# Fertilizing CORN during dry years

Corn Belt Branch
Soil and Water Conservation Research Division
Agricultural Research Service
U.S. Department of Agriculture
Columbia, Missouri

*in cooperation with*
the Missouri Agricultural Experiment Station



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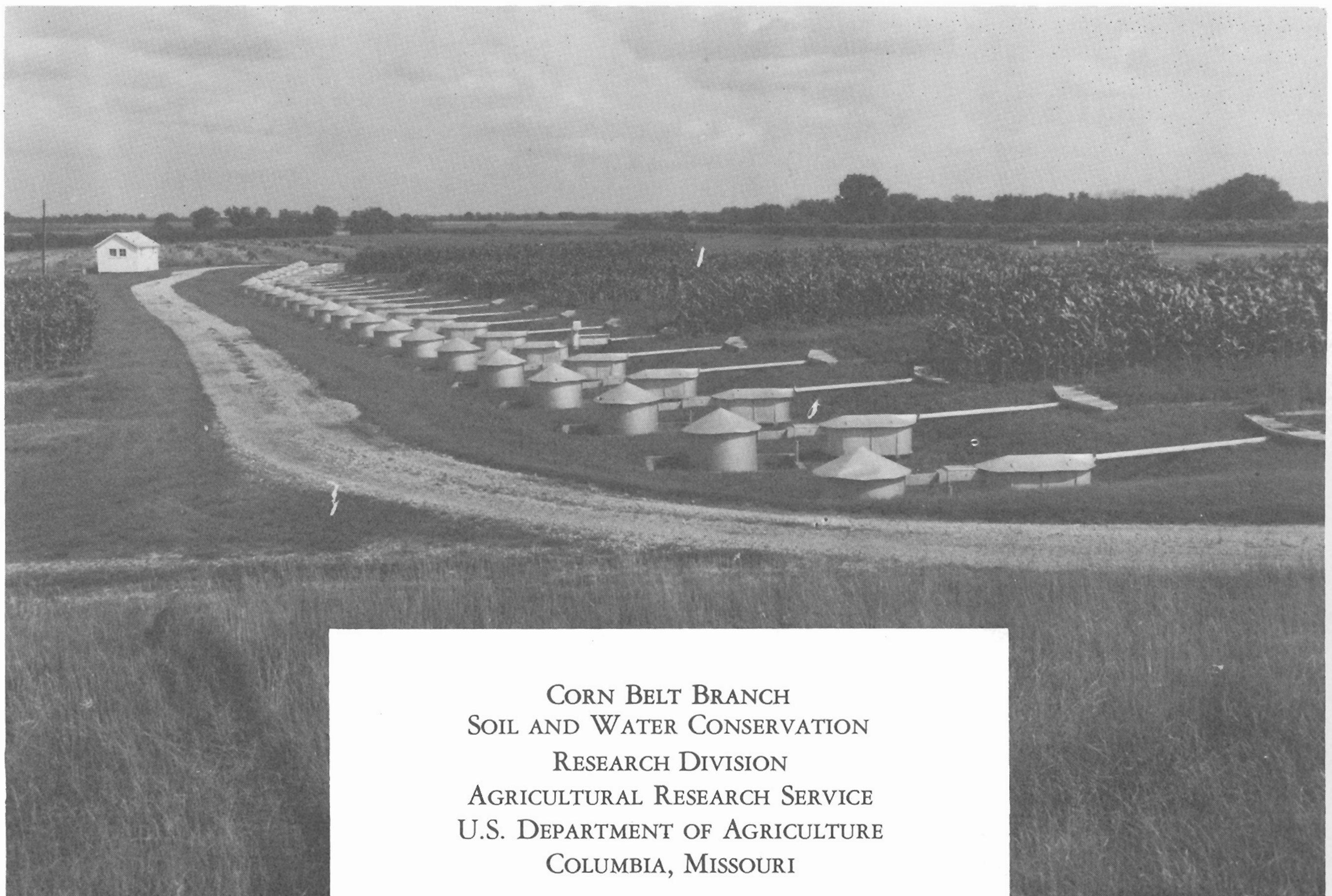


