

SOIL MOISTURE DEPLETION BY VARIOUS
GRASSES AND LEGUMES USED AS ORCHARD SODS

By

Roscoe John Higdon

A THESIS

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Horticulture

Year

1953

SOIL MOISTURE DEPLETION BY VARIOUS
GRASSES AND LEGUMES USED AS ORCHARD SODS

By

Roscoe John Higdon

AN ABSTRACT

Submitted to the School of Graduate Studies of Michigan
State College of Agriculture and Applied Science
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Horticulture

Year 1953

Approved

R. L. Kenworthy

Sod covers of white dutch clover, ladino clover, timothy, redtop, quackgrass, bluegrass, and fescue were grown for two years on plots of Miami silt loam soil. The effect of mowing the sods on soil moisture depletion was the primary purpose of the study. Gypsum soil moisture blocks were placed at 8, 16, 24, 32 and 40 inch depths for the purpose of soil moisture determinations.

The various sod covers showed considerable differences in soil moisture depletion as well as differences in response to mowing. The intensity and distribution of rainfall in relation to the time of mowing appeared to have marked effects on soil moisture depletion by the sod covers. Mowing of non-legume sod covers during periods of deficient soil moisture appeared to conserve soil moisture; however, when soil moisture is not lacking mowing tended to result in increased soil moisture depletion. When mowing resulted in conservation of soil moisture the effect was only temporary and late in the season the mowed sods were depleting soil moisture more than unmowed sods. Mowing sod covers in orchards cannot be depended upon for the conservation of sufficient quantities of soil moisture for best tree growth and production of orchard trees under Michigan conditions.

Bluegrass, fescue, timothy, and redtop sod covers showed less depletion of soil moisture than sod covers of ladino clover, white dutch clover, alfalfa, and quackgrass.

TABLE OF CONTENTS

	Page
INTRODUCTION	1
REVIEW OF THE LITERATURE	2
PROCEDURE.	9
RESULTS.	11
Sod Growth - 1951	11
Soil Moisture Depletion - 1951.	16
White dutch clover.	16
Ladino clover	19
Redtop.	19
Timothy	22
Quackgrass.	26
Kentucky bluegrass.	26
Chewing fescue.	28
Mulched and clean cultivated soil	28
Sod Growth - 1952	31
Soil Moisture Depletion - 1952.	34
White dutch clover.	34
Ladino clover	37
Redtop.	37
Timothy	39
Quackgrass.	43
Kentucky bluegrass.	46
Chewing fescue.	46
Alfalfa	49
Mulched and cultivated soil	49
DISCUSSION	53
Soil Moisture in Relation to Sod Growth	53
Soil Moisture in Relation to Tree Growth.	56
Soil Moisture in Relation to Fruit Development.	58
SUMMARY AND CONCLUSIONS.	63
LITERATURE CITED	64
APPENDIX	69

LIST OF FIGURES

Figure		Page
1	Distribution and intensity of rainfall at Grand Rapids, Michigan, during the growing season of 1951	12
2	Distribution and intensity of rainfall at Grand Rapids, Michigan, during the growing season of 1952	13
3	Soil moisture depletion by white dutch clover sod at all depths (8-40 inches inclusive) for all dates of the 1951 growing season . . .	17
4	Average soil moisture depletion by sods of ladino clover, white dutch clover, and soil moisture conditions in mulched and tilled soils for all depths (8-40 inches inclusive) for all dates of the 1951 growing season . . .	18
5	Soil moisture depletion by ladino clover sod at all depths (8-40 inches inclusive) for all dates of 1951 growing season	20
6	Soil moisture depletion by redtop sod at all depths (8-40 inches inclusive) for all dates of 1951 growing season	21
7	Average soil moisture depletion by sods of redtop, quackgrass and fescue for all depths (8-40 inches inclusive) for all dates of 1951 growing season	23
8	Soil moisture depletion by timothy sod at all depths (8-40 inches inclusive) for all dates of 1951 growing season	24
9	Average soil moisture depletion by sods of bluegrass and timothy for all depths (8-40 inches inclusive), and the distribution and amount of rainfall for all dates of 1951 growing season	25
10	Soil moisture depletion by quackgrass sod at all depths (8-40 inches inclusive) for all dates of 1951 growing season	27
11	Soil moisture depletion by bluegrass sod for all depths (8-40 inches inclusive) for all dates of 1951 growing season.	29
12	Soil moisture depletion by fescue sod at all depths (8-40 inches inclusive) for all dates of 1951 growing season	30

LIST OF FIGURES CONT.

Figure		Page
13	Soil moisture conditions in mulched and tilled soil at all depths (8-40 inches inclusive) for all dates of 1951 growing season	32
14	Soil moisture depletion by white dutch clover sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	35
15	Average soil moisture depletion by sods of white dutch clover, ladino clover and alfalfa at all depths (8-40 inches inclusive) for all dates of 1952 growing season	36
16	Soil moisture depletion by ladino clover sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	38
17	Soil moisture depletion by redtop sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	40
18	Average soil moisture depletion by redtop, quackgrass and fescue sods for all depths (8-40 inches inclusive) for all dates of 1952 growing season.	41
19	Soil moisture depletion by timothy sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	42
20	Average soil moisture depletion by timothy and bluegrass sod for all depths (8-40 inches inclusive); and rainfall intensity and distribution for all dates of 1952 growing season	44
21	Soil moisture depletion by quackgrass sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	45
22	Soil moisture depletion by bluegrass sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	47
23	Soil moisture depletion by fescue sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	48

LIST OF FIGURES CONT.

Figure		Page
24	Soil moisture depletion by alfalfa sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season	50
25	Average soil moisture conditions in mulched and cultivated soils for all depths (8-40 inches inclusive) for all dates of 1952 growing season	52
26	Average soil moisture conditions by depths (8-40 inches) for all sods and treatments on July 14, 1952	60
27	Average soil moisture conditions by depths (8-40 inches) for all sods and treatments on September 1, 1952	61

LIST OF TABLES

Table		Page
I	The amount of rain by weeks for each month of the season for the years 1951-52 at Graham Experiment Station, Grand Rapids, Michigan . .	14
II	Air dry weight of clippings of plants mowed June 8, 1951	15
III	Air dry weight of clippings of plants mowed June 16, 1952.	33
IV	Percent of available soil moisture, by depths and dates (1951), in sods of white dutch clover	70
V	Percent of available soil moisture, by depths and dates (1951), in sods of ladino clover . .	71
VI	Percent of available soil moisture, by depths and dates (1951), in sods of redtop.	72
VII	Percent of available soil moisture, by depths and dates (1951), in sods of timothy	73
VIII	Percent of available soil moisture, by depths and dates (1951), in sods of quackgrass. . . .	74
IX	Percent of available soil moisture, by depths and dates (1951), in sods of bluegrass	75
X	Percent of available soil moisture, by depths and dates (1951), in sods of fescue.	76
XI	Percent of available soil moisture, by depths and dates (1951), in clean cultivated and mulched soil	77
XII	Percent of available soil moisture, by depths and dates (1952), in sods of white dutch clover	78
XIII	Percent of available soil moisture, by depths and dates (1952), in sods of ladino clover . .	79
XIV	Percent of available soil moisture, by depths and dates (1952), in sods of timothy	80
XV	Percent of available soil moisture, by depths and dates (1952), in sods of redtop.	81

LIST OF TABLES CONT.

Table		Page
XVI	Percent of available soil moisture, by depths and dates (1952), in sods of quackgrass. . . .	82
XVII	Percent of available soil moisture, by depths and dates (1952), in sods of bluegrass	83
XVIII	Percent of available soil moisture, by depths and dates (1952), in sods of fescue.	84
XIX	Percent of available soil moisture, by depths and dates (1952), in sods of alfalfa	85
XX	Percent of available soil moisture, by depths and dates (1952), in clean cultivated and mulched soil	86

ACKNOWLEDGEMENT

The author expresses his appreciation to Dr. A. L. Kenworthy of the Department of Horticulture and Mr. Walter Tornjes, Superintendent of the Graham Experiment Station, for their assistance and guidance in this investigation.

The author also wishes to thank Drs. L. M. Turk and R. L. Cook of the Soils Department, C. M. Harrison of the Farm Crops Department, L. W. Mericle of the Department of Botany and Plant Pathology, and H. B. Tukey and A. L. Kenworthy of the Department of Horticulture for serving on his guidance committee.

INTRODUCTION

The management of orchard soils is dependent largely upon soil type, soil topography, and kind of orchard. The use of cover crops or sods in orchards should result in soils with higher organic matter content, improved structure, greater moisture holding capacity, and more resistance to erosion than those clean cultivated. The utilization of soil moisture by cover crops and sod covers may reduce rather than improve tree growth when they are first established. However, continued production of cover crops or sods usually results in better tree growth and production than that obtained by clean cultivation. Sod covers usually reduce tree growth more than cover crops because they occupy the soil for the entire season. The use of sod covers, however, has been generally accepted, for certain fruit crops, after methods of management were developed that reduced their competition with the trees for soil moisture. These methods of management involve species of sod, mowing of sods, mulching of trees, and fertilizer applications. A study of the relation of soil moisture depletion by certain sod crops to management practices was initiated in 1951. The time and amount of soil moisture removed by the various sod crops was the primary aim of this investigation.

REVIEW OF THE LITERATURE

At the turn of the century and for some years later, sods were believed to be harmful to orchard trees. Bedford, Pickering, and Spencer (1911), and Hedrick (1914) suggested that sods released toxic substances to the soil that were detrimental to trees, and also restricted the movement of air and gases into and out of the soil and for this reason had a harmful influence on the roots of the trees. Hedrick (1914), Woodbury, Noyes, and Oskamp (1917), Cullinan and Baker (1927), Anthony (1930), and Clarke (1932) maintained that sods offered serious competition with the trees for soil moisture and nutrients.

Hedrick (1914) concluded after ten years of study in apple orchards of New York that grass sod was the withering palsy of the apple industry in that state. Gourley (1917) and Gourley and Shunk (1916) reported sods were undesirable in the orchards of New Hampshire. Their data showed that often the soil moisture was higher in the soil growing sod than in tilled soil. Woodbury, Noyes, and Oskamp (1917) in Indiana, showed that the moisture content of orchard soil growing sod was less, at certain times of the year, than in tilled soil.

Most of the literature prior to 1935 showed a general agreement that sods in orchards were detrimental to the

trees. There was, however, no clear conception as to why they were detrimental.

From 1901-1948 investigations were conducted which provided information concerning this problem. Ladd (1901), Hall (1905), Lyon and Bizzell (1911), Bizzell (1923), Reuzer (1931), and Rogers et al (1948) found there was little or no accumulation of nitrates in grassland soils. Hall (1905) showed this was not due to lack of nitrifiable organic matter or nitrifying flora, because a virgin grassland soil that had never contained over three ppm of nitrates contained 39.8 ppm of nitrates 18 days after it was plowed. Following Hall's work, Ballou (1910), Stewart (1915-1916), Ballou and Lewis (1920), and Cullinan and Baker (1927) reported that non-legume sods were satisfactory in orchards when nitrogen fertilizers were applied to the trees.

A partial explanation for the failure of nitrates to accumulate in grassland soil was given by Kruger and Schneidewind (1899, 1901), and Doryland (1916). They found that the heavy root growth of perennial plants in grassland vegetation provided a constant supply of organic matter to the soil microorganisms. These microorganisms in the presence of abundant energy sources utilized all of the nitrates in the process of decomposition. More recently, Collison and Conn (1925), Shaw and Wouthwick (1936), Collison (1940), and Dawson (1945) worked with mulches of various sorts and confirmed the theory of nitrate utilization by soil flora

when large amounts of energy materials were available to them. Turk and Partridge (1947) showed that nitrate accumulation was reduced in soil when mulched with gravel. This indicated that the reasons for lowered nitrate accumulation in mulched or covered soil was not entirely due to the effect of plentiful energy sources on soil microorganisms. Lyon and Bizzell (1913) showed that the reduction of the nitrate supply in soils growing grasses was greater than the amount used by the grass.

At present there is an abundance of evidence, presented by Ballou and Lewis (1920), Anthony and Waring (1925), Sax (1925), Cullinan and Baker (1927), Anthony (1929-1930), Faurot (1934), Baker (1936), Collison (1940), Rogers et al (1948), and Kenworthy and Gilligan (1949), showing that orchard tree performance was satisfactory where sods were grown in orchards and fertilized with nitrogen fertilizers. Lyon, Heinicke, and Wilson (1923) stated that the growth of trees was greatest on those sod plots which were lowest in soil moisture, but which had received the heaviest application of nitrogen. These results indicate that growing sods in orchards would be an acceptable practice if nitrogen fertilizers were applied.

Shalius and Merkle (1939) have shown that those soil conditions, i.e., porosity, structure, and organic matter content, that conserve the largest amounts of water can be obtained and maintained in orchards by growing sods. Collison (1935) concluded that soil structure was improved

by growing sods to permit greater absorption and retention of precipitation water. The conflicting reports regarding soil moisture in relation to the use of sods and clean cultivation may have been associated with the age of sods, frequency of plowing or disking, and soil fertility.

Several species of legumes and non-legumes are used for sods in orchards. Plant species vary greatly in the amount of soil water which they normally absorb and use in their development. As early as 1699, Woodward (1699) found variations in the amounts of soil water required by some plants. Lawes (1850) extended his experiments to include the entire growth period of annual crop plants and the effect of fertilizers on the water required by plants. He concluded that the use of fertilizers reduced the water requirement of certain plants. Experiments by Hellriegel (1883), Maeracher (1896), Fortier (1902), Ohlmer (1908), Widtsoe (1909), Leather (1910), Kiesselbach (1910), and Kiesselbach and Montgomery (1911) showed that plants vary greatly in their uptake and transpiration of water and that the water requirement, usually given as the amount of water necessary to produce a given unit of dry matter, tends to increase as the water content of the soil approaches field capacity or wilting point. Their results agreed with those of Lawes (1850) regarding the effect of fertilizers on lowering the water requirement. In highly productive soils, fertilizer applications may reduce the water requirement of plants very little. However, in infertile soils,

the water requirement may be greatly reduced by the addition of fertilizers.

The influence of atmospheric factors on the water requirement of plants becomes evident from the data of Hellriegel (1883), King (1905), and Briggs and Shantz (1913). These investigators concluded that even though the methods and soil conditions are the same for two different years, large differences may be recorded in the water requirement of identical varieties of plants.

Lawes (1850), and Briggs and Shantz (1913) have compared the water requirement of some plants which are used as sods or cover crops in orchards. They found that red clover, sweet clover, and alfalfa all had very high water requirements as compared to such plants as millet, wheat, buckwheat and certain weeds. The water requirement of alfalfa has been reported to be approximately twice that of millet, wheat, and buckwheat, while the water requirement of red and sweet clover was intermediate.

Some workers have compared sod plants in relation to the utilization of soil moisture in orchards. Ellenwood and Gourley (1937) showed that soil moisture levels in soils growing Kentucky bluegrass, timothy, redtop, and orchardgrass was higher than in soils growing an annual cover crop and compared favorably with the moisture levels in clean cultivated soils. Collison (1940) found that moisture levels in soils growing Kentucky bluegrass sod compared favorably with the moisture levels in clean culti-

vated soils. He (1933) also concluded that timothy used much less soil water than alfalfa. Collison concluded from his data that the commonly accepted belief that sods used as covers in orchards seriously compete with the trees for moisture was considerably exaggerated. Howlett (1936) showed that alfalfa and Kentucky bluegrass sods did not seriously compete with orchard trees for soil moisture when the orchard soil was deep, but that alfalfa was more apt to do so in dry seasons than Kentucky bluegrass. Fagan, Anthony, and Clarke (1933), and Anthony, Farris, and Clarke (1948) obtained results which were in agreement with those of Howlett and Collison.

Anthony (1934), Collison (1935), Partridge (1937), Toenjes (1941), Collison and Carleton (1942), and Anthony, Farris, and Clarke (1948) have emphasized the importance of sods in preventing the loss of precipitation water by run-off. Woodbury, Noyes, and Oskamp (1917), Gourley (1917), Ellenwood and Gourley (1937), and Toenjes (1941), have found that sodded soils were not as cool in summer as mulched soils, but were not as warm as bare soils, while in winter they were cooler than mulched soils, but not as cold as bare soils. Orchard soils that are frozen in winter may prevent thawing snow water from penetrating the soil, in which case it may be lost by run-off. Gourley (1917), working in New Hampshire, found that in March, 1916, soils under sods were frozen to depths of 12 inches as compared to depths of 16 inches for bare soils. Ellenwood

and Gourley (1937) working in Ohio, in February, 1936, found the soils frozen to depths of 30 inches when clean cultivated, to depths of 18 inches beneath sods, and to depths of 9 inches when mulched. Toenjes (1941) working in Michigan reported that in March, 1939, the soil in Kentucky bluegrass sod was frozen to depths of 3.4 inches while cleanly tilled soil was frozen to 6.6 inches.

The retention of snow in place against removal by winds, and the interception and retention of drifting snow, is an important consideration in replenishing the soil moisture supply. This is particularly true in areas where a large percentage of the annual precipitation occurs as snowfall. Collison (1940) found in February, 1936, that the snow cover was two to three inches deep on sods of alfalfa, Kentucky bluegrass, and redtop and was less than one inch deep on disked soil. Due to the insulating effect of the snow cover and of the sod itself, sodded soils do not freeze to as great depths as bare soils. If the snow is sufficiently deep, the soil may not freeze at all. Thus, water from melting snow tends to penetrate the sodded soil and results in run-off from the clean cultivated soil which was frozen for lack of insulation.

The literature indicates that the combined effects of sods in orchards on the absorption, retention, and evaporation of water by the soil may result, in the case of some soils, in sufficient soil moisture for the requirements of both the sod and trees.

PROCEDURE

An area of approximately 1.1 acres of Miami silt loam soil was divided into plots 27 feet square. Sods of Kentucky bluegrass (Poa pratensis), Chewing fescue (Festuca rubra, var. commutata), timothy (Phleum pratense), redtop (Agrostis alba), white dutch clover (Trifolium repens), ladino clover (Trifolium repens, var. latum) were established on the plots by seeding in the fall of 1950. Quackgrass (Agropyron repens) sod was established vegetatively by means of plant segments. In addition to the plots growing sods, plots were left to be clean cultivated and mulched.

Each plot was divided into four subplots of equal size (13.5 x 13.5 feet) and an installation of gypsum soil moisture absorption blocks, designed by Bouyoucos (1940), was made in the center of each subplot. The absorption blocks were installed in a vertical hole at depths of 8, 16, 24, 32, and 40 inches so that each plot contained four installations of five blocks or 20 blocks per plot. The wire leads from each installation were collected at the center of each plot. This arrangement made it possible to make moisture determinations for all installations at one point in each plot. The wire leads were intrenched in the soil to avoid interference with treatment of the sods

and soils. The moisture determinations were made weekly by means of a portable, direct reading moisture meter which was calibrated to convert electrical resistance into readings of percentage available soil moisture.

Two subplots, of each sod plot, were mowed in June of 1951 and 1952. The air dry clippings were weighed. All clippings were removed each year to avoid smothering of the sods. The clean cultivated plots were cultivated as necessary to control weeds. The mulched plots received 280 pounds of wheat straw annually.

Alfalfa (Medicago sativa) was seeded on some plots in the fall of 1951 and soil moisture determinations were made in 1952.

The Miami silt loam soil used in this study had a field capacity of approximately 15 percent and a wilting point of 5 percent or approximately 10 percent moisture, by weight, for plant utilization.

RESULTS

Moisture depletion by the different sod covers for any particular part of the growing season was dependent upon the distribution and intensity of rainfall (Figures 1, 2). For example, during the month of June, rainfall was above average in 1951 but below average in 1952 (Table I). During the month of July, rainfall was below average in 1951 but above average in 1952. Soil moisture during these two months, particularly at mowing time, appeared to have a pronounced influence upon moisture depletion by sod growth and the presence of sod regrowth following mowing. Because of the distinct differences in rainfall distribution for the two seasons, observations on soil moisture depletion by the various sod covers are considered separately for the two seasons.

Sod Growth - 1951

Weight of clippings and stage of growth when mowed on June 8 are shown for the various sod covers in Table II. Timothy was the tallest growing sod and produced the greatest amount of air dried clippings. The two clover sods were the shortest of the sod covers and produced the least amount of air dried clippings. Bluegrass, fescue, redtop and quackgrass were all of about the same height.

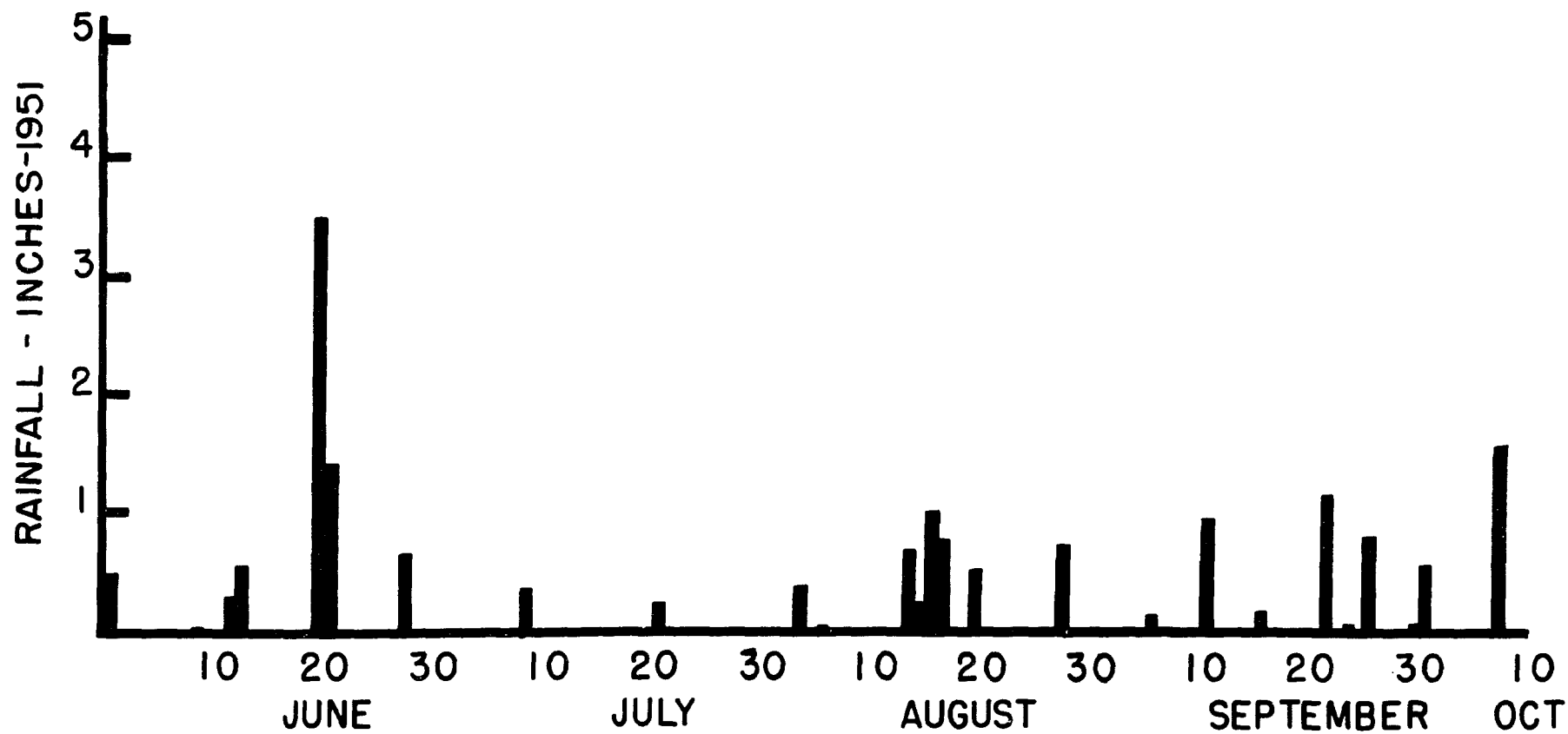


Figure 1. Distribution and intensity of rainfall at Grand Rapids, Michigan, during the growing season of 1951.

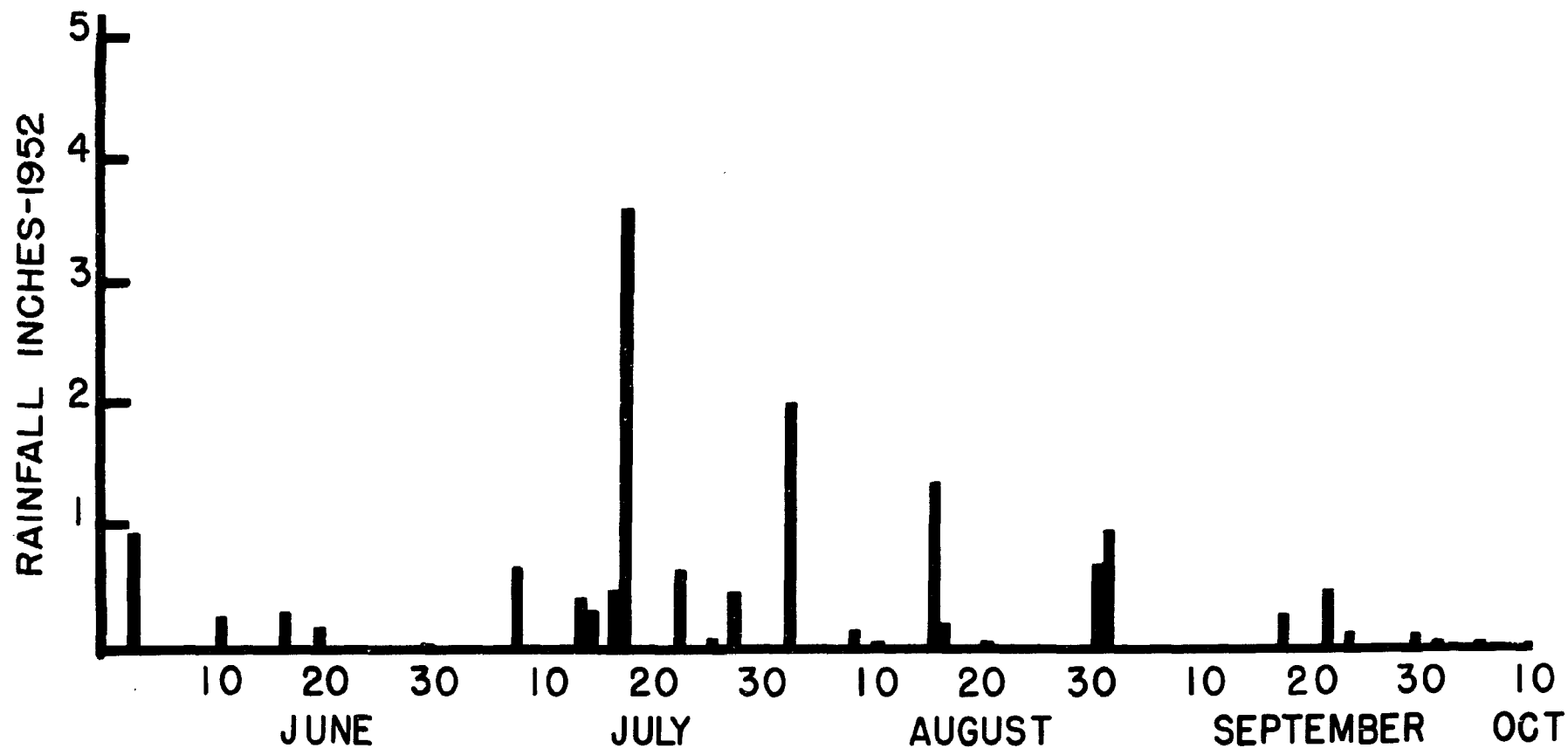


Figure 2. Distribution and intensity of rainfall at Grand Rapids, Michigan, during the growing season of 1952.

