AN ABSTRACT OF THE THESIS OF

Jimmie Lee Andersen for the M. S. degree in Soils

Date thesis is presented June 3, 1963

Title RESPONSE OF FIELD CORN TO IRRIGATION, PLANT POPULATION, AND NITROGEN ON SOILS OF THE WILLAMETTE CATENA.

Abstract approved Redacted for Privacy

The purpose of this study was to make a preliminary investigation of the productivity of some of the soils within the Willamette catena under different systems of soil management. The study was carried out at four experimental sites near Corvallis, Oregon, during the 1962 growing season. The soil at each site was representative of a different soil series. The soil series were Willamette, Woodburn, Amity, and Dayton which are well-drained, moderately well drained, imperfectly drained, and poorly drained, respectively.

Productivity was measured in terms of shelled corn yield. The eight treatments (systems of soil managements) were different combinations of irrigation, plant population, and nitrogen fertilization practices. The irrigation treatments were irrigated and non-irrigated. The levels of plant population were 9000, 14000, 18000, and 22000

plants per acre. The rates of nitrogen fertilization were 60 and 180 pounds of N per acre.

A second objective of this study was to measure the response of field corn to each of the three soil management practices. Data pertaining to the effects of the three practices on shelling percentage and ear moisture at harvest, as well as grain yield, were collected.

There were significant yield responses to irrigation when accompanied by higher levels of plant population at all sites. Generally, yield responses to higher levels of plant population and the higher rate of nitrogen fertilization were measured on the irrigated plots, but not on the non-irrigated plots.

The shelling percentage on the irrigated plots was higher than that on the non-irrigated plots only at the Amity and Dayton sites. Apparently, plant population and nitrogen had no effect on shelling percentage. The amount of moisture in the ears at harvest was apparently not affected by irrigation, plant population, and nitrogen fertilization practices.

In general, the productivities of the soils at the Willamette, Woodburn, and Amity sites were similar and significantly greater than at the Dayton site under all systems of soil management.

# RESPONSE OF FIELD CORN TO IRRIGATION, PLANT POPULATION, AND NITROGEN ON SOILS OF THE WILLAMETTE CATENA

by

JIMMIE LEE ANDERSEN

A THESIS

submitted to

OREGON STATE UNIVERSITY

in partial fulfillment of
the requirements for the
degree of

MASTER OF SCIENCE

August 1963

APPROVED:

Redacted for Privacy

Associate Professor of Soils

In Charge of Major

Redacted for Privacy

Head of Department of Soils

Redacted for Privacy

Dean of Graduate School

Date thesis is presented June 3, 1963

Typed by Norma Hansen

ACKNOWLEDGMENT

I want to take this opportunity to thank the many people who have contributed to the completion of this thesis.

First, I want to thank Art King and Marvin Shearer for introducing me to some of Oregon's soil and water problems and for continued suggestions and help. In addition, Drs. H. B. Cheney, T. L. Jackson, and D. D. Evans of the Department of Soils gave valuable suggestions and criticism whenever needed. Special thanks go to Drs. G. H. Simonson and L. A. Alban for essential help in obtaining profile descriptions and chemical laboratory data. Also, Dr. Donald Jensen of the Department of Statistics, was helpful with the experimental design and statistical analysis.

J. R. "Rich" Guerber and Wheeler Calhoun were very cooperative in their aid with the field operations. The ready help of A. P. "Tony" Crudele, regardless of the time of day, is especially appreciated.

Drs. L. Boersma of Soils, R. E. Fore of Farm Crops, and E. N. Castle of Agricultural Economics, each gave guidance and help at instances too numerous to list, in addition to serving as my graduate committee.

Of course, I am indeed grateful for the generous efforts of my major professor, Dr. Murray Dawson. I want to especially thank him for giving me the freedom to discover for myself the pitfalls and satisfactions of agricultural research.

Finally, I want to thank my wife, Janice, for the extra effort she put forth in typing the first rough draft of this thesis. Far more valuable, however, was her faith and encouragement throughout this period of graduate training.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (Cont'd.)

## LIST OF FIGURES

# RESPONSE OF FIELD CORN TO IRRIGATION, PLANT POPULATION, AND NITROGEN ON SOILS OF THE WILLAMETTE CATENA

## I. INTRODUCTION AND PURPOSE

In Western Oregon there are approximately 195,000 acres under irrigation. One hundred and sixty thousand of these irrigated acres are in the Willamette Valley. Several times as large an acreage could be feasibly irrigated. The development of proposed community projects, such as the Tualatin Valley Project, the Monmouth-Dallas Project, and the Beaver Creek Watershed, will increase the number of irrigated acres (9, p. 6). A substantial portion of the land in new projects, if developed, will undoubtedly include soils of the Willamette catena.

Much remains to be learned concerning the productivity of these soils for the various forage, fruit and vegetable, and feed grain crops grown in the Willamette Valley. Of particular interest is the potential productivity of the more poorly drained soils when irrigated. Therefore, the purpose of this study was to make a preliminary investigation of the productivity of some of the soils within the Willamette catena.

Field corn was the crop selected for this study. Corn is a full season crop and is sensitive to soil management practices. Also, corn production practices are refined and well known. Various levels of irrigation, plant population, and nitrogen fertilization were used in this study. Previous research, which is discussed in Chapter II, indicated that these three factors are particularly important in corn production. Thus, a secondary objective was to study the response of field corn to different combinations of irrigation, plant population, and nitrogen fertilization when grown on different soils.

# II. LITERATURE REVIEW

## Soil Productivity for Field Corn

Most estimates of the productivity of specific soils have been made either by sampling farmer-operated fields (12, p. 50-76) (16, p. 282-292) or by analyzing farm records (17, p. 42-47) (18, p. 316-322) (25, p. 171-175) (28, p. 375-378). Simonson and Englehorn (27, p. 247-252) discussed various methods of estimating the productivity of a soil. They commented that plot experiments, although expensive and sometimes not comparable to farm conditions, are one of the principal methods of determining soil productivity.

Several instances of the use of field plots for the estimation of soil productivity are reported in the literature. Bauer *et al*. (4, p. 105-224) summarized the results of long-term productivity studies of various cropping and soil management systems at 25 sites distributed throughout Illinois. Waggoner and McMillan (33, p. 7) reported a productivity study with field corn on six upland soils, two terrace soils, and three bottomland soils in east-central Mississippi. Nelson and McCracken (14, p. 497-502) studied the influence of soil properties on corn yields at 15 sites located on the Norfolk and Portsmouth soil series in North Carolina. Russ and Bell (24, p. 164-167) carried out an experiment with field corn and various levels of nitrogen and plant population to estimate the productivity of four Tennessee soils.

## Effects of Irrigation, Plant Population, and Nitrogen Fertilization

The literature pertaining to the effects of moisture, plant population, and nitrogen fertilization on corn production is voluminous and has been reviewed by Nelson (15, p. 355-368). However, relatively few studies have been made in which all three of the soil management practices were studied simultaneously.

Some early work was done by Carreker and Liddell (7, p. 301-302, 304) in Georgia with supplemental irrigation and plant populations of 6223, 8279, and 12,445 plants per acre with 20, 60, 100, and 120 pounds of N per acre. They concluded that irrigation increased yields in some years and not in others. In addition, yields were significantly higher with the high plant population and 120 pounds of N per acre. Later in Georgia, Boswell *et al*. (5, p. 1-51) studied supplemental irrigation with three plant populations and three nitrogen rates at three locations with two hybrids for a three-year period. This study indicated that response to irrigation was dependent on natural rainfall. Generally, significant yield increases were obtained by increasing the plant population to 20,000 plants per acre. The response to nitrogen was dependent on the soil at the experimental site. Shelling percentage was not affected by any of the three practices.

The results of several studies in the Great Plains have also been reported. In 1954, Rhoades et al. (21, p. 1-26) summarized the results of several studies. They recommended that farmers in the Republican Valley of Nebraska should use relatively high plant populations and maintain high nitrogen levels for irrigated corn. In North Dakota, Carlson et al. (6, p. 242-245) studied the effects of irrigation, plant population, and nitrogen fertilization on corn yield and evapotranspiration. Without irrigation, nitrogen and plant population had no significant effect on corn yields. With irrigation significant yield responses to both increased nitrogen rates and higher plant population levels were measured. They concluded that maximum yields were realized only with irrigation and high levels of plant population (approximately 20,000 plants per acre) and a 120-pound-per-acre rate of nitrogen fertilizer. They also concluded that high levels of plant population and nitrogen fertilization are necessary for efficient use of soil moisture.

A three-year study in Mississippi with supplemental irrigation and three rates of nitrogen, 120, 180, and 240 pounds of N per acre, on 8,000 and 12,000 plants per acre has been reported by Arnold (3, p. 2). Yield response to irrigation varied from year to year. Again, the higher plant population, 12,000 plants per acre, and at least 180 pounds of nitrogen per acre were necessary for maximum yields.

# III. EXPERIMENTAL METHODS AND MATERIALS

## Experimental Sites and Soils

The experiment was carried out on four sites. Each site represented a different soil series. The series were Willamette, Woodburn, Amity, and Dayton which are members of the Willamette catena. The Woodburn site was located on the Hyslop Agronomy Experimental Farm which is six and one-half miles northeast of Corvallis, Oregon. The Willamette, Amity, and Dayton sites were located on the J. R. Guerber Farm which is approximately eight miles south of Corvallis, Oregon.

The soils of the Willamette catena have been described in detail by Pomerening (19, p. 13-32). Only the prominent features of each soil series will be described herein. The soils making up the Willamette catena are developed in fine alluvial-lacustrine sediments of Pleistocene age. The sediments form a broad, nearly level terrace plain across the Willamette Valley in northwestern Oregon. The soils extend over approximately 800,000 acres (20, p. 24). Most of the area is used for production of grain, seed, and horticultural crops.

The well-drained soils with no mottling above 36 inches make up the Willamette series. The moderately well drained soils with mottling between 24 and 36 inches and with a fragipan below the $B_2$ horizon make up the Woodburn series. The imperfectly drained soils with mottling between 12 and 24 inches and commonly with fragipans below the $B_2$ horizon make up the Amity series. The poorly drained soils showing mottling within the top 12 inches and with a claypan in the upper part of the B horizon make up the Dayton series. The Willamette, Woodburn, and Amity series are classified as intergrades between the Brunizem and Gray-Brown Podzolic great soil groups. The Dayton series is classified within the Planosol great soil group. Profile descriptions (30, p. 123-244) of the soils at each site are presented in Appendix I. Also included in Appendix I are laboratory data of physical (8, p. 15-24) (22, p. 105-110) (23, p. 451-454) and chemical (1, p. 1-8) properties, a legal description of the location, and soil test results for a composite sample of each experimental site. Climatic data (32, p. 1-191) for the 1962 growing season is presented in Appendix III.

Table 1. Description of levels of management.

| Level | Irrigation and Plant Population | | |
|---|---|---|---|
| one | non-irrigated | ; | 9,000 plants/acre |
| two | non-irrigated | ; | 14,000 plants/acre |
| three | irrigated | ; | 18,000 plants/acre |
| four | irrigated | ; | 22,000 plants/acre |

## Experimental Design

The experimental design and treatments were identical at each site. The experimental design was a two-by-four factorial in randomized blocks with three replications. The two-by-four factorial consisted of two rates of nitrogen fertilization and four levels of management. The four levels of management are defined as combinations of irrigation and plant population as designated in Table 1. The factorial arrangement and treatments are presented in Table 2.

There were 24 plots at each of the four sites. The individual plots consisted of eight rows 24 feet long with 36 inches between the rows. Thus each plot was a square 24 feet by 24 feet as shown in Figure 1. Each block or replication contained eight plots in a rectangle 48 feet

Table 2. Treatments and factorial arrangement.

| Rates of Nitrogen Fertilization | Levels of Management I | II | III | IV |
|---|---|---|---|---|
| I | 1*-$I_oPP_1N_1$ | 3-$I_oPP_2N_1$ | 5-$I_1PP_3N_1$ | 7- $I_1PP_4N_1$ |
| II | 2 -$I_oPP_1N_2$ | 4-$I_oPP_2N_2$ | 6-$I_1PP_3N_2$ | 8- $I_1PP_4N_2$ |

* Treatment numbers.

| | | |
|---|---|---|
| $I_o$-Non-irrigated | $PP_1$- 9,000 plants/a. | $N_1$- 60 lbs. of N/a. |
| $I_1$-Irrigated | $PP_2$-14,000 plants/a. | $N_2$-180 lbs. of N/a. |
| | $PP_3$-18,000 plants/a. | |
| | $PP_4$-22,000 plants/a. | |

wide and 96 feet long. The three blocks were arranged in a rectangle 96 feet wide and 144 feet long on the Willamette, Woodburn, and Amity sites. At the Dayton site a different arrangement was necessary to insure that all treatments were located on a typical Dayton soil. Therefore, the blocks were arranged in a rectangle 48 feet wide and 288 feet long.

