March 6, 1961

To the Graduate Council:

I am submitting herewith a thesis written by Rural Allen Peace entitled "The Productivity of Huntington, Waynesboro and Dickson Soils for Corn Under High Levels of Management." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agronomy.

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THE PRODUCTIVITY OF HUNTINGTON, WAYNESBORO AND DICKSON SOILS FOR CORN UNDER HIGH LEVELS OF MANAGEMENT

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Rural Allen Peace

March 1961

21
33

ACKNOWLEDGEMENTS

The writer wishes to express his gratitude and appreciation to:

Dr. Frank F. Bell for his guidance, encouragement and helpful advice in all phases of the graduate program in addition to directing the study.

Dr. O. H. Long and Mr. H. A. Henderson for serving on the author's graduate committee.

Mr. Charles R. Graves for his helpful suggestions in organizing and writing the thesis.

Mr. Robert G. Palmer, Paulus P. Shelby and personnel of the Putnam County Soil Survey Party, George T. Jackson, Buel C. Cox, Charles R. Gass and Sam R. Bacon for their cooperation and assistance with the field work.

The Soil Conservation Service, the Tennessee Valley Authority, the National Plant Food Institute, Tennessee Cooperation and the University of Tennessee Agricultural Experiment Station for making this study possible.

Other members of the University Staff for their cooperation and helpful suggestions.

Agricultural workers and farmers of Putnam County who cooperated in this study.

479738

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CHAPTER I

INTRODUCTION

Soil productivity is the capacity of a soil to produce crops and is subject to three major influences: the inherent productivity of the soil, the management practice and climate. For many years there has been a recognized need for information on the productive capacity of soils and their response to various management inputs and amounts of these inputs under different environmental conditions. Since the many soil types in Tennessee vary greatly in their ability to produce crops, this information is needed in order for farmers to better utilize their land and other resources by selecting the best cropping system and management level.

A preliminary study[1] of the productivity of Huntington, Waynesboro and Dickson soils in 1958 showed that these soils have different productive capacities for corn at low to moderate levels of management and also that these soils do not respond alike to given inputs and, therefore, require different management.

The objective of this study in Putnam County was to determine the maximum productive capacity of these same three soils for a given year and their response to certain management variables at high levels of inputs.

1/ Graves, Charles R. The productivity of Huntington, Waynesboro and Dickson soils for corn. Unpub. M.S. thesis, University of Tennessee, Knoxville, Tennessee. 1959.

CHAPTER II

LITERATURE REVIEW

I. SOIL PRODUCTIVITY

The primary function of soil productivity ratings is to establish the absolute or relative productivity of individual soil types for specific crops under definite systems of management. The importance of management practices as related to the productivity ratings of soils was clearly shown by Bauer et al. (2) in summarizing the work done over several years in Illinois. They stated that appropriate chemical treatments greatly reduced soil productivity differences. Smith (21) stated that the classification of soils based on their capacity to produce corn is closely associated with their ability to supply essential nutrients and moisture. In many cases, if the necessary elements are made available, the soils formerly considered unsuited to this crop can produce profitable yields. Odell (17) indicated that levels of management should be defined when measuring and comparing productivity among soils. Bell and Springer (3) pointed out that soils vary greatly in their capacity to produce crops and in their response to soil and crop management practices.

As far back as 1937, Ableiter (1) showed the value of productivity ratings of soils at the "poor" and "better than average" levels of management, but he also stated that there was an even

greater need for obtaining yield data for rating the productive capacity at a high level of management.

Since a soil productivity rating is an attempt to predict, or estimate, the crop yields that may be expected under specified conditions, the degree of prediction accuracy is very important. Concerning the accuracy of productivity ratings, Smith and Smith (22) found that, with sufficient yield data at a given management level, the productivity of a given soil for a specific crop can be predicted with a reasonable degree of precision. Odell and Smith (18) indicated that when farms are carefully classified according to soil management practices, the average long-time farm yield of a given crop tends to cluster rather closely about the average yield for that soil type.

II. INTER-RELATIONS OF FERTILIZATION, MOISTURE SUPPLY AND PLANT POPULATION

In any study on the productivity of soils for corn and the response of the crop to fertilization, it is important for best interpretation of the data concerned that the inter-relations of moisture supply and plant population with fertilization be considered. Smith (21), working with 6, 8, 12 and 18,000 plants per acre at different fertility levels, got increased yields up to 18,000. As a result of these experiments, he stated that, in order to obtain maximum benefits from higher fertilizer levels, it is necessary to increase the rates of planting. Long (12) stated that the optimum

planting rate of corn largely depends on the fertility of the soil and its capacity to deliver water. He also stated that a stand not exceeding 12,000 plants per acre appears to be best for good corn soils in Tennessee. Parks and Overton (19), using a full-season prolific hybrid, found that during relatively dry years a plant population of 12,000 per acre produced a yield comparable to that obtained from a lower population. Russ[2], working with 8, 12, 16, 20 and 24,000 plants per acre on State loam with different rates of nitrogen fertilization, obtained a maximum yield of 136 bushels per acre with 24,000 plants and an application of 180 pounds of nitrogen per acre. Even though it is possible for moisture stress to reduce or eliminate fertilizer response, numerous experiments have shown that plants growing on fertile soils generally make more efficient use of the available soil moisture than plants growing on soils low in fertility.

MacGregor (13) found that a shortage of soil moisture during the growing season can reduce or eliminate fertilizer effects, even with adequate corn population and with all other growth factors at an optimum. Montgomery and Kiesselbach (15) measured the water requirement of corn as influenced by fertility levels. They observed a marked reduction in the water requirement with increasing soil

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2/ Russ, Porter L. Measurement of soil productivity on four selected soils in terms of corn yields. Unpub. M.S. thesis, University of Tennessee, Knoxville, Tennessee. 1958.

fertility. Hanks and Tanner (9), working with corn and oats in Wisconsin, showed the effects of fertility level on water use. In every comparison they found that there was more efficient use of water under high fertility treatments than under low fertility treatments. In 1949 and 1950, corn yields per inch of water used were on the average 1.4 times greater on the high-fertility plots than on low-fertility plots. Kelly (11), after reviewing the literature on water usage, stated that fertility level has a marked effect on the efficiency of water use by plants. When even higher yields were obtained with increased fertilization, there was a corresponding increase in the efficiency of water use.

III. EFFECT OF ROW SPACING

The development of chemicals for weed control in corn, the use of which makes it possible to grow corn without cultivation, has resulted in some investigations on the feasibility of closer row spacings. Present corn row spacing of 38 to 42 inches is probably a holdover from the time when cultivators were horse-drawn and the row had to be wide enough to accomodate the animal, and which may not be best from the standpoint of yield. Bryan et al. (4) compared 21 by 21 inch spacing with 42 by 42 inch spacing with 14,224 plants per acre at each spacing for a 4-year period in Iowa. In 2 of the 4 years, the yield of the narrower rows exceeded that of the standard rows (42 inches) significantly; however, the closer

spacing consistently had more lodged plants than the wider spacing. Mederski and Hoff (14) found that a 20-inch row spacing not only produced 6 to 10 bushels more per acre, but also reduced the percentage of nubbins and increased the number of ears per plant. They credited this increase to increased shading of soil surface, more conservation of soil moisture, more uniform utilization of soil moisture, and improved utilization of solar energy. They also observed that the 20-inch row spacing provided a more uniform vegetative cover early in the season. This resulted in reduced soil erosion and better weed control. Strickler and Laude (23) noted a significant response from cultivating 20-inch rows, but corn performance in narrow uncultivated rows was unsatisfactory.

IV. ROOTING DEPTH

One of the important factors in explaining variations in yields on different soil types is the difference in the effective rooting depth of plants. Fehrenbacher and Rust (6) studied the depth of corn root penetration in four Illinois soils. They found that the depth of root penetration and available soil moisture storage capacity in acre inches of water to these depths were 54 inches and 10.6 acre inches, respectively, in Saybrook; 48 inches and 9.8 acre inches in Ringwood; 36 inches and 7.1 acre inches in Elliott; and 38 inches and 6.4 acre inches in Clarence. They suggested that the differences in depth of root penetration and in available soil moisture in the rooting zone are probably the main

factors responsible for differences in the long-time average yields on these soils.

Winters and Simonson (26) stated that the difficulties of root penetration are due to one or more of the following soil characteristics: high bulk density, low porosity, restricted aeration, or low fertility.

Corn rooting depth may be increased by soil treatment. Fehrenbacher and Snider (7) showed that soil treatment, including legumes turned under, increased crop yield on a Cisne soil. This soil treatment increased yields by adding needed plant nutrients and by inducing corn root penetration and development into the lower soil horizons, which made it possible for plants to reach and use moisture at greater depths.

V. LODGING

With the increased use of corn pickers, lodging of corn has become a more serious problem. Mechanical harvesters cannot recover all the ears from lodged stalks, thus resulting in a loss of grain to the farmer. Lodging is a serious fault of some corn varieties, and even the most resistant varieties lodge under certain conditions. Nelson (16) stated that the degree of lodging increased progressively with plant populations ranging from 9,300 to 26,200 plants per acre, and that nitrogen increased lodging slightly, but was over-balanced by increased yields. He also said that cultivation did not affect

lodging. Bryan and co-workers (4), working within a range of 10,000 to 20,000 plants per acre, concluded there was no yield advantage in having more than 14,000 plants per acre and that lodging increased materially at the higher populations. Long (12), experimenting with 8,000, 12,000 and 16,000 plants per acre, found that high plant population was a more important factor in inducing lodging than was rate of nitrogen. Hall (8), working under natural rainfall conditions, reported no relationship existed between lodging and ear height, cross section of stalk or weight of ear. Wilson (25), reported that plant height was associated with the vigor of a particular strain and was unrelated to lodging.

CHAPTER III

GENERAL DESCRIPTION OF AREA AND SOILS

This study was conducted in Putnam County, which is located in middle Tennessee. Putnam County consists of three physiographic regions, viz., Cumberland Plateau, Highland Rim and Outer Basin. The soils studied occur on the Highland Rim and Outer Basin only and are developed largely from limestone-derived parent materials. Of the three soils studied, Dickson and Waynesboro are on the Highland Rim while Huntington is found on the Highland Rim and in the Outer Basin. The Huntington found in the Outer Basin is higher in phosphate content than the Huntington found in the Highland Rim.

The Huntington soils are deep, friable, and well drained. They are composed of young sediments on first bottoms and in depressions and are derived largely from limestone uplands. They have a dark brown surface and a friable dark brown to dark yellowish brown subsoil. Beneath the subsoil are stratified layers of different textures that contain some fine chert, gravel, pebbles, and sand. (A profile description of Huntington is shown in Appendix A.) They occupy level to gently-sloping flood plains and narrow bodies of local alluvium along small drainageways and areas at the base of slopes. These soils are slightly acid to mildly alkaline. They are high in natural fertility and organic matter. Although they are important agricultural soils, they are of limited

extent in Putnam County. They occur mainly in the Waynesboro-Holston-Baxter soil area on the Highland Rim and in the Dellrose-Rockland-Mimosa soil area in the Central Basin. The original vegetation was mixed hardwood forest, including oaks, poplar, elm, maples, hickory and ash. Nearly all these soils are cleared and are used principally for producing corn. They are excellent soils for row crops. The main problem in their use is occasional stream overflow.

The Waynesboro soils consist of deep, well-drained, moderately-acid soils developed on relatively old, high-stream terraces. Where uneroded, they have a yellowish brown to brown silt loam or loam surface and a yellowish red silty clay loam or clay loam friable subsoil. The Waynesboro soil series has developed from general alluvium washed from uplands underlain by a variety of sedimentary rocks such as limestone, shale and sandstone. Most of the Waynesboro soils apparently have been formed from a newer thin mantle over an older alluvial deposit. (A profile description of Waynesboro is shown in Appendix B.) Slopes range from 2 to 30%. These soils are medium in natural fertility and organic matter. Soil tests indicate that Waynesboro surface soils contain about 1 to 2% organic matter and are low to very low in phosphate content, but above average in available potash. Surface runoff and infiltration are medium. These soils have a moderate moisture-supplying capacity, a relatively thick layer favorable for roots and are of good tilth.

They are in large areas in the south and central part of the County on the Highland Rim Plateau. The total acreage of these soils is about 5% of the County. About 90% of these soils are in cultivation.

The Dickson soils are well-drained to moderately well-drained upland soils but possess a distinct brittle fragipan. Virgin profiles commonly have a light yellowish brown to brown silt loam surface and a yellowish brown subsoil. The compact, firm fragipan is at a depth of about 26 inches. The fragipan is not a zone of clay concentration; in fact, the clay content is low. The fragipan is not cemented but disintegrates readily if removed and placed in water. These soils have developed from a cherty limestone residuum but are capped with a thin mantle of loess. Depth to limestone varies from 4 to 10 feet. (A profile description of Dickson is shown in Appendix C.) Slopes range from 2 to 12%, but are generally less than 5%. These soils are low in organic matter and plant nutrients and are very strongly acid throughout the soil profile. Soil tests on 20 separate corn fields indicated an average pH of 5.3 in the surface layer. These tests also indicated that the surface soil is low to very low in phosphate and potash. Surface runoff is moderate and internal drainage moderate to slow. The upper part of the soil profile has rapid permeability down to the fragipan where further penetration by water and plant roots is retarded. The fragipan limits the root zone and also the moisture supplying capacity of these soils. These soils are widely distributed throughout the

Highland Rim portion of the County. Owing to gentle slopes and absence of chert in these soils, they are widely cultivated despite their low natural fertility. The Dickson soils are used for general farm crops, such as corn, small grain, hay, tobacco, sorghum, and some legumes.

CHAPTER IV

METHODS AND PROCEDURES

This study was conducted in Putnam County in 1960 in cooperation with the Soil Conservation Service, the Agricultural Extension Service, the Tennessee Valley Authority and the National Plant Food Institute.

The soils studied were Huntington silt loam B1[3], Waynesboro silt loam B1 and B2, and Dickson silt loam B1. The plans for this study were based on the research findings in previous work by Graves[4] with corn on the same soils.

These soils vary widely in their chemical and physical properties, and Graves' previous study showed that they differ greatly in their production potential[5] and response to management under low to moderate levels of inputs. Huntington silt loam, a well-drained bottom soil, showed a high productivity potential for corn, probably due to its excellent physical properties and relatively

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3/ The letter denotes slope gradient and the number following denotes degree of erosion.

4/ Graves, Charles R. The productivity of Huntington, Waynesboro and Dickson soils for corn. Unpub. M.S. thesis. University of Tennessee, Knoxville, Tennessee. 1959.

5/ As used in this study, production potential is defined in terms of corn yields at the levels of fertility and management practices that exist on these soil types.

high fertility. At the other extreme is Dickson silt loam, a moderately well-drained, upland soil which has a fragipan. It is usually low in fertility. Waynesboro silt loam is a well-drained terrace soil with a potential intermediate between that of Huntington and Dickson at a low to moderate level of input.

The design of the experiment and the number of locations used made it necessary to select sites with as much of the area as possible on the same soil mapping unit.[6] Eighteen sites were selected, six on each of the three soil types. (The site numbers, farmer participants and soil types are shown in Appendix D.)

I. EXPERIMENTAL DESIGN AND TREATMENTS

A split-split-split-plot factorial design was used. In this experiment a site was an area 70 feet wide by 310 feet long, or approximately 1/2 acre. A site consisted of eight treatments of varying populations and/or rates of fertilizer. Each treatment consisted of 8 rows, 21 inches apart and 155 feet long.

The fertilizer treatments of N, P_2O_5 and K_2O applied per acre on each site were as follows: 220 pounds of N and 420 pounds of P_2O_5 and K_2O; 420 pounds of N, P_2O_5 and K_2O; 220 pounds of N, P_2O_5 and K_2O; and 420 pounds of N and 220 pounds of P_2O_5 and K_2O.

6/ Soil mapping units are cartographic separations of soils usually based on soil type, slope gradient and degree of erosion.

This fertilizer, except for 20 pounds of N, P_2O_5 and K_2O, was applied as 10-10-10 with 8% soluble magnesium at the rate of 2000 pounds per acre and 0-20-20 and ammonium nitrate at rates of 1000 pounds and 600 pounds per acre, respectively. These materials were applied broadcast with a fertilizer distributor and thoroughly disked into the soil about one week prior to planting. At the time of planting, 20 pounds per acre of N, P_2O_5 and K_2O were applied as 200 pounds of 10-10-10. This was placed about 2 inches to the side and 2 inches below the seed. To avoid possible minor element deficiencies the following materials were applied at the designated per acre rates: $ZnSO_4$, 10 pounds; boron, 1.6 pounds; and Es-min-el, 10 pounds. These materials were applied with the row application of 10-10-10. All soils were limed to a pH of 6.0 or above.

