TB 1367 (1967) USDA TECHNICAL BULLETINS UPDATA
EVALUATON OF AGRICULTURAL HYDROLOGY BY MONOLITH LYSIMETERS, 1956-62
HARROLD, L.L. ; DREIBELBIS, F.R. 1 OF 2

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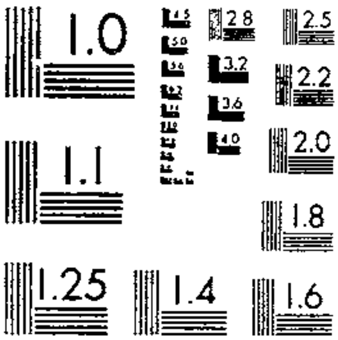

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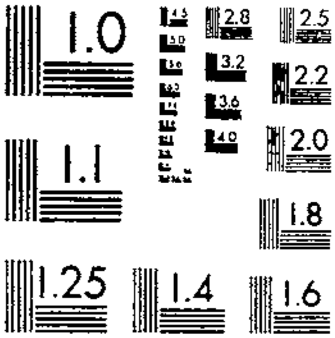

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Technical Bulletin No. 1367

EVALUATION of AGRICULTURAL HYDROLOGY by Monolith Lysimeters

1956-62

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UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
Ohio Agricultural Research and Development Center

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INTRODUCTION

This bulletin is a progress report on the lysimeter investigations carried on at the North Appalachian Experimental Watershed near Coshocton, Ohio, from 1956 through 1962. Summaries of moisture balance studies are presented for 1944-62. Data for 1944-55 represent in part, a revision of those published in U.S. Department of Agriculture Technical Bulletin 1179 (*66*).[3]

The hydrologic data were obtained from 11 monolith lysimeters, each 0.002 acre in area and 8 feet deep, 3 of which were weighed automatically every 10 minutes. The features of these unique installations and the history of their operation have been described in U.S. Department of Agriculture Technical Bulletin 1179 (*66*). Review of lysimeter literature during 1944-55, given in that bulletin, is extended to 1962 in the present report.

The basic research plan developed in 1935 for the North Appalachian Experimental Watershed at Coshocton, Ohio, provided for evaluation of all factors affecting the disposal of precipitation, as part of a comprehensive study designed to uncover basic laws relating to agricultural hydrology. Lysimeters were considered an important part of the instrumentation necessary for this study. Rainfall and runoff measurements provided data for the determination of infiltration. Percolation data were related to recharge of ground water. Weight-change records adjusted for amounts of rainfall, runoff, and percolation provided data on evapotranspiration. All these values were necessary in the analysis and interpretation of the station's watershed records.

Because of the climatic variables, there were times when soil moisture was sufficient to meet crop needs and times when it was not. For the 1956-62 period, annual precipitation was

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[1] Retired.

[2] The work on this experimental watershed project was done at the North Appalachian Experimental Watershed near Coshocton, Ohio, by the Soil and Water Conservation Research Division (SWCRD), Agricultural Research Service, in cooperation with the Ohio Agricultural Research and Development Center. The data were collected by the project staff. Much of the work of operating the lysimeters and tabulating the basic data was performed by William W. Bentz and Robert E. Youker of the SWCRD. J. L. McGuinness (SWCRD) assisted in the statistical treatment of data in parts of the report. J. H. Wilson of the Ohio Agricultural Research and Development Center, Wooster, Ohio, assisted in the chemical analyses of percolation water.

[3] Italic numbers in parentheses refer to Literature Cited, p. 79.

above normal for 3 years and below normal for 4 years. The extremes of annual precipitation for this period were 53.40 inches in 1959 and 36.32 inches in 1958. Thus, evaluation of the data on agricultural hydrology in this bulletin reflects sizeable variations in climate.

REVIEW OF RECENT LYSIMETRY LITERATURE

The lysimetry literature reviewed here covers the period from 1956 to 1962. An extensive review of literature by Kohnke and coworkers (*83*) covered two and a half centuries of research in lysimetry up to 1939. Harrold and Dreibelbis (*66*) reviewed the literature from 1939 to 1955. In the present, as in past reviews, it is possible that inadvertent omissions have occurred, particularly of works published outside of this country.

The purpose of most lysimeter investigations has been to study problems in hydrology, soil fertility, or both. In a few cases, studies have been made dealing with special problems such as lysimeter design. King and coworkers (*81*) described a floating lysimeter for measuring evapotranspiration. McMillan and Paul (*99*) suggested that the major drawback to this design was the large air chamber required to provide buoyancy for the soil mass, thereby restricting the depth of rooting. They suggested a modification in design that extends the usefulness of this installation. McMillan and Burgy (*98*) conducted further studies with floating lysimeters. Cole (*25*) and Cole and coworkers (*26*) described an Alundum[4] tension lysimeter which was designed to minimize the soil-air interface problem. Van Bavel and Myers (*172*) reported the use of a weighing lysimeter that electronically records data from strain gage sensors on punch tape for automatic data processing and analysis. Dylla and Tovey (*42*) reported the use of plastic tanks in Nevada for measuring evapotranspiration. Hide and others (*75*) used 4-inch fallow lysimeters to study percolation, evaporation, and storage of water in soil.

Harrold and Dreibelbis (*69*) reported the results of a special study of the grease seal on the Coshocton lysimeters. The erratic temperature fluctuations in the grease seal resulted in apparent diurnal weight changes that greatly exceeded the true values. The reported values of dew (CA) of 10 inches or more per year were, therefore, much too large. Likewise, published values of evapotranspiration (ET) totaled from weight changes for periods of less than a day were too large. However, the published values of consumptive use, or net evapotranspiration (ET-CA), based on monthly weight changes, were valid.

Of those investigations dealing with hydrologic problems, an increasing percentage have been concerned with evaluating evapotranspiration. Noteworthy among the reports from this country are those of Pruitt (*131*) and of Pruitt and his coworkers (*18, 41, 54, 132, 133, 134, 135*) at Davis, California, and of Van Bavel (*170*), and Van Bavel and his coworkers (*49, 52, 171, 172, 173*), at Tempe, Arizona. Other investigations on ET of interest are those of Peters and Russell (*120*), Tanner (*166, 167*), England and Lesesne (*44*), Mather (*108*), Allison and coworkers (*5*),

[4] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U. S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

Brill and Willits (*17*), Cowan and Innes (*28*), Ekern (*43*), Harbeck (*61*), Morris (*109*), Graham and King (*55*), Dylla and Tovey (*42*), Pelton (*119*), Pierce (*123*), Campbell and coworkers (*20*), and Speir (*159*). Graham and King (*55*) determined the ratio of daily ET to net radiation at various stages in the development of a corn crop. Brakensiek (*14*), Dreibelbis (*33, 34, 35, 36*), Dreibelbis and Harrold (*37*), Harrold (*62, 63*), Harrold and Dreibelbis (*65, 66, 67, 68, 69*), Harrold and coworkers (*64, 70, 71*), and McGuinness and others (*93*) wrote papers on hydrologic data from the Coshocton Station.

Harrold and coworkers (*70, 71*) separated evapotranspiration into its components of evaporation and transpiration. This was achieved by placing plastic sheets over the lysimeter soil during the corn growing season of 1957, thereby preventing evaporation. Soil water transferred to the atmosphere during this period was entirely due to transpiration. Evaporation values were derived by regression analysis from data of previous years in which corn was the crop grown. Dreibelbis and Harrold (*37*) reported data on the water-use efficiency of corn, wheat, and meadow crops. Irrigation on corn in 1953 and on meadow in 1955 resulted in a higher water-use efficiency for these crops than in any year when they were not irrigated.

Dreibelbis (*35*) found that the soil moisture regimen in lysimeters differed from that on adjacent watersheds. The magnitude of the difference varied with soil type and moisture content.

McGuinness and others (*93*) compared values for lysimeter soil moisture changes obtained with the neutron method with values obtained by the weighing lysimeter. Data for the growing season in 1959 showed close agreement between the two methods.

Babcock and coworkers (*10*) conducted lysimeter studies on the effect of composition of irrigation waters in California on soil properties. Hildebrand and Pagenhart (*76*) made lysimeter studies of snowmelt.

Several lysimeter investigations dealing with forestry problems have been carried on by the U.S. Forest Service. Among those reported are the work of Patric (*117, 118*), Zinke (*187*), and Sinclair and Patric (*155*). All of these papers are concerned primarily with the San Dimas (California) lysimeters. Rich (*141*) described the base rock lysimeters of the Sierra Ancho Experimental Watersheds in central Arizona. The data showed that most of the total water yields resulted from percolation flow during the winter. Lowry and Finney (*92*) used lysimeters for measuring the chemical changes in weathering coal spoil.

Lysimeter studies dealing with soil fertility problems have been concerned mostly with the nitrogen balance in soils. Examples of studies of nitrogen losses in percolates are the work of Volk and Sweat (*177*), Owens (*116*), Raney (*138*), Branson (*15, 16*), Allison and coworkers (*4*), Pratt (*125*), Pratt and coworkers (*126, 127*), Shaw and Robinson (*148, 149*), and Shalhevet and Zwerman (*147*).

Bengtson and Voigt (*11*) used lysimeters to study leaching losses of nitrogen and potassium from slash pine seedlings in Lakeland fine sand. They found the slowly soluble fertilizers more efficient sources of nitrogen and potassium than the highly soluble fertilizers. Orlob and Butler (*111*) used lysimeters in waste water reclamation studies.

McKell and Williams (*97*) used lysimeters to study sulfur fertilization of a range soil and Pritchett and Nolan (*130*) studied potassium leaching losses as affected by soil particle size. On an arid Holston sandy loam treated with soybean hay and wheat straw, Shaw and Robinson (*148*) analyzed the leachates for calcium, magnesium, potassium, sulfur, nitrogen and organic matter. Reyes and coworkers (*139*) and Reyes and Galvez (*140*) reported studies on leaching of nutrients from soils planted to paddy rice in the Philippines.

Cole and coworkers (*26*) used lysimeters to study the influence of soil type and fertilization on the vertical movement of nitrogen, phosphorus, potassium, and calcium. Leachates were analyzed also for gamma-emitting radionucleides originating from radioactive fallout. Ru^{106}, Rh^{106}, Sb^{125}, Cs^{137}, Ce^{144}, Pr^{144}, and Eu^{155} were detected.

Harrold and Dreibelbis (*66*) presented data on leaching losses of potassium, calcium, magnesium, nitrogen, manganese, and sulfur for the period 1941-55. Dreibelbis and McGuinness (*38, 39*) reported data on nutrient losses, for the same period, in which a statistical interpretation of the data was made.

Among the lysimeter investigations reported outside the United States are those of Pelton (*119*), who studied ET in Canada and Cavanillas (*21*), who studied ET from cultivated plants in Spain. Cavanillas and coworkers (*22*) studied ET using lucerne, sugar beets, potatoes, and tomatoes. Suarez de Castro and Rodriguez (*163, 164*) of Colombia used monolith lysimeters to study water balance and nutrient losses. They found a relation between volume of percolation and total quantity of nutrients leached. In the Netherlands, Wind (*179, 180, 181*) described lysimeters in that country and reviewed their records up to 1954; Visser (*176*) described lysimeter techniques for determining the water balance of soils; other investigations from that country were reported by Ramsauer (*137*), Makkink (*100* to *106*), Makkink and Heemst (*107*), Hesse (*74*), de Wit (*184*), and Rijtema (*142*). Aslyng and Kristensen (*7, 8, 9*) and Kristensen (*89*) of Denmark studied the water balance with lysimeters.

Green (*56, 57, 58*) of England used lysimeters for evaporation studies and to study the effects of forest areas on water resources. Law (*90*) studied the effect of afforestation upon the yield of water catchment areas. Winter (*182*) and Winter and coworkers (*183*) studied potential and actual ET with small, weighable lysimeters. Among the investigations in Germany are those reported by Koblenz (*82*), Frercks and Kosegarten (*47*), Pfaff (*122*), Kortum (*85, 86*), Kiel (*80*), Prenk (*128, 129*), Kohnlein and Knauer (*84*), Haushofer (*72*), Husemann (*77*), Schroeder (*146*), Janert (*78*), Steubing (*160*), Albrecht (*3*), and Czeratzki (*29*). Kosmat (*87, 88*) in Austria described a microlysimeter in which he studied the stability of soil structure by percolation tests. Gadet and Soubies (*50*) conducted long term lysimeter trials and tests in France utilizing the stable isotope N^{15}. Other lysimeter studies in France include those of Hallaire (*60*), Ringoet (*143*), Demortier (*31*), Henin and Turc (*73*), Turc (*168*), and Roseau and Bats (*144*). Ubell (*169*) in Hungary studied hydrology with lysimeters.

Studies reported from the Soviet Union include the work of Fedorov (*45*); Yuldashev (*185*), who studied the water-salt regime of soils; Shilova (*150*) and Shilova and Korovkina (*151* to *154*), who studied the chemical composition of percolates; and Vasil'ev (*174*), who made a comparative study of Rykachev's and Popov's lysimeters. Kaurichev and Nozdrunova (*79*) suggested that lysimeter chromatographic columns should be used to estimate the migration of various compounds in soil. Popov (*124*) studied the water balance in soils and described three types of soil evaporimeters. One was weighed on hydraulic scales to study 24-hour and seasonal ET of various species of trees and types of grass covers. Petrov and Shishov (*121*) used plastic materials for constructing lysimeters. Other Russian works are those of Ageeva (*1*), Chapovskaya (*23*), Dolgov and coworkers (*32*), Radinovich (*136*), and Smirnova (*158*). Litynski and Kurnatowska (*91*) reported a study of the physico-chemical properties of soils in lysimeters in Szcaecin, Poland. Debski (*30*) conducted hydrologic studies in Poland with lysimeters. Ostromecki studied water requirements (*113, 114*) and nitrogen uptake (*112*) from urea on soils in Poland. Zabek (*186*) studied the reclamation of sandy alluvial with lysimeters in Osbowice, Poland. A lysimeter investigation reported from Rumania is that of Bujorean and Popescu (*19*).

Other lysimeter studies reported outside the United States are the work of Albareda and coworkers (*2*) in Spain; Arthur (*6*), McIlroy (*94, 95*) and McIlroy and Summer (*96*) in Australia; and Schleifer (*145*) in Austria. Cowan and Innes (*28*) in Jamaica related pan evaporation to ET from sugar cane. Ostwald (*115*) reported on lysimeter investigations in Sweden. Velev and Djankov (*175*) and Fekete (*46*) reported results from Czechoslovakia.

Steyn (*161, 162*) in South Africa used both monolith and filled-in lysimeters to study the influence of saline irrigation waters on wheat and maize. Bonfils and coworkers (*13*), Charreau (*24*), and Collot (*27*) carried on lysimeter studies in Senegal (French West Africa). Greenland (*59*) studied the nitrogen balance of tropical soils in Ghana. Glover and Forsgate (*53*) studied ET from large tanks of soil in Kenya. Bernard (*12*) used the energy balance method for studying ET in Africa.

Tanaka and coworkers (*165*) in Japan studied the effect of percolation on the growth of the rice plant. They found that percolation decreased the H_2S content of soil water markedly and reduced leaf spot disease. Okuda and Tokubo (*110*) used lysimeters in Japan to study the effects of synthetic soil conditioners. Slovikovskiy (*157*) studied the leaching of the leaf fall of 21 coniferous and deciduous species. Dupriez (*40*) studied the Thornthwaite lysimeter in the Belgian Congo as an instrument for measuring ET in equatorial regions. Siuta (*156*) used a glass lysimeter to study the effect of anaerobic transformation in organic substances on the mineral components of the soil.

BRIEF DESCRIPTION OF LYSIMETERS AND AGRONOMIC PRACTICES

The 11 Coshocton lysimeters constructed in the late 1930's are of the monolith or undisturbed soil-block type, deemed superior to all other types for the study of soil-water relations. The advantages and limitations of this and other types and the other features of construction of the Coshocton lysimeters have been previously described (*66*).

One lysimeter at each of the three sites chosen was equipped with an automatic weighing device developed expressly for this study. This device records the weight changes in the 65-ton mass to a 5-pound accuracy, which is equivalent to approximately 0.01 inch of water over the lysimeter surface area. From these weight records, it was possible to derive data on precipitation, evapotranspiration, and condensation and to evaluate many hydrologic effects of variations in climate, land use, and soil type.

The three different lysimeter sites and the agronomic practices followed at each lysimeter are described in the following listing:

1. *Site Y101* — permanent grassland on steep (23.2 percent), well-drained Muskingum silt loam. Lysimeters Y101A and Y101B — poor practices since 1937; poverty grass and weeds. Lysimeter Y101C—conservation practice since 1945: bluegrass, heavier fertilizer and lime applications than on Y101A and Y101B. Lysimeter Y101D—conservation practice since 1945: bluegrass to 1947, deep-rooted legumes and grass after 1947, heavier fertilizer and lime applications than on Y101A and Y101B.

2. *Site Y102*—rotation cropland on rolling (12.9 percent), well-drained Muskingum silt loam. Lysimeters Y102A, Y102B, and Y102C—conservation practices since 1941: contour cultivation, moderate applications of fertilizer, liming to pH 6.8, alfalfa-red clover-timothy meadow seeding.

3. *Site Y103*—rotation cropland on rolling (6.0 percent), slowly permeable Keene silt loam. Lysimeters Y103A and Y103B — conservation practice since 1941: contour cultivation, moderate applications of fertilizer, liming to pH 6.8, alfalfa-red clover-timothy meadow seeding. Lysimeters Y103C and Y103D—poor practice since 1941: straight row cultivation, small applications of fertilizer, liming to pH 5.4, red clover-alsike-timothy meadow seeding.

In this bulletin, four-character symbols — such as Y101 — refer to lysimeter sites or corresponding lysimeter batteries. Five character symbols—such as Y103A—refer to individual lysimeters.

Detailed descriptions of the soils, mechanical and chemical analyses, experimental procedures, construction and recording features and limitations of the lysimeter are given in the U.S. Department of Agriculture Technical Bulletin 1179 (*66*).

ERRORS IN EVALUATION OF DEW BY THE COSHOCTON WEIGHING LYSIMETERS

Hourly weight records from the three weighing lysimeters (Y101D, Y102C, Y103A) consistently showed diurnal fluctuations, as illustrated in figure 1. Gains in weight from as early as 1700 and continuing to 0500 the next day were attributed to dew. Visual evidence of dew in this area was common.

Totaling hourly weight change values like these, Harrold and Dreibelbis (*67, 68*) reported annual amounts of moisture gain of over 10 inches of water. Daily totals of 0.05 inch and monthly values of 1.4 inches were reached occasionally. By 1960, data from new lysimeter installations at various locations in the United States became available, showing much smaller values of dew—in some cases about one-tenth as large—than those from the Coshocton lysimeters. This led to a search for reasons for such sizeable differences. The question arose — were these differences real or the result of lysimeter malfunction?

Numerous hypotheses as to the reason for the large diurnal weight gains were advanced and investigated. The scales were examined in extreme detail by the manufacturer and were found to be reliable. The total weight of the maximum amount of water that could be held on the exterior of the lysimeter walls and bottom was found to be negligible. Neither temperature nor vapor pressure fluctuations occurred at any position in the underground gallery of the lysimeter where the scales were housed. Diurnal barometric fluctuations showed no correlation with lysimeter weight changes.

The only factor found to correlate with the recorded diurnal weight fluctuations was temperature at the ground surface. Quite regularly, a few hours after noon, the air temperature 2 inches above the ground surface fell rapidly and at about the same time the lysimeter weight showed a noticeable rise (fig. 1). The opposite trend was apparent beginning fairly early in the morning. This temperature-weight relation had

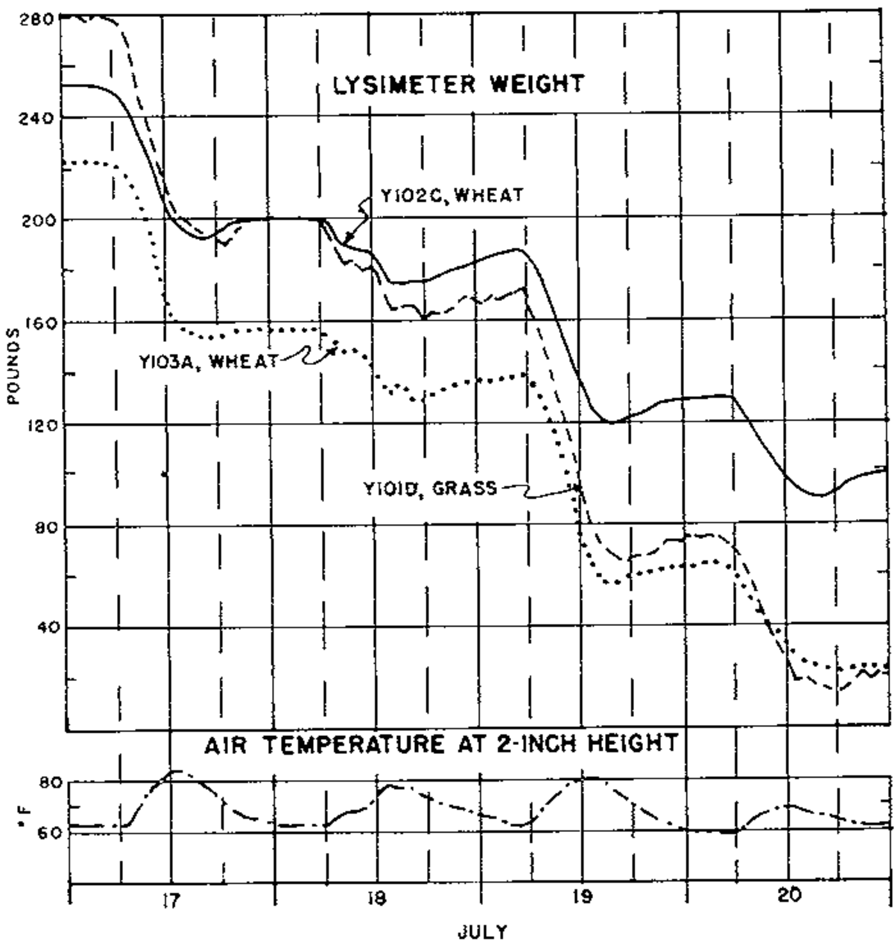

FIGURE 1.—Hourly change in weight of grass lysimeter Y101D and wheat lysimeters Y102C and Y103A, and change in air temperature, July 17-20, 1958.

to be a ground surface phenomenon inasmuch as there was no daily temperature fluctuation in the gallery beneath the ground.

The grease seal around the surface periphery of the weighing lysimeter (fig. 2) was thought to be a possible cause of this fluctuation in weight. Its removal from weighing lysimeter Y101D on February 6, 1962 caused a marked change in the diurnal fluctuation of lysimeter weight. Prior to this, as seen on figure 1, the rapid weight loss began in the early daylight hours and the gain in weight started as early as 1500 or 1600. When the grease seal was removed from Y101D, the loss in lysimeter weight, as shown in figure 3, began more slowly, at about 0600 or 0700, and was quite rapid from 1000 to 1600; a fairly constant weight was maintained from 1900 to 0600 the next day. The gain in weight, which had formerly been attributed to dew or condensation-absorption (CA), disappeared from this record; at other times, weight gains of as much as 5 pounds were recorded over some night periods. It became evident that the weight changes observed had not been real.

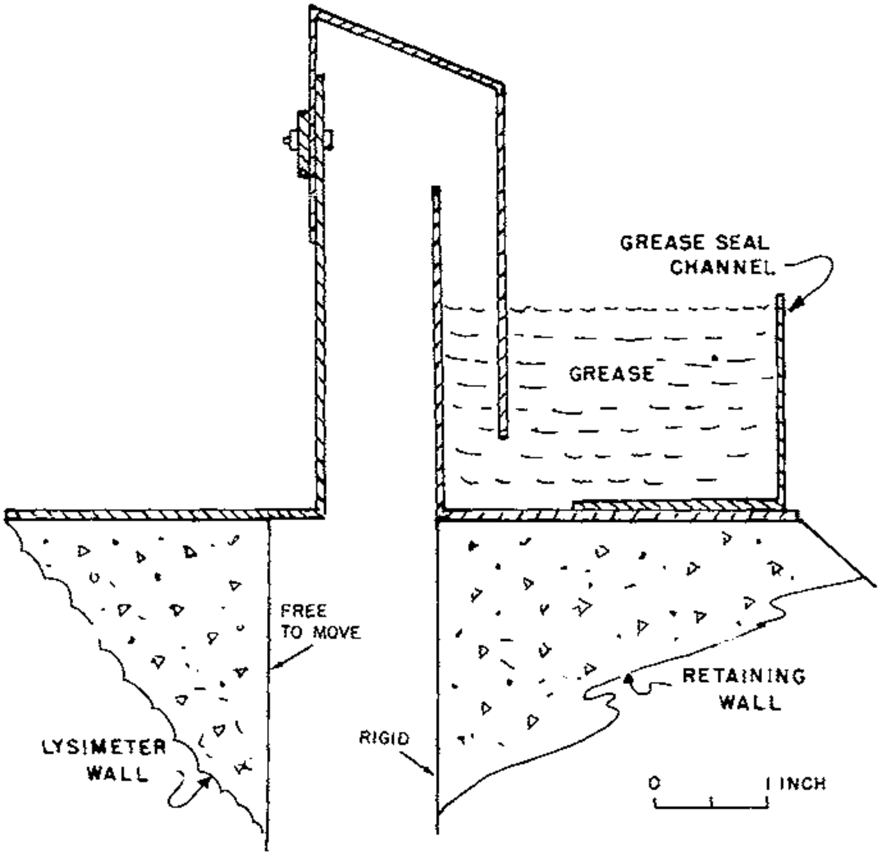

FIGURE 2.—Grease seal around surface periphery of weighing lysimeter.

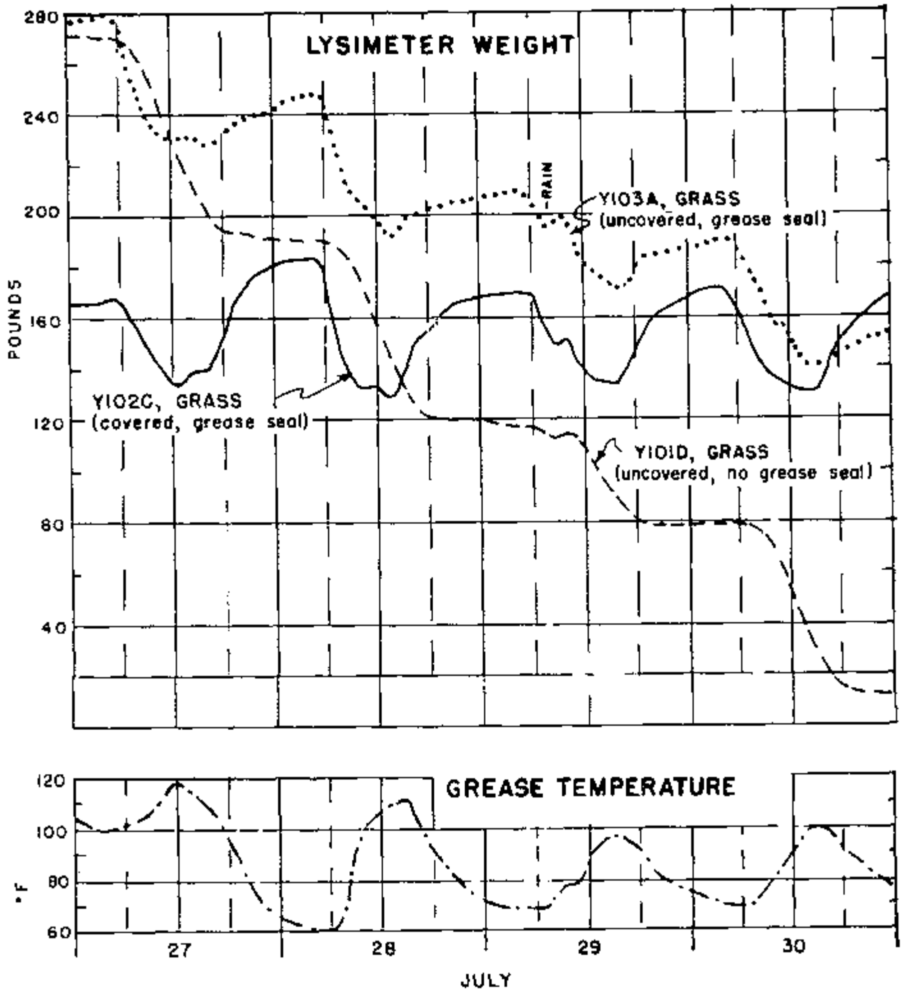

FIGURE 3.—Hourly weight changes of normal lysimeter, lysimeter with grease seal removed, and lysimeter with plastic soil cover; grease temperature fluctuations; July 27-30, 1962.

An additional test was made under conditions of no moisture exchange between the air and soil. The soil surface and crop on lysimeter Y102C (grease seal still in place) was covered (fig. 4) with a 3-layer plastic cover mounted on a frame in such a manner that the two 1-inch dead-air spaces were maintained between the top and bottom layers.

Weight records from the three lysimeters during this period are shown in figure 3. The average trend of the recorded weight for Y102C was horizontal, while the other two lysimeters showed losses, indicating that lysimeter Y102C was indeed sealed against soil moisture transfer with the atmosphere. The fluctuation of the weight curve about the horizontal was quite

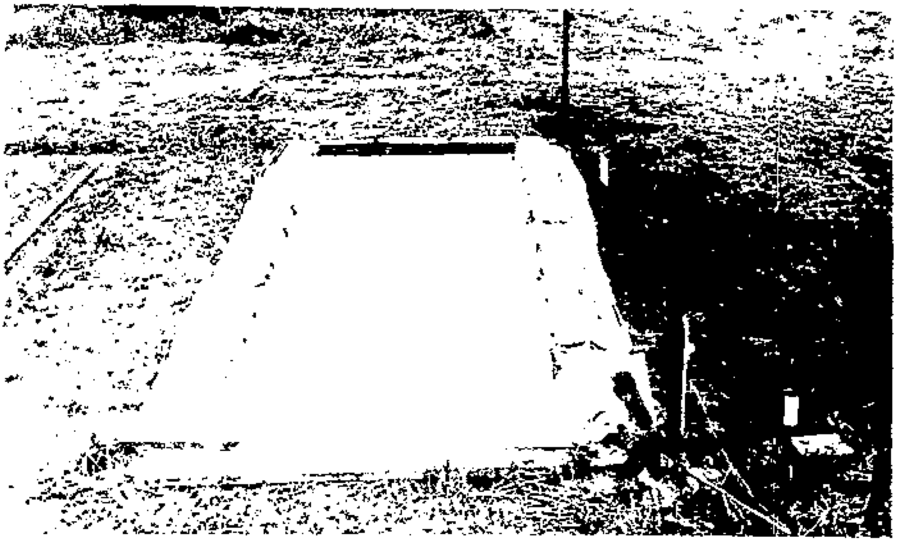

FIGURE 4.—Lysimeter Y102C with plastic sheet cover.

noticeable and there was a marked concurrence of weight peaks with grease temperature troughs. Further evidence that diurnal temperature fluctuations in the grease seal were related to diurnal weight changes appears in the relation between daily temperature drop of the grease and corresponding lysimeter weight gains (fig. 5).

Figure 6 shows a comparison of the weight fluctuations of the three lysimeters after removal of the Y102C grease seal, but before removal of the moisture transfer barrier on the surface. Weight fluctuations in Y102C were almost completely eliminated during the rainless periods.

The physical reason for the relation between grease seal temperature and apparent weight change was the change in linear dimension of the peripheral metal of the grease seal hood with temperature. This hood is the metal attached to the movable lysimeter and comes up over the edge of the channel and down into the grease. When the grease seal temperature rose, the peripheral metal expanded, causing the lysimeter to rise, which indicated a loss in weight. When the temperature decreased, the metal contracted, causing the lysimeter to drop, which indicated a gain in weight.

As it was evident that the published evaluations of dew obtained from the periods of hourly weight gains on the lysimeters were grossly in error, it seemed desirable to develop a method for evaluating the magnitude of the error and to publish corrected values. The relations between the many years of measured air temperature fluctuations and recorded weight changes would be the key to the success of this endeavor. A fair relation was obtained between daily weight gains and corresponding grease temperature drop for lysimeter Y102C during the period when it was sealed against moisture change (fig. 5). Grease temperature data were available, however, only during the

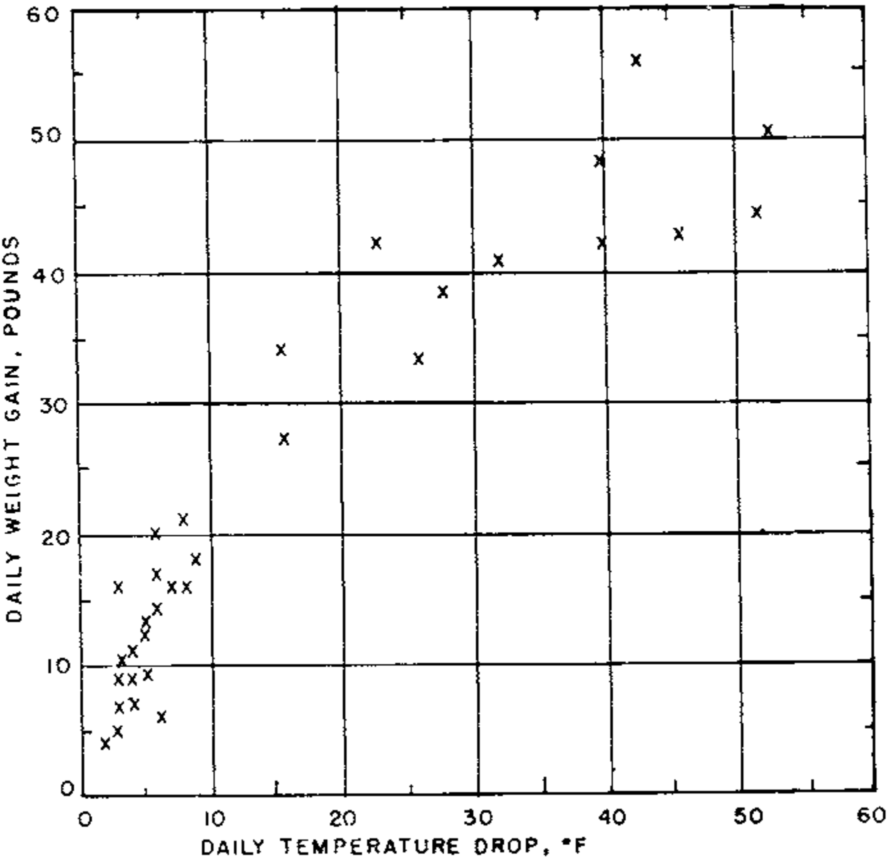

FIGURE 5.—Relation between daily grease temperature drop and weight increase of covered lysimeter Y102C, July-August 1962.

1962 test period. The relation between weight change and air temperature fluctuations for which data are available throughout was so poorly defined as to be unsatisfactory for use in correcting the past weight records. An examination of the records for lysimeter Y101D since its grease seal was removed showed that its daily weight gains were of very small order of magnitude, representing less than 0.005 inch of water. It was concluded that quantitative corrections to past records of dew from these lysimeters are possible if sufficient grease-seal-temperature data are available. In this instance, however, the period for which such data were available was too short for these corrections to be of value.

Consideration was also given to the possibility of sizable errors in the published evaluations of evapotranspiration (ET) for periods of days, weeks, months, seasons, and years. Daily values of ET were determined from midnight weight records. The variations of consecutive midnight

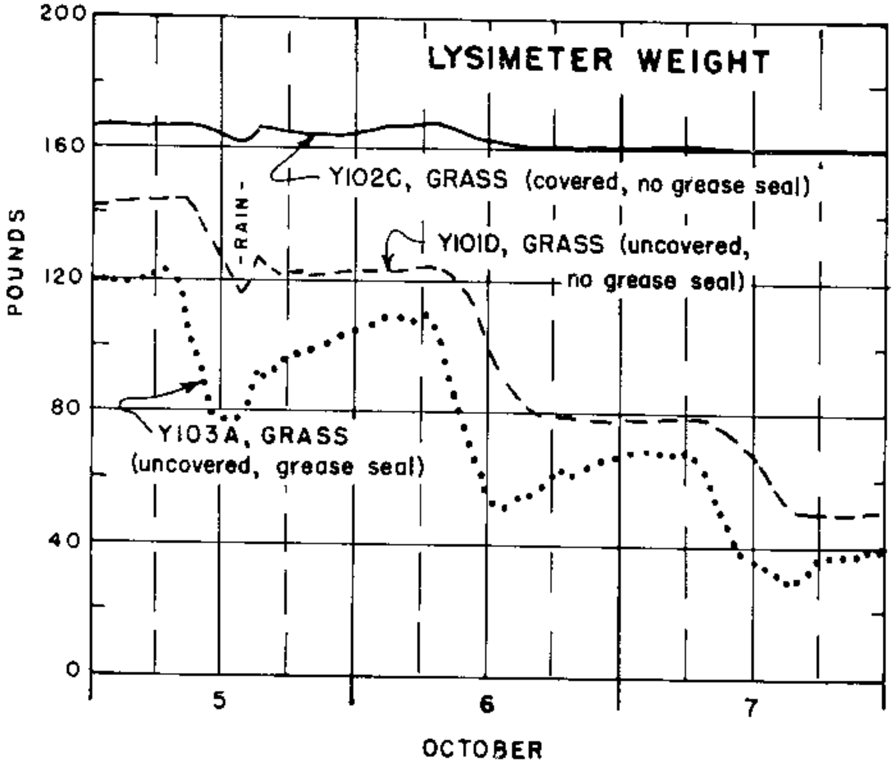

FIGURE 6.—Hourly weight changes of normal lysimeter, lysimeter with grease seal removed, and lysimeter with grease seal removed and plastic soil cover, October 5-7, 1962.

values of grease temperature were most often of small magnitude and their influence on weight records was small. Daily differences in midnight grease temperature of 10° F. or more occurred less than 15 percent of the time. A difference of 10° could result in a weight error of 20 pounds (fig. 5), or 0.05 inch of water, which could be 20 percent of the daily water-use value of 0.25 inch. The effect of differences in midnight temperatures a week apart on lysimeter weight was usually negligible—a difference of 10° F., causing a recorded 20-pound weight 0.05-inch-of-water error (fig. 5) would be only 3 percent of a week's water use (1.6 inches). It is evident that the longer the period, the lesser were the percentage errors in water use as evaluated by weight changes related to grease temperature differences.

Errors in previously published records came from computation of moisture increases or decreases obtained from *part day* gains and losses in weight. These separate periods of cooling and heating of the grease seal caused false weight changes, which were attributed to moisture changes (a weight gain was attributed to dew and a weight loss was attributed to evapotranspiration). These separate moisture change values were totaled for monthly and annual periods. However, when the false weight- or moisture-gain values are subtracted from the false weight- or moisture-loss values, a true value of net daily, weekly, monthly, or annual evapotranspiration is obtained.

The authors regret the previous publications of erroneous data on dew amounts (*66, 67*). It is fortunate that most of the information published in the U.S. Department of Agriculture Technical Bulletin 1179 (*66*) on water use and moisture storage change is reliable. Revisions made in the operation of the weighing lysimeters will make it possible to provide reliable values of diurnal moisture changes as well as to continue to provide accurate information on evapotranspiration under a variety of conditions of crop, treatment, and climate.

CORRECTION OF PUBLISHED DATA

Summaries of monthly accretion, depletion, and storage of soil water as determined by the weighing monolith lysimeters and published in U.S. Department of Agriculture Technical Bulletin 1179 (*66*) contain separate evaluations of condensation-absorption (CA) and evapotranspiration (ET). Cyclic diurnal weight changes on the lysimeters were divided into separate periods of continuous gain and continuous loss. Monthly CA values were the total of the daily weight gains during rainless periods, adjusted for percolation and runoff. Likewise monthly ET values were the total of the daily weight losses similarly adjusted.

As noted in a previous section, these gains and losses of weight within the day contained false values induced by temperature changes in the grease seal. Whereas monthly totals of these separate evaluations are also in error, the difference between them is very close to the true value of moisture change due to evapotranspiration. It was pointed out previously that the overall temperature-induced errors balance out in a period of a month. For example, in table 6 of U.S. Department of Agriculture Technical Bulletin 1179 the September 1944 values for CA and ET are 0.43 and 3.16 inches, respectively. Both values are in error. Yet their difference, 2.73 inches, represents the true value of evapotranspiration, with a possible error of less than 1 percent of 2.73 (0.02 inch) due to temperature-of-grease-seal difference from the beginning to end of the month. All the separate CA and ET values in U.S. Department of Agriculture Technical Bulletin 1179 need to be revised into a single value of ET in this way.

Revised monthly summary accretion and depletion data for these weighing lysimeters for the period 1944-55 and new data for the period 1956-62 are given in appendix tables 29-31. In these tables, precipitation alone is the source of accretion. Depletion losses are due to runoff, evapotranspiration, and percolation.

DATA FOR THE 1956-62 PERIOD

This bulletin presents summaries of hydrologic data from the Coshocton lysimeters for the 1956-62 period. In appendix tables 29-31 the tabular summaries extend back to 1944 as it was necessary to show corrections to previously published data. In a few other cases data prior to 1956 appear in tables and on illustrations in order to clarify the trends and relations.

The records obtained from the three weighing lysimeters furnish basic data for analyses applicable to a wide field of agricultural hydrology. Results were derived in terms of precipitation, runoff, evapotranspiration, percolation, soil moisture storage change, plant nutrient losses in percolation, and crop-use-of-water efficiency.

Accretion

Precipitation values were obtained from lysimeter weight gains plus runoff during precipitation periods. Annual values for each weighing lysimeter and for its adjacent recording rain gage are given in table 1. As explained later in this section, the difference between annual values from the lysimeter and gage was large but there was little difference between individual storm rainfall totals obtained by both methods.

Annual precipitation as evaluated by rain gages (table 1) averaged slightly less than the 38-inch normal (26-year average) for the station. The range in annual values, from 27.91 to 47.86 inches was slightly less than the range in values, from 22.03 to 52.60 inches, recorded at the Coshocton City gage in 1930 and 1926, respectively. Annual values of precipitation for the 1952-55 period were considerably less than normal, averaging 31.94 inches. The previous lowest average for a 4-year period at the Coshocton City gage was 33.85 inches per year. High annual values for the study period were not grouped, but appeared to be scattered at random through the record. The occurrence of years of low and of high precipitation and the sequence of such were important factors in changes in soil moisture storage, runoff, percolation, evapotranspiration, and crop yield. A previous analysis

TABLE 1.—*Annual precipitation as measured by weighing lysimeters and adjacent rain gages, 1944-62*

Year	Y101D, permanent grass		Y102C, rotation		Y103A, rotation	
	Lysimeter	Gage	Lysimeter	Gage	Lysimeter	Gage
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1944	31.96	30.57	38.11	30.70	35.06	29.60
1945	47.06	45.64	50.86	45.49	48.60	45.36
1946	43.02	37.37	41.46	37.41	40.67	38.17
1947	39.45	35.94	40.12	35.79	40.74	36.32
1948	38.54	37.92	42.05	37.67	41.95	37.71
1949	41.21	35.48	39.98	37.44	42.45	37.64
1950	52.14	47.86	52.95	47.28	51.97	47.68
1951	47.94	40.02	47.83	38.23	47.48	39.83
1952	40.02	35.76	37.71	35.16	38.49	35.90
1953	30.67	27.91	32.38	28.34	33.19	28.20
1954	36.68	32.18	34.26	31.81	36.66	31.67
1955	35.40	31.93	33.85	30.59	35.90	31.68
1956	49.11	45.50	47.49	44.75	50.22	45.83
1957	46.04	42.41	47.67	42.19	46.76	43.52
1958	36 80	33.70	36.32	32.96	36.90	33.63
1959	46.52	43.88	53.40	44.97	49.29	44.37
1960	38.78	34.60	39.26	34.62	41.41	35.49
1961	42.46	36.35	42.13	36.76	44.61	37.17
1962	36.73	32.39	(1)	31.76	40.01	33.61
Sum	780.62	710.41	[1] 757.83	[2] 672.16	802.36	713.38
Average	41.09	37.39	[2] 42.10	[2] 37.34	42.23	37.55

[1] Lysimeter not operating continuously.
[2] Values for 1944-61.

(*64*) showed that the study period was representative of the long-term weather pattern of the area.

Mean distribution of monthly precipitation throughout the year during the 1944-62 period (table 2) was ideal for the production of agricultural crops. Average rainfall in May, June, and July ranged from 3.65 to 4.35 inches. The range in monthly values was quite large and had noticeable effects on various phases of agricultural hydrology. For example, rainfall in June 1957 was over 10 inches (appendix tables 29-31), resulting in a sizable increase in percolation.

TABLE 2.—*Monthly distribution of precipitation, rain gage at site Y103, 1944–62*

Month	Average	Maximum	Minimum
	Inches	*Inches*	*Inches*
Jan.	3.10	8.23	0.80
Feb.	2.67	5.64	.37
Mar.	3.25	7.99	.75
Apr.	3.64	6.73	1.45
May	3.65	6.85	1.55
June	4.30	10.54	1.91
July	4.35	9.39	2.34
Aug.	2.62	6.60	.67
Sept.	2.95	9.29	.38
Oct.	2.18	5.85	.39
Nov.	2.58	5.84	.98
Dec.	2.26	4.57	.31
Yearly average	37.55	47.68	28.20

Rain measured by gage was compared with rain measured by weighing lysimeter to determine the effect of grease seal malfunction on rain measured by lysimeters. Only rain periods were used in the analysis since a rain gage does not measure snowfall very accurately. Daily totals of rain for the 1950-61 period on Y101D and Y103A were used in the analysis. The pre-1950 data were in a format which made extraction of rain amounts difficult and for that reason they were not included.

Analysis of the 1,078 rain-day totals showed that the lysimeter catch could be described by:

$$\text{lysimeter catch} = 0.0186 + 1.0007 \text{ rain gage catch}$$

with a correlation coefficient of 0.9931. This indicates that the lysimeter catch was approximately 0.02 inch greater than that recorded by rain gage—for any size rainstorm. This relation was the same on both lysimeters. This is a small difference, but it accumulates to a significant amount in the course of a year.

For these 1,078 rain-day events, the total catch is given in table 3.