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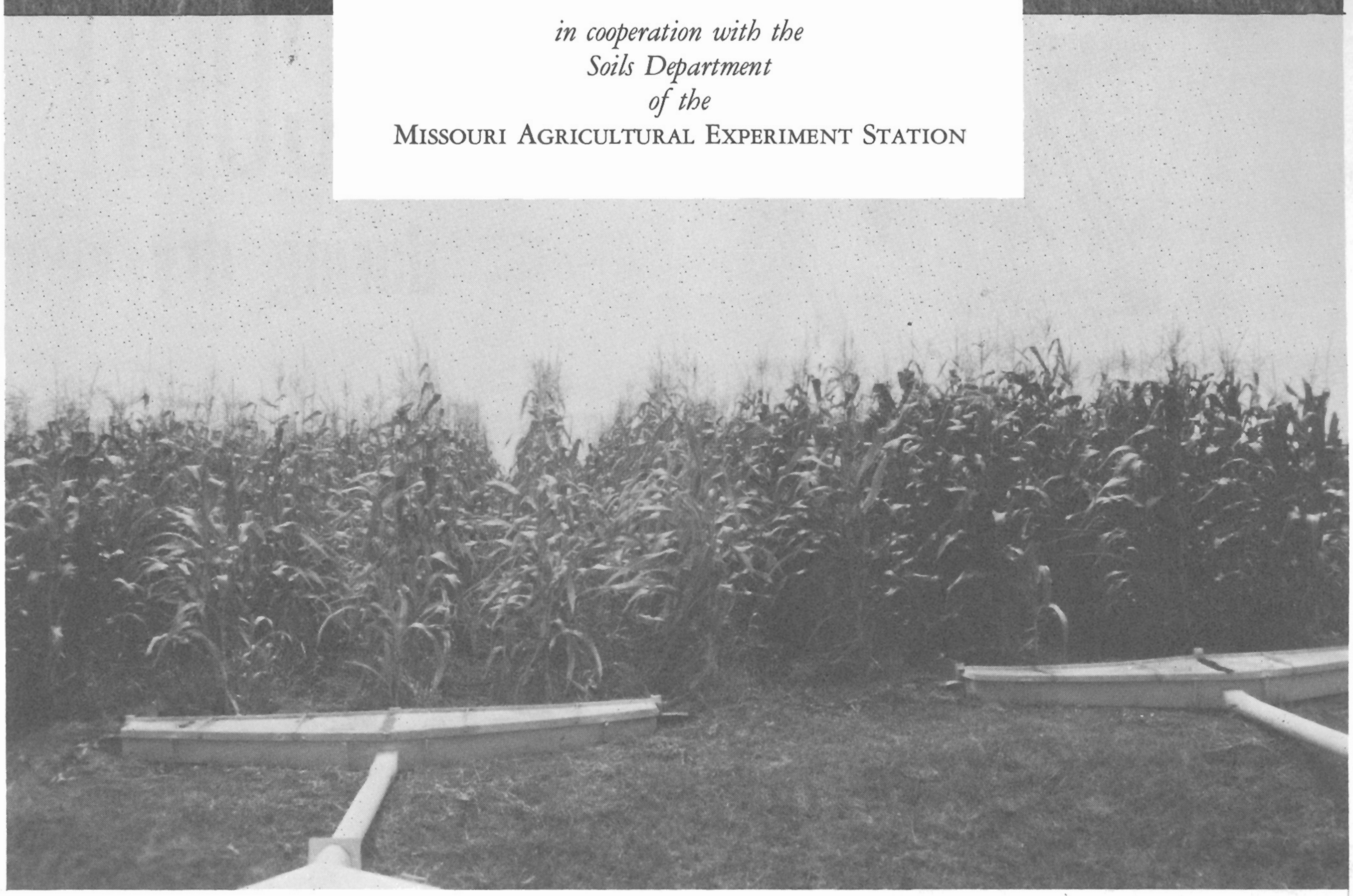


# Fertilizing Corn During Dry Years

## *Results of Experimentation During Three Dry Years at McCredie Claypan Experiment Station*

F. D. WHITAKER AND H. G. HEINEMANN*

Few farmers would consider growing corn on the claypan soils of the Midwest without applying fertilizer. But how much should be applied, especially following seasons with low rainfall or for seasons when drouth is forecast? Farmers do not want to fertilize needlessly, but they are anxious to fertilize if it will pay.

A study of moisture use and corn yield data on the plots of the fertility studies at the Midwest Claypan Experiment Station at McCredie, Mo., (*6*)** shows that it pays to apply enough fertilizer each year to give maximum production. To do otherwise places a limit at planting time on the maximum yield potential. Fertility increases efficiency of the soil moisture (*3*), (*4*).

## Description of McCredie Tests

These studies were started in 1954 to determine the effect of fertility on runoff, soil loss, soil moisture, and crop yields under several cropping systems. The 34 small (0.0217-acre) plots used in the study are 10.5 by 90 feet, with 7-foot border strips between plots. They are tilled with regular farm equipment, lengthwise with the slope (approximately 3 percent). The crop and fertility variables include rotations of corn-wheat-meadow-meadow with starter- and full-fertility treatments, continuous corn at both fertility levels, and corn-oats with no fertility treatment. Two other plots are kept in continuous fallow and are used for comparison.

Seedbeds for corn in rotation and continuous corn are prepared in the conventional manner of plowing and disking, except that on one treatment of continuous corn a form of minimum tillage is used. In this treatment, the seedbed is prepared with a field tiller, which leaves crop residues near the surface. Each treatment is replicated.

### Irrigation Test Added

A study of the effect of irrigation on runoff, erosion, and yields from continuous corn was added in 1958. Furrow irrigation was applied at a soil moisture deficiency of 3 inches in the 0- to 36-inch zone. Conventionally tilled and field-tilled corn seedbeds were used.