Two plant populations were used on each soil. The plant population was varied to allow for apparent differences among soils. On Huntington, plant populations were 16 and 32,000; on Waynesboro, 12 and 24,000; and on Dickson, 8 and 16,000 plants per acre. A diagram of the fertilizer and population treatments is shown in figure 1.

Dixie 29, a full-season prolific hybrid, was used at all but three sites. Dixie 77, another full-season prolific hybrid, was used at one site on each of the three soils. All sites were planted with a corn planter at rates to give as nearly as possible the desired populations. An attempt was made to obtain a distance between plants

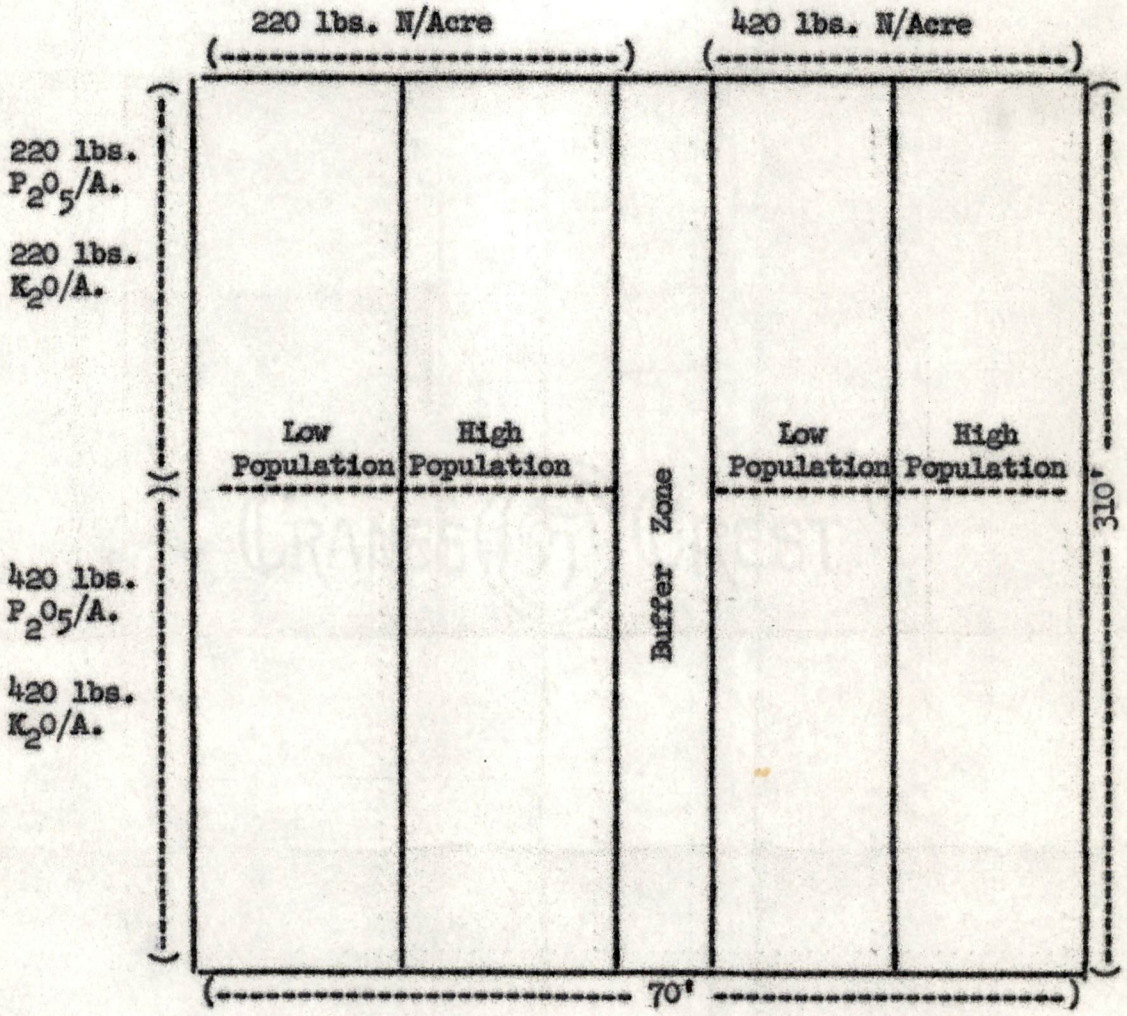


Figure 1. Experimental design and plot layouts used in the 1960 Putnam County corn experiments.

of 30, 20, 15, 10, and 8 inches, respectively, for 8, 12, 16, 24 and 32,000 plants per acre.

All plots were sprayed with a pre-emergence application of Atrazine at the recommended rate of 2 pounds of active material per acre. The plots received no mechanical cultivation.

The planting operation began April 26 and was completed by May 6. The harvest operation began October 3 and ended October 24.

II. COLLECTION OF SOIL SAMPLES AND LABORATORY ANALYSES

Soil samples were taken in the fall of 1959 at four locations on each site, with each sample containing approximately 10 borings. The reason for the four separate soil samples was to determine the variation in fertility within each site as well as among the different sites. These samples were tested for pH, available phosphorus and exchangeable potassium. Using a soil paste, the pH was determined by means of a Beckman pH meter. The procedure used by the University of Tennessee Soil Testing Laboratory was followed in these determinations.

III. COLLECTION OF RAINFALL DATA AND SOIL MOISTURE DETERMINATIONS

To determine the rainfall for the period June through August, rain gauges were placed near each of the 18 sites. Rainfall readings were made by the writer at approximately 10-day intervals. Oil was added to the rain gauge after each reading to prevent loss of water

by evaporation. This information was supplemented with rainfall data of the United States Weather Bureau Station located at Cookeville near the center of the experimental area.

A study of the moisture stress and water extraction pattern by corn roots on Huntington, Waynesboro and Dickson soils was made by H. B. Smith,[7] using a neutron moisture meter.

Two access tubes were installed at one location on each of the three soils and readings were taken with the neutron moisture meter at intervals of two weeks from June 1 to October 1.

From these readings the percent moisture by volume with depth was plotted on graph paper. From these graphs the moisture extraction pattern for each soil type was determined. Soil profile samples were also taken and the moisture content at 1/3 and 15 atmospheres tension was plotted along with the extraction pattern. These data give some indication of the moisture stress and water extraction pattern by corn roots on each of the three soils.

IV. ROOT DEPTH DETERMINATION

Depth and ramification of corn roots were estimated at early tassel stage at all six sites of the three soils. A subsample was taken on one treatment of the test area (220 lbs. N, P_2O_5 and K_2O)

7/ Smith, H. B., Assistant in Agronomy, Department of Agronomy, University of Tennessee.

and where possible on the farmer's field adjoining the test area.

A pit 30 x 30 inches was dug between the 42-inch rows separating the high and low populations to a depth where no corn roots were found. This left about six inches between the sides of the pit and the corn plants on either side. A pocket knife was used to scratch the soil away from the corn roots. The roots of two to four plants in each row could be observed by this method. Measurements were made to a depth which included about 95% of the roots, and a second measurement was made to a point where no corn roots were found. A soil sample was taken from an area six inches above the point where about 95% of the roots stopped, and a second sample was taken below this point. The rooting depths for this 95% of the root system for all samples were totaled and averaged and this average was considered as the rooting depth of corn on each soil. A numerical rating system of 1 to 10 was used to estimate ramification of corn roots. Then the ramification numbers for each site were totaled and averaged and this was considered to be an indication of the relative ramification of roots in each of the three soils.

V. METHOD OF HARVEST

A systematic row method of sampling similar to that described by Walker[8] was used to locate the harvest areas. This plan was

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8/ Walker, William M. Measurement of soil productivity on selected soils in terms of corn yields. Unpub. M.S. thesis, University of Tennessee, Knoxville, Tennessee. 1957.

followed for the reason as presented by Walker, but was modified to fit the present situation. In this experiment, the treatments were harvested as individual units. Since all treatments had the same length and number of rows, a more rigid harvest plan could be followed. The area covered was much smaller and the soil more uniform; therefore the length of row harvested was shortened.

Six 50-foot harvest areas were gathered on each of the 8 treatments within the test area and one from the farmer's field adjoining the test area.

The following plan was used for locating the harvest areas within each treatment. A treatment consisted of 8 rows, 150 feet long. The harvest samples were taken from the six inside rows. A diagram of the harvest procedure is shown in figure 2.

If an ear of corn was missing from the harvest sample, due to factors such as wind or rodents, an ear was harvested from an adjacent row to compensate for this loss.

The shucked corn from each harvest area was weighed and recorded (data sheets used for recording samples are shown in Appendix E), and three ears of corn were selected at random from each harvest sample. Then two rows of kernels were taken from each ear and placed in a sealed can for moisture determination at the laboratory with a Steinlite Moisture Meter (24). All corn yields are expressed at a constand moisture content (15.5% moisture).

Since all measurements were made on an equal harvested area, the total amount of corn per acre was calculated as shown in Appendix F.

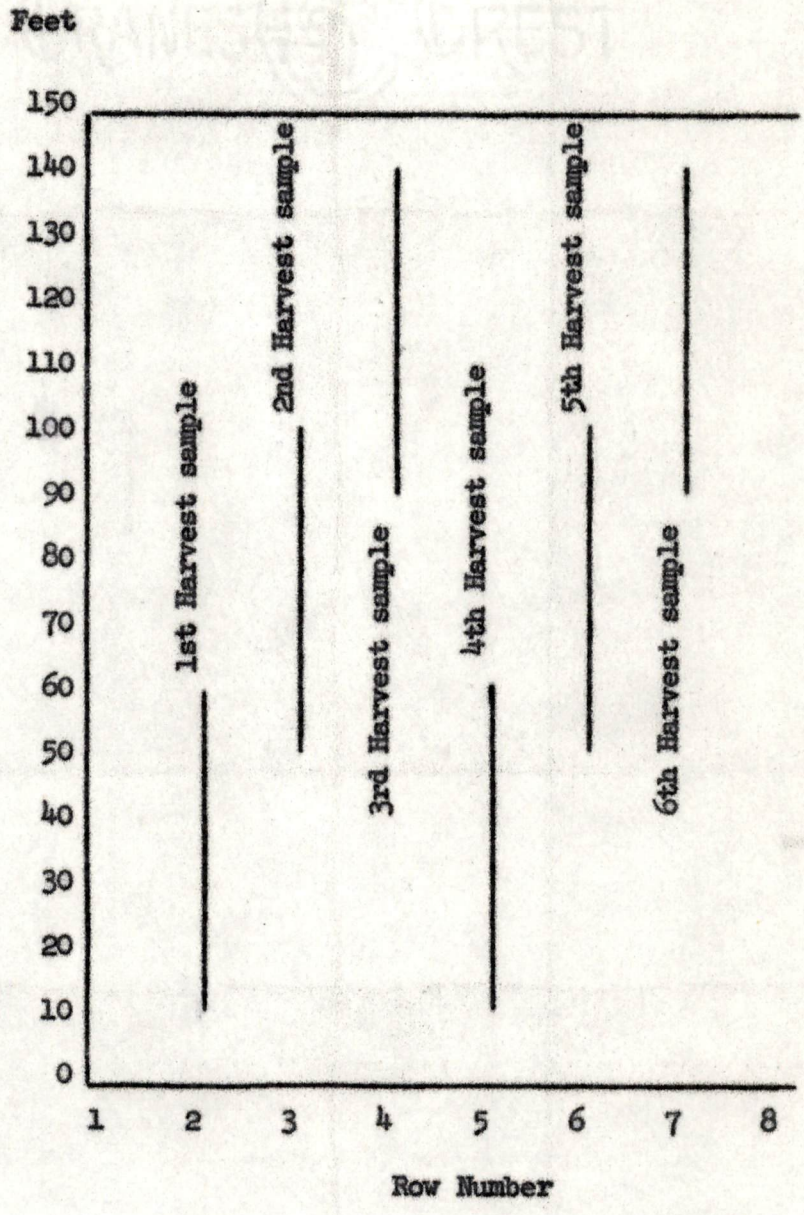


Figure 2. Diagram of the harvest procedure for each treatment.

VI. LODGING AND NUMBER OF EARS

Individual counts were made at harvest time to determine the number of stalks and ears on each harvest area. From this, the number of ears per 100 stalks and weight per ear was calculated. For lodging counts, plants broken below the point of attachment of the main ear and plants leaning more than 45 degrees were considered as lodged plants. A separate count of the two types of lodging was not made.

CHAPTER V

RESULTS AND DISCUSSION

I. GENERAL OBSERVATIONS

Varieties

Data on number of plants per acre, lodging, ears per 100 plants and weight per ear of the two varieties on each treatment are given in Appendix G. Site numbers 6, 12, and 18 were planted to Dixie 77 and all other sites to Dixie 29. It should be noted that Dixie 29 and Dixie 77 on Huntington sites 5 and 6 were located side by side in the same field. The two hybrids on Waynesboro and Dickson were planted at different locations.

The average plants per acre, bushels per acre, percent lodging, ears per 100 stalks, and weight per ear at sites 5 and 6 were as follows: Dixie 29, 22,500 plants per acre, 128 bushels, 51%, 119 ears, and 0.35 pound per ear; Dixie 77, 23,100 plants per acre, 127 bushels, 69%, 108 ears, and 0.38 pound per ear.

Chemical Weed Control

The corn received no mechanical cultivation. Atrazine gave excellent control of all annual weeds except for cockleburs on site 1, but a hand-sprayed application of 2,4-D gave good control of this weed. Crusting was not a major problem on any of three soils. An observation on the amount of water standing on the sprayed and

cultivated plots after a rainfall indicated that the entry of water into the Dickson soil was slower on the sprayed plot. This was not as noticeable on Huntington and Waynesboro soils.

Stand

A good stand was obtained on all but sites 1 and 2. The poor stand on these sites was attributed to poor seedbed preparation and crusting of soil due to an intense 4-inch rainfall soon after planting. The effects of these conditions could have been minimized had a drag harrow been used to break the crust before the corn emerged.

Insect Damage

Budworm damage of varying degree was observed on all 18 sites. On some sites as much as 75% of the plants were infested with budworm. Good control was obtained on one site by applying DDT with a hand sprayer. The effect of the budworm damage on yield was not determined.

Growth Characteristics

During the early part of the growing season the corn at the high population was as much as a foot taller than the corn at the low population.

The corn was considerably taller on the Huntington and Waynesboro soils than on the Dickson soil. On the former they reached a height of 12 to 14 feet. This may have caused the higher percentage lodging on these soils.

The corn at the high populations was later in tasseling and silking than the corn at the low populations. Also the ears were placed higher on the stalk on the high populations than on the low populations.

Rooting Depth

A check was made on the rooting depth of corn on the three soils at the two levels of fertility. The rooting depths at these two fertility levels were as follows: Waynesboro experimental treatment, 23.8 inches; farmer's treatment, 21.3 inches; Huntington experimental treatment, 29.8 inches; farmer's treatment, 29 inches; Dickson experimental treatment, 15.8 inches; farmer's treatment, 15.6 inches. (Corn rooting depth for the different sites are shown in Appendix H.)

Separate soil samples taken from an area 6 inches above and 6 inches below the point where 95% of the roots stopped showed no marked difference in soil tests (pH, P and K). These data are shown in Appendix I. It would therefore appear that fertility was not a factor in limiting root development on these soils.

Rainfall Data and Moisture Extraction Patterns

Rainfall data for June, July and August were obtained for each site. As shown in Appendix J the total rainfall for the 3-month period ranged from 15.0 inches to 19.1 inches among sites. Also, rainfall data for June, July and August were obtained from

the Cookeville Weather Station (located near the center of the experimental sites) for 1956 through 1960. The rainfall data for each year 1956 through 1960 and an average for the 1956-1959 period are shown in table 1. These data show that 5.18 inches more rainfall was recorded during June, July and August in 1960 than was the average for the same months during the period 1956-1959.

During the growing season, July was the month with the greatest amount of precipitation. This was a critical period during the growing season when corn was tasseling and silking. Adequate moisture during this time would favor high yields of corn if other factors were not limiting.

The moisture extraction patterns in figures 3, 4 and 5 show that the moisture stress on the three soils during the growing season was not critical, because the curves did not cross the 15-atmosphere release curve at anytime during the growing season. Due to the high rainfall the differences in the moisture extraction patterns of the three soils were not as great as might normally be expected. However, the neutron moisture measurements do show some differences in depth of moisture extraction. The approximate depths of extraction were estimated by the convergence of the extraction lines in the profile. The approximate depths of moisture extraction by corn roots from the three soils were as follows: Huntington, 50 inches; Waynesboro, 44 inches; and Dickson, 36 inches. As shown

Table 1.--Inches of rainfall recorded by the Cookeville Weather Station for 1956-1960 (June, July and August) and the 4-year average 1956-1959.