TABLE 3.—*Comparison of lysimeter rainfall totals with those of adjacent rain gages, 1950–61*[1]

Lysimeter	Rainfall as determined by— Rain gage	Rainfall as determined by— Lysimeter	Difference Total	Difference Per year
	Inches	*Inches*	*Inches*	*Inches*
Y101D	352.42	371.90	19.48	1.62
Y103A	355.58	376.57	20.99	1.75

[1] For 1,078 rain-day events.

The lysimeter rain catch was about 5.7 percent more than that of the rain gage. Although several factors may have caused this difference, no definite relations could be detected. The grease seal malfunction may have accounted for much of this difference. The sampling area of the lysimeter, 12,540 square inches, was considerably larger than the 50 square inches of the recording rain gage. Also, it is likely that there was less air movement effect at the ground surface of the lysimeter than at the level of the gage top.

Previous analyses (*64*) indicate that about 2 inches of the average annual precipitation of 38 inches fell as snow. On the basis of the relations just developed, the difference between lysimeter and rain gage catch would be that shown in table 4. Rainfall difference was taken to be the average of the values in table

TABLE 4.—*Differences in lysimeter and rain gage catches as estimated from relations in the data*

Form of precipitation	Average annual precipitation—		
	Rain gage	Lysimeter	Difference
	Inches	*Inches*	*Inches*
Rain	36	37.7	1.7
Snow	2	4.7	2.7
Total	[1] 38	42.4	4.4

[1] 26-year average.

3. Total difference was taken to be 11.2 percent (average difference between Y101D and Y103A values in table 1) of normal total. The other values in table 4 were obtained by subtraction. The difference in precipitation amounts measured by the two methods was approximately the same for rain and snow, although much larger proportionately for snow.

On the basis of these analyses, it was concluded that there was little practical difference in a lysimeter or a rain gage for measuring storm or daily rainfall. The values of ET presented in this bulletin and derived from the weighing lysimeter are expected to be similar to those computed from energy balance equations, but will differ from those developed in water budget studies for basins. The main reason for this is that basin study data are from rain gages, whereas lysimeter-derived values of ET come from increases in lysimeter weights. In order to bring these two values into closer agreement, the rain gage values should be increased by about 10 percent.

Depletion

Of the three depletion factors, ET accounted for the most depletion and surface runoff the least (table 5).

TABLE 5.—*Annual depletion factor values for lysimeters Y101D, Y102C, and Y103A, 1944–62*

Year	Y101D, permanent grass				Y102C, rotation				Y103A, rotation			
	Runoff	ET	Percolation	Total	Runoff	ET	Percolation	Total	Runoff	ET	Percolation	Total
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1944	0 .12	24.08	7.13	32.33	0 .43	27.96	7.34	35.73	0 .06	30.37	5.06	35.49
1945	.23	27.17	15.35	42.75	4.63	28.63	16.23	49.49	.42	33.49	11.00	44.91
1946	.14	33.56	9.88	43.58	.29	35.66	6.05	42.00	.04	38.30	4.99	43.33
1947	.16	29.11	14.85	44.12	.29	33.24	12.28	45.81	.11	33.70	9.97	43.87
1948	.03	32.54	5.61	38.18	.15	34.84	6.51	41.50	.10	35.62	6.30	42.02
1949	.06	37.36	5.58	43.00	.32	31.50	5.50	37.32	.25	34.95	5.54	40.74
1950	.16	36.94	8.99	46.09	.18	31.75	17.75	49.68	.09	36.46	12.88	49.43
1951	.05	37.19	13.41	50.65	.58	33.66	15.11	49.35	.27	34.65	13.70	48.62
1952	.05	35.69	8.80	44.54	.19	32.55	11.68	44.42	.18	34.93	9.14	44.25
1953	.03	31.90	1.53	33.46	.16	[1] 32.57	3.02	35.75	.10	30.05	2.50	32.65
1954	.02	31.99	0	32.01	.49	[1] 31.68	3.23	35.40	.33	30.70	.64	31.67
1955	.18	[1] 36.00	1.70	37.88	.38	36.43	7.74	44.55	.06	35.36	5.27	40.69
1956	.19	29.50	13.73	43.42	.20	35.18	8.17	43.55	.09	39.57	6.37	46.03
1957	.27	27.77	16.80	44.84	[2] 16.33	[2] 21.15	7.56	45.04	2.17	33.58	7.14	42.89
1958	.18	33.24	8.40	41.82	.26	33.32	5.82	39.40	.23	37.02	3.70	40.95
1959	.14	35.24	7.85	43.23	.20	38.51	7.87	46.58	.16	38.78	5.11	44.05
1960	.05	35.67	7.49	43.21	.32	36.01	8.05	44.38	.26	38.61	3.86	42.73
1961	.23	31.97	8.06	40.56	1.44	26.60	9.94	37.98	.62	33.84	7.23	41.69
1962	.91	28.28	5.97	35.16	-----	-----	-----	-----	.37	33.89	5.23	39.49
Sum	4.20	615.20	161.73	781.13	(3)	(3)	(3)	(3)	5.91	664.16	125.63	795.70
Average	.22	32.38	8.51	41.11	(3)	(3)	(3)	(4)	.31	34.96	6.61	41.88

[1] Irrigated.
[2] Plastic cover on ground June 6 to Sept. 9.
[3] Not computed.

The average from Y102C was not computed, as data for 3 years were affected by the special treatment given this lysimeter. Annual ET values from permanent grass lysimeter Y101D averaged 32.38 inches and ranged from 24.08 to 37.36 inches; values from crop rotation lysimeter Y103A averaged 34.96 inches and ranged from 30.05 to 39.57 inches.

During the 1952-55 dry period, annual ET from lysimeter Y101D in deep-rooted grass averaged 33.90 inches. Since precipitation averaged only 35.69 inches, only 1.79 inches per year was available for surface runoff and percolation. Minimum annual ET values of less than 30 inches occurred in 1944, when rainfall was deficient and the vegetation cover was shallow-rooted poverty grass; in 1945, 1947, and 1957, when the old sod was killed and reseeded; and in the dry year of 1962. Maximum values of annual ET of about 37 inches occurred in 1949 through 1951, a period of excessive precipitation, soon after the alfalfa-bromegrass sod was established.

On Y101D, the deep-rooted birdsfoot trefoil (1957-62) also removed much water through ET. Its effect on the soil-water regimen was similar to that of the alfalfa-bromegrass cover (Y101D, 1948-55) which removed an annual average of 34.95 inches of water by ET. Birdsfoot trefoil removed an average of 32.88 inches annually during the 1958-62 period. Values for shallow-rooted poverty grass (1944) and bluegrass (1945-46) averaged 28.27 inches. The 1946 value was large. The monthly data in appendix table 29 show that excessive rainfall in June and July 1946 resulted in larger than usual ET values. It is evident that deep-rooted legumes, either alfalfa or birdsfoot trefoil, had a pronounced effect on removal of water by ET.

The relation between annual ET and precipitation on the cultivated lysimeters, Y102C and Y103A, was more complex because of the 4-year crop rotation of corn, wheat, meadow, meadow. The crops harvested were: 1944, hay; 1945, corn; 1946, wheat; and 1947, hay. This sequence was repeated over and over again. Comparisons were also complicated by the use of a plastic sheet over the soil of lysimeter Y102C during the 1957 growing season, when it was in corn. This lysimeter was temporarily removed from operation during the last 5 months of 1962 when special tests were being made to detect the cause of excessively large amounts of diurnal weight changes. This problem and its solution are described on pages 6-13.

The minimum annual value of ET from Y102C, 21.15 inches, occurred in 1957, the season during which evaporation from the soil surface was restricted by a plastic sheet cover on the soil. Results of this special test are presented on pages 50-55. Under normal conditions, the lowest annual value of ET from this lysimeter, 26.60 inches, occurred in 1961, when it was in corn.

Large values of annual ET, nearly 39 inches, occurred on lysimeters Y102C and Y103A in 1959, when they were under a first-year meadow cover of red clover, alfalfa, and timothy and the annual precipitation was high—53.40 inches on Y102C and 49.29 inches on Y103A.

The fluctuation of ET—depletion of soil water by evaporation and transpiration—throughout the year is shown on figures 7 to 13. When the slope of the cumulative curve is steep, the rate of moisture depletion is high. ET values for May, June, July, and August were high each year for the three lysimeters. These figures also show the fluctuations of soil moisture in areas adjacent to each lysimeter. Cumulative daily precipitation and percolation values are also given. The period of high

ET coincides with the period of high solar energy received on the land surface. Vegetation that completely covers the land surface extracts more moisture than vegetation that only partially covers. ET values for corn in May 1957 (appendix tables 30 and 31 and fig. 8) were relatively low, compared to those for wheat or meadow, as indicated by the slope of

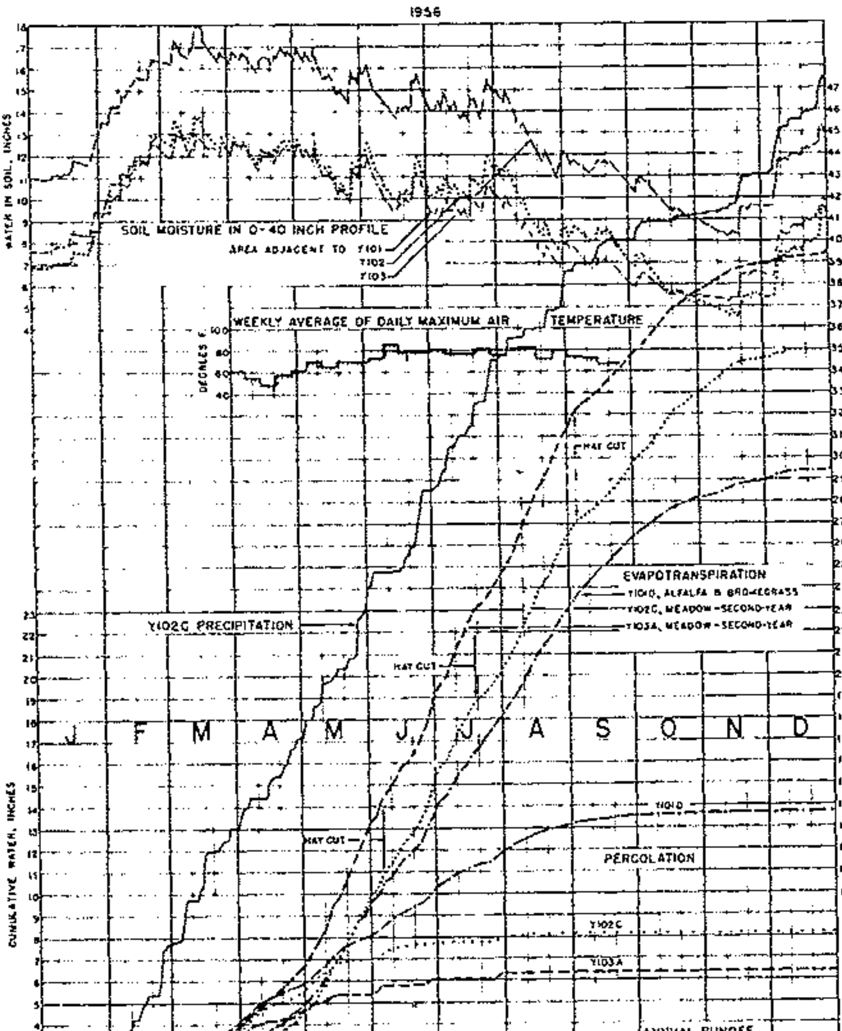

FIGURE 7.—Cumulative daily percolation and evapotranspiration and annual runoff from three weighing lysimeters; cumulative daily precipitation on Y102C; daily soil moisture in adjacent areas; average air temperature; 1956.

the curves. There was little transpiration from the lysimeter in corn in either May or June, when the corn plants were small. On the other hand, when meadow plants completely covered the ground (in May and June) ET values were high. During July and August, when corn plants were large, ET values were high.

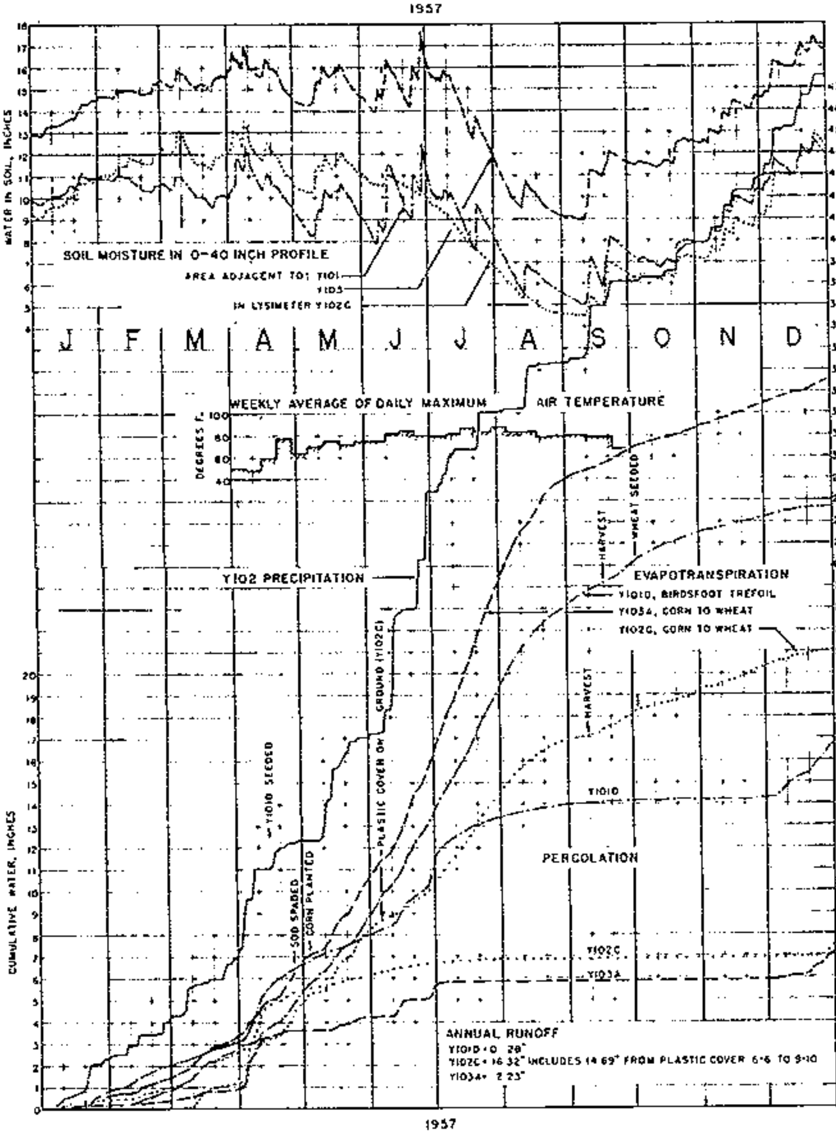

Figure 8.—Cumulative daily percolation and evapotranspiration and annual runoff from three weighing lysimeters; cumulative daily precipitation on Y102C; daily soil moisture in adjacent areas; average air temperature; 1957.

Surface runoff values on the lysimeters (table 5) were relatively low because they were unaffected by surface or subsurface moisture transfer from adjacent areas. In effect, the lysimeter runoff values represented those from a small area of land at the top of a hill. When rainfall in-

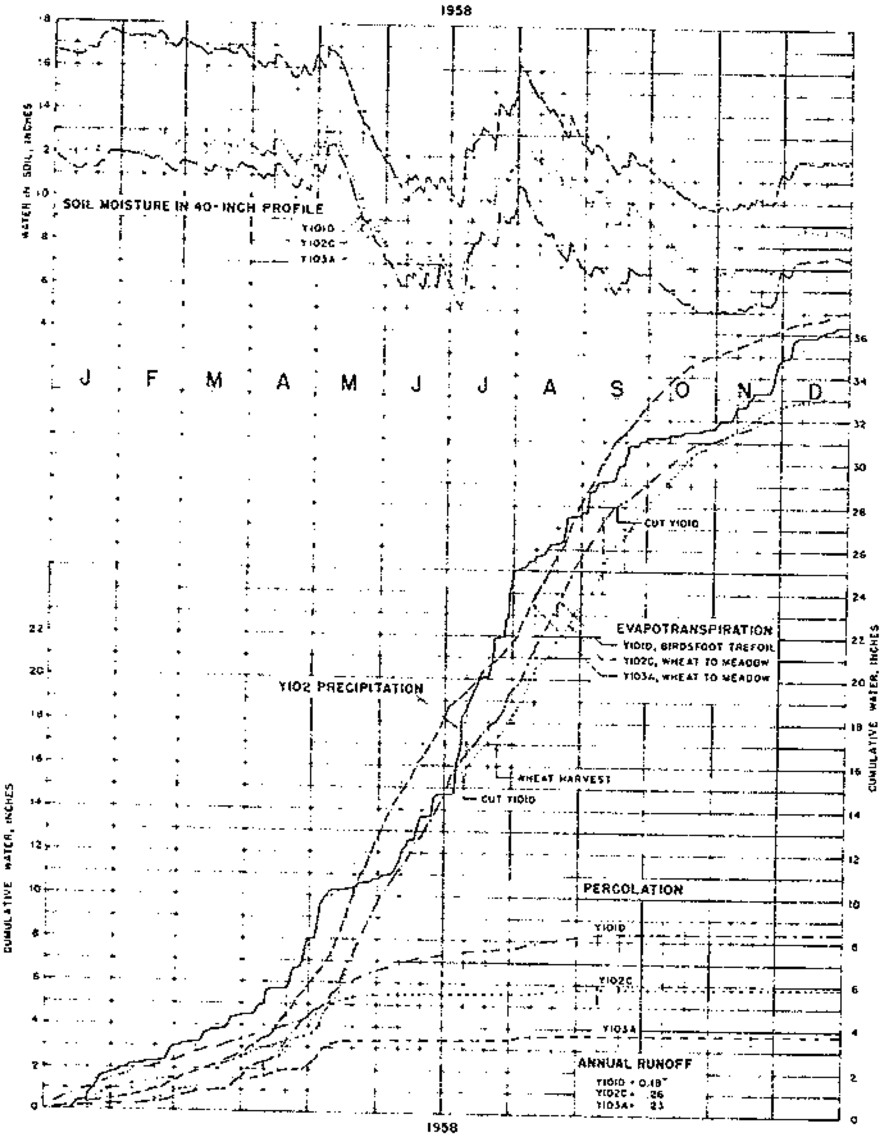

FIGURE 9.—Cumulative daily percolation and evapotranspiration and annual runoff from three weighing lysimeters; cumulative daily precipitation on Y102C; daily soil moisture in adjacent areas; 1958.

tensities were very high, as in 1957, runoff values, especially from Y103A, in corn, were fairly large.

Percolation as measured by the lysimeters was a moisture depletion process. It also represented re-

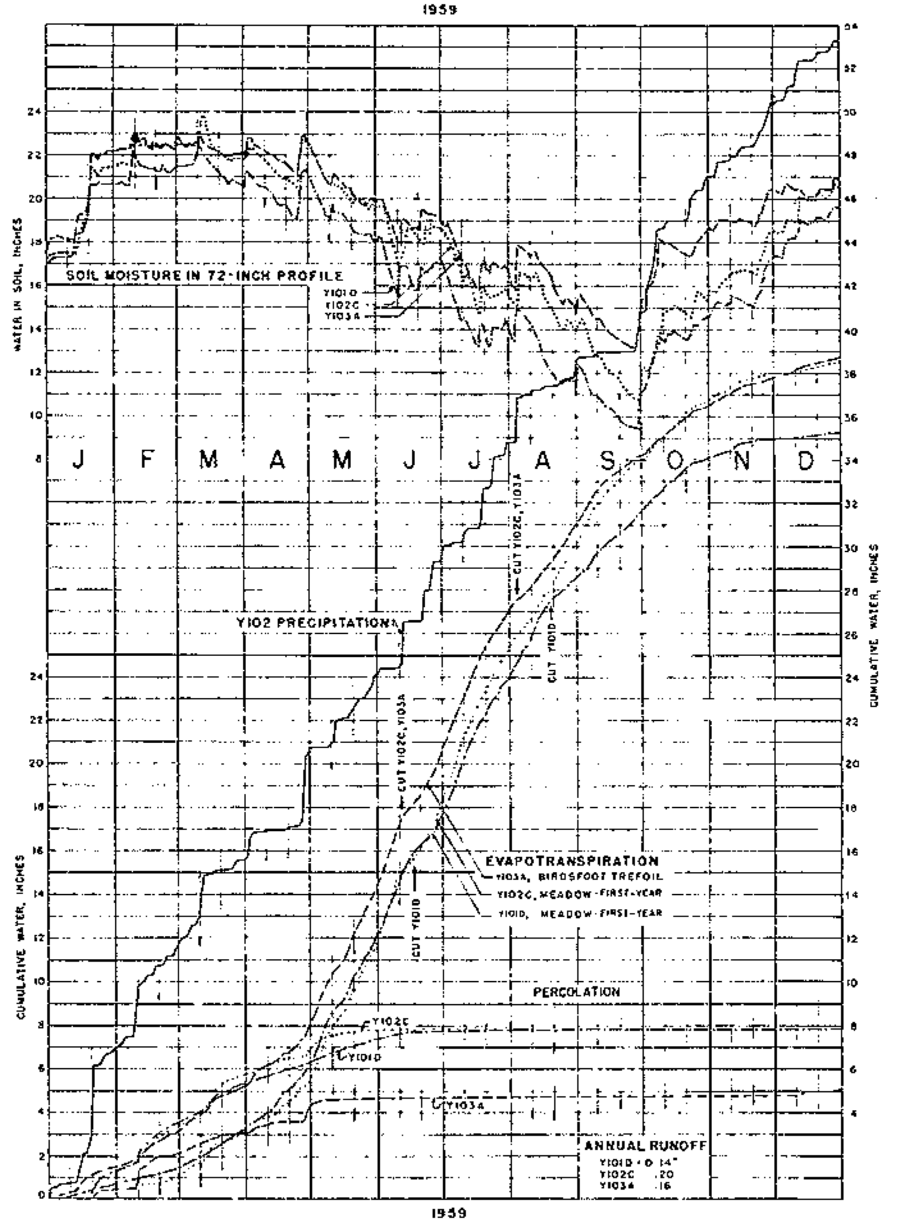

FIGURE 10.—Cumulative daily percolation and evapotranspiration and annual runoff from three weighing lysimeters; cumulative daily precipitation on Y102C; daily soil moisture in adjacent areas; 1959.

charge to ground-water reservoirs. Percolation data for lysimeter Y101D, in permanent grass-legume cover (table 5 and appendix table 29), show the influence of different rooting depth and of climate. These effects are somewhat difficult to detect from calendar year data as percolation quantities were influenced materially by the amount of soil

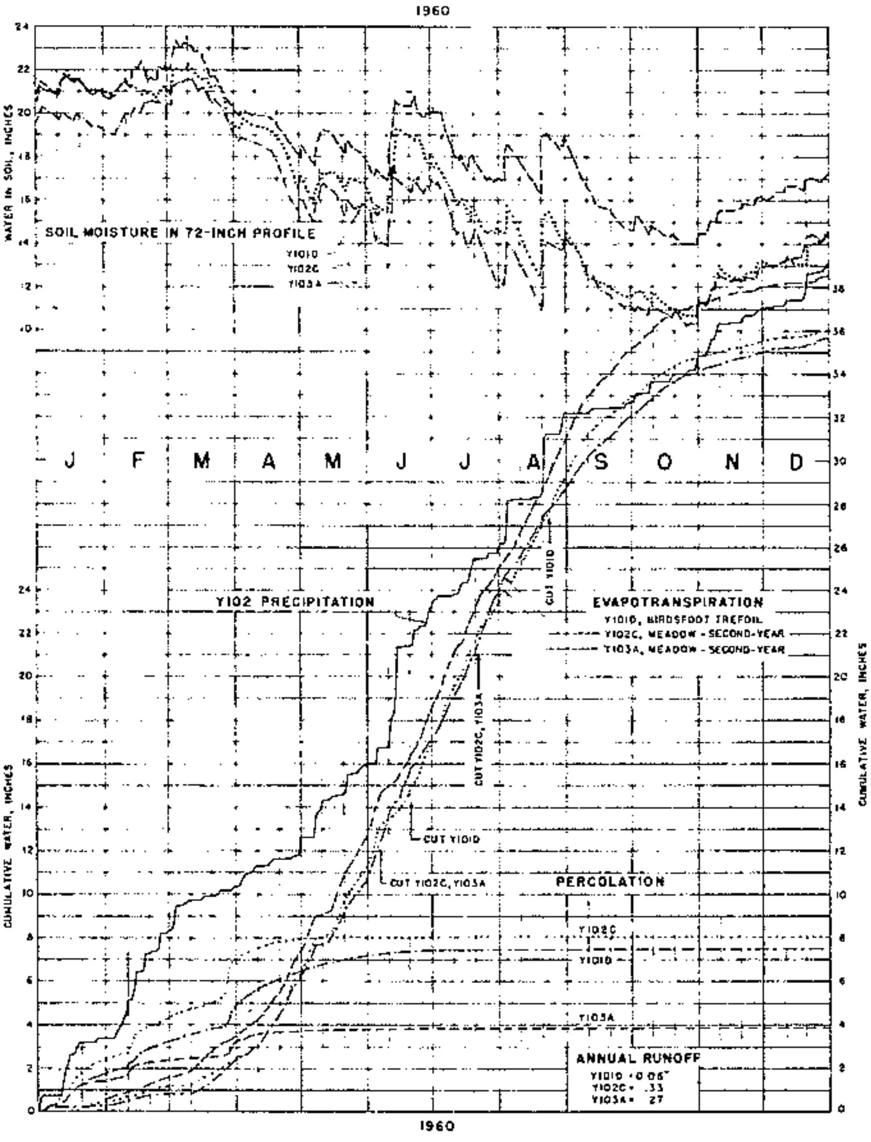

FIGURE 11.—Cumulative daily percolation and evapotranspiration and annual runoff from three weighing lysimeters; cumulative daily precipitation on Y102C; daily soil moisture in adjacent areas; 1960.

moisture storage at the start of the year and by the amount of precipitation during the period of high soil moisture. For example, in 1950, with lysimeter precipitation more than 11 inches over the 1944-62 lysimeter average, percolation totaled only 8.99 inches. Much of the precipitation (appendix table 29) occurred in January, July, September,

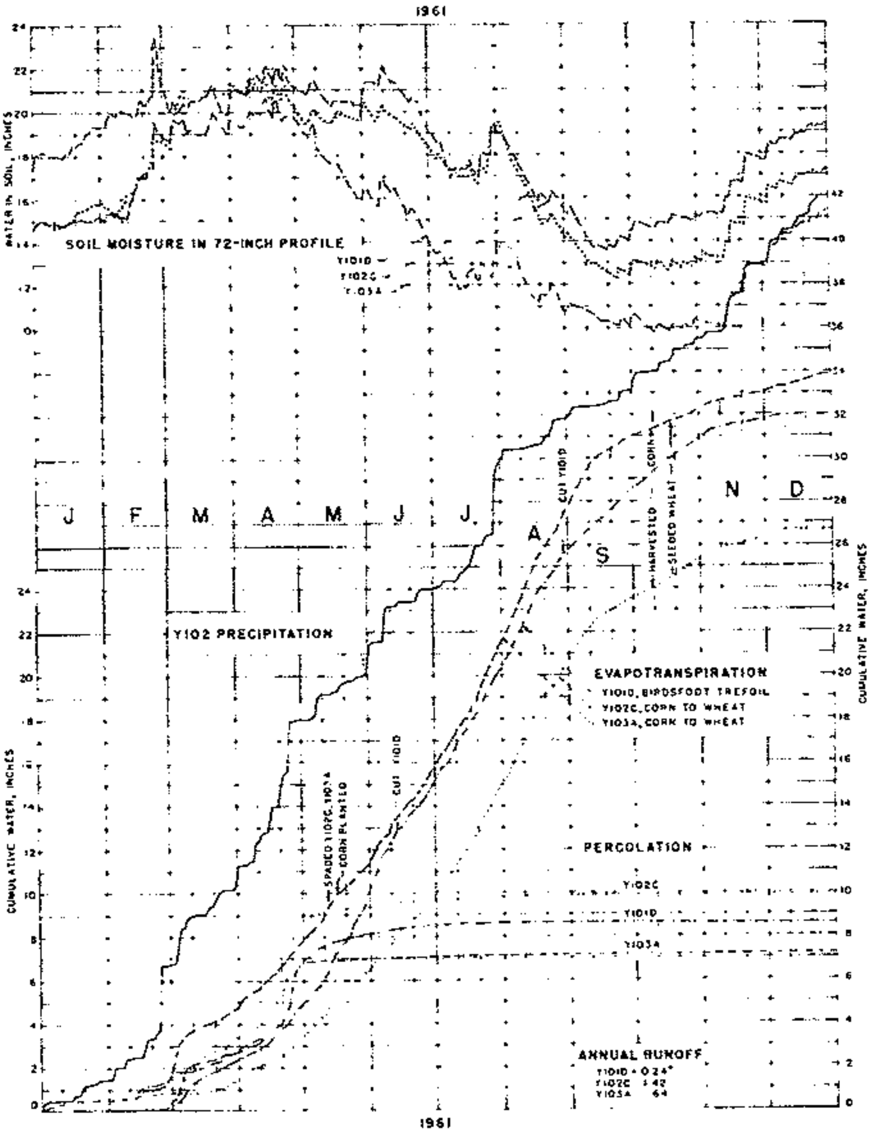

FIGURE 12.—Cumulative daily percolation and evapotranspiration and annual runoff from three weighing lysimeters; cumulative daily precipitation on Y102C; daily soil moisture in adjacent areas; 1961.

and November, when the soil was fairly dry. But in 1951, with precipitation about 7 inches above average, percolation exceeded 13 inches. Soil moisture at the start of this year was large and much of the precipitation occurred during the wet period, January through April.

The effect of different crops on percolation was largely the result of

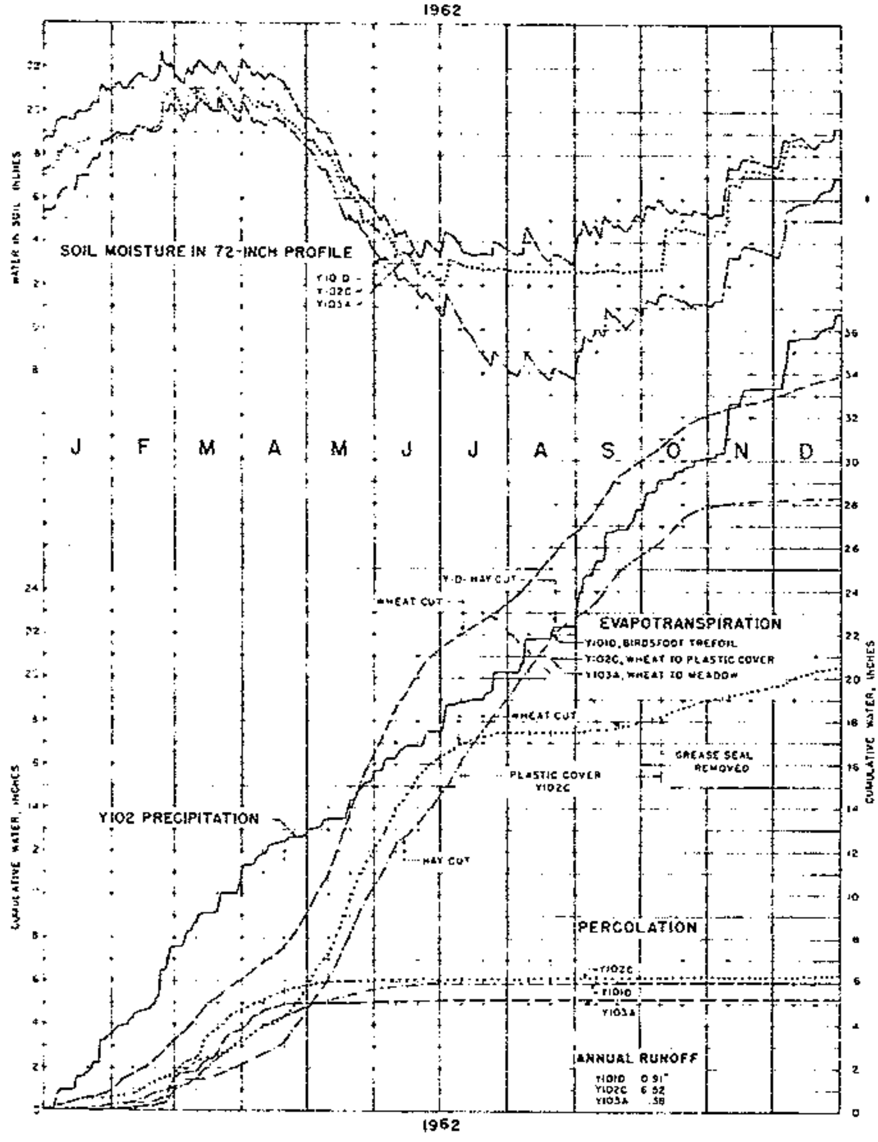

FIGURE 13.—Cumulative daily percolation and evapotranspiration and annual runoff from three weighing lysimeters; cumulative daily percolation on Y102C; daily soil moisture in adjacent areas; 1962.

the different ET values for the different crops, as discussed in detail on pages 58-67. It has been shown that ET from lysimeters in deep-rooted vegetation was greater than ET from lysimeters in shallow-rooted vegetation. Data for Y101D in table 5 further show that percolation from the former was very low, reaching zero in 1954, as compared to 7 to 15 inches from the latter in the 1944-46 period.

Soil Moisture Storage Changes

Soil moisture storage changes are an important part of water budget studies. Evaluation of these changes over large areas is very difficult. Data from the weighing lysimeters (table 6) shows that net annual changes in soil moisture are large, but that the net change over a period of several years is small and can be neglected. Statistical analysis showed that the coefficient of determination (r^2, table 6) for each array of lysimeter data was statistically nonsignificant, indicating that there was no relation between moisture storage change and time. Coupled with this was the fact that in each case the standard error was considerably larger than the mean annual change in stored moisture. This means that the mean annual storage change may be considered to be of zero magnitude. These data validate the assumption, in regional water budget studies, regarding net change in soil moisture over periods of years.

While many of the changes in soil moisture storage from year to year were very small, changes within a year were large. The seasonal pattern of depletion from the March-April peak to the October-November low and the subsequent winter recharge is clearly evident in the top

TABLE 6. —*Annual soil moisture storage changes for lysimeters Y101D, Y102C, and Y103A 1944–62*

Year	Y101D (permanent grass)	Y102C (rotation)	Y103A (rotation)
	Inches	*Inches*	*Inches*
1944	−0.37	2.38	−0.43
1945	4.31	1.37	3.69
1946	−.56	−.54	−2.66
1947	−4.67	−5.60	−3.13
1948	.36	.55	−.07
1949	−1.79	2.66	1.71
1950	6.05	3.27	2.54
1951	−2.71	−1.52	−1.34
1952	−4.52	6.71	−5.76
1953	−2.79	4.70	.54
1954	4.67	[1] 1.64	4.99
1955	[1] 1.13	−5.37	−4.79
1956	5.69	3.94	4.19
1957	1.20	[2] 2.63	3.67
1958	−4.93	−3.08	−4.05
1959	3.29	6.82	5.24
1960	−4.43	−5.12	−1.32
1961	1.60	4.15	2.92
1962	1.57	----	.52
Net for period	3.10	[3] 6.08	6.66
Average for period	.16	.34	.35
Standard error	0.82	0.95	0.78
r^2, coefficient of determination	.002	.006	.02

[1] Irrigated.
[2] Plastic cover on ground June 6 to September 9.
[3] For 1944–61 period.

third of figures 7-13 and from monthly summary of data in appendix tables 29-31.

Access tubes for measuring moisture in the profile by the neutron scattering method were installed on all weighing lysimeters in 1959. They provided a means of obtaining additional information on total moisture storage changes in the profile as well as changes in various parts of the profile. Soil moisture storage data from the neutron probe were found to be quite similar to data from the weighing lysimeters. The former data were used in water budget studies on lysimeters and in watersheds where the latter were not available. Details of these comparisons are presented on pages 27-31 and of the water budget studies on pages 38-43.

Figures 7-13 show soil moisture storage fluctuations on a daily basis. The soil moisture in storage increased throughout the fall and winter because of low ET, little or no percolation, and the retention of much of the precipitation. Periods of precipitation and rises of soil moisture were coincident. Periods of decrease in soil moisture were concurrent with periods of no rainfall. The top soil moisture curve represents soil moisture conditions on the Keene silt loam of Y103A. This relatively high moisture was to be expected, inasmuch as the silty clay subsoil of Y103A held more water than the lighter textured Muskingum soils of Y101D and Y102C.

In 1956 (fig. 7), when both Y101D and Y102C were in deep-rooted grass-legume mixtures, their soil moisture curves were very similar. However, there is a striking difference between the curves for these two lysimeters in the period June to September, 1957 (fig. 8). For Y102C there were no periods of moisture increase because the plastic cover on the ground surface prevented absorption of rainfall. Moisture depletion in this case was due entirely to transpiration, because the plastic cover stopped evaporation from the soil. A detailed report on this special study is given on pages 50-55.

A plastic cover over the soil and the meadow crop of Y102C in 1962 (fig. 4) prevented moisture exchange between the lysimeter and the air. The moisture curve showed no change during this test period, while the cause of the excessive diurnal weight changes was being investigated.

There was a striking departure of the soil moisture curve for Y101D from that of Y102C in 1961 (fig. 12), starting about May 12. On this date, the sod of Y102C was spaded and transpiration ceased. The grass-legume vegetation of Y101D continued to transpire water, resulting in a more rapid removal of soil moisture from Y101D than was evaporated from the bare soil of Y102C.

Changes of slope of the ET lines within the period of high incoming solar energy are noteworthy. Abrupt changes in the slope of the curves for Y102C and Y103A on June 7, 1960 occurred at the time hay was cut on these lysimeters (fig. 11); a similar change in slope appears on the curve for lysimeter Y101D on June 20, 1960, at hay cutting time. Spading of the sod on lysimeters Y102C and Y103A on May 12, 1961 (fig. 12) was followed by a reduction of the slope of their respective ET curves. The curve for Y101D continued at a steep slope throughout this period. Ripening of the wheat in 1962 (fig. 13) was accompanied by a lessening of the slope of the ET lines in late June and early July.

A departure from the normal trend of the slope of the ET lines appears on figure 8. The plastic sheet placed on the ground surface of lysimeter Y102C, in corn, on June 5, 1957 effectively stopped evaporation of moisture from the soil. The slope of the line from June 5 to September 9, at which time the plastic sheet was removed, represents the extraction of soil moisture by transpiration alone. It is much less than the slope of the ET curve for Y103A, also in corn, where both evaporation and transpiration removed soil moisture. Inasmuch as the plastic sheet on Y102C prevented absorption of rainfall, there was no percolation response to the excessive June rainfall. Percolation increases on lysimeters Y101D and Y103A were very apparent. Details of the tests with the plastic cover are given on pages 50-55.

Lysimeter ET was related to pan evaporation in the 1944-55 lysimeter studies at Coshocton (*66*). A summary of monthly pan evaporation data for 1956-62 is given in table 7 for investigators who may desire to continue the study of this relation.

Soil Moisture as Determined by Neutron Scattering and Weighing Lysimeter Methods

Soil moisture measurements made on the lysimeters by the neutron scattering method (*93*) were compared to weighing lysimeter data and were found to be reliable for evaluating ET during periods of little or no percolation; that is, for most of the growing season. Whereas the weighing lysimeters provided data on gross moisture changes for the entire 8-foot block of soil, the neutron scattering method gave data for various layers of the soil profile.

The neutron probe is a cylinder 1.5 inches in diameter and 15 inches long, in the center of which is a radium-beryllium source and a detector tube. An access tube of thin-wall electric conduit 1.61 inches in inside diameter is driven to a depth of 72 inches in the center of the lysimeter. Soil inside the tube is removed by an auger during the driving process. The bottom of the tube is sealed with a rubber stopper and cement to keep out water. The detector tube is connected by electric cable to an electronic scaler for counting. The count is related to soil moisture by field calibration.

Soil moisture in the top 7 inches of the profile, where the neutron probe readings were generally unreliable, was determined by electrical resistance fiber glass-gypsum blocks (*93*). The blocks were placed at 0.5-, 2.5-, and 5.5-inch depths in each lysimeter. Measurements at other depths, 12 inches and greater, were made with the neutron probe. Six replicates were used at each depth—a total of 18 blocks per lysimeter. The

TABLE 7.—*Monthly evaporation from a free water surface*[1]

Year	May		June		July		August		September		October	
	USWB[2]	BPI[3]	USWB	BPI	USWB	BPI	USWB	BPI	USWB	BPI	USWB	BPI
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1956	5.38	3.35	6.70	4.89	5.61	4.63	5.27	4.40	3.68	3.32	3.09	2.45
1957	6.03	4.39	5.68	4.36	6.60	4.96	6.51	5.09	3.90	3.44	2.24	2.08
1958	6.05	4.25	5.20	3.89	6.13	4.21	5.63	3.98	3.69	2.89	3.21	2.58
1959	5.28	3.30	7.06	5.29	6.09	5.00	6.29	4.46	5.49	4.22	2.96	2.55
1960	4.40	2.94	7.07	5.83	7.17	5.43	6.51	5.31	4.21	3.38	3.21	2.65
1961	6.06	4.16	6.72	5.13	6.50	4.52	5.60	4.58	5.32	4.28	3.29	2.74
1962	6.83	[4] 4.02	6.85	5.00	7.11	5.50	8.45	6.58	4.13	3.47	2.81	2.30

[1] Ice-free period only. USWB evaporation pan 4 feet in diameter and entirely above ground. BPI pan 6 feet in diameter, sunken, with water level at ground surface.
[2] U.S. Weather Bureau.
[3] Bureau of Plant Industry.
[4] Record starts on May 9.

soil layers represented by the measurements made at specific depths are given in the following tabulation.

Measuring point in profile	Soil layer represented
Inches	*Inches*
0 5, 2 5, and 5 5	0-7
12	7-18
24	18-30
36	30-42
48	42-54
60	54-64
68	64-72
None	72-96

Moisture in the 72- to 96-inch depth—shale rock—was assumed to be constant. Moisture changes, as determined by the two different methods for 3 years on lysimeter Y101D, permanently in deep-rooted crops, were almost identical (figs. 14, 15, 16). Likewise, moisture changes determined by the two methods in 1961 on lysimeters with different soils and crops (Y101D, Y102C, and Y103A) were very similar (figs. 16, 17, 18). Second-year meadow on Y102C and Y103A was plowed under in April. Corn was planted in May and harvested in October. Wheat was seeded soon thereafter. Moisture changes under different conditions were determined by the two methods. All comparisons indicated that the neutron scattering method gave results adequate for the investigation of many agricultural problems.

Although daily values of moisture change were available from the weighing lysimeters, only those concurrent with the period of neutron probe measurements were used in plotting these graphs (figs. 14-16).

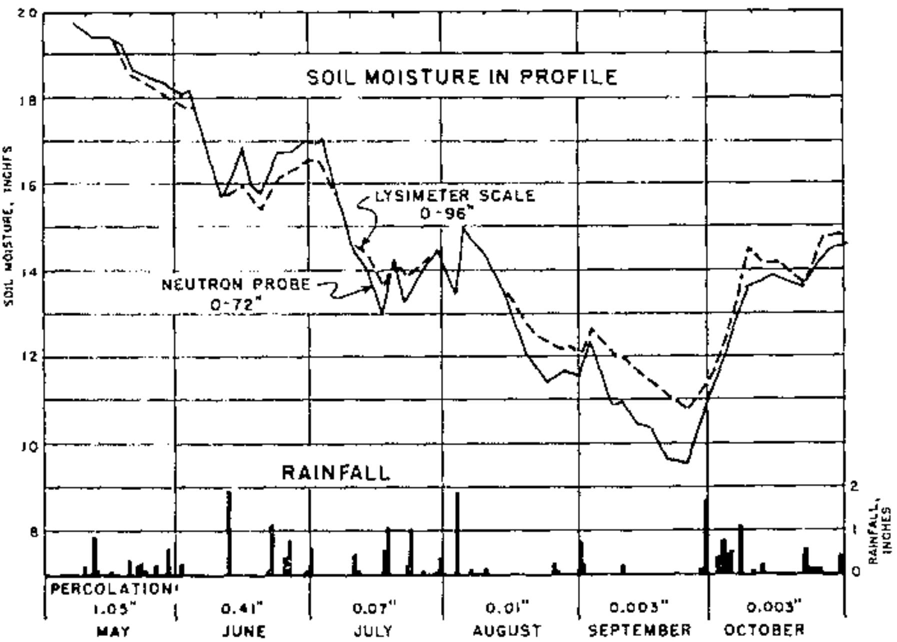

FIGURE 14.—Change in soil moisture in profile as determined by neutron probe and lysimeter scale, monthly percolation, and daily rainfall, lysimeter Y101D, May-October 1959.

Individual observations were plotted and consecutive points connected by straight lines. It is obvious that the lines represent moisture content of the soil only if no rain fell during the period between observations. For example, on figure 15 there was one observation on August 2, and another on August 11. The line between these two points on the graph does

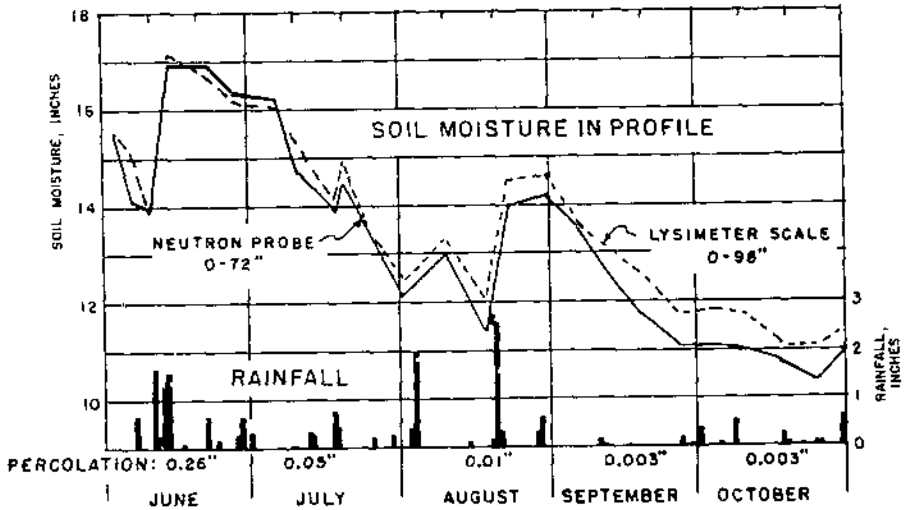

FIGURE 15.—Change in soil moisture in profile as determined by neutron probe and lysimeter scale, monthly percolation, and daily rainfall, lysimeter Y101D, June-October 1960.