Soil tests to determine the nutrient level of the corn plots on all of the treatments are made each year. In the "full fertility" treatment (*2*), lime, phosphate, and potash are applied, as needed, to maintain nutrient levels of phosphate ($P_2O_5$) at 200 pounds per acre, lime (Ca) at 80 percent saturation, and potash at 2.4 percent saturation. For corn in the C-W-M-M rotation, these nutrients, if needed, and 66 pounds of nitrogen (N) per acre are applied before plowing; starter fertilizer (5-20-20) is applied at 200 pounds per acre at corn planting; and 66 pounds of N per acre is applied as sidedressing when

*The work reported in this bulletin is a contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, in cooperation with the Soils Department of the Missouri Agricultural Experiment Station. F. D. Whitaker is hydraulic engineering technician and H. G. Heinemann is hydraulic engineer, ARS, North Central Watershed Research Center, USDA, Columbia, Mo.

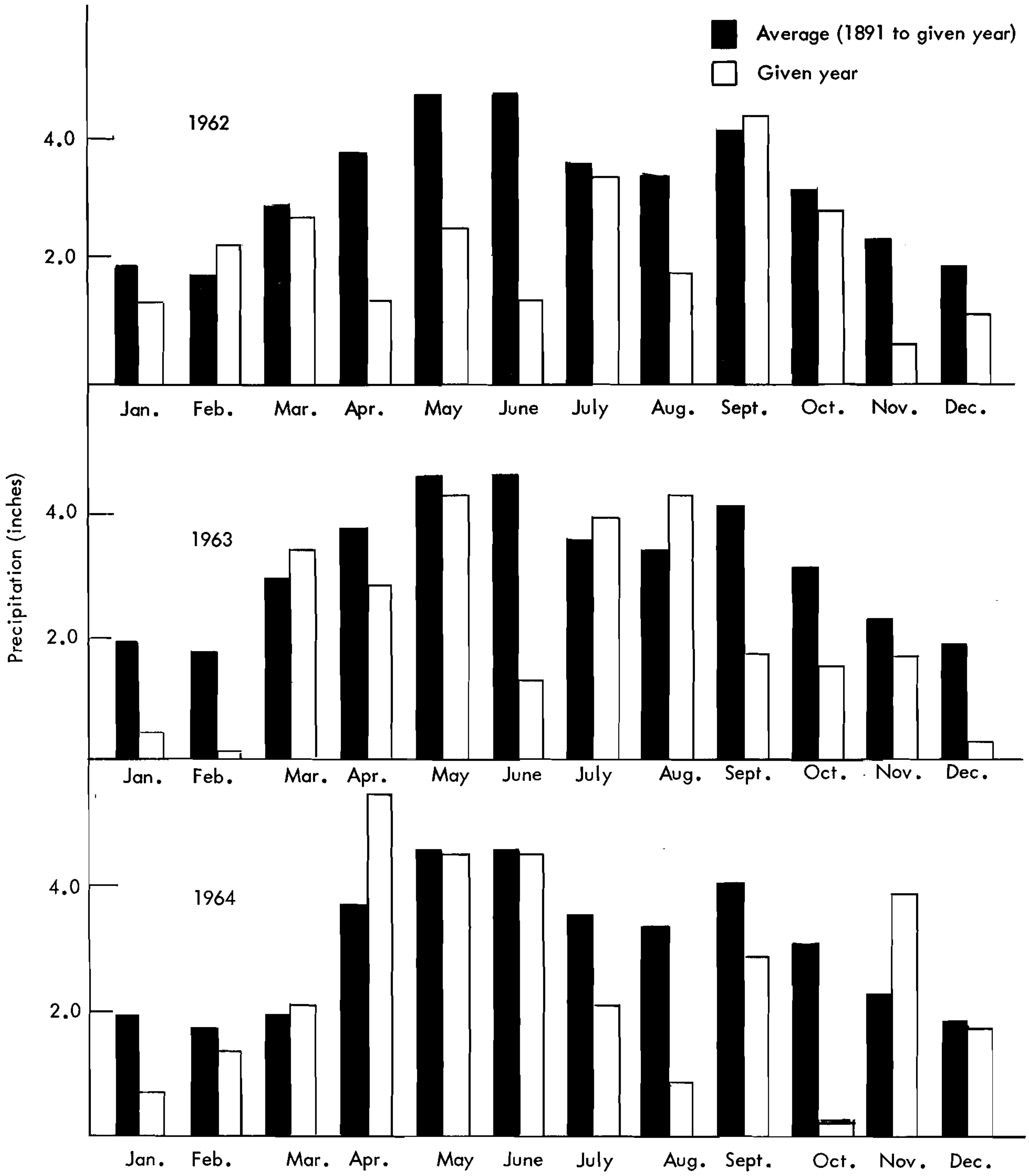
**Italic numbers in parentheses refer to Literature Cited, p. 11.

the corn is about 10 inches tall. The fertility treatments for continuous corn are the same, except that 100 pounds of N is plowed down or tilled in before planting. Nitrogen at the rate of 66 pounds per acre is applied before tillage for wheat, and starter fertilizer (5-20-20) is applied at 200 pounds per acre at seeding. The first- and second-year meadows in the full-fertility plots receive three applications of 33 pounds of N per acre March 1 and after the first and second cuttings.

The "starter fertility" treatment consists of the application of starter fertilizer only, on continuous

**FIGURE 1**

**MONTHLY PRECIPITATION FOR THE PERIOD 1962-1964 AND THE LONG-TERM AVERAGE (1891 TO 1964)**



corn, and on the corn and wheat crops in the corn-wheat-meadow rotation. The application rate for corn is 200 pounds of 5-20-20 at planting time. Nitrogen at the rate of 40 pounds of 5-20-20 at 200 pounds per acre is applied at wheat seeding. The meadows in this treatment are not fertilized.