Year	June	July	August	Total
1956	4.03	9.55	2.52	16.10
1957	4.16	.99	1.48	6.63
1958	3.70	4.27	4.79	12.76
1959	2.71	5.16	5.12	12.99
1960	6.00	7.63	3.67	17.30
4-year av.(1956-59)	3.65	4.99	3.48	12.12

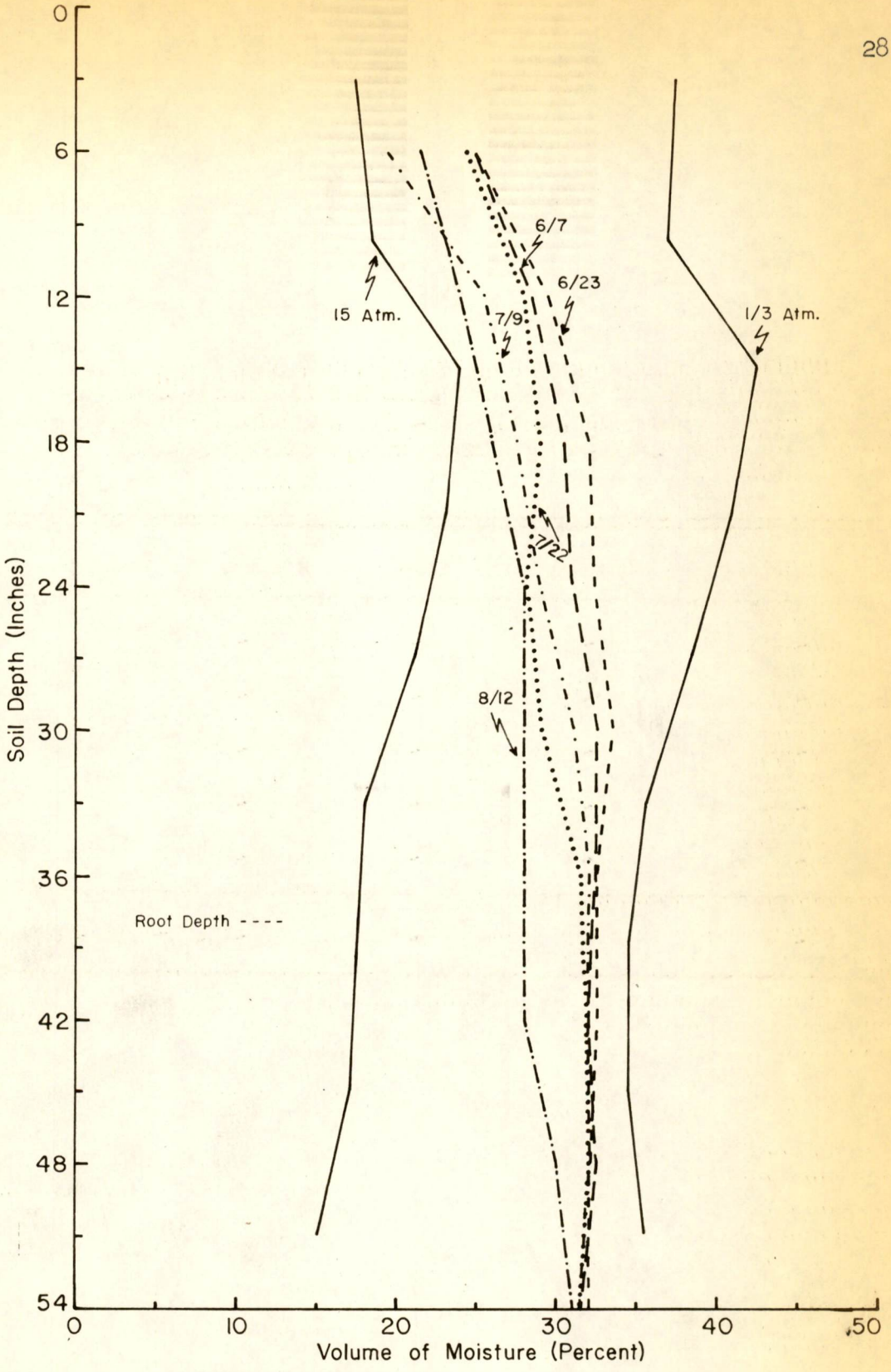


Figure 3.--The moisture extraction pattern of corn roots in a Huntington profile.

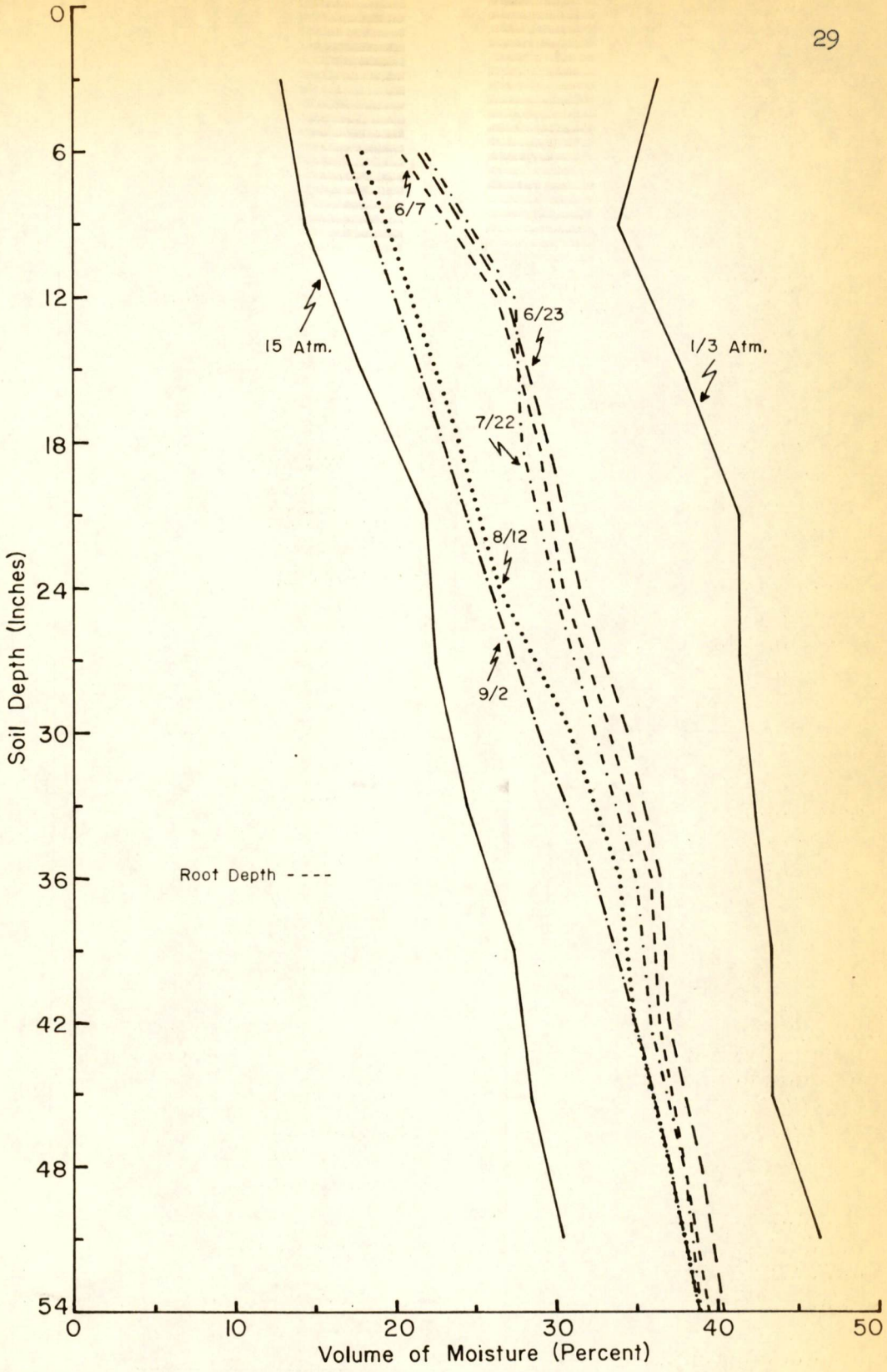


Figure 4.--The moisture extraction pattern of corn roots in a Waynesboro profile.

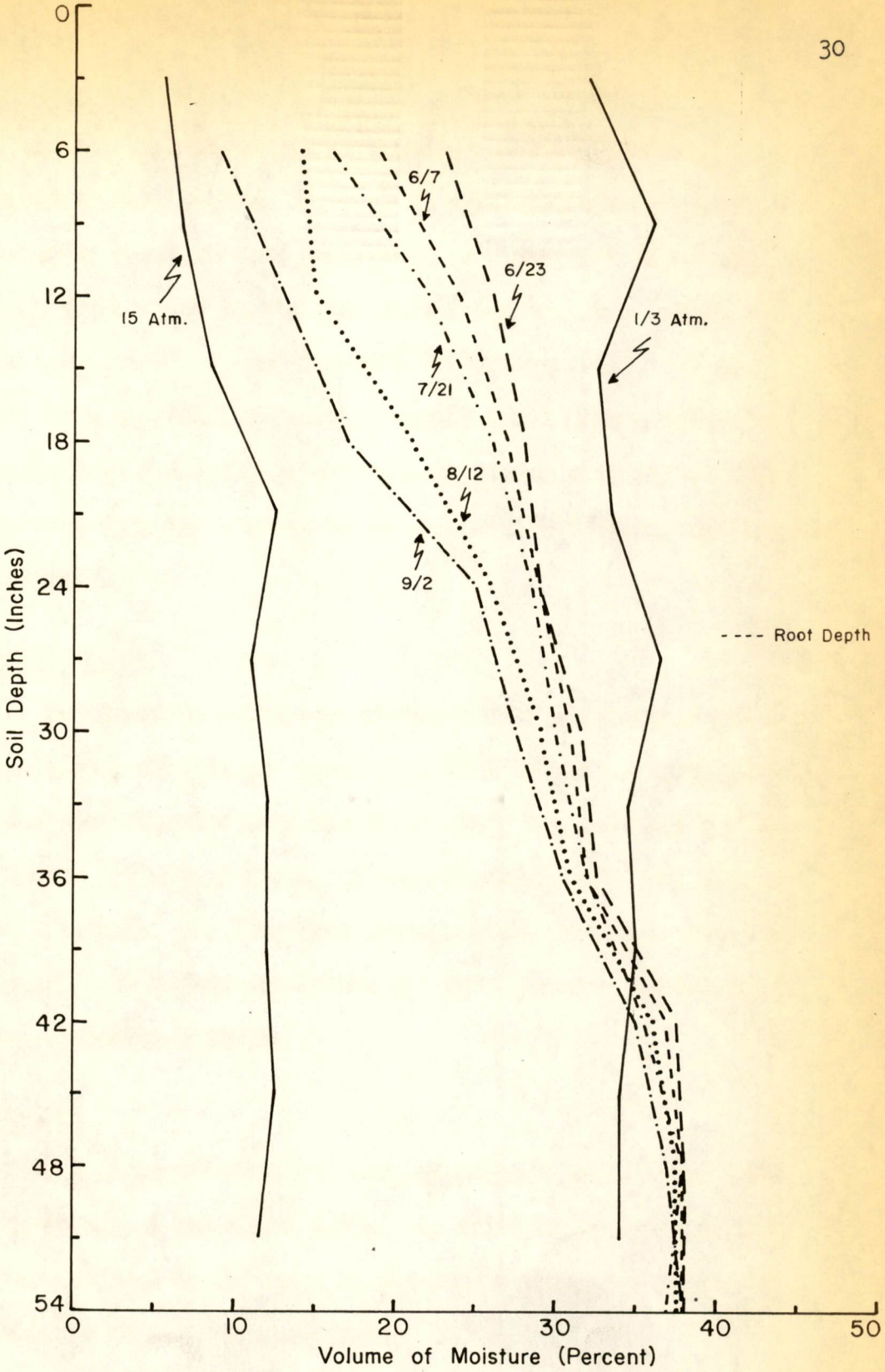


Figure 5.--The moisture extraction pattern of corn roots in a Dickson profile.

in figures 3, 4, and 5 the moisture extraction patterns seem to show extraction of moisture to depths 6 to 12 inches below the observed rooting depths. This is in agreement with results obtained by Richards (20), who found the effective distance through which water in the available range can move toward the roots to be in the order of inches rather than feet. It would appear from the observed rooting depths and moisture extraction patterns that the order of moisture-supplying capacity of these soils was, from the highest to the lowest, Huntington, Waynesboro and Dickson.

Ears Per Plant

On all three soils corn at the higher populations had a lesser number of ears per plant than that at the low populations. The ears per 100 plants on the three soils for the high and low populations were as follows: Huntington high, 98; low, 135; Waynesboro high, 96; low, 139; Dickson high, 107; low, 152. Treatments other than population did not appear to affect the number of ears per plant.

Ear Weight

The average weight per ear was reduced as the population was increased on all three soils. As shown in Appendix G, there were no apparent differences in ear weight among the levels of fertility used in this experiment.

II. YIELD COMPARISONS BETWEEN TREATMENTS AMONG THE THREE SOILS

The average yield for all of the eight experimental treatments and the average yield for the farmers' treatments on the three soils are given in table 2. The average increases in yield for the experimental treatments over the farmers' treatments were as follows: Dickson, 61 bushels per acre; Waynesboro, 43 bushels per acre; and Huntington, 39 bushels per acre.

Table 3 shows an average of the soil test values (pH, available P and exchangeable K) before treatment on the three soils. (The average soil test value for each site is shown in Appendix K.) The distribution of these into arbitrary categories of "low", "medium", and "high" is shown in table 4. As indicated by the soil-test data the general order of soil-test levels before treatment from lowest to highest was Dickson, Waynesboro and Huntington, with the exception of exchangeable K levels on Waynesboro and Huntington. With these soil-test values it would be expected that the response to added fertilizer would increase as the level of fertility (as indicated by the soil test before treatment) decreased. The same response to fertilizer added would not be expected in a year of limited rainfall, due to the differences in physical properties which affect the moisture-supplying capacity of these soils.

Corn yield differences among the three soils for the farmers' treatments and the experimental treatments are shown in table 5.

Table 2.--Average corn yields for the experimental treatments and farmers' treatments on Huntington, Waynesboro and Dickson soils in Putnam County, 1960.

Treatment	Soils		
	Huntington	Waynesboro	Dickson
	Bu./A.	Bu./A.	Bu./A.
Average yield for all the experimental treatments	126	122	105
Average yield for the farmers' treatments	87	79	44
Difference between yields for experimental and farmers' treatments	39	43	61

Table 3.--Average of soil-test values on samples taken in the fall of 1959 before soil treatment.

Soil	pH	Available P lbs./A.	Exchangeable K lbs./A.
Huntington	6.5	20	148
Waynesboro	6.2	12	167
Dickson	6.0	7	74

Table 4.--Number of soil samples testing low, medium, and high in available P and exchangeable K and below pH 6.0 and above pH 6.0 on Huntington, Waynesboro and Dickson soils.

Soil	pH		Available P			Exchangeable K		
	Less than 6.0	6.0 Plus	Low	Medium	High	Low	Medium	High
Huntington	3	21	16	0	8	11	11	2
Waynesboro	8	16	16	3	5	12	4	8
Dickson	10	14	17	4	3	23	0	1

Table 5.--Average yield difference between soils for the experimental treatments and the farmers treatment.

	Farmers' treatment	Experimental treatment
	Bu./A	Bu./A
Average yield difference between Dickson and Huntington	43	21
Average yield difference between Dickson and Waynesboro	35	17
Average yield difference between Waynesboro and Huntington	8	4

As shown in this table the differences in yield between soils for the experimental treatments are about one-half those for the farmers' treatments. In other words, the experimental treatments greatly reduced the yield differences among soils.

The average and range of yields for the eight experimental treatments and the farmers' treatment on the three soils are given in table 6. The highest average yield for the experimental treatments was 137 bushels per acre on Huntington, 133 bushels on Waynesboro, and 113 bushels on Dickson. The highest average yields on Huntington and Waynesboro were obtained from the lower plant population at the lowest fertilizer rate. The highest average yield on Dickson was obtained from the higher plant population fertilized at the lower nitrogen rate but at the higher rate of phosphate and potash.

The greatest range in yields was 98 to 170 bushels (72) on Huntington, 75 to 152 bushels (77) on Waynesboro, and 77 to 122 bushels (45) on Dickson. The average and ranges in yield for each treatment on each soil are also given in table 6.

III. ANALYSIS OF VARIANCE

Yield and lodging data were subjected to statistical analysis as outlined by Cochran and Cox (5) for a split-split-split-plot design. Analyses of variance were computed using an average of the

Table 6.--Average corn yields and range in yields on Huntington, Waynesboro and Dickson soils with nine treatments, Putnam County, 1960.