TABLE I

THE AMOUNT OF RAIN BY WEEKS FOR EACH MONTH OF THE SEASON FOR THE
YEARS 1951-52 AT GRAHAM EXPERIMENT STATION, GRAND RAPIDS, MICHIGAN

Week of month	Month of season									
	June		July		August		September		October	
	1951	1952	1951	1952	1951	1952	1951	1952	1951	1952
1st	0.54	0.86	0.06	0.00	0.45	2.00	0.14	0.95	2.04	0.08
2nd	0.83	0.23	0.36	1.05	0.91	0.17	1.54	0.00	0.04	0.02
3rd	4.86	0.46	0.21	4.43	2.30	1.58	0.18	0.24	--	--
4th	0.64	0.08	0.00	1.15	0.80	0.68	2.28	0.67	--	--
Total for month	6.87	1.63	0.63	6.63	4.46	4.43	4.14	1.86	2.08	0.10

TABLE II

AIR DRY WEIGHT OF CLIPPINGS OF PLANTS MOWED JUNE 8, 1951

Sod crop	Height (in.)	Blossom dates	Air dry weight (lbs./acre)
Kentucky bluegrass	12-14	June 1-5	2353
Chewing fescue	10-12	June 1	2402
Quackgrass	10-14	June 28	1868
Redtop	10-14	June 28	3670
Timothy	18-24	June 28	5204
Ladino clover	6-8	--	1601
White dutch clover	5-8	--	1535

However, redtop produced more air dried clippings than fescue and bluegrass while quackgrass produced less air dried clippings than fescue and bluegrass. Bluegrass and fescue were past bloom when mowed while quackgrass, redtop and timothy did not bloom until June 28. The two clover sods had been blossoming for about two weeks when mowed.

Soil Moisture Depletion - 1951

White dutch clover: The average percentage of available soil moisture for all depths (8-40 inches inclusive) for the season was 63.7 for mowed and 71.3 for unmowed white clover sod (Appendix Table IV). Mowing the white clover reduced the available soil moisture except at the 40 inch depth (Figure 3). Beginning about July 11, approximately one month after mowing, more soil moisture was used where the sod had been mowed than where the sod was not mowed. This relationship was present throughout the remainder of the season but was less pronounced as the season progressed.

During this first year of growth, white clover did not utilize any appreciable amount of soil moisture below the 24 inch depth until August. No appreciable amount of soil moisture was used at the 40 inch depth until late in the season. The average soil moisture conditions for all depths (8-40 inches inclusive) and dates are shown in Figure 4.

Figure 3. Soil moisture depletion by white dutch clover sod at all depths (8-40 inches inclusive) for all dates of the 1951 growing season.

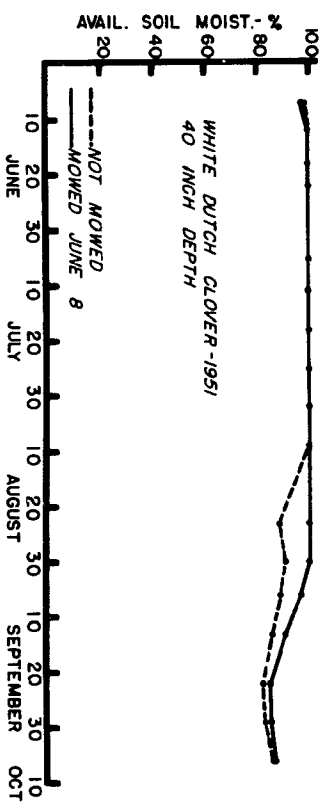
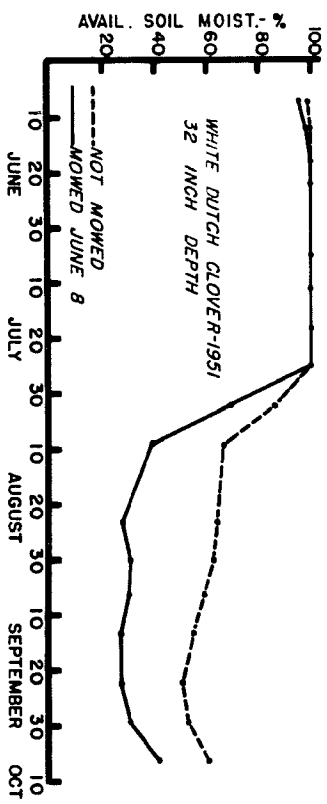
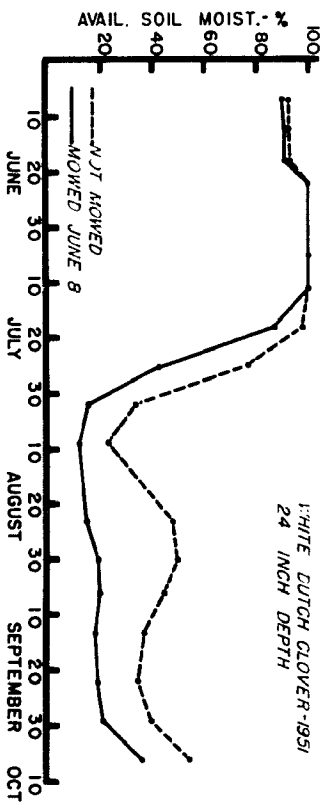
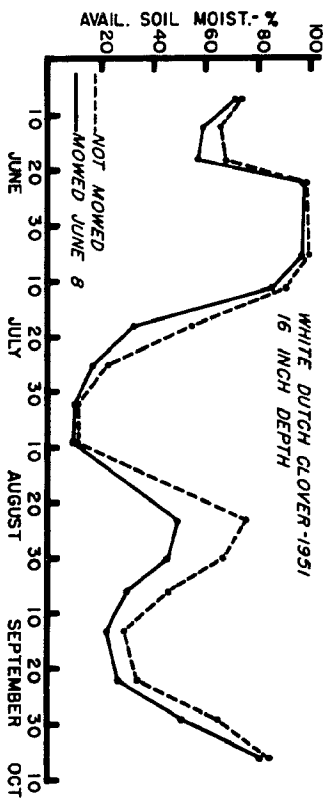
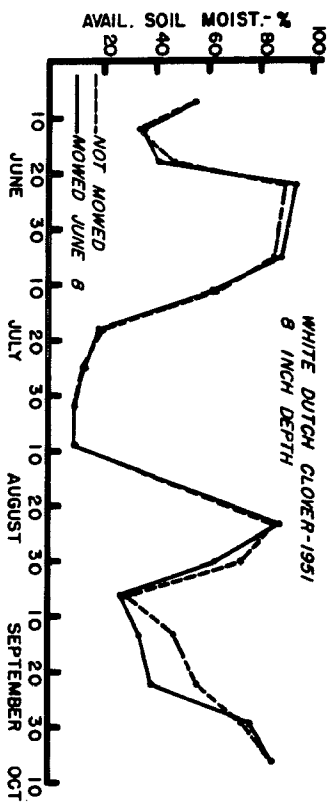
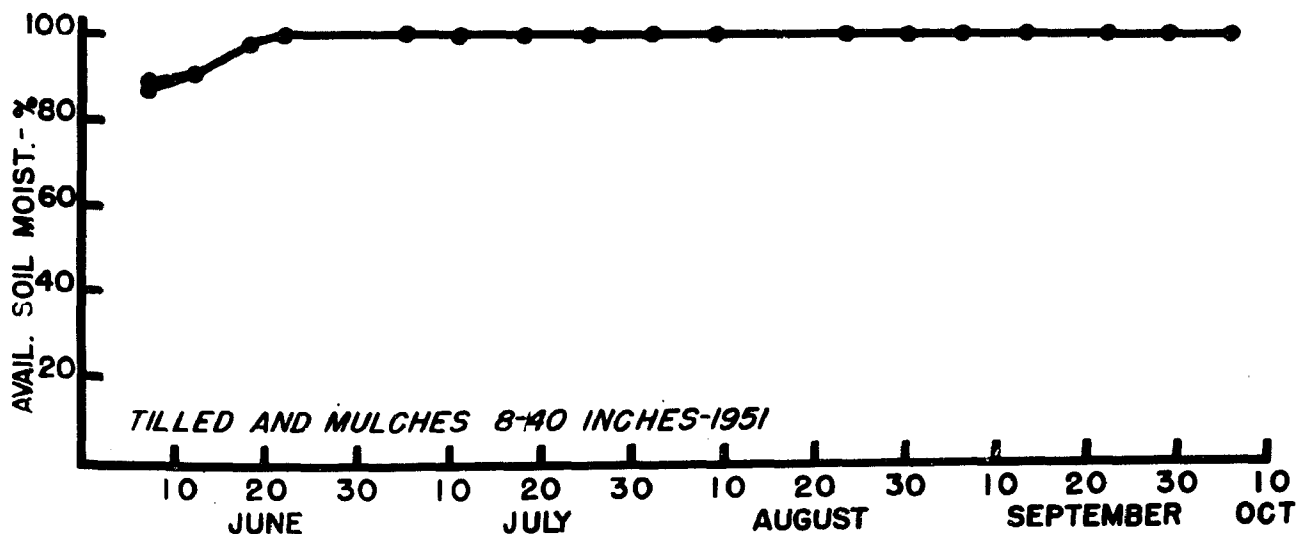
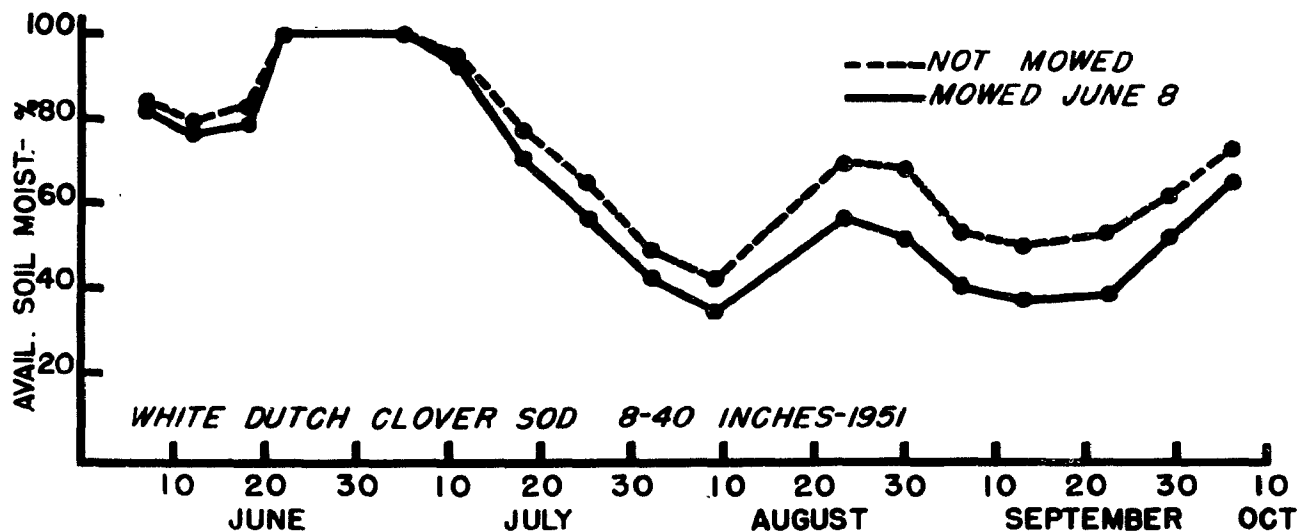
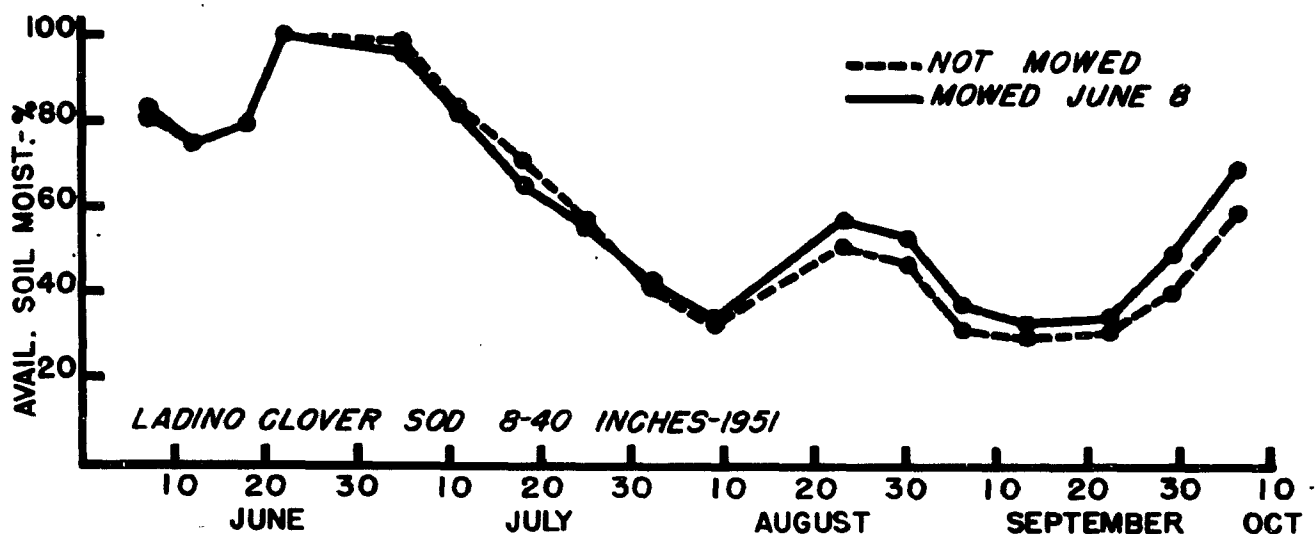


Figure 4. Average soil moisture depletion by sods of ladino clover, white dutch clover, and soil moisture conditions in mulched and tilled soils for all depths (8-40 inches inclusive) for all dates of the 1951 growing season.



Ladino clover: The average percentage of soil moisture available for all depths (8-40 inches inclusive) for the season was 61.0 for mowed and 59.3 for unmowed ladino clover (Appendix Table V). Mowing ladino clover resulted in a slight conservation of soil moisture. Beginning about August 10 and continuing throughout the season, the available soil moisture was reduced at depths of 24, 32, and 40 inches by mowing as compared to not mowing the sod (Figure 5). The unmowed sod used somewhat less soil moisture at the 8 inch depth than the mowed sod. There was no difference in soil moisture conditions at the 16 inch depth from either treatment.

During its first season of growth, ladino clover used rather large amounts of soil moisture from the 24 and 32 inch depths by July 30, and from the 40 inch depth by August 15. The average available soil moisture for all depths (8-40 inches inclusive) for all dates is shown in Figure 4.

Redtop: The average percentage of soil moisture available for all depths (8-40 inches inclusive) for the season was 62.2 for mowed and 76.8 for unmowed redtop sod (Appendix Table VI). Mowing redtop June 8 resulted in a pronounced reduction of the available soil moisture at depths of 8 and 16 inches within two weeks. This effect was noticeable at the 24 inch depth by July 11, at the 32 inch depth by July 25, and at the 40 inch depth by August 8 (Figure 6). The unmowed redtop used very little soil moisture from the 40

Figure 5. Soil moisture depletion by ladino clover sod at all depths (8-40 inches inclusive) for all dates of 1951 growing season.

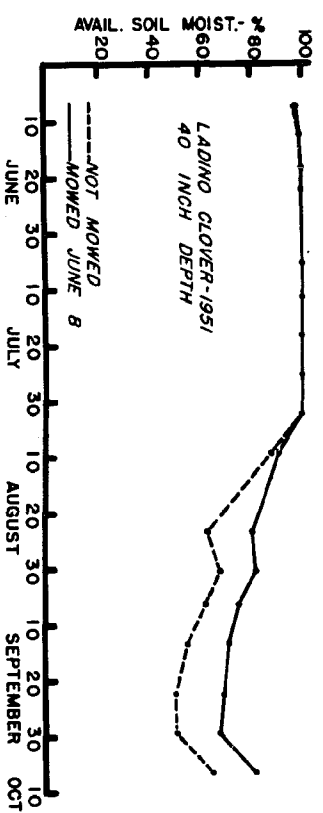
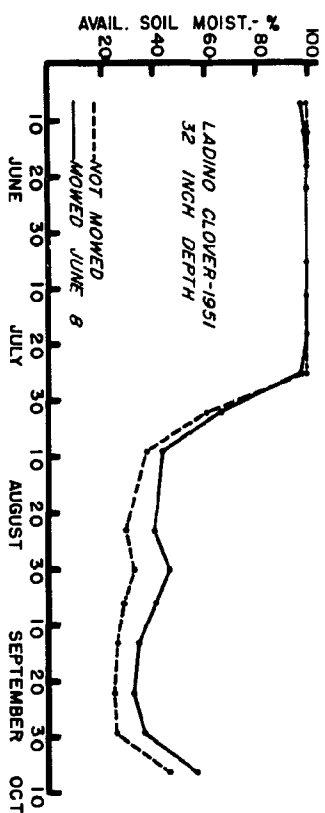
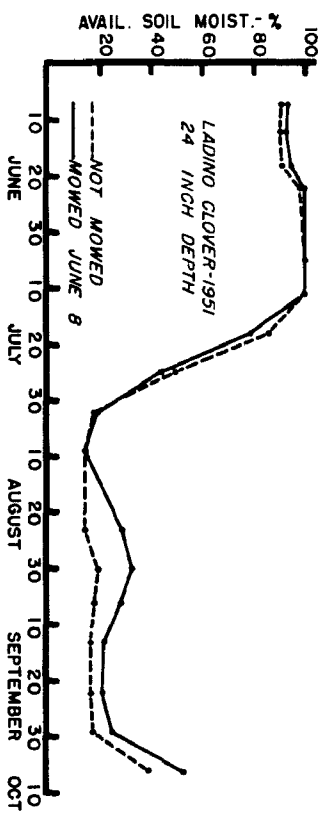
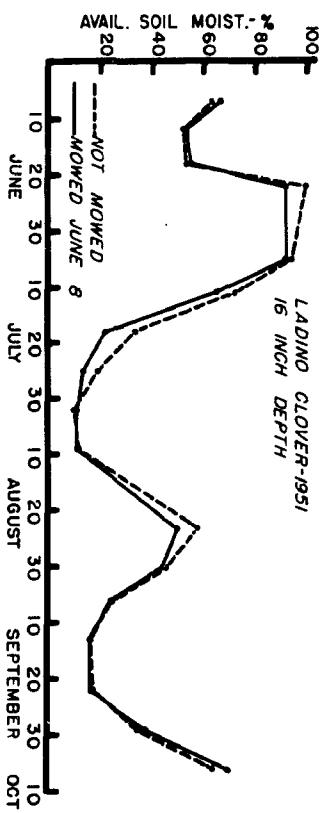
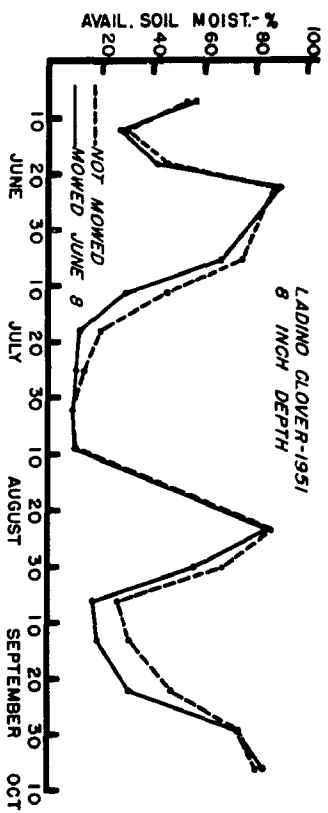
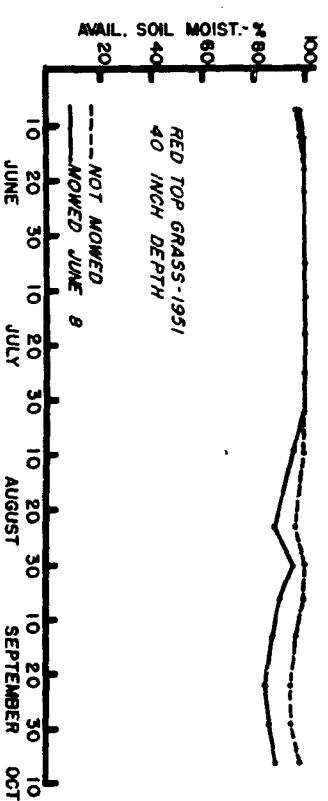
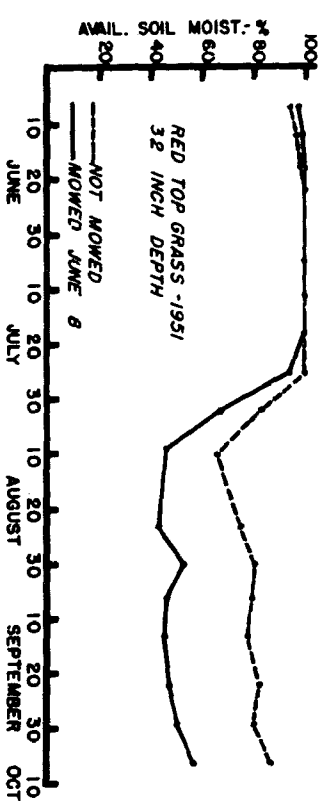
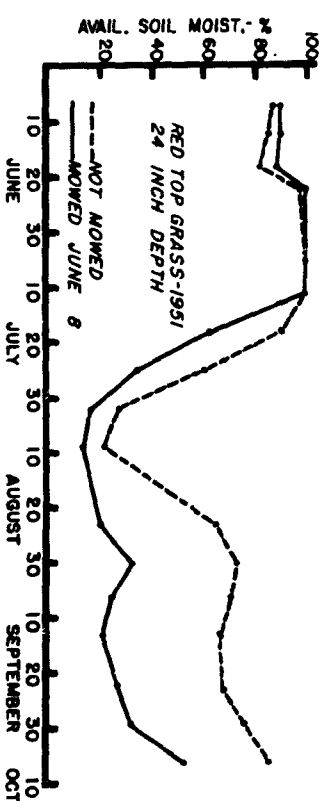
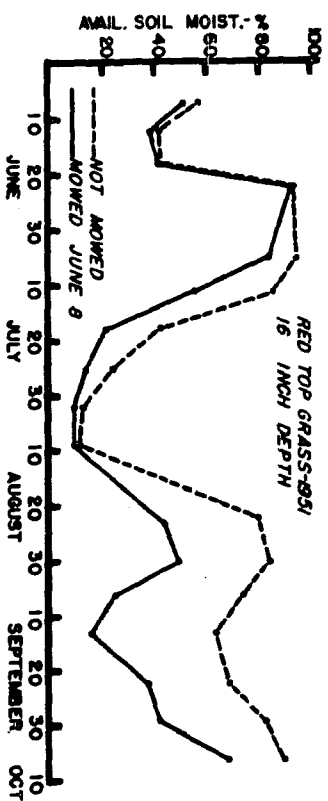
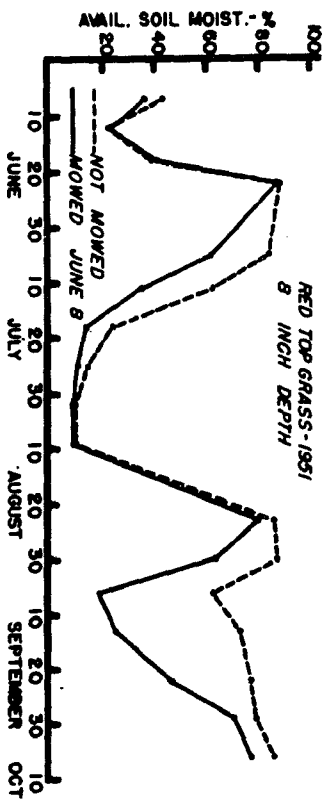


Figure 6. Soil moisture depletion by redtop sod
at all depths (8-40 inches inclusive)
for all dates of 1951 growing season.



inch depth. Mowing redtop had a greater influence on the depletion of soil moisture, than on any other sod used. The soil moisture depleting effect of mowing redtop continued throughout the remainder of the season.

In the first season of growth redtop sod utilized large quantities of soil moisture from the 32 inch depth by July 25, and smaller amounts from the 40 inch depth by August 5. The average available soil moisture in percentage for all depths (8-40 inches inclusive) for the season for redtop sod is shown in Figure 7.

Timothy: While timothy produced 0.75 of a ton more air dry clippings per acre than redtop (Table II), it utilized considerably less soil moisture than redtop. The average percentage of soil moisture available throughout the season at all depths (8-40 inches inclusive) was 76.3 for mowed and 80.0 for unmowed timothy (Appendix Table VII). Mowing timothy did not result in any marked increase in the utilization of soil moisture at the 8, 16, and 24 inch depths until the last week of August (Figure 8). This effect from mowing was not evident at depths of 32 inches until September 22. Timothy failed to utilize very great amounts of soil moisture from either the 32 or 40 inch depths in 1951. The difference in soil moisture levels, induced by mowing, became less pronounced at the end of the season.

The average available soil moisture for all depths (8-40 inches inclusive) for all dates for timothy sod is shown in Figure 9.

Figure 7. Average soil moisture depletion by sods of redtop, quackgrass and fescue for all depths (8-40 inches inclusive) for all dates of 1951 growing season.

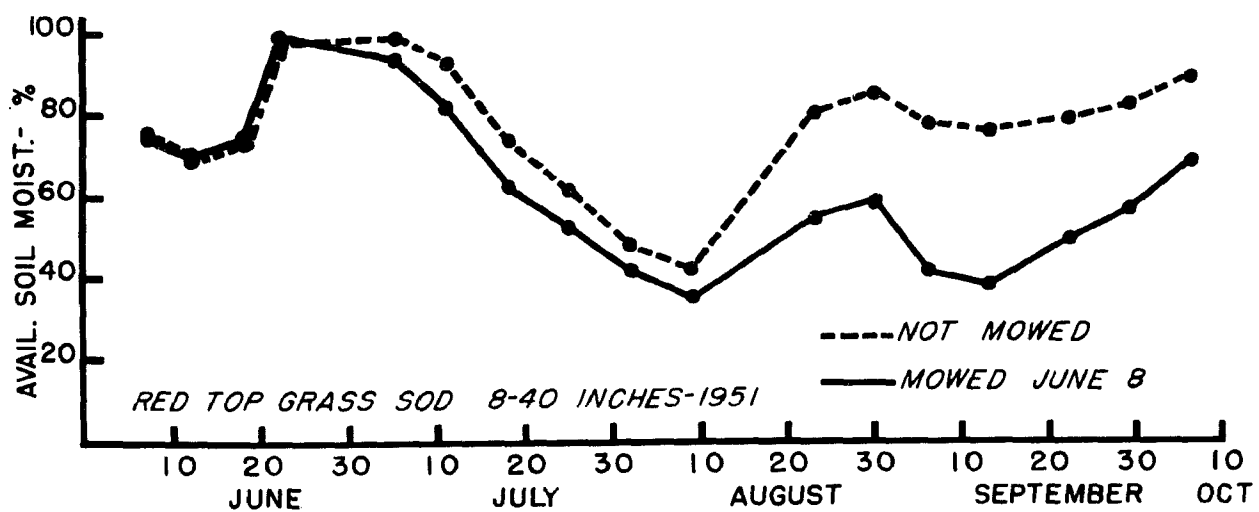
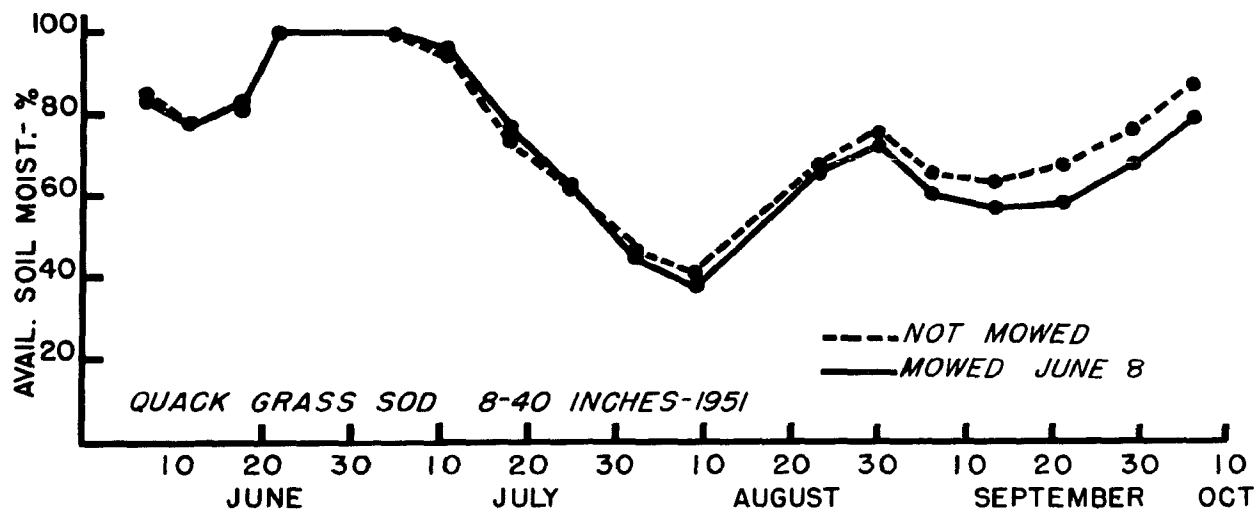
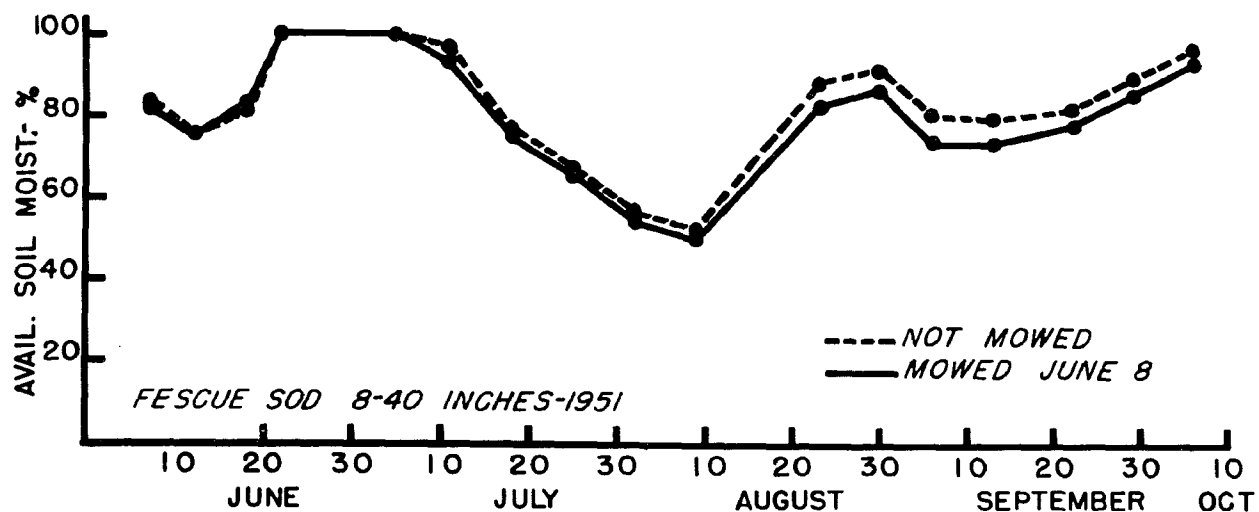


Figure 8. Soil moisture depletion by timothy sod
at all depths (8-40 inches inclusive)
for all dates of 1951 growing season.