Each plot within a block was consecutively numbered. Digits from one to eight were selected from a random number table (10, p. 507-516) and assigned to the consecutively numbered plots. The procedure was repeated for each of the 12 blocks. The treatment numbers shown in Table 2 were assigned to each block according to the random numbers.

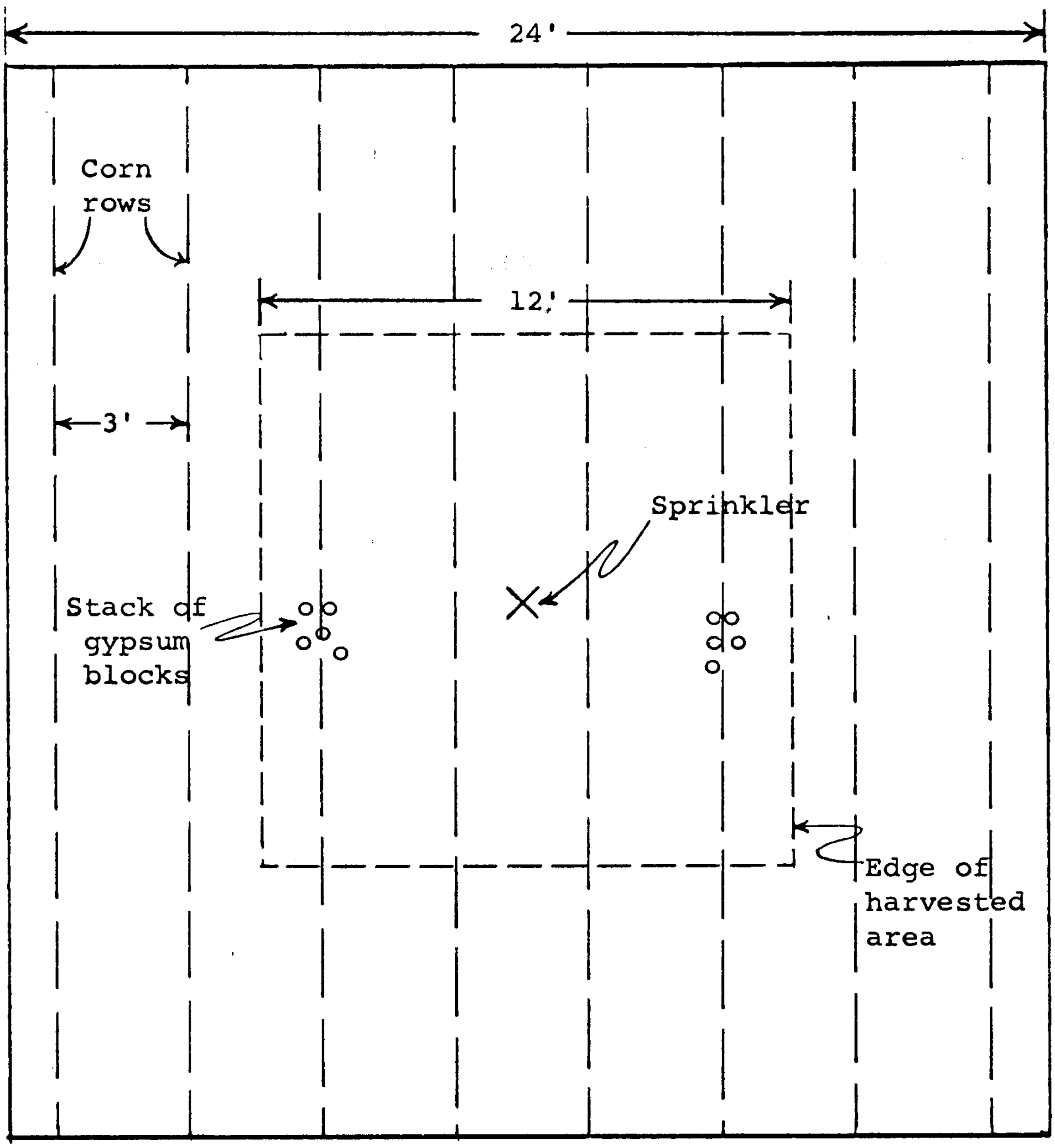



Figure 1. Diagram of an individual plot showing location of corn rows, stacks of gypsum blocks, sprinkler, and harvested area.

Field Methods

The scope of this study excluded fertility treatments other than nitrogen. In order to measure the effect of nitrogen it is desirable that other nutrients should not be limiting. Therefore, blanket applications of potassium, phosphorus, and sulphur were made. The rates of application were based on chemical analyses of a composite soil sample from each experimental site. The data are presented in Appendix I.

The potassium was broadcast in the form of granular muriate of potash (0-0-60) before final seedbed preparation. It was applied at the rate of approximately 83 pounds of K or 100 pounds of $K_2O$ per acre on the Willamette, Woodburn, and Amity sites. At the Dayton site the rate was approximately 166 pounds of K or 200 pounds of $K_2O$ per acre.

The corn was planted May 15, 1962, with a mechanical tractor-mounted corn planter with a dry fertilizer attachment. The double cross hybrid variety used was Oregon 355.

Phosphorus and sulphur were applied at planting in bands eight inches from the row and four inches deep. The ammonium phosphate material (16-20-0) was applied at a rate that supplied approximately 33 pounds of P or 75 pounds of $P_2O_5$ and 53 pounds of S per acre.

A pre-emergence herbicide, atrazine, was applied at the rate of approximately three pounds per acre about ten days after planting. The wettable powder was sprayed on the surface of the soil with a conventional field sprayer.

The lower nitrogen treatment was accomplished by banding approximately 60 pounds of N per acre at planting time on all plots. The material was the same ammonium phosphate previously mentioned. One week after planting the 180-pound-per-acre nitrogen treatment was accomplished by side-dressing granular ammonium nitrate (33.5-0-0). A rate supplying an additional 120 pounds of N per acre was applied to the appropriate plots. The fertilizer was placed twelve inches from the row and four inches deep with equipment particularly designed for plot operations.

The corn emerged between ten days and two weeks after planting. Five weeks after emergence the plant population treatments were imposed by thinning the stand to the desired level on the appropriate plots. Excess plants were pulled by hand. Care was taken to insure the proper number of plants within the proposed harvest area (Figure 1). It should be stated here that on some plots the desired plant population treatments were not completely achieved.

Scheduling of irrigations was based on measurements of soil moisture. The plots were irrigated when the average moisture tension in the top foot of soil apprcached two atmospheres, or about once a week from June 27, 1962, to September 12, 1962. The measurements were taken with stacks of concentric electrical gypsum blocks. A stack consisted of five gypsum blocks installed at depths of six, twelve, eighteen, twenty-four, and thirty inches. There were two stacks in each plot of treatments four, five, six, seven, and eight (Table 2). The stacks were located as shown in Figure 1. Procedures for installation of gypsum blocks are described by Shearer (26, p. 6-8).

The resistance of the blocks was measured, as shown in Figure 2, twice weekly from June 21 to October 2, 1962. The resistance measurements were converted to moisture tension measurements. A soil moisture tension curve was used to convert moisture tension measurements to the percent moisture by weight. The percent moisture by volume was obtained by multiplying the percent moisture by weight and the bulk density of the soils. The percent moisture by volume was used to make comparative statements of soil moisture in terms of inches of water.

The moisture tension measurements were processed by

Figure 2. Technicians measuring and recording the resistance of a stack of electrical gypsum blocks.

Figure 3. A sprinkler in operation at the Woodburn site.

the Oregon State University Statistics Computing Laboratory. The data were processed with an IBM 1620 Computer. The computer program contained the equations of the moisture tension curves together with the average bulk densities for five depths at the four sites. The results were listed as inches of water present in each six-inch layer of soil from three inches to thirty-three inches. The inches of water measured in the profile were subtracted from the inches of water present at field capacity. This amount, plus an allowance for losses during application and for moisture removed after the measurements, was applied at the next irrigation.

Irrigation water was applied with one small sprinkler located in the center of each irrigated plot as shown in Figure 1. The sprinkler was a reaction driven type with a single nozzle. A photograph of one of the sprinklers in operation is shown in Figure 3. The sprinkler was selected because a small amount of water could be uniformly applied over a small area. The average coefficient of uniformity of three trials calculated for a square area 10 feet by 10 feet with one sprinkler in the center was 91.2. The coefficient of uniformity was calculated from the following formula:

Coefficient of Uniformity = 100 $(1- \frac{\Sigma X}{MN})$ where

N = number of observations

M = mean of the N observations

X = absolute value of the deviation of each observation from M.

The sprinklers applied approximately 0.75 gallons per minute when operated at a pressure of 25 pounds per square inch. The sprinklers had a moderate to fast rotation.

The amount of water applied varied among treatments and soils. The total application for the season ranged from 23.5 to 32.6 inches. However, a substantial amount, perhaps one inch in three, was lost by evaporation at the time of application.

## Data Collection Methods

Several days before harvest the plots were trimmed to set apart the area to be harvested. The harvested area consisted of 48 feet of row in a square 12 feet by 12 feet as shown in Figure 1. All ears containing filled kernels were picked by hand and placed in a burlap bag. Harvesting was started October 18, 1962, and finished two days later.

The bags of ear corn were weighed to the nearest one-half pound and placed in the heated-air crop dryer at the Hyslop Agronomy Experimental Farm. After approximately 40 hours of drying the bags were removed and reweighed. The bags were stored at room temperature for several weeks.

The corn was shelled during the last week of November, 1962. The contents of each bag were weighed to the nearest five grams and shelled with a hand sheller powered by an electric motor. The clean grain from each plot was weighed to the nearest five grams.

Plans were made to measure the moisture content of the grain with an electric moisture meter. Unfortunately, the corn was too dry for precise measurement with the meter. Consequently, samples of grain were taken for a gravimetric determination of moisture content. Unfortunately, only 12 samples from treatments five, six, seven, and eight of the Woodburn site were handled according to the standard gravimetric procedure (34, p. 445). The small variation that existed among the 12 observations was not influenced by different treatments. Therefore, the mean moisture content, 9.06 percent on a fresh weight basis, was used for all further calculations.

The grain yield data consisted of the weights of shelled corn in grams per plot. For the 14 plots where the desired plant population treatments were not completely achieved, the yield data was adjusted. The adjustment was made by solving the following equation:

$$\frac{\text{measured yield}}{\text{number of plants grown}} = \frac{\text{adjusted yield}}{\text{desired number of plants}}$$

This assumed that the relationship between yield and plant population was proportional over the range of adjustment.

The shelling percentage data were calculated by dividing the weight of the shelled corn by the weight of the ear corn and multiplying the quotient by 100.

The percent moisture of the ears at harvest was calculated by dividing the weight of the water in the ears by their fresh harvest weight and multiplying the quotient by 100. The weight of water in the ears was equal to the weight lost during drying, plus the nine percent moisture remaining after drying. Hence, the weight of the water in the ears was obtained by subtracting 91 percent of the weight recorded when the bags were taken out of the crop dryer, from the weight recorded when the bags were placed in the dryer.

# IV. RESULTS

The response of field corn to different combinations of soil management practices was measured in terms of yield of shelled corn, shelling percentage, and ear moisture at harvest. First, the data was analyzed with the analysis of variance as described by Li (10, p. 205-208, 316-325). Hypotheses concerning the effects of levels of management and nitrogen and the presence of interaction between levels of management and nitrogen were tested with the fixed model of the analysis of variance. When an analysis of variance indicated that there was a significant response(s) to a soil management practice the multiple range test (10, p. 238-241) was used to identify significant differences. The five percent significance level was used in all testing.