Treatments*	Dickson		Waynesboro		Huntington	
	Range	Average	Range	Average	Range	Average
P1 T1	97-129	110	94-153	128	83-158	128
P2 T1	87-130	113	87-130	113	112-139	122
P1 T2	89-121	101	91-130	118	87-141	114
P2 T2	83-130	111	75-152	118	103-144	119
P1 T3	87-103	95	98-152	133	98-170	137
P2 T3	85-117	105	117-128	123	112-141	126
P1 T4	82-115	97	113-136	123	103-142	129
P2 T4	77-122	105	96-155	117	112-154	131
Farmers' fertilizer treatment	32-60	44	68-97	79	58-114	87

*P1 - Low population
1. Dickson about 8,000
2. Waynesboro about 12,000
3. Huntington about 16,000

P2 - High population
1. Dickson about 16,000
2. Waynesboro about 24,000
3. Huntington about 32,000

T1 - 220 lbs. N
420 lbs. P_2O_5 and K_2O

T2 - 420 lbs. N
420 lbs. P_2O_5 and K_2O

T3 - 220 lbs. N
220 lbs. P_2O_5 and K_2O

T4 - 420 lbs. N
220 lbs. P_2O_5 and K_2O

six individual observations made on each treatment at each location to determine the variations due to nitrogen levels, phosphorus and potassium levels, populations, locations, soils, and their interactions.

It should be noted that the analysis of variance on the yield and lodging data was a comparison of the variation among the three soils with varying populations. The treatments were not randomized and replicated at one location, but duplicated at different locations under similar but not completely controlled conditions. In the analysis of variance locations are used as replications within a soil group.

IV. YIELD COMPARISONS RESPONSE TO INDIVIDUAL SOURCES OF VARIANCE AND THEIR INTERACTIONS AMONG THE THREE SOILS

Statistical computations obtained with the analysis of variance on yield data are presented in tables 7A, 7B and 7C.

As shown by the F test in table 7A, soil differences were highly significant, nitrogen effects were significant at the .05 probability level, and locations were significant at the .10 probability level; however, population, and phosphate-potash treatment, did not explain a significant amount of variation even at the .25 probability level.

There was a significant amount of variation explained by the interactions of population x soils at the .01 probability level,

Table 7A.--Analysis of variance of corn yields for all eight treatments on the three soils in Putnam County, 1960.

Source	Degrees of freedom	Mean squares	F tests
Total	143		
Soils	2	6358	7.86**
Locations within a soil group	5	2227	2.75 NS
Error (a)	10	809	
P_2O_5 and K_2O	1	62	.28 NS
P_2O_5 and K_2O x soils	2	990	4.42*
Error (b)	15	224	
Nitrogen	1	1014	6.46*
Nitrogen x soils	2	118	.75 NS
Nitrogen x P_2O_5 and K_2O	2	224	1.43 NS
N x soils x P_2O_5 and K_2O	2	25	.16 NS
Error (c)	30	157	
Population	1	1	.01 NS
Population x soils	2	516	5.11**
Pop. x P_2O_5 and K_2O	1	66	.65 NS
Population x nitrogen	1	282	2.79 NS
Pop. x soils x P_2O_5 and K_2O	2	75	.74 NS
Pop. x soils x nitrogen	2	76	.75 NS
Pop. x N x P_2O_5 and K_2O	1	10	.10 NS
Pop. x soils x N x P_2O_5 and K_2O	2	21	.21 NS
Error (d)	60	101	

* Significant at the .05 level of probability.

** Significant at the .01 level of probability.

N.S. Not significant at the .05 level of probability.

Table 7B.--Analysis of variance of corn yields for all eight treatments on the three soils in Putnam County, 1960. (L.S.D. for soils.)

Soil type	Mean yield bushels per acre	Difference between means	L.S.D. at probability levels .01	.05
Huntington	126	4	---	N.S.
Waynesboro	122			
Huntington	126	21	18.40	----
Dickson	105			
Waynesboro	122	17	N.S.	12.95
Dickson	105			

Table 7C.--Analysis of variance of corn yields for all eight treatments on the three soils in Putnam County, 1960. (L.S.D. for nitrogen)

Nitrogen rates	Mean yield bushels per acre	Difference between means	L.S.D. at probability levels	
			.01	.05
High	115.00	4.33	N.S.	4.26
Low	119.33			

phosphate-potash treatment x soils at the .05 probability level, and population x nitrogen at the .10 probability level. All other interactions did not show a significant variation even at the .25 level.

Even though there was a significant amount of variation explained by the population x soil interaction, the variation explained was almost meaningless because of the differences in levels of population among soils and the variation within levels of population on each soil.

A significant amount of variation was shown by the phosphate-potash treatment x soil interaction. The higher rate of phosphate-potash resulted in a decrease in yield of 10 and 5 bushels per acre on Huntington and Waynesboro, respectively, and an increase in yield of 8 bushels on Dickson. This difference in response on these three soils to added phosphate and potash may be attributed to the initial available levels of P and K in the soil, being much higher on the Huntington and Waynesboro soils than on the Dickson soil.

The interaction of population x nitrogen was significant at the .10 probability level. A close scrutiny of the data will reveal that there was a greater reduction in yield brought about by the high nitrogen on the low population treatments than was the case with the high nitrogen on the high population treatments. There was a reduction in yield of 8 bushels per acre with the high rate

of nitrogen as compared to the low rate of nitrogen on the low population treatments and only about 1 bushel per acre reduction from the high rate of nitrogen as compared to the low rate of nitrogen on the high population treatments.

As shown in table 7B, corn yields on the Huntington averaged 126 bushels per acre; the Waynesboro, 122 bushels; and the Dickson, 105 bushels. There was no significant difference between the mean yields on the Huntington and Waynesboro soils at the levels of probability tested. The Huntington soil had a significantly greater mean yield than the Dickson soil at the .01 probability level, and the Waynesboro soil had a significantly greater mean yield than the Dickson soil at the .01 probability level, and the Waynesboro soil had a significantly greater mean yield than the Dickson soil at the .05 level.

Table 7C shows that the mean yield for the high rate of nitrogen was significantly lower than the mean yield for the low rate of nitrogen at the .05 probability level. The yield data show that the high rate of nitrogen reduced yields approximately 5 bushels per acre on Huntington and Waynesboro and approximately 2 bushels on Dickson.

V. LODGING COMPARISONS, EFFECTS OF INDIVIDUAL SOURCES OF VARIANCE AND THEIR INTERACTIONS AMONG THE THREE SOILS

Statistical computations obtained with the analysis of variance on lodging data are presented in tables 8A, 8B, 8C, and 8D.

Table 8A.--Analysis of variance of lodging in percent for all eight treatments on the three soils in Putnam County, 1960.

Source	Degrees of freedom	Mean squares	F tests
Total	143		
Soils	2	16304	14.56**
Locations within a soil group	5	2490	2.22
Error (a)	10	1120	
P_2O_5 and K_2O	1	9	.05 NS
P_2O_5 and K_2O x soils	2	46	.23 NS
Error (b)	15	198	
Nitrogen	1	1871	11.01**
Nitrogen x soils	2	818	4.81*
Nitrogen x P_2O_5 and K_2O	1	91	.54
N x soils x P_2O_5 and K_2O	2	74	.44
Error (c)	30	170	
Populations	1	19607	70.78**
Populations x soils	2	2884	11.92**
Pop. x P_2O_5 and K_2O	1	64	.26
Pop. x nitrogen	1	1259	5.20*
Pop. x soils x P_2O_5 and K_2O	2	4	.02
Pop. x soils x nitrogen	2	164	.68
Pop. x N x P_2O_5 and K_2O	1	1279	5.29*
Pop. x soils x N x P_2O_5 and K_2O	2	277	1.14
Error (d)	60	242	

* Significant at the .05 level of probability.
** Significant at the .01 level of probability.
N.S. Not significant at the .05 level of probability.

Table 8B.--Analysis of variance of lodging in percent for all eight treatments on the three soils in Putnam County, 1960. (L.S.D. for nitrogen)

Nitrogen rates	Mean percent lodging	Difference between means	L.S.D. at Probability levels .01	.05
High	41.5	7.1	6.0	----
Low	34.4			

Table 8C.--Analysis of variance of lodging in percent for all eight treatments on the three soils in Putnam County, 1960. (L.S.D. for population)

Population rates	Mean percent lodging	Difference between means	L.S.D. at probability levels .01	.05
High	49.5	23.1	7.4	----
Low	26.4			

Table 8D.--Analysis of variance of lodging in percent for all eight treatments on the three soils in Putnam County, 1960. (L.S.D. for soils)

Soil type	Mean percent lodging	Difference between means	L.S.D. at probability levels .01	.05
Huntington	51.5	6.0	----	N.S.
Waynesboro	45.5			
Huntington	51.5	34.6	22.6	----
Dickson	16.9			
Waynesboro	45.5	28.6	22.6	----
Dickson	16.9			

As shown by the F tests in table 8A, all individual sources of variation are significant at the .01 probability level, except for location and phosphate-potash fertilization.

The populations x soil interaction showed a significant amount of variation at the .01 probability level. The variation in the two-way interactions nitrogen x soils and populations x nitrogen variations and in the three-way interactions populations x nitrogen x phosphate-potash interaction were significant at the .05 probability level. All other interactions did not show a significant difference at the .25 level.

There was a highly significant amount of variation in lodging shown by the population x soil interaction. More lodging occured at the high population than at the low population on all soils. The differences in the degree of lodging at the high and low populations were 33%, 31%, and 6%, respectively, for Huntington, Waynesboro, and Dickson soils. The greater lodging difference between the low and high population levels on Huntington and Waynesboro was probably due to the higher level of populations on these soils.

The nitrogen x soil interaction was significant at the .05 probability. The Huntington and Waynesboro soils had a wider spread in degree of lodging than the Dickson soil at the high and low levels of applied nitrogen. This could be attributed to the higher organic matter content (total nitrogen) of Huntington and Waynesboro soils.

The nitrogen x populations interaction was significant at the .05 level of probability. The difference in percent lodging between the high and low nitrogen treatments was 1% for the high population level and 13% for the low population level. Thus, it appears that the high nitrogen treatment had a greater influence on lodging at the low population than at the high population.

Table 8B shows that the mean percent lodging for the high rate of applied nitrogen is significantly higher than the mean percent lodging for the low rate at the .01 level of probability.

It would seem from the size of the F test (70.78) in table 8A and from the difference in mean percent lodging (23.1) shown in table 8C that plant population was the greatest single factor affecting lodging.

Table 8D shows the mean percent lodging on the three soils. It is thought that since the population levels on the three soils varied so widely, this difference might be a population instead of a soil difference. However, a linear regression was computed on the high population and lodging on Dickson soil and the low population and lodging on Huntington and Waynesboro soils, with lodging being estimated at a comparable population on each soil. Table 9 shows the estimated lodging at a 14,000 plant-per-acre population on each soil. From this, it would appear that there was a difference in lodging that could be attributed to soil differences.

Table 9.--Estimated lodging for 14,000 plants per acre on Huntington, Waynesboro and Dickson soils, as estimated from a linear regression on population and lodging data.

	Soils		
	Huntington	Waynesboro	Dickson
	%	%	%
Estimated lodging for 14,000 population	30	29	16

VI. EFFECT OF POPULATION ON YIELD

The analysis of variance showed no significant difference between the yields at the high and low population levels among the three soils. However, instead of being replicated at one location the treatments were duplicated at different locations, and also, there was a variation in population levels among soils as well as a variation within these levels on any given soil. For these reasons it was decided that graphs showing population and yield data paired as to location would present a better estimate of the effects of the different levels of population on yield.

Figures 6, 7, 8, and 9 show data on yield and population paired as to location on Huntington. On the low nitrogen treatment there was a decrease in yield at every location where the population was over 18,000 plants per acre, as shown in figures 6 and 7. On the high nitrogen treatment there was a decrease in yield at all except 3 locations, and even at these locations there was practically no yield increase where the population exceeded 18,000 plants per acre. However, the decrease in yield with the high nitrogen treatment was of less magnitude than that with the low nitrogen treatment.

Of the 24 observations at six locations and including four different fertilizer treatments on Waynesboro, where the population exceeded 16,000 plants per acre, there was a decrease in yield in 18 of them. This is shown in figures 10, 11, 12, and 13. A search of all known production variables failed to explain the increase in

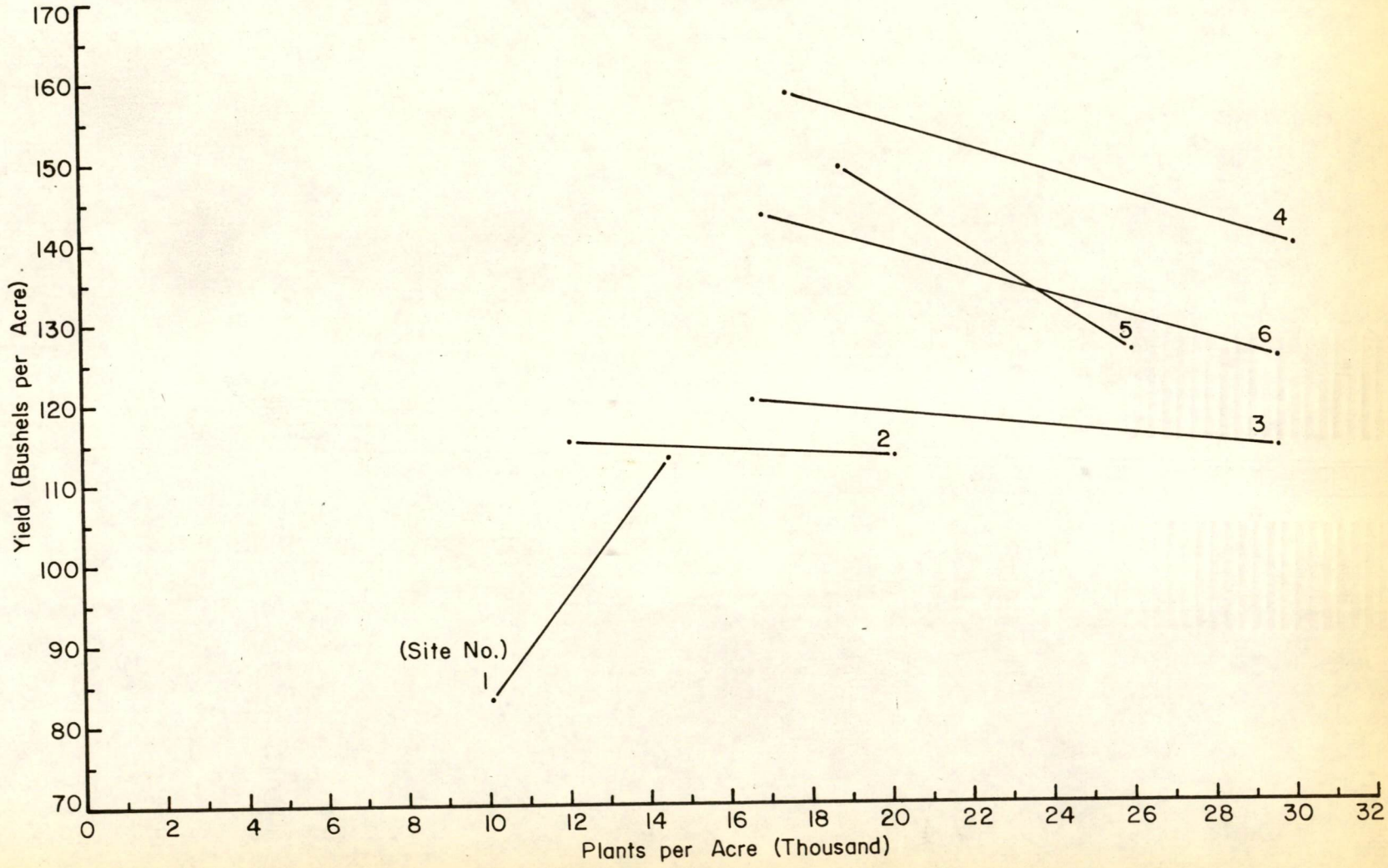


Figure 6.--Yields of corn at minimum and maximum plant populations at 6 sites on Huntington silt loam, fertilized at rate 220-420-420 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