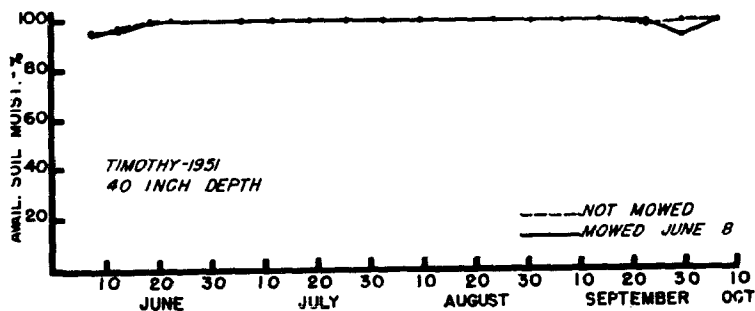
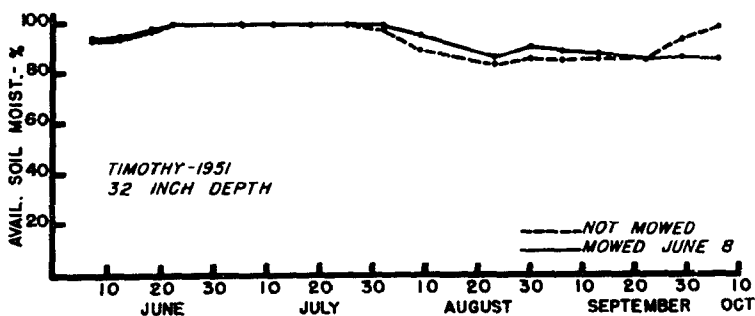
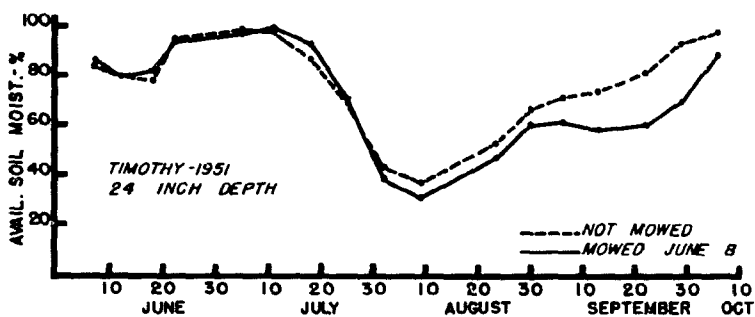
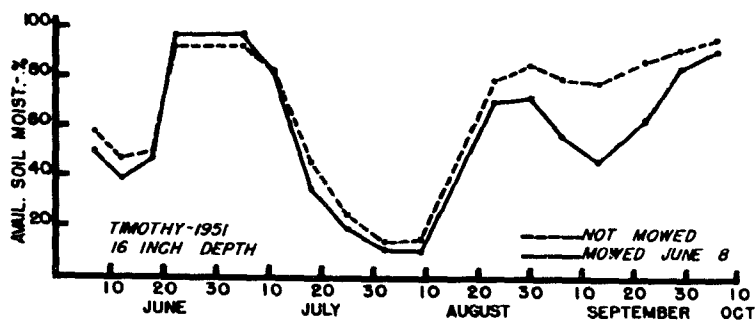
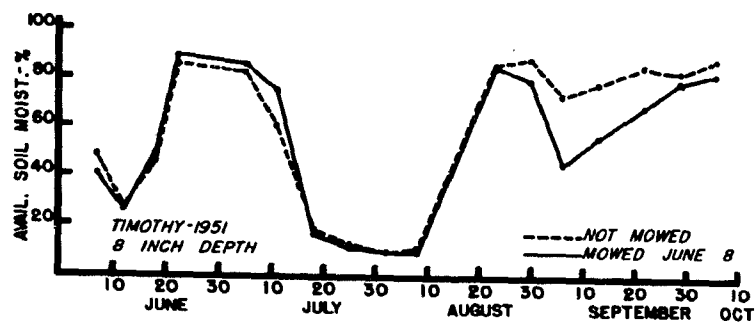
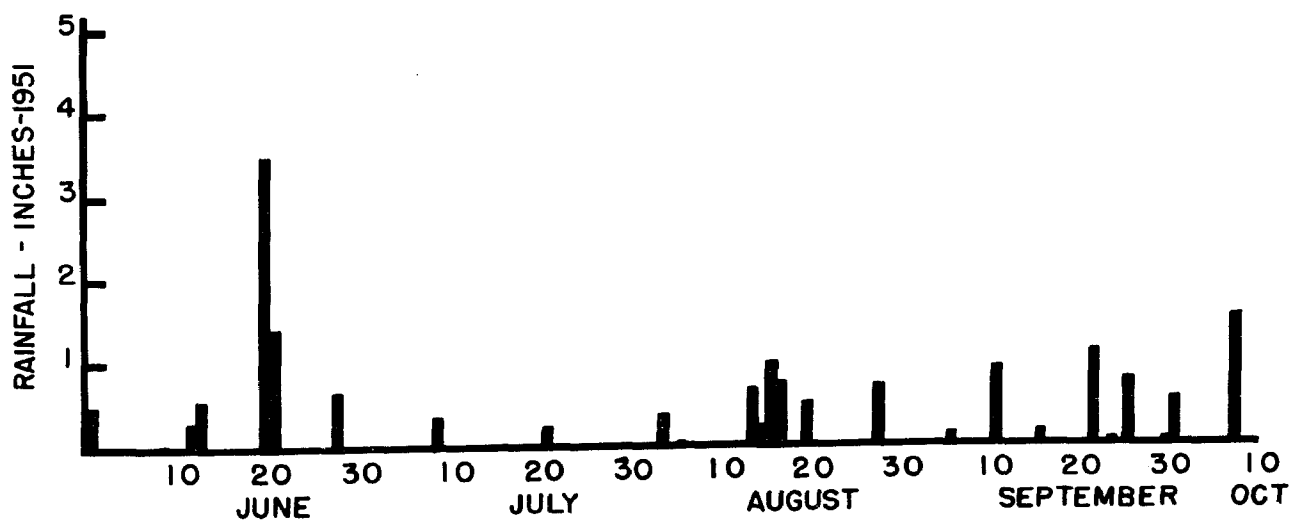
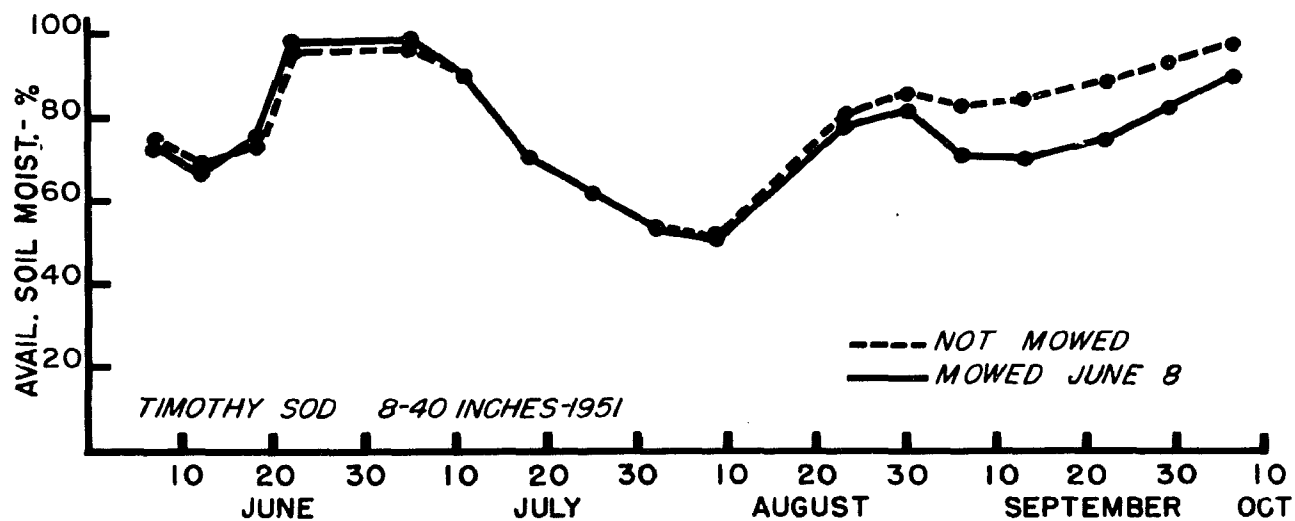
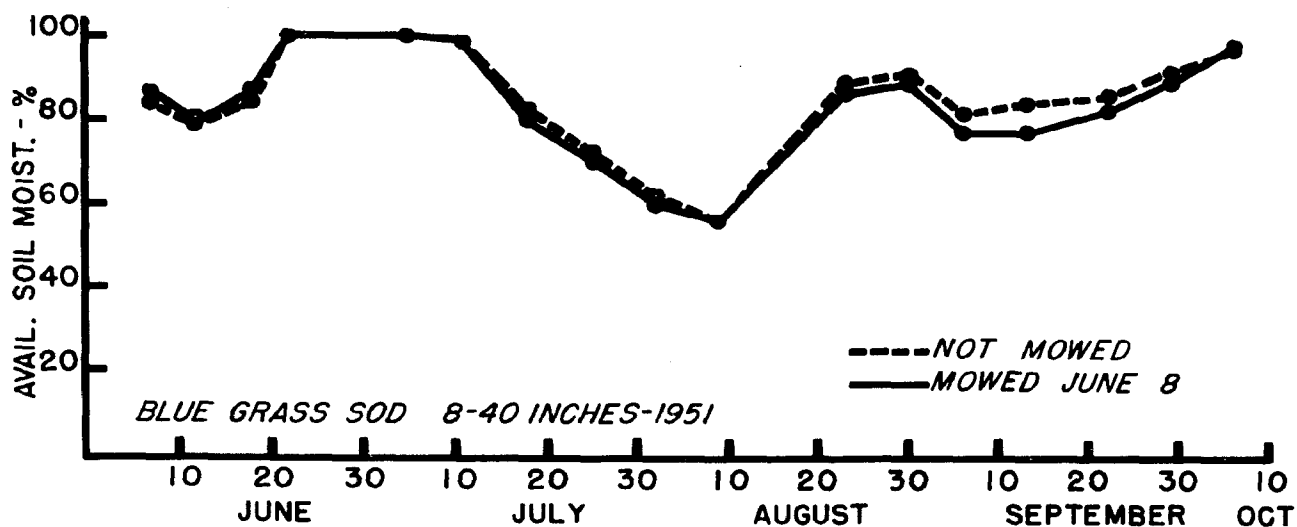


Figure 9. Average soil moisture depletion by sods of bluegrass and timothy for all depths (8-40 inches inclusive), and the distribution and amount of rainfall for all dates of 1951 growing season.



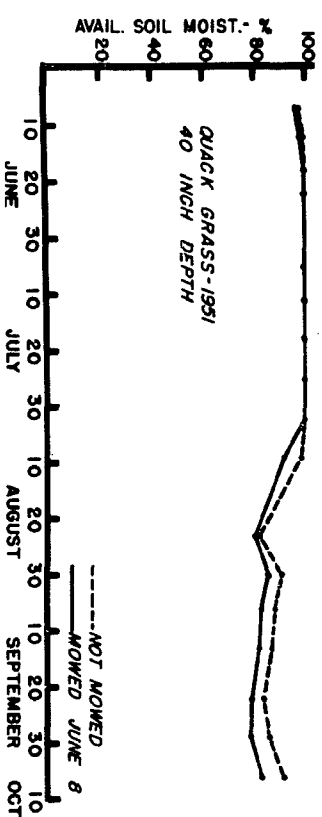
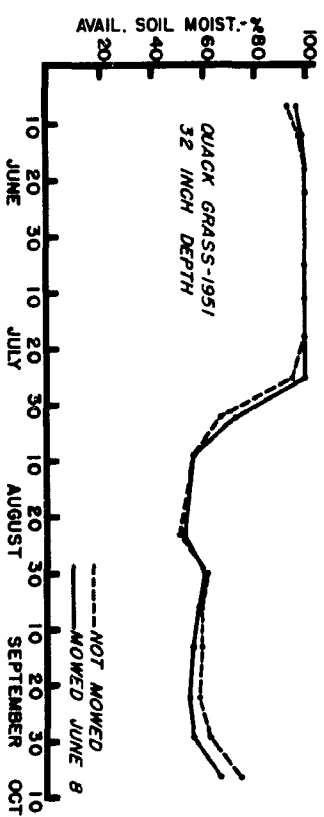
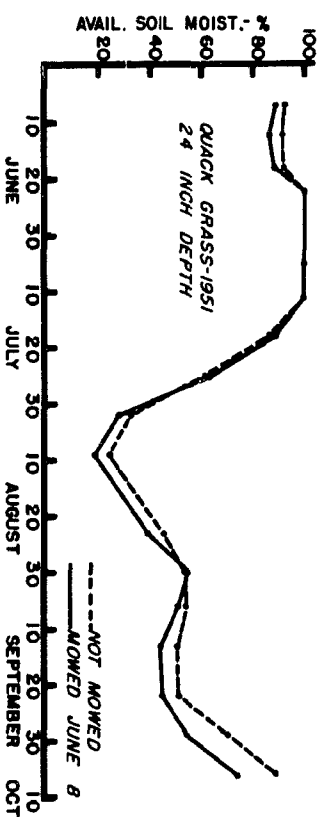
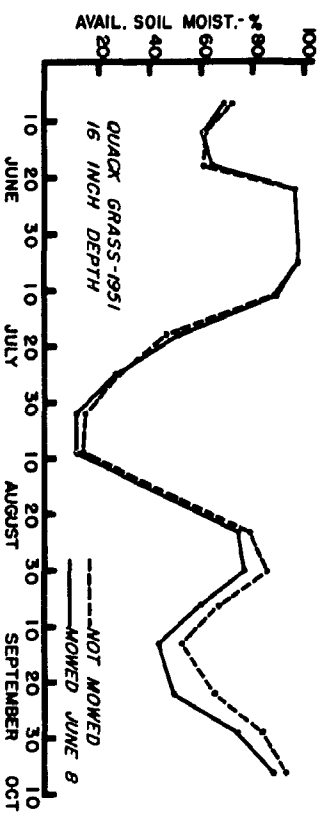
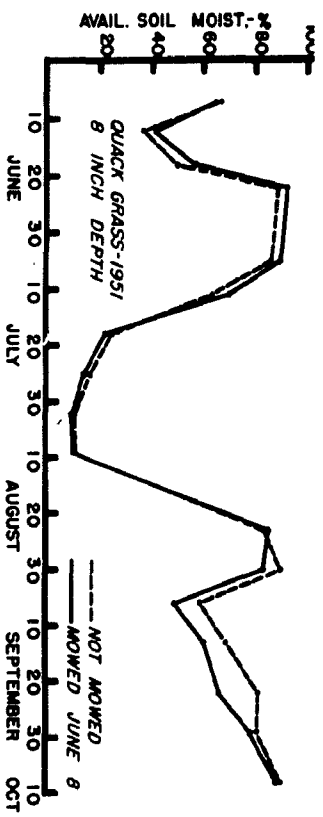
Quackgrass: The stand of quack grass was not as dense in 1951 as it was in 1952. The amount of air dry clippings was only about 1,800 pounds per acre, nevertheless, quackgrass depleted the soil moisture at all depths during its first season of growth.

The average soil moisture in percent available for the season at all depths (8-40 inches inclusive) was 72.2 for mowed and 74.8 for unmowed quackgrass (Appendix Table VIII). While mowing quackgrass had little effect on the amount of moisture depletion, the mowed sod used slightly more soil moisture than when it was not mowed. Quackgrass was using considerable amounts of soil moisture from the 8, 16 and 24 inch depths by the first week of July, from the 32 inch depth by the last week of July, and from the 40 inch depth the first week of August (Figure 10). The small conservation of soil moisture resulting from not mowing quackgrass was only evident late in the season.

The average soil moisture in percent available for all dates and depths (8-40 inches inclusive) for quackgrass sod is shown in Figure 7).

Kentucky bluegrass: Mowing bluegrass had less effect on the consumption of soil moisture than on any other sod with the exception of Chewing fescue and ladino clover. The average soil moisture in percent available for the season at all depths (8-40 inches inclusive) was 83.9 for mowed and 85.1 for unmowed bluegrass (Appendix Table IX).

Figure 10. Soil moisture depletion by quackgrass sod at all depths (8-40 inches inclusive) for all dates of 1951 growing season.



Mowing caused the sod to deplete soil moisture from the 8 and 16 inch depths from September 6-28, and from the 24 inch depth the last week of August to October 6 (Figure 11). The effect of mowing had disappeared by the end of the season.

In its first season of growth bluegrass used practically no soil water from the 32 and 40 inch depths. The average soil moisture conditions for all depths (8-40 inches inclusive) and dates are shown in Figure 9.

Chewing fescue: The average percentage of available soil moisture for all depths (8-40 inches inclusive) throughout the season was 79.9 for mowed and 82.3 for unmowed fescue (Appendix Table X). Mowing fescue increased its utilization of soil moisture at the 24 and 32 inch depths from the first week of August until the end of the season (Figure 12). The other depths (8, 16, and 40 inches) showed no change in soil moisture conditions from mowing. In its first season fescue utilized very little soil water from the 32 inch depth and none from the 40 inch depth. Bluegrass was the only sod that consumed less soil moisture than fescue in 1951.

The average percentage of available soil moisture present at all depths (8-40 inches inclusive) for all dates of the season is shown in Figure 7.

Mulched and clean cultivated soil: Soil moisture levels remained high at all depths in mulched and tilled soil

Figure 11. Soil moisture depletion by bluegrass sod
for all depths (8-40 inches inclusive) for
all dates of 1951 growing season.

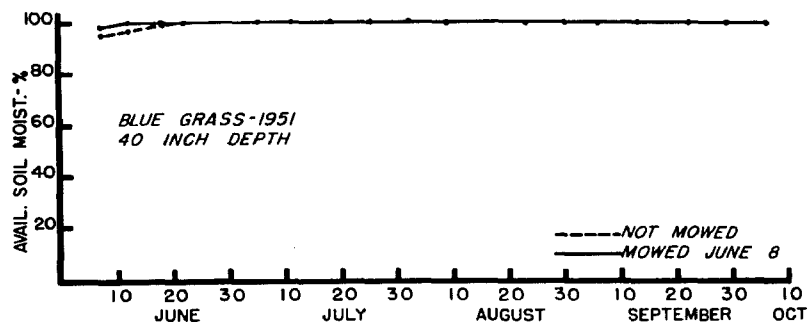
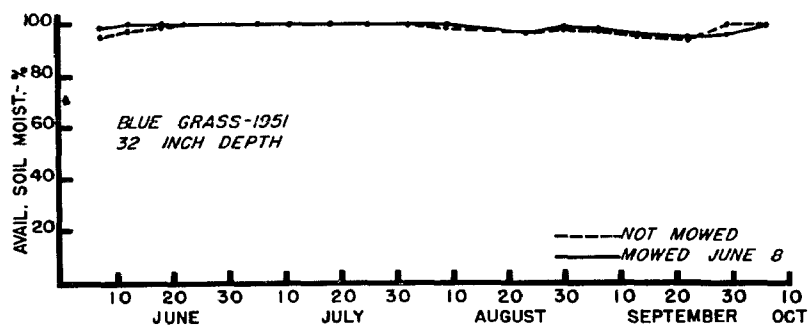
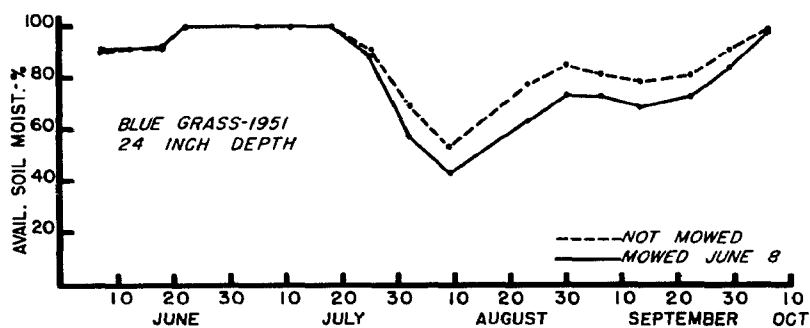
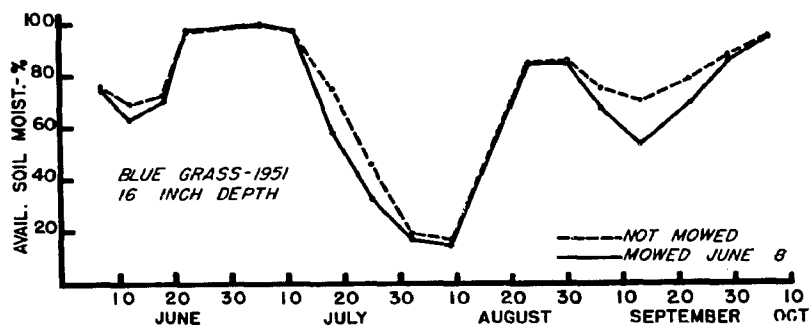
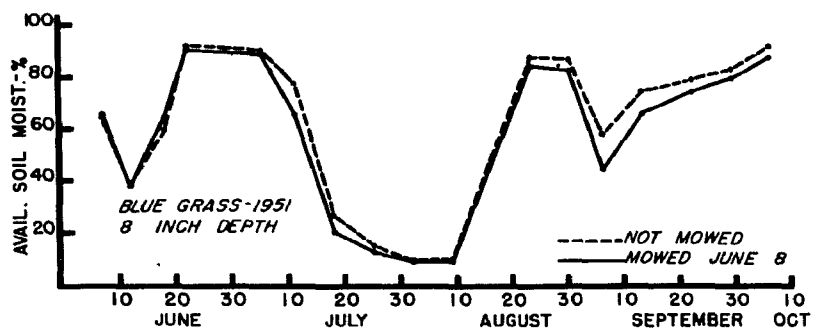
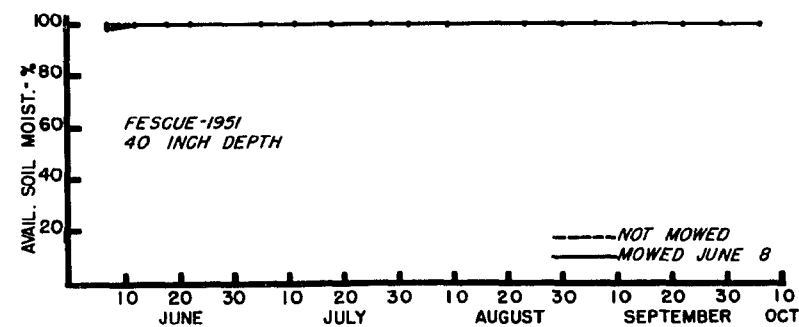
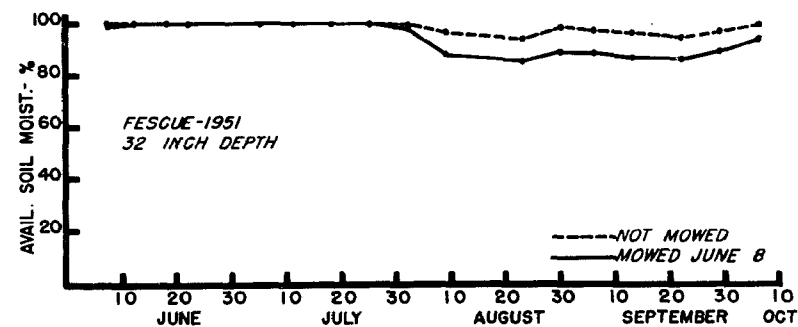
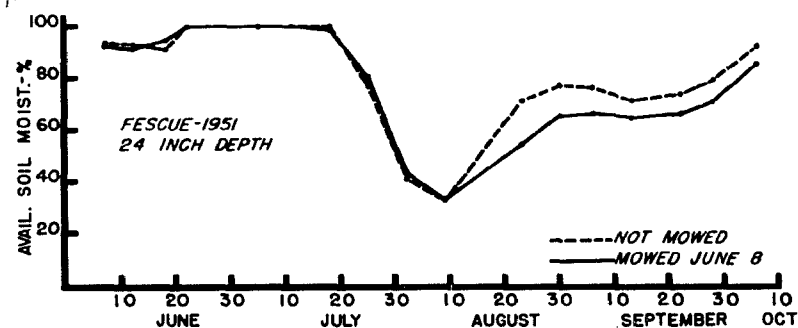
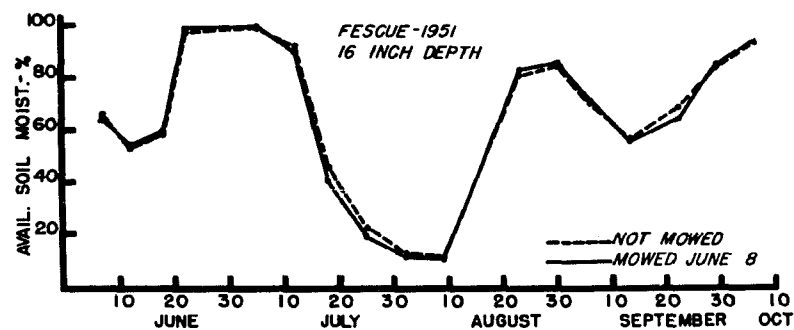
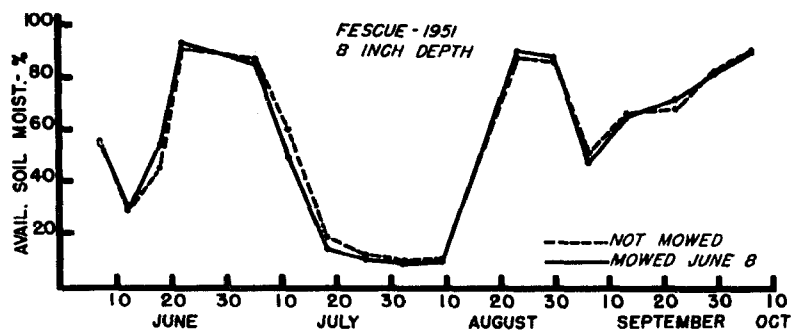


Figure 12. Soil moisture depletion by fescue sod
at all depths (8-40 inches inclusive)
for all dates of 1951 growing season.



throughout the season. The annual cover crop reduced the soil moisture of the 8 inch depth somewhat during September (Figure 13). The average soil moisture available for all depths (8-40 inches inclusive) was 98.7 percent for mulched soil and 98.6 for tilled soils (Appendix Table XI).