## Yield of Shelled Corn

The mean yields of each treatment at each site are presented in Table 3. The means are reported in grams per plot at 9.06 percent moisture on a fresh weight basis. The treatment means were converted to both bushels and tons per acre at 15.5 percent moisture and are presented in Tables 4 and 5, respectively.

Table 3. Mean yields of shelled corn for each treatment at each site in grams per plot at 9.06% moisture.

| Treatment Numbers | Sites Willamette | Woodburn | Amity | Dayton |
|---|---|---|---|---|
| 1 | 4,607 | 3,888 | 3,550 | 1,000 |
| 2 | 3,880 | 4,057 | 3,558 | 1,090 |
| 3 | 4,102 | 3,708 | 2,780 | 912 |
| 4 | 4,937 | 4,633 | 4,025 | 788 |
| 5 | 10,027 | 9,532 | 8,648 | 8,281 |
| 6 | 10,388 | 11,348 | 10,583 | 9,080 |
| 7 | 10,670 | 11,243 | 10,134 | 8,215 |
| 8 | 12,129 | 12,790 | 11,536 | 9,817 |

Table 4. Mean yields of shelled corn for each treatment at each site in bushels per acre at 15.5% moisture.

| Treatment Numbers | Sites Willamette | Woodburn | Amity | Dayton |
|---|---|---|---|---|
| 1 | 59.00* | 49.79 | 45.46 | 12.80 |
| 2 | 49.68 | 51.96 | 45.57 | 13.96 |
| 3 | 52.54 | 47.48 | 35.59 | 11.68 |
| 4 | 63.23 | 59.32 | 51.55 | 10.11 |
| 5 | 128.41 | 122.07 | 110.75 | 106.04 |
| 6 | 133.02 | 145.32 | 135.54 | 116.29 |
| 7 | 136.64 | 143.98 | 129.77 | 105.20 |
| 8 | 155.30 | 163.79 | 147.71 | 125.71 |

$$* \text{ Bushels/acre} = \frac{(\text{grams/plot})\ (1.0762)\ (302.5 \text{ plots/acre})}{(454 \text{ grams/pound})\ (56 \text{ pounds/bushel})}$$

$$1.0762 = \frac{(1.0000 - .0906)}{(1.0000 - .1550)} = \text{moisture factor}$$

Table 5. Mean yields of shelled corn for each treatment at each site in tons per acre at 15.5% moisture.

| Treatment Numbers | Sites Willamette | Woodburn | Amity | Dayton |
|---|---|---|---|---|
| 1 | 1.652* | 1.394 | 1.273 | 0.358 |
| 2 | 1.391 | 1.455 | 1.276 | 0.391 |
| 3 | 1.471 | 1.330 | 0.996 | 0.327 |
| 4 | 1.770 | 1.661 | 1.444 | 0.283 |
| 5 | 3.596 | 3.418 | 3.101 | 2.969 |
| 6 | 3.724 | 4.069 | 3.795 | 3.256 |
| 7 | 3.826 | 4.032 | 3.634 | 2.946 |
| 8 | 4.348 | 4.586 | 4.136 | 3.520 |

$$* \text{ Tons/acre} = \frac{(\text{grams/plot})\ (1.7062)\ (302.5 \text{ plots/acre})}{(454 \text{ grams/pound})\ (2{,}000 \text{ pounds/ton})}$$

Statistical analysis: The analysis of variance of the Willamette site data indicated that levels of management and nitrogen affected yield. There was also significant interaction between management levels and nitrogen.

Analysis of the data from the Woodburn site also disclosed that management and nitrogen influenced yield. However, there was no significant interaction between management levels and nitrogen.

At the Amity site the yield data from one plot was missing. The missing data was replaced by a dummy value. It was calculated according to the method described by Li (10, p. 209-212). The usual analysis of variance procedure was followed with one exception. The error sum of squares had one less degree of freedom because there was one less actual observation. The results of the analysis indicated that both management and nitrogen had influenced yield and that there was interaction between them.

The analysis of variance performed on the Dayton site data revealed that yield was affected by management and by nitrogen, but there was no significant interaction between them.

The data from the four sites was pooled and analyzed with the analysis of variance. Such an analysis was valid because the variances of the individual sites were not significantly different from one another. The homogeneity of the four variances was tested with Bartlett's Test as described by Snedecor (29, p. 285-287).

The results of the pooled analysis indicated that there were differences among the mean yields of each site. In addition, the presence of significant interaction between sites and levels of management implied that at least some levels of management had different effects at some sites. However, there was neither a site by nitrogen interaction nor a site by management by nitrogen interaction.

The multiple range test was used to analyze the management level means at each site (Table 6), the treatment means at each site (Table 7), the treatment means for all sites combined (Table 8), and the general means of the four sites (Table 9).

Table 6. Results of testing for significant differences among the mean yields (grams/plot) of each management level with the multiple range test at each site.

Willamette Site

| | | | | |
|---|---|---|---|---|
| Management level | 1 | 2 | 3 | 4 |
| Mean yield [1] | 4,243 | 4,519 | 10,208 | 11,399 |

Woodburn Site

| | | | | |
|---|---|---|---|---|
| Management level | 1 | 2 | 3 | 4 |
| Mean yield | 3,973 | 4,171 | 10,440 | 12,017 |

Amity Site

| | | | | |
|---|---|---|---|---|
| Management level | 2 | 1 | 3 | 4 |
| Mean yield | 3,403 | 3,554 | 9,616 | 10,835 |

Dayton Site

| | | | | |
|---|---|---|---|---|
| Management level | 2 | 1 | 3 | 4 |
| Mean yield | 850 | 1,045 | 8,681 | 9,016 |

[1] The means underscored by the same line are not different at the 5% significance level.

Table 7. Results of testing for significant differences among the mean yields (grams/plot) of each treatment with the multiple range test at each site.

Willamette Site

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment number | 2 | 3 | 1 | 4 | 5 | 6 | 7 | 8 |
| Treatment mean | [1] 3,880 | 4,102 | 4,607 | 4,937 | 10,027 | 10,388 | 10,670 | 12,129 |

Woodburn Site

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment number | 3 | 1 | 2 | 4 | 5 | 7 | 6 | 8 |
| Treatment mean | 3,708 | 3,888 | 4,057 | 4,633 | 9,532 | 11,243 | 11,348 | 12,790 |

Amity Site

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment number | 3 | 1 | 2 | 4 | 5 | 7 | 6 | 8 |
| Treatment mean | 2,780 | 3,550 | 3,558 | 4,025 | 8,648 | 10,134 | 10,583 | 11,536 |

Dayton Site

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Treatment number | 4 | 3 | 1 | 2 | 7 | 5 | 6 | 8 |
| Treatment mean | 788 | 912 | 1,000 | 1,090 | 8,215 | 8,281 | 9,080 | 9,817 |

[1] The means underscored by the same line are not different at the 5% significance level.

Table 8. Results of testing for significant differences among the mean yields (grams/plot) of each treatment for all sites.

| Site and Treatment No. | D4[1] | D3 | D1 | D2 | A3 | A1 | A2 | Wn3 | Wt2 | Wn1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean[2] | 788 | 912 | 1,000 | 1,090 | 2,780 | 3,550 | 3,558 | 3,708 | 3,880 | 3,888 |

| Site and Treatment No. | D7 | D5 | A5 | D6 | Wn5 | D8 | Wt5 | A7 | Wt6 | A6 |
|---|---|---|---|---|---|---|---|---|---|---|
| Mean | 8,215 | 8,281 | 8,648 | 9,080 | 9,532 | 9,817 | 10,027 | 10,134 | 10,388 | 10,583 |

[1] D - Dayton
A - Amity
Wn - Woodburn
Wt - Willamette

[2] The means underscored by the same line are not different at the 5% significance level.

Table 8 (continued).

| A4 | Wn2 | Wt3 | Wt1 | Wn4 | Wt4 |
|---|---|---|---|---|---|
| 4,025 | 4,057 | 4,102 | 4,607 | 4,633 | 4,937 |

| Wt7 | Wn7 | Wn6 | A8 | Wt8 | Wn8 |
|---|---|---|---|---|---|
| 10,670 | 11,243 | 11,348 | 11,536 | 12,129 | 12,790 |

Table 9. Results of testing for significant differences among the mean yields of each site (grams/plot) with the multiple range test.

| Site | Dayton | Amity | Willamette | Woodburn |
|---|---|---|---|---|
| Mean | 4,898 [1] | 6,852 | 7,592 | 7,650 |

[1] Means underscored by the same line are not different at the 5% significance level.

Soil management systems: Throughout the following discussion of corn yields, each treatment is considered as a specific system of soil management. A system of soil management should not be confused with a level of management. A level of management is referred to in the experimental design as a combination of irrigation and plant population (Table 1). The eight systems of soil management and the component practices of each are defined in Table 10.

Table 10. Levels of the component practices of each soil management system.

| System | Levels of Component Practices | | |
|---|---|---|---|
| one | non-irrigated; | 9,000 plants/acre; | 60 lbs. N/acre |
| two | non-irrigated; | 9,000 plants/acre; | 180 lbs. N/acre |
| three | non-irrigated; | 14,000 plants/acre; | 60 lbs. N/acre |
| four | non-irrigated; | 14,000 plants/acre; | 180 lbs. N/acre |
| five | irrigated; | 18,000 plants/acre; | 60 lbs. N/acre |
| six | irrigated; | 18,000 plants/acre; | 180 lbs. N/acre |
| seven | irrigated; | 22,000 plants/acre; | 60 lbs. N/acre |
| eight | irrigated; | 22,000 plants/acre; | 180 lbs. N/acre |

It is evident in Table 7 that at the Willamette site soil management system eight produced the highest average yield at 12,129 grams per plot or 155 bushels per acre (Table 4). Systems five, six, and seven produced the next highest shelled corn yields. The yields ranged from 128 to 137 bushels per acre (Table 4) and were not significantly different from one another. Average yield under soil management system four at 63 bushels per acre was significantly lower than that on the irrigated plots. However, this 63-bushel-per-acre yield was still significantly greater than the 50-bushel yield of system two (Table 4). Yields produced with management systems one and three were intermediate between those of systems two and four.

At the Woodburn site (Table 7) soil management system eight produced the highest average yield of shelled corn at 164 bushels per acre (Table 4). The yields of systems six and seven were significantly lower at approximately 145 bushels per acre (Table 4). The 122-bushel yield produced under management system five was significantly lower than the yields of systems six and seven. Soil management systems one, two, three, and four produced significantly lower yields than were produced under irrigation at the Woodburn site (Table 7). These yields ranged from 47 to 59 bushels per acre (Table 4) and were not significantly different from one another.

At the Amity site the highest yield, 148 bushels per acre (Table 4), was produced under soil management system eight. Yields produced with systems six and seven were significantly lower (Table 7) at 136 and 130 bushels per acre, respectively. Soil management system five produced a significantly lower yield than systems six and seven at 111 bushels per acre (Table 4). The yield produced under system four, 52 bushels per acre, was significantly lower than that of the systems mentioned above. However, the 52-bushel-per-acre yield was significantly greater than the 36-bushel yield obtained under management system three (Tables 4 and 7). Systems one and two produced intermediate yields of 45.5 bushels per acre which were not significantly different from the yields of either system three or system four.

At the Dayton site soil management system eight produced a significantly greater yield of shelled corn, 126 bushels per acre (Table 4), than systems five and seven (Table 7). Yields under systems five and seven, 106 and 105 bushels per acre, respectively, were similar.

The yield produced with soil management system six, 116 bushels per acre (Table 4), was not significantly different from yields on the other irrigated plots (Table 7). The shelled corn production under soil management systems one, two, three, and four, ranging from 10 to 14 bushels per acre (Table 4), was significantly lower than production on the irrigated plots. These yields were not significantly different from one another (Table 7).

The differences among the eight systems of soil management can be interpreted in terms of yield responses to the three soil management practices, namely irrigation, plant population, and nitrogen fertilization.

Irrigation: Table 6 indicates that on the average, significantly higher yields were produced on irrigated plots with 18,000 and 22,000 plants per acre than on non-irrigated plots with 9,000 and 14,000 plants per acre at all four sites.