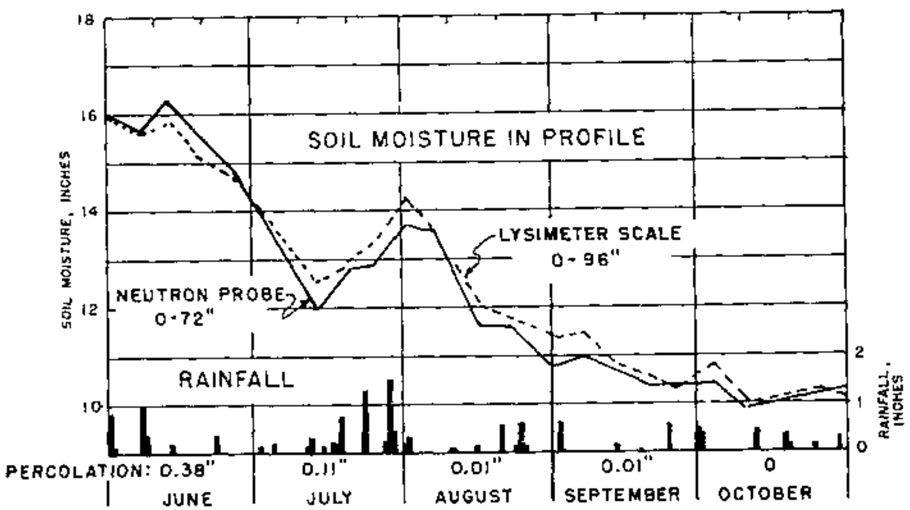

FIGURE 16.—Change in soil moisture in profile as determined by neutron probe and lysimeter scale, monthly percolation, and daily rainfall, lysimeter Y101D, June-October 1961.

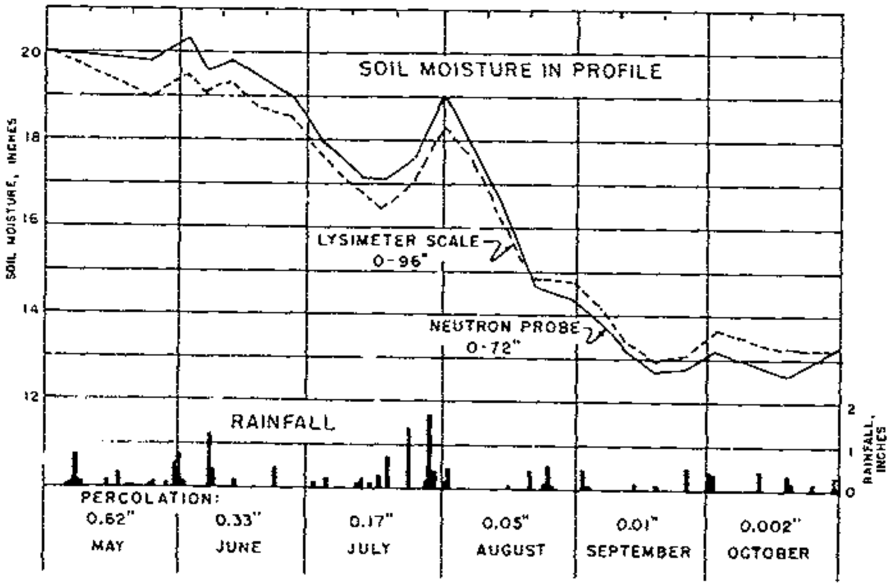

FIGURE 17.—Change in soil moisture in profile as determined by neutron probe and lysimeter scale, monthly percolation, and daily rainfall, lysimeter Y102C, May-October 1961.

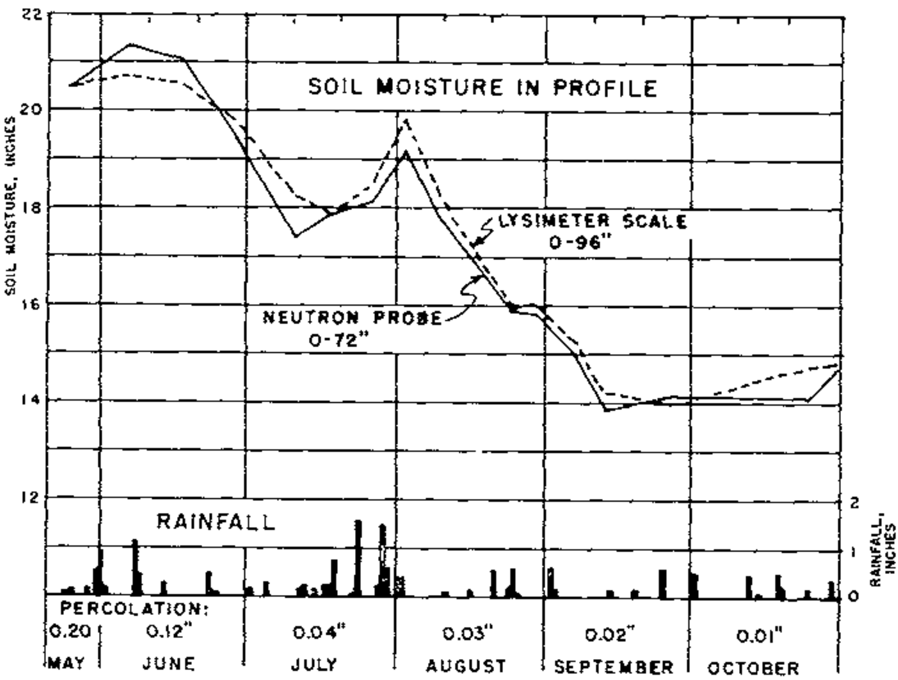

FIGURE 18.—Change in soil moisture in profile as determined by neutron probe and lysimeter scale, monthly percolation, and daily rainfall, lysimeter Y103A, May-October 1961.

not represent the true picture. It is more likely that soil moisture rose rapidly on August 3 and 4, and was then depleted from the 5th to the 10th. Although the exact moisture trends cannot be evaluated with the neutron probe data, they appear to be adequate for use in computing ET values for periods between observations and in making water budget studies. This use is described on pages 38-43.

Soil Moisture Changes Related to Soil Type, Crop Rooting Depth, and Agronomic Practice

The lysimeters and the neutron probe provided a means for evaluating the effect of soil type, crop rooting depth, and land treatment on various phases of agricultural hydrology. This section of the bulletin deals with the effect of these factors on soil moisture distribution. A later section describes the effects on percolation.

Soil Type

Data on the effect of soil type on the soil moisture regimen of first- and second-year meadow and corn of 4-year-rotation lysimeters are given in figure 19 for the 1959-61 growing seasons. (Where a moisture percentage is given in this bulletin, it is percentage of moisture based on the total volume of the soil.) Data for two dates are given, one near the beginning and one near the end of the growing season. The soil types were Keene silt loam and Muskingum silt loam. The latter is a well drained soil, quite permeable, with no mottling in the profile, and with texture becoming lighter with depth. The Keene silt loam is slowly permeable, with mottling beginning at approximately 15 inches. Its upper subsoil is a heavy silt loam, grading into a silty clay loam at about 15 inches, then into a silty clay at approximately 27 to 30 inches. The silty clay is high in colloids, which swell when wet, making the profile almost impermeable at this depth. This impermeability was a deterrent to root penetration. In the upper 21 inches there was little difference in moisture content between the two soil types in May. In the 21- to 48-inch depth, the moisture content of the Muskingum soil was much less than that of the Keene soil, reflecting the contrast in subsoil characteristics.

A greater contrast between the moisture content of the two soil types, however, appeared near the end of the growing season. That of the Muskingum soil was very much less than that of the Keene soil from the 21-inch depth downward. This moisture difference also reflected the difference in soil profile characteristics, as the Muskingum soil is well drained and roots penetrated to a greater depth when it was necessary for them to obtain sufficient moisture. On the Keene soil, the heavier soil layers impeded the downward penetration of roots and the plants had to obtain their moisture from the upper part of the profile. This accounted for the low moisture values in the 0- to 21-inch layer of the Keene soil in September. In the well drained Muskingum soil there was no such deterrent to root penetration and therefore vegetation depleted moisture from the 21- to 60-inch layer to a much greater extent than that on the Keene soil. This contrast in moisture between soil types both above and below the 21-inch depth was consistent for the 3 years regardless of cover.

Crop Rooting Depth

Data from Y101D, seeded to birdsfoot trefoil in April 1957, and Y101B, in a poverty grass cover since 1940 were used to evaluate the influence of

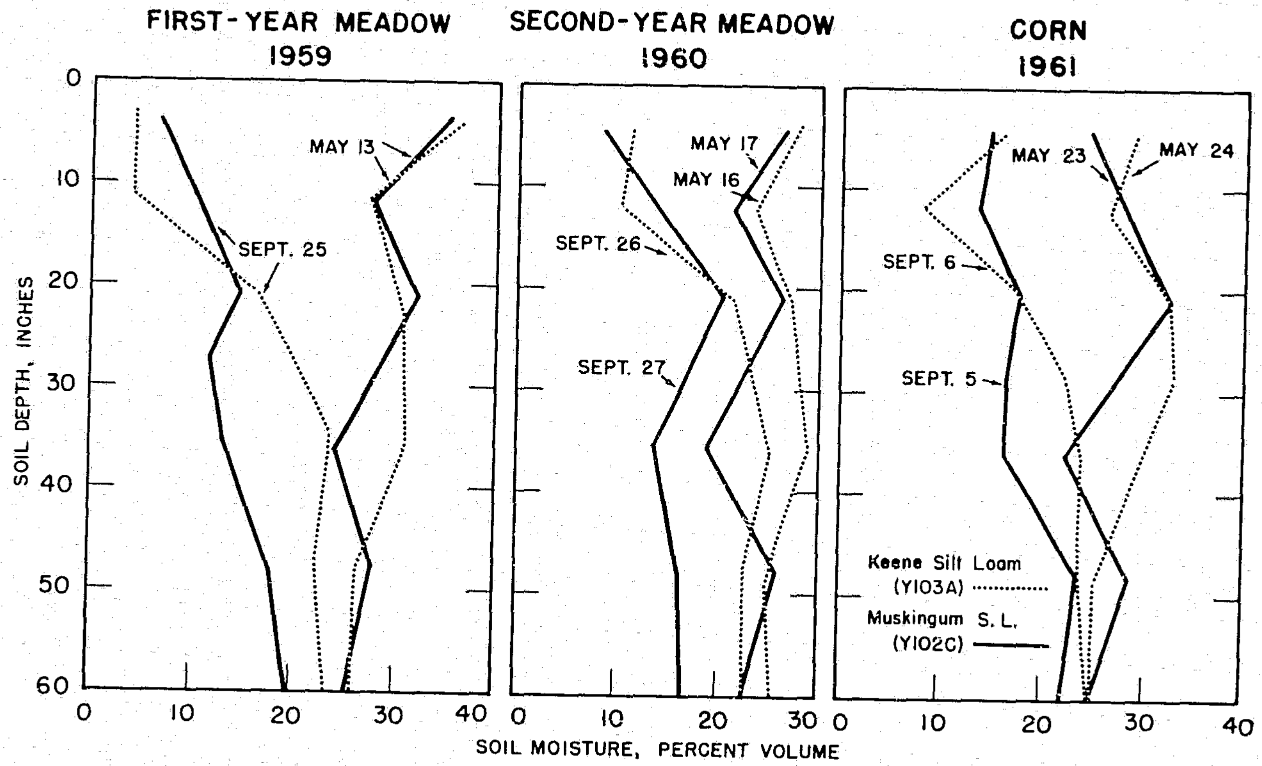

FIGURE 19.—Moisture content of Keene and Muskingum soil profiles at beginning and end of 1959-61 growing seasons.

a deep- versus shallow-rooted crop on soil moisture (fig. 20). These lysimeters were only 36 feet apart and

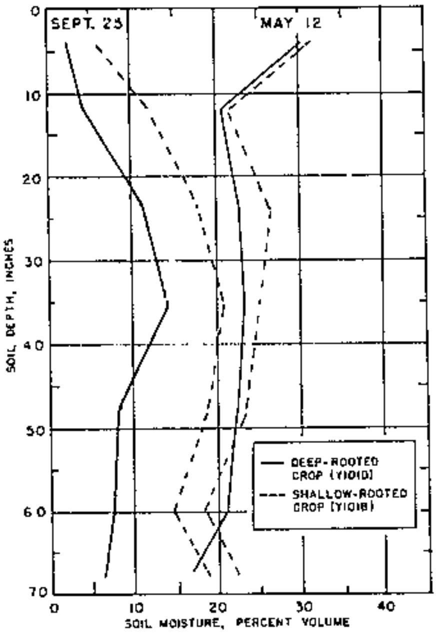

FIGURE 20.—Moisture distribution of soil in deep-rooted birdsfoot trefoil (Y101D) and in shallow-rooted poverty grass (Y101B), 1959.

there was no significant difference in their soil. Moisture differences were therefore, attributed to the effect of crop differences. Soil moisture data were obtained near the beginning and end of the growing season in 1959. During April the moisture content of the soil profile was generally at its peak and both areas were still high in moisture on May 12. On May 12 there was little difference between the moisture content of the two lysimeters down to the 68-inch depth. The moisture evaluations on September 25, near the end of the growing season, showed a sharp contrast between the two moisture curves. Then the moisture content of the entire 68-inch soil profile of the lysimeter in deep-rooted vegetation was considerably less than in May and also than that of the lysimeter in shallow-rooted vegetation. This is the direct result of greater depletion of moisture through the deeper root system. Data for the shallow-rooted poverty grass in September showed that moisture below the 30-inch depth was only slightly less than it was in May. This depletion of moisture below the 30-inch depth is attributed mainly to drainage of gravitational water.

Agronomic Practice

Data on the effect of agronomic practice on the moisture regimen of soil in first- and second-year meadow and in corn in the 4-year rotation lysimeter with Keene silt loam are given in figure 21 for the years 1959-61. Data for dates near the beginning and end of the growing season are shown. In May of each year there was little difference in soil moisture due to agronomic practices. Conservation-practice lysimeters were limed to a pH of 7.0; poor-practice lysimeters were limed to a pH of 5.4. Fertilizer rates on the former were those commonly used by "conservation" farmers and were about three times as large as those used on poor-practice lysimeters. Meadow seeding on the conservation-practice lysimeters consisted of alfalfa, red clover, and timothy. Alsike was used on the poor-practice lysimeters instead of alfalfa. Details on the agronomic practices used on all lysimeters are given in appendix tables 32-34.

In September, at the end of the growing season, there was a sharp contrast in moisture down to the 36-inch depth resulting from the two types of agronomic practice. Below this depth, the moisture difference resulting from different practices was less because of the sparse root penetration below the impeding layer. The

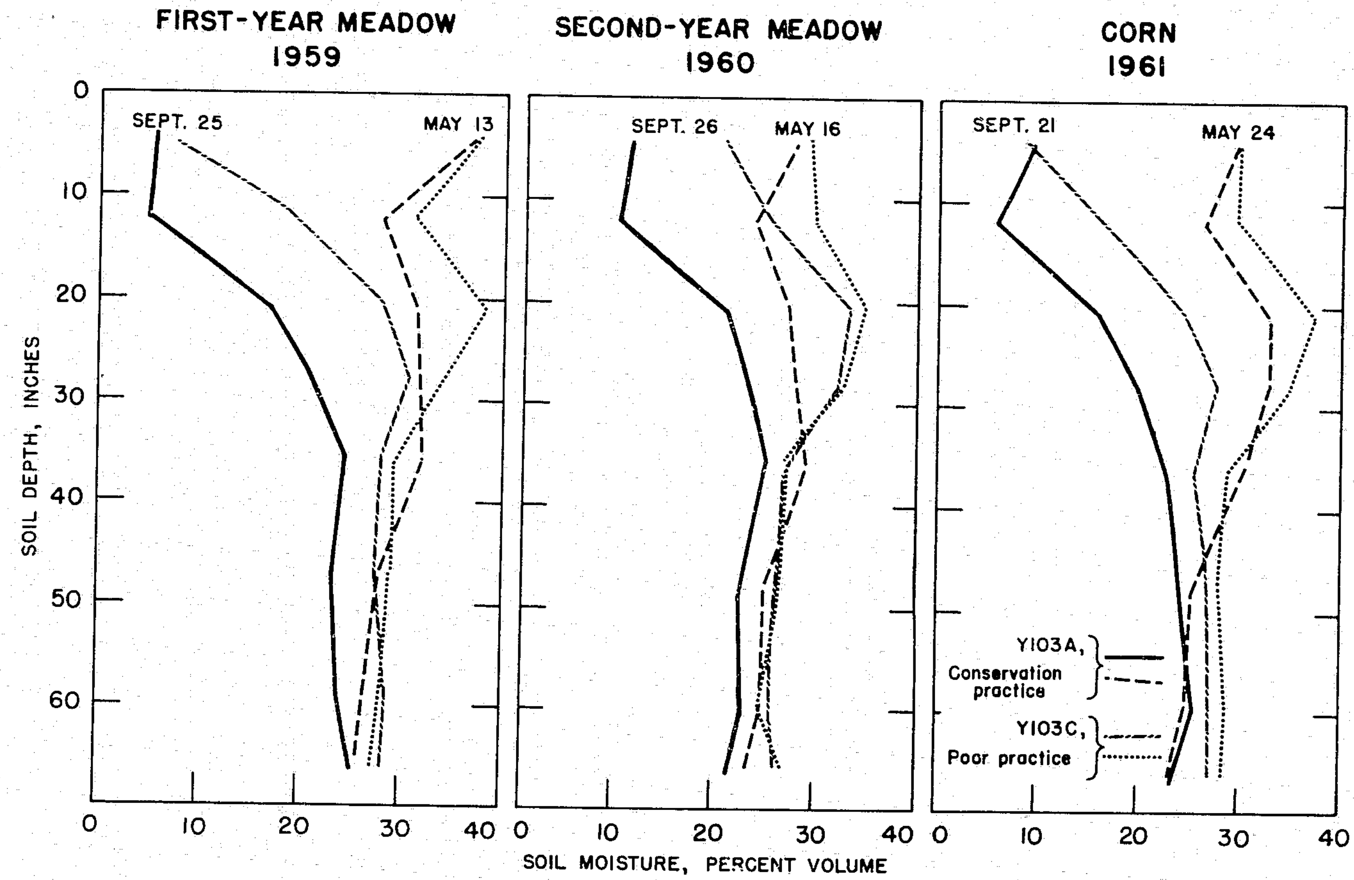

FIGURE 21.—Effect of agronomic practice on moisture content of Keene silt loam profiles at beginning and end of 1959-61 growing seasons.

more luxuriant vegetation, together with the somewhat deeper root penetration of the conservation-treatment crops extracted more moisture throughout the growing season, thereby depleting moisture to a greater extent on Y103A than on the poor-practice Y103C. These results were consistent for each of the 3 years represented. The lower moisture content of the soil under conservation practice was reflected in lower percolation values than those from the poor-practice lysimeters, as described on pages 55-67.

Soil Moisture—Lysimeter Versus Adjacent Watershed

The Coshocton lysimeters were located adjacent to small watersheds and were designed to represent the soil conditions thereon as closely as possible. It was recognized that the concrete sidewalls prevented lateral movement of water within the soil profile and therefore lysimeters could not represent field conditions where such water movement was likely to occur.

Comparisons of the soil moisture regimen of a watershed with that of its representative lysimeter were made in 1960. Moisture measurements in the lysimeter were made by surface soil moisture blocks and by the neutron depth probe in one central access tube. Similar measurements of soil moisture were made at a few selected sites on the adjacent watershed. Some of these sites were at about the same elevation and land slope as the lysimeter. Some were at higher or lower elevations. All sites had land areas of different lengths lying uphill between them and the ridge top, from which surface and subsurface flow could come. In addition, some lateral flow could escape downhill.

Soil moisture sampling sites on the watersheds were selected mainly to represent variations in soil type and position on the slope. On watershed 102, adjacent to lysimeter battery Y101, five sites were instrumented for soil moisture evaluations; on watershed No. 109 (near battery Y102), six sites were instrumented; on watershed 123 (near battery Y103), seven sites; one site in each watershed had a deep (72-inch) access tube. At each site, moisture determinations were made in the 0- to 54-inch profile.

Figure 22 shows soil profile moisture distribution at lysimeter Y101D and at adjacent watershed sites before and after a storm. The lysimeter moisture curve for both dates was close to the average of the data at the various watershed sites, at least down to a depth of 48 inches. Below that depth, data were available from only one watershed site. Moisture increases down to 30 inches in the 4-day period were evident at all locations.

The water budget for the period is shown in table 8. The total moisture computed on the watershed differed from the measured value of total moisture by only 0.11 inch. In the lysimeter, the difference was 0.3 inch. The close agreement indicates that the measurements are of acceptable accuracy.

The total amount of moisture in the watershed soils as evaluated by

TABLE 8.—*Water budget for lysimeter Y101D and for watershed 102, June 10–14, 1960*

Item	Lysimeter	Watershed
	Inches	*Inches*
Total moisture measured in 0- to 54-inch depth,[1] June 10	10.72	10.58
Rain	+4.15	+4.15
ET (lysimeter scale)	− .71	− .71
Percolation	− .04	− .04
Total moisture in profile, June 14, computed	14.12	13.98
Total moisture in profile, June 14, measured[1]	13.82	13.87

[1] Neutron probe measurements made to depth of 48 inches assumed to represent moisture to a depth of 54 inches.

the readings at the access tube sites differed somewhat from that observed in the lysimeter soils. The magnitude of the difference varied by soil type as well as by soil moisture content. The average moisture content of the profiles at the various sites in each watershed for each sam-

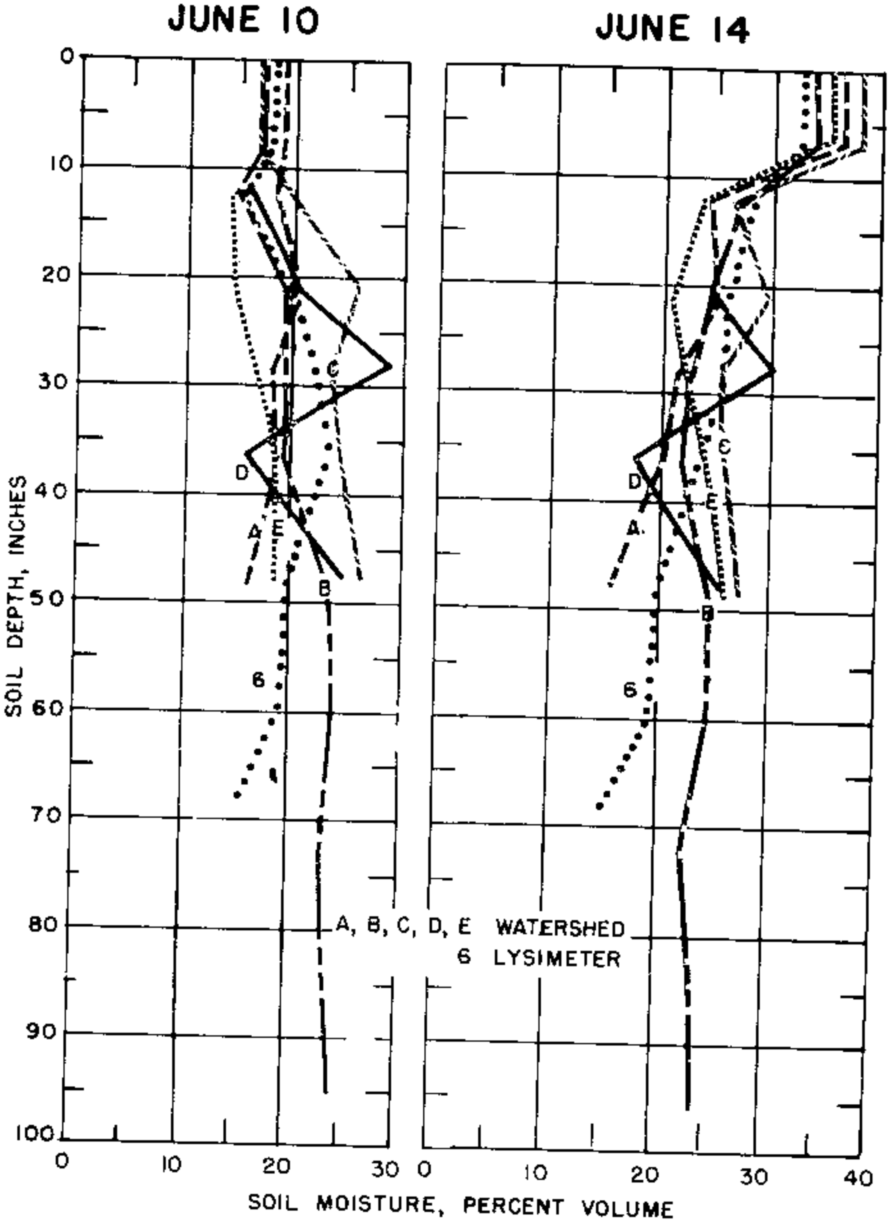

FIGURE 22.—Soil profile moisture distribution for lysimeter Y101D and five sites on adjacent watershed 102, before (June 10) and after (June 14) a storm, 1960.

pling date was compared with that of the lysimeter profile adjacent to the watershed for a 12-month study period beginning in April 1960 (fig. 23).

There was a considerably greater range in moisture content of lysimeter soils than in moisture content of watershed soils for each of the three sites compared (as shown by the greater-than-45° slopes of the solid lines going through data points. The 45° dashed lines represent lines of equal values.) Moisture content of Y101D ranged from 8.1 to 15.6 inches while that for watershed 102 ranged from 9.3 to 14.9 inches. The range for Y102C was 7.8 to 16.3 inches compared to 10.2 to 15.9 inches for watershed 109. The range for Y103A was 10.2 to 17.4 inches compared to 12.9 to 17.2 inches for watershed 123.

Moisture values for Muskingum silt loam over sandstone (watershed 102 versus lysimeter Y101D), which had a birdsfoot trefoil cover, showed the best agreement of the three lysimeter soils with the line of equal values. At the highest moisture content, moisture values of lysimeter Y101D were higher than those of the watershed, but at lower moisture values the reverse was true. Moisture values for Keene silt loam (watershed 123 versus lysimeter Y103A), in second-year meadow, showed the poorest agreement—the lysimeter values were consistently lower than those for the watershed on all dates sampled except two. Moisture values for Muskingum silt loam over shale (watershed 109 versus lysimeter Y102C) were intermediate between the other two in agreement. Only eight lysimeter values indicated a higher moisture content than that of the watershed, and these were close to the line of equal values.

One deep access tube was placed on each watershed to provide a comparison of watershed moisture values with those of the lysimeters to a depth of 72 inches. The contrast be-

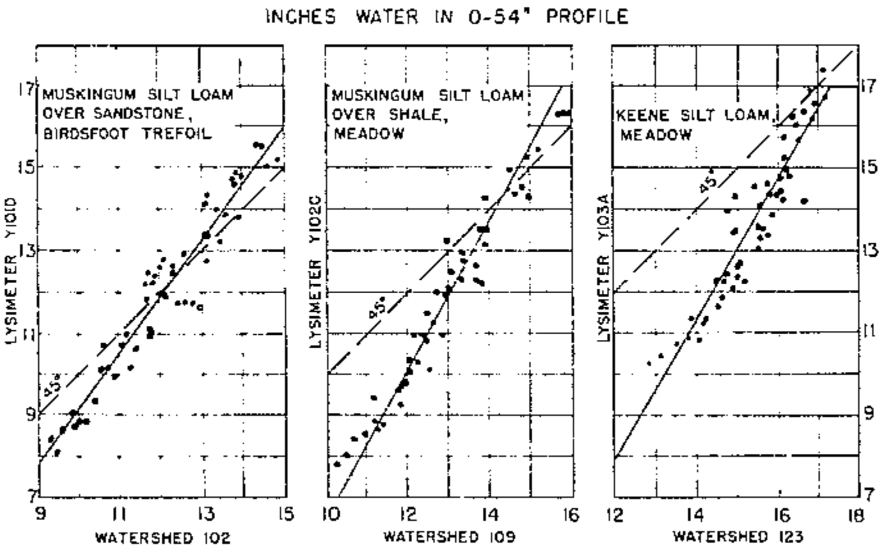

FIGURE 23.—Comparison of soil moisture of three watersheds with that of adjacent lysimeters for the 12-month period ending April 14, 1961. Dashed lines are lines of equal values. Neutron probe measurements to a 48-inch depth assumed to represent moisture to a 54-inch depth.

tween the 0- to 72-inch moisture in lysimeters and that at the deep-tube sites on the respective watersheds was even more pronounced than that between the 0- to 54-inch profiles in every case (*36*).

For the watershed 123 versus lysimeter Y103A study, the moisture in the watershed soil at the deep tube site was greater than that in lysimeter soils each time records were obtained. Soil type exerted some influence on these relations. For Keene silt loam that had impeding layers in the profile, the contrast between lysimeter–watershed moisture relations appeared to be greater.

For all three comparisons, the lysimeter moisture content approached that of the watershed at high moisture levels, whereas at low moisture levels the contrast was greater in most instances.

This study indicated the shortcomings of selecting a 1/500-acre plot on a hillside, isolating it with impervious side walls, and expecting it to represent the hydrologic behavior of a 2- to 3-acre watershed with its variations in soil and degree and slope. The study also raised some questions concerning the validity of watershed moisture values estimated from data from a small number (5-7) of sites.

Water Budget Studies

Values of ET, sometimes termed consumptive use, were determined from the equation

$$ET = P - G - Q - \Delta M$$

where ET = evapotranspiration
P = precipitation
G = percolation
Q = surface runoff
ΔM = change in soil moisture

All factors on the right side of the equation were determined directly from lysimeter data. ΔM was determined from the lysimeter weight record. Water budget summaries for the various crop seasons on lysimeters Y102C and Y103A are given separately in table 9. Net moisture storage change is given for each of 5 years of corn. In 1961 under natural conditions (no irrigation, no plastic cover), the depletion value (negative value of soil moisture) for Y102C exceeded 6 inches. Rainfall on Y102C during that year was the lowest for the corn years, totaling 14.47 inches. In 1953 and 1961, rainfall on Y103A was quite low and the soil moisture depletion values exceeded 7 inches. Moisture depletion on Y102C in 1957 was large because the plastic sheet cover on the ground prevented water absorption during much of its growing season. In the same season the depletion of 4.22 inches on Y103A was about average.

In the wheat seasons, moisture storage gains exceeded losses both in amounts and in numbers of occurrences. During the four first-year meadow seasons, moisture depletion predominated. During the four second-year meadow seasons, moisture gains predominated.

Monthly water budget data (appendix tables 35-38) show relations between precipitation, percolation, runoff, ET, and soil moisture storage changes throughout the different seasons for lysimeters Y102C and Y103A.

The use of a nuclear probe and fiber glass–gypsum blocks for evaluating ΔM, discussed in an earlier section, made it possible to evaluate ET on nonweighing lysimeters. Tables 10-13 present water budget data for weighing lysimeter Y103A and nonweighing lysimeter Y103C.

Data for 21 sampling dates (May 6-Sept. 25, 1959) for lysimeters in first-year meadow are given in table 10. Precipitation values were the same for both lysimeters. Percolation was higher on the poor-practice

TABLE 9.—*Water budget summary for corn, wheat, and meadow crops, lysimeters Y102C and Y103A, 1945–62*

Lysimeter	Crop	Period [1]	Year	Precipitation	Runoff	ET	Percolation	ΔSoil moisture
				Inches	*Inches*	*Inches*	*Inches*	*Inches*
Y102C	Corn	May-Sept.	1945	23.07	3.44	18.62	2.34	−1.33
			1949	17.91	.27	20.63	.97	−3.96
			1953	[2] 20.58	.08	23.01	2.33	−4.84
			1957	24.69	[3] 15.91	[3] 12.84	1.46	−5.52
			1961	14.47	1.14	18.76	.92	−6.35
			Average	20.14	4.17	18.77	1.60	−4.40
	Wheat	Oct.-June	1945–46	32.43	1.06	25.25	7.47	−1.35
			1949–50	36.77	.15	20.72	12.74	3.16
			1953–54	[4] 24.59	.44	22.68	3.23	−1.76
			1957–58	32.64	.28	21.09	6.17	5.10
			1961–62	28.15	1.51	19.62	6.17	.65
			Average	30.92	.69	21.87	7.16	1.50
	First-year meadow	July-July	1946–47	46.38	.36	36.42	12.66	−3.08
			1950–51	54.62	.56	39.96	10.98	−5.88
			1954–55	[5] 46.02	.43	36.69	7.72	1.18
			1958–59	49.14	.21	42.04	8.15	−1.26
			Average	39.23	.39	38.78	12.13	−2.26
	Second-year meadow	Aug.-Apr.	1947–49	69.35	.20	53.30	11.06	4.79
			1951–53	66.89	.28	46.78	12.52	7.31
			1955–57	72.32	.60	52.70	13.64	5.38
			1959–61	77.39	.55	53.69	17.11	6.04
			Average	71.48	.41	51.29	10.87	5.88
				Inches	*Inches*	*Inches*	*Inches*	*Inches*
Y103A	Corn	May-Sept.	1945	23.60	0.28	21.58	1.57	0.17
			1949	19.96	.23	23.61	.19	−4.07
			1953	15.01	.05	21.53	.46	−7.03
			1957	23.32	1.95	23.35	2.24	−4.22
			1961	15.71	.48	22.06	.28	−7.11
			Average	19.52	.60	22.43	.95	−4.45
	Wheat	Oct.-June	1945–46	29.85	.04	27.22	5.86	−3.27
			1949–50	36.40	.07	22.82	10.02	3.49
			1953–54	23.63	.31	22.37	.66	.29
			1957–58	33.86	.25	24.70	4.66	4.25
			1961–62	29.64	.18	24.04	5.21	− .39
			Average	30.88	.17	24.35	5.28	.87
	First-year meadow	July-July	1946–47	46.76	.11	39.41	10.26	−3.0
			1950–51	53.58	.28	43.37	15.43	−5.50
			1954–55	39.99	.09	34.41	5.21	.28
			1958–59	44.99	.16	43.78	5.05	−4.00
			Average	46.33	.16	40.24	8.99	−3.06
	Second-year meadow	Aug.-Apr.	1947–49	69.62	.13	53.60	11.71	4.09
			1951–53	68.61	.23	49.84	12.27	6.27
			1955–57	76.31	.25	57.49	10.08	8.49
			1959–61	80.58	.44	59.16	11.15	9.81
			Average	73.78	.26	55.05	11.30	7.17

[1] Corn, from spading sod to harvest.
Wheat, from corn harvest to wheat harvest.
First-year meadow, from wheat harvest to last hay cutting, following year.
Second-year meadow, from last cutting of first-year meadow to spading sod for corn.
[2] Irrigated 5.83 inches.
[3] Plastic sheet on ground surface, June 6 to Sept. 9.
[4] Irrigated 2.24 inches.
[5] Irrigated 8.11 inches.

TABLE 10.—*Data on factors in the water budget for lysimeters Y103A and Y103C, first-year meadow, 1959*

Period [1]	Precipitation	Percolation		Surface runoff		Moisture storage change [4]		Evapotranspiration [5]			
								Total		Average daily	
		Y103A [2]	Y103C [3]	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C
	Inches	*Inch*	*Inch*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*	*Inch*
May 6											
May 13	1.30	0.04	0.06	0.01	0.01	−0.18	−0.07	1.43	1.30	0.204	0.186
May 18	.05	.02	.02	0	0	−.50	−.45	.53	.48	.106	.096
May 25	.92	.02	.02	0	0	−.93	−.09	1.83	.99	.261	.141
June 1	1.09	.02	.02	0	0	+.28	+.01	.79	1.06	.113	.154
June 8	.36	.01	.01	0	0	−1.32	−.81	1.67	1.16	.239	.166
June 15	1.75	.01	.04	.02	.01	+.38	+.37	1.34	1.33	.191	.190
June 23	1.37	.01	.03	.01	0	+.31	+.21	1.04	1.13	.130	.141
June 29	1.20	.01	.04	0	.01	−.06	+.19	1.25	.96	.208	.160
July 6	.79	.01	.01	0	0	−1.11	−.70	1.89	1.48	.270	.211
July 14	.62	.01	.01	0	0	−1.57	−.95	2.18	1.56	.272	.195
July 20	1.21	0	.03	0	0	+.48	+.28	.73	.90	.122	.150
July 27	1.08	.01	.04	0	0	−.29	−.10	1.36	1.14	.194	.163
Aug. 3	.46	.01	.01	0	0	−1.05	−.95	1.50	1.40	.214	.200
Aug. 10	1.90	.01	.07	.01	.01	+1.67	+.99	.21	.83	.030	.119
Aug. 18	.25	0	.01	0	0	−.72	−.44	.97	.68	.121	.085
Aug. 24	0	0	0	0	0	−1.53	−1.19	1.53	1.19	.255	.198
Aug. 31	.42	0	0	0	0	−.18	−.23	.60	.65	.086	.093
Sept. 8	.89	0	.01	0	0	−.42	+.14	1.31	.74	.164	.092
Sept. 17	.29	.01	.01	0	0	−.79	−.32	1.07	.60	.119	.067
Sept. 26	0	0	0	0	0	−.54	−.47	.54	.47	.068	.059
Total	15.95	.20	.44	.05	.04			[6] 23.77	[7] 20.05	.167	.141

[1] Each period ends at midnight of the date on the line from which data are read and begins at midnight of the date on the preceding line, except first period, which begins at 00:00 a.m. of May 6.
[2] Keene silt loam, conservation practice. Hay cut June 11, Aug. 3.
[3] Keene silt, loam, poor practice. Hay cut June 11, Aug. 3.
[4] Determined by fiber glass gypsum blocks in the 0- to 7-inch layer and by the nuclear probe method in the 7- to 72-inch layer.
[5] Values derived from water budget equation.
[6] Yield 4.31 tons per acre or 0.181 tons per inch of water consumed.
[7] Yield 3.03 tons per acre or 0.151 ton per inch of water consumed.

lysimeter. Runoff values were very small on both. Derived (formula 2) values of total ET and average daily ET are given for each period. Total ET for the season amounted to 23.77 and 20.05 inches for the conservation-practice (Y103A) and poor-practice (Y103C) lysimeter, respectively. When the weight records of lysimeter Y103A were used, ET totaled 24.31 inches for the same period, 2 percent more than that evaluated by the neutron scattering method and the water budget formula.

Similar data are given for second-year meadow in 1960 (table 11). Total ET for the period May 4 to September 26 on Y103A, evaluated by the lysimeter weight record, was 26.30 inches as compared to 24.77 inches, determined by the neutron probe method. The contrast in ET between the two practices—24.77 inches for conservation practice and 18.66 for poor practice—was even greater than in 1959. The yield of hay per inch of water consumed amounted to 0.181 and 0.184 ton on the conservation-practice lysimeters for the two successive years. On the poor-practice lysimeters the values were 0.151 and 0.139 ton, respectively. Although the ET values were lower on the poor-practice lysimeters, the water-use efficiency was greater on the conservation-practice lysimeters during both seasons.

Similar data for the corn crop in 1961 appear in table 12. Total ET for the period May 2 to September

TABLE 11.—*Data on factors in the water budget for lysimeters Y103A and Y103C, second-year meadow, 1960*

Period [1]	Precipitation	Percolation		Surface runoff		Moisture storage change [4]		Evapotranspiration [5]			
								Total		Average daily	
		Y103A [2]	Y103C [3]	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C
	Inches	*Inch*	*Inches*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*	*Inch*
May 4											
May 16	2.02	0.02	0.08	0	0	+0.87	+1.16	1.13	0.78	0.094	0.065
May 24	1.04	.01	.03	0	0	− .44	+ .32	1.47	.69	.184	.086
June 1	.61	.01	.01	0	0	− .95	− .53	1.55	1.13	.194	.141
June 7	.70	.01	.01	0	0	− .52	− .02	1.21	.71	.202	.118
June 21	5.00	.03	1.91	.05	.13	+3.17	+ .02	1.75	2.04	.125	.146
June 28	.88	.02	.06	.01	0	−1.46	−1.00	2.31	1.82	.330	.260
July 5	1.54	.01	.03	.01	.04	+ .15	+ .35	1.37	1.12	.196	.160
July 12	.03	.01	.01	0	0	−1.21	− .44	1.23	.46	.176	.066
July 19	1.44	.01	.03	0	0	+ .21	+ .57	1.22	.84	.190	.120
July 26	.54	.01	.01	.01	.02	−1.18	−1.46	1.70	1.97	.243	.281
Aug. 5	3.04	0	.04	.04	.03	+1.72	+1.30	1.28	1.67	.143	.168
Aug. 17	.14	.01	.02	0	0	−1.76	−1.31	1.89	1.43	.158	.119
Aug. 30	3.64	0	.51	.02	.03	+1.56	+2.05	2.06	1.05	.160	.081
Sept. 6	.72	0	.02	0	0	−1.01	− .40	1.73	1.10	.247	.157
Sept. 14	.24	0	.02	0	0	−1.55	− .56	1.79	.78	.224	.098
Sept. 26	.06	0	.01	0	0	−1.02	−1.02	1.08	1.07	.090	.089
Total	21.64	.15	2.80	.14	.25			[6] 24.77	[7] 18.66	.171	.129

[1] Each period ends at midnight of the date on the line from which data are read and begins at midnight of the date on the preceding line (except first period, which begins at 00:00 a.m. of May 4).
[2] Keene silt loam, conservation practice. Hay cut June 6, July 22.
[3] Keene silt loam, poor practice. Hay cut June 6, July 22.
[4] Determined by fiber glass-gypsum blocks in the 0- to 7-inch layer and by the nuclear probe method in the 7- to 72-inch layer.
[5] Values derived from water budget equation.
[6] Yield 4.57 tons per acre or 0.184 ton per inch of water consumed.
[7] Yield 2.59 tons per acre or 0.130 ton per inch of water consumed.

21 on Y103A, evaluated by the lysimeter weight record, was 22.34 inches, compared to 21.98 inches determined by the neutron probe method. Values of ET (21.98 vs. 19.04 inches) and water-use efficiency (7.73 vs. 6.78 bushels per inch of water use) were greater under conservation than under poor practice. Average daily ET for the period amounted to 0.155 and 0.134 inch for the conservation-practice and poor-practice lysimeter, respectively.

Water budget data for the wheat crop in 1962 appear in table 13. Only five soil moisture sampling dates are reported because soil moisture records after May 7 could not be taken without damaging the wheat crop. The last date for determining soil moisture (July 11) was just after the wheat was cut. Total ET for the period March 29 to July 11 on Y103A, evaluated by the lysimeter weight record, was 16.22 inches as compared to 16.58 inches, determined by the neutron probe method. Average daily ET was very low from March 29 to April 19, amounting to 0.067 and 0.055 inch for the conservation-practice and poor-practice lysimeters, respectively. Little transpiration occurred during this period because the plants were small and incoming solar radiation was low. Values of average daily ET and water-use efficiency for the wheat crop were greater on the conservation-practice than on the poor-practice lysimeters, as they were for the corn and meadow crops.

These ET values, derived from the measured water budget factors, agreed closely with those determined

TABLE 12.—*Data on factors in the water budget for lysimeters Y103A and Y103C, corn, 1961*

Period [1]	Precipitation	Percolation		Surface runoff		Moisture storage change [4]		Evapotranspiration [5]			
								Total		Average daily	
		Y103A [2]	Y103C [3]	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C
	Inches	*Inch*	*Inches*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*	*Inch*
May 2											
May 24	1.78	0.13	0.27	0.01	0	−0.69	−0.06	2.33	1.57	0.106	0.071
June 5	2.01	.04	.16	.13	.08	+.85	+.26	.99	1.51	.082	.126
June 16	1.70	.06	.32	.30	.14	−.19	−.23	1.59	1.53	.145	.139
June 20	0	.01	.03	0	0	−1.24	−.87	1.23	.84	.308	.210
June 28	.67	.02	.05	.01	.01	−.39	−.63	1.03	1.24	.129	.155
July 10	.39	.02	.03	0	0	−2.11	−1.18	2.48	1.54	.207	.128
July 19	.76	.01	.02	0	0	+.43	+.28	.32	.46	.040	.058
July 26	2.52	.01	.05	0	.01	+.29	+.89	2.22	1.57	.278	.196
Aug. 2	2.80	.01	.03	.03	.00	+1.04	+.87	1.72	1.81	.250	.259
Aug. 9	0	.01	.02	0	0	−1.36	−1.01	1.35	.99	.193	.141
Aug. 15	.17	.01	.01	0	0	−1.23	−1.18	1.39	1.34	.232	.223
Aug. 24	.67	.01	.01	0	0	−.68	−.62	1.34	1.28	.149	.142
Aug. 29	.86	.01	.01	0	.01	−.07	+.54	.94	.32	.188	.064
Sept. 6	.73	0	.01	0	0	−.83	−.85	1.56	1.57	.195	.196
Sept. 12	0	0	.01	0	0	−1.12	−.88	1.12	.87	.187	.145
Sept. 21	.24	.01	.01	0	0	−.14	−.37	.37	.60	.041	.067
Total	15.38	.36	1.04	.48	.34			[6] 21.98	[7] 19.04	.155	.134

[1] Each period ends at midnight of the date on the line from which data are read and begins at midnight of the date on the preceding line (except first period, which begins at 00:00 a.m. of May 2).
[2] Keene silt loam, conservation practice. Corn harvested Oct. 9.
[3] Keene silt loam, poor practice. Corn harvested Oct. 9.
[4] Determined by fiber glass-gypsum blocks in the 0- to 7-inch layer and by the nuclear probe method in the 7- to 72-inch layer.
[5] Values derived from water budget equation.
[6] Yield 170 bushels per acre or 7.73 bushels per inch of water consumed.
[7] Yield 129 bushels per acre or 6.78 bushels per inch of water consumed.