The average percentage of available soil moisture for all depths (8-40 inches inclusive) for all dates for mulched and cultivated soils is shown in Figure 4.

Sod Growth - 1952

Weights of clippings and stage of growth of the various sod covers, when mowed on June 16, are shown in Table III. Quackgrass and timothy grew the tallest and produced the largest quantity of air dry clippings of any sod cover used. The stand of quackgrass was very dense in its second season and produced 3.3 times as much air dry clippings as it produced the first season of growth. Ladino and white dutch clover were the shortest growing sod covers and had the least amount of air dry clippings. However, ladino clover produced about 200 pounds per acre more clippings while white dutch clover produced about 300 pounds per acre less than was produced in 1951. Redtop grew taller in 1952 and produced more clippings than in 1951. Alfalfa was 18-20 inches tall when mowed and produced about 5,000 pounds of air dry clippings per acre. Kentucky bluegrass and fescue produced more air dry clippings than in 1951

Figure 13. Soil moisture conditions in mulched and tilled soil at all depths (8-40 inches inclusive) for all dates of 1951 growing season.

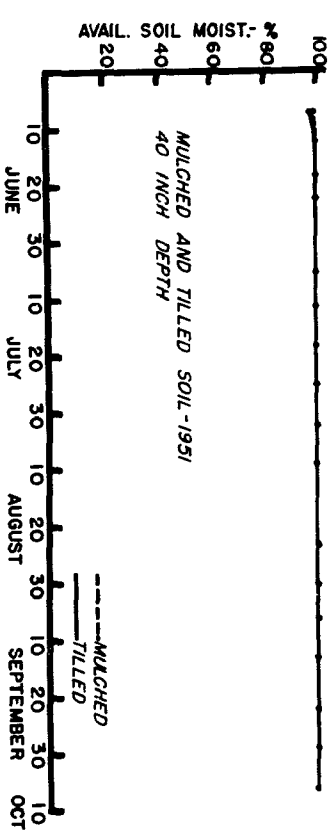
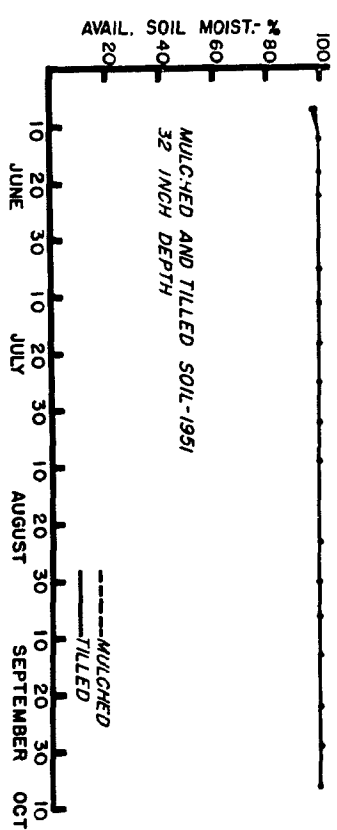
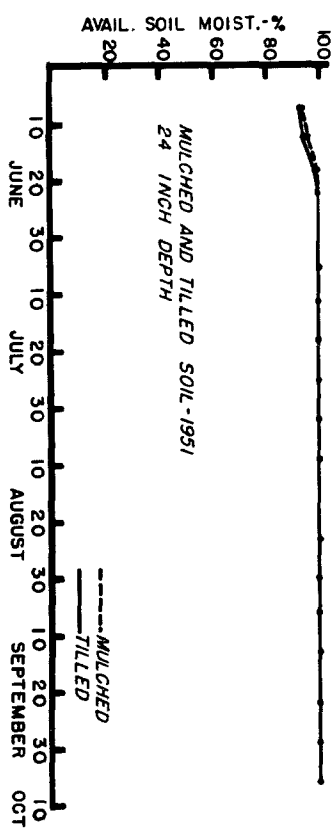
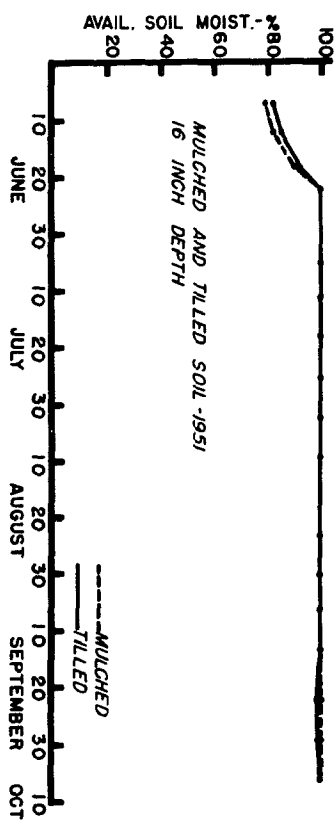
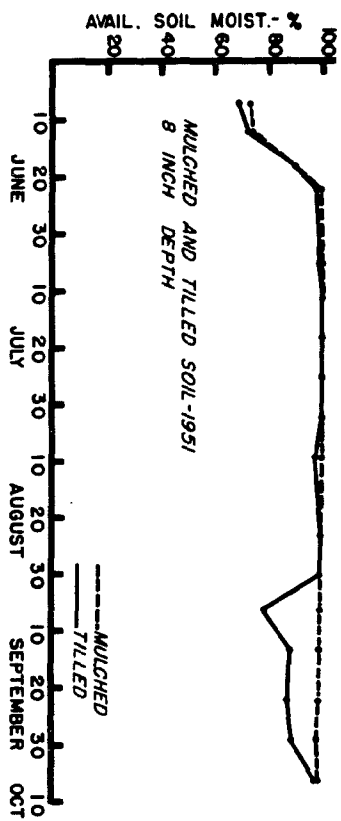


TABLE III

AIR DRY WEIGHT OF CLIPPINGS OF PLANTS MOWED JUNE 16, 1952

Sod crop	Height (in.)	Blossom dates	Air dry weight (lbs./acre)
Kentucky bluegrass	12-14	June 1-5	1143*
Chewing fescue	14-16	May 28	941*
Quackgrass	36-	June 25	6184.
Redtop	14-18	June 28	3227
Timothy	36-	June 28	5512
Ladino clover	10-12	--	1412
White dutch clover	9-10	--	1210
Alfalfa	18-20	--	4974

*Impossible to clip these sods closely due to dead residue from growth of previous season.

even though it was not possible to mow the sods closely. Seed was fully mature on bluegrass and fescue when they were mowed, while redtop, quackgrass, and timothy did not bloom until June 28. Ladino clover, white dutch clover, and alfalfa had been blooming for about three weeks at the time they were mowed.

Soil Moisture Depletion - 1952

White dutch clover: By June 7, or approximately one and one-half weeks before it was mowed in 1952, the white dutch clover sod that was not mowed in 1951 was using considerably more soil moisture from the 8 and 16 inch depths than sod that was mowed in 1951 (Figure 14). The average percentage of available soil moisture at all depths (8-40 inches inclusive) for the season was 48.3 for mowed and 49.8 for unmowed white clover (Appendix Table XII). Mowing white dutch clover resulted in considerably greater depletion of soil moisture beginning the last week of July, at all depths except the 40 inch depth. Sod that was not mowed used relatively great amounts of soil moisture as compared to mowed sod at the 24, 32, and especially at the 40 inch depth, from the last week of June to the first week of August.

The average soil moisture conditions for all depths (8-40 inches inclusive) for all dates of the season are shown in Figure 15. In its second season of growth white dutch clover utilized appreciable quantities of moisture from all depths of the soil regardless of treatment.

Figure 14. Soil moisture depletion by white dutch clover sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season.

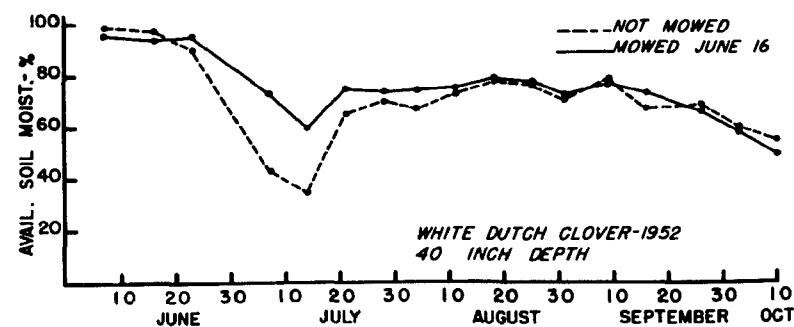
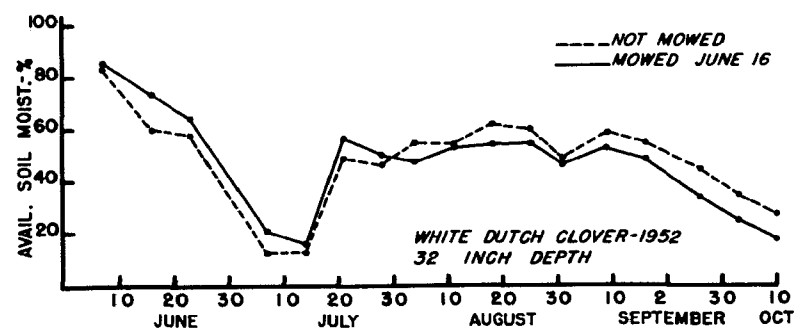
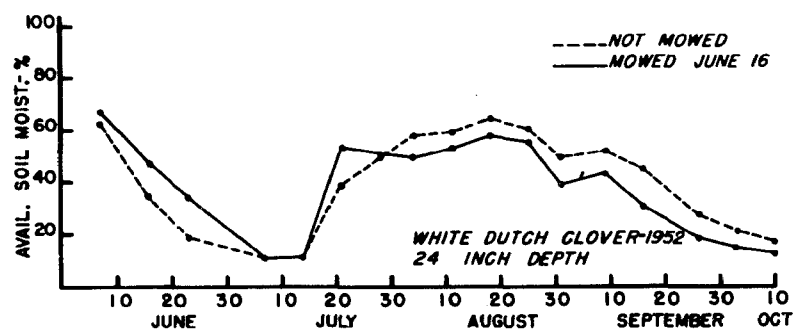
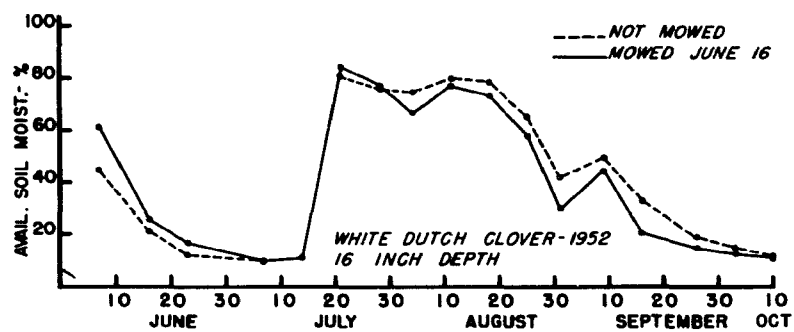
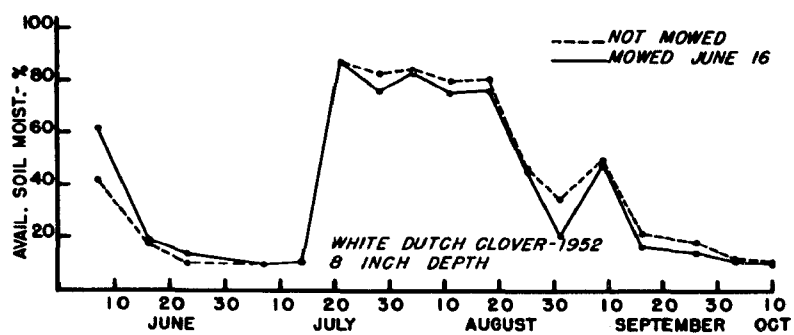
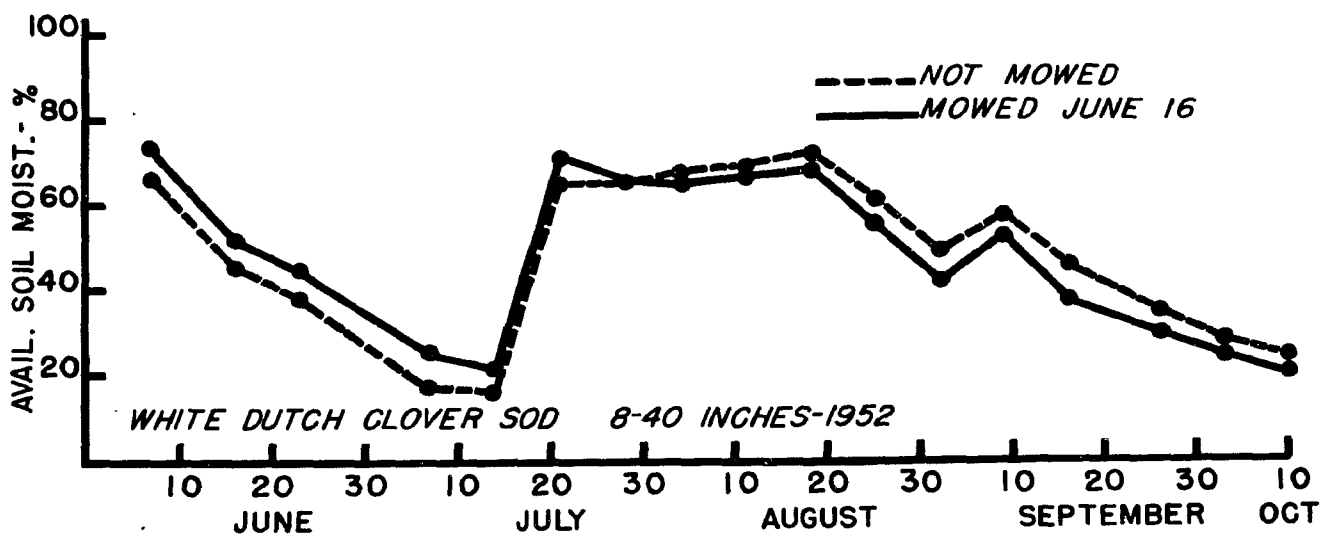
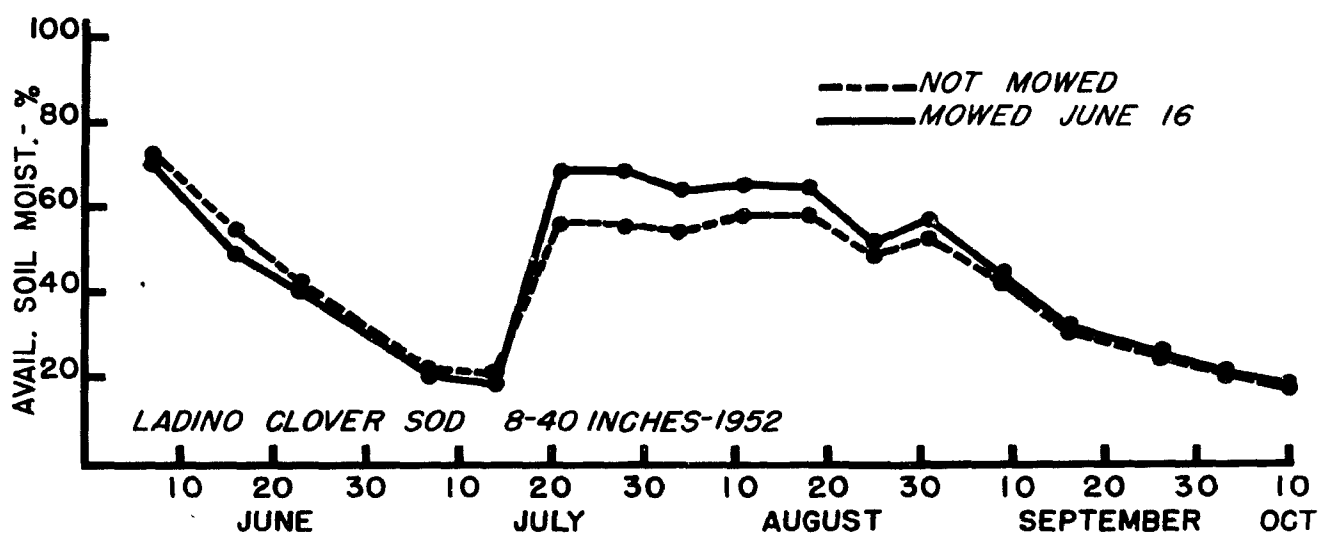
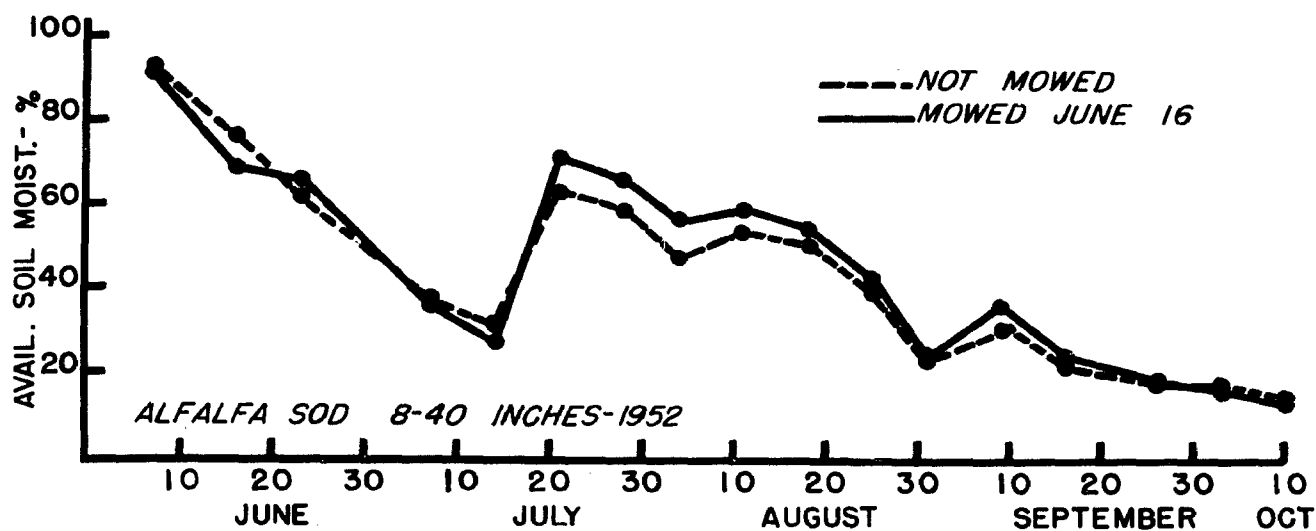


Figure 15. Average soil moisture depletion by sods of white dutch clover, ladino clover and alfalfa at all depths (8-40 inches inclusive) for all dates of 1952 growing season.

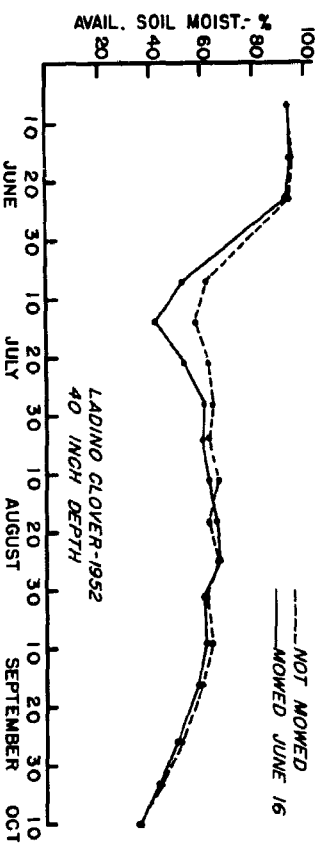
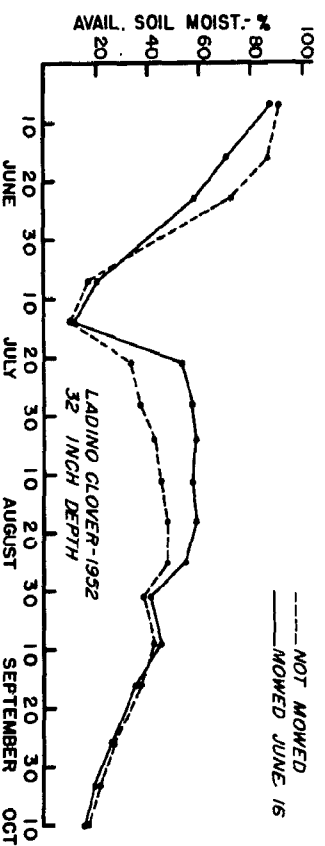
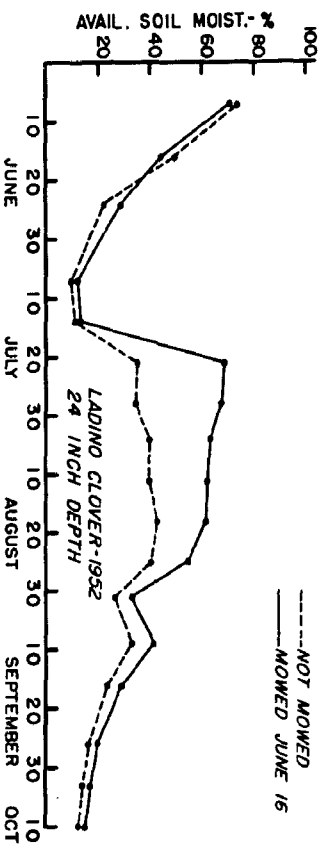
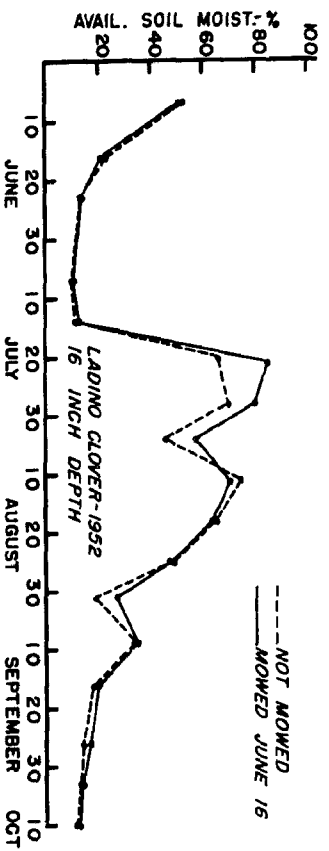
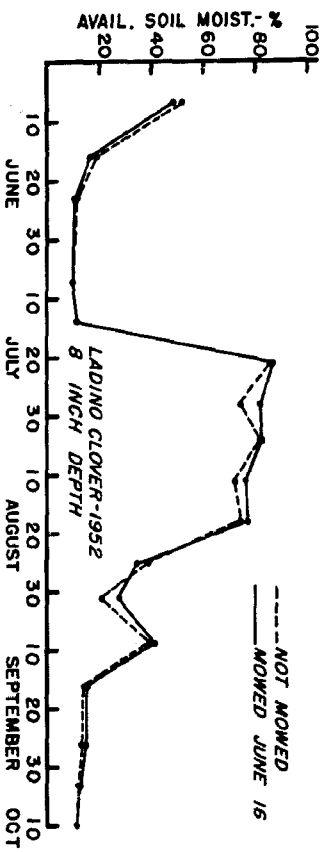


Ladino clover: The average percentage of available soil moisture for all depths (8-40 inches inclusive) for the season was 45.3 for mowed and 42.3 for unmowed ladino clover sod (Appendix Table XIII). Mowing ladino clover on June 16 had little effect on soil moisture depletion until July 13, when the mowed sod began to show a marked reduction in its utilization of soil moisture from the 16, 24, and 32 inch depths (Figure 16). This response to mowing only lasted until the last of August. Mowing had no marked effect on the conservation of soil moisture at 8 inch depths, while at the 40 inch depth, the sod that was not mowed used less soil moisture than where the sod was mowed.

By June 10, in its second season of growth, ladino clover utilized great quantities of soil moisture from all depths except the 40 inch depth, and from the 40 inch depth by the end of June. Ladino clover sod maintained soil moisture levels below 60 percent available water for most of the season at all except the 8 inch depth. The available soil moisture 40 inches deep was never above 70 percent after the last week of June. The average soil moisture conditions for all depths (8-40 inches inclusive) for all dates are shown in Figure 15.

Redtop: During its second season of growth redtop sod behaved very similarly to timothy. Its response to mowing was the same as that of timothy since the mowed sod conserved moisture early in the season, but used more water late in the

Figure 16. Soil moisture depletion by ladino clover
sod at all depths (8-40 inches inclusive)
for all dates of 1952 growing season.



season than if unmowed. The average percentage of soil moisture available for all depths (8-40 inches inclusive) for the season in soil growing redtop was 75.5 for mowed and 71.1 for unmowed sod (Appendix Table XV). Mowing redtop conserved considerable amounts of soil moisture beginning June 15 at depths of 16, 24, 32, and 40 inches (Figure 17). This response continued throughout the season at the 32 inch depth. However, beginning August 18, the mowed sod began to deplete the soil moisture to a greater extent than where not mowed at the 8 and 16 inch depths, and after September 15, the mowed redtop resulted in reducing the amount of moisture depletion at the 24 inch depth. Mowed redtop sod did not markedly deplete the soil moisture from the 32 inch depth in its second season of growth nor did it reduce the soil moisture levels at the 40 inch depth except slightly during the last week of the season.

The average available soil moisture for redtop at all depths (8-40 inches inclusive) for all dates of the 1952 season is shown in Figure 18.

Timothy: The average percentage of available soil moisture at all depths (8-40 inches inclusive) for the season was 77.1 for mowed and 78.4 for unmowed timothy (Appendix Table XIV). Mowing timothy sod resulted in a conservation of soil moisture at depths of 8, 16, 24, and 32 inches for the period of June 23 to August 20 (Figure 19). Beginning August 20 and for the remainder of the season,

Figure 17. Soil moisture depletion by redtop sod
at all depths (8-40 inches inclusive)
for all dates of 1952 growing season.

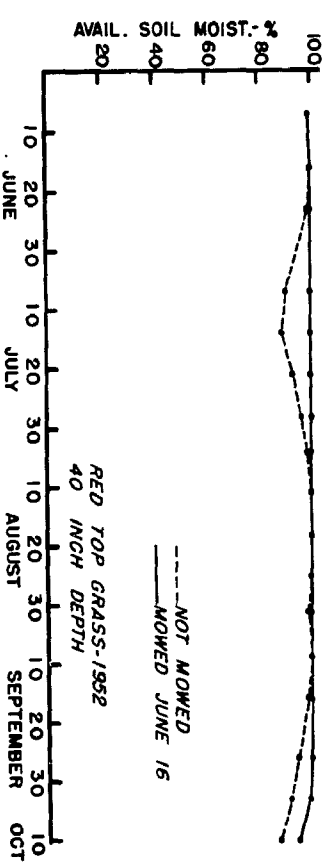
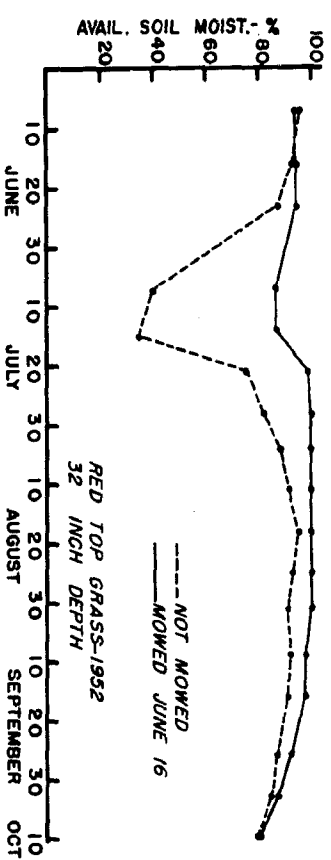
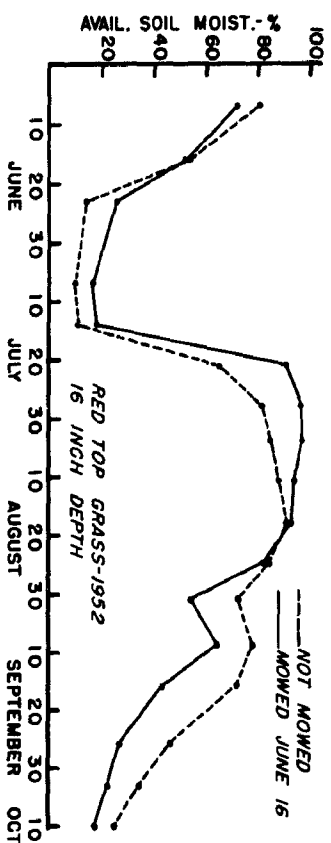


Figure 18. Average soil moisture depletion by redtop, quackgrass and fescue sods for all depths (8-40 inches inclusive) for all dates of 1952 growing season.