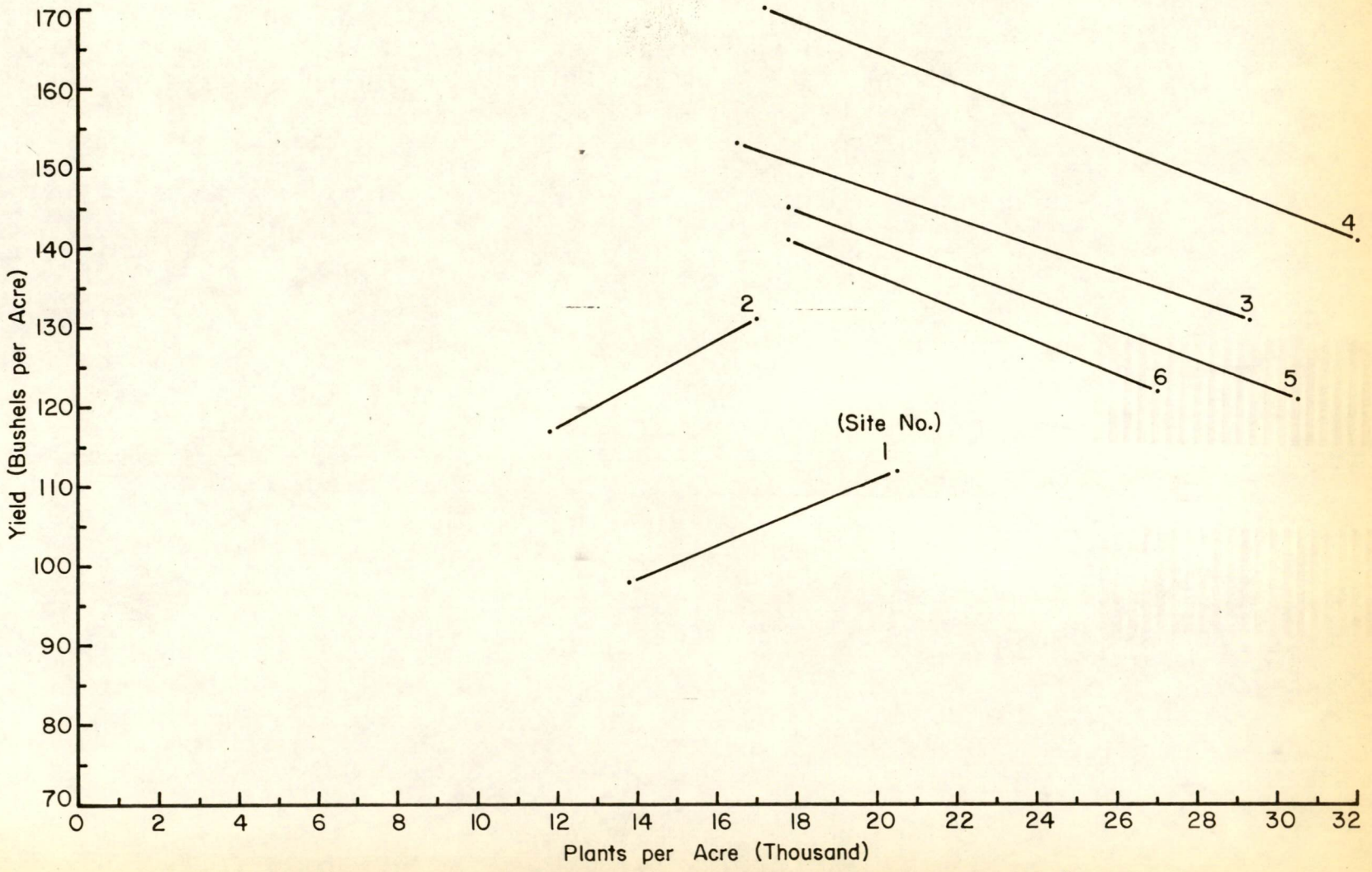


Figure 7.--Yields of corn at minimum and maximum plant populations at 6 sites on Huntington silt loam, fertilized at rate 220-220-220 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

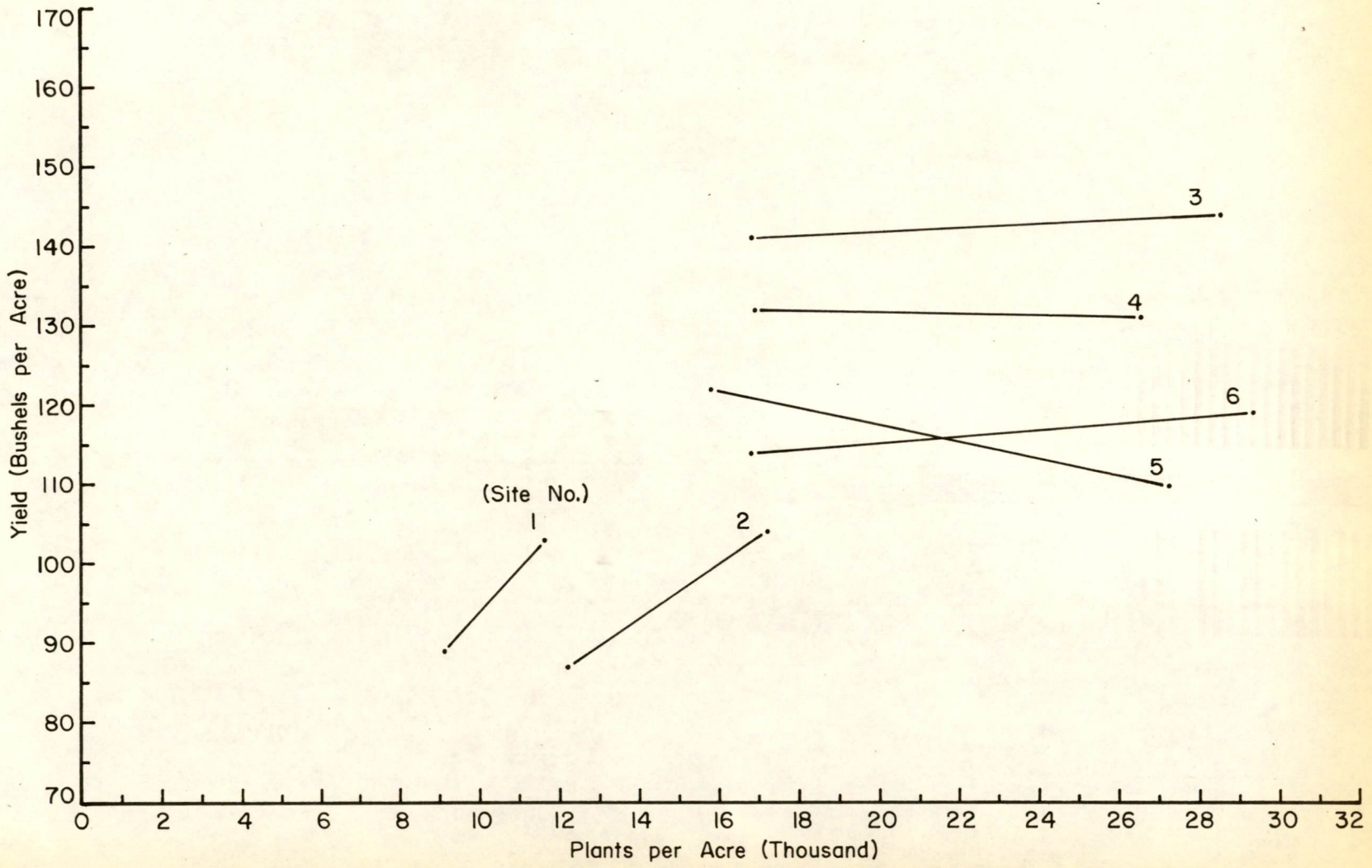


Figure 8.--Yields of corn at minimum and maximum plant populations at 6 sites on Huntington silt loam, fertilized at rate 420-420-420 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

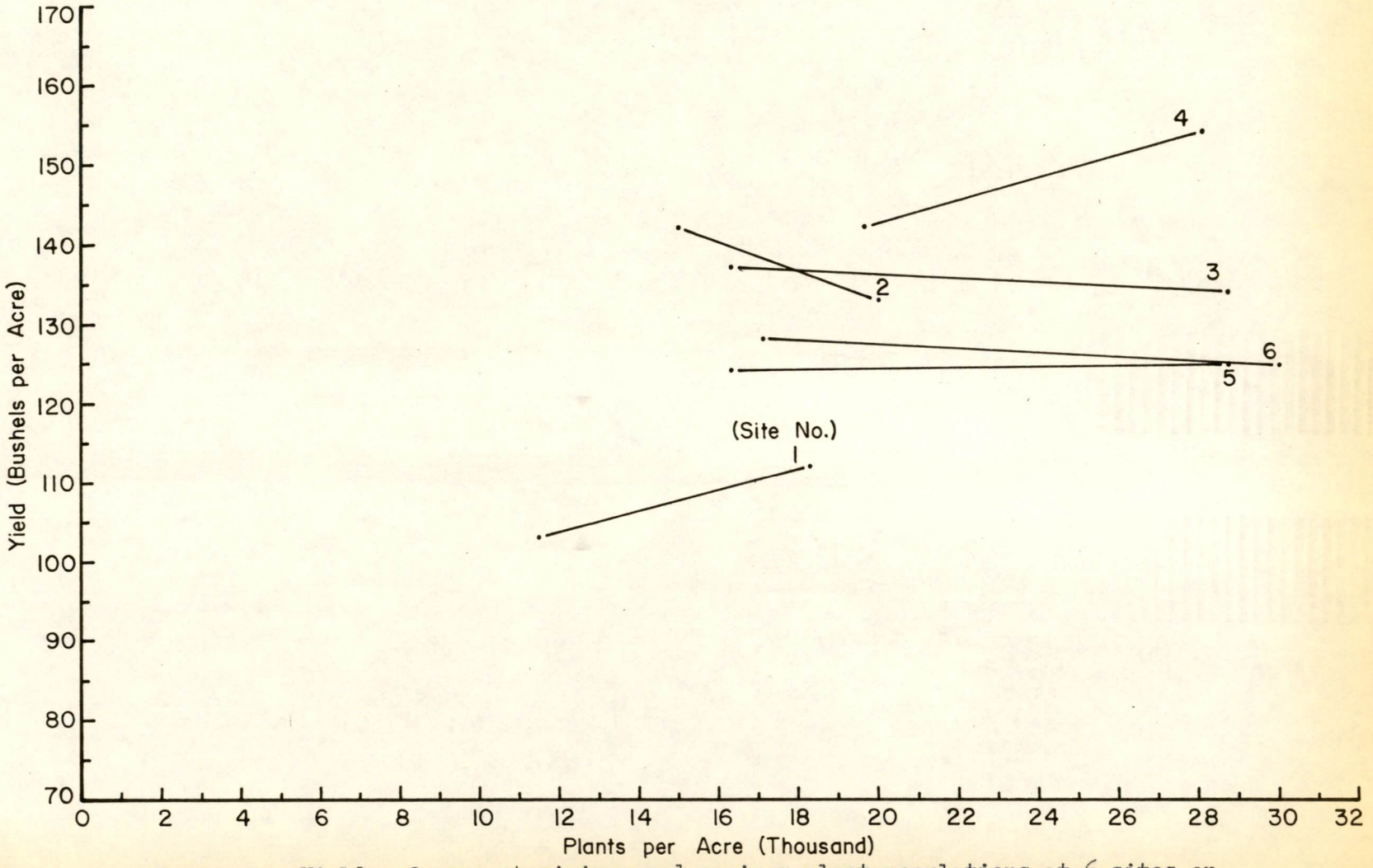


Figure 9.--Yields of corn at minimum and maximum plant populations at 6 sites on Huntington silt loam, fertilized at rate 420-220-220 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

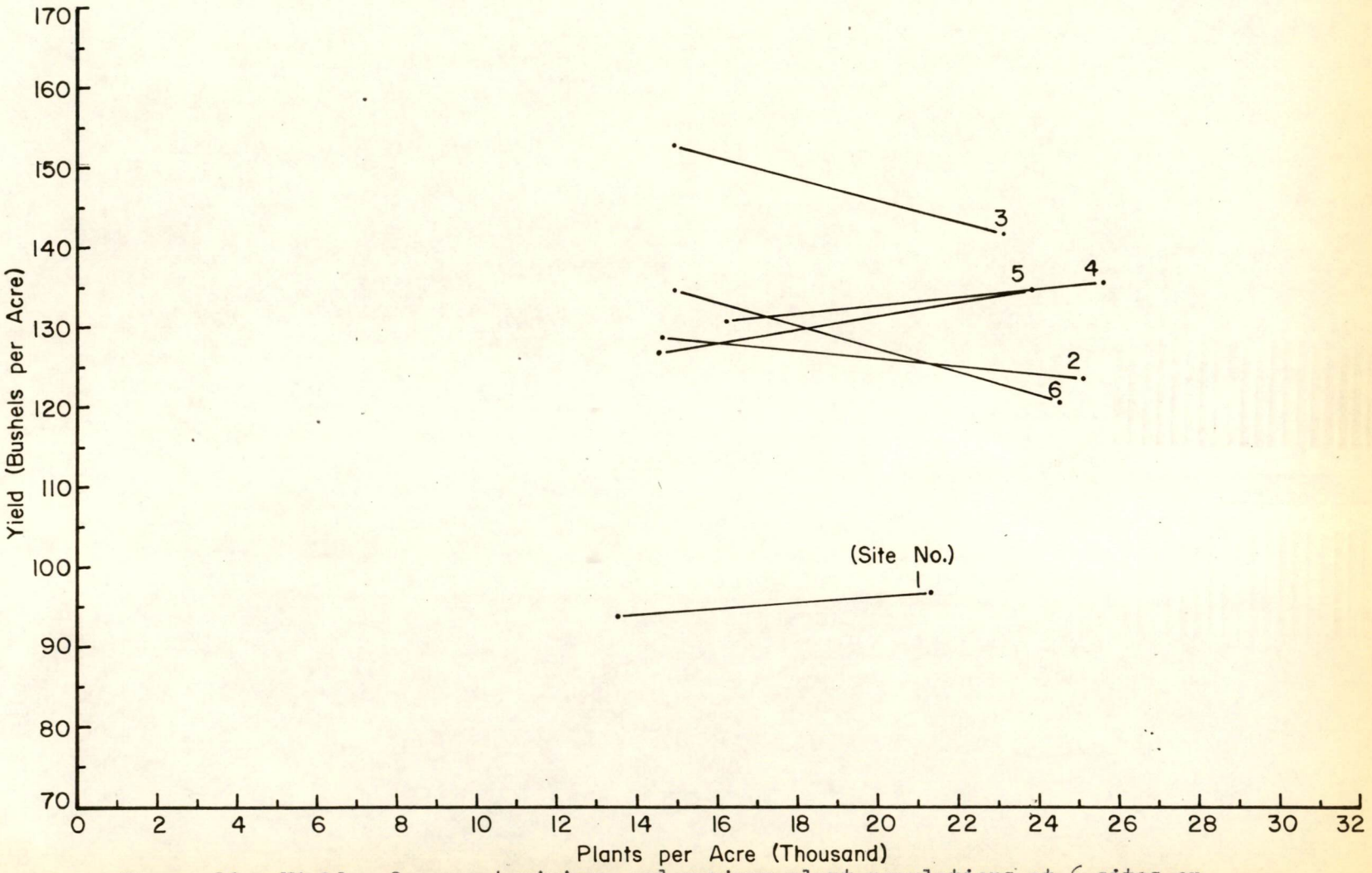


Figure 10.--Yields of corn at minimum and maximum plant populations at 6 sites on Waynesboro silt loam, fertilized at rate 220-420-420 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

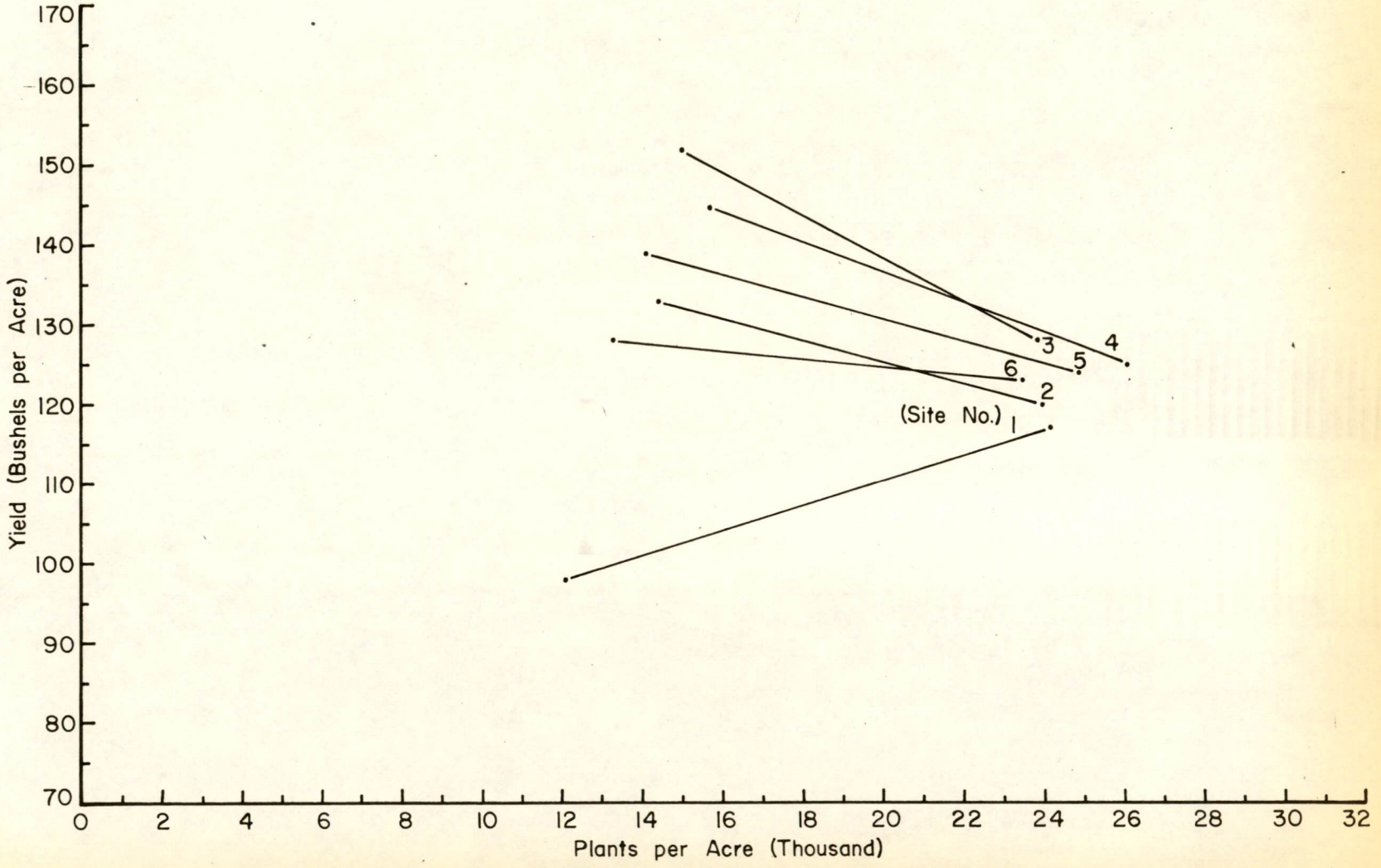


Figure 11.--Yields of corn at minimum and maximum plant populations at 6 sites on Waynesboro silt loam, fertilized at rate 220-220-220 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