TABLE 13.—*Data on factors in the water budget for lysimeters Y103A and Y103C, wheat, 1962*

Period [1]	Precipitation	Percolation		Surface runoff		Moisture storage change [4]		Evapotranspiration [5]			
								Total		Average daily	
		Y103A [2]	Y103C [3]	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C	Y103A	Y103C
	Inches	*Inches*	*Inches*	*Inch*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*	*Inch*
Mar. 29											
Apr. 19	2.80	1.18	1.24	0.02	0.01	+0.19	+0.39	1.41	1.16	0.067	0.056
Apr. 24	.28	.08	.06	0	0	−.88	−.35	1.08	.57	.216	.114
May 7	.57	.09	.08	0	0	−1.51	−1.14	1.99	1.63	.153	.125
July 11	6.73	.12	.13	.01	.01	−5.50	−3.50	12.10	10.09	.186	.155
Total	10.38	1.47	1.51	.03	.02			[6] 16.58	[7] 13.45	.159	.129

[1] Each period ends at midnight of the date on the line from which data are read and begins at midnight of the date on the preceding line (except first period, which begins at 00:00 a.m. of Mar. 29).
[2] Keene silt loam, conservation practice. Wheat harvested July 11.
[3] Keene silt loam, poor practice. Wheat harvested July 11.
[4] Determined by fiber glass-gypsum blocks in the 0- to 7-inch layer and by the nuclear probe method in the 7- to 72-inch layer.
[5] Values derived from water budget equation.
[6] Yield 69 bushels per acre or 4.16 bushels per inch of water consumed.
[7] Yield 30 bushels per acre or 2.23 bushels per inch of water consumed.

from the lysimeter weight data—further evidence that the soil moisture measurements by the fiber glass-gypsum blocks and the neutron scattering method were of reliable accuracy. The nuclear probe thus appears to be a useful tool for determining ET where the factors in the water budget other than soil moisture (runoff and percolation) can be evaluated with a reasonable degree of accuracy.

Water Use by Crops

The amount of water required for crop growth has been the subject of many investigations, especially in the arid and semiarid regions of the country, where irrigation of crops is essential for production. In recent years, irrigation in the humid eastern states has been found to be profitable in many cases. The scarcity of water supplies, the cost of transporting water to the crops, and the loss of plant nutrients through leaching have created a demand for sound technical information on the use of water by crops to help develop plans for wise use of this vital natural resource.

Information on water use by crops is needed to estimate soil moisture depletion rates and subsequently to evaluate soil moisture conditions before critical storm periods. Such evaluations are important in estimating infiltration rates and calculating storm runoff rates and amounts.

Weight records from weighing lysimeters Y102C and Y103A for the 1941-62 period provided data on water use by different crops in a 4-year rotation during their periods of growth (table 14). These data are for 6 corn years, 6 wheat years, 5 first-year-meadow years, and 5 second-year-meadow years. The data include both evaporation and transpiration, inasmuch as both processes deplete soil moisture.

All data in table 14, except those for lysimeter Y102C in 1953, 1955, and 1957 are for natural conditions (no irrigation, no plastic cover), where periods of soil moisture deficiency normally occurred during July, August, and September. If there had been adequate moisture for maximum crop production during the entire growing season of each year, it is likely that more water would have been used.

Inasmuch as crops on lysimeter Y102C were irrigated in 1953 and 1955, data for these years are for optimum moisture conditions. Total amount of water used, crop yield, and efficiency of water use all show the effect of irrigation. In 1957 the soil surface of Y102C and Y102B was covered with plastic to eliminate evaporation losses. This experiment is described on pages 50-55.

The amount of water transpired and evaporated in the May-to-September period in the production of corn ranged from 17.4 to 24.8 inches, with one exception. Only 13.2 inches were removed in 1957, when evaporation was eliminated during most of the season by covering the lysimeter soil with a plastic sheet. Under natural moisture conditions crops on the high-moisture-retaining soil of lysimeter Y103A used more water than those on the light textured Muskingum soil of Y102C. In 1953, however, water use on irrigated lysimeter Y102C exceeded that on Y103A by 1.6 inches.

Yield of corn without irrigation for the 1941-61 period ranged from 34 to 170 bushels per acre. The low yield resulted from insufficient moisture in August 1945. With irrigation, in 1953, 196 bushels per acre were produced on Y102C.

The efficiency of water use was expressed in two ways. One way evaluated water-use efficiency by dividing the dry weight of the crop, in pounds per acre, by the inches of water used

TABLE 14.—*Water used by crops during season of growth, 1941–62*

Crop and year	Lysimeter	Period	Water use (ET)	Crop yield [1]	Dry weight of crop including straw or stover	Water-use efficiency—crop produced per amount of water used	
			In./acre	*Bu./acre*	*Lb./acre*	*Lb./in.*	*Bu./in.*
Corn:							
1941	Y102C	May–Sept.	17.4	80	10,000	575	4.60
1945	Y102C	do	18.8	34	7,300	388	1.81
1945	Y103A	do	21.3	61	10,500	493	2.86
1949	Y102C	do	21.6	144	14,600	676	6.67
1949	Y103A	do	24.8	139	14,100	569	5.60
1953	Y102C	do	[2] 23.5	196	19,530	831	8.34
1953	Y103A	do	21.9	143	15,600	712	6.53
1957	Y102C [3]	do	[3] 13.2	125	18,000	1,364	9.47
1957	Y103A	do	23.4	149	23,520	1,005	6.37
1961	Y102C	do	20.1	166	14,910	742	8.26
1961	Y103A	do	23.2	170	14,560	628	7.33
Average	Y102C		19.1	124	14,057	736	6.49
	Y103A		22.9	132	15,656	684	5.76
Wheat:							
1942	Y102C	Apr.–June	12.4	32	3,720	300	2.58
1942	Y103A	do	12.0	35	4,100	342	2.92
1946	Y102C	do	14.8	38	4,880	330	2.57
1946	Y103A	do	15.1	36	4,160	275	2.38
1950	Y102C	do	12.9	43	6,380	495	3.33
1950	Y103A	do	14.5	43	6,580	454	2.97
1954	Y102C	do	14.0	54	6,040	431	3.86
1954	Y103A	do	14.7	48	5,480	373	3.27
1958	Y102C	do	13.2	42	5,240	397	3.18
1958	Y103A	do	15.5	56	7,320	472	3.61
1962	Y102C	do	13.1	49	6,260	478	3.74
1962	Y103A	do	15.2	69	9,090	598	4.54
Average	Y102C		13.4	43	5,420	404	3.21
	Y103A		14.5	48	6,122	422	3.31
			In./acre	*Tons/acre*	*Lb./acre*	*Lb./in.*	*Ton/in.*
First-year meadow:							
1943	Y102C	Apr.–Aug.	19.4	2.36	4,720	243	0.12
1943	Y103A	do	20.3	1.67	3,340	165	.08
1947	Y102C	do	21.7	2.44	4,880	225	.11
1947	Y103A	do	22.2	1.95	3,900	176	.09
1951	Y102C	do	21.6	2.70	5,400	250	.12
1951	Y103A	do	22.2	2.27	4,540	205	.10
1955	Y102C	do	[4] 27.0	5.97	11,940	442	.22
1955	Y103A	do	24.6	4.43	8,860	360	.18
1959	Y102C	do	27.1	4.67	9,340	345	.17
1959	Y103A	do	25.7	4.31	8,620	335	.17
Average	Y102C		23.4	3.63	7,256	310	.16
	Y103A		23.0	2.93	5,852	254	.13
Second-year meadow:							
1944	Y102C	Apr.–Aug.	19.0	1.50	3,000	158	0.08
1944	Y103A	do	20.4	1.50	3,000	147	.07
1948	Y102C	do	25.7	3.10	6,200	241	.12
1948	Y103A	do	26.6	3.80	7,600	286	.14
1952	Y102C	do	24.0	2.64	5,280	220	.11
1952	Y103A	do	25.0	3.36	6,720	269	.13
1956	Y102C	do	24.1	6.32	12,640	524	.26
1956	Y103A	do	27.5	6.76	13,520	492	.25
1960	Y102C	do	26.9	5.97	11,940	444	.22
1960	Y103A	do	27.4	4.57	9,140	334	.17
Average	Y102C		23.9	3.91	7,812	327	.16
	Y103A		25.4	4.00	7,996	315	.16

[1] Computed on an acre basis from the lysimeter data.
[2] Includes 5.82 inches of irrigation water.
[3] Soil surface covered with sheet of clear plastic from June 5 to Sept. 9 to stop evaporation.
[4] Includes 5.32 inches of irrigation water.

during the season. The other way evaluated water-use efficiency by dividing the crop yield, in bushels per acre, by the inches of water used. The results show that efficiency of water use on cornland without irrigation or evaporation barrier ranged from 388 (1945, Y102C) to 1,005 pounds (1957, Y103A) of crop per inch of water used. In terms of crop yield, the corresponding range in efficiency was 1.81 (1945, Y102C) to 8.26 (1961, Y102C) bushels of corn per inch of water used.

The highest efficiency, 1,364 pounds or 9.47 bushels per inch of water (1957, Y102C) was obtained when evaporation was prevented by use of a plastic sheet. Average values for lysimeters Y102C and Y103A show approximately the same crop yield, a water use of 19 to 23 inches, and a water-use efficiency averaging close to 700 pounds of crop, or 6 bushels of corn, per inch of water used.

The total amount of water used for wheat production during the April to June period ranged from 12.0 to 15.5 inches per acre. The efficiency of water use in producing dry weight of crop was less for wheat than that for corn. The weight of crop produced per inch of water used ranged from 300 to 598 pounds, and averaged 413 pounds. Crop yield ranged from 32 to 69 bushels per acre and averaged 45 bushels per acre. Bushels of wheat produced per inch of water used ranged from 2.38 to 4.54 and averaged 3.26. The greatest efficiency in water use was coincident with the maximum crop yield.

Lysimeter Y102C was irrigated in October 1953 to start the 1954 wheat crop. Apparently this resulted in a slight increase in yield without affecting the amount of water used in the April-June period—14.0 inches for irrigated Y102C and 14.7 inches for unirrigated Y103A. However, efficiency of water use was 431 pounds or 3.86 bushels of wheat per inch of water on the irrigated lysimeter and 373 pounds, or 3.27 bushels, on the unirrigated lysimeter. Water supply was seldom a limiting factor in the production of wheat in this region.

On the meadow lysimeters, crop yields and efficiency of water use were noticeably affected by available moisture. The water-use period of April through August was selected to represent the meadow growing season. However, values for the period beginning April 1 and ending with the date of the last hay harvest may have been more useful. These values can be obtained from the graphs of accumulated ET (figs. 7, 10, 11) of this bulletin and similar graphs in Technical Bulletin 1179 (*66*).

Water-use values for first-year meadow without irrigation ranged from 19.4 to 27.1 inches per acre for the season and averaged about 23 inches for the 5 years of record (table 14). Yields of unirrigated crops on these lysimeters ranged from 1.67 to 4.67 tons per acre. Water-use efficiency ranged from 165 to 360 pounds of crop per inch of water used. With no irrigation, the highest yield corresponded to the greatest water-use efficiency, and vice versa.

With irrigation on Y102C in 1955, water use reached a total of 27.0 inches per acre. Crop yield was 5.97 tons per acre, the highest for any in first-year meadow. Water-use efficiency with irrigation was 442 pounds of crop per inch of water use, the best first-year-meadow value.

Water-use values for second-year meadow for the April-August period ranged from 19.0 to 27.5 inches. Crop yield ranged from 1.50 to 6.76 tons per acre. Water-use efficiency for the 5-month period ranged from 147 to 524 pounds of crop per inch of water used. Information on the dates and number of hay cuttings on each lysimeter are given in appendix tables 32 to 34.

ET from cornland in May and early June was usually low—about 2 inches per half month; leaf area was small, so transpiration was low. Evaporation was high from a wet soil surface and low from a dry soil surface. The difference in ET data for nearly bare cornland (Y102C) and for legume-grass (Y101D) is shown by the wide divergence of their soil moisture curves in May and June 1961 (fig. 12).

Wheat used water most rapidly in May and early June (fig. 13). Soil water was removed by ET from wheatland at about the same rate as from grassland in this period. Water needs for wheat diminished after the middle of June. After the harvest of wheat and the removal of straw, the new meadow of timothy, red clover, and alfalfa grew rapidly and re-established high rates of ET (see fig. 9).

Water-use efficiency, in terms of crop weight, was lower for meadow than for either corn or wheat. The average values of crop weight produced per inch of water used for the 1941-62 period are 736, 404, 310, and 327 pounds of corn, wheat, first-year meadow and second-year meadow, respectively, on lysimeter Y102C. Average values for the same crops on the Keene silt loam of Y103 were 684, 422, 254, and 315 pounds, respectively.

Irrigation on first-year-meadow lysimeter Y102C in July and August of 1955 resulted in continued high use of water until late September (*66*). The contrast in water-use efficiency was quite evident inasmuch as 442 and 360 pounds of crop were produced per inch of water used on the irrigated (Y102C) and unirrigated (Y103A) lysimeters, respectively.

Water-use data for second-year meadow were similar to those of first-year meadow and the period of maximum consumptive use without irrigation for both extended from the last half of May through July.

For certain purposes, such as the design of irrigation systems, it may be necessary to know the maximum consumptive-use rate for periods of a week or 10 days. Table 15 shows the average daily rate of consumptive use for the 10 consecutive days of maximum use (maximum 10 days) and the average daily rate for the entire month. For example, in August 1953, the average consumptive use for the maximum-10-day period for corn lysimeter Y102C was 0.36 inch per day and the average for the month was 0.22 inch per day. An irrigation system designed to meet a water-use rate of 0.22 inch per day would fail to produce the maximum crop when confronted with a demand for 0.36 inch per day. It was not uncommon to find the maximum-10-day average daily consumptive-use rate to be larger than the month-basis average daily rate by 25 percent or more. In some months, the average daily rates of consumptive use for the month and for the maximum-10-day periods were almost the same.

The moisture values for the top 40 inches of soil (table 15) represent an approximate daily average for the month. They are given to help the reader see in general how consumptive-use values dropped in August and September due to lesser available soil moisture. There is some variation in this relation. Sometimes available moisture in the top foot or two of soil was nearly exhausted, causing reduced yields and lower consumptive-use values although there was enough moisture below the 24-inch depth to give a fairly high moisture average for the entire 40-inch profile.

The trend of consumptive use throughout the May-September sea-

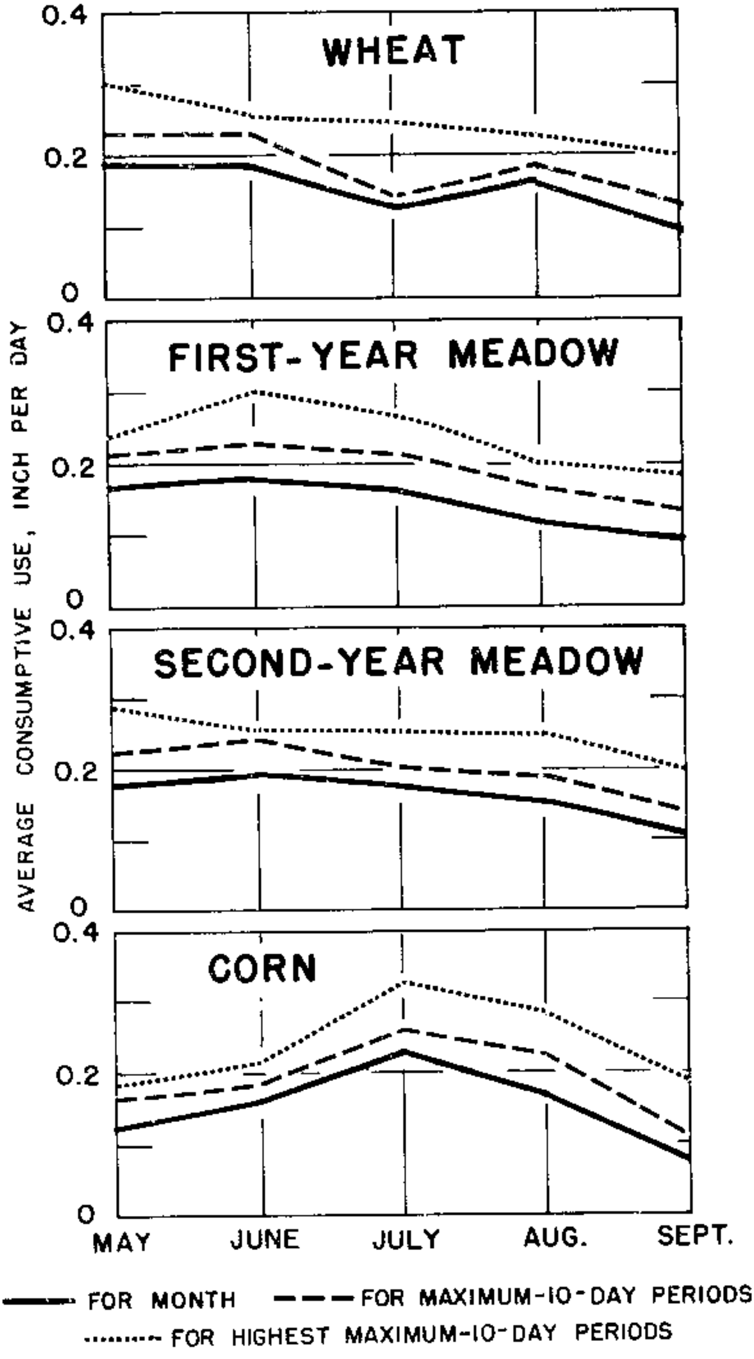

FIGURE 24.—Average daily consumptive use by wheat, meadow, and corn crops grown on lysimeter Y103A during 1942-62 period.

TABLE 15.—*Average daily consumptive use (ET) and soil moisture, lysimeters Y102C and Y103A, May–September 1942–62*

Lysimeter, crop, and year	Average per day in May			Average per day in June			Average per day in July			Average per day in August			Average per day in September			Yield per acre
	Consumptive use		Soil moisture [1]	Consumptive use		Soil moisture [1]	Consumptive use		Soil moisture [1]	Consumptive use		Soil moisture [1]	Consumptive use		Soil moisture [1]	
	For maximum 10 days	For month		For maximum 10 days	For month		For maximum 10 days	For month		For maximum 10 days	For month		For maximum 10 days	For month		
	Inch	*Inch*	*Inches*	*Inch*	*Inch*	*Inches*	*Inch*	*Inch*	*Inches*	*Inch*	*Inch*	*Inches*	*Inch*	*Inch*	*Inches*	
Y102C:																
Wheat to meadow																
1942	0.16	0.13	11.5	0.21	0.15	11.5	0.22	0.17	10.0	0.16	0.11	8.0	0.09	0.08	8.0	32 bu.
1946	.18	.15	10.0	.23	.19	10.0	.23	.17	11.0	.22	.16	9.0	.10	.07	7.0	38 bu.
1950	.20	.17	11.0	.26	.17	11.0	.12	.10	11.0	.16	.13	9.5	.16	.12	10.5	43 bu.
1954	.24	.19	10.5	.22	.14	6.0	.10	.07	[2] 6.0	.16	.14	7.5	.15	.13	[2] 7.0	54 bu.
1958	.23	.19	10.5	.19	.17	7.5	.12	.11	9.5	.21	.18	11.0	.21	.14	9.0	42 bu.
1962	.30	.20	10.0	.19	.14	--------	.06	.06	5.4	--------	--------	--------	--------	--------	--------	--------
First-year meadow																
1943	.13	.11	13.5	.23	.18	12.5	.18	.13	10.5	.20	.18	11.5	.12	.07	9.0	2.4 tons
1947	.23	.12	13.5	.28	.20	12.0	.25	.18	9.0	.19	.13	8.0	.19	.17	7.0	2.5 tons
1951	.22	.18	10.5	.21	.17	9.0	.26	.24	9.0	.10	.07	5.5	.13	.11	6.0	2.7 tons
1955	.21	.12	[2] 9.5	.17	.16	[2] 7.5	.26	.20	7.5	.20	.19	5.0	.13	.10	5.0	6.0 tons
1959	.24	.21	11.4	.27	.21	10.0	.28	.22	9.5	.19	.16	9.5	.18	.13	6.9	4.7 tons
Second-year meadow																
1944	.17	.14	9.5	.18	.14	8.5	.15	.14	7.0	.16	.14	6.0	.12	.10	6.5	1.5 tons
1948	.27	.22	8.0	.25	.22	5.0	.21	.18	5.0	.17	.10	4.5	.11	.09	4.0	3.1 tons
1952	.23	.18	10.0	.30	.20	7.0	.26	.20	6.0	.16	.13	5.0	.11	.10	4.5	2.6 tons
1956	.21	.17	11.5	.24	.18	11.0	.21	.16	10.5	.24	.20	10.0	.13	.11	8.5	6.3 tons
1960	.22	.16	9.1	.23	.19	9.8	.25	.21	8.8	.20	.19	8.4	.19	.12	6.9	6.0 tons
Corn																
1945	.15	.13	12.0	.16	.11	10.5	.17	.14	9.5	.13	.12	7.0	.11	.10	9.0	34 bu.
1949	.15	.09	12.5	.19	.15	11.0	.26	.23	10.0	.23	.15	9.0	.10	.07	7.5	151 bu.
1953	.13	.11	14.0	.14	.11	12.0	.25	.22	[2] 12.0	.36	.22	[2] 11.0	.22	.11	8.5	196 bu.
1957	.14	.11	11.0	.10	.07	10.5	.16	.13	7.5	.11	.08	4.5	.06	.04	3.5	125 bu.
1961	.19	.10	12.2	.12	.11	11.5	.23	.16	9.7	.23	.19	7.2	.20	.09	6.1	166 bu.

Y103A:																
Wheat to meadow																
1942	.20	.15	11.5	.22	.14	13.5	.15	.13	11.5	.18	.15	10.0	.08	.07	9.5	35 bu.
1946	.18	.16	14.0	.24	.21	14.0	.23	.22	14.0	.20	.16	12.5	.11	.09	9.0	36 bu.
1950	.22	.19	14.0	.26	.19	14.0	.12	.12	13.0	.18	.16	11.0	.18	.13	14.0	43 bu.
1954	.23	.20	14.0	.26	.18	10.0	.10	.08	9.0	.15	.14	10.0	.10	.06	9.5	48 bu.
1958	.26	.22	14.5	.19	.18	11.0	.11	.11	13.0	.23	.21	14.5	.20	.15	12.0	56 bu.
1962	.30	.24	10.7	.22	.16	--------	.08	.07	6.5	.12	.11	7.6	.15	.11	7.2	69 bu.
First-year meadow																
1943	.13	.10	12.0	.22	.15	10.5	.18	.15	9.0	.21	.15	8.5	.14	.07	7.0	0.5 ton
1947	.22	.13	16.0	.28	.22	15.5	.23	.16	12.0	.20	.13	10.0	.19	.15	10.0	2.0 tons
1951	.23	.18	13.0	.20	.18	11.5	.25	.21	11.5	.13	.08	9.5	.13	.10	9.0	2.3 tons
1955	.24	.23	13.0	.14	.13	10.0	.20	.15	9.0	.16	.15	8.5	.09	.09	7.5	4.4 tons
1959	.22	.21	11.8	.30	.21	10.3	.26	.20	8.7	.16	.13	9.5	.16	.10	6.5	4.3 tons
Second-year meadow																
1944	.16	.12	13.0	.21	.17	10.0	.15	.15	8.0	.15	.14	7.0	.10	.09	7.5	0.5 ton
1948	.29	.22	12.0	.26	.25	8.0	.23	.18	7.0	.18	.10	7.0	.11	.09	6.5	3.8 tons
1952	.26	.20	13.0	.24	.18	10.0	.23	.20	10.0	.16	.15	7.5	.13	.10	8.0	3.4 tons
1956	.23	.21	15.5	.26	.19	15.0	.21	.18	14.5	.25	.22	13.0	.13	.11	11.5	6.8 tons
1960	.23	.17	10.6	.21	.19	11.1	.25	.21	9.9	.21	.19	10.0	.20	.14	8.9	4.6 tons
Corn																
1945	.19	.15	15.0	.19	.15	14.0	.21	.19	12.5	.18	.13	9.5	.09	.08	13.0	61 bu.
1949	.17	.12	16.0	.21	.18	14.0	.33	.29	14.0	.28	.16	12.5	.10	.07	11.0	148 bu.
1953	.17	.14	16.0	.18	.14	14.0	.25	.23	12.0	.18	.15	10.0	.06	.04	8.0	143 bu.
1957	.17	.12	15.0	.22	.19	15.5	.27	.26	14.0	.21	.15	10.5	.05	.04	10.0	149 bu.
1961	.16	.11	12.6	.15	.15	12.2	.23	.18	9.7	.24	.20	9.0	.18	.11	6.4	170 bu.

[1] Average moisture (inches of water) in top 40 inches of soil.
[2] Irrigated.

son for all four crops is illustrated by figure 24. Comparisons can be made between average daily values for the month, for maximum-10-day periods, and for the highest maximum-10-day period during the 1942-62 period.

Effect of Ground Surface Plastic Cover on Evaporation and Transpiration

The term "consumptive use of water by vegetation" has generally included both evaporation of water from the soil as well as transpiration of water by the plants. With the prospect of increased national demand for water supplies, it was appropriate that a critical examination be made of these two components of consumptive use, since water saved would be of value for the future expansion of urban and industrial areas as well as for farm and recreational uses.

Peters and Russell (*120*) in Illinois found that by stopping evaporation with a plastic soil cover, a good corn crop could be produced with only 5 to 7 inches of stored soil water. However, in their experiment there may have been subsurface water additions to the test area from outside soil sources. To eliminate this variable, they suggested that the study be conducted on lysimeters where lateral movement or capillary rise of water could be controlled.

The objectives of the study described in this section were twofold: (1) to determine the relative magnitudes of evaporation and transpiration from a growing corn crop, and (2) to evaluate the effect of an impermeable soil cover on percolation.

Clear polyethylene plastic covers were placed on the soil surface of lysimeters Y102B and Y102C, as shown in figure 25, when the corn was about 10 inches high. These covers were impervious to water and

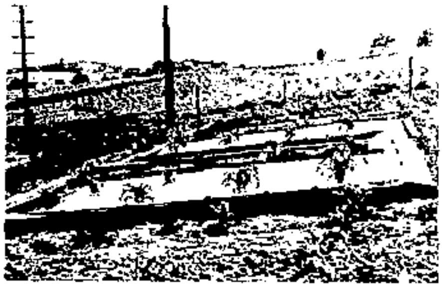

FIGURE 25.—Plastic covers on soil of lysimeters Y102C and Y102B, June 5, 1957.

caused essentially all the rainfall to run off except that which adhered to vegetation (interception) and very small amounts that were retained in pockets on the surface of the plastic (surface storage).

Lysimeter Y102C, with its automatic weighing feature, was selected to obtain data on the relative magnitudes of evaporation and transpiration—the first objective. After the plastic cover was installed, no water was added to the soil.

Lysimeter Y102B was chosen to evaluate the effect of soil cover on percolation — the second objective. Water was added beneath the plastic cover (fig. 26) in amounts equal to that which was absorbed by lysimeter Y102A, which was uncovered. This was done after each storm. Details on the application of water and surface sealing operations have been reported by Harrold and coworkers (*70*).

Weight-change records on the covered lysimeter Y102C were used to evaluate transpiration (T) by corn. To obtain estimates of ET amounts that would have occurred without the cover, the weight changes on uncovered lysimeter Y103A, in corn, were used in a Y102C-Y103A regression ($r = 0.95$ standard error of estimate $= 0.021$ inch per day) developed from previous corn years when treatment on both was identical.

FIGURE 26.—Plastic cover on lysimeter Y102B and infiltration tube. June 5, 1957.

Estimated E values for the covered lysimeter were derived by subtracting recorded T values from predicted ET values.

Rainfall, transpiration, and evaporation data for this experiment are presented in table 16 and figure 27. During the May 1 to June 5 period, before the plastic sheet was placed on the weighing lysimeter (Y102C), there were 3.69 inches of ET (table 16). All other recorded weight data on this lysimeter from June 6 through September 9 represent T.

Of the total predicted ET of 15.44 inches for the period June 6 to September 9, T amounted to 55 percent (8.47 inches) and E, 45 percent (6.97 inches). Prior to June 5, the proportion of E to T was, *no* doubt, considerably greater than afterwards.

For most of the May 1 to June 5 period, there was little or no leaf to

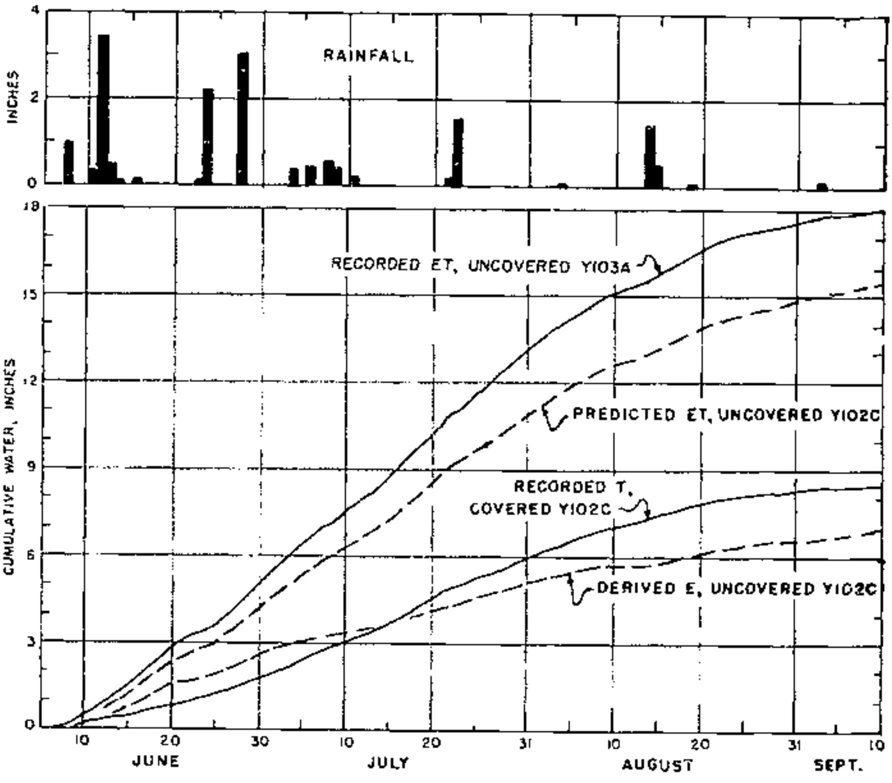

FIGURE 27.—Cumulative values of recorded evapotranspiration (ET) and transpiration (T), predicted evapotranspiration, and derived evaporation (E), June 6-September 9, 1957.

TABLE 16.—*Recorded, predicted, and derived evaporation and transpiration from lysimeter Y102C, May-September 1957*

Period	Rainfall	Evapotranspiration [1] Recorded Y103A	Evapotranspiration [1] Predicted Y102C	Transpiration recorded on Y102C [2]	Evaporation derived on Y102C [1]
	Inches	*Inches*	*Inches*	*Inches*	*Inches*
May 1-June 5	4.91	4.52	[3] 3.69		
June 6-30 [2]	11.15	5.09	4.24	1.77	2.47
July 1-31	3.69	7.98	6.67	4.14	2.53
Aug. 1-31	2.23	4.56	3.99	2.40	1.59
Sept. 1-9	.16	.36	.54	.16	.38
Totals:					
May 1-Sept. 9	22.14	22.49	19.13		
June 6-Sept. 9	17.23	17.97	15.44	8.47	6.97

[1] Lysimeter uncovered.
[2] Plastic cover placed on ground over lysimeter Y102C on June 5.
[3] Measured

transpire water. By the time the plastic cover was applied, the plants covered approximately 5 percent of the lysimeter area (fig. 25). If all the 3.69 inches of moisture removed before June 6 were E, total E for the May 1 to September 9 growing season would have been 6.97 + 3.69, or 10.66 inches, and the total ET 15.44 + 3.69, or 19.13 inches. In this case, E would have been 56 percent and T 44 percent of the total. The assumption that all of the measured 3.69 inches of moisture removal in the May 1 to June 5 period was E necessarily resulted in a small underestimate of T for this period.

It was concluded that a seasonal estimate of E equal to 45 percent and T equal to 55 percent of ET under the conditions of this study was reasonably accurate. Relations of E to T throughout the season appear on figure 27. Here the daily values of recorded ET on the uncovered weighing lysimeter (Y103A) and T on the covered weighing lysimeter (Y102C) are shown by cumulative curves for the period June 6 to September 9. Predicted ET and derived E curves for the covered lysimeters are also shown in this figure along with rainfall amounts.

The plastic cover introduced some unnatural conditions. Several checks and comparisons made as described subsequently indicate that the results were reasonable. Estimates of E were compared to potential evaporation as evaluated by evaporation pan data. The effect of the cover on the energy balance was considered. Soil temperature and crop yield data were compared to those under natural conditions.

A comparison of derived E with pan evaporation is shown in figure 28, where cumulative derived values of daily E from the covered lysimeter are plotted against cumulative values of daily evaporation from a sunken pan 6 feet in diameter. These double cumulative curves are often termed "double-mass curves." For much of June, the slope of the double-mass curve is roughly parallel to the line of equal values. This means that E for the uncovered soil surface of cornland was approximately equal to pan evaporation. This relationship is the same as that for evaporation from conventional cornland during June 1953, as reported by Harrold and Dreibelbis (*66*). The slope of the double-mass curve (fig. 28) departed noticeably from this relationship once that month. This corresponded to a dry period of 8 days having about 0.1 inch total rainfall.

As the shade from the corn plants increased and available soil water decreased, the derived values of soil E became less than those of pan evaporation. Further increase of leaf shade and decreased evaporation of soil water in August produced a soil-E to pan-E ratio of 0.5. Noticeable departures from the general trend which appear in the curve on figure 28 are associated with dry periods. The most striking one was from July 24 to August 13, when total rainfall was less than 0.1 inch. Near the end of this period, the soil surface was very dry, the derived values of daily soil E were almost zero, and the double-mass curve approached a horizontal line. In this case, the derived soil-E values seem to be about what one would expect in relation to pan evaporation.

It is possible that the solar energy causing transpiration was not exactly the same for the covered and uncovered cornland surfaces. The dusty, translucent, plastic cover was not expected to increase reflected solar energy sufficiently to significantly increase transpiration. Transpiration values from the covered treatment, especially after the plants shaded the surface, were considered to be comparable to those under field condi-

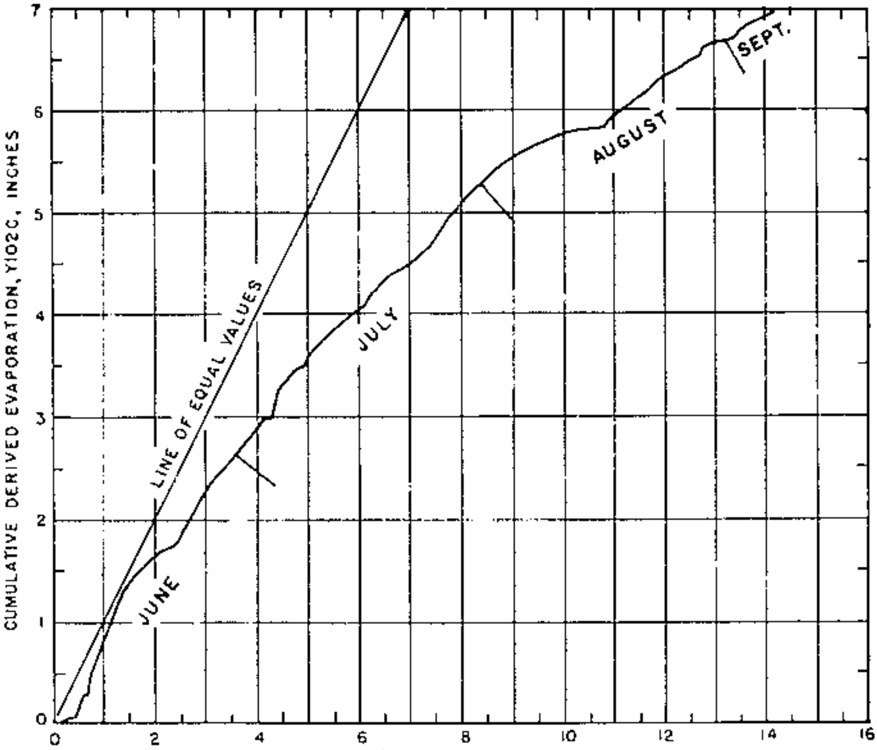

FIGURE 28.—Cumulative derived evaporation from lysimeter Y102C versus cumulative pan (6-ft. diameter) evaporation, June 6-September 9, 1957.

tions as simulated by the uncovered treatment. Fritschen and Shaw (*48*) and Waggoner and Reifsnyder (*178*) also evaluated this influence.

The translucent cover, however, caused some abnormal effect on the temperature of the soil and air beneath the cover (table 17). The soil of the covered lysimeter with no water added (Y102C) showed consistently higher maximum and somewhat lower minimum temperatures than that of Y102B, to which water was added under the cover. The temperature of the soil of both covered lysimeters was higher than that of Y102A, without a cover. Geiger (*51*), in his study on microclimate, gives examples of analogous conditions and shows their effect on temperature relationships in and near the ground surface. The confined air space between the soil and the plastic sheet served as an insulation against heat transfer; the plastic cover touched the ground surface at only a few points. Soil heat losses associated with evaporation of soil moisture were reduced by the cover. Heat exchange from soil to atmosphere through turbulence was prevented by the plastic cover. Loss of heat from soil to the atmosphere was further minimized by the poor conductive properties of the air layer beneath the plastic. Furthermore, the beads of water constantly on the bottom side of the plastic sheet practically stopped the infrared radiation from the soil to the atmosphere. As a result, soil temperatures were higher under the plastic cover.

The slightly lower maximum soil temperatures on Y102B compared with those on Y102C were probably due to the higher available soil moisture in the former, in view of the high specific heat of water. Part of the energy received by the covered and irrigated lysimeter was used to evaporate the moisture available in the profile while less was used for this purpose on Y102C. Table 17 also illustrates the effect of the plastic cover on air temperature above the soil surface. Both maximum and minimum air temperatures near the ground surface were higher under the plastic than when there was no plastic soil cover.

TABLE 17.—*Temperature*[1] *data, June-September 1957*

Period	Soil temperature at 3½ inch depth						Air temperature			
							One inch above ground surface		Between cover and soil surface	
	Y102A—No cover, no water added		Y102B—Cover, water added		Y102C—Cover, no water added		Cornland—No cover, no water added		Y102C—Cover, no water added	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
June 10-20							80	68	104	
June 21-39							86	64	99	70
July 1-10	78	70	91	75	95	75	82	64	100	64
July 11-20	79	69	90	74	93	74	87	66	95	66
July 21-31	79	68	90	75	93	74	85	67	93	67
Aug. 1-10	79	68	90	75	96	73	87	65	100	74
Aug. 11-20	79	68	92	75	95	73	86	63	105	68
Aug. 21-31	74	68	84	73	90	73	83	63	108	73
Sept. 1-10	74	65	82	74	87	70	84	60	104	71

[1] Readings taken daily at approximately 6.30 a.m. are averaged for each period and listed under minimum; readings taken from 2 to 4 p.m. are averaged for each period and listed under maximum.

Yield data given in table 18 show very high values for all treatments. The plastic cover placed on June 5 over lysimeter Y102C, with no water added, in effect created a drought lasting from June 6 to September 9. The 125 bushels of corn per acre produced can be attributed almost entirely to the water stored in the soil.

The corn plants on the covered lysimeters never showed serious need for water. But there must have been some water stress on Y102C (covered, no water added) as corn yield thereon was less than on either the uncovered Y102A or the covered and watered Y102B. At harvesttime, the moisture content of the top 7 inches of soil on covered lysimeter Y102C was 4 percent by volume. Wilting point was about 9 percent by volume. Total moisture in the 8-foot profile of this lysimeter on October 1 was less than that for any previous corn year. The soil in both the uncovered lysimeter Y102A and in the covered but irrigated lysimeter Y102B received 10.85 inches of water during the June 5 to September 9 period. The yield on Y102A, without a plastic cover, was 169 bushels per acre. With T, but with no E, and with water added, the yield was 182 bushels per acre (Y102B).

The evaluation of the effect of the plastic cover on percolation, the second objective of the study, was evaluated on Y102B. Water in the amount equal to that absorbed by Y102A (10.85 inches) was applied through plastic tubes (fig. 26) during the period June 6 to September 9. Percolation from this lysimeter amounted to 5.27 inches during the same period, whereas that from the uncovered lysimeter totaled 3.08 inches. In previous years, when treatment on these two lysimeters was the same, there was very little difference in the percolation during the corn season. The best estimate

TABLE 18.—*Yield of corn and water use, 1957*

Lysimeter	Treatment	Yield	Water used [1]
		Bu. acre	*Inches*
Y102A	No cover, no water added	169	[2]
Y102B	Plastic cover, water added	182	[2]
Y102C	Plastic cover, no water added	125	[3] 12.16
Y103A	No cover, no water added	149	22.49

[1] May 1 to Sept. 9.
[2] Could not be evaluated accurately these lysimeters not equipped for weight measurements.
[3] T of 8.47 inches plus E of 3.69 inches for May 1 to June 5.

of the net increase in percolation during this period was, therefore, 5.27 − 3.08, or 2.19 inches, due to the stoppage of E.

The winter-spring recharge was quite normal. From September 10, 1957, to June 5, 1958, percolation of 6.07 inches would normally be expected from the covered and watered lysimeter, based on a regression relationship between percolation from Y102A and Y102B. Measured percolation during this same period was 6.40 inches, an increase of only 0.33 inch. The total increase in percolation amounted to 2.19 + 0.33, or 2.52 inches. There was little evidence of any sizable residual effect on percolation that year. Apparently much of the water saved as a result of stopping E was used by T.

Percolation

This section presents interrelations between percolation, soil type, crop, cropping practice, and chemical analysis of percolates.

Percolation water — the water moves under gravitational force downward through the soil profile—was measured at each of the eleven lysimeters. Normally, this water contributes to the supply of groundwater and thus replenishes the water in wells, springs, and streams.

Seasonal Variations in Percolation

Data in tables 19, 20, and 21 and in figures 29 and 30 show that most of the percolation occurred in late winter and early spring. During this period, soil moisture often approached saturation. The near-saturation condition was reached after a period of almost continuous accretion that usually began at the start of the dormant season. The soil moisture peak was generally reached during March or April, when rates and amounts of percolation also reached their peak (*14, 33, 66*). For the 1938-62 period, approximately 75 percent of the percolation occurred during the first 4 months of the year. During late spring and summer, when ET rates were high, soil moisture diminished to such an extent that little water was available for percolation. Monthly percolation data for the 1956-62 period are given in appendix tables 39 to 41. Seasonal trends in soil moisture are shown in figures 7 to 13.

The amounts and distribution of precipitation, especially during the winter and spring months, directly affected percolation. Other factors such as soil type, land use, soil moisture, and freezing also affected the amount of water available for percolation. A reduction in either surface runoff or ET tended to increase percolation.

Effect of Soil Type

A study of the effects of soil type on percolation was made from the 15-year record for 1941-52 and 1959-61 on the 4-year rotation lysimeters (Y102, Y103). Data for the 1953-58 period were not used, as those for Y102C were affected, at times, by irrigation and by a plastic soil cover. Percolation from lysimeters Y102A, Y102B, and Y102C (Muskingum silt loam over shale) averaged 8.02 inches (appendix table 40) during this 15-year period compared to 6.90 inches (appendix table 41) from lysimeters Y103A and Y103B (Keene silt loam). This difference was statistically significant.

The highest monthly percolation from any lysimeter in battery Y102 (Muskingum silt loam over shale)—7.74 inches from Y102C—occurred in March 1945 (table 20). Maximum annual values of 17.77 inches occurred on Y102C. This soil profile

TABLE 19.—*Summary of monthly percolation, Y101*[1], *1938-62*

Period	Y101A[2]			Y101B[2]			Y101C[3]			Y101D[3]		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inch*
Jan.	1.85	6.20	0	1.26	3.52	0	1.87	6.58	0.02	0.95	3.26	0
Feb.	1.90	3.97	0	1.27	2.58	.18	1.92	3.91	.24	1.26	3.46	0
Mar.	2.69	7.44	.83	1.85	4.52	.68	2.88	7.52	1.03	1.94	5.74	0
Apr.	2.40	5.00	.67	1.84	3.87	.79	2.46	5.07	.52	1.72	4.48	0
May	1.57	3.41	.64	1.36	2.49	.76	1.44	3.18	.44	1.13	3.10	0
June	1.35	4.10	.38	1.15	2.48	.36	1.22	3.13	.29	.82	3.34	0
July	.80	2.18	.14	.70	1.95	.15	.77	2.02	.13	.36	2.02	0
Aug.	.42	2.00	.04	.41	1.73	.02	.46	2.00	.04	.18	1.21	0
Sept.	.27	1.75	0	.19	1.06	0	.22	1.62	.01	.05	.38	0
Oct.	.18	1.83	0	.17	1.32	0	.17	1.10	0	.06	.81	0
Nov.	.34	1.67	0	.27	1.31	0	.23	.92	0	.04	.70	0
Dec.	.91	3.56	0	.73	2.51	0	.80	3.86	0	.24	2.52	0
Total for year	14.77	25.88	6.20	11.20	18.41	6.04	14.44	26.37	7.44	8.75	16.81	0

[1] Monthly data for 1938-55 in U.S. Dept. Agr. Tech. Bul. 1179 (*66*); data for 1956-62 in appendix table 39.
[2] Shallow-rooted crops; Muskingum silt loam over sandstone.
[3] Data for 1943-62; shallow rooted crops, 1943-47; deep rooted crops, 1948-62.