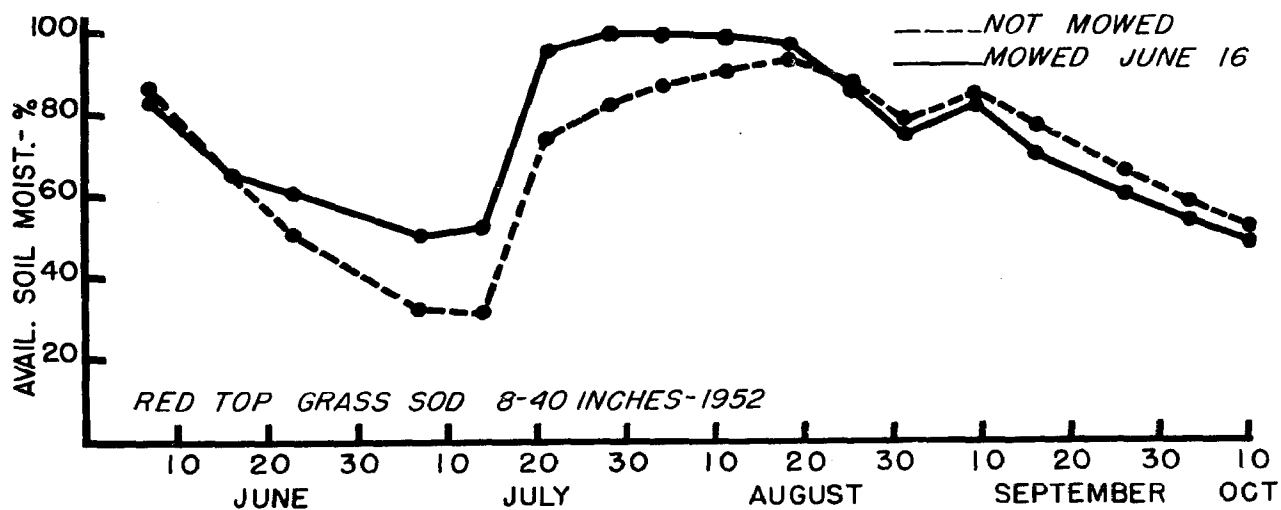
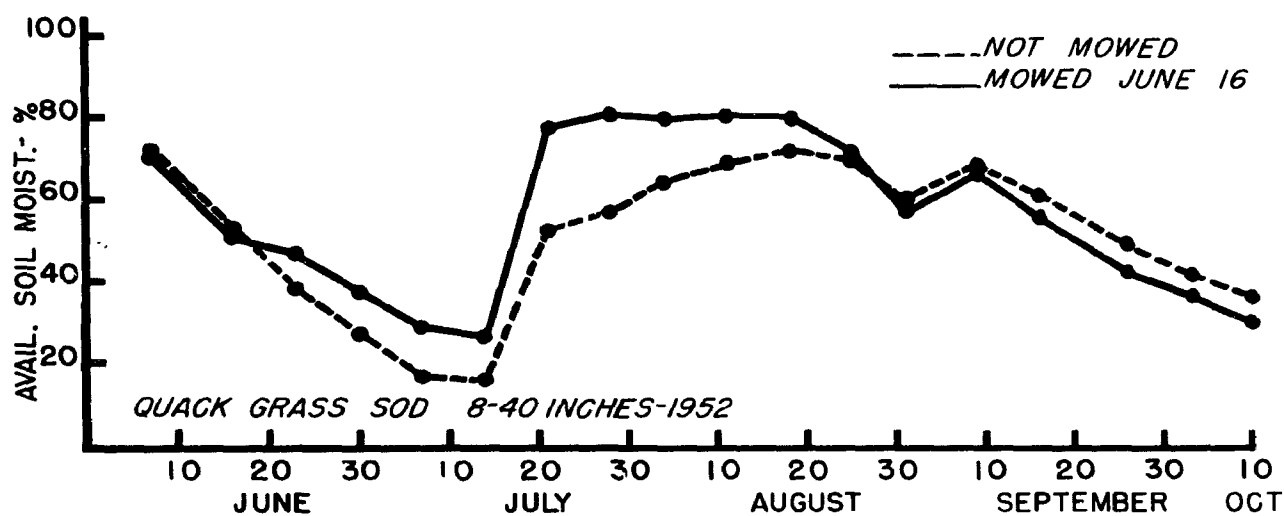
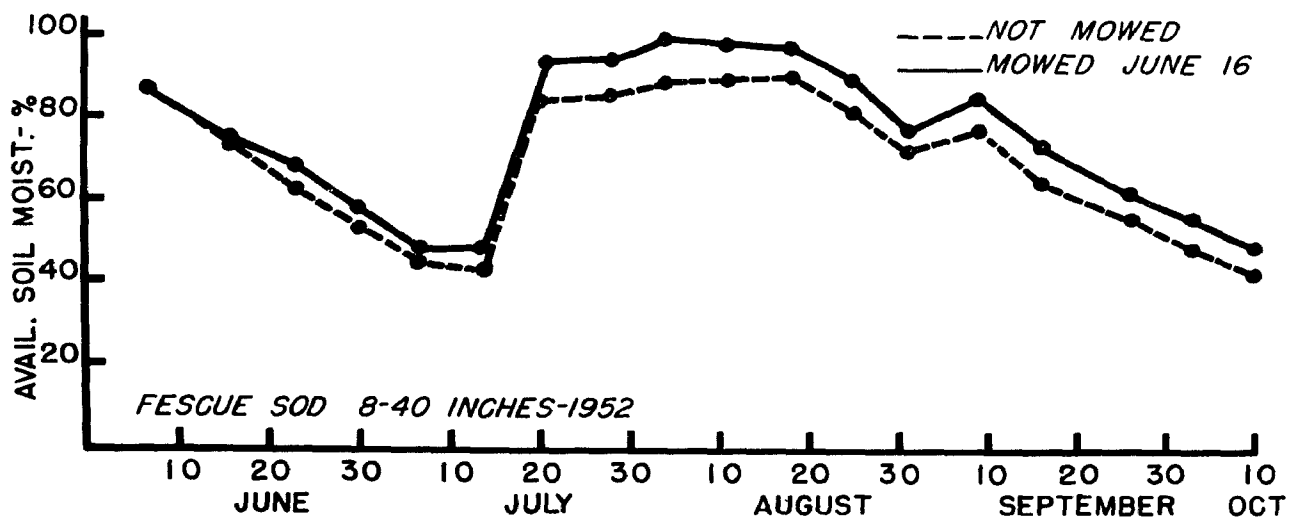
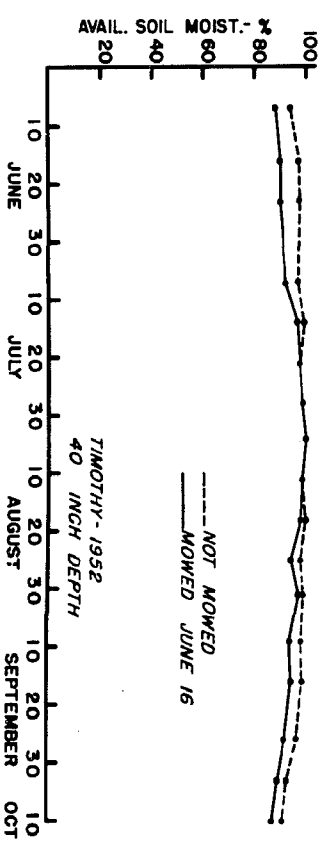
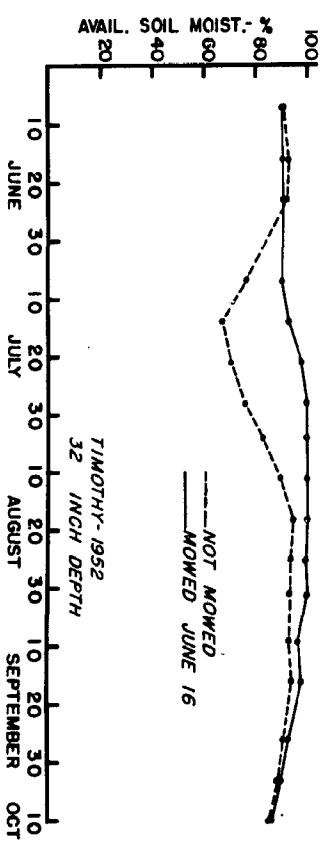
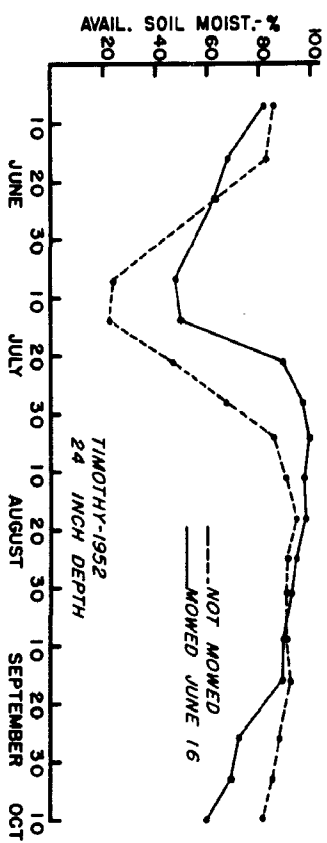
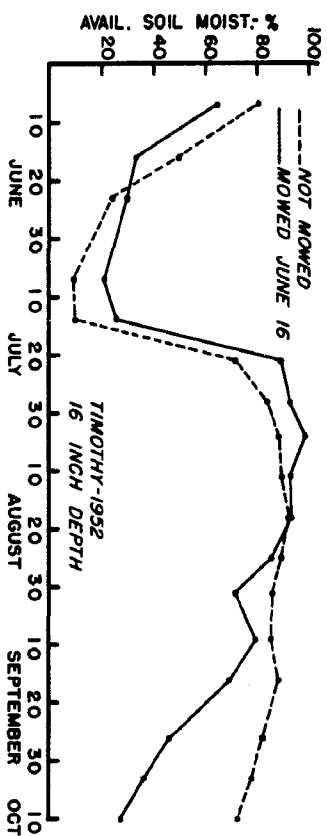
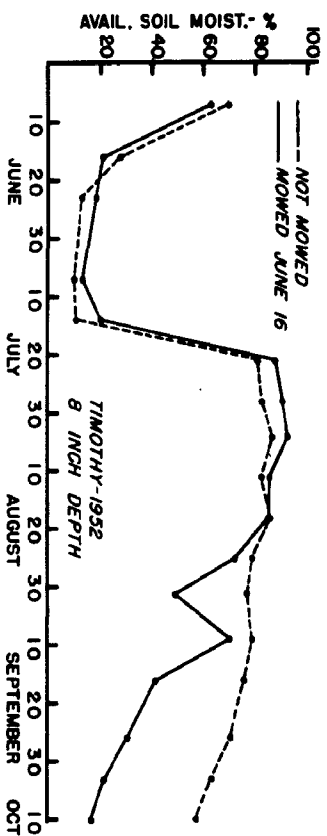


Figure 19. Soil moisture depletion by timothy sod
at all depths (8-40 inches inclusive)
for all dates of 1952 growing season.



mowed timothy used considerably more soil moisture at the 8, 16, and 24 inch depths than sod that was not mowed. With the exception of unmowed sod, timothy did not use any appreciable amounts of soil moisture from the 32 or 40 inch depths in its second season of growth.

The average soil moisture conditions for all depths (8-40 inches inclusive) for all dates of the season of timothy sod are shown in Figure 20.

Quackgrass: Quackgrass sod showed very little response to mowing in 1951, but showed a marked response to mowing in 1952. While quackgrass produced a greater amount of air dry clippings in its second season of growth, it also used larger amounts of soil moisture from greater depths in the soil than during its first season's growth. Mowed quackgrass sod used much less soil moisture from the 32 and 40 inch depths for almost the entire season than sods which were not mowed (Figure 21). Mowing also reduced its use of soil moisture from the 24 inch depth from the date of mowing (June 16) until August 25. After mid-August mowed sod depleted the soil moisture from the 8, 16, and 24 inch depths less than sods that were not mowed. The average percentage of available soil moisture for all depths (8-40 inches inclusive) for the season was 58.5 for mowed and 53.4 for not mowed quackgrass (Appendix Table XVI).

The average available soil moisture for quackgrass for all depths (8-40 inches inclusive) and for all dates of the 1952 season is shown in Figure 18.

Figure 20. Average soil moisture depletion by timothy and bluegrass sod for all depths (8-40 inches inclusive); and rainfall intensity and distribution for all dates of 1952 growing season.

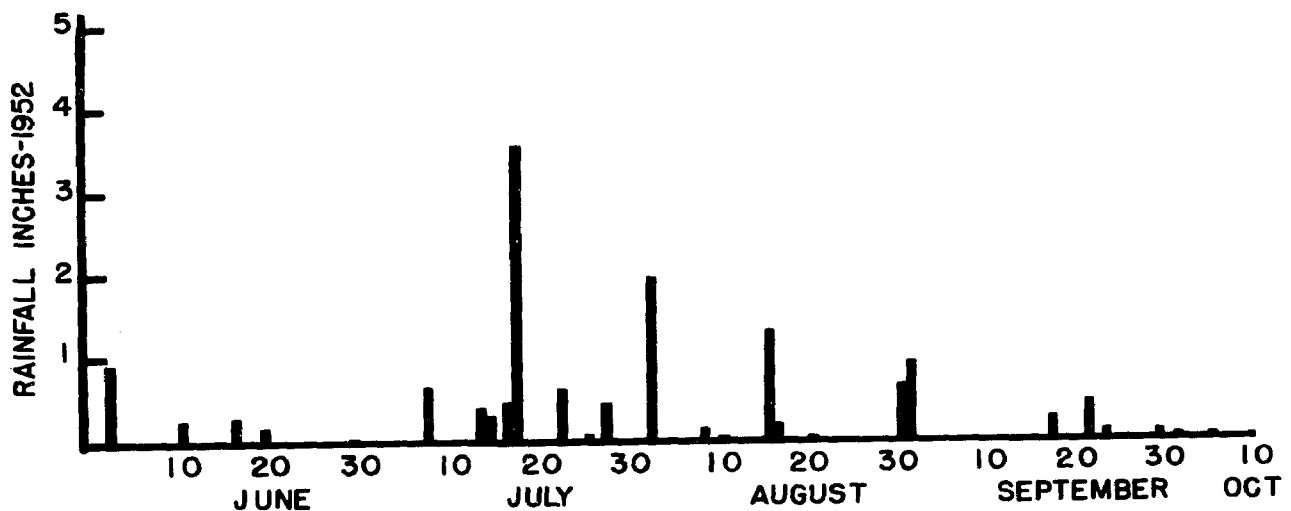
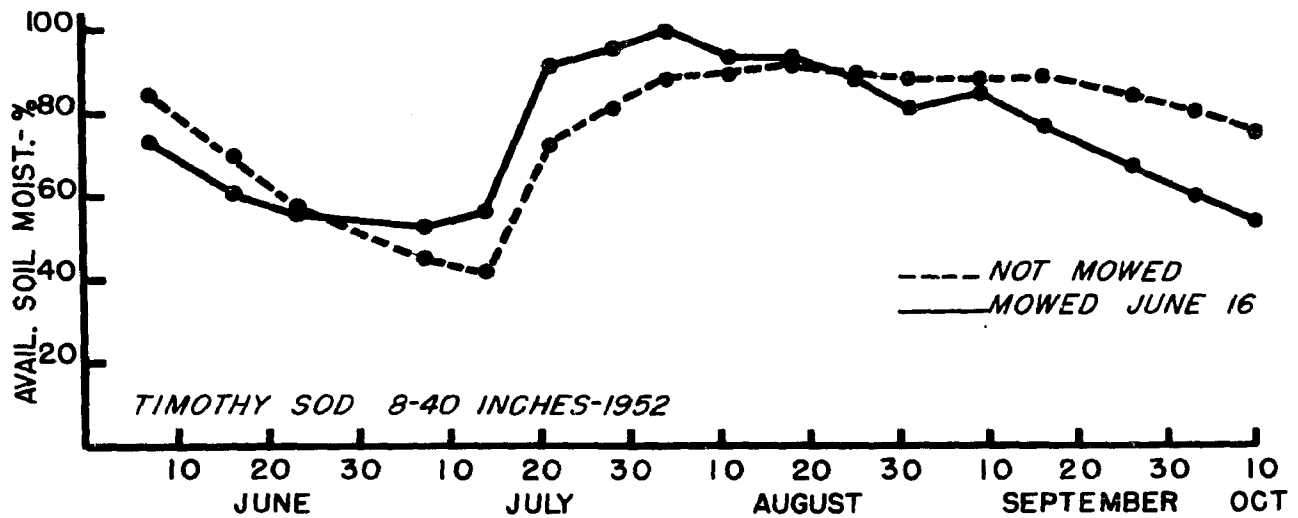
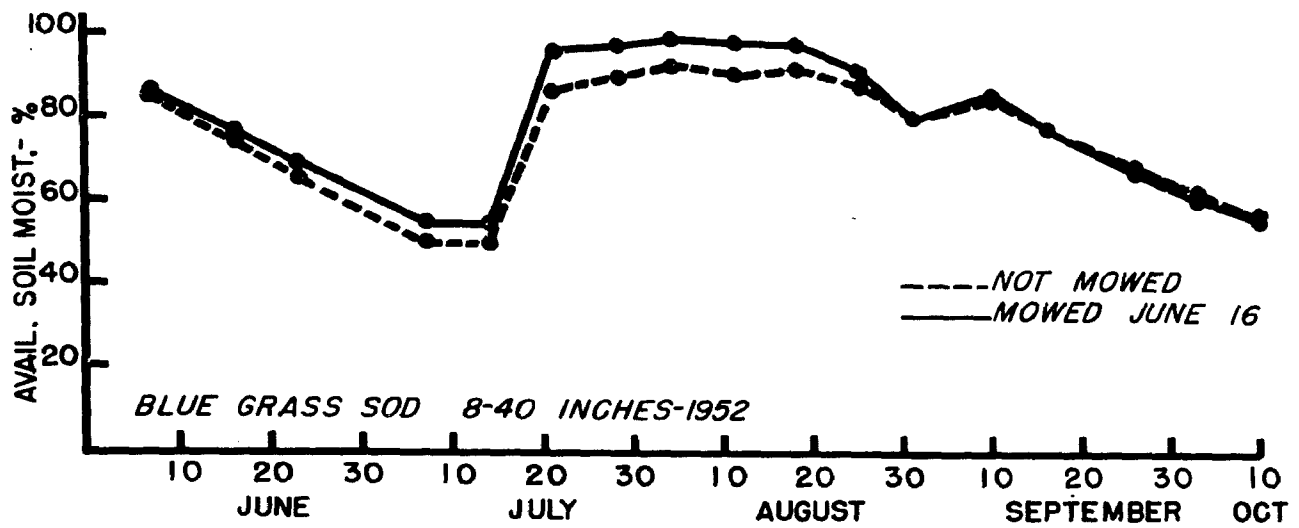
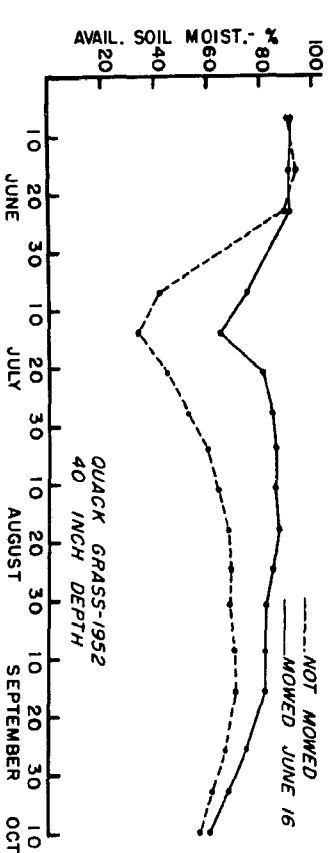
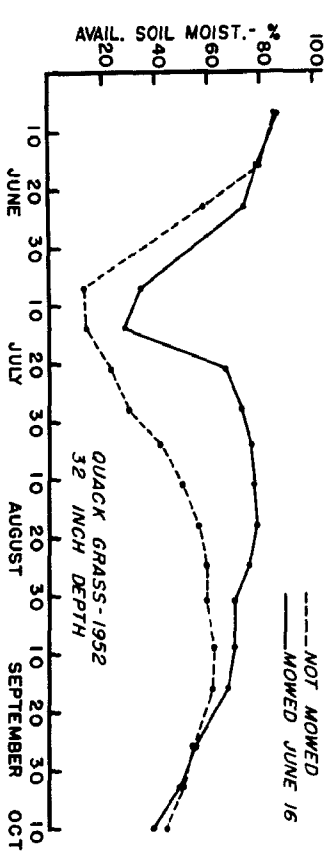
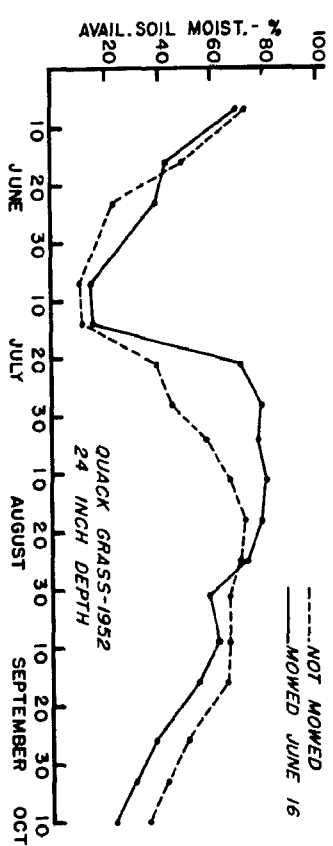
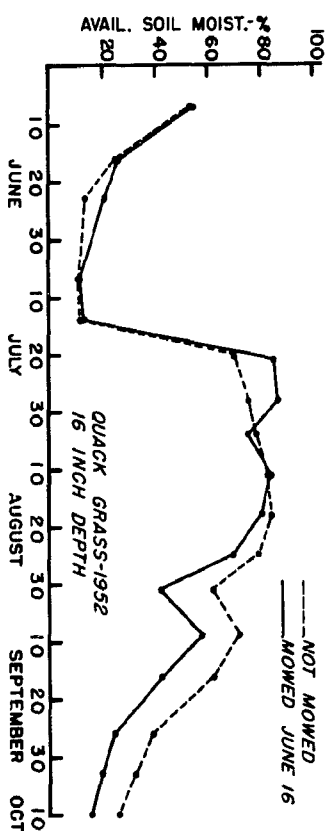
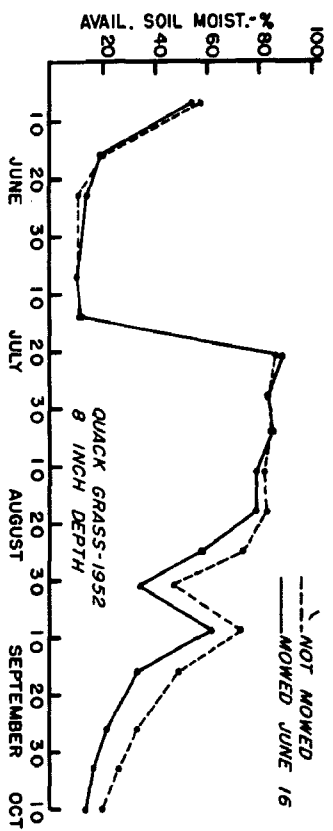


Figure 21. Soil moisture depletion by quackgrass sod at all depths (8-40 inches inclusive) for all dates of 1952 growing season.



Kentucky bluegrass: Sod of bluegrass continued to maintain the best soil moisture conditions of any sod cover used. The average percentage of available soil moisture for the season for all depths (8-40 inches inclusive) was 80.1 for mowed and 77.1 for unmowed bluegrass (Appendix Table XVII). Mowing on June 16 resulted in a conservation of soil moisture at depths of 16 and 24 inches from July 20 to September 1 (Figure 22). However, after August and continuing for the remainder of the season mowed sod depleted the soil moisture of the 8 and 16 inch depths more than sod that was not mowed.

In its second season of growth, bluegrass did not greatly deplete soil moisture at depths of 32 and 40 inches, and used less soil moisture from the 24 inch depth than any other sod cover used. The average available soil moisture at all depths (8-40 inches inclusive) for all dates of the season is shown in Figure 20.

Chewing fescue: Fescue sod mowed June 16 used less soil moisture than sods that were not mowed. The average percentage of available soil moisture at all depths (8-40 inches inclusive) for the season was 77.0 for mowed and 70.5 for unmowed sod (Appendix Table XVIII). The reduced utilization of soil moisture resulting from mowing was noticeable at the 8 and 32 inch depths and especially noticeable at the 16 and 24 inch depths (Figure 23). Fescue did not appreciably reduce the soil moisture content at depths of 32 and 40

Figure 22. Soil moisture depletion by bluegrass sod
at all depths (8-40 inches inclusive)
for all dates of 1952 growing season.