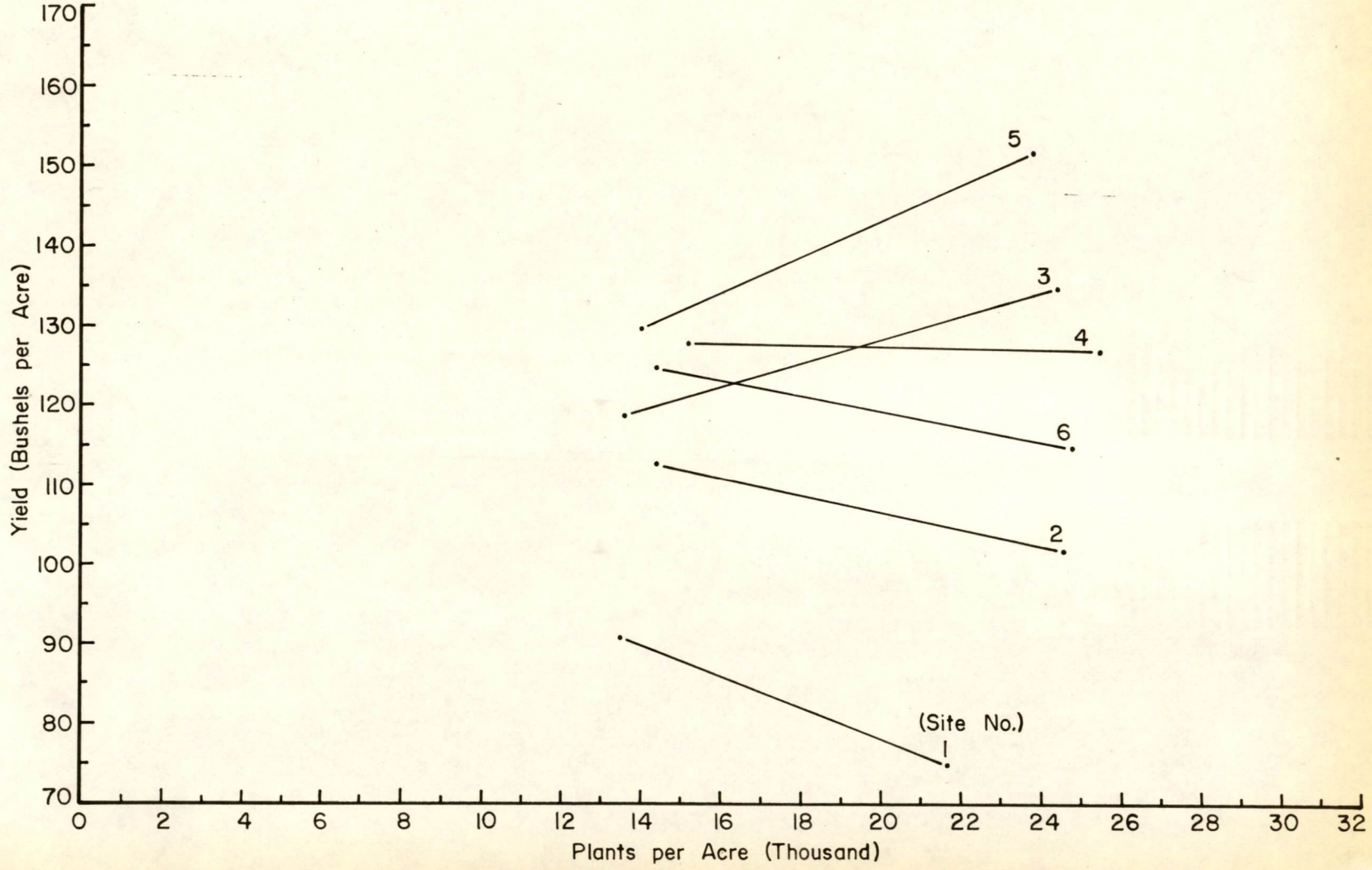


Figure 12.--Yields of corn at minimum and maximum plant populations at 6 sites on Waynesboro silt loam, fertilized at rate 420-420-420 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

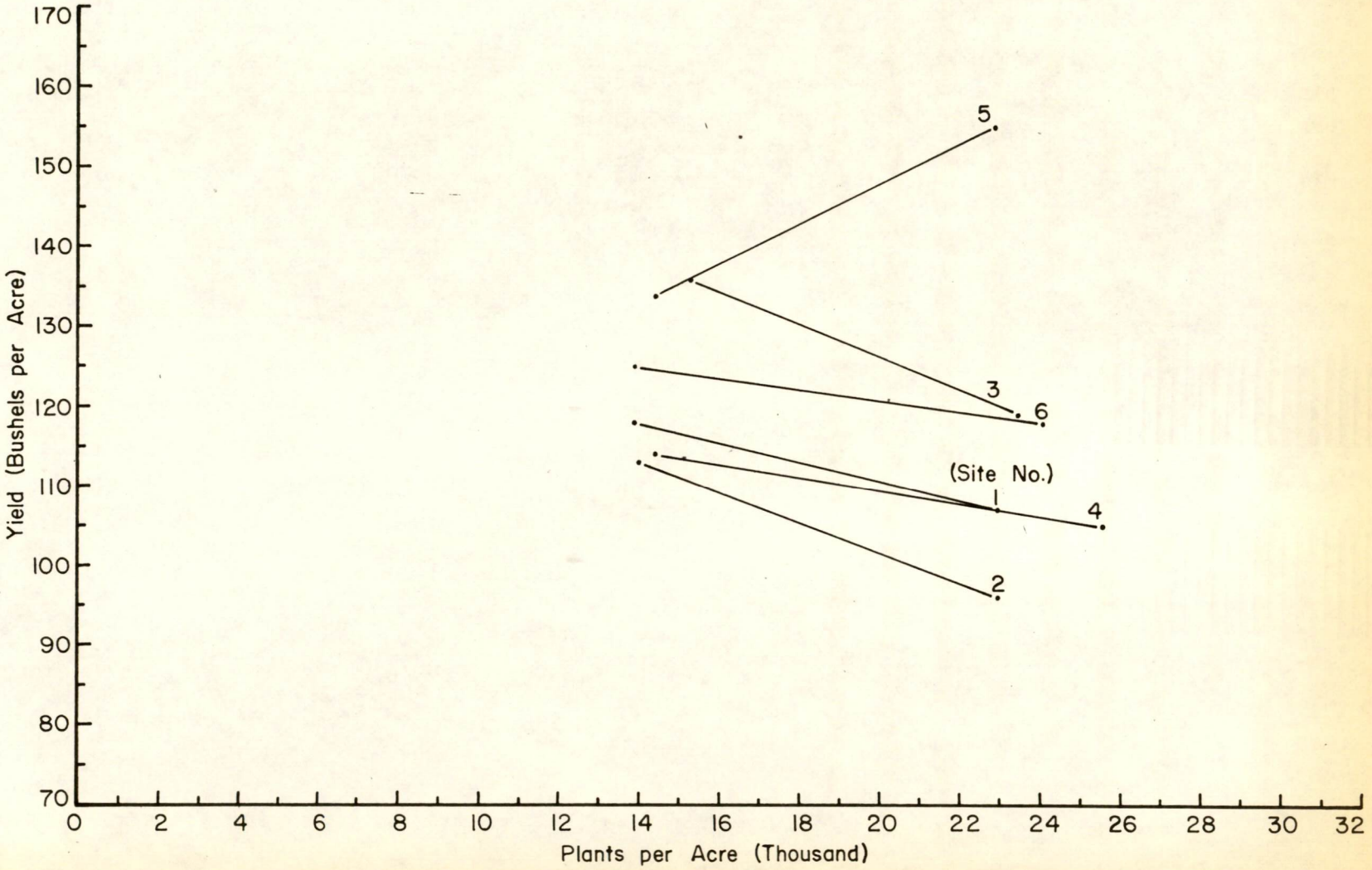


Figure 13.--Yields of corn at minimum and maximum plant populations at 6 sites on Waynesboro silt loam, fertilized at rate 420-220-220 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

yield for the high population on the six remaining observations. However, three of these six were at the same location.

Corn yields were higher at the maximum plant population than at the minimum on 18 of the 24 observations on Dickson soil, as shown in figures 14, 15, 16, and 17. None of the known production variables explained the decrease in yield in the remaining 6, but 3 of these 6 were at the same location. However, the rooting depth of corn at this location was only 13 inches as compared to an average of 16.4 inches at the other five sites.

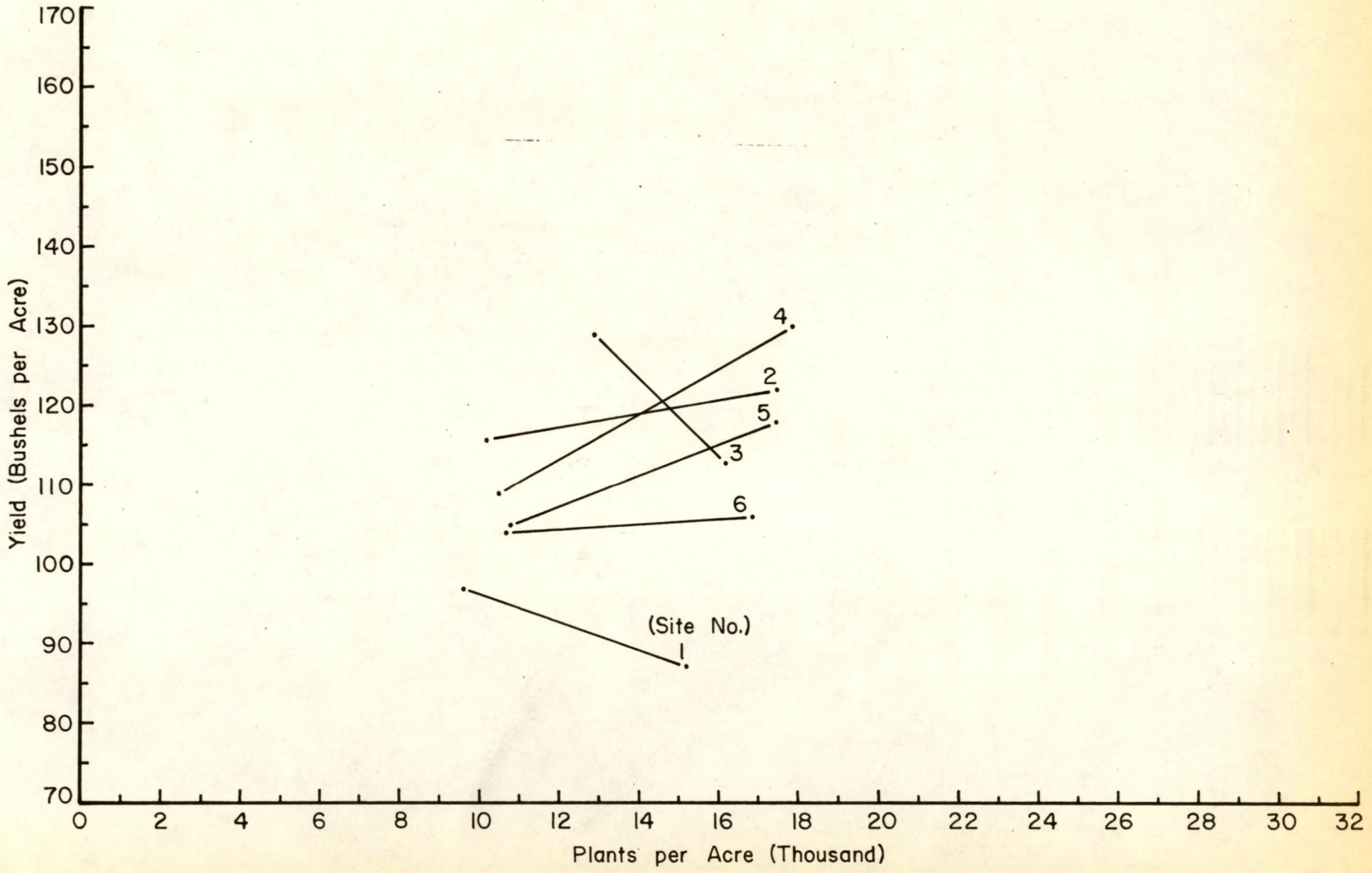


Figure 14.--Yields of corn at minimum and maximum plant populations at 6 sites on Dickson silt loam, fertilized at rate 220-420-420 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

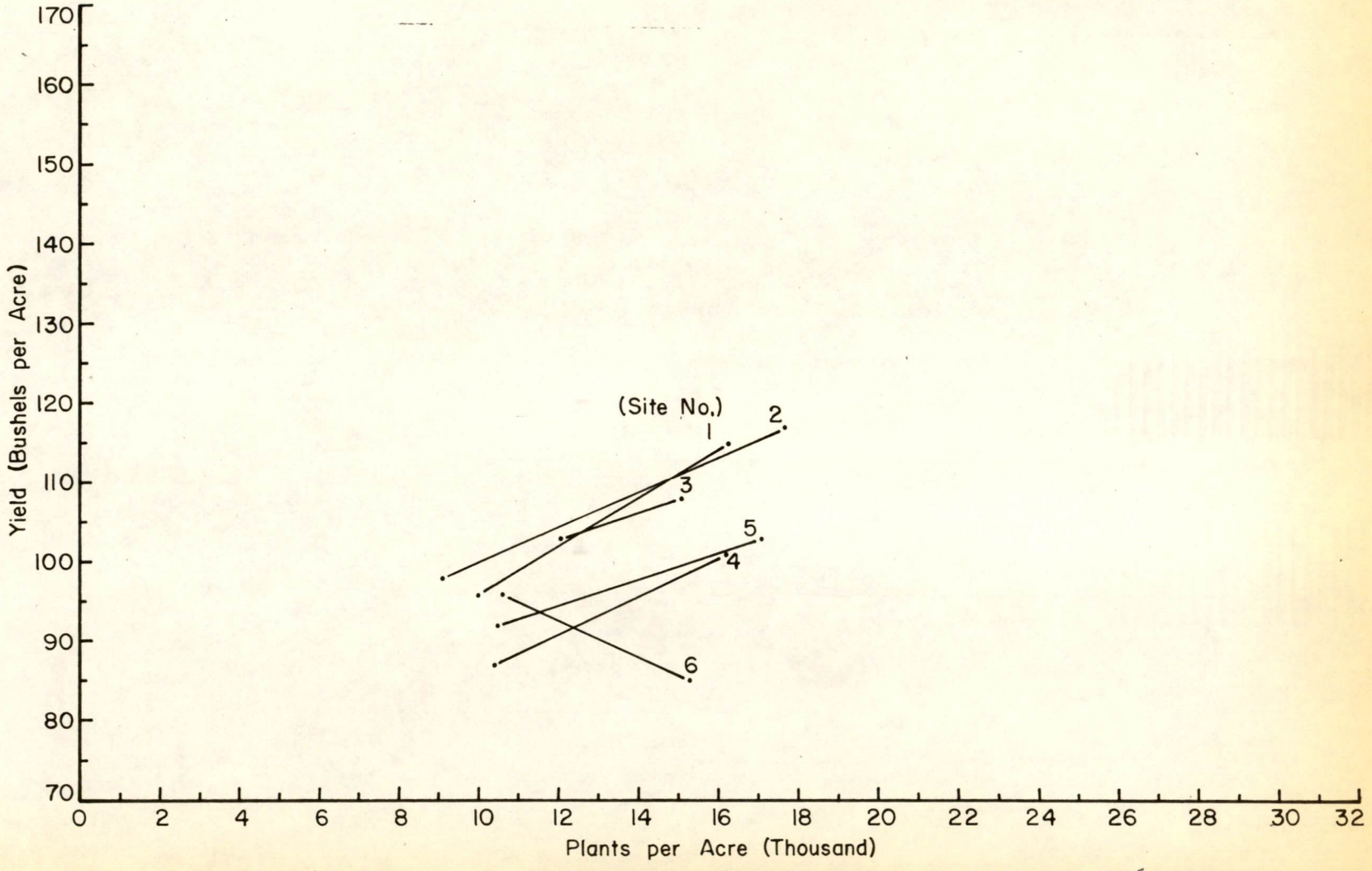


Figure 15.--Yields of corn at minimum and maximum plant populations at 6 sites on Dickson silt loam, fertilized at rate 220-220-220 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