TABLE 20.—*Summary of monthly percolation, Y102*[1], *1938-62*

Period	Y102A [2]			Y102B [2]			Y102C [3]		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
	Inches	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*	*Inches*	*Inches*	*Inch*
Jan.	0.74	4.14	0	0.82	4.50	0	1.06	4.84	0
Feb.	.91	3.61	0	1.02	3.61	0	1.27	4.09	0
Mar.	1.84	6.60	.02	2.02	6.94	.02	2.42	7.74	.06
Apr.	1.09	4.14	.02	1.79	4.12	.06	1.88	5.35	.04
May	.52	1.67	0	.60	1.93	.07	.71	3.00	.08
June	.30	2.35	.01	.37	3.10	.02	.29	[3] 1.67	0
July	.10	.75	0	.15	2.12	.02	.08	.39	0
Aug.	.06	.56	0	.08	.51	0	.05	.22	0
Sept.	.05	.70	0	.07	1.28	0	.08	1.75	0
Oct.	.04	.48	0	.02	.11	0	.02	.25	0
Nov.	.04	.64	0	.01	.09	0	.04	.68	0
Dec.	.16	1.96	0	.21	2.76	0	.22	2.93	0
Total for year	5.55	14.49	.32	7.19	16.52	.96	8.12	17.77	.66

[1] Monthly data for 1938-55 in U.S. Dept. Agr. Tech. Bul. 1179 (*66*); data for 1956-62 in appendix table 40.
[2] Rotation of corn, wheat, and 2 years of meadow; improved practices; Muskingum silt loam over shale.
[3] Plastic cover June 6 to Sept. 9, 1957 prevented infiltration and reduced percolation.

TABLE 21.—*Summary of monthly percolation, Y103*[1], *1941-62*

Period	Y103A [2]			Y103B [2]			Y103C [2]			Y103D [2]		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
	Inches	*Inches*	*Inch*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Jan.	1.05	4.76	0	0.90	5.04	0.01	1.37	5.30	0.02	1.30	5.17	0
Feb.	1.16	3.47	.01	1.06	2.24	.07	1.44	2.69	.02	1.35	3.98	.02
Mar.	1.75	5.47	.19	1.65	3.74	.27	2.06	4.96	.68	1.87	4.75	.35
Apr.	1.24	4.03	.05	1.25	4.02	.06	1.45	4.36	.07	1.31	4.82	.06
May	.44	2.66	.03	.50	1.30	.03	.64	2.87	.04	.52	2.14	.03
June	.24	1.55	.01	.26	1.49	.01	.45	2.01	.04	.35	2.04	.01
July	.04	.23	.01	.10	.74	.02	.17	1.24	.03	.14	1.02	.01
Aug.	.03	.22	0	.04	.29	0	.09	.59	.02	.08	.46	0
Sept.	.04	.55	0	.04	.31	0	.07	.88	0	.08	.84	0
Oct.	.03	.43	0	.02	.15	0	.07	.86	0	.04	.33	0
Nov.	.06	.76	0	.05	.16	0	.16	1.30	0	.10	.68	0
Dec.	.36	2.67	0	.36	1.87	.01	.62	2.33	.01	.68	3.10	.01
Total for year	6.44	13.69	.64	6.32	12.35	1.08	8.58	13.57	2.97	7.82	13.76	2.22

[1] Monthly data for 1941-55 in U.S. Dept. Agr. Bul. 1179 (*66*). Data for 1956-62 in appendix table 41. Percolation records began in 1940.
[2] Rotation of corn, wheat, and 2 years of meadow; improved practices used on Y103A and Y103B; poor practices used on Y103C and Y103D; Keene silt loam.

is well drained and its percolation values are expected to exceed those of Y103, Keene silt loam of slow permeability. There were a number of years when no percolate was obtained in September, October, November, December, or January.

Percolation rates were more erratic on the Keene soil (battery Y103) because of the texture and structure of the various horizons. The Keene subsoil is a heavy silt loam grading into silty clay loam and then into silty clay. The colloidal content of the latter enhanced swelling and shrinking of the soil, which directly affected percolation. When the soil was saturated or nearly so, the swelling of the colloids made this layer almost impermeable. When this layer became dry, the shrinkage of the colloids produced cracks in this layer, which facilitated percolation. The highest monthly percolation on the Keene silt loam was 5.47 inches (from Y103A) in March 1945 (table 21). Its highest annual percolation amounted to 13.76 inches (from Y103D) in 1961 and the lowest was 0.64 inch in 1954 (from Y103A). The maximum percolation values on Y103 were usually less than those on Y102.

The variation in percolation among lysimeters on the same soil type and the same cover reflects the general heterogeneity of soils in this area. The coefficients of variability are in the 20- to 25-percent range.

Interrelations Among Crop Species, Crop Yield, and Percolation

A comparison of data from lysimeters in deep- and in shallow-rooted vegetation showed that rooting depth had a sizable effect on percolation. Vegetation on all lysimeters of battery Y101 was shallow-rooted poverty grass or bluegrass through 1946. Data in appendix table 39 and on

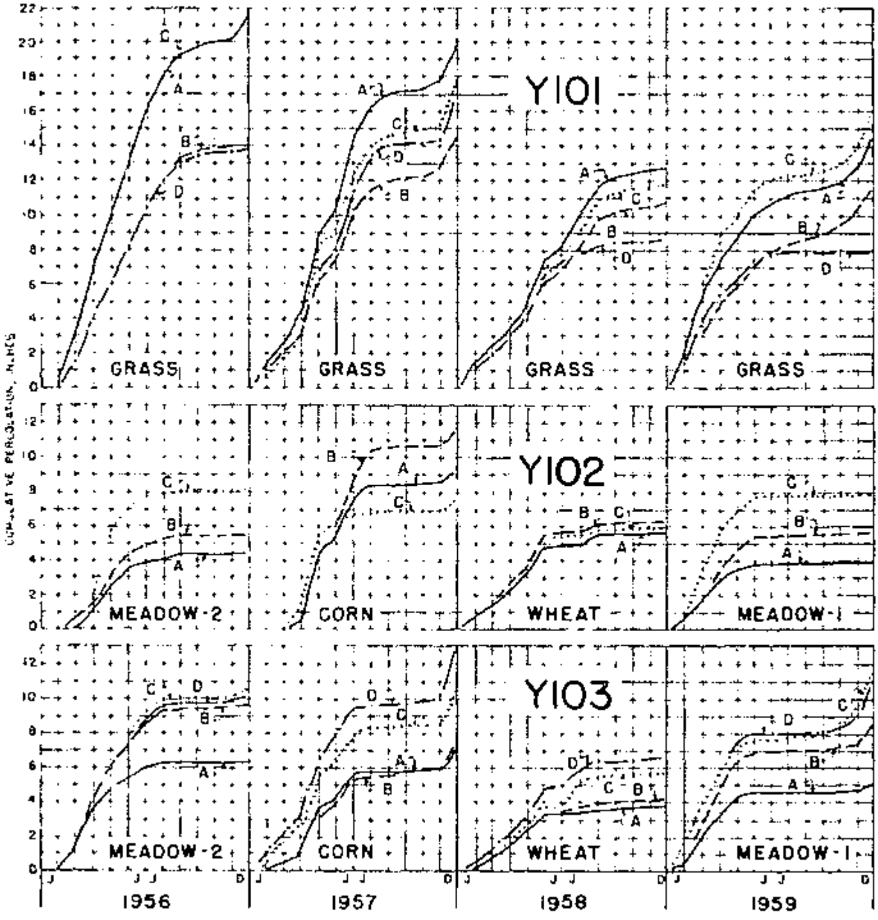

FIGURE 29.—Cumulative monthly percolation by years, 1956-59.

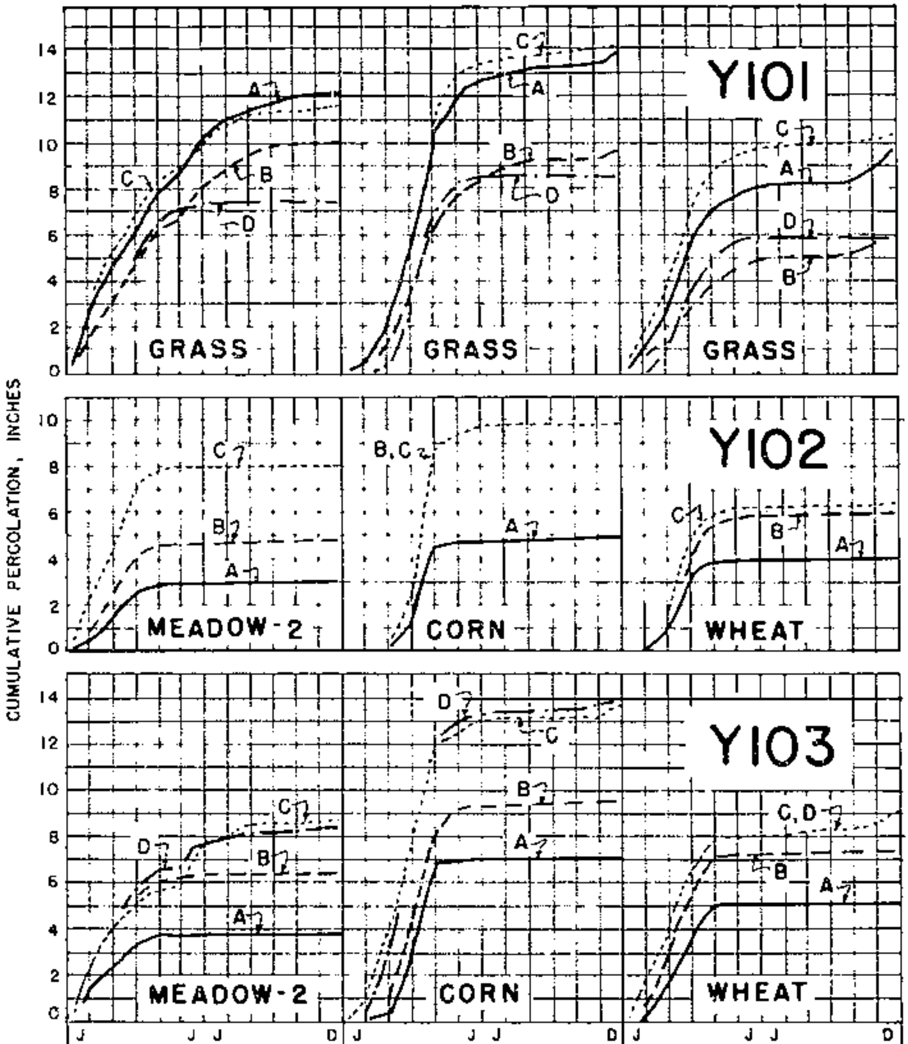

FIGURE 30.—Cumulative monthly percolation by years, 1960-62.

the double-mass curve of figure 31 show that percolation during the 1943-47 period was about the same from lysimeters Y101B and Y101D, averaging 11.42 inches per year on Y101B and 12.24 on Y101D. The general trend of the curve during this period coincides essentially with the line of equal values. In 1947 the soil on Y101D was seeded to a mixture of alfalfa and bromegrass—both deep rooted. Beginning with 1948, percolation on Y101D was much less than that on Y101B, still in poverty grass. The slope of the graph on figure 31 for a period of years begin-

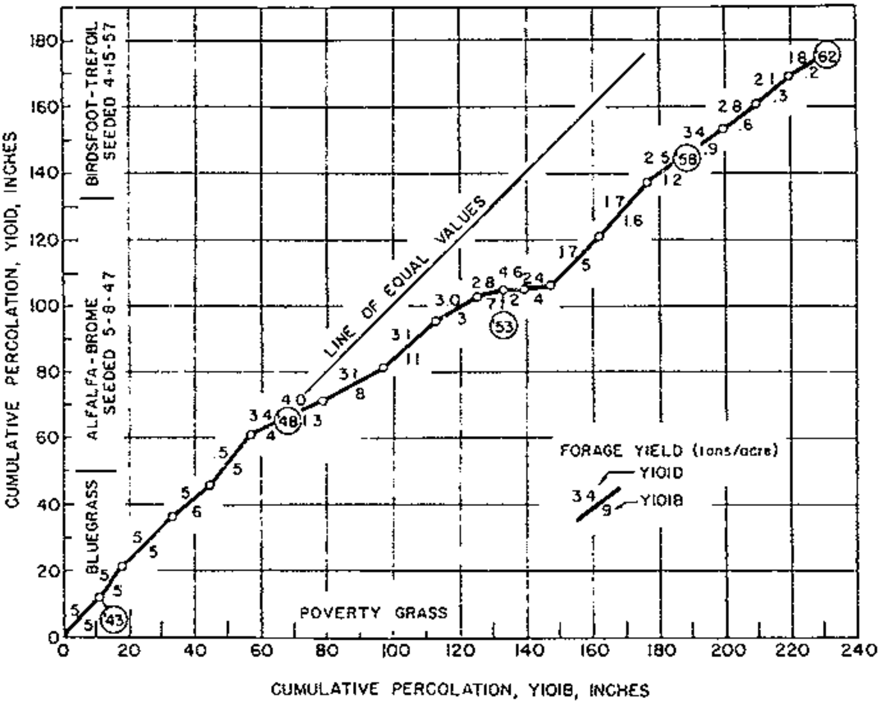

FIGURE 31.—Relation between cumulative percolation from Y101B and Y101D during 1943-62 and forage yields. Y101B was in poverty grass (shallow-rooted) throughout this period. Y101D was in bluegrass (shallow-rooted) until May 8, 1947, in alfalfa-brome (deep-rooted) until April 15, 1957, and in birdsfoot trefoil (deep-rooted) until the end of the experiment.

ning in 1948 departs materially from the line of equal values.

Statistical analyses were performed on the Y101 percolation data for the 1947-62 period. The average annual percolation for deep-rooted grass, 8.09 inches, was significantly lower than the 13.73-inch average for shallow-rooted grass. The variations in the plotted points around the general-trend line for the period 1948-62 may be due to chance. However, there are numerous features of the trend line that appear to be worthy of consideration.

Crop yield data are shown along the curve of figure 31. After 1947, the crop yield on Y101D was much greater than before. Furthermore, it was much larger than that of Y101B during the same period. During the very dry years, 1953 and 1954, the deep-rooted crops depleted soil moisture to such a depth that subsequent fall and winter rain was not sufficient to overcome the deficit and to cause the normal amount of percolation. The curve is almost horizontal in this period, showing that percolation from Y101D was negligible compared to that for Y101B. By 1956, percolation on Y101D had recovered to a large extent and was almost as large as that on Y101B. Alfalfa on Y101D had died out by 1956. Birdsfoot trefoil, another deep-rooted legume and reputedly of longer life, was seeded in its place in the spring of 1957. It was much slower in starting than alfalfa and the increase in crop yield did not show up until 1958. Percolation from Y101D in the 1956-57 period totaled slightly greater than that from Y101B—a situation somewhat like that prevailing before Y101D was seeded to deep-rooted crops. By 1958 the stand of birdsfoot trefoil on Y101D had become well established, as evidenced by crop yield increase and by the reduction of percolation below that of Y101B.

As previously noted, the greater the crop yield, the greater the water consumption (ET). This increased soil moisture depletion and decreased percolation—an effect more apparent in dry than in wet years. The effect of a sequence of wet and dry years on annual percolation from deep- and shallow-rooted vegetation is shown in figure 32.

During the pretreatment period (1943-46), when both Y101D and Y101B were in bluegrass, annual precipitation varied from slightly below to slightly above normal. Percolation values were approximately the same from the two lysimeters and were fairly high, ranging from about 7 to 15 inches per year.

Data from 1947, the year Y101D was reseeded, are omitted. The bluegrass was chopped and killed in April and alfalfa and bromegrass were seeded in May. Very little vegetal growth occurred that year.

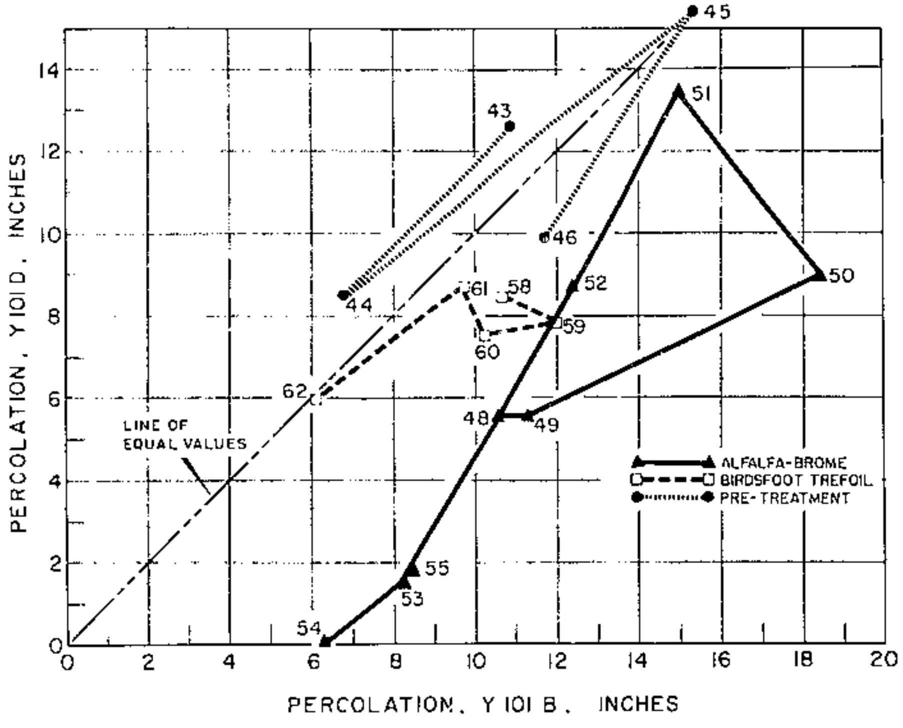

FIGURE 32.—Effect of vegetation on percolation, 1943-62. Y101B was in poverty grass throughout this period; Y101D vegetation shown on curves. Numbers on graph indicate calendar years. Data for 1956 not given because alfalfa was gone; 1957 data not given because birdsfoot trefoil was seeded then.

For the first 3 years after Y101D was reseeded with deep-rooted alfalfa and bromegrass, its percolation (ranging from zero to 13 inches annually) was considerably below that of Y101B, in shallow-rooted bluegrass (ranging from 6 to 18 inches annually). In the September-December 1950 period, before the soil moisture deficits on the lysimeters were overcome, percolation from the shallow-rooted crop lysimeter totaled 5.03 versus 0.13 inches from the deep-rooted-crop lysimeter.

Only one set of values, for 1951, plotted near the line of equal values. This followed the wet year of 1950 (annual precipitation 12 inches greater than normal), which had higher-than-average precipitation in November and December. Since the moisture deficits on Y101D and Y101B were both overcome before 1951, there was very little difference that year between percolation from the deep-rooted-vegetation lysimeter (13.39 inches) and from the shallow-rooted-vegetation lysimeter (14.96 inches). This shows that in wet periods the effect of different rooting depth on percolation was greatly diminished.

Annual precipitation for the 1952-59 period ranged from normal to 9 inches below normal. Whereas this sequence of dry years reduced percolation on both lysimeters, its effect on percolation from Y101D was much more pronounced—in fact there was no percolation in 1954.

The years 1956 and 1957 were wet years. Furthermore, the deep-rooted legume on Y101D had almost disappeared. Percolation from Y101B and Y101D was 14.50 and 13.73 inches, respectively for 1956, and 14.52 and 16.81 inches, respectively for 1957 (table 39). In March of 1957, the old vegetation on Y101D was destroyed and birdsfoot trefoil seeded. As in 1947 when alfalfa was seeded on Y101D, there was little vegetative growth on Y101D in 1957. Percolation from Y101D exceeded that of Y101B in both these reseeding years.

In the birdsfoot trefoil period on Y101D (fig. 32), percolation was less than from Y101B. By 1962 most of the trefoil had disappeared from Y101D. Its extra effect on moisture extraction and on percolation also vanished.

A comparison of percolation data from cropped lysimeters in battery Y103 (fig. 33) showed that conservation practices (higher fertility and deeper-rooted meadow) generally reduced percolation. The contrast between accumulated values of annual percolation from conservation-practice and from poor-practice lysimeters is not nearly as striking as the contrast between these values from continuous grass-legume and poverty grass lysimeters (fig. 31). Conservation practices began with higher application of chemical fertilizer to the 1941 corn crop on lysimeters Y103A and Y103B. Rates of applications, use of manure, seeding specifications, and yield data for the period 1936-55 are given in the appendix to U.S. Department of Agriculture Technical Bulletin 1179 (*66*). Similar information for the period 1956-62 is given in appendix table 34 in this bulletin.

There are three periods, each showing a distinct relation between the accumulated percolation under the two types of treatment (fig. 33). The initial relation between accumulated percolation under the two practices is shown by the trend of the double-mass curve from the start, 1941, through 1946. By the end of 1946, the 6-year accumulated percolation from the poor-practice lysimeters (Y103C and Y103D) totaled 34.48 inches and that from the conservation-practice lysimeters (Y103A and Y103B) was 31.20 inches. Average annual rates for

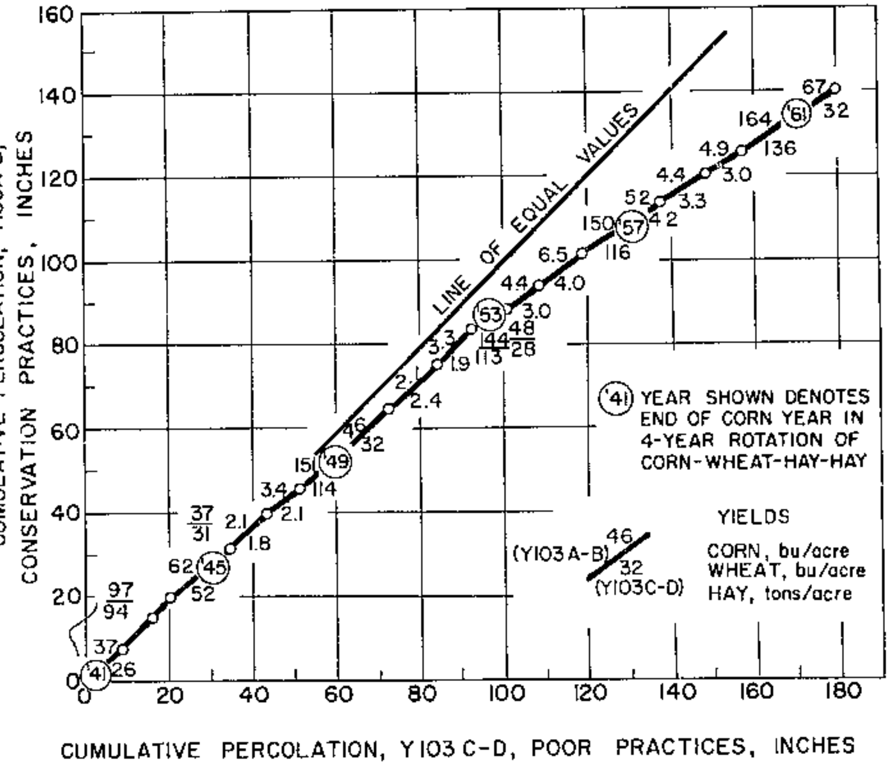

FIGURE 33.—Relation between cumulative percolation from conservation-practice lysimeters (Y103A, Y103B) and from poor-practice lysimeters (Y103C, Y103D) during 1941-62 period; and crop yields.

this period were 5.75 and 5.20 inches, respectively.

In the second period, 1947-52, the average annual percolation rates were 9.68 and 8.65 inches, respectively. The first-period difference in average annual rate, 0.55 inch, was 9.6 percent of the average Y103C and Y103D percolation value. The difference of 1.03 inches in the second period was 10.6 percent of the average annual percolation rate from the poor-practice lysimeters. The crop yield difference between the treatments was quite noticeable in this second period. (Where there are no data shown, values are missing from the record.)

The third period apparent on figure 33 covers the years 1953-62. The average annual percolation rate was 8.25 inches for the poor-practice lysimeters (Y103C and Y103D) and 5.38 inches for the conservation-practice lysimeters (Y103A and Y103B). The difference of 2.87 inches in this third period was 34.8 percent of the average annual percolation rate from the poor-practice lysimeters. The change in percolation relations between practices from the initial to the second period was slight. That between the second and third periods was considerable. Statistical analyses showed that, for the entire 1941-62 period, the average annual percolation from the conservation-practice lysimeters, 6.36 inches, was significantly (at a 5-percent level) less than the 8.18 inches average from the poor-practice lysimeters. This relationship was true for all crops of the rotation.

Table 22 shows the increase in crop yields between the second and third periods. There was practically no change in corn yields; yields for the second period were 114 and 151 bushels per acre from poor-practice and conservation-practice lysimeters respectively; the corresponding values for the third period were 122 and 153 bushels per acre. The corresponding increase in yield for the wheat crop was more noticeable—32 and 46 bushels per acre for the second period compared to 34 and 56 for the third period, an increase of 8 bushels per acre in the difference between practices. The corresponding increase in yield for the meadow crop was also considerable—2.1 and 2.9 tons per acre versus 3.3 and 5.1 tons per acre, an increase of 1 ton per acre in the difference between practices. Increases in yields were related to increases in total use of water (table 14). In turn, increased use of water by the crops resulted in reduction of percolation.

The reduction in percolation was not always concurrent with the crop yield increase. The reduction often appeared at the start of the percolation period following the crop season. Greater moisture deficits caused by increased water use by crops had to be largely replenished before percolation started. Comparisons of crop yield and percolation differences for individual seasons or single years are not always valid. The carryover effect from one year to another may be minimized when comparisons of values are made for periods of several years.

The effect of different rooting depth on delay in the start of appreciable amounts of percolation can be illustrated by graphs of monthly and daily percolation values. Monthly percolation and precipitation data for the 1942-46 period, when lysimeters Y101B and Y101D were both in shallow-rooted vegetation, are shown on figure 34. The seasonal trend of percolation and its response to precipitation as shown on this figure, indicate that there was no consistent difference between the monthly percolation values from the two lysimeters during this period.

In the first treatment period—deep-rooted alfalfa and bromegrass

TABLE 22.—*Crop yields on poor-practice lysimeters (Y103C and Y103D) and on conservation-practice lysimeters (Y103A and Y103B), 1947–62*

Period	Corn yield from—		Wheat yield from—		Meadow yield from—	
	Poor-practice lysimeters	Conservation-practice lysimeters	Poor-practice lysimeters	Conservation-practice lysimeters	Poor-practice lysimeters	Conservation-practice lysimeters
	Bu./acre	*Bu./acre*	*Bu./acre*	*Bu./acre*	*Tons/acre*	*Tons/acre*
1947-52	114	151	32	46	2.1	3.4
	----------	----------	----------	----------	2.4	2.1
	----------	----------	----------	----------	1.9	3.3
Average	----------	----------	----------	----------	2.1	2.9
1953-62	----------	----------	----------	----------	3.0	4.4
	113	144	28	48	4.0	6.5
	116	150	42	52	3.3	4.4
	136	164	32	67	3.0	4.9
Average	122	153	34	56	3.3	5.1

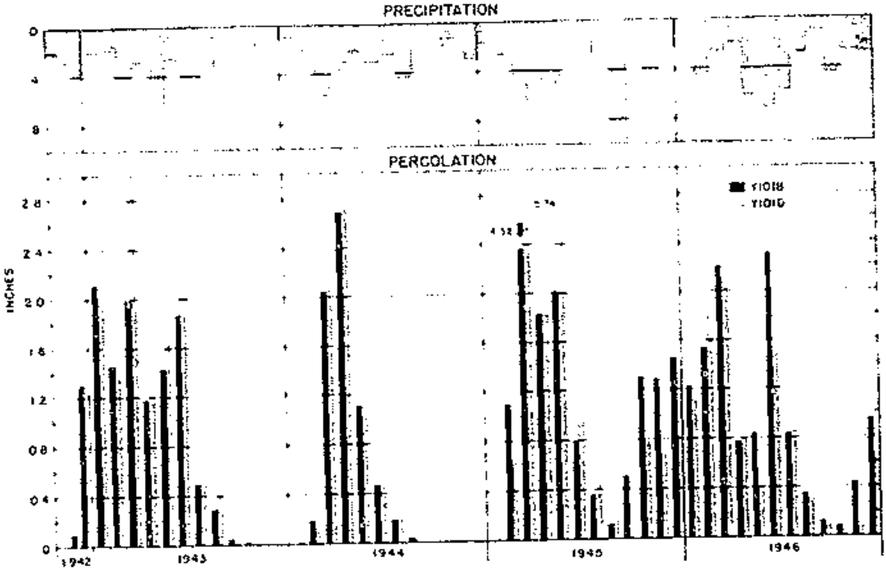

FIGURE 34.—Monthly percolation and precipitation for two lysimeters (Y101B, Y101D) in shallow-rooted vegetation (poverty grass), pretreatment period, 1942-46.

on Y101D (1947-51)—there was a consistent delay in the time of seasonal increase in percolation from the lysimeter in a deep-rooted crop. For example, in December 1948, percolation from Y101B rose to 0.76 inch, whereas, there was none from Y101D (fig. 35); in the following month, percolation from Y101B reached 1.95 inches and that from Y101D was only 0.69. By March 1949, percolation from both lysimeters was nearly the same. The percolation decrease in the summer was more rapid on Y101D than that on lysimeter Y101B, in shallow-rooted vegetation.

In the second treatment period, 1957-62, the effect of birdsfoot trefoil on the delay in the seasonal increase of percolation and the advance in the time of its recession was also apparent (fig. 36).

The effect of the change from shallow- to deep-rooted vegetation on the date of significant rise in percolation can also be illustrated by daily percolation-precipitation graphs. The day of the first small increase, or the beginning of percolation, is of little importance compared with the date of large increase. The graph of daily percolation for the pretreatment period (fig. 37) shows that percolation from the two lysimeters, both with shallow-rooted vegetation, was practically the same after February 22, 1945. A significant rise in percolation from Y101B occurred in mid-February but daily percolation soon fell to a small amount. Percolation from Y101D did not show this initial rise, but, after March 5, the percolation rate was practically the same as that of Y101B.

After Y101D was seeded to alfalfa-bromegrass, its rise in percolation, as compared to that for Y101B was strikingly delayed (fig. 38). Where-

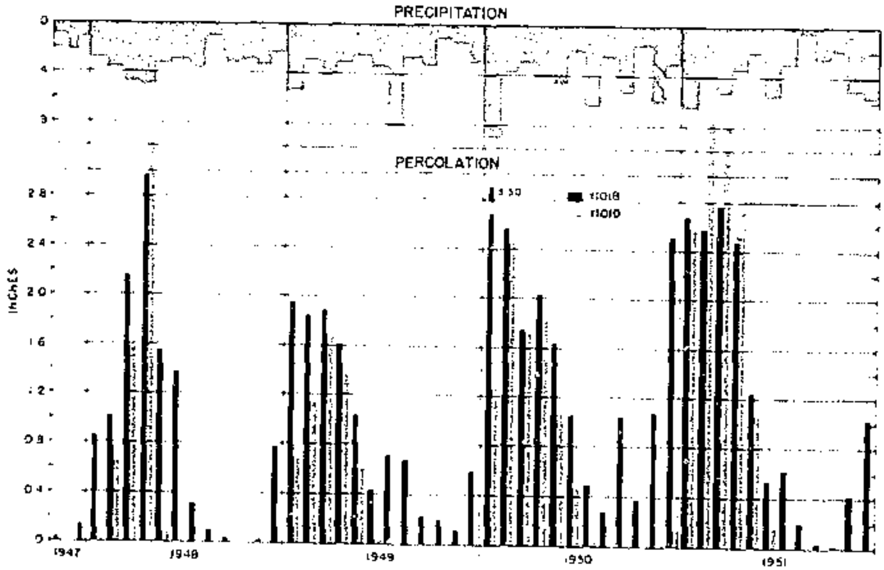

FIGURE 35.—Effect of alfalfa-brome on monthly percolation, first treatment period, 1947-51. During this period Y101D was in alfalfa-brome and Y101B was in poverty grass.

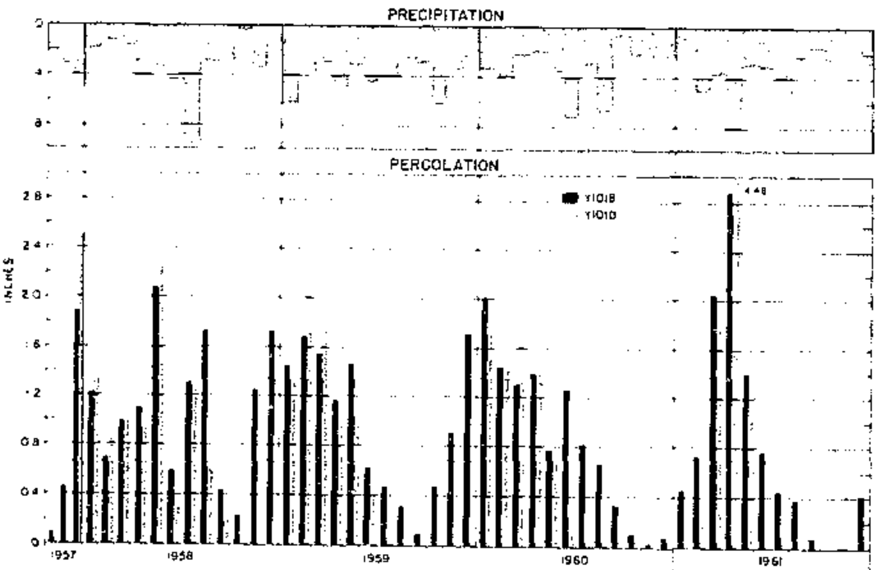

FIGURE 36.—Effect of birdsfoot trefoil on monthly percolation, second treatment period, 1957-62. During this period Y101D was in birdsfoot trefoil and Y101B was in poverty grass.

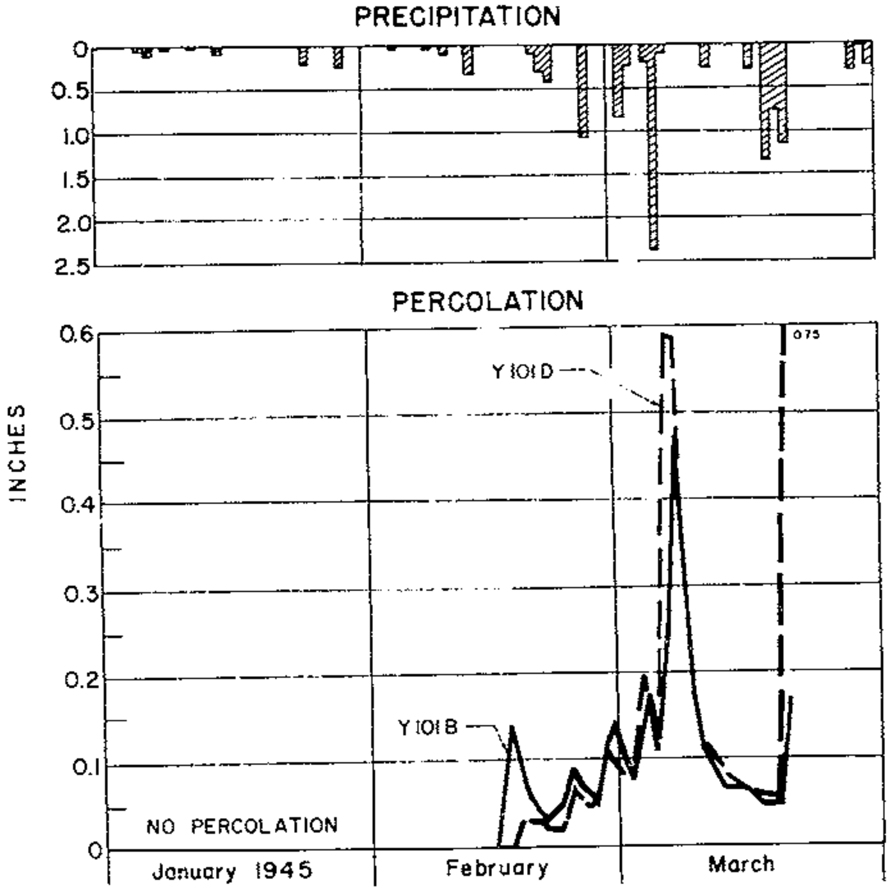

FIGURE 37.—Daily percolation for two lysimeters in shallow-rooted vegetation, February-March 1945.

as a significant amount of percolation from lysimeter Y101B, in shallow-rooted vegetation, began on about December 20, 1949, percolation from Y101D did not show a sizable rise until January 10, 1950 and did not approach percolation from Y101B until about January 25. Thereafter, the percolation values were comparable. A similar pattern is shown by the shallow-rooted lysimeters versus deep-rooted lysimeter percolation curves for the birdsfoot trefoil treatment period (fig. 39).

Interrelations Among Plant Nutrient Losses, Precipitation, Soil Type, Crop, and Agronomic Practice

Losses of chemical constituents of the soil through percolation, commonly termed leaching, were determined by chemical analysis of the lysimeter percolates. Leaching of plant nutrients has been studied by numerous investigators. The reviews of the literature by Kohnke and coworkers (*83*) and by Harrold and Dreibelbis (*66*) have listed various investigations carried on pri-

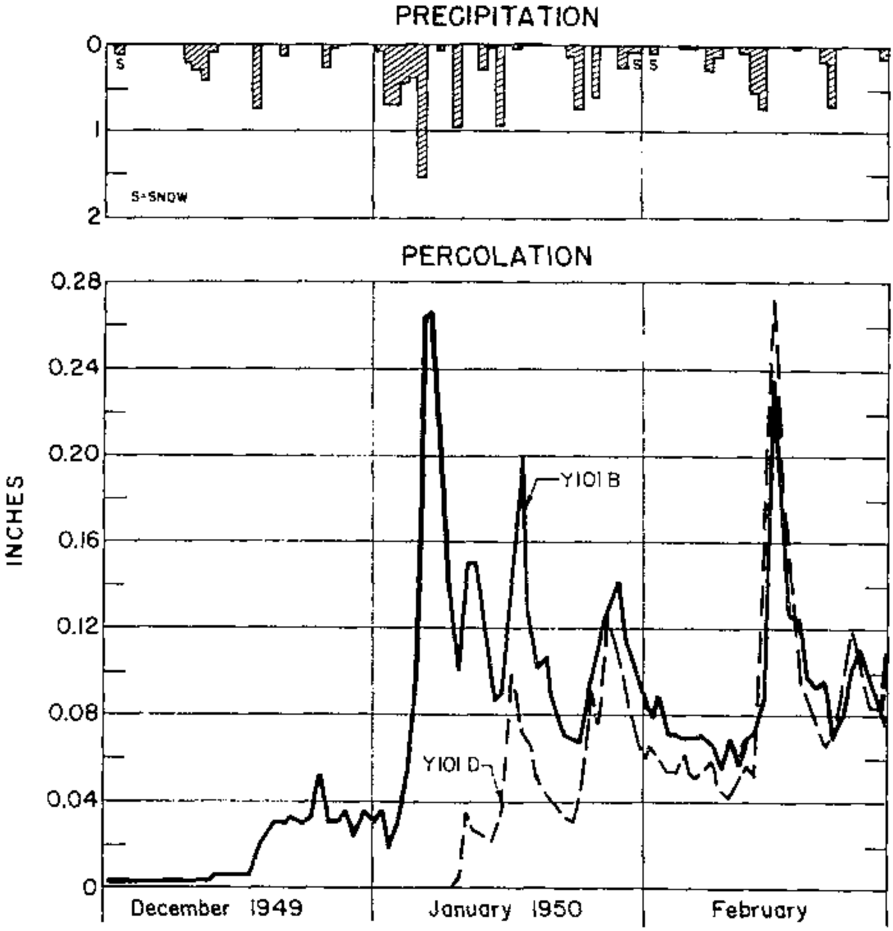

FIGURE 38.—Effect of shallow-rooted vegetation on daily percolation, December 1949 to February 1950. During this period Y101D was in deep-rooted vegetation and Y101B was in shallow-rooted vegetation.

marily for the study of loss of nutrients through leaching. Some of these investigations have called attention to the shortcomings of many lysimeters resulting from the unnatural conditions under which percolation occurs, the most serious being percolation from filled-in lysimeters or from lysimeters that do not permit surface runoff. The Coshocton lysimeters more nearly approached natural conditions than many others, and the evaluations made of plant nutrient losses through leaching were considered reliable. A knowledge of the extent of plant nutrient losses in percolation provides useful information for various agricultural programs.

Data on leaching of nutrients under different practices on the lysimeters and on the amount of lime, fertilizer, and manure applied to each lysimeter from 1956 to 1962 are given

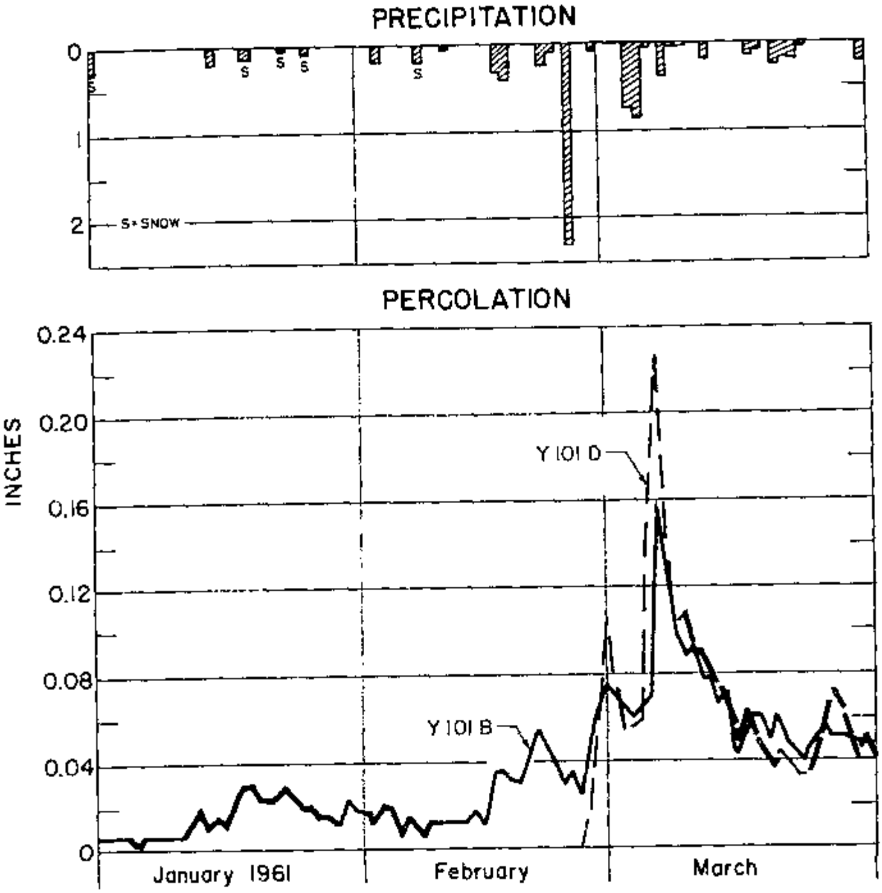

FIGURE 39.—Effect of shallow-rooted vegetation on daily percolation, January-March 1961. During this period Y101D was in deep-rooted vegetation and Y101B was in shallow-rooted vegetation.

in table 23. It is apparent that these applications exerted a great influence on the composition of the percolate.

More calcium was lost through leaching than any other nutrient; manganese losses were the least. (Plant requirements for manganese were small.) Sulfur losses during the 1941-62 period were higher from the lysimeters receiving the greater amounts of fertilizer.