### Precipitation 10 Inches Below Normal

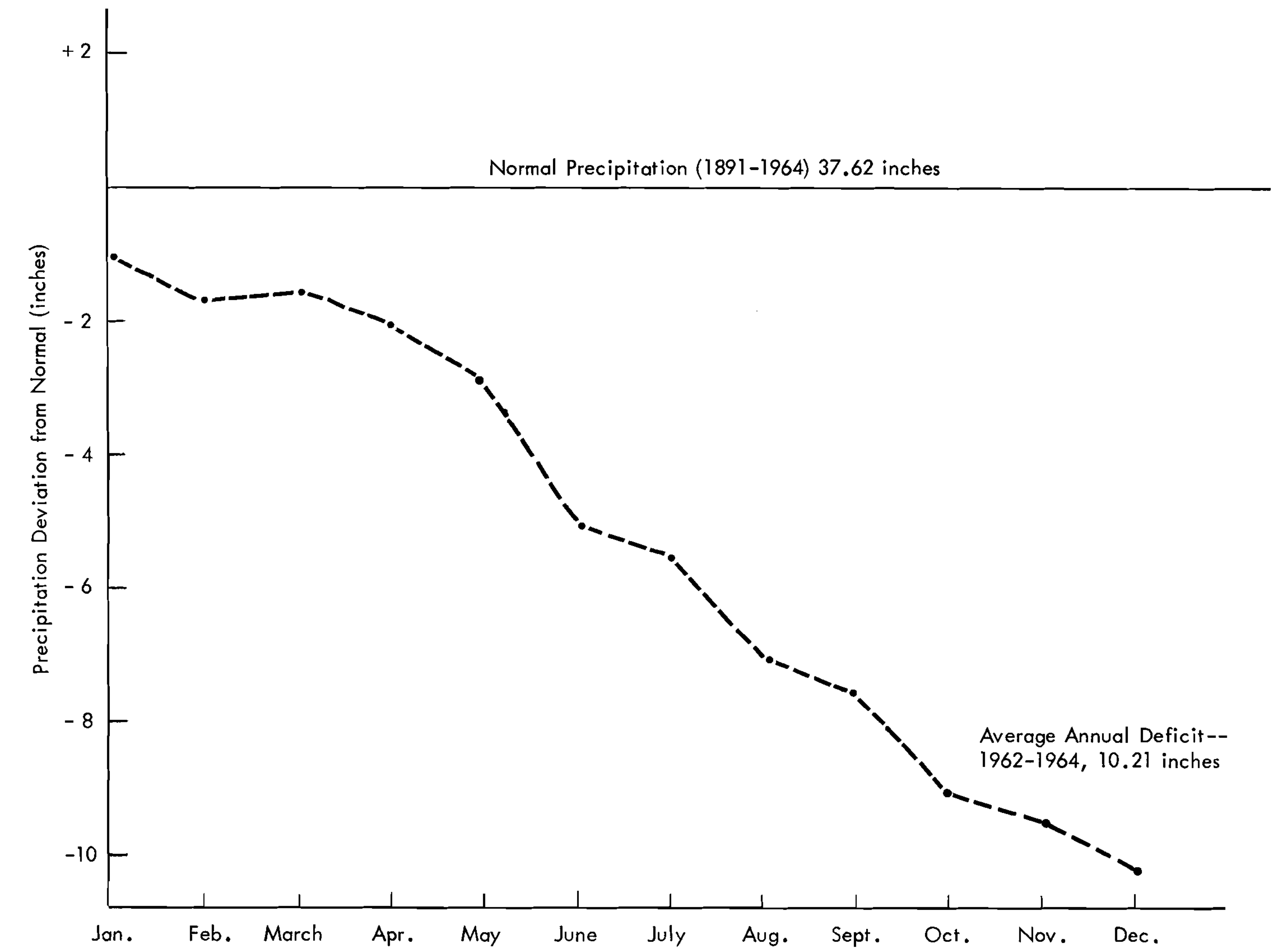
Figure 1 gives a comparison of the precipitation, by months, during the three consecutive dry years of this study (1962-1964) with the long-term (1891-1964) averages. There was a precipitation deficiency each of the three years during the critical growing period. The accumulative average monthly deviation of these three years from the long-term average is shown in Figure 2. The average annual deficit was 10.21 inches from the long-time average precipitation for this area (37.62 inches per year).

The average precipitation during the period between corn-growing seasons (October 3-April 6) for the three years was 10.24 inches, nearly 4.50 inches less than the long-time (1891-1964) average. However, the soil moisture in the 12- to 36-inch zone was near field capacity each year at corn-planting time on all of the treatments.

### Shredded Stalks

Shredded stalks provide excellent conditions for fast recharge of soil moisture during the fall and

**FIGURE 2**
**CUMULATIVE DEVIATION OF PRECIPITATION DURING 1962-1964 FROM 1891-1964 AVERAGE**



winter months. The stalks are shredded soon after the corn harvest so they help protect the soil surface from raindrop impact and surface sealing during rains and runoff.