Plant population: Table 7 reveals that there was a significant yield response to an increase in plant population from 18,000 to 22,000 plants per acre on irrigated plots with 180 pounds of applied nitrogen per acre at the Willamette, Woodburn, and Amity sites. The increases in yield were 22, 19, and 12 bushels per acre at the

Willamette, Woodburn, and Amity sites, respectively (Table 4). At the Woodburn and Amity sites, there was a response to an increase in the plant population from 18,000 to 22,000 plants per acre on irrigated plots with the 60-pound-per-acre rate of added nitrogen (Table 7). The yield increases were 22 and 19 bushels per acre at the Woodburn and Amity sites, respectively (Table 4).

On non-irrigated plots there was only one instance of a significant increase in corn yield when the plant population was increased. A 13-bushel-per-acre response occurred at the Willamette site when the plant population was increased from 9,000 to 14,000 plants per acre on the non-irrigated plots that received the 180-pound-per-acre rate of nitrogen fertilizer.

Nitrogen fertilization: Table 7 also indicates that there were significant yield responses when the rate of nitrogen fertilization was increased. There was a significant increase in yield, when the nitrogen fertilization rate was increased from 60 to 180 pounds of N per acre on the irrigated plots with 22,000 plants per acre at all four sites. The increase in yield was 18 bushels per acre at both the Willamette and Amity sites. At the Woodburn and Dayton sites the yield increases were

20 and 21 bushels per acre, respectively (Table 4).

At the Woodburn and Amity sites there were increases in corn yields when the nitrogen fertilization rate was increased from 60 to 180 pounds of N per acre on irrigated plots with 18,000 plants per acre (Table 7). A yield increase of 23 bushels per acre was measured at the Woodburn site. There was a 25-bushel-per-acre increase at the Amity site (Table 4).

There was only one instance of a significant yield response to added nitrogen on non-irrigated plots. A 16-bushel-per-acre increase occurred at the Amity site when the nitrogen fertilization rate was increased from 60 to 180 pounds of N per acre on non-irrigated plots with 14,000 plants per acre (Tables 4 and 7).

## Shelling Percentage

The mean shelling percentages for each system of soil management (Table 10) at each site are presented in Table 11.

The analysis of the data from the Willamette and Woodburn sites revealed that the levels of management (Table 1) did not affect shelling percentage. However, data from the Amity and Dayton sites indicated that

Table 11. Mean shelling percentages for each soil management system at each site.

| System | Sites<br>Willamette | Woodburn | Amity | Dayton |
|---|---|---|---|---|
| 1 | 81.47 | 81.89 | 78.61 | 64.14 |
| 2 | 79.73 | 81.73 | 78.91 | 69.94 |
| 3 | 79.72 | 80.23 | 76.51 | 61.50 |
| 4 | 81.01 | 81.66 | 79.57 | 65.97 |
| 5 | 81.63 | 82.30 | 82.16 | 79.11 |
| 6 | 81.28 | 81.55 | 81.10 | 80.57 |
| 7 | 81.59 | 81.97 | 80.92 | 79.99 |
| 8 | 81.46 | 82.61 | 80.16 | 79.82 |

shelling percentage was affected by the level of management. Since the analysis of variance indicated that there were differences among management levels at those two sites, the means were analyzed with the multiple range test. The results are presented in Table 12.

Table 12 indicates that irrigated plots with 18,000 and 22,000 plants per acre had significantly higher shelling percentages than non-irrigated plots with 9,000 and 14,000 plants per acre at the Amity and Dayton sites. The difference in shelling percentages was approximately 2.5 percent at the Amity site. At the Dayton site the difference was much larger, approximately 15 percent.

Table 12. Results of testing for differences among the mean shelling percentages of each management level with the multiple range test at the Amity and Dayton sites.

Amity Site

| Management level | 2 | 1 | 4 | 3 |
| --- | --- | --- | --- | --- |
| Mean | 78.04 | 78.76 | 80.54 | 81.63 |

[1] 78.04 and 78.76 are underscored by one line; 80.54 and 81.63 are underscored by a second line.

Dayton Site

| Management level | 2 | 1 | 3 | 4 |
| --- | --- | --- | --- | --- |
| Mean | 63.73 | 67.04 | 79.84 | 79.91 |

[1] Means underscored by the same line are not different at the 5% significance level.

## Ear Moisture at Harvest

The mean moisture percentages of the whole ears when harvested for each system of soil management at each site are presented in Table 13.

Analysis of the data revealed that neither management levels nor nitrogen affected ear moisture at any site. Also there was no significant interaction between management and nitrogen.

Table 13. Soil management system means of ear moisture percentages at harvest for each site.

| | Sites | | | |
|---|---|---|---|---|
| System | Willamette | Woodburn | Amity | Dayton |
| 1 | 48.5 | 46.7 | 49.7 | 61.5 |
| 2 | 49.5 | 46.3 | 52.2 | 59.7 |
| 3 | 50.8 | 47.2 | 53.7 | 56.6 |
| 4 | 50.8 | 47.4 | 50.7 | 59.8 |
| 5 | 50.3 | 46.9 | 51.9 | 55.2 |
| 6 | 51.3 | 46.7 | 51.1 | 55.1 |
| 7 | 51.9 | 45.7 | 53.3 | 54.8 |
| 8 | 50.1 | 45.2 | 51.3 | 55.6 |

# V. DISCUSSION AND CONCLUSIONS

It should be stated at the outset that the conclusions herein are subject to several limitations. The major limitation is that this was only one trial carried out during a particular growing season. Moreover, each one-third-acre site had its own local environment. The descriptions of some of the important components of that environment, such as location, soil, climate, and past management, are presented in the appendices.

## Yield of Shelled Corn

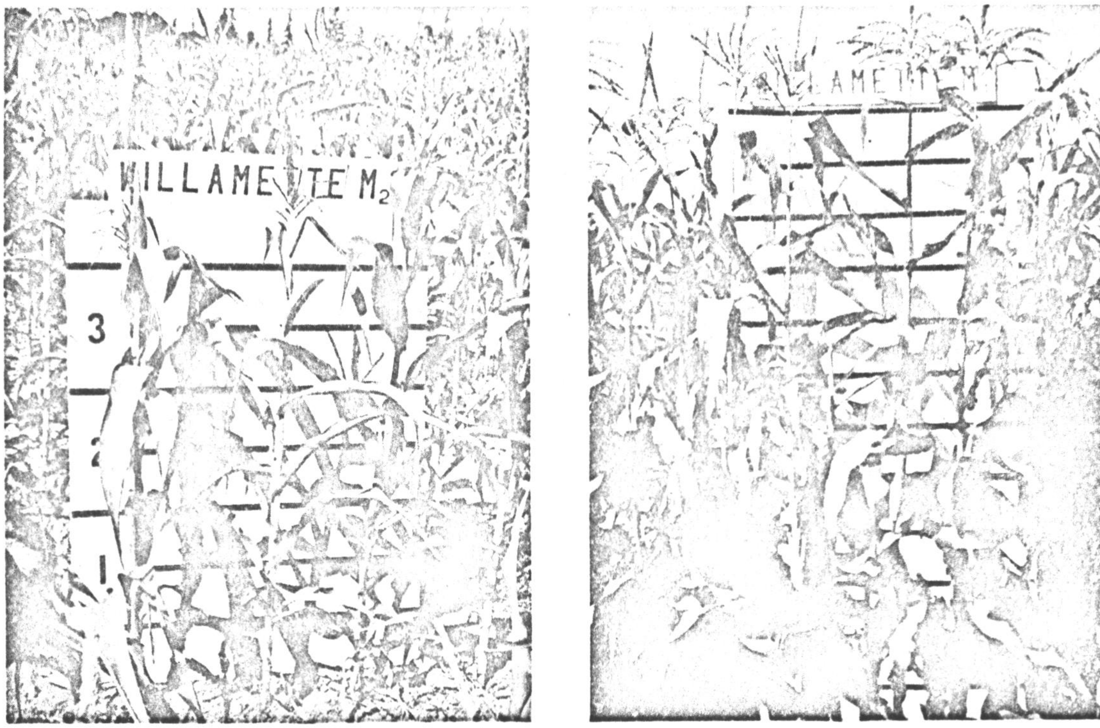
For convenience, the discussion is divided in the following manner. The yield responses to irrigation, plant population, and nitrogen fertilization are first discussed. Tentative conclusions concerning the comparative productivity of the four sites, in terms of corn yield, under each soil management system are then considered.

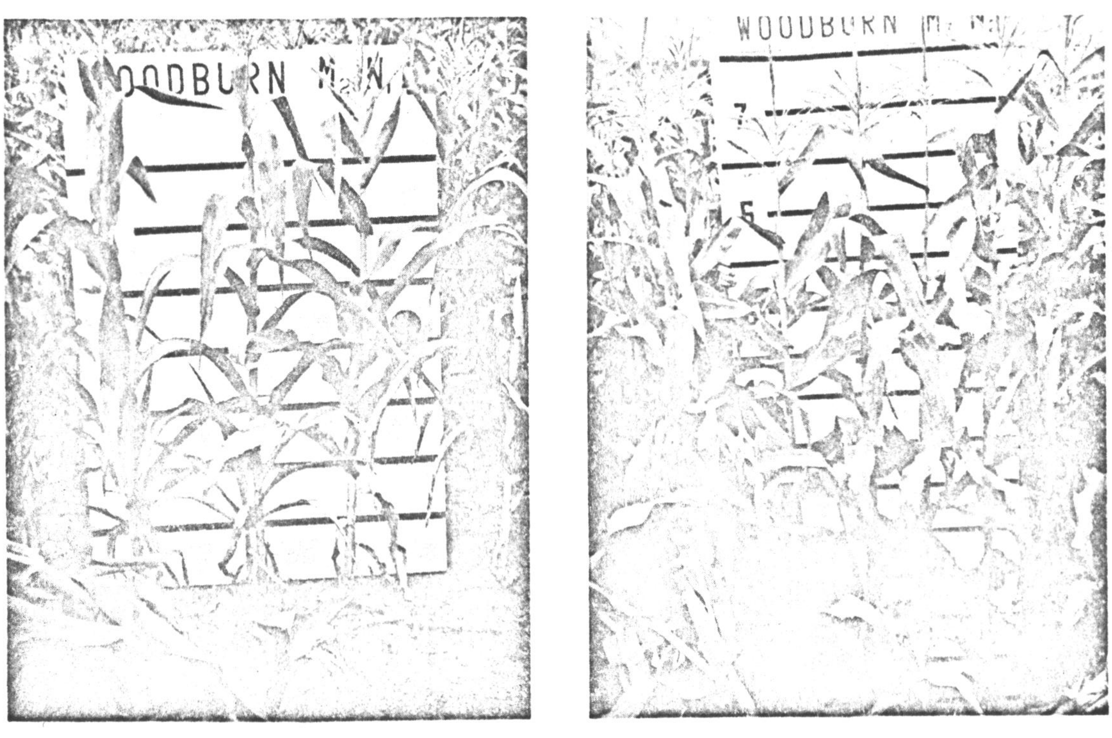
Irrigation: There are two explanations which might account for the significantly higher yields of shelled corn that were produced under irrigation with relatively high plant populations at all four sites (Tables 4 and 7).

First, moisture stress retarded plant growth, and hence yield, on the non-irrigated plots. It was noted that the plants on these plots were wilted much of the time between pre-tasseling and maturity. By contrast, the plants on the irrigated plots were tall and vigorous (Figures 4, 5, 6, and 7). Several of the experiments reviewed by Stringfield (31, p. 368) indicated that yields are sharply reduced when wilting occurs during tasseling.