Nitrogen occurred in the percolate mostly, if not entirely, in the form of nitrate and in this study was determined only as such. A summary of the data on nitrate losses in percolates from each lysimeter for the 1940-62 period appears in table 24. These data show the contrast in nitrogen losses by soil type and agronomic practice as well as the large variation in replicates on the same soil type and agronomic practice. Nitrate losses were least on the Muskingum silt loam lysimeters over sandstone that were in permanent grass, lysimeter battery Y101; annual values from this battery ranged

TABLE 23.—*Application of fertilizer, lime, and manure; loss of nutrients through percolation; and amount of percolation from lysimeters in batteries Y101, Y102, and Y103, 1956–62*[1]

Year and lysimeter	Soil[2]	Crop	Agronomic practice	Application of— Fertilizer Amount	Fertilizer Kind	Agricultural lime	Manure	Nutrient loss K	Ca	Mg	N[3]	Mn	S	Percolation water
				Lb./acre		*Lb./acre*	*Tons/acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*In./acre*
1956:														
Y101, AB	Ms	Grass	Poor	0	--------	0	0	7.08	6.55	4.54	0.60	0.27	12.28	17.79
Y101, CD	Ms	do	Conservation	0	--------	0	0	7.68	31.89	5.21	.61	.30	42.58	17.07
Y102, ABC	M1	Meadow	do	0	--------	1.0	0	6.16	13.06	10.98	4.03	.16	15.72	6.04
Y103, AB	K	do	do	0	--------	0	0	14.00	38.52	17.00	2.58	.16	22.36	8.00
Y103, CD	K	do	Poor	0	--------	0	0	21.34	31.61	11.02	2.09	.22	26.47	10.40
1957:														
Y101, AB	Ms	Grass	Poor	0	--------	0	0	6.77	8.81	4.31	.41	.28	13.19	17.10
Y101, CD	Ms	do	Conservation	300	5-20-20	0	0	11.47	36.07	32.50	3.25	.32	39.48	17.42
Y102, ABC	M1	Corn	do	[4] 360	5-20-20	0	10.0	14.79	43.97	23.55	4.75	.31	34.94	9.46
Y103, AB	K	do	do	[4] 360	5-20-20	0	10.0	14.36	44.87	11.94	5.95	.05	27.93	7.37
Y103, CD	K	do	Poor	[5] 150	5-20-20	0	7.5	24.81	57.72	29.48	8.83	.26	26.47	12.04
1958:														
Y101, AB	Ms	Grass	Poor	0	--------	0	0	3.54	2.40	1.01	.13	.22	8.74	11.72
Y101, CD	Ms	do	Conservation	0	--------	0	0	18.35	22.56	18.23	1.88	.22	25.59	10.16
Y102, ABC	M1	Wheat	do	0	--------	0	0	6.06	15.03	20.18	9.53	.16	15.44	5.92
Y103, AB	K	do	do	0	--------	0	0	7.45	22.79	21.98	6.71	.18	15.24	4.51
Y103, CD	K	do	Poor	0	--------	0	0	17.59	22.12	19.14	7.30	.24	14.08	6.24
1959:														
Y191, AB	Ms	Grass	Poor	0	--------	0	0	4.36	3.88	.15	.18	.40	11.32	19.49
Y101, CD	Ms	do	Conservation	0	--------	0	0	7.79	19.37	6.95	.61	.55	25.36	12.09
Y102, ABC	M1	Meadow	do	0	--------	0	0	5.37	15.66	21.50	10.48	.20	16.92	5.83
Y103, AB	K	do	do	0	--------	0	0	8.58	33.79	27.50	5.19	.40	23.51	6.81
Y103, CD	K	do	Poor	0	--------	0	0	18.14	37.89	31.79	8.22	.60	22.78	11.49

1960:														
Y101, AB	Ms	Grass	Poor	0	----------	0	0	4.38	6.85	3.50	.07	----------	----------	11.17
Y101, CD	Ms	do	Conservation	0	----------	0	0	6.25	20.99	15.67	.66	----------	----------	9.52
Y102, ABC	M1	Meadow	do	0	----------	0	0	5.40	11.23	23.35	8.79	----------	----------	5.31
Y103, AB	K	do	do	0	----------	0	0	5.66	16.43	22.72	3.30	----------	----------	5.18
Y103, CD	K	do	Poor	0	----------	0	0	9.78	17.94	25.09	3.91	----------	----------	8.57
1961:														
Y101, AB	Ms	Grass	Poor	0	----------	0	0	4.79	3.80	3.28	.11	----------	----------	11.80
Y101, CD	Ms	do	Conservation	0	----------	0	0	9.50	19.47	15.80	1.19	----------	----------	11.42
Y102, ABC	M1	Corn	do	[4] 360	5-20-20	0	10.0	6.25	16.28	23.78	9.54	----------	----------	6.59
Y103, AB	K	do	do	[4] 360	5-20-20	0	10.0	8.76	29.06	30.47	5.41	----------	----------	8.43
Y103, CD	K	do	Poor	[5] 150	5-20-20	0	7.5	16.55	30.18	23.22	5.51	----------	----------	13.66
1962:														
Y101, AB	Ms	Grass	Poor	0	----------	0	0	2.25	3.06	1.55	.09	----------	----------	7.86
Y101, CD	Ms	do	Conservation	0	----------	0	0	4.23	14.66	4.47	1.32	----------	----------	8.13
Y102, ABC	M1	Wheat	do	0	----------	0	12.0	4.46	14.90	8.08	9.32	----------	----------	5.50
Y103, AB	K	do	do	0	----------	0	12.0	6.60	32.56	10.91	7.64	----------	----------	6.31
Y103, CD	K	do	Poor	0	----------	0	7.5	13.56	23.10	11.21	5.13	----------	----------	9.01
1941-62 [6] average:														
Y101, AB	Ms	----------	Poor	0	0	0	0	5.82	7.64	3.47	.25	.37	10.59	12.82
Y101, CD	Ms	----------	Conservation	200	4-10-6	.2	.2	9.20	17.59	8.49	.72	.34	20.82	11.49
Y102, ABC	M1	----------	do	200	4-20-8	.3	3.2	5.62	14.51	13.25	5.61	.29	14.06	6.91
Y103, AB	K	----------	do	200	2-20-8	.2	3.2	9.55	24.85	18.27	4.13	.27	28.68	6.40
Y103, CD	K	----------	Poor	100	1-7-5	0	1.8	15.86	22.54	17.35	4.72	.37	22.03	8.28

[1] For 1941-55 data see table 30 of U.S. Dept. Agr. Tech. Bul. 1179 *(66)*.
[2] Ms=Muskingum silt loam over sandstone; M1=Muskingum silt loam over shale; K=Keene silt loam.
[3] Nitrate nitrogen.
[4] 180 pounds at corn planting and 180 pounds at wheat planting.
[5] 50 pounds at corn planting and 100 pounds at wheat planting.
[6] Nutrient loss data for 1945 and 1946 omitted because of incomplete records; Mn and S data are 15-year averages.

from zero to 5.93 pounds per acre. Zero loss of nitrates resulted from zero percolation, Y101D in 1954. The addition of nitrates Y101C and Y101D (none to Y101A and Y101B) several times during the period 1945-62 (table 23) influenced this variation. Furthermore, nitrogen fixing legumes were seeded on Y101D in 1947 and 1957.

Nitrate applied on April 15, 1957 on Y101C and Y101D was followed by heavy rainfall in June and increased percolation from both lysimeters in June and July (table 39). Percolation from Y101D was slightly greater than that from Y101C. Nitrate leaching loss from Y101C in 1957 (table 24) was practically unchanged. That from Y101D in 1957 was the largest on record. It is likely that the nitrate buildup during the previous years of alfalfa on Y101D (no legume on Y101C) caused the large nitrate loss. Percolation from both lysimeters was also large in 1958. Nitrate leaching from Y101D continued at high rates in 1958, but declined to less than 1 pound per acre in 1959. There seemed to be practically no relation between annual percolation amounts and corresponding leaching losses of nitrates during the period 1959-62. No nitrates were added after 1957 and annual losses of N were small (1 to 2 pounds per acre).

Variation in nitrogen losses from year to year from batteries Y102 and Y103 (table 24) was less be-

TABLE 24.—*Nitrates*[1] *in lysimeter percolates, 1940-62*

Year	Battery Y101[2]				Battery Y102[5]			Battery Y103[7]			
	Y101A	Y101B	Y101C	Y101D[3,4]	A[6]	B[6]	C[6]	A[6]	B[8]	C[8]	D[8]
	Lb./acre	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*
1940	0.27	0.30	----	----	6.53	6.62	5.76	----	----	4.48	4.25
1941	.44	.36	0.40	----	2.72	2.53	----	0.23	0.75	.72	.57
1942	.40	.35	.25	----	2.76	2.93	4.98	.29	.96	1.84	1.09
1943	40	19	.43	----	5.40	4.71	9.63	3.39	1.52	3.58	1.42
1944	.31	.17	.36	----	2.87	2.86	5.44	6.23	1.50	3.44	5.95
1945	1.22	22	.62	2.39	2.25	2.03	6.03	5.04	.46	2.89	5.74
1946											
1947	40	.14	.20	.81	1.52	3.07	7.58	14.85	8.79	14.53	13.46
1948	.47	.18	.39	1.86	1.26	1.91	3.57	4.55	2.22	10.44	3.23
1949	32	.15	.41	.43	.59	.73	1.19	3.25	1.68	1.70	1.41
1950	50	.23	.67	.15	8.22	8.01	12.87	5.15	6.08	2.37	3.36
1951	.21	.15	.31	.13	8.40	5.88	6.89	14.24	2.77	2.66	7.35
1952	.34	.13	.33	.08	3.31	3.02	5.77	2.21	1.68	3.93	10.44
1953	.13	.12	.17	.07	.03	.07	1.14	.56	.73	.60	1.76
1954	.22	.29	.21	0	.03	.42	3.03	.36	2.31	1.64	4.12
1955	.30	.15	.32	.01	6.23	6.34	10.37	2.03	2.66	1.90	2.63
1956	.86	.34	.73	.50	1.58	2.58	7.63	2.54	2.62	2.86	1.32
1957	.60	.22	.56	5.93	4.57	4.30	5.38	5.37	6.52	6.00	11.66
1958	.17	.08	.31	3.45	8.74	8.57	10.77	6.17	7.25	4.69	9.92
1959	25	.11	.20	.93	7.02	6.77	17.66	4.78	5.59	5.93	10.52
1960	.10	.04	.29	1.04	4.89	7.00	14.49	3.32	3.20	3.62	4.20
1961	.16	.06	.29	2.08	6.56	5.43	16.62	6.26	4.57	6.77	4.24
1962	.12	.06	.27	2.36	8.15	8.60	10.93	4.88	10.40	3.80	6.37
Average[9]	.37	.18	.37	1.29	4.28	4.34	8.03	4.58	3.55	4.12	5.24

[1] In terms of N per acre per year.
[2] Muskingum silt loam over sandstone; permanent grassland.
[3] Nitrates added several times during 1954-62.
[4] Legumes seeded in 1947 and 1957.
[5] Muskingum silt loam over shale; crop rotation.
[6] Conservation practice; nitrate added in 1941, 1945, 1949, 1953, 1957, and 1961.
[7] Keene silt loam; crop rotation.
[8] Poor practice, nitrates added in 1941, 1945, 1949, 1953, 1957, 1961.
[9] Average of years for which data are available.

tween practices than between lysimeters under the same practice. Y103A and Y103B were under conservation practice and Y103C and Y103D were under poor practice. There does not appear to be any consistency in leaching losses between the various batteries or treatments. Annual values ranged from 0.03 to 17.66 pounds per acre. This variation was influenced largely by the amount of percolate, by the addition of fertilizer and manure, by the growth of legumes with their concomitant influence on nitrogen supply, and by biological activity in the soil. Fertilizer application on May 2, 1957 (table 23 and appendix table 34) was followed by large amounts of rain in June. Percolation from all lysimeters at Y103 site (table 41) increased noticeably in June 1957. More fertilizer was added on October 2, 1957. Percolation increased again in December. Nitrate leaching from all lysimeters at this site for 1957 (table 24) showed sizable increases over those of 1956. This was due to the large increases in percolation so soon after fertilizer application. Leaching losses of nitrates remained high in 1958 although percolation totals were only about half of those in 1957. In fact, the nitrate loss values showed no sizable reduction until 1960, the third year after fertilization.

It was impossible to determine the source of the nutrients in the leachate. Nutrients in drainage water were derived from the applied manure, fertilizer, and limestone materials and from the soil itself. Some of these applied nutrients appeared in the percolates the same year or in the following year. It was difficult, therefore, to attribute nutrient leaching losses to any particular application. It was also likely that contaminants in the atmosphere, such as nitrogen and sulfur, contributed appreciably to the composition of the leachate.

A detailed study of the leaching of chemical constituents of soil was made on the untreated lysimeter Y101B for a 12-month period ending September 1960 (table 25). Quantitative determinations of a number of anions and cations were made and expressed as parts per million. As this lysimeter received no fertility treatment during the period 1936-62, the composition of the percolate bears some relation to the chemistry of soil development. In this connection, it is interesting to observe the relatively high content of silica in the percolate. Bicarbonates and sulfates are the only anions found in greater concentration than silica. Of the cations, sodium and potassium were highest in concentration. Losses of the other cations were relatively small.

The average annual percolation and nutrient losses under permanent meadow for the period 1947-62 are given in table 26. Losses from one year to another were different as expected because of differences in yearly percolation. Analyses indicated, however, that, even after adjustment for differences in yearly percolation, the nutrient losses were not the same from year to year. The addition of fertilizers at irregular intervals to the conservation practice lysimeters (Y101C, Y101D) was the main reason for the variation in annual nutrient losses. However, in the case of nitrogen, the annual average of 1.24 pounds per acre leached from Y101D in alfalfa probably reflected the contribution of nitrogen to the soil by legumes. On theY101 lysimeters without legumes, the annual average amount of N leached was only 0.24 and 0.36 pound per acre, on the poverty grass and bluegrass lysimeters, respectively. Although the applications of potassium in fertilizer were the same on both Y101C and Y101D, the leaching was much less from Y101D (4.68 pounds annual average) than from Y101C

(11.14 pounds). This probably reflected the greater amount of potassium removed by the alfalfa crop than by the bluegrass, as yields were considerably greater on the former. (See appendix table 32 for data on yields.) Because no limestone was added to the poor-practice lysimeters, the amounts of calcium and magnesium leached therefrom were considerably below those from the lysimeters in conservation practice.

Average annual percolation and nutrient loss data from the 4-year-rotation lysimeters of the Keene silt loam and the Muskingum silt loam over shale appear in table 27. The effect of conservation practice and poor practice on the amount of percolate and nutrient losses under this rotation for battery Y103 is apparent. Conservation practice caused a significant reduction in percolation amounts (8.28 inches to 6.40 inches per year). The nutrient losses of nitrogen, potassium, and magnesium from battery Y103 were less from the conservation-practice lysimeters.

TABLE 25.—*Analysis of lysimeter percolates from Y101B (no fertilizer added) at monthly intervals, October 1959 to September 1960*[1]

Determination and units		1959			1960								
		Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
Silica (SiO_2)	p.p.m.	5.9	5.6	7.2	7.8	8.0	8.7	8.2	10.0	8.7	11.0	10.0	9.0
Iron (Fe)	p.p.m.	.07	.02	.01	.04	.05	.06	.04	.02	.02	.07	.02	0
Calcium (Ca)	p.p.m.	1.3	1.5	1.3	.9	.7	1.9	1.6	1.6	1.7	2.0	1.7	1.7
Magnesium (Mg)	p.p.m.	1.5	1.0	.6	.6	1.0	.8	.8	.8	1.0	.1	1.4	1.4
Sodium (Na)	p.p.m.	3.8	3.3	2.8	2.4	2.1	2.9	3.1	2.2	2.3	2.3	3.2	2.8
Potassium (K)	p.p.m.	4.6	3.2	1.6	.8	1.2	5.0	1.4	1.0	1.9	1.5	2.4	2.4
Dissolved solids	p.p.m.	40.0	34.0	30.0	27.0	28.0	39.0	31.0	30.0	32.0	34.0	38.0	37.0
Hardness as $CaCO_3$:													
Ca, Mg	p.p.m.	9.0	8.0	6.0	4.0	6.0	8.0	5.0	6.0	8.0	6.0	10.0	10.0
Noncarbonate	p.p.m.	0	0	0	0	0	2	0	0	0	0	0	0
Bicarbonate (HCO_3)	p.p.m.	21.0	15.0	9.0	8.0	8.0	8.0	11.0	8.0	10.0	10.0	12.0	12.0
Carbonate (CO_3)	p.p.m.	0	0	0	0	0	0	0	0	0	0	0	0
Sulfate (SO_4)	p.p.m.	11.0	12.0	11.0	9.4	9.0	9.2	9.6	9.6	10.0	11.0	12.0	13.0
Chloride (Cl)	p.p.m.	1.0	0	1.0	.6	2.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Fluoride (F)	p.p.m.	0	.1	0	.1	.1	0	.1	0	0	0	.1	0
Nitrate (NO_3)	p.p.m.	.1	.1	.2	.4	.2	.2	.2	.2	.2	.1	.1	0
Specific conductance	micromhos at 25°C	63.0	58.0	43.0	36.0	41.0	43.0	60.0	39.0	46.0	39.0	50.0	50.0
pH		6.6	7.2	6.6	6.0	6.6	6.3	6.3	6.2	6.7	6.3	6.5	6.5
Precipitation	in./mo.	5.48	3.01	2.36	3.04	3.21	1.17	1.67	3.27	6.88	3.06	6.64	.48
Percolation	in./mo.	.49	.92	1.73	2.03	1.46	1.20	1.41	.77	1.28	.83	.67	.34

[1] Data furnished by the U.S. Geological Survey, Columbus, Ohio, which made the determinations on samples collected near the first of the month by the Soil and Water Conservation Research Station, Coshocton, Ohio.

TABLE 26.—*Average annual percolation and nutrient losses from battery Y101, permanent meadow, Muskingum silt loam over sandstone, 1947–62*[1]

Lysimeter, crop, and agronomic practice	Percolation	Yearly loss of—			
		Nitrogen	Potassium	Calcium	Magnesium
	In./yr.	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*
Y101A–Y101B average, poverty grass, poor practice.	13.22	0.24	4.63	7.16	3.58
Y101C, bluegrass, conservation practice.	14.75	.36	11.14	12.24	5.74
Y101D, alfalfa, conservation practice	8.09	1.24	4.68	23.61	13.42

[1] Legume seeded on Y101D in 1947

TABLE 27.—*Average annual percolation and nutrient losses from lysimeters in rotation crops, 1941–62*[1]

Lysimeter, soil, and agronomic practice	Percolation	Yearly loss of—			
		Nitrogen	Potassium	Calcium	Magnesium
	In. yr.	*Lb. acre*	*Lb. acre*	*Lb. acre*	*Lb. acre*
Y103, CD, Keene silt loam, poor practice.	8.28	4.72	15.86	22.[illegible]	17.35
Y103, AB, Keene silt loam, conservation practice	6.40	4.13	9.55	20.[illegible]5	15.27
Y102, ABC, Muskingum silt loam over shale, conservation practice.	6.91	5.61	5.62	14.5[illegible]	13.25

[1] No data for 1945–46.

The greater losses of K through percolation from poor-practice lysimeters were partly due to the greater solubility of potassium from soil that was more acid than soil under conservation practice. Lime was added to Y103A and Y103B in 1944 to raise the pH to 6.8. None has been needed since that time. The lesser amount of potassium removed by the crops and the greater amount of percolate under poor practice were additional influences. The greater solubility of manganese under acid soil conditions would also partly account for the greater loss of manganese under poor practice. Calcium and magnesium losses were only slightly greater from conservation-practice than from poor-practice areas.

The effect of soil type on nutrient losses was apparent from the greater loss of potassium, calcium, and magnesium from the Keene silt loam than from the Muskingum silt loam (table 27). A more detailed account of the statistical interpretation of the data was reported by Dreibelbis and McGuinness (*38*). The smaller loss of all nutrients except nitrogen from the Muskingum profile was likely due to the greater permeability and better drainage characteristics of this soil. Movement of water through the soil was fairly rapid and there was less opportunity for the water to exert its solvent effect on the soil mass than there was on the Keene. Percolation through Keene soils was generally slow, especially in early spring when the soil became almost impermeable. However, percolation was fairly rapid when the percolate flowed along vertical cracks that had developed after prolonged dry periods. These fissures, resulting from shrinking of the soil colloids, gradually closed again after moisture swelled the colloids.

Data on nutrient losses for high (1950) and low (1953) precipitation years are given in table 28 to show the contrast under these extremes in rainfall. Low percolation and minimal nutrient losses were associated with years of low precipitation. Loss of nutrients, except nitrogen, for the year of maximum precipitation is likely to be close to the maximum, occurring under the climatic and fertility conditions prevailing at the Coshocton station. The 20-year annual average for nitrogen losses from Y103C and Y103D under poor practice (4.72 lb./acre) is higher than the value for the high precipitation year of 1950 (2.87 lb./acre). The growth of legumes and the addition of fertilizers resulted in high nitrogen leaching losses for some years (table 24). These high values increased the average above that for the year 1950.

TABLE 28.—*Plant nutrient losses in lysimeter percolates from Keene silt loam during years of high precipitation (1950) and low precipitation (1953) compared with the 20-year[1] (1941–62) average*

Agronomic practice and period	Total precipitation	Percolation	Nutrients percolated					
			Ca	Mg	K	N	Mn	S
	Inches	*Inches*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*	*Lb./acre*
Conservation practice:								
1950 (high precipitation)	51.97	13.60	51.79	30.16	11.55	5.62	0.64	82.21
1953 (low precipitation)	33.19	3.54	5.88	.74	2.77	.64	.13	8.28
20-year[1] average (1941–62)	36.93	0.38	24.85	15.27	9.55	4.13	.27	28.68
Poor practice:								
1950 (high precipitation)	51.97	13.40	30.81	18.69	20.56	2.87	.94	51.18
1953 (low precipitation)	33.19	5.05	4.50	.68	3.61	1.18	.10	12.51
20-year[1] average (1941–62)	36.93	8.20	22.54	17.35	15.86	4.72	.37	22.03

[1] Data for 1945 and 1946 omitted because of incomplete records; Mn and S data are 15-year averages.

The data in table 28 also provide a comparison of the effects of agronomic practice on nutrient losses through percolation. Nutrient losses were considerably lower under poor practice except in the case of potassium and manganese, for reasons previously given. The differences in nutrient losses between practices were less than those between high and low precipitation years. The application of excessive amounts of water, by irrigation or by appreciable amounts of rainfall soon after irrigation, is likely to result in increased nutrient losses through percolation.

Although annual losses of plant nutrients resulting from percolation are small compared to those resulting from surface runoff from cultivated land, they are of practical importance. For example, 5 pounds of nitrogen per acre and 10 pounds of potassium per acre would be equivalent to 100 pounds of 5-10-10 fertilizer; 50 pounds of calcium per acre would be equivalent to approximately 125 pounds of limestone ($CaCO_3$). Data from the Coshocton station indicate that nutrient losses through drainage are less than formerly supposed. Many of the data from earlier studies elsewhere were obtained under relatively unnatural conditions resulting from lack of provision for runoff or from the use of filled-in lysimeters.

SUMMARY AND CONCLUSIONS

Data on agricultural hydrology are needed in the solution of many water management problems. The efficient use of water supply in crop production depends on a knowledge of consumptive-use rates throughout the entire growing season. Data on moisture extraction rates by ET (evapotranspiration) are needed to develop a knowledge of the amount of soil pore space available for storm rainfall absorption. Forecasts of flood peaks and volumes depend on this knowledge.

When watershed management programs are being developed, lysimeter ET and percolation data are of considerable importance in evaluating the hydrologic effect of various land treatment practices. Vegetative changes that affect removal of soil moisture may cause changes in flood runoff, percolation recharge to ground water reservoirs, and the subsequent transfer of this water to streamflow.

Data from weighing lysimeters were used to compute ET—the value left after runoff, percolation, and weight change are subtracted from measured precipitation. Errors in the measurement of any one of these factors would result in errors in evaluation of ET. However, separate determinations of ET over periods of several days made on these same lysimeters were also made by the neutron probe and were found to be in close agreement with those resulting from lysimeter data computation. Therefore, possible errors in the separate measurements involved in the computations were considered to be of little consequence.

Some of the previous data summaries from the Coshocton weighing lysimeters separated the daily weight increases and decreases into periods of condensation-absorption (dew) and evapotranspiration. Annual values of dew of over 10 inches were reported. In 1962 it was discovered that these diurnal weight change values were in error and that the error was caused by temperature changes in the metal and grease peripheral seal between the free-to-move lysimeter and the contiguous rigid land areas. Although these errors in separate diurnal values were sizable, the daily, weekly, monthly, seasonal and annual values of net weight change converted to consumptive use of water were essentially correct and are acceptable. Annual values of dew, however, are in the order of 2 to 3 inches instead of 10 inches.

Changes in soil moisture storage from month to month were large. Monthly increases during the winter-spring period reached 7 inches at times. Decreases in storage of 3 to 4 inches per month during the growing season were common. Net changes over a year varied from year to year, the largest increase being 6 inches and the largest decrease over 6 inches. Years of large gain were usually preceded by years of loss. The average annual moisture storage change for the period 1944-62 was less than ½ inch. Water budget studies for periods of 5 or more years can neglect moisture storage change because it is small. Studies for a period of a year or less should take account of moisture storage change, which may be large.

Data from the neutron probe and soil moisture blocks made it possible to study the water budget on the nonweighing lysimeters. These results showed that growing-season ET values for meadow on the conservation-practice lysimeter totaled 23.77 inches compared to 20.05 for the poor-practice lysimeters. Although vegetation on the conservation-practice lysimeter used more water, its water-use efficiency was greater—0.181 ton per acre for each inch of water used versus 0.151 for the poor-practice lysimeter. Similar evaluations for the corn crop showed a total water use of 21.98 inches for the conservation-practice lysimeter and 19.04 inches for the poor-practice one. Water-use efficiency values were, respectively, 7.73 and 6.78 bushels of corn per acre for each inch of water used.

Moisture extraction by crops of root systems deep enough to tap sufficient moisture for their needs reached maximum monthly values of over 7 inches. Average daily values of evapotranspiration for 10-day periods of maximum use exceeded 0.3 inch. This and similar information pertaining to consumptive use of water by crops is valuable in the design of irrigation systems.

Water-use efficiency values for the same crop varied widely from year to year. Variations between crops were also large. Under conventional farming practices and without irrigation 1 inch of water produced from 1.81 to 8.26 bushels of corn per acre. In general, the greatest efficiency was associated with the greatest yield. At an 80-bushel-per-acre corn yield, 1 inch of water produced 4.60 bushels of corn and at a 166-bushel-per-acre yield, 1 inch of water produced 8.26 bushels. At the lower yield, 17.4 inches of water was consumed and at the higher yield, 20.1 inches. At high yields more water was used, but with greater efficiency.

Prevention of evaporation of water in cornland further increased the efficiency of water use. A plastic cover placed on the ground surface of a lysimeter on June 5, 1957 stopped evaporation. Total water use was 13.2 inches, 125 bushels per acre were produced, and 1 inch of water produced nearly 10 bushels of corn. This experiment showed that about 45 percent of the evapotranspiration under conventional cornland treatment can be attributed to evaporation and 55 percent to actual crop use.

Comparisons of the soil water regimen in lysimeters with that on small adjacent watersheds indicated that lysimeters did not exactly simulate watershed conditions, possibly because of the artificial barriers to lateral flow. The magnitude of the deviations in the comparative soil moisture regimens was affected by soil moisture and by soil type. In the Keene silt loam with impeding layers in the profile, underground lateral flow in the watershed was more likely to be greater than in the well drained Muskingum silt loam. These conditions place some limitations on the general application of lysimeter data to watershed hydrology.

Monolith lysimeters, despite their imperfections, have supplied valuable information that illustrates many principles and relations in watershed hydrology. In water budget studies they have also provided valuable data on percolation which cannot, at present, be evaluated on a watershed basis. They have also been useful in evaluating the accuracy of the neutron method for determining moisture changes in the soil profile.

Percolation data given in this bulletin are essentially evaluations of the monthly, seasonal, and annual recharge to ground water for different soil types and for different crops. Percolation evaluations have direct application to water yield studies since they relate to ground-water recharge and discharge into streams. The period of appreciable amounts of percolation coincided with peak soil moisture values, with about 80 percent of the annual percolation occurring in the January-April period. Under poor practice, the values for this season ranged from 58.4 to 74.2 percent of the annual value. About May 1, near the start of the growing season, rapid extraction of moisture by ET began, resulting in lesser amounts of water available for percolation. Near the end of the growing season, percolation often ceased or decreased to minute quantities. In 1954, no percolation was obtained from lysimeter Y101D in alfalfa-bromegrass. This was a dry year following a dry year and moisture deficiencies extended deep into the soil.

Crops and agronomic practice had a pronounced influence on percolation. The 8.09 inches of average annual percolation from lysimeters in deep-rooted grass was much less than the 13.73-inch average from lysimeters in shallow-rooted grass. Of the 4-year rotation lysimeters on the Keene slit loam, those under poor practice showed higher percolation amounts (8.20 inches) than those under improved practice (6.38 inches) and the difference was statistically significant. Graphs of monthly and daily percolation indicated that percolation response to fall and winter rain was considerably delayed in the lysimeters with deep-rooted vegetation.

Annual amounts of plant nutrient losses through percolation varied considerably. The variation was caused by large differences in the amounts of percolation and by fertilizer applications. Data for high (1950) and low (1953) precipitation years show that low values of percolation and minimal nutrient losses were associated with years of low rainfall.

Statistical treatment of the data on nutrient losses indicated significant differences due to the effect of agronomic practice and soil type. Under the 4-year rotation on the Keene silt loam, calcium and magnesium losses were greater from conservation-practice lysimeters than from poor-practice lysimeters. Potassium losses under a conservation practice were lower than those under a poor practice. Greater losses of potassium, calcium, magnesium, and sulfur occurred from the 4-year rotation lysimeters with Keene silt loam than from those with Muskingum silt loam.

Data provided by the Coshocton lysimeters now cover a period of approximately two decades. In agricultural research this is not considered a long period inasmuch as one crop in a 4-year rotation provides only 5 years of data, with the result that climatic variables are not the same for any of these years and they do not cover a wide range. However, the results provided so far do illustrate principles and can be of practical use in agricultural hydrology.

Climatic variations from year to year produced different results, as did crop and soil management practices. Thus, water control and utilization problems were numerous and varied. The solution of these problems requires much knowledge of how the use and treatment of the land affects surface runoff, percolation, ET, and soil moisture storage changes. Data in this report may help solve many of these problems and may be of particular benefit in formulating soil and water conservation and watershed management programs.

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APPENDIX

TABLE 29.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y101D, 1944–62*

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1944–poverty grass:							
Jan.	0.92	0	0.26	0.07	0.33	0.59	----------
Feb.	1.97	0	.67	.11	.78	1.19	----------
Mar.	5.71	.02	1.75	2.40	4.17	1.54	----------
Apr.	3.71	.01	1.81	2.73	4.55	----------	0.84
May	2.16	.04	3.51	1.04	4.59	----------	2.43
June	3.09	.22	4.19	.55	4.96	----------	1.87
July	2.42	.14	4.48	.22	4.84	----------	2.42
Aug.	4.27	.48	3.54	.01	4.03	.24	----------
Sept.	1.82	.10	1.97	0	2.70	----------	.25
Oct.	1.83	.11	1.35	0	1.46	.37	----------
Nov.	1.23	0	.60	0	.60	.63	----------
Dec.	2.83	0	[1] −.05	0	−.05	2.88	----------
Total	31.96	1.12	24.08	7.13	32.33	7.44	7.81
1945–bluegrass:							
Jan.	1.68	0	[1] −.60	0	−.60	2.28	----------
Feb.	2.60	0	[1] .56	.64	1.20	1.49	----------
Mar.	7.87	.01	2.26	5.74	8.01	----------	.14
Apr.	4.48	.02	2.43	1.97	4.42	.06	----------
May	4.67	.04	3.22	2.44	5.70	----------	1.03
June	3.51	.02	4.46	1.01	5.49	----------	1.98
July	2.66	.01	5.29	.47	5.77	----------	3.11
Aug.	.94	.01	3.19	.20	3.40	----------	2.46
Sept.	9.67	.02	2.41	.02	2.45	7.22	----------
Oct.	2.91	.01	2.52	.81	3.34	----------	.43
Nov.	3.90	0	.93	.70	1.63	2.27	----------
Dec.	2.17	.09	.50	1.35	1.94	.23	----------
Total	47.06	.23	27.17	15.35	42.75	13.46	9.15
1946–bluegrass:							
Jan.	1.06	0	[1] .64	1.12	1.76	----------	.70
Feb.	4.48	.03	[1] 1.00	1.88	2.91	1.57	----------
Mar.	2.61	0	2.63	2.11	4.74	----------	2.13
Apr.	1.84	0	3.61	.80	4.41	----------	2.57
May	6.27	.02	3.97	.42	4.41	1.86	----------
June	7.20	.05	6.39	1.49	7.93	----------	.73
July	5.81	.02	5.88	.86	6.76	----------	.95
Aug.	2.71	.01	3.84	.32	4.17	----------	1.46
Sept.	.99	0	2.22	.10	2.32	----------	1.33
Oct.	4.62	.01	1.73	.02	1.76	2.86	----------
Nov.	2.66	0	1.05	.09	1.14	1.52	----------
Dec.	2.77	0	[1] .60	.67	1.27	1.50	----------
Total	43.02	.14	33.56	9.88	43.58	9.31	9.87

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EVALUATON OF AGRICULTURAL HYDROLOGY BY MONOLITH LYSIMETERS, 1956-62
GARROLD, L.L. ; DREIBELBIS, F.R. 2 OF 2

TABLE 29.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y101D, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1947–brome-alfalfa:							
Jan.	5.39	0	0.59	3.26	3.85	1.54	----------
Feb.	1.11	0	[1] .39	1.93	2.32	----------	1.21
Mar.	2.45	.10	[1] 1.36	1.01	2.47	----------	.02
Apr.	4.47	0	2.79	1.65	4.44	.03	----------
May	6.49	.03	3.23	3.10	6.36	.13	----------
June	5.61	.02	5.47	2.85	8.34	----------	2.73
July	2.78	0	5.11	.73	5.84	----------	3.06
Aug.	3.60	.01	3.62	.28	3.91	----------	.31
Sept.	3.10	0	4.27	.04	4.31	----------	1.21
Oct.	.94	0	1.98	0	1.98	----------	1.04
Nov.	2.32	0	.22	0	.22	2.10	----------
Dec.	1.19	0	.08	0	.08	1.11	----------
Total	39.45	.16	29.11	14.85	44.12	4.91	9.58
1948–brome-alfalfa:							
Jan.	2.85	0	[1] .07	0	.07	2.78	----------
Feb.	3.49	0	.86	.66	1.52	1.97	----------
Mar.	4.76	.01	2.12	1.59	3.72	1.04	----------
Apr.	4.95	.01	4.09	3.26	7.36	----------	2.-- 41
May	3.25	0	5.37	.08	5.45	----------	2.
June	3.09	.01	4.08	.01	4.01	----------	1.20
July	3.56	0	5.52	0	5.52	----------	1.01
Aug.	1.04	0	4.15	.01	4.16	----------	3.96 12
Sept.	3.15	0	2.66	0	2.66	.49	----------
Oct.	2.83	0	1.88	0	1.88	.95	----------
Nov.	3.22	0	1.35	0	1.35	1.87	----------
Dec.	2.35	0	[1] .39	0	.39	1.96	----------
Total	38.54	.03	32.54	5.61	38.18	11.06	10.70
1949–brome-alfalfa:							
Jan.	5.40	0	[1] .53	.69	1.22	4.18	----------
Feb.	2.90	0	[1] .72	1.15	1.87	1.03	----------
Mar.	4.17	0	1.77	1.72	3.49	.68	----------
Apr.	3.04	0	3.92	1.38	5.30	----------	2.26
May	2.60	.01	6.49	.60	7.10	----------	4.50
June	3.43	.01	5.49	.04	5.54	----------	2.11
July	8.24	.02	6.52	0	6.54	1.70	----------
Aug.	2.74	.01	4.63	0	4.64	----------	1.90
Sept.	3.38	.01	3.52	0	3.53	----------	.15
Oct.	1.01	0	2.67	0	2.67	----------	1.66
Nov.	1.49	0	.92	0	.92	.57	----------
Dec.	2.81	0	.18	0	.18	2.63	----------
Total	41.21	.06	37.36	5.58	43.00	10.79	12.58
1950–brome-alfalfa:							
Jan.	9.06	.01	.63	1.27	1.91	7.15	----------
Feb.	3.78	.01	[1] .68	2.46	3.15	.63	----------
Mar.	2.93	0	[1] 1.61	1.74	3.35	----------	.42
Apr.	4.38	0	2.38	1.83	4.21	.17	----------
May	4.50	.02	5.40	1.06	6.48	----------	1.98
June	2.08	0	4.83	.47	5.30	----------	3.22
July	6.51	.02	7.07	.03	7.12	----------	.61
Aug.	2.49	0	5.83	0	5.83	----------	3.34
Sept.	5.44	.10	3.89	0	3.99	1.45	----------
Oct.	1.50	0	2.80	0	2.80	----------	1.30
Nov.	6.23	0	[1] .77	0	.77	5.46	----------
Dec.	3.24	0	[1] 1.05	.13	1.18	2.06	----------
Total	52.14	.16	36.94	8.99	46.09	16.92	10.87

TABLE 29.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y101D, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1951–brome-alfalfa:							
Jan.	6.58	0.01	[1]1.75	2.57	4.33	2.25	----------
Feb.	4.22	0	[1]1.44	3.46	4.90	----------	0.68
Mar.	5.78	0	[1]1.45	3.42	4.87	.91	----------
Apr.	3.62	.01	2.47	2.73	5.21	----------	1.59
May	2.33	.01	6.20	1.06	7.27	----------	4.94
June	5.83	.02	4.40	.16	4.58	1.25	----------
July	3.07	0	7.75	.01	7.76	----------	4.60
Aug.	.48	0	3.34	0	3.34	----------	2.86
Sept.	2.72	0	3.22	0	3.22	----------	.50
Oct.	2.12	0	2.69	0	2.69	----------	.57
Nov.	5.34	0	[1].82	0	.82	4.52	----------
Dec.	5.85	0	[1]1.66	0	1.66	4.19	----------
Total	47.04	.05	37.19	13.41	50.65	13.12	15.83
1952–brome-alfalfa:							
Jan.	6.38	0	[1].74	1.69	2.43	3.95	----------
Feb.	3.06	.01	[1].97	2.29	3.27	----------	.21
Mar.	4.15	0	1.54	2.03	3.57	.58	----------
Apr.	4.56	0	3.67	1.83	5.50	----------	.94
May	4.99	.02	6.43	.87	7.32	----------	2.33
June	2.73	.01	5.11	.09	5.21	----------	2.48
July	4.34	.01	7.08	0	7.09	----------	2.75
Aug.	2.03	0	4.72	0	4.72	----------	2.69
Sept.	2.50	0	3.25	0	3.25	----------	.75
Oct.	.69	0	1.25	0	1.25	----------	.56
Nov.	1.03	0	[1].61	0	.61	[illegible].32	----------
Dec.	2.66	0	[1].32	0	.32	2.34	----------
Total	40.02	.05	35.69	8.80	44.54	8.19	12.71
1953–brome-alfalfa:							
Jan.	5.60	0	[1].46	0	.46	5.14	----------
Feb.	1.45	0	[1].70	0	.70	.75	----------
Mar.	3.54	0	[1]1.28	.22	1.50	2.04	----------
Apr.	2.71	0	2.30	.74	3.04	----------	.33
May	4.22	.01	5.60	.54	6.15	----------	1.93
June	2.36	.02	5.61	.03	5.66	----------	3.30
July	4.20	0	5.82	0	5.82	----------	1.62
Aug.	1.01	0	4.08	0	4.08	----------	3.07
Sept.	1.12	0	3.54	0	3.54	----------	2.42
Oct.	.57	0	1.43	0	1.43	----------	.86
Nov.	1.33	0	[1].52	0	.52	.81	----------
Dec.	2.56	0	[1].56	0	.56	2.00	----------
Total	30.67	.03	31.90	1.53	33.46	10.74	13.53
1954–brome-alfalfa:							
Jan.	2.82	.01	[1].47	0	.48	2.34	----------
Feb.	2.21	0	[1].89	0	.89	1.32	----------
Mar.	4.77	0	[1]2.04	0	2.04	2.73	----------
Apr.	3.29	0	3.61	0	3.61	----------	.32
May	2.44	0	5.38	0	5.38	----------	2.94
June	2.21	.01	4.48	0	4.49	----------	2.28
July	3.39	0	5.18	0	5.18	----------	1.79
Aug.	3.57	0	4.04	0	4.04	----------	.47
Sept.	1.42	0	2.77	0	2.77	----------	1.35
Oct.	6.24	0	1.87	0	1.87	4.37	----------
Nov.	1.56	0	[1].84	0	.84	.71	----------
Dec.	2.77	0	[1].42	0	.42	2.35	----------
Total	36.68	.02	31.99	0	32.01	13.82	9.15

TABLE 29.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y101D, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1955–brome-alfalfa:							
Jan.	1.82	0	[1] 0.67	0	0.67	1.15	
Feb.	3.57	.17	[1] .86	.12	1.15	2.42	
Mar.	5.87	0	[1] 2.04	1.05	3.09	1.98	
Apr.	3.89	.01	4.25	.44	4.70		0.81
May	1.70	0	6.22	.09	6.31		4.61
June	[2] 6.74	0	4.80	0	4.80	1.94	
July	3.82	0	6.26	0	6.26		2.44
Aug.	3.66	0	4.60	0	4.60		.94
Sept.	2.45	0	3.13	0	3.13		.68
Oct.	2.40	0	2.03	0	2.03	.37	
Nov.	[1] 3.54	0	[1] .77	0	.77	2.77	
Dec.	.35	0	[1] .37	0	.37		.02
Total	39.01	.18	36.00	1.70	37.88	10.63	9.50
1956–alfalfa-brome:							
Jan.	2.27	0	[1] .50	0	.50	1.77	
Feb.	5.65	.05	.43	1.45	1.93	3.72	
Mar.	5.27	0	1.68	2.67	4.35	.92	
Apr.	4.25	0	2.34	1.79	4.13	.12	
May	7.08	.01	4.66	2.19	6.86	.22	
June	5.51	.08	4.21	2.18	6.47		.96
July	6.24	.04	4.40	1.66	6.10	.14	
Aug.	4.13	.01	4.91	1.21	6.13		2.00
Sept.	1.67	0	3.23	.38	3.61		1.94
Oct.	1.16	0	1.78	.12	1.90		.74
Nov.	1.89	0	.82	.04	.86	1.03	
Dec.	3.99	0	[1] .54	.04	.58	3.41	
Total	49.11	.10	29.50	13.73	43.42	11.33	5.64
1957–birdsfoot trefoil:							
Jan.	2.06	.02	[1] .20	.83	1.05	1.01	
Feb.	1.74	.01	[1] .69	1.20	1.90		.16
Mar.	2.36	0	[1] 2.00	1.00	3.00		.73
Apr.	5.75	0	2.61	3.58	6.19		.44
May	4.35	.02	3.50	1.35	4.87		.52
June	10.62	.22	4.75	3.34	8.31	2.31	
July	3.38	0	5.69	2.02	7.71		4.33
Aug.	1.86	0	3.77	.56	4.33		2.47
Sept.	3.07	0	1.92	.19	2.11	1.86	
Oct.	1.82	0	1.38	.05	1.43	.39	
Nov.	3.16	0	.68	.07	.75	2.41	
Dec.	4.97	0	[1] .58	2.52	3.10	1.87	
Total	46.04	.27	27.77	16.80	44.84	9.85	8.65
1958–birdsfoot trefoil:							
Jan.	1.87	.05	[1] .21	1.45	1.71	0.16	
Feb.	1.20	.10	[1] .58	.85	1.53		.33
Mar.	1.52	0	[1] .81	1.05	1.86		.34
Apr.	4.05	.01	2.78	.94	3.73	.32	
May	3.24	0	5.34	2.25	7.59		4.35
June	4.30	.01	5.12	.72	5.85		1.55
July	9.49	.01	4.59	.29	4.89	4.60	
Aug.	2.90	0	6.06	.62	6.68		3.78
Sept.	3.30	0	3.36	.20	3.56		.26
Oct.	.35	0	2.18	.02	2.20		1.85
Nov.	3.37	0	[1] 1.35	.01	1.36	2.01	
Dec.	1.30	0	[1] .86	0	.86	.44	
Total	36.89	.18	33.24	8.40	41.82	7.53	12.46

TABLE 29.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y101D, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1959–birdsfoot trefoil:							
Jan.	6.24	0.09	[1] 0.57	1.31	1.97	4.27	
Feb.	3.76	.02	[1] .84	2.17	3.03	.73	----------
Mar.	2.79	.02	[1] 1.78	1.84	3.64	----------	0.85
Apr.	5.00	0	3.01	.96	3.97	1.03	----------
May	2.97	0	5.03	1.05	6.98	----------	4.01
June	4.44	.01	5.63	.41	6.05	----------	1.61
July	3.99	0	6.23	.07	6.30	----------	2.31
Aug.	2.40	0	4.62	.01	4.63	----------	2.23
Sept.	2.74	0	3.08	0	3.08	----------	.34
Oct.	6.21	0	2.39	0	2.39	3.82	----------
Nov.	3.20	0	[1] .79	0	.79	2.50	----------
Dec.	2.69	0	[1] .37	.03	.40	2.29	----------
Total	46.52	.14	35.24	7.85	43.23	14.64	11.35
1960–birdsfoot trefoil:							
Jan.	3.28	0	[1] .29	1.74	2.03	1.25	----------
Feb.	4.01	0	[1] .04	1.50	1.54	2.47	----------
Mar.	2.22	.01	[1] 2.15	1.65	3.81	----------	1.59
Apr.	2.03	0	3.79	1.58	5.37	----------	3.34
May	3.47	0	4.52	.70	5.22	----------	1.75
June	7.16	.02	6.40	.26	6.68	.48	----------
July	2.92	0	6.87	.05	6.92	----------	4.00
Aug.	6.70	.02	4.66	.01	4.69	2.01	----------
Sept.	.52	0	3.30	0	3.30	----------	2.78
Oct.	2.08	0	2.08	0	2.08	----------	0
Nov.	2.20	0	[1] .94	0	.94	1.26	----------
Dec.	2.19	0	[1] .63	0	.63	1.56	----------
Total	38.78	.05	35.67	7.49	43.21	9.03	13.46
1961–birdsfoot trefoil:							
Jan.	1.37	0	[1] .36	0	.36	1.01	----------
Feb.	5.17	0	[1] 1.44	.18	1.62	3.55	----------
Mar.	3.79	0	[1] .99	2.18	3.17	.62	----------
Apr.	7.97	.22	2.08	4.48	6.78	1.19	----------
May	2.84	0	5.20	1.31	6.51	----------	3.67
June	3.21	.01	5.05	.38	5.44	----------	2.23
July	5.73	0	5.26	.11	5.37	.36	----------
Aug.	2.37	0	5.40	.01	5.41	----------	3.04
Sept.	1.49	0	2.87	.01	2.88	----------	1.39
Oct.	2.42	0	2.24	0	2.24	.18	----------
Nov.	3.41	0	.90	0	.90	2.51	----------
Dec.	2.69	0	[1] .18	0	.18	2.51	----------
Total	42.46	.23	31.07	8.66	40.86	11.93	10.33
1962–birdsfoot trefoil:							
Jan.	3.48	0.31	[1] .31	.08	.70	2.78	----------
Feb.	4.10	.57	[1] .77	.83	2.17	1.93	----------
Mar.	3.52	.02	[1] 1.12	2.41	3.55	----------	.03
Apr.	1.73	0	2.44	1.49	3.93	----------	2.20
May	2.86	.01	5.71	.83	6.55	----------	3.69
June	1.84	0	4.25	.30	4.55	----------	2.71
July	2.72	0	4.56	.02	4.58	----------	1.86
Aug.	2.12	0	3.59	.01	3.60	----------	1.48
Sept.	5.36	0	2.88	0	2.88	2.48	----------
Oct.	2.39	0	2.25	0	2.25	.14	----------
Nov.	3.19	0	.74	0	.74	2.45	----------
Dec.	3.42	0	[1] −.34	0	−.34	3.76	----------
Total	36.73	91	28.28	5.97	35.16	13.54	11.97

[1] Some snow fell during the month; some values may be too high or too low because of drifting snow.
[2] Includes irrigation of 3.61 inches.