Soil moisture measurements were made in 1-foot increments to a depth of 3 feet at planting and when the corn plants were practically mature (September 20). The evapotranspiration from corn with adequate fertility was slightly higher than the amounts measured because moisture was also used from a greater depth.

## What the Tests Revealed

### Slight Effect on Water Use

Soil moisture measurements in the 0- to 36-inch depth showed that the total moisture (evaporation and transpiration) used during the corn-growing period (April 7 to October 2) during the dry years by continuous corn receiving full-fertility averaged 18.9 inches. Comparable corn with starter fertilizer used 18.5 inches, only 0.4 inch less than that used by the corn with the high-fertility level. The avarage yield from the adequately fertilized corn during these drouthy seasons was 100 bushels per acre. The yield from the corn receiving only starter fertilizer was only 36 bushels per acre.

The average evapotranspiration from continuous corn receiving adequate fertility treatments and supplemental irrigation, as needed, was 23.8 inches during the corn-growing period. The average corn yield for the 3-year period was 130 bushels per acre.

Evapotranspiration from corn in the corn-oats rotation (no fertility treatment) was 17.1 inches per year, and the average yield was 17.0 bushels per acre. Soil moisture removed by evaporation from fallow plots for the same period averaged 15.8 inches per year.

These figures show relatively small differences between water losses by evapotranspiration with good vegetal cover and evaporation from poorly covered or bare soils. This shows that the water was successfully channeled through the plants rather than directly from the soil to the atmosphere.

Figure 3 shows relationships developed between average corn yields and evapotranspiration rates per bushel of corn produced on these plots during the period 1962-1964.

### Full Fertility Gave 5 Bu. per Inch Water

Since peak moisture requirements of corn plants are considerably lower for several weeks before the final sampling date, enough rainfall usually occurs to partially recharge the soil moisture in the 3-foot profile. However, the final 1964 samples were taken before appreciable rainfall occurred. These measurements show that adequately fertilized corn removed about 0.2 inch more soil moisture from the 0- to 24-inch depth and about 0.7 inch more from the 24- to 36-inch depth than corn with only starter fertilizer; also, runoff in 1964 was 0.85 inch less than from corn with starter fertilizer only. Practically all moisture used by corn grown without fertilizer was obtained from the 0- to 24-inch soil layer.

Corn with adequate fertility produced more than 5 bushels of grain per inch of soil moisture removed by evapotranspiration, corn with only starter fertilizer produced 2 bushels per inch of soil moisture, and corn without fertility treatments produced only 1 bushel per inch of soil moisture used (*1*). The moisture used per bushel of corn produced was not increased by supplemental irrigation; however, corn yields were 30 and 34 bushels per acre more than without irrigation. Three irrigations were applied in 1962 and 1963, and two in 1964. Total annual applications were 7.65, 6.25, and 3.50 inches, respectively.