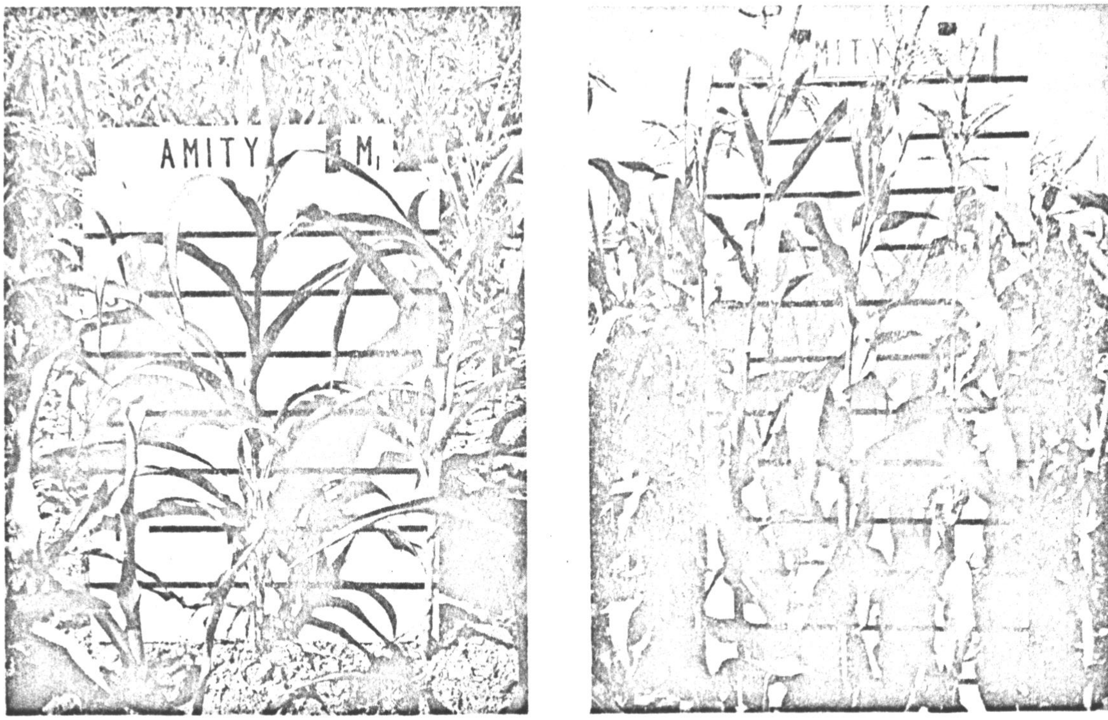
Nandpori (13, p. 21), working under reasonably comparable conditions on a Chehalis soil, observed that irrigated plots with 9,900 and 14,000 plants per acre yielded, on the average, 75 and 92 bushels per acre, respectively. It is interesting to note that in the present study the non-irrigated Willamette plots with 9,000 and 14,000 plants per acre produced average yields of 54 and 58 bushels per acre, respectively (Table 4). The average yields produced on the non-irrigated plots at the other sites considered in the present study were generally even lower, ranging from 59 down to 10 bushels per acre.

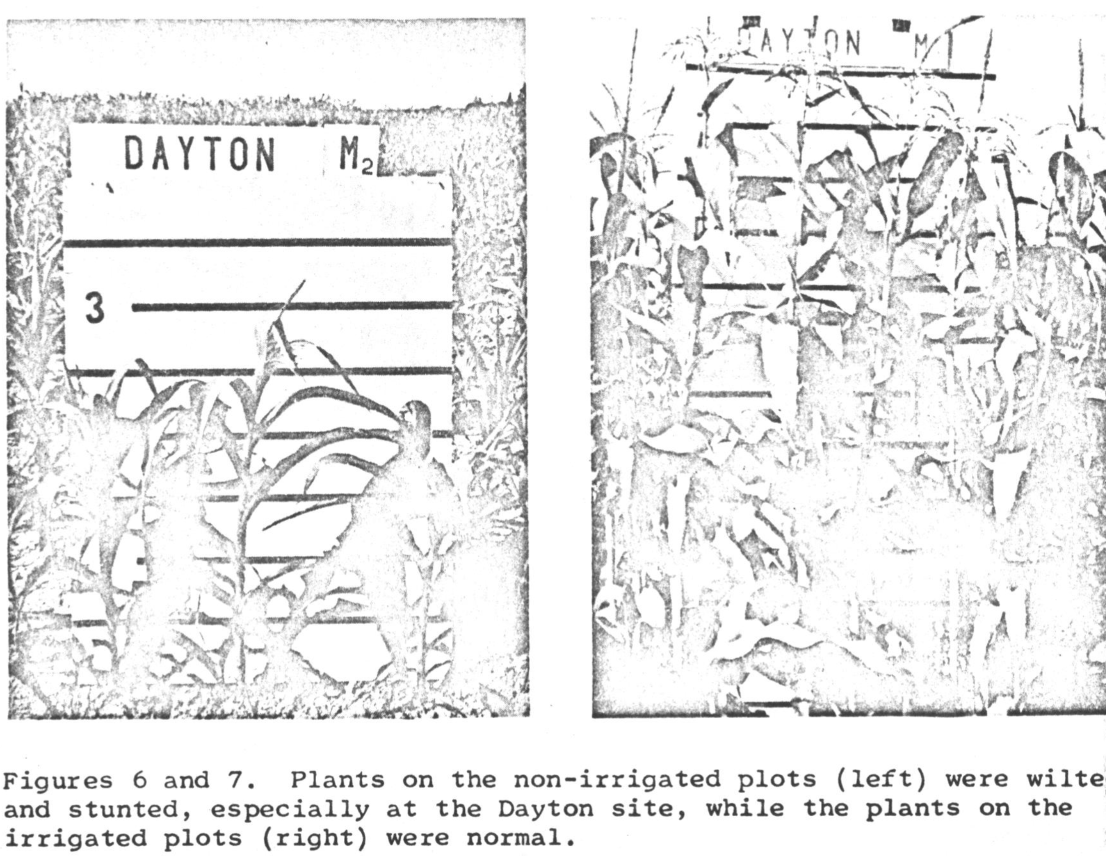
Secondly, under irrigation high plant populations (approximately 20,000 plants per acre) have produced





Figures 4 and 5. Plants on non-irrigated plots (left) were wilted and stunted while the plants on irrigated plots (right) were normal.




Figures 6 and 7. Plants on the non-irrigated plots (left) were wilted and stunted, especially at the Dayton site, while the plants on the irrigated plots (right) were normal.

greater yields than low plant populations (10,000 to 14,000 plants per acre). This has been previously demonstrated by Nandpori (13, p. 21) and other workers (5, p. 1-51) (6, p. 242-245) (21, p. 1-26).

The response to irrigation was probably greatly influenced by the marked shortage of summer rainfall in the Willamette Valley (Appendix III). Although the soil profiles were near field capacity at the beginning of the growing season they could not store enough moisture to maintain a full season crop, such as corn.

It is apparent in Table 4 that on non-irrigated plots, yields trend downward as the internal drainage of the soils becomes more restricted. It is characteristic of this catena that, generally speaking, the restricting layers become more strongly developed and/or shallower as one moves from the well-drained Willamette to the poorly drained Dayton. The same layers that restrict percolation of water through the soil probably restricted root growth at the experimental sites.

It was noted at the Dayton site that root growth did not extend below the two-foot depth. It was also noted that corn roots were frequently found going below the three-foot depth on the non-irrigated plots at the

Willamette site. Therefore, it is evident that a smaller volume of soil, and presumably a smaller amount of moisture, was available to the crop at the Dayton site.

Moreover, it is probable that the claypan at the Dayton site also restricted the upward capillary movement of water into the root zone. This hypothesis is supported by moisture measurement records. On July 30, 1962, the moisture tension measurements at the six-inch and 30-inch depths averaged 7.38 and 0.30 atmospheres, respectively, on non-irrigated plots at the Dayton site. On August 30, 1962, six-inch and 30-inch measurements taken on the same plots averaged 16.33 and 2.10 atmospheres, respectively. Thus, it is evident that the moisture did not readily move upward.

Plant population: At the Willamette, Woodburn, and Amity sites there were significant yield responses when the plant population was increased from 18,000 to 22,000 plants per acre along with irrigation and a high nitrogen rate (180 pounds of N per acre). Under these conditions the supply of moisture and nutrients was probably more than adequate for 18,000 plants per acre. Working under comparable conditions, Nandpori (13, p. 21) reported that plant populations of less than 22,270 plants per acre appeared to limit yield on irrigated plots that were fertilized with 180 pounds of nitrogen per acre.

Increasing the plant population from 18,000 to 22,000 plants per acre, resulted in significantly greater yields under irrigation at the Woodburn and Amity sites with only 60 pounds of added nitrogen per acre. Again, the supply of moisture and nutrients was probably more than adequate for 18,000 plants per acre. However, at this lower level of nitrogen, Nandpori (13, p. 21) reported that yields decreased significantly when the plant population was increased beyond 18,000 plants per acre.

At the Willamette site, significantly greater yields were produced without irrigation when the plant population was increased from 9,000 to 14,000 plants per acre only when there was a high nitrogen rate (180 pounds of N per acre). There are several plausible explanations for the plant population-nitrogen interaction under non-irrigated conditions. Possibly the higher rate of applied nitrogen stimulated root growth. Larger root systems would have exploited the soil moisture supply to a greater degree. However, examination of the roots did not reveal a noticeable difference between nitrogen treatments.

Another possible explanation of this interaction is that low nitrogen and plant population levels, as well as moisture, were limiting yield. With adequate levels of nitrogen and plant population the available moisture is used more efficiently. In other words, greater yields are produced with the same amount of water. This concept is set forth by several researchers whose work was reviewed by Nelson (15, p. 362, 365).

Apart from the instance at the Willamette site which is discussed above, there were no significant responses to an increase in plant population without irrigation. It is quite probable that the lack of available moisture was a major factor limiting yield under non-irrigated conditions.

At the Willamette site, the response to increasing plant population from 18,000 to 22,000 plants per acre under irrigation with the lower nitrogen rate (60 pounds of N per acre) was not significant. It might be suggested that nitrogen apparently limited yield at 18,000 plants per acre. However, Table 7 indicates that a significant response to increasing the nitrogen fertilization rate was not evident on these plots.

Increasing the plant population did not result in increased yields on the irrigated plots at the Dayton site. On the irrigated Dayton plots the supply of soil moisture probably was not limiting for 22,000 plants per acre. No extended wilting was noted. Also, the supply of available nitrogen was probably ample. This would suggest that some other components of the soil system were apparently limiting yield at the highest level of plant population.

There are several features of the soil at the Dayton site that may have adversely affected corn production. The acidity of a composite sample of the plow layer was moderately strong at pH 5.5 (Appendix I). Also, other nutrients may have been limiting. However, severe deficiency symptoms were not noted.

The organic matter content of the A horizon at the Dayton site was low compared with that of the other soils in the catena (Appendix I). The absence of strong, stable granular structure was probably related to the organic matter content. Thus, the comparatively high bulk densities presented in Appendix I are not surprising. Assuming a particle density of 2.65, the total pore space in the A horizon ranged from 39.6 to 44.5 percent. The combination of relatively low porosity and fairly heavy irrigation could have produced periodic conditions of poor aeration. The wet, poorly aerated soil probably had relatively cool soil temperatures.

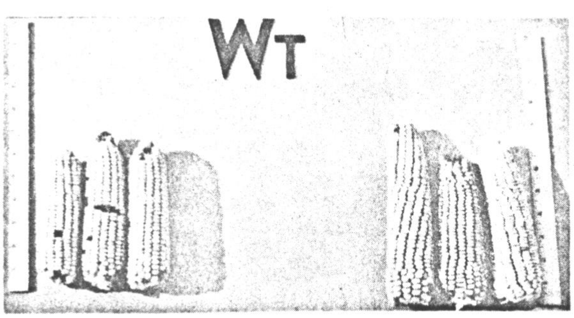
This combination of soil properties was probably responsible for the slow growth rate that was especially noticeable early in the season. The lack of response to a higher plant population was probably related to the reduced growth. Hence, the particular properties of the Dayton soil probably precluded the most effective use of such factors as nitrogen, moisture, and solar energy.

Nitrogen fertilization: There were significant nitrogen responses at all four sites when the highest plant population (22,000 plants per acre) was irrigated. At the Woodburn and Amity sites there were significant nitrogen responses when a plant population of 18,000 plants per acre was irrigated. These yield increases were likely due to an increase in the supply of available nitrogen. This explanation is substantiated by field observations. Typical nitrogen deficiency symptoms were noted on the plots receiving the 60-pound-per-acre nitrogen rate while the plants on the plots receiving the 180-pound rate had dark green leaves from top to bottom (Figure 8).

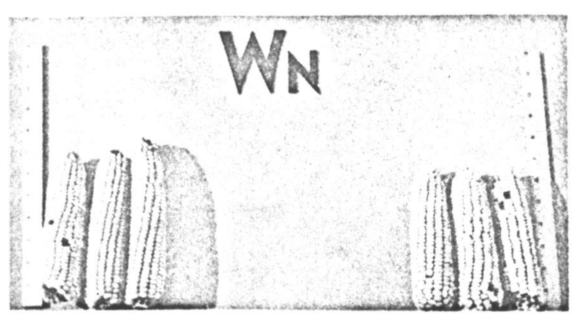


Figure 8. Nitrogen deficiency in lower leaves (60 lbs N/ac.)