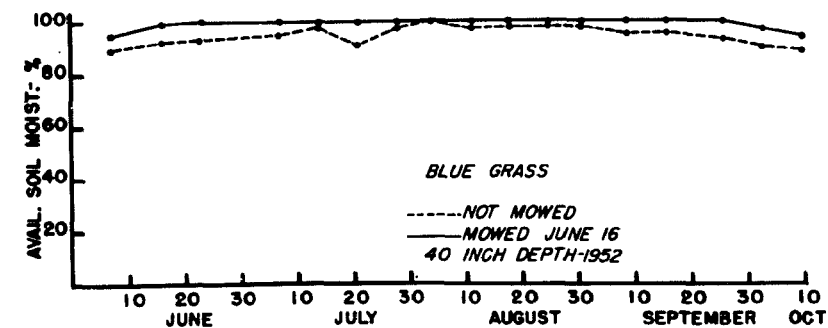
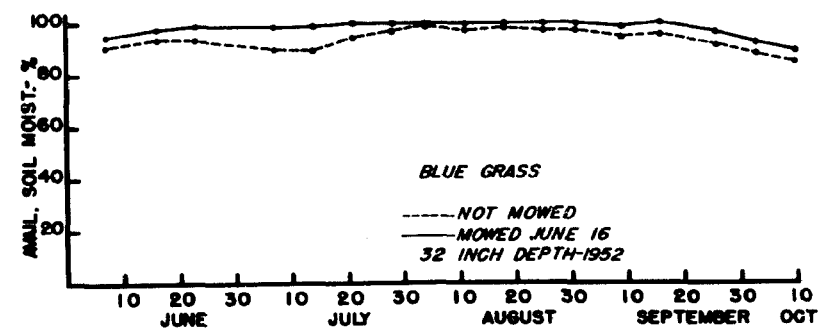
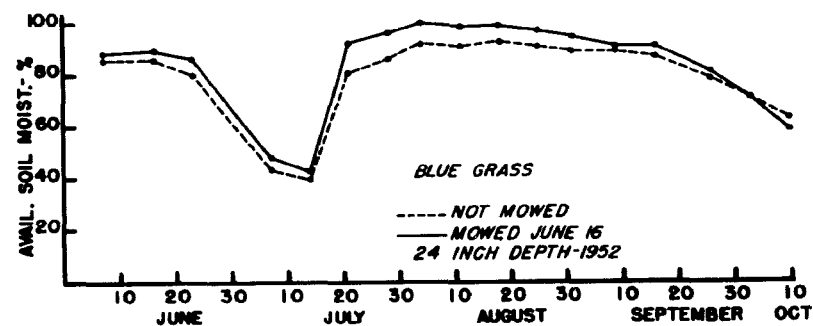
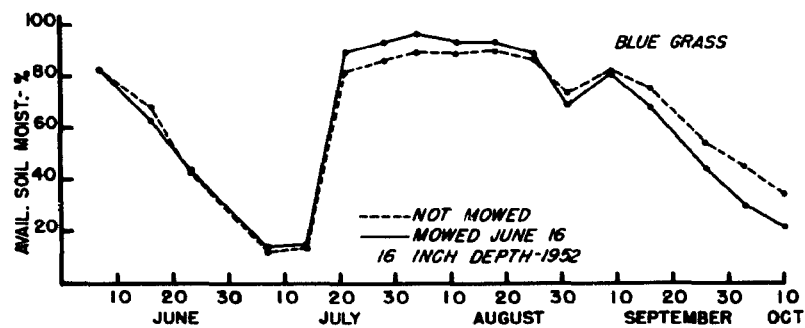
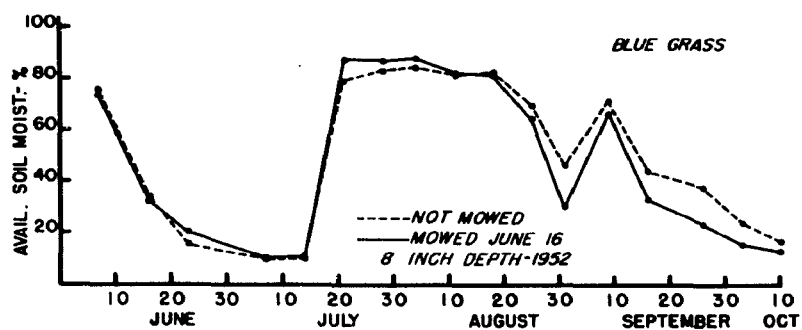
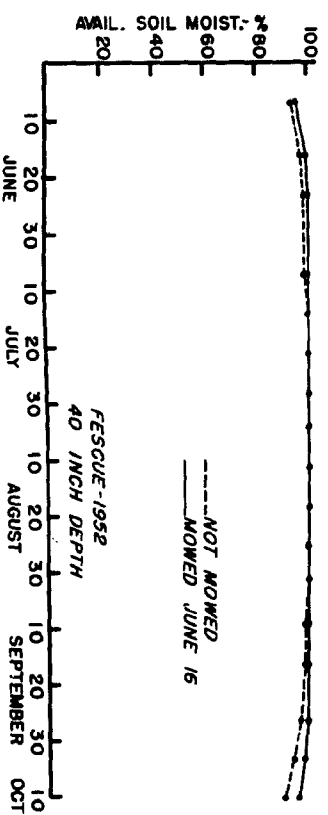
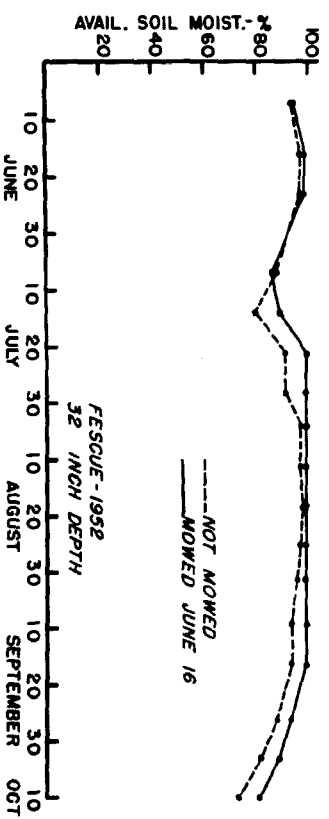
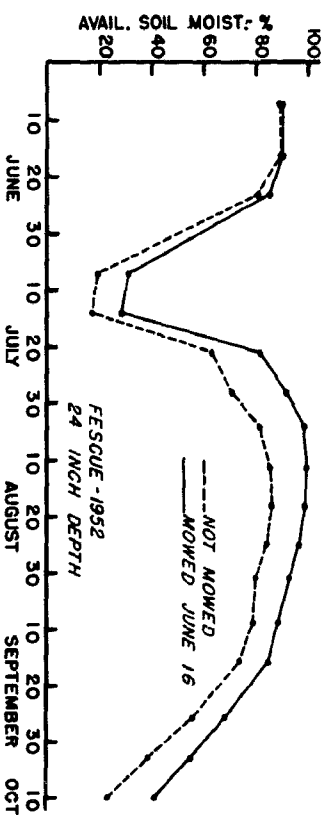
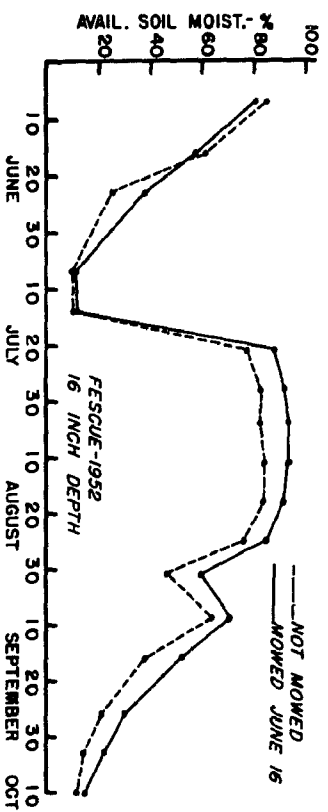
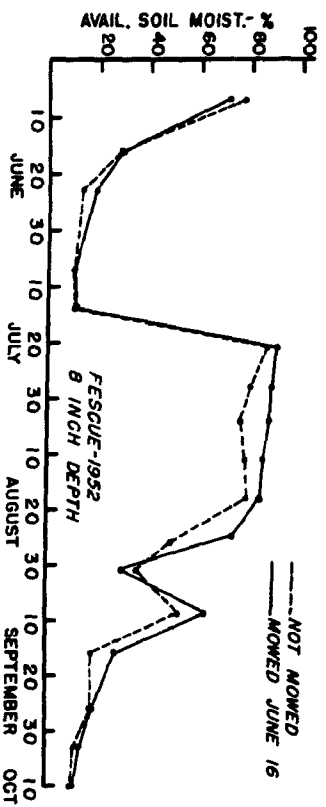


Figure 23. Soil moisture depletion by fescue sod
at all depths (8-40 inches inclusive)
for all dates of 1952 growing season.



inches during its second season of growth, but was beginning to deplete moisture at all depths late in the season.

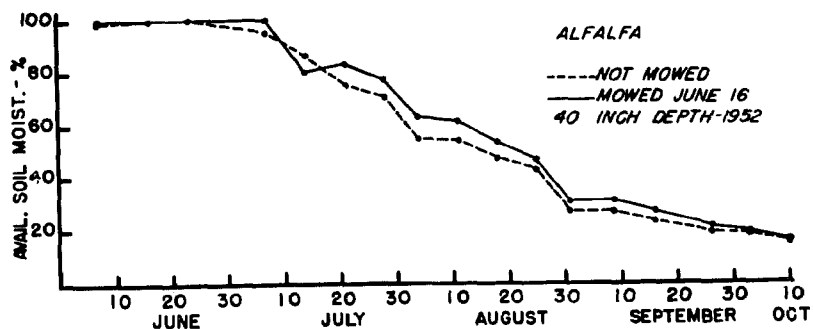
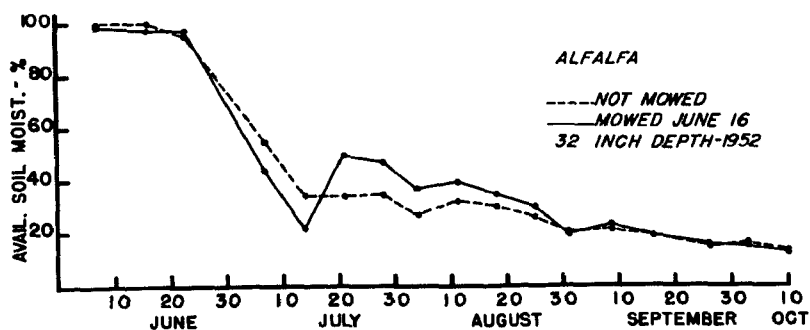
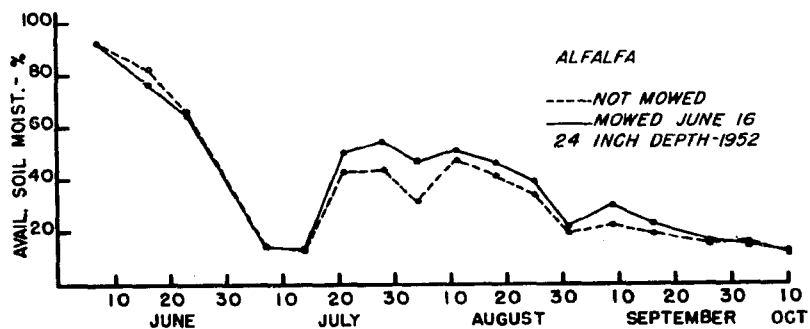
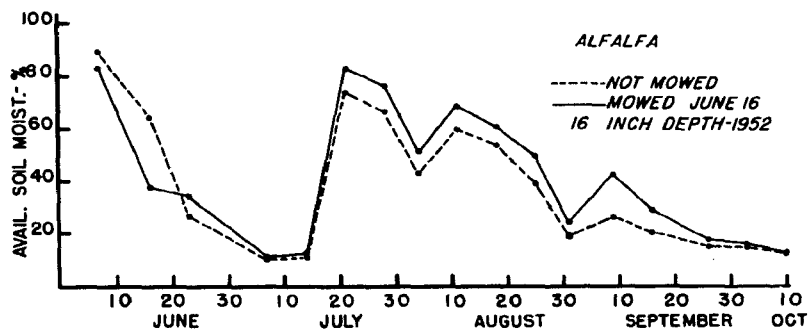
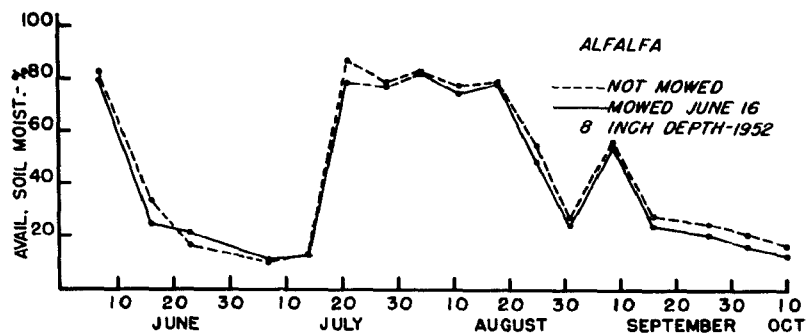
The average percent available moisture for all depths (8-40 inches inclusive) for all dates is shown in Figure 18.

Alfalfa: In its first season of growth, alfalfa depleted the soil moisture at depths of 24, 32, and 40 inches to below 50 percent available, where it remained for most of the season. The soil growing alfalfa was so dry that heavy rains at the end of July failed to stop the downward trend of soil moisture levels at depths of 32 and 40 inches, and had only a slight effect on the moisture conditions at the 24 inch depth (Figure 24). At season's end, the available soil moisture was at or below 20.0 percent available at all depths. Mowing resulted in some conservation of soil water for most of the season at all depths deeper than 8 inches. The average soil moisture in percent available for the season at all depths (8-40 inches inclusive) was 45.6 for mowed and 43.5 for unmowed alfalfa sod (Appendix Table XIX).

The average percentage of available soil moisture for all dates and depths (8-40 inches inclusive) is shown in Figure 15.

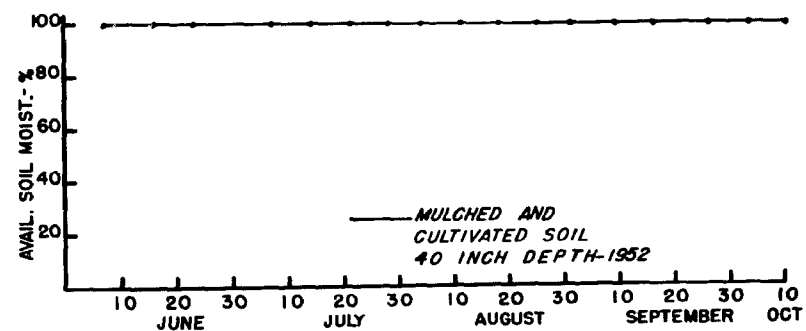
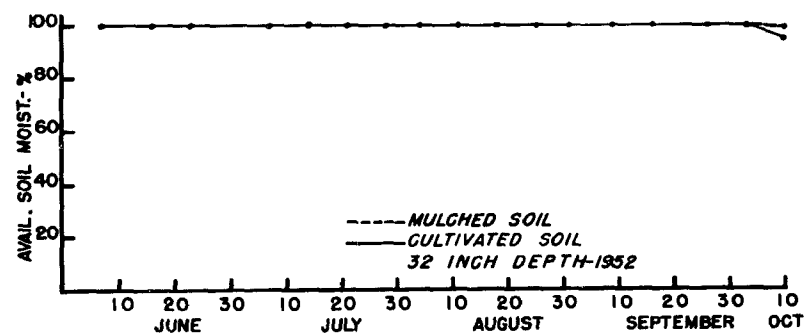
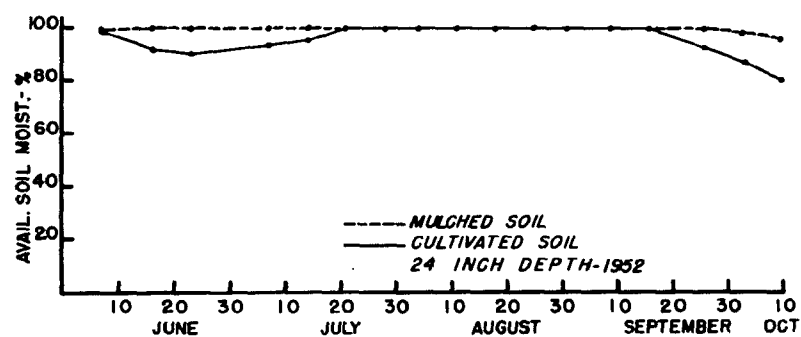
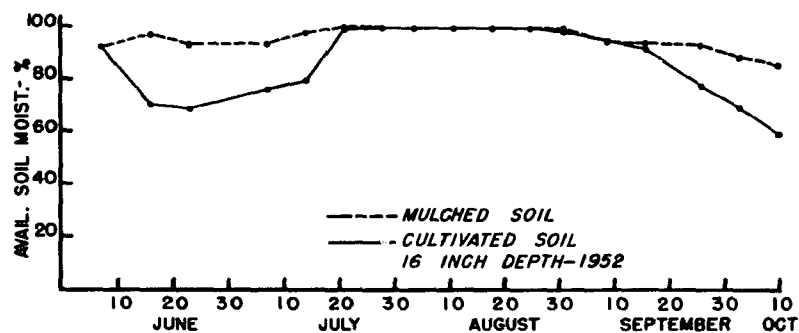
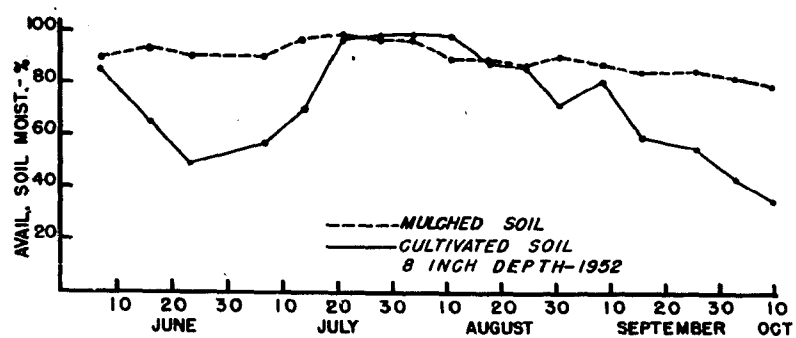
Mulched and cultivated soil: The average percentage of available soil moisture at all depths (8-40 inches inclusive) for the season was 98.3 for mulched and 93.2 for cultivated soil (Appendix Table XX). Soil moisture was lost from depths of 8 and 16 inches in cultivated soil

Figure 24. Soil moisture depletion by alfalfa sod
at all depths (8-40 inches inclusive)
for all dates of 1952 growing season.



during the dry period of June and again after September 1
(Figure 25).

Figure 25. Average soil moisture conditions in mulched and cultivated soils for all depths (8-40 inches inclusive) for all dates of 1952 growing season.



DISCUSSION

Water may be classified as the most important plant nutrient. Large quantities are required for normal growth and reproduction. Deficient soil moisture causes more damage to orchard crops than any other factor, except frost, associated with weather conditions. Crop losses due to deficiencies of soil moisture in orchards are greater than the combined losses due to ravages of insects, diseases, and animals. Since precipitation can not be controlled, orchard soils must be managed in a manner that will provide as nearly as possible adequate amounts of soil moisture for the orchard crop.

Soil Moisture in Relation to Sod Growth

The various sod covers varied considerably in regard to utilization of soil moisture. Mowing of sod covers to conserve soil moisture appeared to be dependent upon soil moisture conditions existing at the time of or shortly after mowing. Depletion of soil moisture was increased in 1951, by mowing of sod covers. However, soil moisture was conserved by mowing of sod covers in 1952.

The depletion of soil moisture in relation to mowed sods appeared to be dependent upon the extent of regrowth after mowing. The regrowth of sod covers following mowing

was more or less dependent upon existing soil moisture conditions. In 1951, soil moisture was more favorable for growth at the time of mowing than in 1952. Also, the depletion of soil moisture by sod regrowth was observed earlier in 1951 than in 1952.

The relative deficiency of soil moisture, when the sod covers were mowed in 1952, delayed regrowth of the grass sods and temporarily conserved soil moisture. Legume sods, however, initiated regrowth almost immediately after mowing and there was little or no conservation of soil moisture. Shortly after mowing in 1951, soil moisture was near field capacity for two to three weeks. This abundant soil moisture stimulated a regrowth by mowed sod covers that depleted soil moisture either as much or more than sods not mowed. In both years, the regrowth of sods after mowing increased soil moisture depletion late in the season.

Certain sod covers initiated regrowth, following mowing, sooner than others. Redtop and white clover, when soil moisture was abundant, began to regrow sooner than all other sod covers. Under such conditions, the mowed portion of these sods showed an almost immediate depletion of soil moisture. Regrowth of the other sods, under similar conditions, did not increase depletion of soil moisture until about August 10, approximately eight weeks after mowing. Mowing white clover sod caused soil moisture depletion while mowing ladino clover sod tended to conserve soil moisture.

Certain sods, such as redtop and timothy, appeared to conserve soil moisture when not mowed because they matured seeds and ceased to grow for rather long periods. If soil moisture was deficient during the growth period prior to seed production; these sods may produce more than normal growth late in the season. In such cases, those sods that do not grow for some time after seed production may deplete soil moisture late, whereas there would be little depletion of soil moisture if soil moisture had been adequate prior to seed production.

Other sod covers, such as bluegrass and fescue, appeared to conserve soil moisture because they turned brown and became almost dormant during periods of hot dry weather. This apparent dormancy reduced soil moisture depletion by the sod, regardless of mowing. However, when sufficient soil moisture was available and cooler weather prevailed, these sods tended to initiate growth again. The renewed growth could result in severe moisture depletion by late season.

Sod covers that reproduce plants by means of underground stems tend to grow and produce new shoots after seed maturity. When quackgrass was not well established, mowing appeared to have no benefit in the conservation of soil moisture. However, after the sod was well established, mowing quackgrass sod influenced soil moisture in a manner similar to that found for sods which tend to cease growth after seed production.

In general, mowing of orchard sod covers during periods of adequate soil moisture did not tend to conserve soil moisture. However, mowing of orchard sods during periods of moisture deficiencies appeared to conserve soil moisture.

Soil Moisture in Relation to Tree Growth

Photosynthetic activity of apple trees has been found to be reduced as the soil moisture approaches the wilting point (Magness, Regeimbal and Degman, 1932; Heinike and Childers, 1936). Tree growth and production may be reduced when 50-60 percent of the available soil moisture has been depleted (Lewis, Work and Aldrich, 1934; Kenworthy, 1949).

The average available soil moisture for the upper 40 inches of soil beneath sods of white dutch clover, ladino clover, alfalfa and quackgrass frequently was depleted below this critical level. Sods of bluegrass, fescue, redtop and timothy usually did not deplete soil moisture as much as other sods. However, when rainfall was deficient, these sods depleted the available soil moisture to or below this critical level. Mowing of the various sod covers did not conserve sufficient soil moisture to prevent the depletion of soil moisture to levels that may have been below that considered desirable for best performance of orchard trees.

Since sod covers are desirable in Michigan orchards (Partridge, 1937; Toenjes, 1941) some method of management, other than mowing, must be used to reduce soil moisture

depletion by sod covers. The roots of apple trees appear to be concentrated in the soil directly beneath the tree (Yocum, 1937). This would indicate that conservation of soil moisture in the soil directly beneath the trees would be desirable. Crown mulches of straw, hay or other plant residues have been used to accomplish a reduction in the depletion of soil moisture by sod covers. Wherever crown mulches of organic materials have been used tree performance has been improved. Therefore, the combination of crown mulches with sod covers appears to be the best logical solution of soil moisture conservation in Michigan orchards.

Certain growers believe that it is more economical to use clean cultivation in the tree rows when the trees are young. Such a practice would tend to increase depth of rooting of the young trees (Yocum, 1937). An application of a crown mulch may tend to result in a greater concentration of roots in the soil directly beneath the mulch. Recent research in relation to mulching of young trees has shown that clean cultivation is not essential for desired performance of the trees. However, a crown mulch has been observed to increase growth and production of trees growing under a clean cultivation system. The depth of most soils in Michigan is not sufficient to require the encouragement of deep rooting by means of clean cultivation.

After several years of growing sod covers, some soils especially silt and clay loam soils, may become improved

sufficiently in structure to provide ample soil moisture for both sod and tree growth (Collison, 1935; Shalius and Merkle, 1939). Even on such soils, soil moisture may become a limiting factor in tree growth if the area is subject to prolonged periods of drought. Most of the fruit-producing areas east of the Mississippi river are frequently subject to periods of drought that would permit serious depletion of soil moisture by the trees. Particularly in certain areas of Michigan, where rainfall is lower than in other areas east of the Mississippi river, it is doubtful that the soils currently being used for fruit production would provide ample soil moisture for growth of both sod and trees. However, rainfall distribution is not usually adequate to prevent periods of serious drought except during what may be considered the unusual years.

Soil Moisture in Relation to Fruit Development

Soil moisture deficiencies may have a greater influence upon fruit size and quality than upon tree growth. The reduction in yield associated with moisture deficiencies is largely a result of reduced fruit size. Soil moisture deficits early in the season may reduce terminal growth of fruit trees and in this manner influence fruit size and quality because of a corresponding reduction in the production of carbohydrates by the tree. Soil moisture deficits occurring at any time during the growing season may deplete the carbohydrate reserves of the trees and

result in a corresponding reduction in fruit production during the following season. Size of fruit produced by an existing crop is more dependent upon soil moisture conditions during a relatively short period prior to harvest. It is during this period that the fruit is making the greatest growth increments in size and has the highest demands for soil moisture.

Two dates were selected to demonstrate the possible influence of orchard sods upon fruit size of the principle orchard crops grown in Michigan. July 14 was considered as the date on which soil moisture conditions would be especially important in the fruit development of cherry and early peaches. Soil moisture conditions in relation to the various sod covers on July 14 is shown in Figure 26. All sods had depleted soil moisture sufficiently to have a limiting effect upon fruit growth. Mowed sods of fescue, bluegrass, timothy and redtop had the most favorable soil moisture conditions. Soil moisture beneath the other sods, although improved by mowing, was definitely limiting.

Soil moisture conditions on September 1 were selected as an index date that would be important for fruits maturing later in the season (Figure 27). The regrowth of mowed sods was sufficient by September 1 to result in a greater depletion of soil moisture than occurred where the sods were unmowed. This was a reversal of the influence of mowing upon soil moisture conditions found on July 14. The influence of sod regrowth upon soil moisture depletion emphasizes the necessity

Figure 26. Average soil moisture conditions by depths (8-40 inches) for all sods and treatments on July 14, 1952.