TABLE 30.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y102C, 1944–62*

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1944–meadow:							
Jan.	1.13	0	0.42	0	0.42	0.71	
Feb.	1.97	.02	.62	.01	.65	1.32	
March	6.98	.02	1.02	3.47	5.11	1.87	
Apr.	4.30	.01	1.96	3.22	5.19		0.89
May	2.49	0	4.42	.50	4.92		2.43
June	3.80	.05	4.40	.10	4.55		.75
July	2.72	.06	4.05	.02	4.13		1.41
Aug.	4.72	.16	4.19	0	4.35	.37	
Sept.	2.07	.04	2.73	0	2.77		.70
Oct.	1.90	.01	1.50	0	1.51	.39	
Nov.	1.48	0	.88	0	.88	.60	
Dec.	4.55	.06	[1] 1.17	.02	1.25	3.30	
Total	38.11	.43	27.96	7.34	35.73	8.56	6.18
1945–corn:							
Jan.	1.63	.08	[1] −.08	.26	.26	1.37	
Feb.	2.93	.02	[1] .82	2.22	2.86	.07	
Mar.	9.03	.19	1.99	7.74	9.92		.89
Apr.	4.86	.05	2.94	1.82	4.81	.07	
May	5.32	.20	4.19	1.83	6.22		.90
June	4.34	1.09	3.40	.34	4.83		.49
July	2.85	.08	4.50	.13	4.71		1.86
Aug.	4.23	.05	3.'1	.04	3.80		2.57
Sept.	9.66	2.03	2.96	0	4.99	4.67	
Oct.	2.74	.39	2.33	.25	2.07		.23
Nov.	3.85	.05	1.33	.67	2.05	1.80	
Dec.	2.40	.40	[1] .74	.93	2.07	.33	
Total	50.86	4.63	28.63	16.23	49.49	8.31	6.94
1946–wheat:							
Jan.	1.09	.05	[1] .86	1.08	1.09		.90
Feb.	4.63	.11	[1] 1.16	2.46	3.73	.90	
Mar.	2.61	.01	2.79	1.66	4.46		1.85
Apr.	1.87	0	4.43	.24	4.67		2.8
May	5.98	.02	4.84	.08	4.94	1.04	
June	6.72	.02	5.55	.07	5.64	1.08	
July	5.33	.04	5.22	.10	5.36		.03
Aug.	2.40	0	4.69	.12	4.81		2.41
Sept.	.88	0	2.45	.02	2.47		1.59
Oct.	4.38	.02	1.80	.03	1.85	2.53	
Nov.	2.74	.01	1.07	.04	1.12	1.62	
Dec.	2.83	.01	[1] .80	.15	.96	1.87	
Total	41.46	.29	35.66	6.05	42.00	9.04	9.58
1947–meadow:							
Jan.	5.35	.02	[1] .54	4.10	4.66	.69	
Feb.	1.15	.06	[1] .74	1.16	1.96		.81
Mar.	2.33	.11	1.59	.42	2.12	.2[illegible]	
Apr.	4.28	.01	2.19	2.01	4.21	.07	
May	6.43	.03	3.90	3.00	6.93		.50
June	5.65	.04	6.18	1.46	7.68		2.03
July	2.84	.01	5.36	.08	5.45		2.61
Aug.	3.76	.01	4.05	.02	4.08		.32
Sept.	3.13	0	4.92	.01	4.93		1.80
Oct.	1.04	0	2.57	0	2.57		1.53
Nov.	2.67	0	.73	.01	.74	1.93	
Dec.	1.40	0	.47	.01	.48	1.01	
Total	40.12	.29	33.24	12.28	45.81	3.91	9.60

TABLE 30.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y102C, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depleton	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1948–meadow:							
Jan.	3.42	0	0.36	0.01	0.37	3.05	----------
Feb.	3.14	.01	.44	.14	.59	2.55	----------
Mar.	4.80	.08	1.66	2.33	4.07	.73	----------
Apr.	5.17	.02	3.47	3.88	7.37	----------	2.20
May	3.65	0	6.68	.10	6.78	----------	3.13
June	5.05	.01	6.76	.01	6.78	----------	1.73
July	3.57	.01	5.73	.01	5.75	----------	2.18
Aug.	1.12	0	3.10	0	3.10	----------	1.98
Sept.	3.74	.01	3.03	0	3.04	.70	----------
Oct.	2.85	.01	1.93	.01	1.95	.90	----------
Nov.	3.23	0	1.25	.01	1.26	1.97	----------
Dec.	2.31	0	.43	.01	.44	1.87	----------
Total	43.05	.15	34.84	6.51	41.50	11.77	11.22
1949–corn:							
Jan.	5.54	.01	.56	.14	.71	4.83	----------
Feb.	2.85	.01	.90	1.35	2.26	.59	----------
Mar.	3.89	.01	1.56	2.02	3.59	.30	----------
Apr.	2.93	.01	3.19	.94	4.14	----------	1.21
May	3.01	.06	2.90	.46	3.42	----------	.41
June	3.40	.05	4.41	.32	4.78	----------	1.38
July	6.71	.16	7.21	.18	7.55	----------	.84
Aug.	2.68	0	4.84	.06	4.90	----------	2.22
Sept.	3.45	.01	2.23	0	2.24	1.21	----------
Oct.	1.03	0	1.62	.01	1.63	----------	.60
Nov.	1.55	0	1.31	.02	1.33	.22	----------
Dec.	2.94	0	.77	0	.77	2.17	----------
Total	39.98	.33	31.50	5.50	37.32	9.32	6.66
1950–wheat:							
Jan.	9.11	.06	.94	4.84	5.84	3.27	----------
Feb.	3.74	0	[1] .54	3.26	3.80	----------	.06
Mar.	3.01	.04	[1] 1.62	1.85	3.51	----------	.50
Apr.	4.44	.02	2.19	2.02	4.23	.21	----------
May	4.42	.01	5.62	.62	6.25	----------	1.83
June	2.27	0	5.11	.11	5.22	----------	2.95
July	6.98	.02	3.11	.04	3.17	3.81	----------
Aug.	2.14	0	3.93	.20	4.13	----------	1.99
Sept.	5.61	.01	3.53	1.75	5.29	.32	----------
Oct.	1.50	0	2.80	.07	2.87	----------	1.37
Nov.	6.41	0	[1] 1.25	.06	1.31	5.10	----------
Dec.	3.32	.02	[1] 1.11	2.93	4.06	----------	.74
Total	52.95	.15	31.75	17.75	49.68	12.71	9.44
1951–meadow:							
Jan.	6.41	.10	[1] 1.45	4.10	5.65	.76	----------
Feb.	4.83	.35	[1] 1.50	4.09	5.94	----------	1.11
Mar.	5.80	.06	[1] 1.43	3.63	5.12	.68	----------
Apr.	3.41	0	1.83	2.54	4.37	----------	.96
May	2.38	0	5.67	.51	6.18	----------	3.80
June	5.73	.01	5.01	.06	5.08	.65	----------
July	2.90	0	6.93	.01	6.94	----------	4.04
Aug.	.65	0	2.13	0	2.13	----------	1.48
Sept.	3.02	.01	3.13	0	3.14	----------	.12
Oct.	1.88	.01	2.32	.01	2.34	----------	.46
Nov.	5.04	.01	[1] .88	.01	.90	4.14	----------
Dec.	5.78	.03	[1] 1.38	.15	1.56	4.22	----------
Total	47.83	.58	33.66	15.11	49.35	10.45	11.97

TABLE 30.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y102C, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1952–meadow:							
Jan.	6.24	0.04	[1] 1.00	4.13	5.17	1.17	-----
Feb.	2.92	0	[1] .84	2.72	3.56	-----	0.64
Mar.	4.01	.04	[1] 1.23	2.50	3.77	.24	-----
Apr.	4.14	.02	2.81	1.93	4.76	-----	.62
May	3.92	.01	5.46	.37	5.84	-----	1.92
June	2.69	.02	5.67	.02	5.71	-----	3.02
July	3.94	.02	6.29	0	6.31	-----	2.37
Aug.	2.05	.01	3.80	0	3.81	-----	1.76
Sept.	2.56	.02	3.01	0	3.03	-----	.47
Oct.	.78	0	1.26	.01	1.27	-----	.49
Nov.	1.72	.01	[1] .74	0	.75	.97	-----
Dec.	2.64	0	[1] .44	0	.44	2.20	-----
Total	37.71	.19	32.55	11.68	44.42	4.58	11.29
1953–corn:							
Jan.	5.44	.01	[1] .65	0	.66	4.78	-----
Feb.	1.44	0	[1] .87	0	.87	.57	-----
Mar.	3.44	.01	[1] 1.38	.16	1.55	1.89	-----
Apr.	2.61	.01	2.42	.51	2.94	-----	.33
May	4.28	.02	3.28	1.24	4.54	-----	.26
June	2.36	.03	3.26	.43	3.72	-----	1.36
July	[2] 8.15	.02	6.79	.39	7.20	.95	-----
Aug.	[2] 4.69	.01	6.75	.22	6.98	-----	2.29
Sept.	1.10	0	3.45	.05	3.50	-----	2.40
Oct.	[2] 2.93	.01	1.40	.01	1.42	1.51	-----
Nov.	1.32	0	[1] 1.12	0	1.12	.20	-----
Dec.	2.69	.04	[1] 1.20	.01	1.25	1.44	-----
Total	40.45	.16	32.57	3.02	35.75	11.34	6.64
1954–wheat:							
Jan.	2.97	.23	[1] .78	.05	1.06	1.91	-----
Feb.	2.06	.05	[1] 1.09	.07	1.21	.85	-----
Mar.	4.43	.09	[1] 1.91	1.80	3.80	.63	-----
Apr.	2.82	.02	3.98	1.10	5.10	-----	2.28
May	2.20	0	5.95	.16	6.11	-----	3.91
June	2.31	0	4.11	.03	4.14	-----	1.83
July	[2] 4.45	.04	2.24	0	2.28	2.17	-----
Aug.	3.23	.02	4.38	.01	4.41	-----	1.18
Sept.	[2] 2.98	.01	3.83	0	3.84	-----	.86
Oct.	5.48	.02	2.16	0	2.18	3.30	-----
Nov.	1.43	0	[1] .83	0	.83	.60	-----
Dec.	2.68	.01	[1] .42	.01	.44	2.24	-----
Total	37.04	.49	31.68	3.23	35.40	11.70	10.06
1955–meadow:							
Jan.	1.70	0	[1] .81	.12	.93	.77	-----
Feb.	3.81	.13	[1] .82	2.29	3.24	.57	-----
Mar.	4.96	.14	[1] 1.08	4.02	5.24	-----	.28
Apr.	3.73	.02	3.53	.92	4.47	-----	.74
May	[2] 3.84	.01	6.60	.32	6.93	-----	3.09
June	[2] 5.99	.03	4.92	.03	4.98	1.01	-----
July	3.61	.01	6.17	.01	6.19	-----	2.58
Aug.	3.12	.02	5.79	0	5.81	-----	2.69
Sept.	2.36	0	3.02	0	3.02	-----	.66
Oct.	2.23	0	2.59	.01	2.60	-----	.37
Nov.	3.48	.02	[1] .79	.01	.82	2.66	-----
Dec.	.35	0	[1] .31	.01	.32	.03	-----
Total	39.18	.38	36.43	7.74	44.55	6.04	10.41

TABLE 30.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y102C, 1944-62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1956-meadow:							
Jan.	2.06	0	[1] 0.38	0	0.38	1.68	
Feb.	5.64	.04	.52	.48	1.04	4.60	
Mar.	5.37	.02	1.40	3.19	4.61	.76	
Apr.	4.08	.02	2.23	1.86	4.11		0.03
May	6.90	.01	5.38	1.50	6.89	.01	
June	4.52	.01	5.29	.70	6.00		1.48
July	5.96	.02	5.08	.25	5.35	.61	
Aug.	3.95	.01	6.14	.17	6.32		2.37
Sept.	1.60	0	3.31	.01	3.32		1.72
Oct.	1.08	0	3.31	0	3.31		2.23
Nov.	1.89	.04	1.54	0	1.58	.31	
Dec.	4.44	.03	[1] .60	.01	.64	3.80	
Total	47.49	.20	35.18	8.17	43.55	11.77	7.83
1957-corn:							
Jan.	2.36	.25	[1] .44	.01	.70	1.66	
Feb.	1.86	.03	[1] .58	0	.61	1.25	
Mar.	2.70	.04	[1] 1.68	1.29	3.01		.31
Apr.	5.45	.03	2.30	4.24	6.57		1.12
May	4.73	.73	3.28	.70	4.71	.02	
June	11.33	9.70	[2] 2.17	.50	12.37		1.04
July	3.69	2.91	[2] 4.14	.13	7.18		3.49
Aug.	2.23	1.83	[2] 2.40	.02	4.25		2.02
Sept.	3.78	.77	1.17	0	1.94	1.84	
Oct.	1.72	0	1.06	0	1.06	.66	
Nov.	3.07	.02	1.06	.01	1.09	1.98	
Dec.	4.75	.02	[1] .87	.66	1.55	3.20	
Total	47.67	16.33	21.15	7.56	45.04	10.61	7.98
1958-wheat:							
Jan.	1.80	.02	[1] .28	.96	1.26	.54	
Feb.	1.25	.12	[1] .57	.52	1.21	.04	
Mar.	1.42	.02	[1] .78	1.10	1.90		.48
Apr.	3.53	.02	2.40	1.00	3.42	.11	
May	2.77	.02	5.74	1.84	7.60		4.83
June	3.95	.01	5.02	.08	5.11		1.16
July	10.25	.05	3.55	.01	3.61	6.64	
Aug.	2.77	0	5.26	.20	5.46		2.69
Sept.	3.46	0	4.27	.09	4.36		.00
Oct.	.41	0	3.01	.01	3.20		2.61
Nov.	3.29	0	[1] 1.84	0	1.84	1.45	
Dec.	1.42	0	[1] .60	.01	.61	.81	
Total	36.32	.26	33.32	5.82	39.40	9.59	12.67
1959-meadow:							
Jan.	6.83	.03	[1] 0	1.02	1.05	5.78	
Feb.	4.75	.04	[1] 1.02	2.35	3.41	1.34	
Mar.	4.00	0	[1] 2.05	2.34	4.39		.39
Apr.	5.14	.01	2.44	1.24	3.69	1.45	
May	3.36	0	6.57	.81	7.38		4.02
June	5.34	.07	6.31	.06	6.44		1.10
July	5.34	.01	6.93	.01	6.95		1.61
Aug.	2.87	.02	4.88	0	4.90		2.03
Sept.	3.15	0	3.80	0	3.80		.65
Oct.	6.24	.01	2.78	0	2.79	3.45	
Nov.	3.52	0	[1] 1.11	.01	1.12	2.40	
Dec.	2.86	.01	[1] .62	.03	.66	2.20	
Total	53.40	.20	38.51	7.87	46.58	16.62	9.80

TABLE 30.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y102C, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1960–meadow:							
Jan.	3.35	0	[1] 0.38	2.40	2.78	0.57	
Feb.	4.98	.02	[1] .77	1.94	2.73	2.25	
Mar.	2.04	.08	[1] 1.25	2.65	3.98		1.94
Apr.	2.23	0	4.13	.96	5.09		2.86
May	3.42	0	4.87	.08	4.95		1.53
June	7.16	.17	5.68	.01	5.86	1.30	
July	2.99	.01	6.40	0	6.41		3.42
Aug.	5.97	.04	5.82	0	5.86	.11	
Sept.	.54	0	3.59	0	3.59		3.05
Oct.	2.15	0	1.84	0	1.84	.31	
Nov.	2.22	0	[1] .80	.01	.81	1.41	
Dec.	2.21	0	[1] .48	0	.48	1.73	
Total	39.26	.32	36.01	8.05	44.38	7.68	12.80
1961–corn:							
Jan.	1.41	.01	[1] .31	.01	.33	1.08	
Feb.	5.38	.15	[1] .27	.04	.46	4.92	
Mar.	3.76	.01	[1] .90	3.36	4.27		.51
Apr.	7.49	.02	1.97	5.35	7.34	.15	
May	2.58	.01	3.05	.62	3.68		1.10
June	3.40	.85	3.44	.33	4.62		1.22
July	5.76	.26	5.03	.17	5.46	.30	
Aug.	2.07	.02	5.81	.05	5.88		3.81
Sept.	1.25	0	2.80	.01	2.81		1.56
Oct.	2.43	.02	1.76	0	1.78	.65	
Nov.	3.52	.01	.96	0	.97	2.55	
Dec.	3.08	.08	[1] .30	0	.38	2.70	
Total	42.13	1.44	26.60	9.94	37.98	12.35	8.20
1962–wheat:							
Jan.	2.74	.81	[1] .67	.12	1.60	1.14	
Feb.	4.48	.48	[1] .98	1.43	2.89	1.59	
Mar.	4.37	.05	[1] 1.65	3.12	4.82		.45
Apr.	1.86	.03	2.47	1.16	3.66		1.80
May	3.06	.02	6.29	.29	6.60		3.54
June	2.02	.01	4.30	.05	4.36		2.34
July	2.99	1.11	1.15	.02	2.28	.71	
Aug.[4]							
Sept.[4]							
Oct.[4]							
Nov.[4]							
Dec.[4]							

[1] Some snow fell during the month; some values may be too high or too low because of drifting snow.
[2] Includes irrigation: July 1953, 2.93 inches; Aug. 1953, 2.90 inches; Oct. 1953, 2.24 inches; July 1954, 1.13 inches; Sept. 1954, 1.65 inches; May 1955, 2.26 inches; June 1955, 3.07 inches.
[3] Largely transpiration. Plastic cover on ground surface prevented evaporation, June 6 to Sept. 9.
[4] Lysimeter not in operation, soil covered with plastic moisture barrier, or work on grease seal.

TABLE 31.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y103A, 1944–62*

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapo-transpiration	Percolation	Total	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1944–meadow:							
Jan.	1.15	0	0.41	0.04	0.45	0.70	----------
Feb.	2.14	0	1.00	.25	1.25	.89	----------
Mar.	6.10	0	2.66	2.93	5.59	.51	----------
Apr.	3.83	0	2.56	1.67	4.23	----------	0.40
May	2.40	0	3.80	.07	3.87	----------	1.47
June	3.15	.01	5.18	.04	5.23	----------	2.08
July	2.46	.01	4.61	.02	4.64	----------	2.18
Aug.	4.39	.02	4.20	.02	4.24	.15	----------
Sept.	1.84	.01	2.69	.01	2.71	----------	.87
Oct.	1.81	0	1.25	.01	1.26	.55	----------
Nov.	1.25	0	.62	0	.62	.63	----------
Dec.	4.54	.01	[1] 1.39	0	1.40	3.14	----------
Total	35.06	.06	30.37	5.06	35.49	6.57	7.00
1945–corn:							
Jan.	2.04	.04	[1] .59	0	.63	1.41	----------
Feb.	2.66	.01	[1] .83	1.37	2.21	.45	----------
Mar.	8.11	.07	2.23	5.47	7.77	.34	----------
Apr.	4.89	0	3.46	1.37	4.83	.06	----------
May	4.82	.01	4.96	.78	5.75	----------	.93
June	4.37	.24	4.11	.06	4.41	----------	.04
July	2.71	.02	5.72	.02	5.76	----------	3.05
Aug.	1.04	0	4.21	.01	4.22	----------	3.18
Sept.	9.42	.01	2.28	.55	2.84	6.58	----------
Oct.	2.78	.01	2.45	.43	2.89	----------	.11
Nov.	3.61	0	1.54	.76	2.30	1.31	----------
Dec.	2.15	.01	1.11	.18	1.30	.85	----------
Total	48.60	.42	33.49	11.00	44.91	11.00	7.31
1946–wheat:							
Jan.	0.89	0	[1] .88	.80	1.68	----------	.79
Feb.	4.11	.01	[1] 1.84	2.20	4.05	.06	----------
Mar.	2.46	0	3.00	1.03	4.03	----------	1.57
Apr.	1.59	0	4.05	.06	4.11	----------	2.52
May	5.92	0	4.98	.03	5.01	.91	----------
June	7.16	.01	6.10	.50	6.61	.55	----------
July	5.17	.01	6.38	.04	6.43	----------	1.26
Aug.	2.47	0	5.09	.02	5.11	----------	2.64
Sept.	.90	0	2.58	.01	2.59	----------	1.69
Oct.	4.42	.01	1.68	.01	1.70	2.72	----------
Nov.	2.78	0	.92	.01	.93	1.85	----------
Dec.	2.80	0	.80	.28	1.08	1.72	----------
Total	40.67	.04	38.30	4.99	43.33	7.81	10.47
1947–meadow:							
Jan.	5.28	0	[1] 1.02	3.32	[illegible]	.94	----------
Feb.	1.12	.02	[1] .66	.28	[illegible]	.16	----------
Mar.	2.30	.03	1.80	.58	[illegible]	----------	.17
Apr.	4.43	0	2.38	1.90	4.28	.15	----------
May	6.44	.01	4.11	2.66	6.78	----------	.34
June	5.79	.02	6.45	1.11	7.58	----------	1.79
July	3.03	.01	5.15	.05	5.21	----------	2.18
Aug.	3.70	.02	4.06	.03	4.11	----------	.41
Sept.	3.18	0	4.68	.02	4.70	----------	1.52
Oct.	1.21	0	2.31	.01	2.32	----------	1.11
Nov.	2.74	0	.73	.01	.74	2.00	----------
Dec.	1.52	0	.38	0	.38	1.14	----------
Total	40.74	.11	33.79	9.97	43.87	4.39	7.52

TABLE 31.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y103A, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1948–meadow:							
Jan.	3.12	0	[1] 0.31	0.01	0.32	2.80	
Feb.	3.23	0	[1] .88	1.54	2.42	.81	
Mar.	4.96	.02	1.98	2.19	4.19	.77	
Apr.	4.89	.02	4.03	2.42	6.47		1.58
May	3.81	.01	6.54	.10	6.65		2.84
June	5.39	.02	7.26	.02	7.30		1.91
July	3.56	.01	5.65	.01	5.67		2.11
Aug.	.99	0	3.14	.01	3.15		2.16
Sept.	3.91	.01	2.83	0	2.84	1.07	
Oct.	2.72	.01	1.71	0	1.72	1.00	
Nov.	3.00	0	.88	0	.88	2.12	
Dec.	2.37	0	.41	0	.41	1.96	
Total	41.95	.10	35.62	6.30	42.02	10.53	10.60
1949–corn:							
Jan.	5.49	0	[1] .79	1.96	2.75	2.74	
Feb.	2.87	.01	[1] 1.05	1.59	2.65	.22	
Mar.	3.95	0	1.89	1.42	3.31	.64	
Apr.	2.98	0	3.24	.37	3.61		.63
May	3.04	.02	3.77	.14	3.93		.89
June	3.40	.01	5.23	.01	5.25		1.85
July	8.90	.19	8.55	.05	8.79	.11	
Aug.	2.75	.01	5.12	0	5.13		2.38
Sept.	3.43	0	2.12	0	2.12	1.31	
Oct.	1.04	0	1.41	0	1.41		.37
Nov.	1.59	0	1.13	0	1.13	.46	
Dec.	3.01	.01	.65	0	.66	2.35	
Total	42.45	.25	34.95	5.54	40.74	7.83	6.12
1950–wheat:							
Jan.	8.59	.03	1.18	4.76	5.97	2.62	
Feb.	3.59	.01	[1] .92	2.21	3.14	.45	
Mar.	2.94	0	[1] 1.96	1.25	3.21		.27
Apr.	4.54	.01	2.55	1.63	4.19	.35	
May	4.70	.01	6.11	.13	6.25		1.55
June	2.03	0	5.85	.04	5.89		3.86
July	6.66	.01	3.73	.02	3.76	2.90	
Aug.	2.12	0	4.85	.02	4.87		2.75
Sept.	5.58	.01	3.76	.04	3.81	1.77	
Oct.	1.58	0	2.57	.02	2.59		1.01
Nov.	6.23	0	[1] 1.47	.09	1.56	4.67	
Dec.	3.41	.01	[1] 1.51	2.67	4.19		.78
Total	51.97	.09	36.46	12.88	49.43	12.76	10.22
1951–meadow:							
Jan.	5.65	.04	[1] 1.34	3.62	5.00	.65	
Feb.	4.30	.12	[1] 1.86	3.47	5.45		1.15
Mar.	5.71	.03	[1] 1.95	3.30	5.28	.43	
Apr.	3.58	.01	2.22	1.91	4.14		.56
May	2.62	.01	5.73	.17	5.91		3.29
June	5.81	.02	5.22	.06	5.30	.51	
July	3.04	.02	6.73	.03	6.78		3.74
Aug.	.75	0	2.27	.02	2.29		1.54
Sept.	3.12	.01	3.01	.01	3.03	.09	
Oct.	1.94	0	2.20	.01	2.21		.27
Nov.	5.04	0	[1] .77	.01	.78	4.26	
Dec.	5.92	.01	[1] 1.55	1.09	2.65	3.27	
Total	47.48	.27	34.85	13.70	48.82	9.21	10.55

TABLE 31.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y103A, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1952–meadow:							
Jan.	5.54	0.03	[1] 1.32	3.65	5.00	0.54	
Feb.	3.02	.02	[1] 1.33	1.86	3.21		0.19
Mar.	4.02	.03	[1] 1.86	1.92	3.81	.21	
Apr.	4.39	.02	3.52	1.58	5.12		.73
May	4.42	0	6.07	.07	6.14		1.72
June	2.79	.02	5.19	.02	5.23		2.44
July	4.15	.02	6.36	.02	6.40		2.25
Aug.	2.12	.01	3.86	.01	3.88		1.76
Sept.	2.59	.01	3.05	0	3.06		.47
Oct.	.78	0	1.13	0	1.13		.35
Nov.	1.94	.01	[1] .73	0	.74	1.20	
Dec.	2.73	.01	[1] .51	.01	.53	2.20	
Total	38.49	.18	34.93	9.14	44.25	4.15	9.91
1953–corn:							
Jan.	5.64	.02	[1] .80	.18	1.00	4.64	
Feb.	1.49	0	[1] .87	.34	1.21	.28	
Mar.	3.48	.01	[1] 1.64	.98	2.63	.85	
Apr.	2.87	0	2.71	.50	3.21		.34
May	4.20	.02	4.35	.42	4.79		.59
June	2.69	.02	4.21	.02	4.25		1.56
July	5.20	0	7.34	.01	7.35		2.15
Aug.	1.74	.01	4.64	.01	4.66		2.92
Sept.	1.18	0	1.38	0	1.38		.20
Oct.	.72	0	.65	.01	.66	.06	
Nov.	1.35	0	[1] .44	.01	.45	.90	
Dec.	2.63	.02	[1] 1.02	.02	1.06	1.57	
Total	33.19	.10	30.05	2.50	32.65	8.30	7.76
1954–wheat:							
Jan.	2.96	.11	[1] .70	.04	.85	2.11	
Feb.	2.17	.02	[1] .99	.01	1.02	1.15	
Mar.	5.12	.08	[1] 2.70	.24	3.02	2.10	
Apr.	3.29	.07	3.26	.26	3.59		.30
May	2.40	0	6.15	.05	6.20		3.80
June	2.09	.01	5.33	.01	5.35		3.26
July	3.37	.01	2.38	.01	2.40	.97	
Aug.	3.49	.01	4.22	.01	4.24		.75
Sept.	1.43	0	1.86	0	1.86		.43
Oct.	5.94	.02	1.76	0	1.78	4.16	
Nov.	1.58	0	[1] .93	0	.93	.65	
Dec.	2.82	0	[1] .42	.01	.43	2.39	
Total	36.66	.33	30.70	.64	31.67	13.53	8.54
1955–meadow:							
Jan.	2.15	0	[1] .59	.08	.67	1.48	
Feb.	3.87	.02	[1] 1.43	1.93	3.38	.49	
Mar.	5.13	.02	[1] 2.40	2.68	5.10	.03	
Apr.	3.97	0	4.23	.35	4.58		.61
May	1.82	0	7.10	.11	7.21		5.39
June	3.14	0	4.03	.03	4.06		.92
July	3.45	.01	4.61	.02	4.64		1.19
Aug.	3.53	.01	4.68	.01	4.70		1.17
Sept.	2.43	0	2.57	.01	2.58		.15
Oct.	2.42	0	2.52	.01	2.53		.11
Nov.	3.60	0	[1] .85	.02	.87	2.73	
Dec.	.39	0	[1] .35	.02	.37	.02	
Total	35.90	.06	35.36	5.27	40.69	4.75	9.54

TABLE 31.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y103A, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1956–meadow:							
Jan.	2.25	0	[1] 0.41	0.01	0.42	1.83	
Feb.	5.86	.01	.87	1.22	2.10	3.76	
Mar.	6.08	0	2.62	2.30	4.92	1.16	
Apr.	4.36	.01	2.79	1.16	3.96	.40	
May	7.13	.01	6.48	.65	7.14		0.01
June	5.17	.02	5.79	.73	6.54		1.37
July	6.24	.01	5.73	.23	5.97	.27	
Aug.	4.17	.01	6.70	.03	6.74		2.57
Sept.	1.78	0	3.31	.01	3.32		1.54
Oct.	1.19	0	2.92	.01	2.93		1.74
Nov.	1.91	0	1.27	.01	1.28	.63	
Dec.	4.08	.02	[1] .68	.01	.71	3.37	
Total	50.22	.09	39.57	6.37	46.03	11.42	7.23
1957–corn:							
Jan.	2.52	.07	[1] .66	.18	.91	1.61	
Feb.	1.94	.02	[1] .80	.24	1.06	.88	
Mar.	2.61	.02	[1] 1.99	.49	2.50	.11	
Apr.	5.47	.04	3.43	2.74	6.21		.74
May	4.46	.16	3.82	.56	4.54		.08
June	10.72	1.69	5.79	1.55	9.03	1.69	
July	3.49	0	7.96	.08	8.04		4.55
Aug.	1.94	.02	4.56	.02	4.60		2.66
Sept.	3.91	.08	1.31	.01	1.40	2.51	
Oct.	1.92	.01	1.06	.02	1.09	.83	
Nov.	3.10	.01	1.07	.01	1.09	2.01	
Dec.	4.68	.05	[1] 1.13	1.24	2.42	2.26	
Total	46.76	2.17	33.58	7.14	42.89	11.90	8.03
1958–wheat:							
Jan.	2.04	.03	[1] .54	.27	.84	1.20	
Feb.	1.25	.08	[1] .86	.40	1.34		.09
Mar.	1.51	.02	[1] 1.34	.84	2.20		.69
Apr.	4.03	.01	3.15	.66	3.82	.24	
May	3.08	.01	6.85	1.13	7.99		4.91
June	4.23	0	5.53	.06	5.59		1.36
July	9.74	.06	3.48	.04	3.58	6.16	
Aug.	2.96	0	6.39	.22	6.61		3.65
Sept.	3.39	0	4.43	.03	4.46		1.07
Oct.	.32	0	2.43	.02	2.45		2.13
Nov.	2.92	0	[1] 1.20	.01	1.21	1.71	
Dec.	1.40	.02	[1] .82	.02	.86	.54	
Total	36.90	.23	37.02	3.70	40.95	9.85	13.90
1959–meadow:							
Jan.	6.95	.02	[1] 1.42	.44	1.88	5.07	
Feb.	4.09	.02	[1] 1.67	1.68	3.37	.72	
Mar.	2.70	.01	[1] 2.24	.98	3.23		.53
Apr.	5.02	.02	2.77	1.23	4.02	1.00	
May	3.36	.01	6.37	.32	6.70		3.34
June	4.77	.03	6.17	.05	6.25		1.48
July	4.07	0	6.36	.04	6.40		2.33
Aug.	2.58	.01	4.04	.02	4.07		1.49
Sept.	3.13	.01	3.13	.01	3.15		.02
Oct.	6.24	.01	2.37	0	2.38	3.86	
Nov.	3.51	.01	[1] 1.27	.01	1.29	2.22	
Dec.	2.87	.01	[1] .97	.33	1.31	1.56	
Total	49.29	.16	38.78	5.11	44.05	14.43	9.19

TABLE 31.—*Monthly summary of accretion, depletion, and storage of soil water as determined by weighing lysimeter Y103A, 1944–62*—Continued

Year, crop, and month	Accretion	Depletion				Storage in 8-foot profile	
	Precipitation	Runoff	Evapotranspiration	Percolation	Total depletion	Net increase	Net decrease
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1960–meadow:							
Jan.	3.25	0.01	[1] 0.47	1.44	1.82	1.33	
Feb.	5.23	.04	[1] 1.10	.92	2.06	3.17	
Mar.	2.20	.07	[1] 1.90	.94	2.91		0.71
Apr.	2.16	0	3.97	.43	4.40		2.24
May	3.67	0	5.34	.05	5.39		1.72
June	7.50	.07	5.80	.05	5.92	1.58	
July	3.24	.02	6.42	.02	6.46		3.22
Aug.	6.93	.04	5.92	.01	5.97	.96	
Sept.	.47	0	4.17	0	4.17		3.70
Oct.	2.24	0	2.09	0	2.09	.15	
Nov.	2.28	.01	[1] .86	0	.87	1.41	
Dec.	2.24	0	[1] .57	0	.57	1.67	
Total	41.41	.26	38.61	3.86	42.73	10.27	11.69
1961–corn:							
Jan.	1.53	.01	[1] .01	0	.02	1.51	
Feb.	6.82	.02	[1] 1.69	.39	2.10	4.72	
Mar.	3.79	.01	[1] 3.10	2.37	5.48		1.69
Apr.	7.53	.08	3.02	4.03	7.13	.40	
May	2.69	.01	3.55	.20	3.76		1.07
June	3.52	.45	4.40	.12	4.97		1.45
July	5.92	.02	5.69	.04	5.75	.17	
Aug.	2.27	.01	6.30	.03	6.34		4.07
Sept.	1.56	0	3.24	.02	3.26		1.70
Oct.	2.55	0	1.22	.01	1.23	1.32	
Nov.	3.44	0	[1] .85	.01	.86	2.58	
Dec.	2.99	.01	[1] .77	.01	.79	2.20	
Total	44.61	.62	33.84	7.23	41.69	12.90	9.98
1962–wheat:							
Jan.	3.81	.06	[1] 1.17	.29	1.52	2.29	
Feb.	4.49	.07	[1] 2.17	1.27	3.51	.98	
Mar.	4.12	.03	[1] 2.75	2.21	4.99		.87
Apr.	2.02	.01	2.95	1.25	4.21		2.19
May	3.24	0	7.41	.11	7.52		4.28
June	2.43	0	4.89	.04	4.93		2.50
July	2.93	.02	2.08	.04	2.14	.79	
Aug.	2.16	.03	3.27	.01	3.31		1.15
Sept.	5.73	.02	3.30	.01	3.33	2.40	
Oct.	2.59	.01	2.10	0	2.11	.48	
Nov.	3.43	.03	.83	0	.86	2.57	
Dec.	3.06	.09	[1] .97	0	1.06	2.00	
Total	40.01	.37	33.89	5.23	39.49	11.51	10.99

[1] Some snow fell during the month; some values may be too high or too low because of drifting snow.

TABLE 32.—*Summary of farming operations and yields for lysimeters in lysimeter battery Y101, 1956–62*

Year	Lysimeter	Cover	First cutting		Second cutting	
			Date	Yield	Date	Yield
				Tons/acre		*Tons/acre*
1956	Y101A	Poverty grass	June 6	0.35	July 19	0.17
	Y101B	do	do	.34	do	.20
	Y101C	Bluegrass	do	.63	do	.26
	Y101D	Alfalfa-brome	do	1.45	do	.23
1957	Y101A	Poverty grass	June 12	.79	Aug. 14	.65
	Y101B	do	do	.74	do	.82
	Y101C [1]	Bluegrass	do	1.01	do	.73
	Y101D [1,2]	Birdsfoot trefoil	July 17	.58	do	1.13
1958	Y101A	Poverty grass	July 9	.60	Sept. 16	.50
	Y101B	do	do	.68	do	.57
	Y101C	Bluegrass	do	.52	do	.96
	Y101D	Birdsfoot trefoil	do	.91	do	1.55
1959	Y101A	Poverty grass	June 17	.38	Aug. 19	.50
	Y101B	do	do	.30	do	.58
	Y101C	Bluegrass	do	.83	do	.55
	Y101D	Birdsfoot trefoil	do	1.75	do	1.63
1960	Y101A	Poverty grass	June 20	.28	Aug. 23	.26
	Y101B	do	do	.31	do	.31
	Y101C	Bluegrass	do	.99	do	.27
	Y101D	Birdsfoot trefoil	do	2.06	do	.70
1961	Y101A	Poverty grass	June 13	.26	Aug. 30	.27
	Y101B	do	do	.17	do	.17
	Y101C	Bluegrass	do	.52	do	.31
	Y101D	Birdsfoot trefoil	do	1.40	do	.72
1962	Y101A	Poverty grass	June 14	.21	Aug. 22	.04
	Y101B	do	do	.15	do	.02
	Y101C	Bluegrass	do	.33	do	.02
	Y101D	Birdsfoot trefoil	do	1.38	do	.45

[1] Fertilized with 300 lb./acre 5–20–20, Apr. 15.
Seeded 8 lb./acre birdsfoot trefoil, Apr. 15.

TABLE 33.—*Summary of farming operations and yields for lysimeters in lysimeter battery Y102, 1956–62*

Year	Lysimeter	Crop	Farming operations: On all lysimeters	Farming operations: Additional practices	Date of harvest	Yield per acre
						Tons
1956	Y102A	Second-year meadow.	Agricultural lime 1 ton/acre, Nov. 19.		June 6 July 19 Sept. 4	2.68 2.01 1.78
	Y102B	do	do		June 6 July 19 Sept. 4	3.07 2.01 1.89
	Y102C	do	do		June 6 July 19 Sept. 4	2.54 2.00 1.78
						Bushels
1957	Y102A	Corn to wheat	Sod spaded Apr. 26; corn planted May 2; fertilized (180 lb/acre 5–20–20) May 2; cultivated May 29; rototilled and seeded (2 bu./acre wheat; 3 lb./acre timothy) Oct. 1; fertilized (180 lb./acre 5–20–20) Oct. 1; manure applied (10 tons/acre) Nov. 25.	Cultivated June 20; stalks chopped and returned to lysimeter Sept. 23.	Sept. 9	169
	Y102B	do	do	Plastic cover placed on surface of lysimeter June 5; stalks chopped and returned to lysimeter Sept. 23.	do	182
	Y102C	do	do	Plastic cover placed on surface of lysimeter June 5; stalks chopped and returned to lysimeter Sept. 15.	do	125
1958	Y102A	Wheat to meadow.	Seeded (6 lb./acre alfalfa; 3 lb./acre red clover; 3 lb./acre timothy) April 4.		July 24	45.6
	Y102B	do	do		do	40.6
	Y102C	do	do		do	42.1
						Tons
1959	Y102A	First-year meadow.			June 11 Aug. 3	2.70 1.98
	Y102B	do			June 11 Aug. 3	2.43 1.86
	Y102C	do			June 11 Aug. 3	2.35 2.32
1960	Y102A	Second-year meadow.			June 6 July 22	4.21 2.24
	Y102A	do			June 6 July 22	4.86 2.62
	Y102C	do			June 6 July 22	3.77 2.20
						Bushels
1961	Y102A	Corn to wheat	Manured (10 tons/acre) Mar. 29; sod spaded May 12; corn planted, fertilized (180 lb./acre 5–20–20) May 16; cultivated June 14, June 22, July 7; seeded (2 bu./acre wheat; 3 lb/acre timothy) Oct. 17; fertilized (180 lb./acre 5–20–20) Oct. 17.		Oct. 9	154
	Y102B	do	do		do	157
	Y102C	do	do		do	166
1962	Y102A	Wheat to meadow.	Seeded (6 lb./acre alfalfa; 3 lb./acre red clover; 3 lb./acre timothy) Mar. 28.	Manured (12 tons/acre) Jan. 23.	July 9	52.3
	Y102B	do	do	do	do	48.9
	Y102C	do	do	Manured (12 tons/acre) Mar. 1.	do	48.9

TABLE 34.—*Summary of farming operations and yields for lysimeters in lysimeter battery Y103, 1956–62*

Year	Lysimeter	Crop	Farming operations: On all lysimeters	Farming operations: Additional practices	Date of harvest	Yield per acre
						Tons
1956	Y103A	Second-year meadow.			June 6	2.86
					July 19	2.10
					Sept. 5	1.80
	Y103B	do			June 6	2.35
					July 19	2.06
					Sept. 5	1.82
	Y103C	do			June 6	1.13
					July 19	1.18
					Sept. 5	1.91
	Y103D	do			June 6	1.92
					July 19	1.53
					Sept. 5	1.18
						Bushels
1957	Y103A	Corn to wheat	Sod spaced Apr. 26; *corn planted* May 2; cultivated May 29, June 20; stalks chopped and returned to soil Oct. 1.	Fertilized (180 lb./acre 5-20-20) May 2 seeded (2 bu./acre wheat; 3 lb./acre timothy) Oct. 2; fertilized (180 lb./acre 5-20-20) Oct. 2; manure (10 tons/acre) Nov. 25.	Sept. 16	149
	Y103B	do	do	do	do	150
	Y103C	do	do	Fertilized (60 lb./acre 5-20-20) May 2; seeded (2 bu./acre wheat; 3 lb./acre timothy) Oct. 2; fertilized (100 lb./acre 5-20-20) Oct. 2; manured (7.5 tons/acre) Nov. 25.	do	118
	Y103D	do	do	do	do	113
1958	Y103A	Wheat to meadow.		Seeded (6 lb./acre alfalfa; 3 lb/acre red clover; 3 lb./acre timothy) Apr. 4.	July 24	56.0
	Y103B	do		do	do	47.4
	Y103C	do		Seeded (3 lb./acre alsike; 3 lb./acre timothy; 6 lb./acre red clover) Apr. 4.	do	42.8
	Y103D	do		do	do	42.0
						Tons
1959	Y103A	First-year meadow.			June 11	2.19
					Aug. 3	2.12
	Y103B	do			June 11	2.47
					Aug. 3	1.92
	Y103C	do			June 11	1.66
					Aug. 3	1.38
	Y103D	do			June 11	1.76
					Aug. 3	1.86
						Tons
1960	Y103A	Second-year meadow.			June 6	2.92
					July 22	1.65
	Y103B	do			June 6	3.51
					July 22	1.65
	Y103C	do			June 6	2.09
					July 22	.50
	Y103D	do			June 6	2.39
					July 22	.76

TABLE 34.—*Summary of farming operations and yields for lysimeters in lysimeter battery Y103, 1956–62*—Continued

Year	Lysimeter	Crop	Farming operations		Date of harvest	Yield per acre
			On all lysimeters	Additional practices		
						Bushels
1961	Y103A	Corn to wheat	Sod spaded May 12; corn planted May 16; corn cultivated June 14, 22, July 5; seeded (2 bu./acre wheat; 3 lbs./acre timothy) Oct. 18.	Manured (10 tons/acre May 29; fertilized (180 lb./acre 5-20-20) May 16; fertilized (180 lb./acre 5-20-20) Oct. 18.	Oct. 9	170
	Y103B	do	do	do	do	158
	Y103C	do	do	Manured (7.5 tons/acre) Mar. 29; fertilized (50 lb./acre 5-20-20) May 16; fertilized (100 lb./acre 5-20-20) Oct. 18.	do	129
	Y103D	do	do	do	do	144
1962	Y103A	Wheat to meadow	Manured (12 tons/acre) Jan. 23.	Seeded (6 lb./acre alfalfa; 3 lb./acre red clover; 3 lb./acre timothy) Mar. 29.	July 11	68.7
	Y103B	do	do	do	do	66.3
	Y103C	do	do	Seeded (6 lb./acre red clover; 3 lb./acre timothy; 3 lb./acre alsike) Mar. 29.	do	29.8
	Y103D	do	do	do	do	34.8

TABLE 35.—*Water budget for corn seasons, Y102C and Y103A, 1945–61*

LYSIMETER Y102C

Period [1]	Item	Apr. [2]	May [2]	June	July	Aug.	Sept. [2]	Oct. [2]	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
May 1 to Sept. 28, 1945.	Rainfall		5.32	4.34	2.85	1.23	9.33		23.07
	Runoff		.20	1.09	.08	.05	2.02		3.44
	ET		4.19	3.40	4.50	3.71	2.82		18.62
	Percolation		1.83	.34	.13	.04	0		2.34
	ΔSoil moisture		−.90	−.49	−1.86	−2.57	4.49		−1.33
May 7 to Sept. 21, 1949.	Rainfall		3.01	3.40	6.71	2.68	2.11		17.91
	Runoff		.06	.05	.16	0	0		.27
	ET		2.42	4.41	7.21	4.84	1.75		20.63
	Percolation		.41	.32	.18	.06	0		.97
	ΔSoil moisture		.12	−1.38	−.84	−2.22	.36		−3.06
May 1 to Sept. 21, 1953.	Rainfall		4.28	2.36	[3] 8.15	[4] 4.60	1.10		[3,4] 20.58
	Runoff		.02	.03	.02	.01	0		.08
	ET		3.28	3.26	6.79	6.75	2.03		23.01
	Percolation		1.24	.43	.30	.22	.05		2.33
	ΔSoil moisture		−.26	−1.36	.95	−2.29	−1.88		−4.84
Apr. 26 to Sept. 16, 1957.	Rainfall	0.09	4.73	11.33	3.69	2.23	2.62		24.69
	Runoff	0	.73	[5] 9.70	[5] 2.91	[5] 1.83	[5] .74		[5] 15.91
	ET	.46	3.28	[5] 2.17	[5] 4.14	[5] 2.40	[5] .39		[5] 12.64
	Percolation	.11	.70	.50	.13	.02	0		1.46
	ΔSoil moisture	−.48	.02	−1.04	−3.49	−2.02	1.49		−5.52
May 12 to Oct. 9, 1961.	Rainfall		1.13	3.40	5.76	2.07	1.25	0.86	14.47
	Runoff		.01	.85	.26	.02	0	0	1.14
	ET		1.29	3.44	503	5.81	2.80	.39	18.76
	Percolation		.36	.33	.17	.05	.01	0	.92
	ΔSoil moisture		−.53	−1.22	.30	−3.81	−1.56	.47	−6.35

TABLE 35.—*Water budget for corn seasons, Y102C and Y103A, 1945–61*—Continued

LYSIMETER Y103A

Period[1]	Item	Apr.[2]	May[3]	June	July	Aug.	Sept.[3]	Oct.[2]	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Apr. 30 to Oct. 2, 1945.	Rainfall	0.26	4.82	4.37	2.71	1.04	9.42	0.96	23.60
	Runoff	0	.01	.24	.02	0	.01	0	.28
	ET	.14	4.96	4.11	5.72	4.21	2.28	.16	21.58
	Percolation	.01	.78	.06	.02	.01	.55	.14	1.57
	ΔSoil moisture	.11	−.93	−.04	−3.05	−3.18	6.58	.68	.17
May 6 to Sept. 21, 1949.	Rainfall	--------	3.01	3.40	8.98	2.75	1.90	--------	19.96
	Runoff	--------	.02	.01	.19	.01	0	--------	.23
	ET	--------	3.07	5.23	8.55	5.12	1.64	--------	23.61
	Percolation	--------	.13	.01	.05	0	0	--------	.19
	ΔSoil moisture	--------	−.21	−1.85	.11	−2.38	.26	--------	−4.07
May 1 to Sept. 21, 1953.	Rainfall	--------	4.20	2.69	5.20	1.74	1.18	--------	15.01
	Runoff	--------	.02	.02	0	.01	0	--------	.05
	ET	--------	4.25	4.21	7.34	4.64	1.09	--------	21.53
	Percolation	--------	.42	.02	.01	.01	0	--------	.46
	ΔSoil moisture	--------	−.49	−1.56	−2.15	−2.92	.09	--------	−7.03
Apr. 26 to Sept. 16, 1957.	Rainfall	.09	4.46	10.72	3.49	1.94	2.62	--------	23.32
	Runoff	0	.16	1.69	0	.02	.08	--------	1.95
	ET	.64	3.82	5.79	7.86	4.56	.58	--------	[illegible]
	Percolation	.02	.56	1.55	.08	.02	.01	--------	2.24
	ΔSoil moisture	−.57	−.08	1.69	−4.55	−2.66	1.95	--------	−4.22
May 12 to Oct. 9, 1961.	Rainfall	--------	1.54	3.52	5.92	2.27	1.56	.90	15.71
	Runoff	--------	0	.45	.02	.01	0	0	.48
	ET	--------	2.13	4.40	5.69	6.30	3.24	.30	22.06
	Percolation	--------	.07	.12	.04	.03	.02	0	.28
	ΔSoil moisture	--------	−.66	−1.45	.17	−4.07	−1.70	.60	−7.11

[1] From spading sod to corn harvest.
[2] Partial months.
[3] Irrigation, 2.93 inches.
[4] Irrigation, 2.90 inches.
[5] Plastic sheet on ground surface, June 6 to Sept. 9.