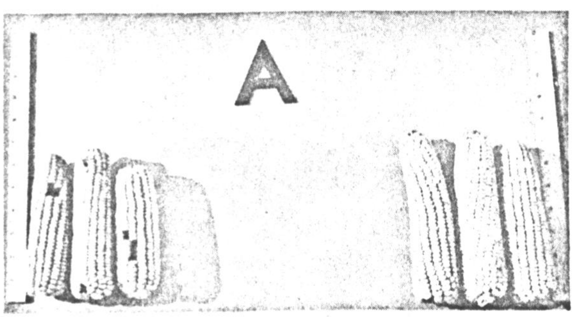
Normal plots with high nitrogen rate (180 lbs N/ac.)



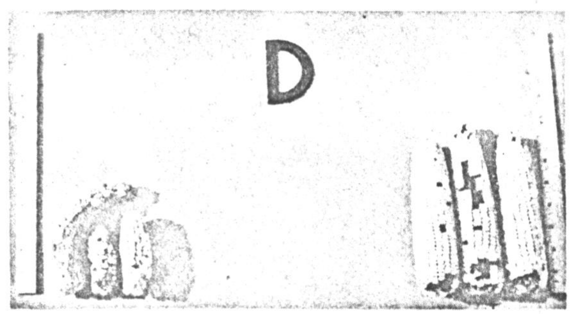

Willamette




Woodburn




Amity




Dayton

Figure 9. Ears from non-irrigated (left) and irrigated (right) plots at each site.

The one occurrence of nitrogen response without irrigation was at the Amity site on plots with 14,000 plants per acre. In this instance, nitrogen, as well as moisture, was probably limiting yield when there were 14,000 plants per acre. However, no striking difference in the appearance of the plants was noted. The addition to the supply of available nitrogen probably allowed the plants to make more efficient use of the available moisture. Nelson (15, p. 365) reviewed several research reports which set forth this concept. Recently, Linscott et al. (11, p. 185-189) also reported this conclusion.

At the Willamette and Amity sites no significant nitrogen responses were measured on irrigated plots with 18,000 plants per acre. Although nitrogen deficiency symptoms were apparent on the plots that received the 60-pound-per-acre rate, the nitrogen shortage was probably not severe enough to significantly influence yields.

There were no nitrogen responses on the non-irrigated plots excepting the one instance at the Amity site discussed above. Shortage of available moisture was probably the major factor limiting yields. Hence, there was no response to added nitrogen.

The pattern of nitrogen responses suggests that there may have been differences in the amount of microbial nitrogen release at the different experimental sites. The first significant nitrogen response occurred with 22,000 plants per acre at the Willamette site, 18,000 plants per acre at the Woodburn site, and 14,000 plants per acre at the Amity site. A simultaneous examination of the yield data (Table 4) indicates that the extra nitrogen was apparently needed to produce 52, 145, and 155 bushels per acre at the Amity, Woodburn, and Willamette sites, respectively.

This suggests that greater amounts of organic nitrogen may have been released as one progressed from the imperfectly drained Amity soil to the well-drained Willamette soil. In other words, the mineralization of organic nitrogen at the Willamette site may have been greater than that at the Woodburn site, which may, in turn, have been greater than that at the Amity site.

There are trends in certain laboratory data (Appendix I), such as pH, organic matter content, nitrogen content, and bulk density, which lend support to the foregoing hypothesis. However, there is no clear cut evidence of changes in factors that influence organic nitrogen release (2, p. 253-256).

Comparative productivity: The comparative productivity of the four sites for field corn under the eight different systems of soil management (Table 10) is discussed below. The conclusions are based on the results of the statistical analysis presented in Table 8. The conclusions presented below are restricted to the specific experimental sites. However, it seems plausible that soils with similar properties might respond in a similar manner.

Under soil management systems one, two, three, and four (Table 10) the productivity of the soil at the Dayton site was significantly lower than that of the soil at the Willamette, Woodburn, and Amity sites. Generally, the corn yields, and thus the soil productivities at the latter three sites were not significantly different from one another.

The lower yields on the non-irrigated plots at the Dayton site were quite probably due to lower soil moisture availability at this site. A smaller root zone and the slow movement of soil moisture into this zone were probably the factors that contributed to this condition. The availability of soil moisture at the Dayton site is discussed in more detail at the end of the section concerning responses to irrigation.

The productivities of the soils at the other sites were apparently limited by one or more factors. It is quite probable that moisture stress hindered corn production under each of the first four systems of soil management (Table 10). Under soil management system two plant population may have also limited yields.

Under soil management system three (Table 10) the yield at the Willamette site, 53 bushels per acre (Table 4), was significantly higher than the 36-bushel-per-acre yield at the Amity site. This single instance of a significant difference in soil productivity between non-irrigated Willamette and Amity plots could possibly have been due to a difference in the microbial release of organic nitrogen at these sites. A discussion of nitrogen release is presented near the end of the discussion concerning responses to nitrogen fertilization.

Under soil management system five (Table 10) the differences in soil productivity are not clear cut. Using the appropriate data from Table 8 and the yield data (bushels per acre) from Table 4 the following table was constructed.

Soil Management System Five

| Site | Dayton | Amity | Woodburn | Willamette |
|---|---|---|---|---|
| Mean Yield | 106 | 111 | 122 | 128 |

The productivity of sites underscored by the same line is not different at the five percent level of significance.

The lower yield at the Dayton site was probably due to the particular chemical and physical properties of the soil. These properties are referred to in the discussion of responses to higher plant populations. The difference in productivity between the Amity and Willamette sites may be accounted for by the possible differences in the mineralization of organic nitrogen which is referred to in the discussion of responses to nitrogen fertilizer.

Under soil management systems six, seven, and eight (Table 10) the productivity of the soil at the Dayton site continued to be significantly lower than that of the soils at the Willamette, Woodburn, and Amity sites (Table 8). The inherent properties of the soil at the Dayton site are probably responsible for the lower productivity under these management systems.

The productivities of the soils at the Willamette, Woodburn, and Amity sites were not significantly different from one another under soil management systems six and seven (Tables 8 and 10). With management system six plant population may have limited yields. The shortage of available nitrogen may have been an equalizing factor under system seven.

Under soil management system eight the yield at the Amity site, 148 bushels per acre (Table 4), was significantly lower than that of the Woodburn site at 164 bushels per acre (Table 8). The 155-bushel-per-acre yield at the Willamette site was intermediate and not significantly different from that of either the Amity or the Woodburn sites. The reason for the difference between the productivities of the soils at the Amity and Woodburn sites is not readily apparent.

On the average over the eight systems of soil management, the soil at the Dayton site was not as productive, in terms of yields of field corn, as the soils at the Willamette, Woodburn, and Amity sites (Table 9). The productivities of the soils at the latter three sites were not significantly different from one another.

Without irrigation the lower availability of soil moisture at the Dayton site limited yields. With irrigation other properties of the Dayton soil apparently limited the production of field corn.

## Shelling Percentage

The shelling percentage on the irrigated plots was significantly higher than on the non-irrigated plots at the Amity and Dayton sites. This difference was probably due to the severe moisture stress on the non-irrigated plots. The effect of the moisture stress at the Amity site was largely the occurrence of shriveled, chaffy kernels. At the Dayton site there was a large number of poorly filled ears in addition to a high percentage of shriveled kernels. The ears from the irrigated plots were generally well-filled with large, plump kernels as shown in Figure 9.

At the Willamette and Woodburn sites the ears and kernels were well developed regardless of treatment (Figure 9).

## Ear Moisture at Harvest

Ear moisture at harvest was not significantly affected by irrigation, plant population, or nitrogen fertilization. Ear moisture is apparently a function of the climate and the maturity of the crop. These factors were not noticeably different at each site.

## General Conclusions

In general, it is evident that irrigation increased yields, increased the shelling percentage in some instances, and had no effect on ear moisture at harvest on soils of the Willamette catena. Increases in the levels of plant population and nitrogen fertilization increased yields on irrigated plots, and had no effect on either shelling percentage or ear moisture at harvest. Also, the soils at the Willamette, Woodburn, and Amity sites had greater productivity for field corn than did the soil at the Dayton site in 1962.

# BIBLIOGRAPHY

1. Alban, L. A. and Mildred Kellogg. Methods of soil analysis. Corvallis, 1959. 9 numb. leaves. (Oregon Agricultural Experiment Station. Miscellaneous Paper 65)

2. Alexander, Martin. Introduction to soil microbiology. New York, Wiley, 1961. 472 p.

3. Arnold, B. L. North Mississippi irrigation tests with cotton, corn. Mississippi Farm Research 24:2. June, 1961.

4. Bauer, C. F. et al. Effects of soil treatment on soil productivity. Urbana, 1945. p. 105-224. (Illinois. Agricultural Experiment Station. Bulletin 516)

5. Boswell, F. C., O. E. Anderson and S. V. Stacey. Some effects of irrigation, nitrogen, and plant population on corn. Athens, 1959. 51 p. (Georgia. Agricultural Experiment Stations. Bulletin new ser. no. 60)

6. Carlson, C. W., J. Alessi and R. H. Mickelson. Evapotranspiration and yield of corn as influenced by moisture level, nitrogen fertilization, and plant density. Soil Science Society of America Proceedings 23:242-245. 1959.

7. Carreker, John R. and W. J. Liddell. Results of irrigation research in Georgia. Part II. Agricultural Engineering 29:301-302, 304. 1948.

8. Kilmer, Victor J. and Lyle T. Alexander. Methods of making mechanical analyses of soils. Soil Science 68:15-24. 1949.

9. King, Arthur S. Western Oregon irrigation--30 years a-growing. Oregon Farmer 85:1,5-6. May 3, 1962.

10. Li, Jerome C. R. Introduction to statistical inference. Ann Arbor, Edwards Brothers, 1957. 553 p.

11. Linscott, D. L., R. L. Fox and R. C. Lipps. Corn root distribution and moisture extraction in relation to nitrogen fertilization and soil properties. Agronomy Journal 54:185-189. 1962.

12. Murray, W. G., A. J. Englehorn and R. A. Griffin. Yield tests and land valuation. Ames, 1939. p. 50-76. (Iowa. Agricultural Experiment Station. Research Bulletin 252)

13. Nandpori, Karam Singh. Effect of different plant population and nitrogen levels on the yield of corn silage and grain. Master's thesis. Corvallis, Oregon State University, 1955. 44 numb. leaves.

14. Nelson, L. A. and R. J. McCracken. Properties of Norfolk and Portsmouth soils: Statistical summarization and influence upon corn yields. Soil Science Society of America Proceedings 26:497-502. 1962.

15. Nelson, Lewis B. The mineral nutrition of corn as related to its growth and culture. Advances in Agronomy 8:321-375. 1956.

16. Odell, R. T. Measurement of the productivity of soils under various environmental conditions. Agronomy Journal 42:282-292. 1950.

17. Odell, R. T. The effects of physical properties of soils on productivity. Journal of the American Society of Farm Managers and Rural Appraisers 12:42-47. 1948.

18. Odell, R. T. and G. D. Smith. A study of crop yield records by soil types. Soil Science Society of America Proceedings 5:316-322. 1940.

19. Pomerening, James Albert. A test of the differentiation of soil series within the Willamette catena. Ph.D. thesis. Corvallis, Oregon State University, 1961. 185 numb. leaves.

20. Powers, W. L., E. F. Torgerson and E. V. Dannen. Identification and productivity of western Oregon soil types. Corvallis, 1948. 29 p. (Oregon. Agricultural Experiment Station. Station Circular 175)

21. Rhoades, H. F., et al. Fertilization and irrigation practices for corn production on newly irrigated land in the Republican Valley. Lincoln, 1954. 26 p. (Nebraska. Agricultural Experiment Station. Bulletin 424)

22. Richards, L. A. Porous plate apparatus for measuring moisture retention and transpiration by soil. Soil Science 66:105-110. 1948.