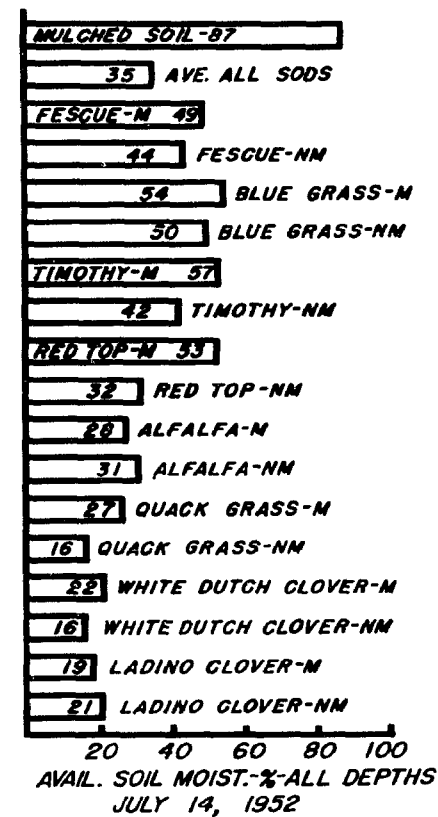
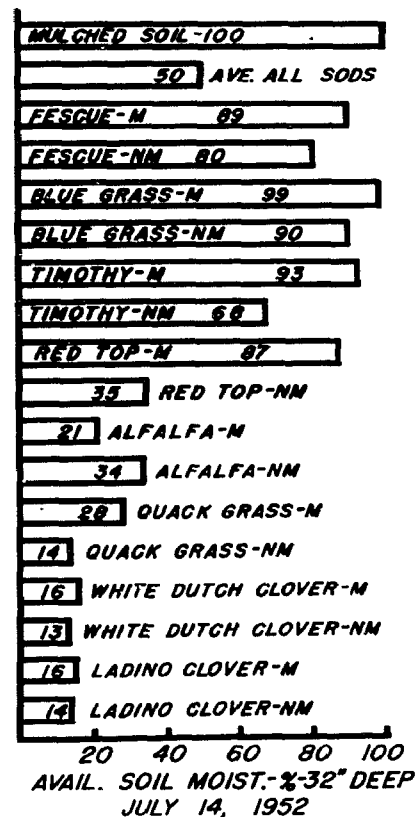
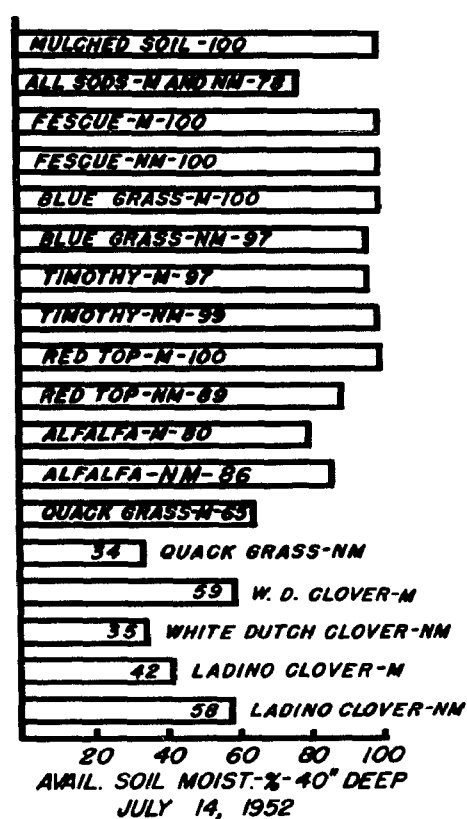
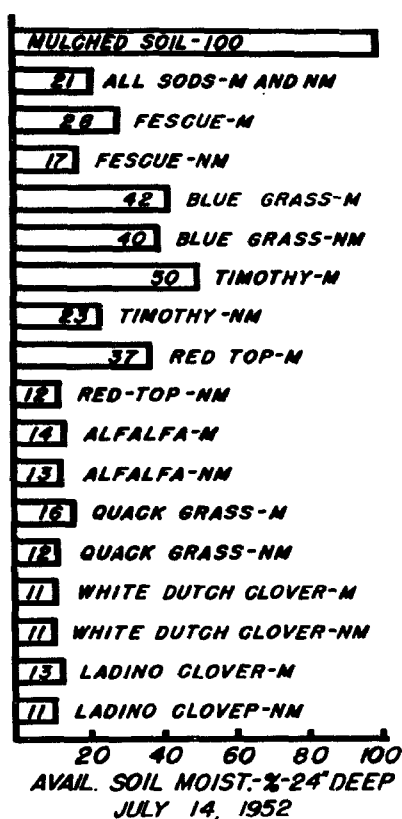
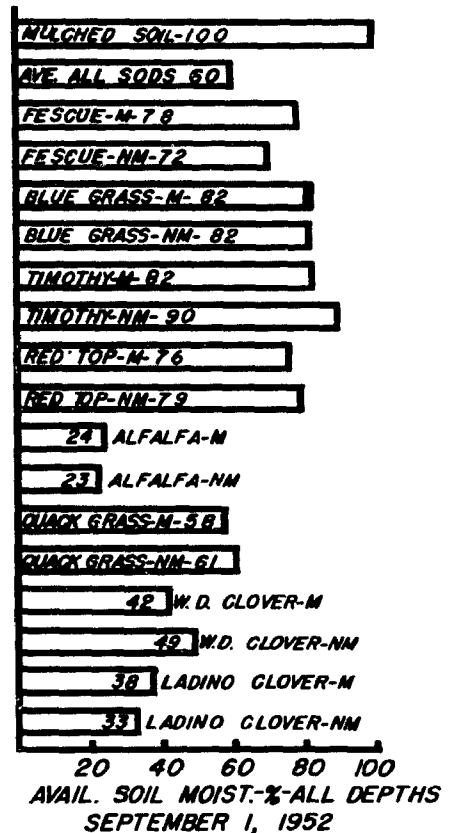
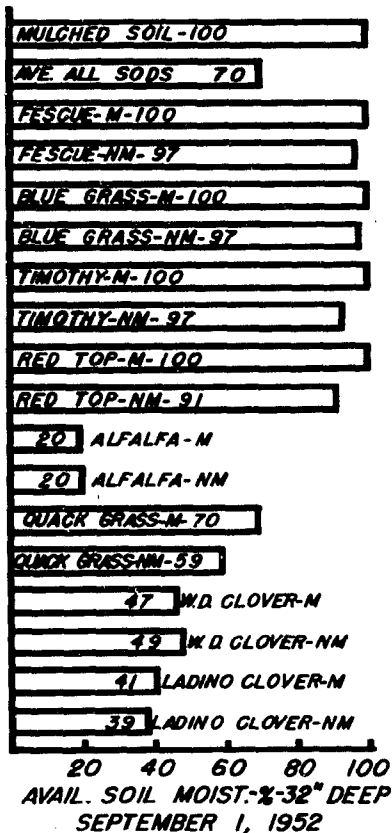
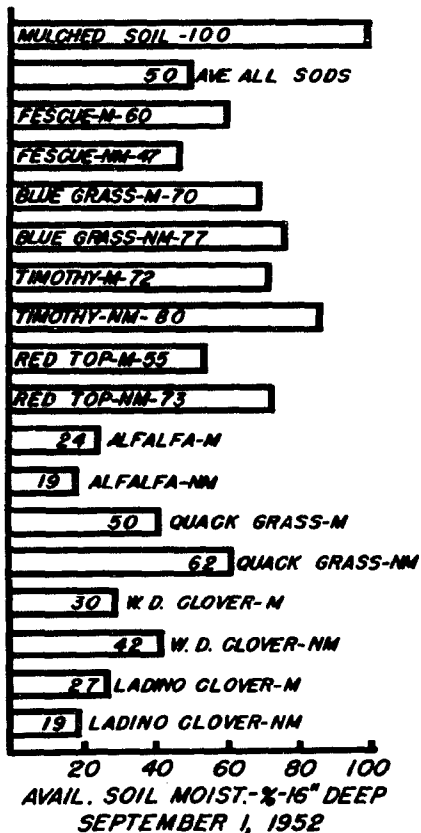
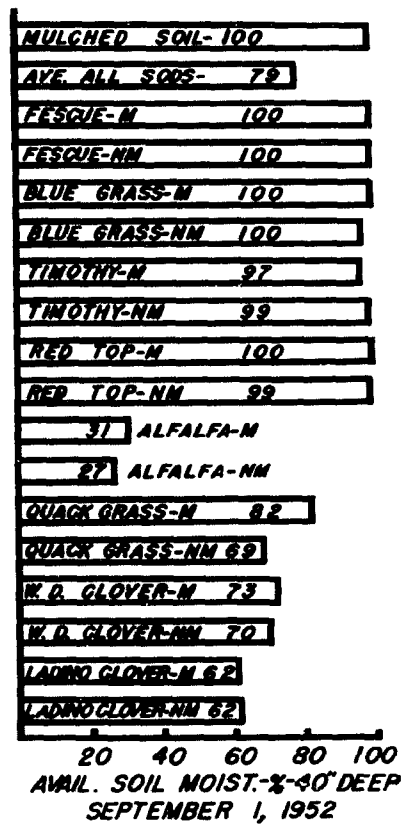
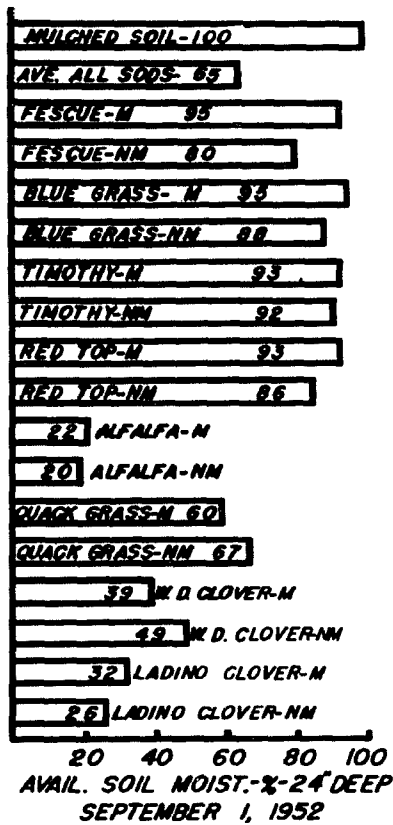
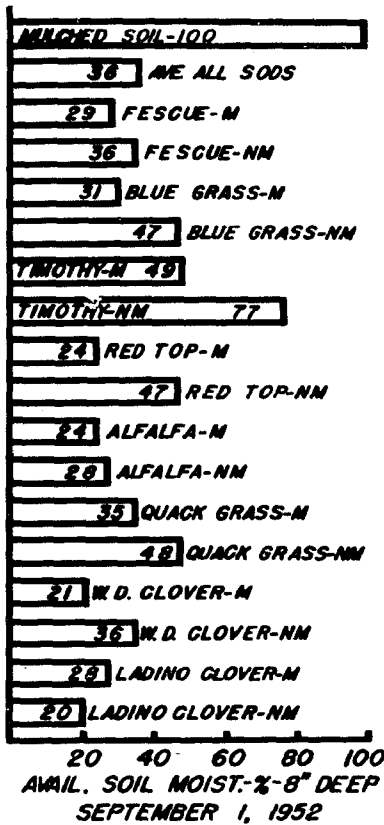


Figure 27. Average soil moisture conditions by depths (8-40 inches) for all sods and treatments on September 1, 1952.



of selecting a system of sod management in relation to the kind and variety of fruit grown. Mowing sods early in the growing season appeared to conserve moisture for those early maturing fruit varieties but resulted in greater soil moisture depletion by the time for harvest of late maturing varieties.

If the sod covers are not mowed, soil moisture conditions associated with bluegrass, fescue, redtop and timothy would be more favorable for late maturing varieties than found for the other sod covers. The legume sod covers and quackgrass would compete more seriously with the trees for soil moisture than the other grass sods. A crown mulch would appear to be mandatory if these sods were to be used in orchards. Some of the grass sods did not deplete soil moisture to as great a depth as did the legume sods. This would indicate that these shallower rooted sod covers may be used without mulching the trees if the soil is sufficiently deep to provide good conditions for root development of the tree to depths greater than observed for these sod covers.

SUMMARY AND CONCLUSIONS

1. Sod covers of white dutch clover, ladino clover, alfalfa, timothy, redtop, quackgrass, bluegrass and fescue were grown on plots of a typical Michigan orchard soil. The effect of mowing sods on soil moisture conditions was the primary purpose of the study.

2. The various sod covers showed considerable differences in soil moisture depletion.

3. The intensity and distribution of rainfall appeared to have rather marked effects on soil moisture depletion by sod covers, as well as on the response of sods to mowing.

4. During periods of deficient soil moisture, mowing of non-legume sod covers appeared to conserve soil moisture; however, when soil moisture is not lacking mowing tended to result in increased soil moisture depletion.

5. Mowing of sod covers cannot be depended upon for the conservation of sufficient quantities of soil moisture for best tree growth and production in Michigan orchards.

6. Bluegrass, fescue, timothy, and redtop sods showed less depletion of soil moisture than sods of ladino clover, white dutch clover, alfalfa, and quackgrass.

7. Crown mulching of orchard trees seems to be a logical method of maintaining orchards in sod without having serious competition for soil moisture by the sod cover.

LITERATURE CITED

- Anthony, R. D. and Waring, J. H. 1925. Fertility in the apple orchard. Pa. Agr. Exp. Sta. Bull. 192.
- _____. 1929. Unexpected influence of bluegrass sods in apple orchards. Proc. Amer. Soc. Hort. Sci. 26:158-159.
- _____. 1930. Sulphate of ammonia and nitrate of sods in a sod orchard. Pa. Agr. Exp. Sta. Bull. 249.
- _____. 1934. Making the most of rainfall in the orchard. Hoosier Horticulture 16(5):76-78.
- _____, Farris, N. F., and Clarke, W. S., Jr. 1948. Effects of certain cultural treatments on orchard soil and water losses and on apple tree growth. Pa. Agr. Exp. Sta. Bull. 493.
- Baker, C. E. 1936. The relation of nitrogen and soil moisture to growth and fruitfulness of apple trees under different systems of soil management. Purdue Univ. Agr. Exp. Sta. Bull. 414.
- Ballou, F. H. 1910. Apple culture in Ohio. Ohio Agr. Exp. Sta. Bull. 217.
- _____. and Lewis, L. P. 1920. Orchard rejuvenation in southeastern Ohio. Ohio Agr. Exp. Sta. Bull. 339.
- Bedford, The Duke of, and Pickering, Spencer V. 1911. The effect of grass on trees. Woburn Experimental Fruit Farm Report 13.
- Bizzell, J. A. 1923. Disappearance of nitrates from soil under timothy. J. Amer. Soc. Agron. 14:320-326.
- Bouyoucos, G. J. and Mick, A. H. 1940. An electrical resistance method for the continuous measurement of soil moisture under field conditions. Mich. Agr. Exp. Sta. Tech. Bull. 172.
- Briggs, L. J. and Shantz, H. L. 1913. The water requirement of plants. I. Investigations in the great plains in 1910 and 1911. U.S.D.A. Bur. of Plant Industry Bull. 284.

- Clarke, William S. 1932. Orchard soil moisture under different fertility experiments. Proc. Amer. Soc. Hort. Sci. 29:176-180.
- Collison, R. C. and Conn, H. J. 1925. The effect of straw on plant growth. N. Y. State Agr. Exp. Sta. (Geneva) Tech. Bull. 114.
- _____ and Mensching, J. E. 1930. Lysimeter investigations. I: Nitrogen and water relations of crops in legume and non-legume rotations. N. Y. State Agr. Exp. Sta. (Geneva) Tech. Bull. 166.
- _____. 1933. Relations between orchard soils and cover crops. N. Y. State Agr. Exp. Sta. (Geneva) Bull. 632.
- _____. 1935. Lysimeter investigations. IV: Water movement, soil temperatures, and root activity under apple trees. N. Y. State Agr. Exp. Sta. (Geneva) Tech. Bull. 237.
- _____. 1940. Experiments in orchard soil management: Fertilizers, mulches, and cover crops. N. Y. State Agr. Exp. Sta. (Geneva) Bull. 691.
- _____ and Carleton, E. A. 1942. Orchard soil covers and their relation to soil conservation. N. Y. State Agr. Exp. Sta. (Geneva) Bull. 701.
- Cullinan, F. P. and Baker, C. E. 1927. Orchard soil management studies. Purdue Univ. Agr. Exp. Sta. Bull. 315.
- Dawson, R. C. 1945. Effect of crop residues on soil micro-populations, aggregation, and fertility under Maryland conditions. Soil Sci. Soc. Amer. Proc. 10:180-184.
- Doryland, C. J. L. 1916. The influence of energy material upon the relation of soil microorganisms to soluble plant food. N. Dakota Agr. Exp. Sta. Bull. 116.
- Ellenwood, C. W. and Gourley, J. H. 1937. Cultural systems for the apple in Ohio. Ohio Agr. Exp. Sta. Bull. 580.
- Fagan, F. N., Anthony, R. D., and Clarke, W. S., Jr. 1933. Twenty-five years of orchard fertility experiments. Pa. Agr. Exp. Sta. Bull. 294.
- Faurot, F. W. 1934. Orchard soil management. Mo. State Fruit Exp. Sta. Bull. 28.

- Fortier, Samuel. 1902. Soil moisture in relation to crop yield. Montana Agr. Exp. Sta. Ninth Ann. Rpt.
- Gourley, J. H. and Shunk, V. D. 1916. Notes on the presence of nitrates in orchard soil. N. Hamp. College Agr. Exp. Sta. Tech. Bull. 11.
- _____. 1917. Some observations on growth of apple trees. N. Hamp. College Agr. Exp. Sta. Tech. Bull. 12.
- Hall, A. D. 1905. On the accumulation of fertility by soil allowed to run wild. J. Agr. Sci. 1:241-249.
- Hedrick, U. P. 1914. A comparison of tillage and sod mulch in an apple orchard. N. Y. Agr. Exp. Sta. Bull. 383.
- Hellriegel, F. H. 1883. Verhältnis zwischen produktion und verdunstung. - Wie viel wasser verbraucht eine pflanze während der Erzeugung von einem Gramm Trockensubstanz durchschnittlich? In Bis Beiträge zu den Naturwissenschaftlichen Grundlagen des Ackerbaus. Braunschweig: 622-664.
- Howlett, F. S. 1936. Soil management systems in a young Bartlett pear orchard. Ohio Agr. Exp. Sta. Bull. 578.
- Heinicke, A. J. and Childers, N. F. 1936. The influence of water deficiency in photosynthesis and transpiration of apple leaves. Proc. Amer. Soc. Hort. Sci. 33:155-159.
- King, F. H. 1905. Relative rates of respiration at stations in four states from soil surfaces saturated by capillarity, and from corn. U.S.D.A. Bur. Soils Bull. 26:192-198.
- Kiesselbach, T. A. 1910. Transpiration experiments with the corn plant. Neb. Agr. Exp. Sta. 23rd Ann. Rpt.
- _____. and Montgomery, E. G. 1911. The relation of climatic factors to the water used by the corn plant. Neb. Agr. Exp. Sta. 24th Ann. Rpt.
- Krüger, W. and Schneidewind, W. 1899. Ursoche und bedeutung der Salpterzersetzung. Landw. Jahrb. 28:217-252.
- _____. 1901. Zersetzungen und Umsetzungen von stickstoffverbindungen im boden durch niedere organismen und der einfluss auf das Wachstum der Pflanzen. Landw. Jahrb. 30:633-648.
- Kenworthy, A. L. and Gilligan, G. M. 1949. Tree growth, soil and leaf analysis in response to various soil management practices in a young apple orchard. Univ. Dela. Agr. Exp. Sta. Cir. 24.

- _____. 1949. Soil moisture and growth of apple trees. Proc. Amer. Soc. Hort. Sci. 54:29-39.
- Ladd, E. F. 1901. Humus and soil nitrogen. N. Dakota Agr. Exp. Sta. Bull. 43.
- Lawes, J. B. 1950. Experimental investigations into the amount of water given off by plants during their growth; especially in relation to the fixation and source of their various constituents. J. Hort. Soc. London 5:38-63.
- Leather, J. W. 1910. Water requirements of crops in India. Memoirs, Dept. Agr. India Chem. Series 1(8):133-184.
- Lewis, M. R., Work, R. A., and Aldrich, W. W. 1934. Studies of the irrigation of pear orchards in heavy soils near Medford, Oregon. U.S.D.A. Tech. Bull. 432.
- Lyon, T. L. and Bizzell, J. A. 1911. The relation of certain non-leguminous plants to the nitrate content of soils. J. Franklin Institute 171.
- _____. 1913. Some relations of certain higher plants to the formation of nitrates in soils. Cornell Univ. Agr. Exp. Sta. Memoir 1.
- _____. 1918. Lysimeter experiments. Cornell Univ. Agr. Exp. Sta. Memoir 12.
- _____. 1921. Lysimeter experiments II. Cornell Univ. Agr. Exp. Sta. Memoir 41.
- _____, Heinicke, A. J., and Wilson, B. D. 1923. The relation of soil moisture and nitrates to the effects of sod on apple trees. Cornell Univ. Agr. Exp. Sta. Memoir 63.
- Maeracher, Max. 1896. ⁿÜber die Wirkung der Kalisalze auf Sandboden. Arbeiten Deutsche Landwirtschaft-Gesellschaft, Heft. 20:7-30.
- Magness, J. R., Regeimbal, L. O., and Degman, E. S. 1932. Accumulation of carbohydrates in apple foliage, bark, and wood as influenced by moisture supply. Proc. Amer. Soc. Hort. Sci. 39:246-252.
- Ohlmer, W. 1908. ⁿÜber den Einfluss der Düngung und der Bodenfeuchtigkeit bei gleichem Standraum auf die Aulage und Ausbildung der Ahre und die Ausbildung der Kalbenform beim Gottinger begroßten Squarehead - Winterweigen. Jour. für Landwirtschaft, Bd. 56, Heft 2:153-171.

- Partridge, N. E. 1937. Soil erosion in Michigan orchards. Mich. Agr. Exp. Sta. Cir. Bull. 162.
- Reuszer, H. W. 1931. Microbial changes in soils. J. Amer. Soc. Agron. 23:417-427.
- Rogers, W. S., Ratpopoulos, Th., and Greenham, D. W. P. 1948. Cover crops for fruit plantations. V. Effect of form and time of application of nitrogen on orchard swords. J. Hort. Sci. 24:271-283.
- Sax, Karl. 1925. Fertilization of apple orchards in Maine. Me. Agr. Exp. Sta. Bull. 322.
- Shaw, J. H. and Southwick, L. 1936. Heavy mulching in bearing apple orchards. Mass. Agr. Exp. Sta. Bull. 328.
- Shaulis, N. J. and Merkle, F. G. 1939. Some effects on the soil of different orchard soil management practices. Pa. Agr. Exp. Sta. Bull. 373.
- Stewart, J. P. 1915. Experimental results in young orchards in Pennsylvania. Pa. Agr. Exp. Sta. Bull. 134.
- _____. 1916. Cultural methods in bearing orchards. Pa. Agr. Exp. Sta. Bull. 141.
- Toenjes, Walter. 1941. The first twenty years' results in a Michigan apple orchard. Mich. Agr. Exp. Sta. Spec. Bull. 313.
- Turk, L. M. and Partridge, N. L. 1947. Effect of various mulching materials on orchard soils. Soil Sci. Soc. Amer. Proc. 64:111-125.
- Widtsoe, J. A. 1909. Irrigation investigations. Factors influencing evaporation and transpiration. Utah Agr. Exp. Sta. Bull. 105.
- Woodbury, C. G., Noyes, H. A., and Oskamp, Joseph. 1917. Soil management investigations in a young apple orchard. Purdue Univ. Agr. Exp. Sta. Bull. 205.
- Woodward, John. 1699. Some thoughts and experiments concerning vegetation. Philosophical Transactions of the Royal Society London 21(253):193-227.
- Yocum, W. W. 1937. Root development of young delicious apple trees as affected by soils and cultural treatments. Neb. Agr. Exp. Sta. Res. Bull. 95:1-53.

APPENDIX

APPENDIX TABLE IV

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN SODS OF WHITE DUTCH CLOVER

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not Mowed
June	7	55.5	55.3	71.7	74.0	89.7	92.5	95.8	99.5	97.5	98.7	82.0	84.0
	12	35.2	34.0	59.1	66.3	90.7	92.3	98.2	100.0	100.0	100.0	76.6	78.5
	18	41.0	47.2	56.7	68.2	91.0	92.7	100.0	100.0	100.0	100.0	77.7	81.6
	22	93.2	89.2	97.5	99.2	100.0	100.0	100.0	100.0	100.0	100.0	98.1	97.7
July	5	88.0	85.2	97.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.0	97.0
	11	61.7	63.8	86.3	91.2	100.0	100.0	100.0	100.0	100.0	100.0	89.6	91.0
	18	18.8	19.3	33.0	55.3	86.8	98.0	100.0	100.0	100.0	100.0	67.7	74.5
	25	12.8	12.3	17.2	22.8	41.8	76.7	100.0	100.0	100.0	100.0	54.4	62.4
Aug.	2	9.2	9.3	10.0	11.3	15.2	33.3	68.8	86.2	100.0	100.0	40.6	48.0
	9	9.5	9.5	9.7	11.2	12.0	22.7	39.0	66.7	100.0	100.0	34.0	42.0
	23	87.3	86.7	49.3	76.2	14.7	47.8	27.7	64.0	100.0	88.3	55.8	72.6
	30	63.6	73.3	45.5	67.8	18.8	49.2	30.8	62.5	100.0	90.8	51.7	68.7
Sept.	6	26.7	29.2	29.5	46.0	19.8	44.2	30.0	59.0	96.8	89.0	41.1	53.5
	13	33.8	47.5	21.8	29.0	17.8	36.8	27.5	55.0	90.7	86.2	38.3	70.9
	22	38.5	56.3	26.8	34.0	18.8	34.5	27.5	51.0	85.0	82.3	39.3	51.6
	29	76.8	74.3	50.5	65.0	20.7	39.8	30.8	53.5	85.6	83.5	52.9	63.2
Oct.	6	85.3	85.5	81.5	84.8	36.0	54.2	41.7	61.0	87.2	86.7	66.3	74.4
Average		49.2	51.6	49.6	59.0	51.4	65.6	65.8	79.9	96.6	94.4	63.7	71.3

APPENDIX TABLE V

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN SODS OF LADINO CLOVER

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	57.0	53.2	66.5	63.3	93.7	91.3	97.5	100.0	98.1	98.0	82.6	81.2
	12	27.5	30.2	53.0	52.0	93.0	90.5	99.2	100.0	99.3	99.5	74.4	80.5
	18	41.5	46.0	55.2	53.1	94.7	91.5	100.0	100.0	100.0	100.0	78.3	78.1
	22	89.5	87.3	92.0	100.0	100.0	98.2	100.0	100.0	100.0	100.0	96.3	97.1
July	5	66.8	75.0	92.2	94.3	100.0	100.0	100.0	100.0	100.0	100.0	91.8	93.9
	11	29.8	46.0	65.3	72.3	100.0	100.0	100.0	100.0	100.0	100.0	79.0	83.7
	18	12.0	20.0	21.8	33.5	78.7	86.2	100.0	100.0	100.0	100.0	62.5	67.9
	25	10.3	13.2	73.1	19.3	44.0	49.7	98.0	100.0	100.0	100.0	65.1	56.4
Aug.	2	9.7	9.5	11.2	10.8	18.8	18.0	67.0	61.2	100.0	100.0	41.3	57.0
	9	10.0	10.2	11.2	11.2	14.5	14.3	44.0	37.8	91.3	88.0	34.2	32.3
	23	83.3	87.0	49.8	58.0	28.8	14.8	40.8	29.5	80.6	67.5	74.1	51.4
	30	56.5	67.8	44.7	45.0	32.8	19.7	46.8	33.0	82.0	68.1	52.4	46.7
Sept.	6	17.2	26.5	24.3	24.3	28.2	18.0	41.3	28.8	75.5	62.0	37.3	31.9
	13	19.3	31.8	16.5	16.3	21.8	16.7	35.3	27.2	71.8	55.8	32.9	29.6
	22	31.7	47.8	16.5	16.3	21.0	16.5	32.8	25.0	69.0	50.6	34.2	31.2
	29	73.7	73.8	38.0	34.7	28.5	17.2	37.3	26.3	67.8	50.8	49.1	40.6
Oct.	6	84.0	80.7	70.2	64.0	53.2	39.7	57.5	47.5	82.3	64.6	69.4	59.3
Average		42.3	48.6	47.1	45.2	56.0	51.9	70.4	65.7	89.3	82.6	61.0	59.3

APPENDIX TABLE VI

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN SODS OF REDTOP

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	36.7	43.7	51.8	57.3	90.2	87.2	97.4	94.5	97.5	96.4	74.7	75.8
	12	23.8	22.5	38.8	42.1	90.0	85.4	99.1	96.9	99.9	98.7	70.3	69.1
	18	41.5	39.8	42.4	43.4	88.8	82.3	100.0	98.3	100.0	100.0	74.6	72.8
	22	87.7	88.1	93.3	94.2	100.0	98.2	100.0	100.0	100.0	100.0	96.2	96.1
July	5	61.8	84.2	84.7	95.7	100.0	100.0	100.0	100.0	100.0	100.0	89.3	96.0
	11	35.9	62.7	56.1	86.9	99.7	100.0	100.0	100.0	100.0	100.0	78.3	89.9
	18	14.9	24.1	22.0	43.6	62.7	90.5	100.0	100.0	100.0	100.0	59.9	71.6
	25	11.3	15.2	14.9	25.0	35.1	60.5	94.4	100.0	100.0	100.0	51.1	60.1
Aug.	2	9.1	9.8	10.0	13.4	16.4	27.9	67.6	82.9	100.0	100.0	40.6	46.8
	9	9.3	10.0	9.9	12.1	13.6	22.3	46.3	65.6	96.0	100.0	35.0	42.0
	23	80.5	86.6	44.5	80.8	20.2	65.3	43.3	75.3	88.8	96.4	55.5	80.9
	30	63.9	87.8	50.3	85.3	32.6	73.2	52.6	80.4	95.8	100.0	59.0	85.3
Sept.	6	19.5	62.8	25.3	75.5	25.3	71.6	46.0	79.9	90.7	99.2	41.4	77.8
	13	25.3	73.6	16.3	64.6	21.8	67.6	43.4	77.6	87.5	96.8	38.9	76.0
	22	46.9	77.7	38.4	70.0	27.6	68.8	47.6	82.4	84.8	95.6	49.1	78.9
	29	71.7	80.0	42.7	83.8	32.2	76.2	50.4	80.2	86.5	94.9	56.7	83.0
Oct.	6	77.8	87.1	69.1	90.8	53.3	85.5	56.8	86.8	88.9	98.4	69.2	89.7
Average		42.2	56.2	41.8	62.6	53.5	74.3	73.2	88.3	95.1	98.6	62.2	76.8

APPENDIX TABLE VII

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN SODS OF TIMOTHY

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	41.2	48.9	49.7	58.3	86.4	84.1	94.2	92.8	95.2	95.0	73.3	75.8
	12	25.9	27.0	39.4	47.5	80.1	80.1	95.2	93.9	96.5	97.0	67.4	69.1
	18	50.0	45.5	47.7	49.6	82.3	78.4	98.3	96.6	99.6	99.4	75.6	73.9
	22	89.5	86.2	97.3	92.5	93.8	95.5	100.0	100.0	100.0	100.0	96.1	94.8
July	5	85.9	82.5	97.9	93.1	97.3	99.3	100.0	100.0	100.0	100.0	96.2	95.0
	11	55.8	61.1	82.4	83.4	100.0	97.9	100.0	100.0	100.0	100.0	87.6	88.5
	18	16.3	18.2	35.8	45.7	93.1	87.7	100.0	100.0	100.0	100.0	69.0	52.1
	25	11.1	12.2	19.4	25.1	71.1	69.1	100.0	100.0	100.0	100.0	60.3	61.3
Aug.	2	9.4	9.4	11.1	14.2	39.3	43.9	100.0	98.1	100.0	100.0	34.0	53.1
	9	9.4	10.7	10.8	15.8	31.6	37.4	96.3	90.2	100.0	100.0	49.6	50.8
	23	85.8	86.5	71.6	80.1	47.7	52.6	87.6	84.0	100.0	100.0	78.5	80.6
	30	80.2	88.9	73.1	86.7	61.0	67.0	91.6	86.7	100.0	100.0	81.2	85.9
Sept.	6	46.1	74.6	58.2	80.7	61.9	72.1	90.1	86.2	100.0	100.0	71.3	82.7
	13	57.6	79.8	47.5	79.6	59.6	74.6	89.1	86.9	100.0	100.0	70.8	84.2
	22	69.8	87.3	64.3	88.3	61.2	82.3	86.7	86.8	99.1	89.9	76.2	86.9
	29	81.3	84.5	85.8	93.3	70.8	94.9	87.7	94.9	94.3	100.0	84.0	93.5
Oct.	6	84.1	90.1	93.3	98.3	89.9	98.4	86.7	100.0	100.0	100.0	90.8	97.4
Average		52.9	58.4	58.0	66.6	72.2	77.4	94.3	93.9	99.1	98.9	76.3	80.0