TABLE 36.—*Water budget for wheat seasons, Y102C and Y103A, 1945–62*

LYSIMETER Y102C

Period [1]	Item	Sept. [2]	Oct. [2]	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July [2]	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Sept. 28, 1945 to July 9, 1946.	Rainfall	0.33	2.74	3.85	2.40	1.09	4.63	2.61	1.87	5.98	6.72	0.21	32.43
	Runoff	.01	.39	.05	.40	.05	.11	.01	0	.02	.02	0	1.06
	ET	.14	2.33	1.33	.74	.86	1.16	2.79	4.43	4.84	5.55	1.08	25.25
	Percolation	0	.25	.67	.93	1.08	2.46	1.66	.24	.08	.07	.03	7.47
	Δ Soil moisture	.18	−.23	1.80	.33	−.90	.90	−1.85	−2.80	1.04	1.08	−.90	−1.35
Sept. 21, 1949 to July 1, 1950	Rainfall	1.34	1.03	1.55	2.94	9.11	3.74	3.01	4.44	4.42	2.27	2.92	36.77
	Runoff	.01	0	0	0	.06	0	.04	.02	.01	0	.01	.15
	ET	.48	1.62	1.31	.77	.94	.54	1.62	2.19	5.62	5.11	.52	20.72
	Percolation	0	.01	.02	0	4.84	3.26	1.85	2.02	.62	.11	.01	12.74
	Δ Soil moisture	.85	−.60	.22	2.17	3.27	−.06	−.50	.21	−1.83	−2.95	2.38	3.16
Sept. 21, 1953 to July 13, 1954	Rainfall	0	[3] 2.93	1.32	2.69	2.97	2.06	4.43	2.82	2.20	2.31	.86	24.59
	Runoff	0	.01	0	.04	.23	.05	.09	.02	0	0	0	.44
	ET	.52	1.40	1.12	1.20	.78	1.09	1.91	3.98	5.95	4.11	.62	22.68
	Percolation	0	.01	0	.01	.05	.07	1.60	1.10	.16	.03	0	3.23
	Δ Soil moisture	−.52	1.51	.20	1.44	1.91	.85	.63	−2.28	−3.91	−1.83	.24	−1.76
Sept. 16, 1957 to July 24, 1958	Rainfall	1.16	1.72	3.07	4.75	1.80	1.25	1.42	3.53	2.77	3.95	7.22	32.64
	Runoff	.03	0	.02	.02	.02	.12	.02	.02	.02	.01	0	.28
	ET	.78	1.06	1.06	.87	.28	.57	.78	2.40	5.74	5.02	2.53	21.09
	Percolation	0	0	.01	.66	.96	.52	1.10	1.00	1.84	.08	0	6.17
	Δ Soil moisture	.35	.66	1.98	3.20	.54	.04	−.48	.11	−4.83	−1.16	4.69	5.10
Oct. 9, 1961 to July 9, 1962	Rainfall	----------	1.57	3.52	3.08	2.74	4.48	4.37	1.86	3.06	2.02	1.45	28.15
	Runoff	----------	.02	.01	.08	.81	.48	.05	.03	.02	.01	0	1.51
	ET	----------	1.37	.96	.30	.67	.98	1.65	2.47	6.29	4.30	.63	19.62
	Percolation	----------	0	0	0	.12	1.43	3.12	1.16	.29	.05	0	6.17
	Δ Soil moisture	----------	.18	2.55	2.70	1.14	1.59	−.45	−1.80	−3.54	−2.34	.82	.85

LYSIMETER Y103A

Period [1]	Item	Sept. [2]	Oct. [2]	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July [2]	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Oct. 2, 1945 to July 9, 1946	Rainfall	....	1.79	3.61	2.15	0.89	4.11	2.46	1.59	5.92	7.16	0.17	29.85
	Runoff	....	.01	0	.01	0	.01	0	0	0	.01	0	.04
	ET	....	2.29	1.54	1.11	.88	1.84	3.00	[illegible]	4.98	6.10	1.43	27.22
	Percolation	....	.28	.76	.18	.80	2.20	1.03	.06	.03	.50	.02	5.86
	△ Soil moisture	....	−.79	1.31	.85	−.79	.06	−1.57	−2.52	.91	.55	−1.28	−3.27
Sept. 21, 1949 to July 7, 1950.	Rainfall	1.53	1.04	1.59	3.01	8.59	3.59	2.94	4.54	4.70	2.03	2.84	36.40
	Runoff	0	0	0	.01	.03	.01	0	.01	.01	0	0	.07
	ET	.48	1.41	1.13	.65	1.18	.92	1.96	2.55	6.11	5.85	.58	22.82
	Percolation	0	0	0	0	4.76	2.21	1.25	1.63	.13	.04	0	10.02
	△ Soil moisture	1.05	−.37	.46	2.35	2.62	.45	−.27	.35	−1.55	−3.86	2.26	3.49
Sept. 21, 1953 to July 13, 1954	Rainfall	0	.72	1.35	2.63	2.96	2.17	5.12	3.29	2.40	2.09	.90	23.63
	Runoff	0	0	0	.02	.11	.02	.08	.07	0	.01	0	.31
	ET	.29	.65	.44	1.02	.70	.99	2.70	3.26	6.15	5.33	.84	22.37
	Percolation	0	.01	.01	.02	.04	.01	.24	.26	.05	.01	.01	.66
	△ Soil moisture	−.29	.06	.90	1.57	2.11	1.15	2.10	−.30	−3.80	−3.26	.05	.29
Sept. 16, 1957 to July 24, 1958	Rainfall	1.29	.92	3.10	4.68	2.04	1.26	1.51	4.06	3.08	4.23	6.70	33.86
	Runoff	0	.01	.01	.05	.03	.08	.02	.01	.01	0	.03	.25
	ET	.73	1.06	1.07	1.13	.54	.86	1.34	3.15	6.85	5.53	2.44	24.70
	Percolation	0	.02	.01	1.24	.27	.40	.84	.66	1.13	.06	.03	4.66
	△ Soil moisture	.56	.83	2.01	2.26	1.20	−.09	−.69	.24	−4.91	−1.36	4.20	4.25
Oct. 9, 1961 to July 11, 1962.	Rainfall	....	1.65	3.44	2.99	3.81	4.49	4.12	2.02	3.24	2.43	1.45	29.64
	Runoff	....	0	0	.01	.06	.07	.03	.01	0	0	0	.18
	ET	....	.92	.85	.77	1.17	2.17	2.75	2.95	7.41	4.89	.76	24.64
	Percolation	....	.01	.01	.01	.29	1.27	2.21	1.25	.11	.04	.01	5.21
	△ Soil moisture	....	.72	2.58	2.20	2.29	.98	−.87	−2.19	−4.28	−2.50	.08	−.39

[1] From corn harvest to wheat harvest.
[2] Partial months.
[3] Irrigation, 2.24 inches.

TABLE 37.—*Water budget for first-year meadow seasons, Y102C and Y103A, 1946–59*

LYSIMETER Y102C

Period [1]	Item	July [2]	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July [3]	Aug. [2]	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
July 9, 1946 to Aug. 5, 1947.	Rainfall	5.12	2.40	0.88	4.38	2.74	2.83	5.55	1.15	2.33	4.28	6.43	5.[illegible]5	2.84	0	46.38
	Runoff	.04	0	0	.02	.01	.01	.02	.06	.11	.01	.03	.04	.01	0	.36
	ET	4.14	4.69	2.45	1.80	1.07	.80	.54	.74	1.59	2.19	3.90	6.18	5.36	.97	36.42
	Percolation	.07	.12	.02	.03	.04	.15	4.10	1.16	.42	2.10	3.00	1.[illegible]6	.08	0	12.66
	△ Soil moisture	.87	−2.41	−1.59	2.53	1.62	1.87	.69	− .81	.21	.07	− .50	−2.03	−2.61	− .97	− 3.06
July 7, 1950 to Aug. 8, 1951.	Rainfall	4.06	2.14	5.61	1.50	6.41	3.32	6.41	4.83	5.80	3.41	2.38	5.73	2.90	.12	54.62
	Runoff	.01	0	.01	0	0	.02	.10	.35	.06	0	0	.01	0	0	.56
	ET	2.59	3.93	3.53	2.80	1.25	1.11	1.45	1.50	1.43	1.83	5.67	5.01	6.93	.93	39.96
	Percolation	.03	.20	1.75	.07	.06	2.93	4.10	4.09	3.63	2.54	.51	.06	.01	0	19.98
	△ Soil moisture	1.43	−1.09	.32	−1.37	5.10	− .74	.76	−1.11	.68	− .96	−3.80	.65	−4.04	− .81	− 5.88
July 13, 1954 to July 22, 1955.	Rainfall	[3] 3.59	3.23	[4] 2.98	5.48	1.43	2.68	1.70	3.81	4.96	3.73	[5] 3.84	[6] 5.99	2.60	----------	46.02
	Runoff	.04	.02	.01	.02	0	.01	0	.13	.14	.02	.01	.03	0	----------	.43
	ET	1.62	4.38	3.83	2.16	.83	.42	.81	.82	1.08	3.53	6.60	4.92	5.69	----------	36.69
	Percolation	0	.01	0	0	0	.01	.12	2.29	4.02	.92	.32	.03	0	----------	7.72
	△ Soil moisture	1.93	−1.18	− .86	3.30	.60	2.24	.77	.57	− .28	− .74	−3.09	1.01	−3.09	----------	1.18
July 24, 1958 to Aug. 3, 1959.	Rainfall	3.03	2.77	3.46	.41	3.29	1.42	6.83	4.75	4.00	5.14	3.36	5.34	5.34	0	49.14
	Runoff	.05	0	0	0	0	0	.03	.04	0	.01	0	.07	.01	0	.21
	ET	1.02	5.26	4.27	3.01	1.84	.60	0	1.02	2.05	2.44	6.57	6.31	6.93	.72	42.04
	Percolation	.01	.20	.09	.01	0	.01	1.02	2.35	2.34	1.24	.81	.06	.01	0	8.15
	△ Soil moisture	1.95	−2.69	− .90	−2.61	1.45	.81	5.78	1.34	− .39	1.45	−4.02	−1.10	−1.61	− .72	− 1.26

LYSIMETER Y103A

Period [1]	Item	July [2]	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July [3]	Aug. [3]	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
July 9, 1946 to Aug. 11, 1947.	Rainfall	5.00	2.47	0.90	4.42	2.78	2.80	5.28	1.12	2.30	4.43	6.44	5.79	3.03	0	46.76
	Runoff	.01	0	0	.01	0	0	0	.02	.03	0	.01	.02	.01	0	.11
	ET	4.95	5.09	2.58	1.68	.92	.80	1.02	.66	1.86	2.38	4.11	6.45	5.15	1.76	39.41
	Percolation	.02	.02	.01	.01	.01	.28	3.32	.28	.58	1.90	2.66	1.11	.05	.01	10.26
	△ Soil moisture	.02	−2.64	−1.69	2.72	1.85	1.72	.94	.16	− .17	15	− .34	−1.79	−2.18	−1.77	− 3.02
July 7, 1950 to Aug. 8, 1951.	Rainfall	3.82	2.12	5.58	1.58	6.23	3.41	5.65	4.30	5.71	3.58	2.62	5.81	3.04	.13	53.58
	Runoff	.01	0	.01	0	0	.01	.04	.12	.03	.01	.01	.02	.02	0	.28
	ET	3.15	4.85	3.76	2.57	1.47	1.51	1.34	1.86	1.95	2.22	5.73	5.22	6.73	1.01	43.37
	Percolation	.02	.02	.04	.02	.09	2.67	3.62	3.47	3.30	1.91	.17	.06	.03	.01	15.43
	△ Soil moisture	.64	−2.75	1.77	− 1.01	4.67	− .78	.65	−1.15	.43	− .56	−3.29	.51	−3.74	− .89	− 5.50
July 13, 1954 to July 22, 1955.	Rainfall	2.47	3.49	1.43	5.94	1.58	2.82	2.15	3.87	5.13	3.97	1.82	3.14	2.18	---------	39.99
	Runoff	.01	.01	0	.02	0	0	0	.02	.02	0	0	0	.01	---------	.09
	ET	1.54	4.22	1.86	1.76	.93	.42	.59	1.43	2.40	4.23	7.10	4.03	3.90	---------	34.41
	Percolation	0	.01	0	0	0	.01	.08	1.93	2.68	.35	.11	.03	.01	---------	5.21
	△ Soil moisture	.92	− .75	− .43	4.16	.65	2.39	1.48	.49	.03	− .61	−5.39	− .92	−1.74	---------	.28
July 24, 1958 to Aug. 3, 1959.	Rainfall	3.04	2.96	3.39	.32	2.92	1.40	6.95	4.09	2.70	5.02	3.36	4.77	4.07	0	44.99
	Runoff	.03	0	0	0	0	.02	.02	.02	.01	.02	.01	.03	0	0	.16
	ET	1.04	6.39	4.43	2.43	1.20	.82	1.42	1.67	2.24	2.77	6.37	6.17	6.36	.47	43.78
	Percolation	.01	.22	.03	.02	.01	.02	.44	1.68	.08	1.23	.32	.05	.04	0	5.05
	△ Soil moisture	1.96	−3.65	−1.07	−2.13	1.71	.54	5.07	.72	− .53	1.00	−3.34	−1.48	−2.33	− .47	− 4.00

[1] From wheat harvest until last hay cutting the following year.
[2] Partial months.
[3] Irrigation, 1.13 inches
[4] Irrigation, 1.65 inches
[5] Irrigation, 2.26 inches
[6] Irrigation, 3.07 inches

TABLE 38.—*Water budget for second-year meadow seasons, Y102C and Y103A, 1947–61*

LYSIMETER Y102C

Period[1]	Item	July[2]	Aug.[2]	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.[2]	May[2]	June	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
Aug. 5, 1947	Rainfall	----------	3.76	3.13	1.04	2.67	1.49	3.42	3.14	4.80	5.17	3.65	5.05	([3])
to	Runoff	----------	.01	0	0	0	0	0	.01	.08	.02	0	.01	([3])
June 30, 1948.	ET	----------	3.08	4.92	2.57	.73	.47	.36	.44	1.66	3.47	6.68	6.76	([3])
	Percolation	----------	.02	.01	0	.01	.01	.01	.14	2.33	3.88	.10	.01	([3])
	△ Soil moisture	----------	.65	−1.80	−1.53	1.93	1.01	3.05	2.55	.73	−2.20	−3.13	−1.73	([3])
July 1, 1948	Rainfall	3.57	1.12	3.74	2.85	3.23	2.31	5.54	2.85	3.89	2.93	0	----------	69.35
to	Runoff	.01	0	.01	.01	0	0	.01	.01	.01	.01	0	----------	[4] .20
May 7, 1949.	ET	5.73	3.10	3.03	1.93	1.25	.43	.56	.90	1.56	3.19	.48	----------	[4] 53.30
	Percolation	.01	0	0	.01	.01	.01	.14	1.35	2.02	.94	.05	----------	[4] 11.06
	△ Soil moisture	−2.18	−1.98	.70	.90	1.97	1.87	4.83	.59	.30	−1.21	−.53	----------	[4] 4.79
Aug. 8, 1951	Rainfall	----------	.53	3.02	1.88	5.04	5.78	6.34	2.92	4.01	4.14	3.92	2.69	([5])
to	Runoff	----------	0	.01	.01	.01	.03	.04	0	.04	.02	.01	.02	([5])
June 30, 1952.	ET	----------	1.20	3.13	2.32	.88	1.38	1.00	.84	1.23	2.81	5.46	5.67	([5])
	Percolation	----------	0	0	.01	.01	.15	4.13	2.72	2.50	1.03	.37	.02	([5])
	△ Soil moisture	----------	−.67	−.12	−.46	4.14	4.22	1.17	−.64	.24	−.62	−1.92	−3.02	([5])
July 1, 1952	Rainfall	3.94	2.05	2.56	.78	1.72	2.64	5.44	1.44	3.44	2.61	----------	----------	[6] 60.89
to	Runoff	.02	.01	.02	0	.01	0	.01	0	.01	.01	----------	----------	[6] .28
May 1, 1953.	ET	6.29	3.80	3.01	1.26	.74	.44	.65	.87	1.38	2.42	----------	----------	[6] 40.78
	Percolation	0	0	0	.01	0	0	0	0	.16	.51	----------	----------	[6] 12.52
	△ Soil moisture	−2.37	−1.76	−.47	−.49	.97	2.20	4.78	.57	1.89	−.33	----------	----------	[6] 7.31
July 22, 1955	Rainfall	1.01	3.12	2.36	2.23	3.48	.35	2.06	5.64	5.37	4.08	6.90	4.52	([7])
to	Runoff	.01	.02	0	0	.02	0	0	.04	.02	.02	.01	.01	([7])
June 30, 1956.	ET	.48	5.79	3.02	2.59	.79	.31	.38	.52	1.40	2.23	5.38	5.29	([7])
	Percolation	.01	0	0	.01	.01	.01	0	.48	3.19	1.86	1.50	.70	([7])
	△ Soil moisture	.51	−2.69	−.66	−.37	2.66	.03	1.68	4.60	.76	−.03	.01	−1.48	([7])
July 1, 1956	Rainfall	5.96	3.95	1.40	1.08	1.89	4.44	2.36	1.86	2.70	5.36	----------	----------	[8] 72.32
to	Runoff	.02	.01	0	0	.04	.03	.25	.03	.04	.03	----------	----------	[8] .60
Apr. 26, 1957.	ET	5.08	6.14	3.31	3.31	1.54	.60	.44	.58	1.68	1.84	----------	----------	[8] 52.70
	Percolation	.25	.17	.01	0	0	.01	.01	0	1.29	4.13	----------	----------	[8] 13.64
	△ Soil moisture	.61	−2.37	−1.72	−2.23	.31	3.80	1.66	−1.25	−.31	−.64	----------	----------	[8] 5.38

Aug. 3, 1959 to June 30, 1960.	Rainfall		2.87	3.15	6.24	3.52	2.86	3.35	4.98	2.04	2.23	3.42	7.16	[9]
	Runoff		.02	0	.01	0	.01	0	.02	.08	0	0	.17	[9]
	ET		4.16	3.80	2.78	1.11	.62	.38	.77	1.25	4.13	4.87	5.68	[9]
	Percolation		0	0	0	.01	.03	2.40	1.94	2.65	.96	.08	.01	[9]
	Δ Soil moisture		−1.31	− .65	3.45	2.40	2.20	.57	2.25	−1.94	−2.86	−1.53	1.30	[9]
July 1, 1960 to May 12, 1961.	Rainfall	2.99	5.97	.54	2.15	2.22	2.21	1.41	5.38	3.76	7.49	1.45	....	[10] 77.39
	Runoff	.01	.04	0	0	0	0	.01	.15	.01	02	0	....	[10] .55
	ET	6.40	5.82	3.59	1.84	.80	.48	.31	.27	.90	1.97	1.76	....	[10] 53.69
	Percolation	0	0	0	0	.01	0	.01	.04	3.36	5.35	.26	....	[10] 17.11
	Δ Soil moisture	−3.42	.11	−3.05	.31	1.41	1.73	1.08	4.92	− .51	.15	− .57	....	[10] 6.04

LYSIMETER Y103A

Aug. 11, 1947 to June 30, 1948.	Rainfall		3.70	3.18	1.21	2.74	1.52	3.12	3.23	4.96	4.89	3.81	5.39	[11]
	Runoff		.02	0	0	0	0	0	0	.02	.02	.01	.02	[11]
	ET		2.30	4.68	2.31	.73	.38	.31	.88	1.98	4.03	6.54	7.26	[11]
	Percolation		.02	.02	.01	.01	0	.01	1.54	2.19	2.42	.10	.02	[11]
	Δ Soil moisture		1.36	−1.52	−1.11	2.00	1.14	2.80	.81	.77	−1.58	−2.84	−1.91	[11]
July 1, 1948 to May 6, 1949.	Rainfall	3.56	0.99	3.91	2.72	3.00	2.37	5.49	2.87	3.95	2.98	0.03	....	[12] 69.62
	Runoff	.01	0	.01	.01	0	0	0	.01	0	0	0	....	[12] .13
	ET	5.65	3.14	2.83	1.71	.88	.41	.79	1.05	1.89	3.24	.70	....	[12] 53.69
	Percolation	.01	.01	0	0	0	0	1.96	1.59	1.42	.37	.01	....	[12] 11.71
	Δ Soil moisture	−2.11	−2.16	1.07	1.00	2.12	1.96	2.74	.22	.64	− .63	− .68	....	[12] 4.09
Aug. 8, 1951 to June 30, 1952.	Rainfall		.62	3.12	1.94	5.04	5.92	5.54	3.02	4.02	4.39	4.42	2.79	[13]
	Runoff		0	.01	0	0	.01	.03	.02	.03	.02	0	.02	[13]
	ET		1.26	3.01	2.20	.77	1.55	1.32	1.33	1.86	3.52	6.07	5.19	[13]
	Percolation		.01	.01	.01	.01	1.09	3.65	1.86	1.92	1.58	.07	.02	[13]
	Δ Soil moisture		− .65	.09	− .27	4.26	3.27	.54	− .19	.21	− .73	−1.72	−2.44	[13]
July 1, 1952 to May 1, 1953.	Rainfall	4.15	2.12	2.59	.78	1.94	2.73	5.64	1.49	3.48	2.87	0	....	[14] 68.61
	Runoff	.02	.01	.01	0	.01	.01	.02	0	.01	0	0	....	[14] .23
	ET	6.36	3.86	3.05	1.13	.73	.51	.80	.87	1.64	2.71	.10	....	[14] 49.84
	Percolation	.02	.01	0	0	0	.01	.18	.34	.98	.50	0	....	[14] 12.27
	Δ Soil moisture	−2.25	−1.76	− .47	− .35	1.20	2.20	4.64	.28	.85	− .34	− .10	....	[14] 6.27
July 22, 1955 to June 30, 1956.	Rainfall	1.27	3.53	2.43	2.42	3.60	.39	2.25	5.86	6.08	4.36	7.13	5.17	[15]
	Runoff	0	.01	0	0	0	0	0	.01	0	.01	.01	.02	[15]
	ET	.71	4.68	2.57	2.52	.85	.35	.41	.87	2.62	2.79	6.48	5.79	[15]
	Percolation	.01	.01	.01	.01	.02	.02	.01	1.22	2.30	1.16	.65	.73	[15]
	Δ Soil moisture	.55	−1.17	− .15	− .11	2.73	.02	1.83	3.76	1.16	.40	− .01	−1.37	[15]

TABLE 38.—*Water budget for second-year meadow seasons, Y102C and Y103A, 1947–61*—Continued

LYSIMETER Y103A

Period[1]	Item	July[2]	Aug.[2]	Sept.	Oct.	Oct.	Nov.	Dec.	Jan.	Mar.	Apr.[2]	May[2]	June	Total
		Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
July 1, 1956 to Apr. 26, 1957.	Rainfall	6.24	4.17	1.78	1.19	1.91	4.08	2.52	1.94	2.61	5.38	----------	----------	[16] 76.31
	Runoff	.01	.01	0	0	0	.02	.07	.02	.02	.04	----------	----------	[16] .25
	ET	5.73	6.70	3.31	2.92	1.27	.68	.66	.50	1.99	2.79	----------	----------	[16] 57.49
	Percolation	.23	.03	.01	.01	.01	.01	.18	.24	.49	2.72	----------	----------	[16] 10.08
	△ Soil moisture	.27	−2.57	−1.54	−1.74	.63	3.37	1.61	.88	.11	− .17	----------	----------	[16] 8.49
Aug. 3, 1959 to June 30, 1960.	Rainfall	----------	2.58	3.13	6.24	3.51	2.87	3.25	5.23	2.20	2.16	3.67	7.50	([17])
	Runoff	----------	.01	.01	.01	.01	.01	.01	.04	.07	0	0	.07	([17])
	ET	----------	3.57	3.13	2.37	1.27	.97	.47	1.10	1.90	3.97	5.34	5.80	([17]
	Percolation	----------	.02	.01	0	.01	.33	1.44	.92	.94	.43	.05	.05	([17])
	△ Soil moisture	----------	−1.02	− .02	3.86	2.22	1.56	1.33	3.17	− .71	−2.24	−1.72	1.58	([17])
July 1, 1960 to May 12, 1961.	Rainfall	3.24	6.93	.47	2.24	2.28	2.24	1.53	6.82	3.79	7.53	1.15	----------	[16] 80.56
	Runoff	.02	.04	0	0	.01	0	.01	.02	.01	.08	.01	----------	[18] .44.
	ET	6.42	5.92	4.17	2.09	.86	.57	.01	1.69	3.10	3.02	1.42	----------	[18] 59.16
	Percolation	.02	.01	0	0	0	0	0	.39	2.37	4.03	.13	----------	[18] 11.15
	△ Soil moisture	−3.22	.96	−3.70	.15	1.41	1.67	1.51	4.72	−1.69	.40	− .41	----------	[18] 9.81

[1] Periods for which totals are given correspond to periods from last cutting of first-year meadow to spading of sod for corn. These periods are defined in table footnotes 3 to 18.
[2] May be partial months; check dates.
[3] Included in Aug. 5, 1947 to May 7, 1949 total.
[4] Total for Aug. 5, 1947 to May 7, 1949.
[5] Included in Aug. 8, 1951 to May 1, 1953 total.
[6] Total for Aug. 8, 1951 to May 1, 1953.
[7] Included in July 22, 1955 to Apr. 26, 1957.
[8] Total for July 22, 1955 to Apr. 26, 1957.
[9] Included in Aug. 3, 1959 to May 12, 1961 total.
[10] Total for Aug. 3, 1959 to May 12, 1961.
[11] Included in Aug. 11, 1947 to May 6, 1949 total.
[12] Total for Aug. 11, 1947 to May 6, 1949.
[13] Included in Aug. 8, 1951 s May 1, 1953 total.
[14] Total for Aug. 8, 1951 to May 1, 1953.
[15] Included in July 22, 1955 to Apr. 26, 1957.
[16] Total for July 22, 1955 to Apr. 26, 1957.
[17] Included in Aug. 3, 1959 to May 12, 1961 total.
[18] Total for Aug. 3, 1959 to May 12, 1961.

TABLE 39.—*Monthly percolation data and 20- and 25-year averages, lysimeter battery Y101, 1956–62*[1]

Year and lysimeter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual total
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1956:													
Y101A	0.273	3.696	3.507	2.511	3.159	2.964	2.007	1.320	0.465	0.237	0.128	0.802	21.069
Y101B	.258	1.689	2.256	1.797	2.094	2.103	1.677	1.347	.432	.216	.075	.531	14.502
Average	.279	2.692	2.882	2.154	2.626	2.534	1.842	1.334	.448	.226	.102	.667	17.786
Y101C	.201	3.648	3.873	2.562	3.075	2.883	1.968	1.434	.420	.159	.075	.102	20.400
Y101D	0	1.446	2.667	1.791	2.193	2.184	1.659	1.206	.381	.125	.037	.045	13.734
Average	.100	2.547	3.270	2.176	2.634	2.534	1.814	1.320	.400	.142	.056	.074	17.067
1957:													
Y101A	1.446	1.200	1.686	4.608	1.419	4.104	1.917	.513	.198	.138	.420	2.139	19.738
Y101B	1.044	1.056	1.266	2.700	1.251	2.478	1.671	.477	.141	.093	.450	1.896	14.523
Average	1.245	1.128	1.476	3.654	1.335	3.291	1.794	.495	.170	.166	.435	2.018	17.156
Y101C	.666	1.128	1.515	4.803	1.011	3.129	1.755	.483	.270	.186	.150	2.928	18.024
Y101D	.834	1.200	1.092	3.576	1.347	3.345	2.022	.564	.192	.046	.071	2.517	16.806
Average	.750	1.164	1.304	4.190	1.179	3.237	1.888	.524	.231	.116	.110	2.722	17.415
1958:													
Y101A	1.422	.915	1.086	1.251	2.784	.636	1.725	1.998	.459	.234	.108	.069	12.687
Y101B	1.227	.699	1.005	1.113	2.079	.594	1.323	1.731	.441	.240	.126	.174	10.752
Average	1.324	.807	1.046	1.182	2.432	.615	1.524	1.864	.450	.237	.117	.122	11.720
Y101C	1.503	.654	1.026	1.125	2.649	.612	1.269	1.995	.450	.243	.147	.144	11.895
Y101D	1.452	.852	1.050	.945	2.253	.720	1.288	.624	.201	.024	.006	.003	8.418
Average	1.470	.753	1.038	1.035	2.451	.666	.778	1.320	.326	.134	.076	.074	10.157

TABLE 39.—*Monthly percolation data and 20- and 25-year averages, lysimeter battery Y101, 1956–62*[1]—Continued

Year and lysimeter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual total
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1959:													
Y101A	2.598	2.874	1.923	1.281	1.503	0.594	0.438	0.294	0.105	0.252	0.927	2.184	14.973
Y101B	1.446	1.692	1.548	1.176	1.473	.627	.483	.321	.111	.486	.921	1.728	12.012
Average	2.022	2.283	1.736	1.228	1.488	.610	.460	.308	.108	.369	.924	1.956	13.492
Y101C	2.550	3.102	2.979	1.356	1.530	.498	.240	.159	.068	.391	.918	2.511	16.302
Y101D	1.314	2.172	1.842	.960	1.050	.414	.073	.008	.003	.003	.003	.030	7.872
Average	1.932	2.637	2.410	1.158	1.290	.456	.156	.084	.036	.197	.460	1.270	12.087
1960:													
Y101A	2.691	1.836	1.668	1.632	.693	1.758	.804	.468	.339	.153	.052	.059	12.153
Y101B	2.028	1.458	1.203	1.410	.771	1.278	.831	.672	.333	.102	.025	.080	10.191
Average	2.360	1.647	1.436	1.521	.732	1.518	.818	.570	.336	.128	.038	.070	11.172
Y101C	3.102	2.070	1.581	1.596	.597	1.056	.723	.357	.174	.120	.105	.069	11.550
Y101D	1.743	1.500	1.653	1.578	.699	.255	.050	.013	.003	.003	0	.003	7.500
Average	2.422	1.785	1.617	1.587	.648	.656	.386	.185	.088	.062	.052	.036	9.525
1961:													
Y101A	0.432	1.422	3.495	5.004	1.560	.666	.417	.303	.111	.018	.010	.425	13.863
Y101B	.462	.774	2.061	2.889	1.410	.768	.453	.387	.087	.006	.015	.426	9.738
Average	.447	1.098	2.778	3.946	1.485	.717	.435	.345	.099	.012	.012	.425	11.800
Y101C	.066	1.518	4.059	5.670	1.449	.486	.270	.174	.111	.090	.093	.189	14.184
Y101D	.003	.180	2.178	4.485	1.311	.378	.108	.012	.006	0	0	0	8.664
Average	.034	.849	3.118	5.078	1.380	.432	.189	.093	.058	.050	.046	.094	11.424
1962:													
Y101A	1.128	1.260	2.853	1.716	.816	.390	.174	.037	.011	.003	.618	.663	9.669
Y101B	.717	.615	1.293	1.191	.762	.384	.165	.022	.011	.006	.438	.453	6.057
Average	.922	.938	2.073	1.454	.789	.387	.170	.030	.011	.004	.528	.558	7.863
Y101C	1.677	1.749	3.381	1.839	.771	.288	.138	.089	.038	.014	.054	.258	10.296
Y101D	.075	.828	2.412	1.488	.828	.297	.022	.008	.003	.003	0	.003	5.967
Average	.876	1.288	2.896	1.664	.800	.292	.080	.048	.020	.008	.027	.130	8.132

1938–62 average:													
Y101A	1.848	1.899	2.694	2.486	1.571	1.347	0.801	0.417	0.275	0.183	0.335	0.913	14.769
Y101B	1.260	1.274	1.850	1.842	1.360	1.148	.701	.405	.186	.171	.266	.733	11.196
Average Y101,AB	1.554	1.586	2.272	2.164	1.466	1.248	.751	.411	.230	.177	.300	.823	12.982
Y101, AB:													
Pct. annual total	12.0	12.2	17.5	16.7	11.3	9.6	5.8	3.2	1.8	1.3	2.3	6.3	100.0
Pct. cumulative total	12.0	24.2	41.7	58.4	69.7	79.3	85.1	88.3	90.1	91.4	93.7	100.0	----------
Y101C	1.865	1.924	2.885	2.456	1.440	1.223	.772	.457	.216	.173	.227	.799	14.437
Pct. annual total	12.9	13.3	20.0	17.0	10.0	8.5	5.3	3.2	1.5	1.2	1.6	5.5	100.0
Pct. cumulative total	12.9	26.2	46.2	63.2	73.2	81.7	87.0	90.2	91.7	92.9	94.5	100.0	----------
1943–62 average:													
Y101D	.946	1.262	1.940	1.720	1.133	.824	.357	.180	.054	.056	.045	.237	8.754
Pct. annual total	10.8	14.4	22.2	19.7	12.9	9.4	4.1	2.1	.6	.6	.5	2.7	100.0
Pct. cumulative total	10.8	25.2	47.4	67.1	80.0	89.4	93.5	95.6	96.2	96.8	97.3	100.0	----------

[1] For 1938–55 data, see table 26 of U.S. Dept. Agr. Tech. Bul. 1179 (*66*).

TABLE 40.—*Monthly percolation data and 25-year averages, lysimeter battery Y102, 1956–62*[1]

Year and lysimeter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual total
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1956:													
Y102A	0	0.057	0.861	1.365	1.252	0.377	0.360	0.163	0.002	0	0	0	4.437
Y102B	0	.168	1.179	1.602	1.320	.672	.399	.156	0	.006	0	.009	5.511
Y102C	0	.477	3.189	1.863	1.500	.696	.249	.166	.011	0	.003	.009	8.163
Average	0	.234	1.743	1.610	1.357	.582	.336	.162	.004	.002	.001	.006	6.037
1957:													
Y102A	0	0	.543	4.140	.645	2.349	.747	.072	.009	0	0	.750	9.255
Y102B	.012	.009	.651	4.119	.513	3.105	2.121	.146	.022	.006	0	.876	11.580
Y102C	.006	0	1.293	4.239	.696	[2] .498	[2] .126	[2] .022	[2] .002	.003	.011	.661	7.557
Average	.006	.003	.829	4.166	.618	1.984	.998	.080	.011	.003	.004	.762	9.464
1958:													
Y102A	.774	.480	.984	.921	1.674	.096	.018	.560	.067	.021	0	0	5.595
Y102B	.903	.519	1.020	1.098	1.932	.138	.036	.510	.129	.031	.010	.004	6.330
Y102C	.957	.525	1.101	.996	1.845	.084	.011	.199	.093	.009	.003	.009	5.832
Average	.878	.508	1.035	1.005	1.817	.106	.022	.423	.096	.020	.004	.004	5.919
1959:													
Y102A	.714	1.041	1.176	.576	.399	.012	.012	.009	.006	.003	0	0	3.948
Y102B	.444	1.101	2.139	1.113	.783	.099	.033	.018	.006	.009	.008	.010	5.661
Y102C	1.020	2.352	2.337	1.236	.810	.062	.014	.005	0	.005	.013	.027	7.881
Average	.726	1.498	1.884	.975	.664	.058	.020	.011	.004	.006	.007	.012	5.830
1960:													
Y102A	.336	.948	1.302	.362	.005	.008	.007	.002	0	0	.003	.003	2.976
Y102B	.624	1.680	1.770	.516	.074	.042	.038	.038	.030	.030	.030	.024	4.896
Y102C	2.400	1.944	2.652	.963	.081	.006	.003	0	0	.003	.006	.003	8.061
Average	1.120	1.524	1.908	.614	.053	.019	.016	.013	.010	.011	.013	.010	5.311

1961:													
Y102A	0	0	1.230	3.360	0.234	0.080	0.022	0.015	0.014	0.007	0	0.006	4 968
Y102B	.024	.027	.672	3.738	.207	.071	.044	.024	.016	.016	.009	.014	4.802
Y102C	.009	.036	3.357	5.352	.621	.327	.168	.051	.007	.002	0	.003	9.933
Average	.011	.021	1.753	4.150	.354	.159	.078	.030	.012	.008	.003	.008	6.588
1962:													
Y102A	0	.792	2.328	.717	.204	.011	.010	.007	.005	.003	.006	0	4.083
Y102B	.022	.957	3.135	1.293	.390	.120	.038	.020	.030	.017	.012	.012	6.046
Y102C	.120	1.434	3.123	1.155	.294	.048	.018	.012	.014	.010	.019	.113	6.361
Average	.047	1.061	2.862	1.055	.296	.060	.022	.013	.016	.010	.012	.042	5.497
25-yr. average:													
Y102A	.739	.906	1.843	1.090	.524	.296	.105	.063	047	.037	.038	.164	5.852
Y102B	.821	1.017	2.014	1.788	.604	.373	.182	.083	.071	.023	.013	.206	7.195
Y102C	1.059	1.274	2.424	1.876	.713	.288	.079	.051	.081	.019	.039	.218	8.121
Average	.873	1.066	2.094	1.585	.614	.319	.122	.066	.066	.026	.030	.196	7.057
Y102, ABC:													
Pct. annual total	12.4	15.1	29.7	22.5	8.7	4.7	1.7	.9	.9	.4	.4	2.8	100.0
Pct. cumulative total	12.4	27.5	57.2	79.7	88.4	92.9	94.6	95.5	96.4	96.8	97.2	100.0	....

[1] For 1938-55 data, see table 27 of U. S. Dept. Agr. Tech. Bul. 1179(66).
[2] Plastic cover June 6 - Sept. 9 prevented infiltration and reduced percolation.

TABLE 41.—*Monthly percolation data and 22-year averages, lysimeter battery Y103, 1956–62*[1]

Year and lysimeter	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept	Oct	Nov	Dec	Annual total
	Inches	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
1956:													
Y103A	0.012	1.215	2.304	1.161	0.651	0.729	0.231	0.028	0.008	0.009	0.009	0.006	6.363
Y103B	.114	1.302	2.688	1.944	1.239	1.266	738	108	.030	.009	.033	.156	9 62
Average	.63	1.258	2.496	1.552	.945	.998	.484	.068	.019	.009	021	.081	7.995
Y103C	.186	1.524	2.826	1.581	1.461	1.449	.846	.126	020	.010	.015	.582	10 626
Y013D	.117	1.299	2.700	1.722	1.365	1.599	.924	.144	.048	.012	.054	.192	10.176
Average	.152	1.412	2.763	1.652	1.413	1.524	.885	.135	.034	.011	.034	.387	10.401
1957:													
Y103A	.183	.267	.492	2.742	.561	1.551	.084	.019	.011	.018	.012	1.236	7.146
Y103B	.279	.360	.666	1.839	.672	1.491	.252	.034	.041	.033	.052	1.868	7.587
Average	.231	.314	.579	2.290	.616	1.521	.168	.026	.026	.026	.032	1.552	7.366
Y103C	.507	1.179	.966	2.913	.903	1.626	.198	.057	.071	.031	.083	2.329	10.863
Y103D	.981	1.161	1.071	3.366	.864	2.043	.189	.060	.095	.060	236	3.095	13.221
Average	.744	1.170	1.018	3.140	.884	1.835	.194	.058	.083	.046	.160	2.712	12.042
1958:													
Y103A	.270	.405	.843	.660	1.131	.057	.045	.216	.033	.025	.011	.018	3.714
Y103B	.246	.300	1.293	1.038	1.643	.061	.198	.291	.054	.010	.017	.150	5.301
Average	.258	.358	1.068	.849	1.387	.059	.122	.254	.044	.018	.014	.084	4.508
Y103C	.414	.474	.726	.543	1.583	.102	1.240	.470	.061	.013	.012	.143	5.781
Y103D	.531	.642	.924	1.032	1.731	.124	1.016	.464	.046	.020	.020	.146	6.696
Average	.472	.558	.825	.788	1.657	.113	1.128	.467	.054	.016	.016	.144	6.238
1959:													
Y103A	.438	1.680	.975	1.233	.315	.051	.035	.015	.013	.003	.006	.333	5.097
Y103B	.627	2.208	1.767	1.776	.537	.070	.059	.041	.046	.099	0.75	1.218	8.523
Average	.532	1.944	1.371	1.504	.426	.060	.047	;028	.030	.051	.040	.776	6.810
Y103C	1.833	2.310	1.506	1.461	.390	.137	.097	.087	.102	.294	1.299	2.211	11.727
Y103D	1.980	2.133	1.734	1.680	.441	.063	.043	.034	.016	.048	.675	2.412	11.259
Average	1.906	2.222	1.620	1.570	.416	.100	.070	.060	.059	.171	.987	2.312	11.493
1960:													
Y103A	1.437	.921	.936	.429	.054	.052	.025	.013	.003	.003	0	0	3.873
Y103B	2.634	1.470	1.107	.930	.084	.168	.049	.032	0	0	0	.012	6.486
Average	2.036	1.195	1.022	.680	.069	.110	.037	.022	.002	.002	0	.006	5.180

Y103C	2.472	1.371	1.155	0.686	0.132	2.011	0.080	0.586	0.048	0.051	0.072	0.099	8.763
Y103D	2.691	1.560	2.099	.813	.095	1.306	.069	.282	.060	.030	.045	.030	8.385
Average	2.582	1.465	1.622	.750	.114	1.658	.074	.434	.054	.040	.058	.064	8.574
1961:													
Y103A	0	.390	2.370	4.032	.198	.116	.036	.029	.015	.014	.006	.006	7.212
Y103B	.024	.921	3.744	4.017	.492	.201	.075	.048	.029	.040	.049	.015	9.655
Average	.012	.656	3.057	4.024	.345	.158	.056	.038	.022	.027	.028	.010	8.434
Y103C	1.095	2.823	3.765	4.356	.351	.522	.123	.057	.033	.021	.126	.294	13.566
Y103D	.312	3.234	4.410	4.815	.210	.363	.081	.072	.027	.021	.036	.174	13.755
Average	.704	3.028	4.088	4.586	.280	.442	.102	.064	.030	.021	.081	.234	13.660
1962:													
Y103A	.288	1.266	2.208	1.251	.108	.045	.036	.012	.006	0	0	0	5.220
Y103B	.776	1.989	2.955	1.437	.087	.047	.034	.026	.021	.010	.004	.008	7.304
Average	.532	1.628	2.582	1.344	.098	.046	.035	.019	.014	.005	.002	.004	6.307
Y103C	1.806	1.941	2.781	1.278	.117	.074	.050	.073	.101	.029	.261	.501	9.012
Y103D	1.815	1.926	2.922	1.007	.114	.053	.046	.029	.039	.016	.320	.646	9.003
Average	1.810	1.934	2.852	1.178	.116	.064	.048	.051	.070	.022	.290	.574	9.008
1941-62 average:													
Y103A	1.046	1.164	1.754	1.236	.442	.243	.044	.027	.038	.029	.054	.363	6.440
Y103B	.990	1.064	1.648	1.254	.498	.259	.101	.045	.040	.024	.046	.355	6.324
Average	1.018	1.114	1.701	1.245	.470	.251	.072	.036	.039	.026	.050	.359	6.381
Y103, AB:													
Pct. annual total	16.0	17.5	26.7	19.5	7.4	3.9	1.1	.6	.6	.4	.7	5.6	100.0
Pct. cumulative total	16.0	33.5	60.2	79.7	87.1	91.0	92.1	92.7	93.3	93.7	94.4	100.0	....
1941-62 average													
Y103C	1.371	1.443	2.057	1.448	.640	.448	.172	.085	.074	.066	.158	.615	8.577
Y103D	1.303	1.353	1.873	1.307	.516	.355	.137	.070	.082	.041	.097	.681	7.815
Average	1.337	1.398	1.965	1.378	.578	.402	.154	.078	.078	.054	.128	.648	8.198
Y103, CD:													
Pct. annual total	16.3	17.1	24.0	16.8	7.0	4.9	1.9	.9	.9	.7	1.6	7.9	100.0
Pct. cumulative total	16.3	33.4	57.4	74.2	81.2	86.1	88.0	88.9	89.8	90.5	92.1	100.0	....

[1] For 1940-55 data, see table 28 of U. S. Dept. Agr. Tech. Bul. 1179(*66*).

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