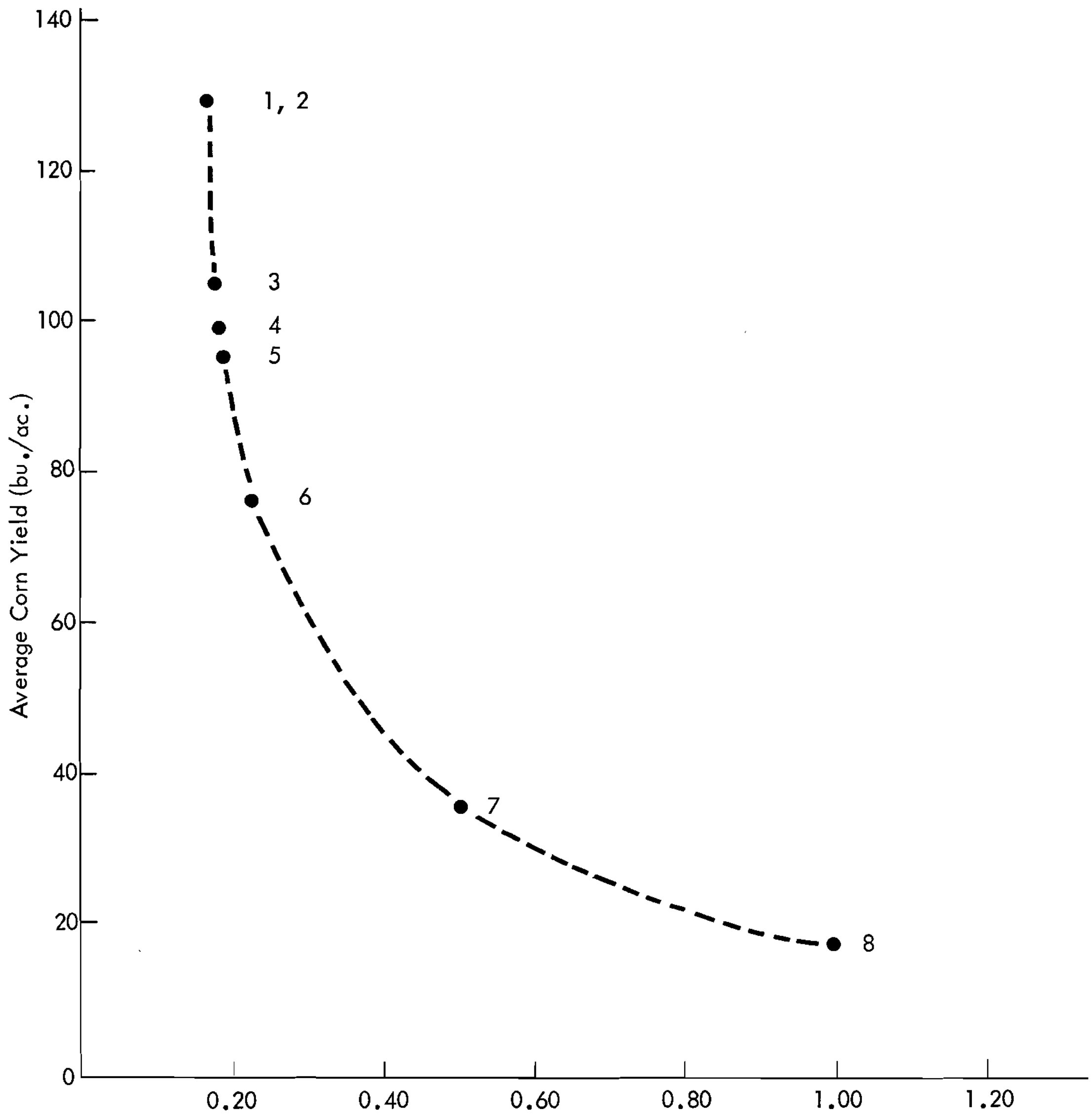
### Fertility and Crop Canopy

The leaves of corn plants grown with adequate fertility covered the area between the corn rows about 3 weeks sooner than corn with only starter fertility. Corn grown without fertilizer seldom provided a complete canopy during the growing season. The improved cover provided more shade, thereby reducing soil moisture loss by evaporation. Soil surface sealing and soil loss by raindrop impact were also reduced by the better vegetative canopy.

### High Fertility Cuts Runoff

Runoff losses are shown in Figure 4 for the corn-growing period (April 7 to October 2) and stalk period (October 3 to April 6) for each of the seven test conditions. The average yearly loss for each of the various conditions is also given. Although runoff losses were relatively low from all treatments, the value of good soil cover was evident. Runoff from corn with a full fertility treatment and with a field-tilled seedbed was very low during the growing