APPENDIX TABLE VIII

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN SODS OF QUACKGRASS

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	64.8	67.2	69.3	72.3	89.2	93.2	97.0	93.4	97.3	98.0	83.5	84.8
	12	41.5	36.7	61.1	61.8	87.4	92.0	98.9	98.2	98.8	99.8	77.5	77.7
	18	57.0	50.1	64.7	61.3	88.8	92.3	100.0	100.0	100.0	100.0	82.1	80.7
	22	92.3	89.1	96.4	96.2	100.0	100.0	100.0	100.0	100.0	100.0	97.8	97.1
July	5	90.0	86.4	98.3	98.5	100.0	100.0	100.0	100.0	100.0	100.0	97.7	97.0
	11	70.3	63.8	90.0	89.5	100.0	100.0	100.0	100.0	100.0	100.0	92.1	90.7
	18	21.9	24.1	52.1	47.3	89.2	87.3	100.0	100.0	100.0	100.0	72.6	71.7
	25	14.2	16.3	27.8	28.2	63.7	62.0	100.0	95.6	100.0	100.0	61.1	60.4
Aug.	2	9.4	10.4	12.5	16.0	28.3	32.6	73.1	67.7	100.0	100.0	44.7	45.3
	9	10.4	11.0	12.5	14.8	19.3	24.7	56.4	56.6	92.0	97.8	38.1	41.0
	23	85.3	84.0	75.4	79.8	39.7	42.6	53.1	51.0	80.0	82.9	66.7	68.1
	30	83.8	90.8	77.7	85.5	54.7	54.8	61.1	61.6	85.9	91.1	72.6	76.8
Sept.	6	49.3	59.3	60.8	67.8	51.2	54.3	58.9	59.8	83.2	88.4	60.7	66.0
	13	61.0	69.5	44.2	53.4	44.3	50.9	56.4	59.8	81.8	87.2	57.5	64.2
	22	67.1	81.7	49.5	66.0	45.2	51.8	55.0	58.6	78.8	83.7	59.1	68.4
	29	79.3	81.5	75.0	84.3	55.2	70.4	56.8	63.5	78.6	85.9	69.0	77.1
Oct.	6	88.8	91.5	88.4	93.6	74.0	88.8	67.8	75.8	83.2	91.7	80.4	88.3
Average		58.0	59.6	62.1	65.7	66.5	70.5	78.5	78.9	91.7	93.9	72.2	74.8

APPENDIX TABLE IX

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN SODS OF BLUEGRASS

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	65.4	64.5	74.1	76.0	90.9	90.2	98.7	94.9	98.2	95.4	85.5	84.2
	12	38.4	38.7	63.4	69.2	90.7	90.7	100.0	96.5	100.0	96.6	78.5	78.3
	18	64.3	59.8	70.2	72.2	92.0	91.7	100.0	98.7	100.0	99.0	85.3	84.5
	22	90.2	92.0	97.9	97.5	100.0	100.0	100.0	100.0	100.0	100.0	97.6	97.9
July	5	88.5	90.1	100.0	99.8	100.0	100.0	100.0	100.0	100.0	100.0	97.7	98.0
	11	65.8	77.6	98.0	98.0	100.0	100.0	100.0	100.0	100.0	100.0	92.7	95.1
	18	20.1	26.7	58.9	75.7	100.0	100.0	100.0	100.0	100.0	100.0	75.8	80.5
	25	13.1	15.4	32.4	46.1	88.1	90.7	100.0	100.0	100.0	100.0	66.7	70.4
Aug.	2	9.2	9.4	16.8	19.7	57.0	69.0	100.0	100.0	100.0	100.0	56.6	76.5
	9	9.4	9.7	15.3	16.9	42.9	53.0	100.0	98.5	100.0	100.0	53.5	55.6
	23	84.3	87.8	84.6	85.1	63.7	77.5	96.4	96.3	100.0	100.0	85.8	89.3
	30	82.5	86.5	84.9	85.7	73.2	84.5	99.0	97.9	100.0	100.0	87.9	90.9
Sept.	6	44.7	58.3	68.0	75.9	72.7	81.5	98.9	97.2	100.0	100.0	76.9	84.6
	13	66.0	75.4	54.3	70.6	69.1	79.1	96.4	95.8	100.0	100.0	77.2	84.2
	22	75.0	79.8	70.3	79.0	73.1	81.1	95.2	94.4	100.0	100.0	82.7	86.9
	29	80.2	83.8	86.6	88.5	84.0	91.2	96.3	100.0	100.0	100.0	89.4	92.7
Oct.	6	88.4	92.5	95.8	96.0	98.2	98.5	100.0	100.0	100.0	100.0	96.5	97.4
Average		58.0	61.6	69.6	73.6	82.1	87.0	98.9	98.2	99.9	99.5	83.9	85.1

APPENDIX TABLE X

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN SODS OF FESCUE

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	55.9	54.8	64.9	67.7	92.0	93.7	99.5	100.0	98.7	100.0	82.2	83.2
	12	29.7	29.1	54.9	52.9	91.2	93.3	100.0	100.0	100.0	100.0	75.2	75.1
	18	54.5	45.1	59.8	58.8	94.3	90.8	100.0	100.0	100.0	100.0	81.7	78.9
	22	93.1	90.6	99.0	98.0	100.0	100.0	100.0	100.0	100.0	100.0	98.4	97.7
July	5	85.2	87.5	100.0	99.4	100.0	100.0	100.0	100.0	100.0	100.0	97.0	97.4
	11	49.3	60.1	90.2	92.7	100.0	100.0	100.0	100.0	100.0	100.0	88.0	90.6
	18	14.4	19.0	40.6	45.3	98.9	100.0	100.0	100.0	100.0	100.0	70.8	72.9
	25	10.5	12.0	19.9	22.9	80.7	76.9	100.0	100.0	100.0	100.0	62.2	62.4
Aug.	2	8.9	9.3	11.6	12.3	43.9	41.2	98.5	100.0	100.0	100.0	52.6	52.6
	9	9.2	9.6	10.8	11.4	32.3	32.3	88.3	97.1	100.0	100.0	48.1	50.1
	23	90.5	88.0	83.6	81.3	54.7	71.7	85.9	94.5	100.0	100.0	82.9	87.1
	30	88.3	86.6	85.8	84.9	65.3	77.2	89.5	99.2	100.0	100.0	85.8	89.6
Sept.	6	47.8	51.2	71.7	71.3	66.3	76.2	89.0	97.6	100.0	100.0	75.0	79.3
	13	65.5	66.4	56.1	56.7	64.3	71.5	87.2	96.5	100.0	100.0	74.6	78.2
	22	72.0	68.4	64.6	69.3	66.3	73.5	86.6	95.4	100.0	100.0	77.9	81.3
	29	81.7	82.5	85.1	84.8	70.9	79.5	89.4	97.1	100.0	100.0	85.4	88.8
Oct.	6	90.5	91.0	94.7	94.5	85.1	92.0	94.5	100.0	100.0	100.0	92.9	95.5
Average		55.7	56.0	64.3	65.0	76.8	80.6	95.3	98.7	99.9	100.0	79.9	82.3

APPENDIX TABLE XI

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1951),
IN CLEAN CULTIVATED AND MULCHED SOIL

Date		Depth in inches										Average	
		8		16		24		32		40			
		Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch
June	7	68.4	80.7	82.0	79.5	92.7	93.7	98.3	95.5	98.0	97.2	87.9	89.3
	12	72.3	78.5	84.8	82.5	94.9	97.5	100.0	98.5	100.0	99.0	90.4	91.2
	18	90.1	92.7	92.2	89.5	99.4	100.0	100.0	100.0	100.0	100.0	96.5	96.4
	22	98.0	98.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.6	99.7
July	5	99.6	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	100.0
	11	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	18	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	25	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Aug.	2	100.0	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9
	9	98.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.7	100.0
	23	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	30	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Sept.	6	79.1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	95.8	100.0
	13	88.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.7	100.0
	22	88.2	100.0	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	97.5	100.0
	29	90.2	100.0	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.0	100.0
Oct.	6	99.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.8	100.0
Average		92.5	97.1	98.2	97.1	99.2	99.5	99.9	99.9	99.9	99.8	98.6	98.7

APPENDIX TABLE XII

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952),
IN SODS OF WHITE DUTCH CLOVER

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	61.5	41.8	61.8	44.8	67.5	63.2	86.0	83.5	95.8	98.8	74.5	66.4
	16	19.8	17.3	26.3	21.0	47.8	33.2	73.5	60.0	93.8	97.0	52.2	45.7
	23	14.3	10.5	17.0	12.2	34.5	19.3	64.3	58.3	94.8	89.7	45.0	38.0
July	7	10.0	10.0	10.0	10.0	10.8	10.2	21.3	13.3	73.0	43.7	25.0	17.4
	14	10.8	10.7	10.8	10.7	11.3	11.0	16.2	13.3	59.2	34.8	21.7	16.1
	21	88.0	88.0	84.8	81.3	53.5	39.2	56.8	49.8	74.7	65.2	71.6	64.7
	28	77.2	83.8	78.0	76.3	51.5	49.7	49.8	46.5	74.0	70.5	66.1	65.4
Aug.	4	83.8	85.3	67.0	75.5	49.7	58.3	47.8	55.2	78.8	67.7	65.4	68.4
	11	76.2	80.8	77.7	80.3	53.3	59.5	52.7	54.7	75.8	73.5	67.0	69.8
	18	77.3	81.3	74.2	76.7	58.3	64.3	54.7	62.3	79.0	78.3	68.7	72.6
	25	46.0	47.7	58.8	66.3	55.8	60.8	55.3	60.3	78.0	76.8	58.8	62.4
Sept.	1	21.3	35.5	29.5	42.3	39.3	49.2	46.8	49.2	72.8	70.3	41.9	49.3
	9	48.3	50.8	44.8	49.7	43.8	52.0	53.2	59.0	77.0	78.7	53.4	58.0
	16	16.8	21.7	20.5	33.3	30.8	45.2	48.7	55.2	73.0	66.7	38.0	44.4
	26	15.2	18.8	15.2	19.5	18.5	27.8	34.7	44.7	65.5	68.3	29.8	35.8
Oct.	3	11.8	12.2	12.8	15.2	15.2	21.2	24.8	34.5	57.8	59.5	24.5	28.5
	10	10.3	11.2	11.2	11.8	12.5	16.5	18.2	27.5	48.5	54.0	20.2	24.2
Average		40.5	41.6	41.2	41.6	38.5	40.0	47.3	48.2	74.8	70.2	48.3	49.8

APPENDIX TABLE XIII

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952), IN SODS OF LADINO CLOVER

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	48.3	52.3	51.2	52.7	71.5	74.0	87.7	91.0	94.0	94.3	70.5	72.9
	16	17.0	18.7	21.2	23.2	44.2	49.3	71.3	86.8	94.8	95.7	49.7	54.7
	23	11.0	11.8	13.5	13.0	28.5	22.3	58.3	72.7	93.0	94.3	40.9	42.8
July	7	10.2	10.0	10.8	10.0	12.0	10.2	20.8	17.2	52.8	62.5	21.3	22.0
	14	11.5	11.2	12.2	10.8	13.0	11.0	15.7	14.3	42.0	58.3	18.9	21.1
	21	86.7	85.8	85.3	66.3	68.3	35.3	53.5	33.0	53.5	63.2	69.5	56.7
	28	81.7	74.3	80.0	70.0	67.3	34.3	57.0	37.2	61.0	64.7	69.4	56.1
Aug.	4	82.5	82.2	57.5	45.0	62.8	39.7	58.5	42.8	60.3	63.3	64.3	54.6
	11	77.0	72.5	71.0	70.5	61.8	39.5	57.3	45.0	63.3	66.5	66.1	58.8
	18	77.5	75.0	64.2	65.2	61.3	42.3	58.7	47.8	66.3	63.5	65.6	58.8
	25	35.3	39.2	48.2	49.0	54.5	40.2	55.3	47.7	67.7	67.0	52.2	48.6
Sept.	1	27.8	20.3	27.2	19.3	32.3	26.2	41.2	38.5	61.5	62.2	38.0	33.3
	9	41.3	39.7	35.7	35.0	41.0	32.7	45.3	42.7	62.7	64.8	45.2	43.0
	16	15.8	14.5	20.3	18.0	28.8	23.7	35.5	37.5	59.8	61.3	32.0	31.0
	26	15.3	13.5	16.7	14.2	19.5	16.2	26.0	27.3	51.3	52.8	25.8	24.8
Oct.	3	12.8	12.0	14.3	13.0	17.0	13.8	19.8	21.8	44.0	44.8	21.6	21.1
	10	11.7	11.7	12.8	11.8	14.5	12.3	16.2	17.2	36.5	36.2	18.3	17.8
Average		39.0	37.9	37.8	34.5	41.1	30.8	45.8	42.4	62.6	65.6	45.3	42.3

APPENDIX TABLE XIV

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952),
IN SODS OF TIMOTHY

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	62.5	69.3	64.5	80.8	81.8	86.1	89.9	91.3	88.3	95.3	77.4	88.6
	16	20.6	27.8	33.4	49.9	68.0	83.5	90.8	92.8	90.0	97.0	60.6	70.2
	23	18.3	12.5	29.5	24.3	63.0	63.6	90.9	92.4	90.1	97.4	58.4	58.0
July	7	13.0	10.0	21.5	10.0	48.4	24.4	90.3	76.6	92.1	96.8	53.1	43.6
	14	20.0	10.8	26.4	10.6	50.1	23.3	92.9	67.5	96.9	99.5	57.3	42.3
	21	88.1	81.3	89.8	72.3	89.5	46.9	98.1	70.9	97.6	97.8	92.6	73.8
	28	90.4	82.9	93.0	84.4	97.6	68.1	100.0	76.3	98.6	99.0	95.9	82.1
Aug.	4	92.6	87.4	99.0	89.0	100.0	86.0	100.0	83.1	100.0	100.0	98.3	89.1
	11	85.4	82.9	93.3	90.1	98.3	91.0	100.0	89.5	98.5	99.1	95.1	90.5
	18	85.1	86.0	93.4	92.8	98.5	95.4	100.0	94.9	98.3	100.0	95.1	93.8
	25	72.4	79.4	86.3	89.4	95.0	91.9	99.5	93.5	95.8	98.1	89.8	90.5
Sept.	1	48.9	77.3	72.1	86.9	93.3	91.5	100.0	93.1	97.1	99.0	82.3	89.6
	9	70.9	79.6	80.0	86.1	90.6	91.8	96.8	93.1	93.8	98.6	86.4	89.8
	16	41.9	76.1	69.8	88.6	89.9	92.8	97.8	94.0	94.5	98.6	78.8	90.0
	26	30.4	70.8	46.9	83.1	78.8	88.4	92.9	90.8	91.9	96.4	68.2	85.9
Oct.	3	21.3	63.8	36.8	78.9	69.8	85.4	89.9	88.5	89.3	93.0	61.4	81.9
	10	16.4	57.1	27.9	62.8	60.0	81.6	86.0	85.5	87.0	91.0	55.5	75.6
Average		51.7	62.1	62.6	69.4	80.7	76.0	95.0	86.7	94.1	97.4	77.1	78.4

APPENDIX TABLE XV

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952), IN SODS OF REDTOP

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not-mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	58.6	67.7	72.1	80.9	89.2	89.2	93.9	96.2	99.9	99.7	82.7	86.7
	16	19.6	20.0	32.5	34.1	78.1	79.3	94.7	92.8	100.0	100.0	65.0	65.2
	23	13.3	11.5	26.0	14.7	67.2	43.6	94.6	87.9	100.0	99.5	60.2	51.2
July	7	10.1	10.0	16.5	10.2	34.7	11.1	87.4	40.1	100.0	90.4	49.7	32.4
	14	13.9	11.0	18.1	11.7	37.1	12.1	87.4	35.4	100.0	89.1	51.3	31.9
	21	88.9	86.5	91.6	65.6	91.3	55.5	99.2	75.9	100.0	93.3	94.2	75.4
	28	90.5	84.8	97.1	81.6	98.7	69.1	100.0	82.0	100.0	96.3	97.3	82.8
Aug.	4	88.8	84.1	97.8	85.2	100.0	83.2	100.0	88.4	100.0	98.8	97.3	87.9
	11	84.6	84.4	95.3	88.7	100.0	88.8	100.0	91.9	100.0	100.0	96.0	90.8
	18	80.6	86.2	93.7	92.2	100.0	92.1	100.0	95.6	100.0	100.0	94.9	93.2
	25	48.0	72.3	83.3	84.6	96.2	89.0	100.0	93.1	100.0	100.0	85.5	87.8
Sept.	1	24.3	47.4	54.7	73.2	93.3	85.5	100.0	91.1	100.0	99.3	74.5	79.3
	9	51.6	71.0	65.0	78.9	90.0	85.9	98.1	92.1	100.0	100.0	80.9	85.6
	16	21.5	40.5	44.0	72.4	85.0	84.2	97.7	91.0	100.0	99.3	69.6	77.5
	26	15.8	29.8	27.0	46.8	64.6	75.3	92.2	86.6	100.0	95.5	59.9	66.8
Oct.	3	13.3	20.0	22.4	34.8	50.8	66.7	87.8	84.4	99.6	92.1	54.8	59.6
	10	12.0	15.7	17.5	25.1	36.9	54.3	80.3	79.8	95.7	88.1	48.5	52.6
Average		43.3	49.7	56.2	58.1	77.2	68.5	94.9	82.6	99.7	96.5	75.5	71.1

APPENDIX TABLE XVI

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952),
IN SODS OF QUACKGRASS

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	54.4	57.4	54.4	52.9	69.3	73.4	87.0	85.8	92.2	90.9	71.5	72.1
	16	19.1	20.0	26.1	25.2	43.4	49.1	79.1	80.1	91.8	94.2	51.9	53.7
	23	13.6	11.0	20.6	13.4	39.2	23.1	74.3	58.6	91.9	89.4	47.9	39.1
July	7	10.4	10.3	10.9	10.4	14.5	10.7	34.9	13.1	75.9	42.2	29.3	17.3
	14	11.9	11.2	12.5	11.1	15.9	11.9	28.1	13.6	65.1	34.0	26.7	16.4
	21	88.2	85.9	85.9	69.8	71.7	39.3	67.1	23.4	80.9	46.8	78.8	53.0
	28	82.9	82.9	86.9	75.9	78.9	45.1	73.2	29.6	84.4	53.1	81.3	57.3
Aug.	4	84.8	84.4	75.9	78.6	77.6	58.3	76.4	42.0	85.6	60.1	80.1	64.7
	11	79.2	81.6	84.0	83.1	80.4	67.5	77.6	50.3	85.7	64.1	81.4	69.3
	18	79.9	83.4	80.6	84.6	79.1	72.9	78.8	56.5	86.6	68.1	81.0	73.1
	25	58.5	75.1	69.7	79.6	73.9	70.9	75.0	59.3	84.9	69.0	72.6	70.8
Sept.	1	35.3	47.9	41.9	61.9	59.7	67.4	69.6	59.1	82.3	68.6	57.8	61.0
	9	62.4	73.9	58.2	72.2	62.9	67.4	69.8	62.0	81.6	70.4	67.0	69.2
	16	34.0	49.5	42.9	62.7	55.6	66.2	67.6	61.5	81.7	70.6	56.4	62.1
	26	21.9	34.1	24.4	39.1	38.8	51.4	55.6	55.1	74.8	66.8	43.1	49.3
Oct.	3	17.4	26.6	19.9	32.3	31.1	43.5	48.7	50.3	68.1	61.9	37.0	42.9
	10	14.2	20.2	15.8	25.7	23.9	36.1	39.5	44.0	61.0	57.1	30.9	30.6
Average		45.1	75.7	47.7	51.7	53.9	50.2	64.9	49.7	80.9	65.1	58.5	53.4

APPENDIX TABLE XVII

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952),
IN SODS OF BLUEGRASS

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	74.1	76.3	82.6	82.5	88.2	85.9	95.3	90.6	95.4	89.8	87.1	85.0
	16	32.7	34.1	66.5	63.6	89.3	86.1	98.2	94.1	99.4	92.3	77.2	74.0
	23	20.4	16.0	43.8	44.1	86.4	80.0	98.7	93.4	100.0	93.4	69.9	65.4
July	7	10.3	10.1	13.1	14.2	48.0	43.6	98.3	90.0	100.0	94.9	53.9	50.6
	14	11.1	10.5	14.1	14.9	42.4	39.6	98.8	89.8	100.0	96.7	70.6	50.3
	21	87.9	79.2	85.8	89.7	90.4	80.9	100.0	94.9	100.0	91.1	92.8	57.2
	28	87.2	83.9	90.3	93.4	96.2	86.1	100.0	96.6	100.0	97.4	94.7	91.5
Aug.	4	88.0	84.6	93.5	96.9	100.0	92.0	100.0	99.6	100.0	100.0	96.3	94.6
	11	82.6	82.1	91.7	94.1	98.6	91.3	100.0	97.5	100.0	97.5	94.6	92.5
	18	82.1	83.2	92.2	93.9	99.0	92.9	100.0	98.6	100.0	98.1	94.7	93.3
	25	65.2	70.6	88.4	89.8	97.1	90.6	100.0	97.3	100.0	97.9	90.1	89.2
Sept.	1	30.6	47.4	73.1	69.6	95.3	88.6	100.0	97.3	100.0	97.6	79.8	80.1
	9	67.9	72.2	82.5	81.4	91.6	88.4	98.6	95.0	100.0	95.6	88.1	86.5
	16	34.3	44.7	72.4	68.5	91.5	87.2	100.0	95.9	100.0	95.6	79.6	78.4
	26	24.0	38.9	49.9	44.5	81.2	78.8	96.3	91.9	100.0	93.4	72.3	69.5
Oct.	3	16.5	24.7	38.0	30.6	71.0	71.3	92.4	88.1	97.1	90.4	63.0	61.0
	10	13.6	17.5	28.4	21.9	58.2	63.4	88.9	84.8	94.3	88.7	56.7	55.3
Average		48.7	51.5	65.1	64.3	83.8	79.2	98.0	93.8	99.2	94.7	80.1	77.1

APPENDIX TABLE XVIII

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952),
IN SODS OF FESCUE

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	71.3	77.2	80.6	84.6	90.6	88.9	95.4	94.2	96.0	94.3	86.8	87.8
	16	29.0	28.2	57.3	61.3	90.2	89.7	99.3	97.0	99.9	97.5	75.1	74.7
	23	18.3	13.0	37.9	24.9	85.3	80.6	98.5	97.1	100.0	98.7	68.0	62.9
July	7	10.1	10.0	11.2	10.0	31.0	19.8	87.3	88.1	100.0	98.7	47.9	45.3
	14	10.8	10.3	11.8	10.8	28.2	17.3	89.4	80.3	100.0	100.0	48.0	43.7
	21	89.8	85.6	88.5	77.9	82.3	63.2	100.0	92.0	100.0	100.0	92.1	83.7
	28	87.9	79.6	92.5	83.8	92.1	71.8	100.0	92.3	100.0	100.0	94.5	85.5
Aug.	4	86.9	75.9	94.8	83.5	99.3	81.6	100.0	97.9	100.0	100.0	96.2	87.8
	11	84.1	77.3	94.6	84.7	100.0	85.8	100.0	97.8	100.0	100.0	95.7	89.1
	18	83.1	78.3	92.4	84.6	99.9	86.9	100.0	99.1	100.0	100.0	95.2	89.8
	25	58.9	49.1	86.0	76.7	97.1	84.8	100.0	98.0	100.0	100.0	88.4	81.7
Sept.	1	28.9	35.7	60.3	47.3	93.5	80.4	100.0	96.8	100.0	100.0	76.5	72.0
	9	62.6	52.3	72.0	64.7	89.2	79.7	100.0	94.6	100.0	99.2	84.8	78.1
	16	27.6	17.8	52.9	38.6	85.4	75.1	100.0	94.8	100.0	99.4	73.2	65.1
	26	18.9	17.9	31.3	21.4	69.3	56.2	94.7	88.8	100.0	97.3	62.8	56.3
Oct.	3	13.7	11.5	22.9	14.9	55.9	39.8	89.3	82.9	99.1	94.6	56.2	48.7
	10	11.3	10.4	15.5	12.0	41.7	23.7	81.8	74.4	96.8	91.8	49.4	42.5
Average		46.7	42.9	59.3	51.9	73.3	66.2	96.2	92.0	99.5	98.3	77.0	70.5

APPENDIX TABLE XIX

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952),
IN SODS OF ALFALFA

Date		Depth in inches										Average	
		8		16		24		32		40			
		Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed	Mowed	Not mowed
June	7	78.3	82.0	83.0	89.3	92.3	92.2	98.8	100.0	100.0	99.7	90.5	92.6
	16	24.5	33.8	37.7	64.0	76.5	82.3	97.7	100.0	100.0	100.0	67.3	76.0
	23	21.3	16.3	33.8	26.8	64.5	66.0	97.3	95.5	100.0	100.0	63.4	60.9
July	7	11.0	10.2	11.2	10.2	14.0	14.2	44.0	55.5	100.0	95.7	36.0	37.2
	14	12.2	12.7	12.2	11.0	13.7	12.7	21.3	33.8	80.0	86.3	27.9	31.3
	21	89.2	87.8	83.5	76.3	49.8	42.8	49.7	34.0	83.3	75.5	71.1	63.3
	28	77.5	79.0	76.7	66.7	53.7	43.7	47.3	35.3	76.5	69.7	66.3	58.9
Aug.	4	82.7	83.3	51.8	43.2	46.8	31.2	37.0	27.0	62.5	54.3	56.2	47.8
	11	75.2	77.5	69.2	60.0	51.0	46.7	39.8	32.2	61.0	53.8	59.2	54.0
	18	78.7	79.8	61.0	54.3	45.8	41.2	35.2	30.3	52.8	47.7	54.7	50.7
	25	48.7	55.0	49.8	39.5	39.2	33.7	29.7	26.2	47.3	42.7	42.9	39.4
Sept.	1	24.2	27.7	24.3	18.7	21.5	19.5	19.7	20.0	31.0	27.0	24.1	22.6
	9	54.5	56.8	42.5	26.7	30.2	22.2	23.3	21.2	31.3	26.7	36.4	30.7
	16	24.2	28.0	29.3	20.8	23.5	19.5	19.5	19.2	27.0	23.5	24.7	22.2
	26	20.8	24.7	17.8	15.7	16.5	15.8	16.0	15.7	21.3	19.2	18.5	18.2
Oct.	3	16.3	21.0	16.3	15.7	15.5	16.2	15.7	16.5	19.7	18.5	16.7	17.6
	10	13.2	16.7	13.3	12.5	13.3	13.0	12.8	13.3	16.2	15.7	13.8	14.2
Average		44.3	46.6	42.0	38.3	39.3	36.1	41.5	39.7	60.1	56.2	45.6	43.5

APPENDIX TABLE XX

PERCENT OF AVAILABLE SOIL MOISTURE, BY DEPTHS AND DATES (1952),
IN CLEAN CULTIVATED AND MULCHED SOIL

Date		Depth in inches										Average	
		8		16		24		32		40			
		Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch	Clean cult.	Mulch
June	7	84.9	89.8	92.3	92.3	97.8	99.0	100.0	97.3	100.0	97.0	95.0	95.1
	16	45.1	93.5	70.0	97.3	92.0	100.0	100.0	100.0	100.0	100.0	81.4	98.2
	23	49.0	91.0	68.6	93.3	90.3	100.0	100.0	100.0	100.0	100.0	81.6	96.9
July	7	57.1	90.5	76.0	94.0	93.5	100.0	100.0	100.0	100.0	100.0	85.3	96.9
	14	70.0	97.5	79.4	97.8	95.8	100.0	100.0	100.0	100.0	100.0	89.0	99.1
	21	97.4	99.0	99.4	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.4	100.0
	28	99.7	97.5	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5
Aug.	4	100.0	97.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5
	11	97.7	90.8	100.0	96.5	100.0	100.0	100.0	100.0	100.0	100.0	99.5	98.2
	18	88.7	90.8	100.0	98.8	100.0	100.0	100.0	100.0	100.0	100.0	97.7	97.9
	25	87.0	88.8	100.0	94.0	100.0	100.0	100.0	100.0	100.0	100.0	97.4	95.8
Sept.	1	73.3	92.3	97.3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	94.1	98.5
	9	82.3	89.8	95.4	94.5	100.0	100.0	100.0	100.0	100.0	100.0	95.5	96.9
	16	60.5	85.8	92.1	94.3	100.0	100.0	100.0	100.0	100.0	100.0	90.5	96.0
	26	56.3	86.5	77.7	93.5	93.0	100.0	100.0	100.0	100.0	100.0	85.4	96.0
Oct.	3	44.6	84.0	69.3	88.5	87.8	98.5	100.0	99.3	100.0	98.5	80.3	93.8
	10	36.2	81.3	59.3	85.5	80.5	96.5	95.7	99.0	100.0	96.5	74.3	91.8
Average		72.3	91.0	86.9	95.3	95.9	99.6	99.7	99.7	100.0	99.5	93.2	98.3