23. Richards, L. A. Pressure membrane apparatus--construction and use. Agricultural Engineering 28: 451-454. 1947.

24. Russ, Porter L. and Frank F. Bell. Productivity of four selected Tennessee soils in terms of corn yield. Agronomy Journal 54:164-167. 1962.

25. Rust, R. H. and R. T. Odell. Methods used in evaluation of the productivity of some Illinois soils. Soil Science Society of America Proceedings 21:171-175. 1957.

26. Shearer, Marvin N. Electrical resistance gypsum blocks for scheduling irrigations. Corvallis, 1963. 11 p. (Oregon State University. Cooperative Extension Service. Extension Bulletin 810)

27. Simonson, R. W. and A. J. Englehorn. Methods of estimating the productive capacities of soils. Soil Science Society of America Proceedings 3:247-252. 1938.

28. Smith, G. D. and R. S. Smith. A study of crop yield records by soil types and soil ratings. Soil Science Society of America Proceedings 4:375-378. 1939.

29. Snedecor, George W. Statistical methods applied to experiments in agriculture and biology. 5th ed. Ames,

Iowa State College Press, 1956. 534 p.

30. Soil Survey Staff. Soil survey manual. Washington, 1951. 503 p. (U. S. Dept. of Agriculture. Handbook no. 18)

31. Stringfield, G. H. Corn culture. In: American Society of Agronomy's Corn and corn improvement. vol. 5. New York, Academic Press, 1955. p. 343-378.

32. U. S. Weather Bureau. Climatological data. Oregon 68:1-191. 1962.

33. Waggoner, B. E. and John W. McMillan. Information on corn production by soil types. Mississippi Farm Research 23:7. April, 1960.

34. Zeleny, Lawrence. Ways to test seed for moisture. In: U. S. Dept. of Agriculture. Seeds; The Yearbook of Agriculture, 1961. p. 443-447.

# APPENDIX I. Soil Properties and Profile Descriptions[1]

Soil type: Willamette silt loam.
Location: J. R. Guerber farm in the W 1/2 SE 1/4 SW 1/4 of section 14, T13S, R5W of Willamette Meridian.

Profile Description

Alp 0-9 inches, dark grayish brown (10YR 3.4/2)[2] silt loam with weak fine granular structure; friable, slightly sticky, and slightly plastic; very strongly acid (pH 5.0); abrupt boundary.

A12 9-17 inches, dark brown (10YR 3/3) silt loam with moderate fine and medium granular structure; friable, slightly sticky, and slightly plastic; moderately acid (pH 5.6); clear boundary.

B1 17-30 inches, dark brown (10YR 3.5/3) heavy silt loam with weak medium subangular blocky structure; friable, slightly sticky, and slightly plastic; common medium pores; strongly acid (pH 5.5); gradual boundary.

B2 30-44 inches, brown to dark brown (10YR 4/3) light silty clay loam with weak medium prismatic breaking to weak medium blocky structure; slightly firm, slightly sticky, and slightly plastic; common medium pores; thin to thick discontinuous dark yellowish brown (10YR 4/4, moist) clayskins; moderately acid (pH 5.9); gradual boundary.

B3 44-58 inches, brown to dark brown (10YR 4/3) light silty clay loam with weak coarse prismatic breaking to weak coarse blocky structure; slightly firm, slightly sticky, and slightly plastic; some large strong brown (7.5YR 5/6, moist) and grayish brown (2.5Y 5/2, moist) mottles; common large pores; some thick patchy clay skins in pores and on vertical ped surfaces; slightly acid (pH 6.2); gradual boundary.

C 58-66+ inches, brown (10YR 5/3) silt loam; massive; slightly firm, slightly sticky, and slightly plastic; few low contrast mottles; common large pores; thick continuous clayskins in some pores; slightly acid (pH 6.5).

[1] Profiles were moist when described.

[2] Munsell colors of moist soil.

Willamette silt loam

| Depth (inches) | Horizon | Mechanical Analysis % Sand | % Silt | % Clay |
|---|---|---|---|---|
| 0-9 | Alp | 2.80 | 72.12 | 25.08 |
| 9-17 | A12 | 2.44 | 72.37 | 25.19 |
| 17-30 | B1 | 2.38 | 73.76 | 23.86 |
| 30-44 | B2 | 2.23 | 63.92 | 33.85 |
| 44-58 | B3 | 6.26 | 66.31 | 27.43 |
| 58-66+ | C | 3.31 | 72.70 | 23:99 |

| Horizon | Organic Matter % O.M. | % C | % N | C:N | Extractable Cations (Meq/100g.) Ca | Mg | K | CEC | pH | Phosphorus (ppm.) |
|---|---|---|---|---|---|---|---|---|---|---|
| Alp | 3.54 | 2.05 | .194 | 10.6 | 8.8 | 1.6 | 0.42 | 17.5 | 5.0 | 24.0 |
| A12 | 2.07 | 1.20 | .109 | 11.0 | 7.7 | 2.0 | 0.23 | 16.0 | 5.6 | 13.0 |
| B1 | | | | | 8.0 | 2.5 | 0.21 | 14.3 | 5.5 | 14.0 |
| B2 | | | | | 14.2 | 6.2 | 0.53 | 25.5 | 5.9 | 29.0 |
| B3 | | | | | 14.5 | 6.2 | 0.46 | 23.2 | 6.2 | 23.0 |
| C | | | | | 15.2 | 6.4 | 0.44 | 22.8 | 6.5 | 11.0 |
| Composite plowlayer sample | | | | | 9.3 | 2.4 | 0.56 | 17.5 | 5.9 | 28.0 |

| Depth (inches) | Bulk Density | Moisture Tension Data (% by weight) 15.0 atm. | 5.0 atm. | 2.0 atm. | 1.0 atm. | 0.3 atm. | 0.1 atm. |
|---|---|---|---|---|---|---|---|
| 3 | 1.34 | 11.12 | 17.13 | 23.06 | 24.16 | 25.66 | 26.97 |
| 16 | 1.54 | 11.56 | 16.61 | 22.34 | 22.49 | 23.82 | 25.16 |
| 24 | 1.54 | 11.98 | 16.85 | 22.91 | 24.39 | 25.81 | 26.97 |

Soil type: Woodburn silt loam
Location: Hyslop Agronomy Experimental Farm in the NW1/4 NW1/4 of section 9, T11S, R4W of Willamette Meridian.

Profile Description

Ap 0-7 inches, very dark grayish brown(10YR 3/2) silt loam with weak fine and medium subangular blocky structure; friable, slightly sticky, and slightly plastic; many interstitial and tubular pores; strongly acid (pH 5.4); abrupt smooth boundary.

A3 7-13 inches, dark brown (10YR 3/3) light silty clay loam with weak medium prismatic structure; friable, slightly sticky, and slightly plastic; many very fine tubular pores; moderately acid (pH 5.7); clear smooth boundary.

B1 13-19 inches, dark yellowish brown(10YR 3/4) light silty clay loam with weak coarse prismatic breaking to weak coarse subangular blocky structure; friable, slightly sticky, and slightly plastic; many very fine tubular pores; common thin clayskins; moderately acid (pH 5.8); clear wavy boundary.

B21 19-26 inches, dark yellowish brown(10YR 3/4) heavy silty clay loam with weak coarse prismatic breaking to moderate coarse subangular blocky structure; firm, sticky, and plastic; few dark stains (Mn) on ped surfaces; many very fine tubular pores; continuous medium clayskins; moderately acid (pH 5.9); gradual wavy boundary.

B22 26-34 inches, dark yellowish brown(10YR 3/4) silty clay loam with weak coarse prismatic breaking to moderate coarse subangular blocky structure; firm, sticky, and plastic; few dark stains (Mn) on ped surfaces; many very fine tubular pores; continuous medium clayskin; moderately acid (pH 5.9); gradual wavy boundary.

B31x 34-41 inches, dark brown(10YR 4/3) silty clay loam with moderate coarse prismatic breaking to weak coarse subangular blocky structure; firm, sticky, and plastic; common fine distinct mottles; common dark stains (Mn) on ped surfaces; common very fine tubular pores; common medium and thick clayskins; moderately acid (pH 6.0); gradual wavy boundary.

B32 41-55 inches, dark brown(10YR 4/3) light silty clay loam with weak coarse prismatic breaking to weak coarse subangular blocky structure; firm, slightly sticky, and slightly plastic; common fine and medium distinct mottles; common dark stains (Mn) on ped surfaces; common very fine tubular pores; few medium clayskins; slightly acid (pH 6.2); gradual boundary.

C1 55-70+ inches, dark brown (10YR 4/3) light silty clay loam; massive; friable, slightly sticky, and slightly plastic; few very fine tubular pores; few thick clay-skins in pores; slightly acid (pH 6.4).

Woodburn silt loam

| Depth (inches) | Horizon | Mechanical Analysis % Sand | % Silt | % Clay |
|---|---|---|---|---|
| 0-7 | Ap | 8.96 | 69.99 | 21.05 |
| 7-13 | A3 | 8.56 | 64.24 | 27.20 |
| 13-19 | B1 | 8.40 | 62.79 | 28.81 |
| 19-26 | B21 | 6.16 | 56.81 | 37.03 |
| 26-34 | B22 | 7.79 | 58.84 | 33.37 |
| 34-41 | B31x | 8.64 | 58.46 | 32.90 |
| 41-55 | B32 | 9.57 | 61.91 | 28.52 |
| 55-70+ | C1 | 7.69 | 65.30 | 27.01 |

| Horizon | Organic Matter % O.M. | % C | % N | C:N | Extractable Cations (meq/100g.) Ca | Mg | K | CEC | pH | Phosphorus (ppm.) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ap | 3.00 | 1.74 | .131 | 13.3 | 6.2 | 1.3 | 0.55 | 15.5 | 5.4 | 50.0 |
| A3 | 1.85 | 1.07 | .095 | 11.3 | 7.4 | 1.6 | 0.57 | 16.8 | 5.7 | 65.5 |
| B1 | | | | | 8.5 | 2.1 | 0.53 | 17.0 | 5.8 | 44.5 |
| B21 | | | | | 12.0 | 4.1 | 0.68 | 23.3 | 5.9 | 44.0 |
| B22 | | | | | 11.4 | 3.9 | 0.57 | 22.2 | 5.9 | 41.5 |
| B31x | | | | | 15.6 | 5.7 | 0.66 | 25.7 | 6.0 | 45.0 |
| B32 | | | | | 15.9 | 5.5 | 0.57 | 25.7 | 6.2 | 32.5 |
| C1 | | | | | 17.6 | 5.7 | 0.57 | 25.5 | 6.4 | 17.0 |
| Composite plowlayer sample | | | | | 9.1 | 1.8 | 0.68 | 16.7 | 6.2 | 26.5 |

| Depth (inches) | Bulk Density | Moisture Tension Data (% by weight) 15.0 atm. | 5.0 atm. | 2.0 atm. | 1.0 atm. | 0.3 atm. | 0.1 atm. |
|---|---|---|---|---|---|---|---|
| 6 | 1.19 | 13.1 | 17.1 | 20.6 | 22.8 | 25.8 | 27.7 |
| 12 | 1.21 | 13.1 | 17.1 | 20.6 | 22.8 | 25.8 | 27.7 |
| 18 and 24 | 1.21 | 14.9 | 18.2 | 21.2 | 23.4 | 26.3 | 27.9 |

Soil type: Amity silty clay loam
Location: J. R. Guerber farm in the E1/2 SW1/4 SW1/4 of section 14, T13S, R5W of the Willamette Meridian.

Profile Description

Alp 0-8 inches, very dark grayish brown (10YR 3/2) light silty clay loam with weak medium granular structure to massive; friable, slightly sticky, and slightly plastic; strongly acid (pH 5.4); clear wavy boundary.

A12 8-11 inches, very dark grayish brown (10YR 3/2) light silty clay loam with moderate medium granular structure; friable, slightly sticky, and slightly plastic; clear wavy boundary.

A2 11-18 inches, dark grayish brown (10YR 4/2) light silty clay loam with moderate fine subangular blocky structure; friable, sticky, and plastic; many fine concretions (Fe-Mn); abundant fine brown mottles; many fine and medium pores; strongly acid (pH 5.5); gradual boundary.

B1 18-25 inches, dark grayish brown (10YR 4/2) light silty clay loam with moderate fine and medium subangular blocky structure; friable, sticky, and plastic; abundant fine and medium concretions (Fe-Mn); abundant medium brown mottles; many fine and medium pores; moderately acid (pH 5.6); clear boundary.

