuyendo a un promedio de 0.114 pulgados diarias en los últimos 41 días del período de crecimiento.

5. Hubo un aumento altamente significativo en la producción de maíz con la aplicación de 80 libras de nitrógeno por acre en todos los niveles de riego; sin embargo, la diferencia en producción entre las parcelas que recibièron nitrógeno a razón de 80 y 160 libras por acre no fué estadísticamente significativa.

6. Hubo una interacción altamente significativa entre nitrógeno y riego.

7. Hubo un aumento en producción altamente significativo con un au-

mento en la población de plantas de 9,400 a 19,400 plantas por acre en las parcelas bajo riego en los experimentos números 1 y 2; sin embargo, en las parcelas sin riego del experimento número 2 hubo una disminución en la producción y un aumento en la población de plantas.

8. Hubo una interacción altamente significativa entre el riego y la población de plantas; y entre la población de plantas y el nitrógeno.

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