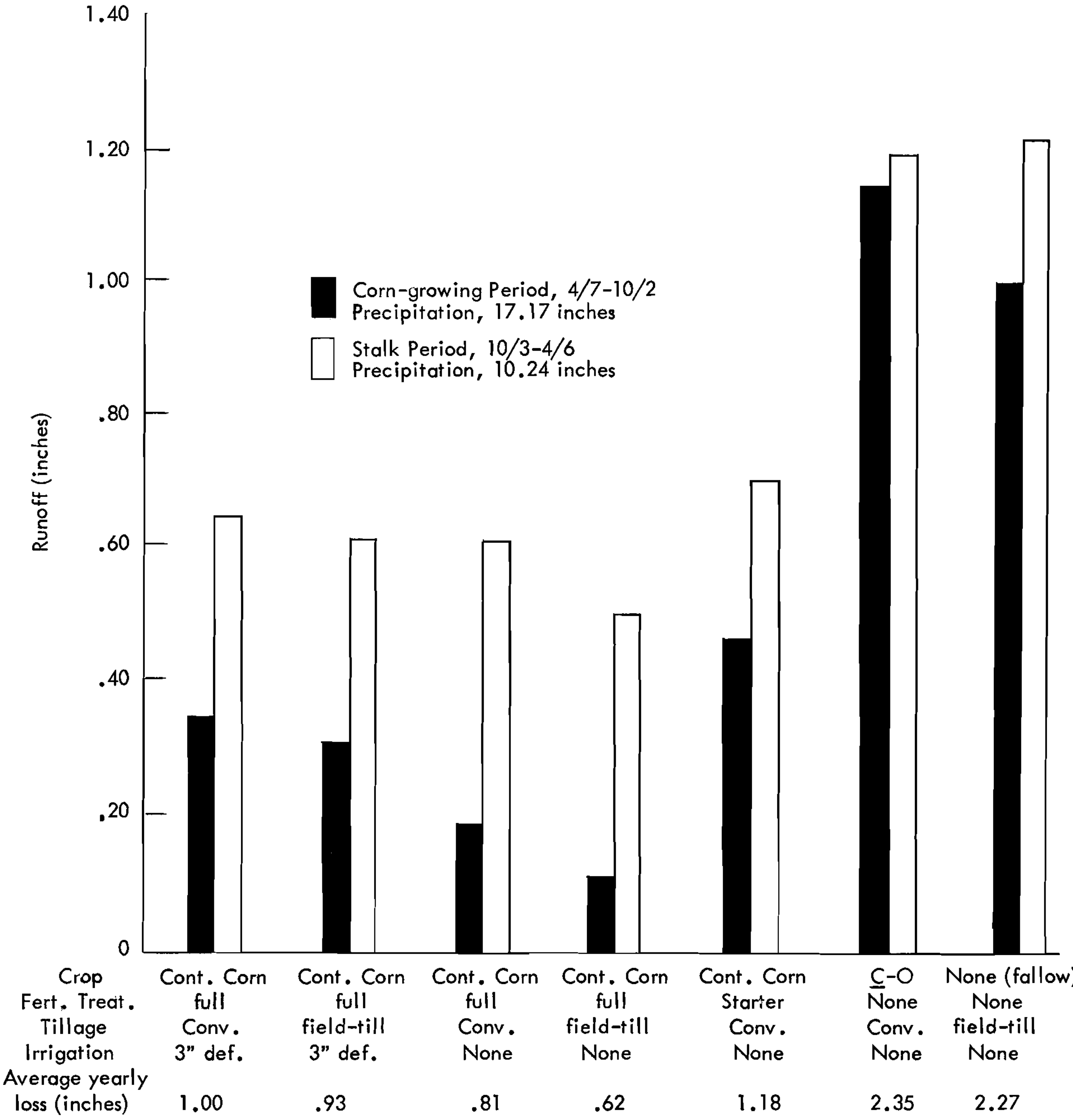
**FIGURE 3**
**AVERAGE CORN YIELD-EVAPOTRANSPIRATION RELATIONSHIP**




Average Evapotranspiration (inches per bushel) from corn planting to maturity (approximately September 30) for the period 1962 to 1964.

| | Crop Sequence | Fertility Treatment | Type of Tillage | Irrigation |
|---|---|---|---|---|
| 1 | Continuous Corn | full | Conventional | 3" def. (0-48") |
| 2 | Continuous Corn | full | Field-tilled seedbed | 3" def. (0-48") |
| 3 | Corn in C-W-M-M rotation | full | Conventional | None |
| 4 | Continuous corn | full | Conventional | None |
| 5 | Continuous corn | full | Field-tilled seedbed | None |
| 6 | Corn in C-W-M-M rotation | Starter | Conventional | None |
| 7 | Continuous corn | Starter | Conventional | None |
| 8 | Corn in corn-oats rotation | None | Conventional | None |

**FIGURE 4**
**EFFECT OF FERTILITY, TILLAGE, AND SUPPLEMENTAL IRRIGATION ON RUNOFF BY CROP PERIODS. LOSSES ARE THE AVERAGE FOR THE PERIOD 1962-1964.**




season. This was the result of good crop cover as well as residue from the previous corn on or near the soil surface (*5*). The transpiration rate of the more vigorous plants was also increased, thereby reducing runoff since more water storage was available in the soil. Runoff during the growing period from all of the corn with full-fertility treatment and without irrigation was more than 50 percent lower than from corn with only starter fertilizer.

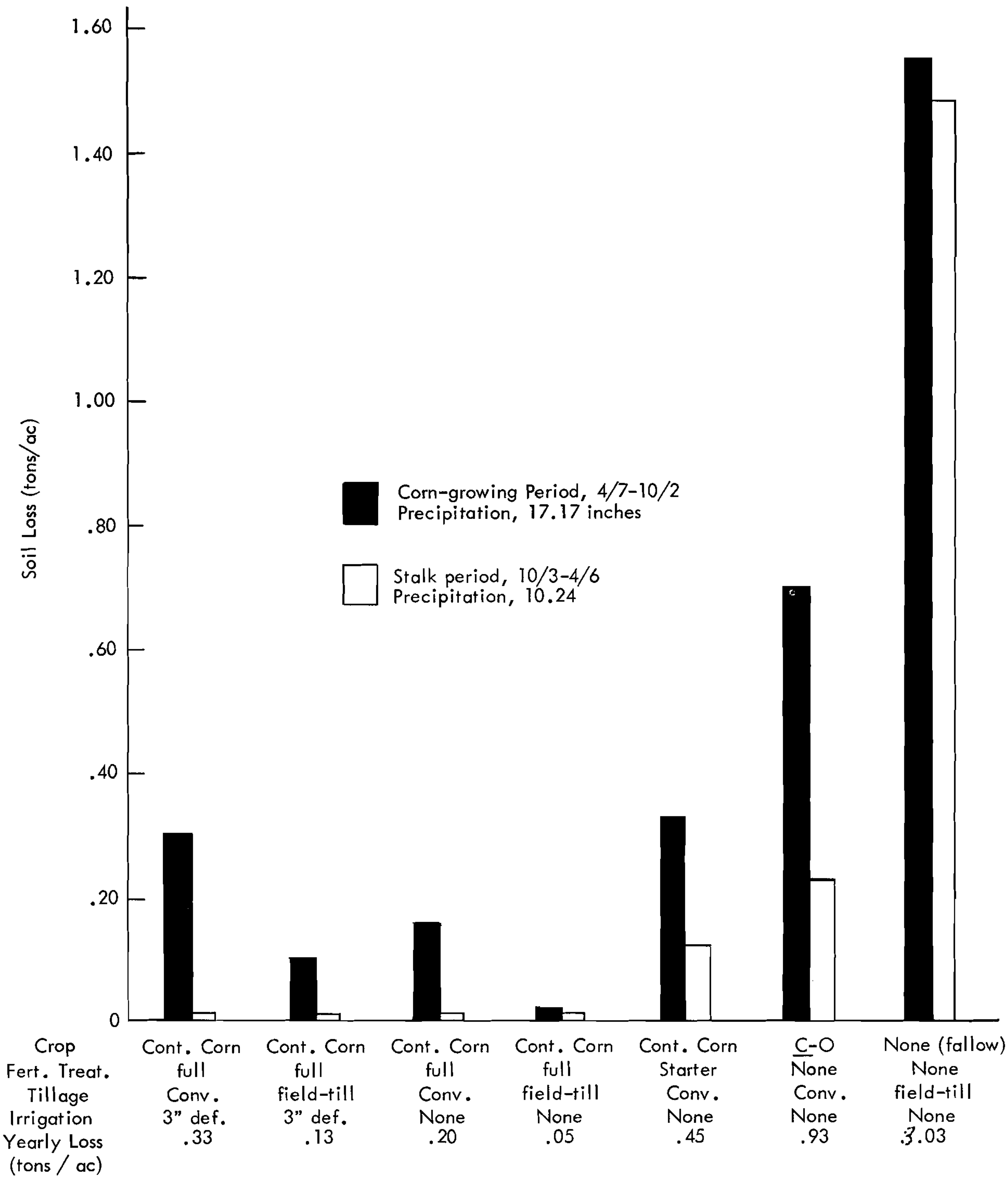
Runoff during the growing season from the unfertilized corn in the corn-oats rotation was about six times that from adequately fertilized corn. The poor cover and low transpiration rate of the unfertilized corn permitted runoff losses about equal to those from fallow soil.