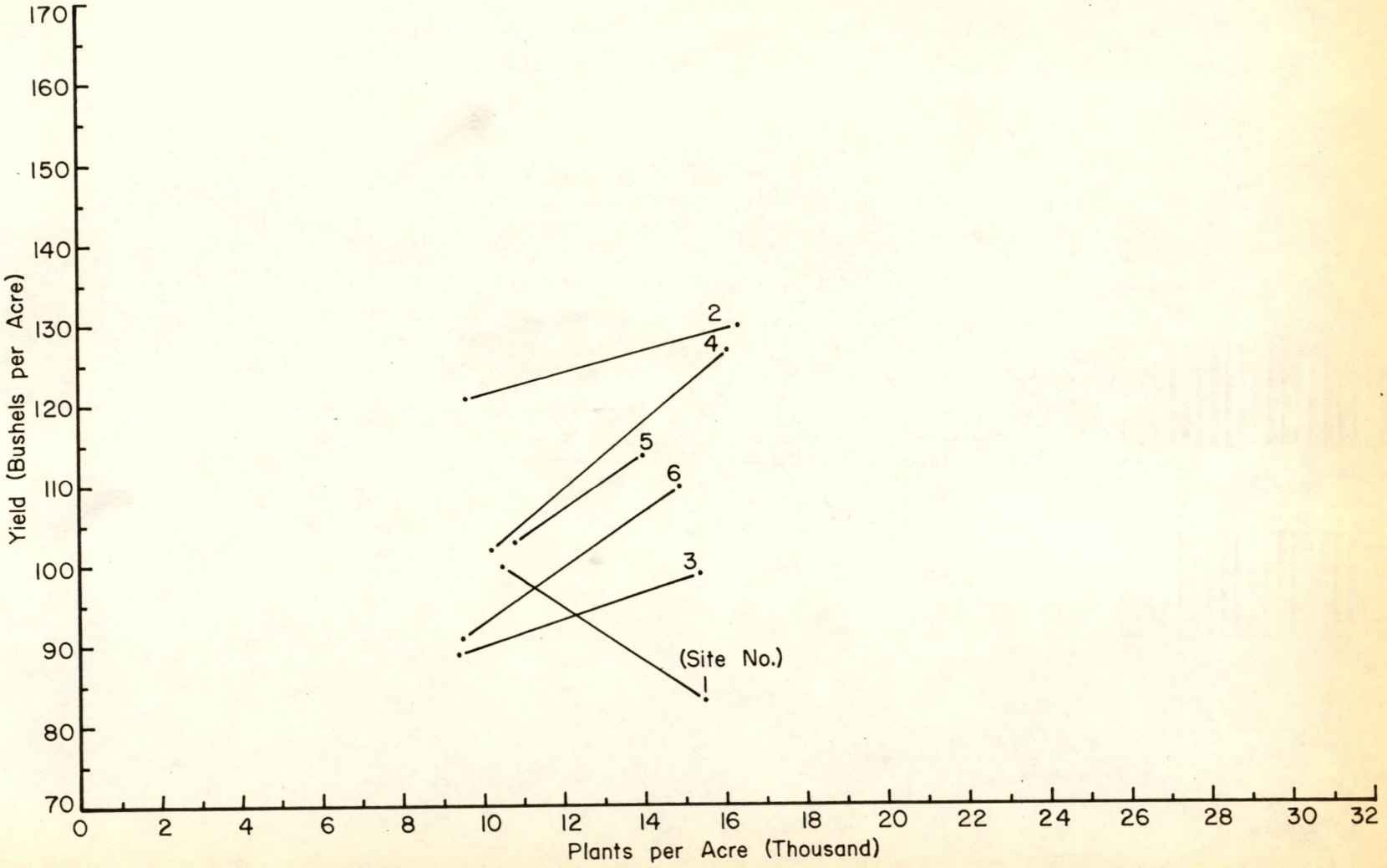


Figure 16.--Yields of corn at minimum and maximum plant populations at 6 sites on Dickson silt loam, fertilized at rate 420-420-420 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

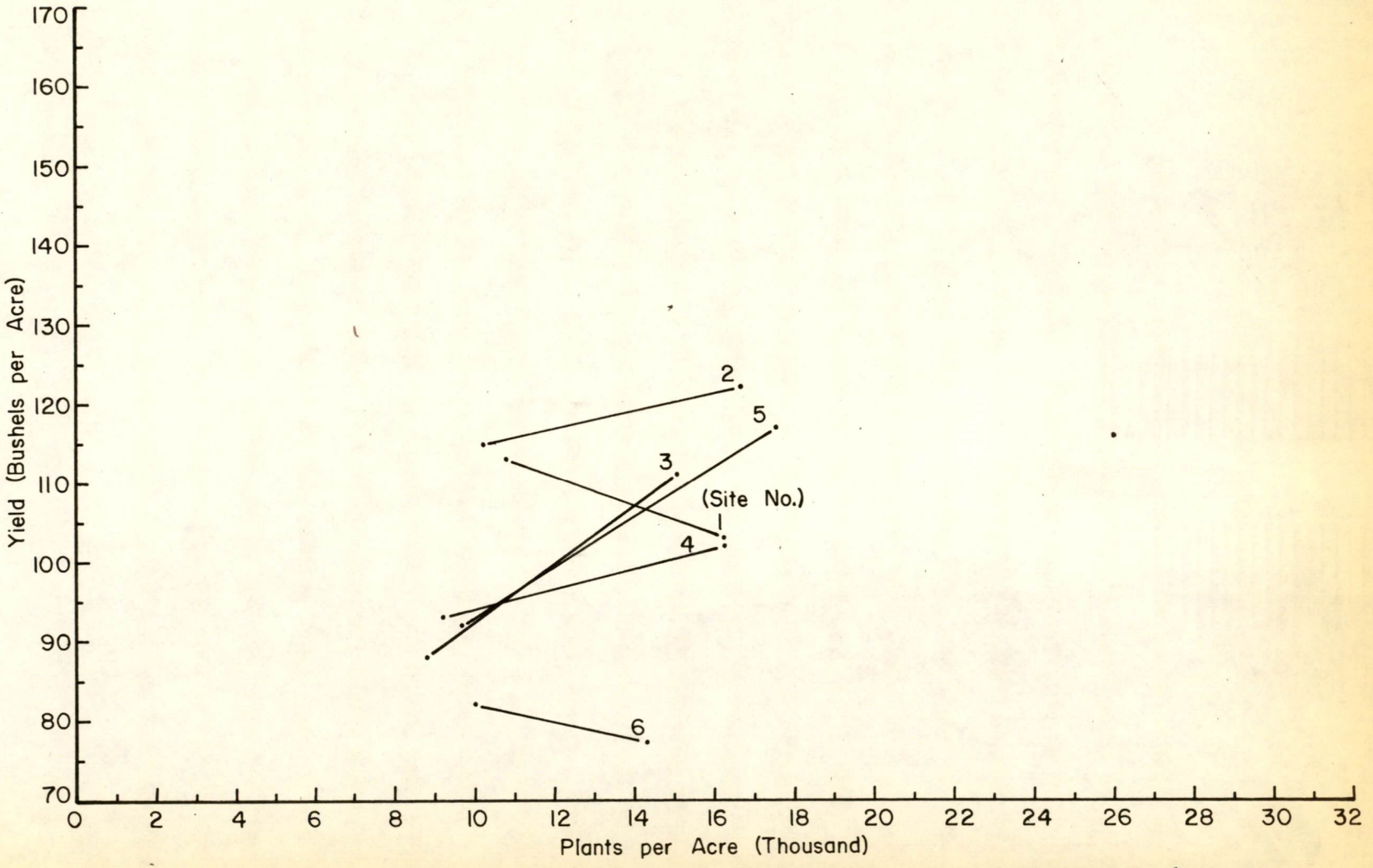


Figure 17.--Yields of corn at minimum and maximum plant populations at 6 sites on Dickson silt loam, fertilized at rate 420-220-220 (N, P_2O_5, K_2O) per acre, Putnam County, Tennessee, 1960. (Yields at minimum and maximum plant populations are connected by a line.)

CHAPTER VI

SUMMARY AND CONCLUSIONS

The production potential of corn was measured at high levels of fertility and varying plant populations on Huntington, Waynesboro, and Dickson soils in 1960. The average yields of corn in bushels per acre obtained on these soils, including all experimental treatments were: Huntington, 126; Waynesboro, 122, and Dickson, 105. At a lower level of added fertilizer and plant population (200 to 500 lbs. of 6-12-12 and 4,900 to 12,700 plants per acre) the following yields were obtained on the three soils: Huntington, 87 bushels; Waynesboro, 79 bushels; and Dickson, 44 bushels.

Under high levels of management, fertility and with adequate moisture, the production potentials of these soils were brought closer together, as is shown by the average yields above. Also the response to added fertilizer increased as the level of fertility (as indicated by the soil tests before treatment) decreased.

The above yields for the experimental treatments were obtained at comparable levels of added fertility; however, plant populations on the three soils were tested at two levels. They were as follows: Huntington, high level about 32,000 plants per acre and low level about 16,000; Waynesboro, high level about 24,000 and low level about 12,000; and Dickson, high level about 16,000 and low level about 8,000.

At the high levels of population lodging was greater on Waynesboro and Huntington than it was on Dickson. Also yields were depressed at the high level of population on Huntington and Waynesboro, but not at the high level on Dickson. From this it can be concluded that the high population on Huntington and Waynesboro was above the optimum.

The yield data indicate that a population of about 18,000 plants per acre would give the highest yield on Huntington, and about 16,000 on Waynesboro and Dickson in this year of adequate rainfall. However, the high degree of lodging might make these populations impractical for commercial production. When lodging as well as yield is considered a lesser number of plants would appear to be better for these soils from a practical point of view. Since not all of the plants considered lodged would have been missed by a mechanical picker, it is impossible to say exactly what should have been a practical population.

The high rate of nitrogen (420 lbs.) increased lodging over that at the low rate (220 lbs.) on Waynesboro and in every instance except one on Huntington. However, on Dickson there was no difference in the degree of lodging at the two rates.

Nitrogen at the higher level on Huntington and Waynesboro decreased yields in every case except one on each soil. On Dickson there was very little difference in yield between the high and low levels of nitrogen.

Phosphate and potash, at the high level (420 lbs. of P_2O_5 and K_2O) decreased yields as compared to the low rate (220 lbs. of P_2O_5 and K_2O) in all instances on Huntington and all except one on Waynesboro. The high level of applied phosphate and potash increased yields in every case on Dickson.

There was no apparent difference between the performance of Dixie 29 and Dixie 77 under the high level of management provided in this experiment.

A pre-emergence application of Atrazine at 2 pounds of active ingredient per acre gave excellent control of all annual weeds except for cockleburs at one site.

The higher populations on all three soils decreased the number of ears per plant about one-third when compared with the number obtained at the low populations. The average weight per ear was reduced as the population increased on all three soils. The amount of fertilizer added had little effect on ear weight or number of ears per plant.

There was very little difference between the rooting depth of corn on the experimental treatments and on the farmers' treatments. Separate soil tests taken from an area 6 inches above and 6 inches below the point where 95% of the roots stopped, showed no marked differences in pH, P and K. It would therefore appear that fertility was not a limiting factor in depth of rooting on these soils.

The rainfall in June, July and August of 1960 exceeded the average of that for the same 3-month period in the preceding 4 years.

Although the moisture extraction patterns showed differences in the depth of moisture extraction, there was little moisture stress in any of the three soils during the growing season.

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LITERATURE CITED

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APPENDIXES

APPENDIX A

PROFILE DESCRIPTION OF HUNTINGTON SILT LOAM

Horizon description	Depth inches	Color (moist)		Consistence (moist)	Structure	Texture
		Name	Munsell notation			
A_p	0-12	Dark Brown	10YR 4/3	Very friable	Weak, fine, granular	Silt loam
C_1	12-26	Dark Brown	10YR 4/3	Friable	Weak, fine, granular	Silt loam
C_2	26-40	Dark Brown to Yellowish Brown	10YR 3/3 10YR 3/4	Friable	Weak, fine, granular	Silt loam

APPENDIX B

PROFILE DESCRIPTION OF WAYNESBORO SILT LOAM

Horizon description	Depth inches	Color (moist)		Consistence (moist)	Structure	Texture
		Name	Munsell notation			
A_p	0-8	Brown to Dark Grayish Brown	10YR 4/3 10YR 4/2	Very friable	Weak, fine, granular	Silt loam
B_1	8-13	Reddish Brown	5YR 4/4	Friable	Moderate to medium, sub-angular blocky	Fine silt loam
B_{21}	13-21	Yellowish Red	5YR 4/8	Friable	Weak to medium sub-angular blocky	Silty clay loam
B_{22}	21-27	Dark Reddish	2.5YR 3/4	Friable	Moderate, fine subangular blocky	Fine silty clay loam
B_{25}	27-37	Dark red	10YR 3/6	Friable to firm	Strong, fine, angular blocky	Silty clay
C	37-50	Dark red	10YR 3/6	Firm	Strong, fine, and medium angular blocky	Silty clay

APPENDIX C

PROFILE DESCRIPTION OF DICKSON SILT LOAM

Horizon description	Depth inches	Color (moist) Name	Color (moist) Munsell notation	Consistence (moist)	Structure	Texture
A_1	0-1	Dark Grayish Brown	10YR 4/2	Very friable	Weak, medium	Silt loam
A_2	1-6	Yellowish Brown or Pale Brown	10YR 5/4 10YR 6/3	Very friable	Weak, fine, granular	Silt loam
B_1	6-10	Yellowish Brown	10YR 5/4-5/6	Friable	Weak, fine, subangular blocky	Silt loam
B_2	10-25	Yellowish Brown	10YR 5/6	Friable	Moderate, medium, subangular blocky	Coarse silty clay loam or clay loam
B_{3m}	25-38	Brownish Yellow Light Brownish Gray, Light Gray	10YR 6/6 10YR 6/2 10YR 7/2	Friable but brittle compact	Strong, medium coarse, angular blocky	Silt loam
C	38+	Variegated Yellowish Yellowish Brown Yellow and Gray	5YR 4/6 10YR 5/6 10YR 7/2-7/6	Firm	Moderate to medium, angular blocky	Silty clay loam

APPENDIX D

FARMER PARTICIPANTS, SITE NUMBER, VARIETIES AND SOILS USED IN THE 1960 CORN STUDY IN PUTNAM COUNTY

Site No.	Name of farmer	Variety	Soil
1.	Howard Hutchinson	Dixie 29	Huntington
2.	Logan Halfacre	"	"
3.	Vance Bartlett	"	"
4.	Horce Henry	"	"
5.	Arnold Hunter	"	"
6.	Arnold Hunter	Dixie 77	"
7.	Roley Bullington	Dixie 29	Waynesboro
8.	Dallas Jackson	"	"
9.	Pleas Deering	"	"
10.	Harlin Mullins	"	"
11.	Jeff Burton	"	"
12.	Clyde Bohannon	Dixie 77	"
13.	Asbury Ramsey	Dixie 29	Dickson
14.	Jones & Chaffin	"	"
15.	E. L. Stone	"	"
16.	Curtis Williams	"	"
17.	Charlie Cambell	"	"
18.	Charlie Palk	Dixie 77	"

APPENDIX E

DATA SHEETS USED FOR RECORDING HARVEST SAMPLES OF CORN

Farmer's Name _____ Soil type _____

1. Row width _____ Acre Factor _____

2. Shucked weight, total number of plants per 50 feet of row, barren plants, number of ears, and number of lodged plants per 50 feet of row from sample rows are as follows:

No. 1 Low Population - 220 lbs. N and 420 lbs. P_2O_5, K_2O

Sampled Row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture Test* _____ Moisture Factor _____

4. Bushels/Acre _____ Plants/Acre _____ Lodged Plants/Acre _____

5. Ears/Stalk _____ Wt./ear _____

No. 2 High Population - 220 lbs. N and 420 lbs. P_2O_5, K_2O

Sampled row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test*_____ Moisture Factor_____

4. Bushels/Acre_____ Plants/Acre_____ Lodged Plants/Acre_____

5. Ears/Stalk_____ Wt./Ear_____

No. 3 Low Population - 420 lbs. N, P_2O_5, K_2O

Sampled row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test*_____ Moisture Factor_____

4. Bushels/Acre_____ Plants/Acre_____ Lodged Plants/Acre_____

5. Ears/Stalk_____ Wt./Ear_____

APPENDIX E (continued)

No. 4 High Population - 420 lbs. N, P_2O_5, K_2O

Sampled Row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test* _____ Moisture Factor _____

4. Bushels/Acre _____ Plants/Acre _____ Lodged Plants/Acre _____

5. Ears/Stalk _____ Wt./Ear _____

No. 5 Low Population - 220 lbs. N, P_2O_5, K_2O

Sampled Row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test* _____ Moisture Factor _____

4. Bushels/Acre _____ Plants/Acre _____ Lodged Plants/Acre _____

5. Ears/Stalk _____ Wt./Ear _____

No. 6 High Population - 220 lbs. N, P_2O_5, K_2O

Sampled Row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test*_____ Moisture Factor_____

4. Bushels/Acre_____ Plants/Acre_____ Lodged Plants/Acre_____

5. Ears/Stalk_____ Wt./Ear_____

No. 7 Low Population - 420 lbs. N and 220 lbs. P_2O_5, K_2O

Sampled Row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test*_____ Moisture Factor_____

4. Bushels/Acre_____ Plants/Acre_____ Lodged Plants/Acre_____

5. Ears/Stalk_____ Wt./Ear_____

APPENDIX E (continued)

No. 8 High Population - 420 lbs. N and 220 lbs. P_2O_5, K_2O

Sampled Row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test*_____ Moisture Factor_____

4. Bushels/Acre_____ Plants/Acre_____ Lodged Plants/Acre_____

5. Ears/Stalk_____ Wt./Ear_____

No. 9 Farmers Fertilization

Sampled Row	Lbs. shucked corn/50' row	Total plants	Lodged plants	Barren plants	No. of ears
1					
2					
3					
4					
5					
6					
Total					

3. Moisture test*_____ Moisture Factor_____

4. Bushels/Acre_____ Plants/Acre_____ Lodged Plants/Acre_____

5. Ears/Stalk_____ Wt./Ear_____

*(18) ears of corn for moisture sample

APPENDIX F

AN EXAMPLE OF THE CALCULATION OF ACRE YIELD FROM A HARVEST SAMPLE

1. Calculation of factor for conversion of sample to an acre basis

   six 50-foot rows 21 inches apart $\frac{43,560}{(6 \times 50 \times \frac{21}{12})}$ = 82.97 acre factor

2. Acre factor $\frac{82.97}{70}$ = 1.185
   Lbs./bu.

3. Total field weight of the harvest samples - 126.5 pounds

4. Weight of harvest samples converted to Bu. per acre

   (a) 1.185 x 126.5 = 149.90

5. Moisture by Steinlite -- 21.58 percent

   Moisture factor .928

6. To adjust bushels per acre to 15.5 percent moisture basis, the following calculation was made: 149.90 x .928 = 139 bushels per acre.

APPENDIX G

HARVEST DATA FOR THE EIGHT EXPERIMENTAL TREATMENTS AND THE FARMERS' TREATMENTS AT SIX LOCATIONS ON HUNTINGTON, WAYNESBORO AND DICKSON SOILS IN PUTNAM COUNTY, 1960

Site No.	Tmt. No. 1(220 lbs. N,420 lbs.P_2O_5,K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ ear	Tmt.No. 2(220 lbs. N,420 lbs. P_2O_5, K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ ear	Tmt.No. 3(420 lbs. N, P_2O_5, K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ ear
HUNTINGTON															
1	10,100	83.0	11	142	.41	14,500	113.0	10	103	.53	9,100	89.0	11	154	.45
2	12,600	115.0	24	137	.47	20,100	113.0	68	92	.43	12,200	87.0	21	124	.40
3	16,600	120.0	43	126	.40	29,600	114.0	92	87	.31	16,800	141.0	63	147	.40
4	17,500	158.0	33	143	.44	30,000	139.0	89	99	.33	16,900	132.0	50	129	.42
5	18,800	149.0	13	132	.42	26,000	126.0	71	105	.32	15,800	122.0	43	141	.38
6	16,900	143.0	30	139	.43	29,600	125.0	92	90	.33	16,800	114.0	81	114	.42
Ave.	15,400	128.0	26	136	.43	25,000	122.0	70	96	.37	14,600	114.0	45	135	.41
WAYNESBORO															
7	13,500	94.0	3	119	.41	21,300	97.0	16	95	.34	13,500	91.0	15	111	.42
8	14,600	129.0	11	143	.43	25,100	124.0	64	99	.35	14,400	113.0	51	127	.43
9	14,900	153.0	26	150	.48	23,100	142.0	63	105	.41	13,600	119.0	61	159	.38
10	16,200	131.0	33	146	.39	25,600	136.0	71	102	.37	15,200	128.0	37	148	.40
11	14,500	127.0	29	135	.45	23,800	135.0	64	98	.41	14,000	130.0	38	148	.44
12	14,900	135.0	24	135	.51	24,500	121.0	65	96	.36	14,400	125.0	33	132	.46
Ave.	14,800	128.0	21	138	.45	23,900	126.0	57	99	.37	14,200	118.0	39	137	.42
DICKSON															
13	9,600	97.0	16	163	.43	15,200	87.0	36	97	.41	10,500	100.0	15	136	.49
14	10,200	116.0	14	167	.48	17,500	122.0	21	108	.45	9,600	121.0	14	178	.49
15	12,900	129.0	5	150	.46	16,200	113.0	13	107	.45	9,400	89.0	4	147	.45
16	10,500	109.0	16	162	.45	17,900	130.0	18	112	.45	10,200	102.0	20	158	.44
17	10,800	105.0	20	148	.46	17,500	118.0	36	113	.42	10,800	103.0	22	164	.41
18	10,700	104.0	13	158	.43	16,900	106.0	23	108	.41	9,500	91.0	17	151	.44
Ave.	10,800	110.0	14	158	.45	16,900	113.0	24	107	.43	10,000	101.0	15	156	.45

APPENDIX G (continued)

HUNTINGTON

Site No.	Tmt. No. 4(420 lbs. N, P_2O_5, K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ ear	Tmt. No. 5(220 lbs. N, P_2O_5, K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ ear	Tmt. No. 6(220 lbs. N, P_2O_5, K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ ear
1	11,600	103.0	18	120	.52	13,800	98.0	26	108	.46	20,500	112.0	54	86	.45
2	17,200	104.0	21	98	.43	11,800	117.0	25	153	.45	17,000	131.0	49	120	.45
3	28,500	144.0	76	99	.41	16,500	153.0	30	144	.45	29,300	131.0	84	89	.35
4	26,500	131.0	78	92	.38	17,200	170.0	25	147	.47	32,000	141.0	78	85	.36
5	27,200	110.0	91	99	.29	17,800	145.0	10	142	.40	30,500	121.0	40	96	.29
6	29,300	119.0	90	91	.32	17,800	141.0	32	126	.44	27,000	122.0	86	96	.33
Ave.	23,400	119.0	62	100	.39	15,800	137.0	25	137	.45	26,100	126.0	65	95	.37
WAYNESBORO															
7	21,700	75.0	24	74	.32	12,100	98.0	5	127	.45	24,200	117.0	19	92	.37
8	24,600	102.0	90	96	.30	14,400	133.0	12	142	.46	24,000	120.0	41	108	.32
9	24,400	135.0	78	100	.39	15,000	152.0	23	161	.44	23,900	128.0	74	98	.38
10	25,500	127.0	78	94	.37	15,700	145.0	35	161	.40	26,100	125.0	90	100	.34
11	23,800	152.0	51	106	.42	14,100	139.0	14	133	.52	24,900	124.0	65	89	.39
12	24,800	115.0	71	87	.37	13,500	128.0	24	134	.50	23,500	123.0	58	97	.38
Ave.	24,100	118.0	65	93	.36	14,100	133.0	19	143	.46	24,400	123.0	58	97	.36
DICKSON															
13	15,500	83.0	10	98	.38	10,000	96.0	22	152	.44	16,300	115.0	29	109	.45
14	16,400	130.0	24	126	.44	9,100	98.0	9	167	.45	17,700	117.0	14	105	.44
15	15,400	99.0	12	103	.44	12,100	103.0	12	114	.53	15,100	108.0	13	118	.43
16	16,100	127.0	17	110	.50	10,400	87.0	14	133	.44	16,200	101.0	18	102	.43
17	16,000	114.0	31	118	.42	10,300	92.0	15	148	.42	17,100	103.0	21	109	.39
18	14,900	110.0	22	123	.42	10,600	96.0	17	146	.43	15,300	85.0	18	109	.36
Ave.	15,700	111.0	19	113	.43	10,400	95.0	15	143	.45	16,300	105.0	19	109	.42

APPENDIX G (continued)

Site No.	Tmt. No. 7(420 lbs. N,220 lbs. P_2O_5,K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears/100 stalks	Wt./ear	Tmt. No. 8(420 lbs. N,220 lbs. P_2O_5,K_2O) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ear	Tmt. No. 9 (Farmers) Pop. Plants/acre	Yield Bu./acre	Lodging %	Ears /100 stalks	Wt./ear
						HUNTINGTON									
1	11,500	103.0	19	137	.46	18,300	112.0	44	105	.41	8,500	58.0	7	96	.50
2	15,000	142.0	43	142	.47	20,000	133.0	43	142	.47	8,300	82.0	16	131	.53
3	16,300	137.0	35	123	.48	28,700	134.0	88	95	.34	8,600	98.0	4	159	.50
4	19,600	142.0	71	128	.40	28,000	154.0	88	102	.38	12,700	114.0	3	124	.50
5	16,300	124.0	53	140	.38	28,700	125.0	89	98	.31	6,800	82.0	8	131	.64
6	17,100	128.0	49	116	.45	30,000	125.0	90	92	.35					
Ave.	16,000	129.0	45	131	.40	25,600	131.0	74	100	.38	9,000	87.0	8	128	.53
						WAYNESBORO									
7	13,900	118.0	19	134	.44	23,000	107.0	32	91	.36					
8	14,000	113.0	36	136	.42	23,000	96.0	71	94	.31					
9	15,300	136.0	42	157	.39	23,500	119.0	79	98	.36	8,400	91.0	4	150	.50
10	14,400	114.0	72	141	.39	25,600	105.0	96	84	.34	8,700	83.0	14	126	.53
11	14,400	134.0	44	135	.48	22,900	155.0	43	107	.44	6,700	72.0	2	131	.57
12	13,900	125.0	26	123	.51	24,100	118.0	71	92	.37	7,300	68.0	1	105	.57
Ave.	14,300	123.0	40	138	.44	23,700	117.0	65	94	.36	7,800	79.0	5	128	.54
						DICKSON									
13	10,800	113.0	11	151	.48	16,300	103.0	18	104	.47					
14	10,200	115.0	10	177	.44	16,700	122.0	12	113	.45	7,400	44.0	10	98	.42
15	8,800	88.0	11	157	.50	15,100	111.0	14	115	.45	4,900	32.0	12	110	.42
16	9,200	93.0	15	161	.44	16,300	102.0	14	106	.42	6,300	60.0	16	109	.58
17	9,700	92.0	20	165	.40	17,600	117.0	21	110	.42	5,400	42.0	20	124	.44
18	10,000	82.0	9	137	.42	14,300	77.0	20	106	.36	5,900	40.0	7	109	.43
Ave.	9,800	97.0	13	158	.45	16,000	105.0	16	109	.43	6,000	44.0	13	110	.46

APPENDIX H

ROOTING DEPTH AND RAMIFICATION OF ROOTS ON THE EXPERIMENTAL TREATMENT (220 lbs. N, P_2O_5 and K_2O) AND FARMERS' TREATMENT (200-500 lbs. 6-12-12) ON HUNTINGTON, WAYNESBORO AND DICKSON SOILS IN PUTNAM COUNTY, 1960

Site No.	Rooting depths				Ramification* Scale of 1-10	
	Experimental treatment		Farmers treatment		Experimental treatment	Farmers treatment
	95% In.	All In.	95% In.	All In.		
1	23	33	25	35	10	9
2	34	42	30	38	10	9
3	26	32	28	36	9	9
4	32	38	32	36	7	9
5	32	38	32	36	8	8
6	32	38	32	36	8	8
7	21	25	--	--	8	-
8	21	26	--	--	10	-
9	26	36	24	34	9	8
10	26	36	18	26	10	8
11	23	36	22	35	8	9
12	26	36	24	34	9	8
13	13	13	--	--	9	-
14	18	26	18	26	7	6
15	18	22	17	20	8	7
16	16	22	15	22	9	8
17	16	22	14	20	8	8
18	14	18	14	18	8	8

* 10 = highest degree of ramification.

APPENDIX I

SOIL TEST VALUES (pH, AVAILABLE P AND EXCHANGEABLE K) ON HUNTINGTON, WAYNESBORO AND DICKSON SOILS IN PUTNAM COUNTY, 1960

Site No.	Sample No.*	pH	Available P lbs./A.	Exchangeable K lbs./A.
1	1	6.9	35	122
	2	6.8	35	120
2	1	6.9	35	111
	2	7.1	35	78
3	1	6.3	6	95
	2	6.2	5	103
4	1	6.0	9	121
	2	5.9	4	103
5	1	5.7	4	143
	2	5.9	6	143
6	1	5.7	4	143
	2	5.9	6	143
7	1	6.5	4	95
	2	4.4	4	70
8	1	5.1	3	125
	2	5.1	5	195
9	1	5.8	7	118
	2	5.8	7	112
10	1	5.0	6	74
	2	5.4	5	74
11	1	6.1	3	121
	2	5.0	3	103
12	1	5.9	5	95
	2	5.7	7	118

APPENDIX I (continued)

Site No.	Sample No.*	pH	Available P lbs./A.	Exchangeable K lbs./A.
13	1	4.6	4	26
	2	4.7	3	38
14	1	5.8	7	89
	2	4.9	3	45
15	1	5.6	9	84
	2	5.4	8	78
16	1	4.8	3	63
	2	5.0	3	78
17	1	4.6	4	26
	2	4.7	3	38
18	1	5.8	5	74
	2	4.8	6	70

* Sample number refers to the area from which the soil sample was taken. No. 1 was taken from an area six inches above the point where 95% of the roots terminated. No. 2 was taken from an area six inches below the point where 95% of the roots terminated.

APPENDIX J

INCHES OF RAINFALL AT THE DIFFERENT SITES DURING THE 1960 GROWING SEASON IN PUTNAM COUNTY

Code No. Sites	Months			Total
	June	July	August	
1	5.3	9.6	4.2	19.1
2	5.4	9.5	4.1	19.0
3	5.6	8.3	4.3	18.2
4	5.4	7.6	4.0	17.0
5	5.2	7.7	4.5	17.4
6	5.2	7.7	4.5	17.4
7	4.3	7.3	3.4	15.0
8	4.4	7.4	3.4	15.2
9	4.5	7.0	3.5	15.0
10	4.4	9.6	2.3	16.3
11	4.3	9.3	2.6	16.2
12	4.3	9.5	2.4	16.2
13	4.2	9.6	2.7	16.5
14	3.9	9.8	8.6	16.3
15	4.5	10.5	3.0	18.0
16	5.3	8.2	2.9	16.4
17	5.3	8.2	2.9	16.4
18	3.9	9.8	2.6	16.3

APPENDIX K

AVERAGE SOIL TEST VALUES (pH, AVAILABLE P AND EXCHANGEABLE K) OF THE FOUR SOIL SAMPLES TAKEN BEFORE SOIL TREATMENT ON HUNTINGTON, WAYNESBORO AND DICKSON SOILS IN PUTNAM COUNTY, 1960

Site No.	pH	Available P lbs./A.	Exchangeable K lbs./A.
1	6.7	35	161
2	6.8	35	122
3	6.2	13	188
4	6.2	7	136
5	6.4	8	131
6	6.4	8	131
7	6.0	27	217
8	5.0	4	140
9	6.8	24	272
10	6.4	5	164
11	6.2	2	114
12	6.6	2	96
13	5.4	8	58
14	6.3	6	51
15	6.0	24	154
16	6.3	8	72
17	6.1	23	52
18	6.0	12	55