B21 25-34 inches, grayish brown (2.5Y 4.6/2) silty clay loam with strong medium subangular blocky breaking to moderate fine subangular blocky structure; slightly firm, sticky, and plastic; common medium and large concretions (Fe-Mn); abundant large brown and strong brown mottles; many large pores,; some firm peds with manganese stained coatings; moderately acid (pH 5.7); clear boundary.

B22 34-43 inches, grayish brown (2.5Y 5/2) heavy silty clay loam with strong medium blocky structure; firm, sticky, and plastic; common medium and large concretions (Fe-Mn); abundant large strong brown mottles; common medium pores; some firm peds with manganese stained coatings; thick continuous clayskins; slightly acid (pH 6.3); clear boundary.

B3m 43-53 inches, brown to dark brown (10YR 4/3) silty clay loam with moderate coarse prismatic breaking to weak coarse blocky structure; firm, sticky and plastic; few faint mottles; dark staining (Mn) on ped surfaces; few medium pores, thick continuous clayskins on ped surfaces; neutral (pH 6.8); gradual boundary.

C1 53-65+ inches, brown to dark brown (10YR 4/3) silt loam; massive; slightly firm, sticky, and plastic; few low contrast grayish mottles; few medium pores; few thin clayskins in pores and on vertical ped surfaces; neutral (pH 6.9).

Amity silty clay loam

| Depth (inches) | Horizon | Mechanical Analysis % Sand | % Silt | % Clay |
|---|---|---|---|---|
| 0-8 | A1p | 10.67 | 61.93 | 27.40 |
| 8-11 | A12 | -- | -- | -- |
| 11-18 | A2 | 9.72 | 61.59 | 28.69 |
| 18-25 | B1 | 8.38 | 62.61 | 29.01 |
| 25-34 | B21 | 5.68 | 59.94 | 34.38 |
| 34-43 | B22 | 3.35 | 58.80 | 37.85 |
| 43-53 | B3m | 3.08 | 63.80 | 33.12 |
| 53-56+ | C1 | 5.20 | 72.46 | 22.34 |

| Horizon | Organic Matter % O.M. | % C | % N | C:N | Extractable Cations (meq/100g.) Ca | Mg | K | CEC | pH | Phosphorus (ppm.) |
|---|---|---|---|---|---|---|---|---|---|---|
| A1p | 3.54 | 2.05 | .160 | 12.8 | 7.7 | 1.8 | 0.40 | 18.3 | 5.4 | 27.5 |
| A2 | | | | | 6.7 | 2.7 | 0.23 | 16.5 | 5.5 | 17.0 |
| B1 | | | | | 7.0 | 3.9 | 0.23 | 16.5 | 5.6 | 16.0 |
| B21 | | | | | 9.6 | 6.2 | 0.36 | 21.6 | 5.7 | 16.0 |
| B22 | | | | | 13.5 | 9.2 | 0.42 | 26.2 | 6.3 | 9.5 |
| B3m | | | | | 16.2 | 10.6 | 0.42 | 26.7 | 6.8 | 4.0 |
| C1 | | | | | 13.9 | 9.2 | 0.36 | 22.3 | 6.9 | 3.5 |
| Composite plowlayer sample | | | | | 7.8 | 2.6 | 0.56 | 18.4 | 5.6 | 29.0 |

| Depth (inches) | Bulk Density | Moisture Tension Data 15.0 atm. | 5.0 atm. | 2.0 atm. | 1.0 atm. | 0.3 atm. | 0.1 atm. |
|---|---|---|---|---|---|---|---|
| 3 | 1.41 | 11.23 | 17.45 | 22.05 | 24.82 | 26.18 | 27.40 |
| 15 | 1.60 | 12.48 | 17.61 | 21.24 | 23.33 | 24.34 | 25.26 |
| 23 | 1.53 | 14.16 | 19.41 | 22.83 | 27.09 | 28.20 | 29.08 |

Soil type: Dayton silt loam
Location: J. R. Guerber farm in the E1/2 SW1/4 SW1/4 of section 14, T13S, R5W of the Willamette Meridian.

Profile Description

Ap 0-9 inches, very dark grayish brown (10YR 3/2) silt loam with weak medium granular structure to massive; friable, slightly sticky, and slightly plastic; common shot-like concretions (Fe-Mn), common fine faint brownish mottles; very strongly acid (pH 4.7) abrupt boundary.

A21 9-16 inches, grayish brown (2.5Y 5/2) silt loam with moderate fine subangular blocky structure; friable, slightly sticky and slightly plastic; abundant irregular concretions (Fe-Mn); abundant fine and medium (7.5YR 4/4, moist) mottles; many fine and medium pores; strongly acid (pH 5.3), gradual boundary.

A22 16-24 inches, grayish brown (2.5Y 5/2) silt loam with moderate fine subangular blocky structure; friable, slightly sticky, and slightly plastic; abundant to common concretions (Fe-Mn); abundant fine and medium yellowish brown (10YR 5/4, moist) mottles; many fine and medium pores; strongly acid (pH 5.5); abrupt boundary.

B21 24-33 inches, dark grayish brown (2.5Y 4.4/2) silty clay with weak medium prismatic breaking to moderate medium blocky structure; firm, very sticky and very plastic; common soft concretions (Fe-Mn); abundant fine and medium yellowish brown (10YR 5/4, moist) mottles; common large and medium pores; thick continuous clayskins; moderately acid (pH 5.9) gradual boundary.

B22 33-43 inches, dark grayish brown (2.5Y 4.4/2) silty clay with moderate medium prismatic breaking to moderate medium blocky structure; firm, very sticky and very plastic; few concretions (Fe-Mn); common medium yellowish brown (10YR 5/4, moist) mottles; common large and medium pores, thick continuous clay skins; slightly acid (pH 6.5) clear boundary.

B3 43-60 inches, dark yellowish brown (10YR 4/4) silty clay loam with moderate coarse prismatic structure; slightly firm, sticky and plastic; few faint mottles; common medium pores; thick continuous clay skins on vertical surfaces; neutral (pH 6.9) gradual boundary.

C1 60+ inches, brown to dark brown (10YR 4/3) silt loam; massive; friable sl. sticky, sl. plastic; few faint mottles; few medium pores; neutral (pH 6.6).

Dayton silt loam

| Depth (inches) | Horizon | Mechanical Analysis % Sand | % Silt | % Clay |
|---|---|---|---|---|
| 0-9 | Ap | 5.80 | 74.38 | 19.82 |
| 9-16 | A21 | 7.12 | 71.40 | 21.48 |
| 16-24 | A22 | 7.20 | 66.96 | 25.84 |
| 24-33 | B21 | 4.57 | 55.32 | 40.11 |
| 33-43 | B22 | 2.62 | 55.64 | 41.74 |
| 43-60 | B3 | 4.32 | 68.03 | 27.65 |
| 60+ | C1 | 9.15 | 66.13 | 24.72 |

| Horizon | Organic Matter % O.M. | % C | % N | C:N | Extractable Cations (meq/100g.) Ca | Mg | K | CEC | pH | Phosphorus (ppm.) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ap | 2.56 | 1.48 | .131 | 11.3 | 4.0 | 1.3 | 0.27 | 12.8 | 4.7 | 35.5 |
| A21 | 0.76 | 0.44 | .061 | 7.2 | 5.0 | 2.5 | 0.19 | 12.6 | 5.3 | 9.0 |
| A22 | 0.55 | 0.32 | .045 | 7.1 | 5.7 | 4.1 | 0.19 | 14.9 | 5.5 | 4.0 |
| B21 | | | | | 12.3 | 10.1 | 0.42 | 27.2 | 5.9 | 2.0 |
| B22 | | | | | 15.2 | 12.5 | 0.46 | 29.3 | 6.5 | 3.0 |
| B3 | | | | | 14.2 | 11.1 | 0.38 | 25.1 | 6.9 | 2.0 |
| C1 | | | | | 12.3 | 9.4 | 0.38 | 22.1 | 6.6 | 7.5 |
| Composite plowlayer sample | | | | | 4.8 | 2.0 | 0.32 | 13.6 | 5.5 | 31.5 |

| Depth (inches) | Bulk Density | Moisture Tension Data 15.0 atm. | 5.0 atm. | 2.0 atm. | 1.0 atm. | 0.3 atm. | 0.1 atm. |
|---|---|---|---|---|---|---|---|
| 3 | 1.47 | 8.80 | 13.30 | 19.22 | 26.55 | 27.08 | 28.11 |
| 10 | 1.60 | 9.37 | 13.48 | 18.64 | 22.44 | 25.29 | 26.79 |
| 20 | 1.56 | 15.80 | 20.60 | 25.81 | 26.98 | 28.26 | 29.24 |
| 36 | 1.51 | 22.01 | 28.46 | 34.18 | 34.52 | 35.57 | 35.95 |

Appendix II. Soil Management History of Experimental Sites.

Willamette site

| Year | Crop | Fertilizer |
|---|---|---|
| | | 2 ton of lime/A |
| 1956 | Red clover | -------in 1954 |
| 1957 | Red clover | ------- |
| 1958 | Barley | 40#N/A |
| 1959 | Sweetcorn | 100#N/A |
| 1960 | Sweetcorn | 100#N/A |
| 1961 | Sweetcorn | 100#N/A |

Woodburn site

| Year | Crop | Fertilizer |
|---|---|---|
| 1956 | Field corn | N & P |
| 1957 | Ryegrass trials | 60#N/A |
| 1958 | Ryegrass trials | 60#N/A |
| 1959 | Ryegrass trials | 60#N/A |
| 1960 | Ryegrass trials | 60#N/A |
| 1961 | Cover crop of barley after fallow | None |

Amity and Dayton sites

| Year | Crop | Fertilizer |
|---|---|---|
| 1956 | Ryegrass | 65#N/A |
| 1957 | Ryegrass | 65#N/A |
| 1958 | Ryegrass | 65#N/A |
| 1959 | Oats | 40#N/A |
| 1960 | Sweetcorn | 100#N/A |
| 1961 | Sweetcorn | 100#N/A |

## Appendix III Climatological Data-1962

| Month | Air Temperature (°F) Average Daily Max. | Air Temperature (°F) Average Daily Min. | Air Temperature (°F) Average Daily Mean | Air Temperature (°F) Deviation from Normal | Soil Temperature (°F) Average Daily 4" Max. | Soil Temperature (°F) Average Daily 4" Min. | Soil Temperature (°F) Average Daily 20" Max. | Soil Temperature (°F) Average Daily 20" Min. | Precipitation Monthly Total | Precipitation Deviation from Normal | Evaporation |
|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 43.8 | 29.5 | 36.7 | -2.7 | 39.8 | 36.0 | 44.3 | 42.7 | 1.12 | -5.09 | ---- |
| February | 48.8 | 33.8 | 41.3 | -1.6 | 44.4 | 40.2 | 45.8 | 43.2 | 3.82 | - .97 | ---- |
| March | 51.4 | 35.2 | 43.3 | -3.2 | 48.0 | 41.0 | 46.1 | 44.9 | 6.37 | 2.25 | ---- |
| April | 62.5 | 40.6 | 51.6 | -0.1 | 58.7 | 48.9 | 54.1 | 52.8 | 2.90 | .86 | 3.64 |
| May | 59.5 | 42.4 | 51.0 | -6.0 | 59.6 | 50.8 | 56.7 | 55.5 | 2.31 | .51 | 3.38 |
| June | 72.6 | 45.5 | 59.1 | -2.5 | 74.7 | 60.4 | 65.4 | 63.4 | 0.39 | - .85 | 6.88 |
| July | 80.5 | 48.7 | 64.6 | -2.0 | 81.8 | 67.2 | 72.1 | 70.7 | .00 | - .31 | 8.74 |
| August | 78.2 | 50.0 | 64.1 | -2.3 | 78.1 | 65.8 | 72.7 | 71.4 | .57 | .19 | 6.75 |
| September | 76.1 | 48.5 | 62.3 | -0.4 | 72.9 | 62.6 | 70.0 | 68.9 | 1.60 | .35 | 5.28 |
| October | 61.7 | 43.5 | 52.6 | -1.8 | 56.2 | 52.2 | 60.0 | 59.4 | 4.62 | 1.10 | 1.33 |