### Fertility and Soil Loss

Average soil losses for the three-year period for the fertility, irrigation, and rotation conditions included in this study are shown in Figure 5. Information is given for the corn-growing period and the stalk period. The effect of fertility in reducing soil loss was outstanding.

The effects of the higher evapotranspiration rates and heavier stalk cover provided by the adequately fertilized corn are reflected in Figures 4 and 5. Runoff was less during the growing seasons than during the stalk periods, even though the rainfall

**FIGURE 5**
**EFFECT OF FERTILITY, TILLAGE, AND SUPPLEMENTAL IRRIGATION ON SOIL LOSS BY CROP PERIODS. LOSSES ARE THE AVERAGE FOR THE PERIOD 1962-1964.**



intensities were usually higher during the growing season. However, soil losses were higher during the growing season, since the soil did not have a good crop cover until about 6 to 8 weeks after corn planting. Soil losses after the stalks were shredded were very low from the adequately fertilized corn.

## Summary


Study underway since 1954 to evaluate the effect of fertility on soil moisture, crop yields, runoff, and soil loss under several different crop rotations provided a unique opportunity to answer questions on the value of full fertility during periods of below-normal precipitation. For three consecutive years, 1962-1964, there was an average annual deficit of 10.21 inches from the long-term average precipitation for this area. The data obtained during this period showed how adequate fertilization of corn paid off.

Data and observations for the entire period of study, and especially for the 1962-1964 period of three drouth years, showed that:

1. Adequately fertilized corn plants were more efficient users of soil moisture than those grown with only a moderate amount of starter fertilizer. Corn with full-fertility treatments produced more than 5 bushels per inch of moisture used, but corn with only starter fertility produced just 2 bushels per inch of soil moisture removed. Where no fertilizer was applied, corn produced only 1 bushel per inch of soil moisture removed.
2. Adequate fertility increased root development in the 0- to 24-inch zone and promoted deeper rooting.
3. Soil moisture available in the 0- to 36-inch zone at corn planting time was not decreased during the three consecutive years, even with an average annual precipitation deficit of 10.31 inches.
4. Adequate fertility promoted rapid early growth of the plants at the time when soil moisture was usually abundant (May-June). This provided an early canopy.
5. Rapid early growth of corn materially reduced runoff and erosion losses.

Although the use of adequate fertility did not increase the moisture supply, the amount available to corn plants may have increased significantly. During 1964, adequately fertilized corn removed 0.90 inch more soil moisture from the 0- to 36-inch depth, and runoff was 0.85 inch less than from corn grown with starter fertilizer only. In many seasons, this additional moisture could be the difference between a good crop and a poor crop.

# Literature Cited


(1) Anonymous.
1953. Less Water Required per Bushel of Corn with Adequate Fertility. Missouri Farm News Service.

(2) Graham, E. R.
1959. An Explanation of Theory and Methods of Soil Testing. Missouri Agricultural Experiment Station Bulletin 734, 20 pp. July.

(3) Jamison, Vernon C.
1957. Make Full Use of Stored Soil Moisture. Journal of Soil and Water Conservation 12(3): 122-125.

(4) Smith, Dwight D.
1954. Fertility Increases Efficiency of Soil Moisture. Better Crops with Plant Food. 38 (6): 11-12, 39.

(5) Smith, Dwight D.
1950. Soil and Water Losses Reduced by Improved Fertility. USDA Soil Conservation 15(11): 254-257. Beltsville, Maryland.

(6) Whitaker, F. D., Jamison, V. C., and Thornton, J. F.
1961. Runoff and Erosion Losses from Mexico Silt Loam in Relation to Fertilization and other Management Practices. Soil Science Society of America Proceedings 25(5): 401-403.