A STUDY OF TRICKLE IRRIGATION
ON MATURE PECAN
TREES

By

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1973

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1975

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ACKNOWLEDGMENTS

The author wishes to express his sincere appreciation to Professor Herman A. Hinrichs for his guidance, cooperation, and patience throughout my graduate program.

Appreciation is due to Professor W. R. Kays, Head, Department of Horticulture, and Professor A. D. Barefoot, Department of Agricultural Engineering for their interest, cooperation and contributions to this study.

Special appreciation is extended to Harold Davis and Donnie Quinn for their assistance in carrying out this study.

Appreciation is also extended to my Mother and Father for all their assistance and support during my education.

My wife, Carole, deserves the final and most sincere measure of appreciation. It has been her faith and her support that have seen this thesis to completion.

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CHAPTER I

INTRODUCTION

Pecan producers in Oklahoma have many problems. They are plagued with insects, diseases, alternate bearing, and unfavorable weather conditions. Pecan trees are large plants formerly believed to easily withstand short periods of drought via their ability to extract needed moisture from great depths. Now we realize that a majority of the highly active pecan feeder roots are in the upper fifteen inches of soil [32] even though a large amount of roots extend to thirty-six inches and beyond.

Inadequate soil moisture has been reported to cause an array of pecan maladies and disorders such as: (1) growth retardation, (2) decreased nut size, (3) poor nut filling, (4) nut drop, and (5) tree mortality [26, 27, 32]. Critical times for moisture are during rapid sizing of the nut between the eighth and fourteenth weeks after pollination (mid-July to early August), and during nut filling between the fourteenth and eighteenth weeks after pollination (early August to early September) [23, 26, 32]. Inadequate moisture during this time will result in a small nut with a shriveled kernel. This greatly reduces the yield, quality, and marketability of the pecan.

Premature defoliation due to insufficient water may greatly affect the yield of next year's crop. Lack of water reduces photosynthetic capabilities of the plant reducing the production and storage of reserve food [12, 27]. This is one reason pecan trees tend to bear alternate years. A growth substance is produced in the leaves during September and translocated to the buds, which is responsible for pistillate flower formation. For these reasons, excellent foliage on the tree in the fall is essential for maximum pistillate flower development for next year's crop [21, 23].

Irrigation can, at critical times, overcome the problem of an inadequate water supply. Irrigation may increase the size of nuts when applied at critical times [22, 26]. The question now arises as to the type of irrigation system to select. One may choose from flood, sprinkler, subsurface, or trickle (drip) irrigation systems. Recent research on other crops indicate that trickle and subsurface irrigation systems may have some definite advantages over flood or sprinkler irrigation. These are increased yield, decreased water use and cost, improved produce quality, decreased salt accumulation, decreased irrigation labor cost, and decreased weed control cost [1, 2, 3, 4, 8, 10, 11, 13, 14, 15, 16, 17, 18, 19, 20, 28, 32, 34].

Little research has been conducted with trickle irrigation on pecans. The purpose of this study is to determine the effectiveness of trickle irrigation as a supplemental water source for pecan production. Nut size, nut quality, and tree growth will be determined to evaluate its effectiveness. The amount of water and the wetting patterns will be determined for the set of conditions in this experiment.

CHAPTER II

LITERATURE REVIEW

Trickle Irrigation Design

The primary objective in designing an irrigation system is to supply sufficient water to meet the moisture requirements of the crop and to deliver the water efficiently, economically, and uniformly to all parts of the irrigated area. The first step in designing a trickle system is the collection of the following information.

A. Size of the area--length, width, acres

B. Location and type of water source, quality, quantity, and rate of water availability

C. General soil type, percolation rate, water retention

D. Topography--general slope and significant changes in elevation

E. Type of trees, age, and size

F. Tree spacing in a row, row spacing, number of rows, and number of trees in each row [24].

Although water requirements have not been accurately defined, application of water may be based on daily evaporation from a Class A evaporation pan. The formula used is as follows:

$$DWR = E \times A \times .40 \times \% \text{ coverage}$$

where:

DWR is the daily water requirement per tree, in gallons

E is the daily evaporation from a Class A pan in inches

A is the area in tree spacing, in square feet

.40 is a constant, 7.48 gallons per cubic foot ÷ 12 inches per foot x water use factor .65.

Friction between the flowing water and the walls of pipe cause a loss of pressure. Variation in pressure between the first and last emitter should be no greater than 20 percent. This can be accomplished by using larger pipe, shorter laterals, or both [24, 29].

The selection of an adequate filter, pump, and power unit is also important. The filter should be able to screen out foreign material which may clog emitters. In selection of the pump, the flow rate and "Total Dynamic Head" should be considered. The values necessary in determining power unit requirements are pumping rate, total dynamic head, and pump efficiency [24]. With this information, a properly designed trickle irrigation system may be obtained.

Water Distribution

Brandt, et al. [5], working with a Gilant loam soil in laboratory conditions, reported the shape of the overall wetted zone is affected by the discharge rate. The wetted zone is deeper and narrower for slow trickle rates than for faster ones. Continuing their work the following year, Brandt and colleagues [7] worked in both laboratory and field conditions. Results of this work were in agreement with the work reported earlier.

Goldberg, et al. [14] used carnations in beds with two irrigation lines 45 centimeters apart and emitters 50 centimeters apart placed in beds. The emitters were designed to deliver two liters of water per hour. They reported a uniform moisutre distribution throughout the bed except for a reduction of moisture in the area between the emitters in the uppermost layer and lowest layer of the bed. This is the area 0 - 3 centimeters in the top and 30 - 40 centimeters depth in the bottom, 25 centimeters from either emitter.

Whitney, et al. [35] used subsurface irrigation in a silt loam soil. Mounds of soil two feet square by eight inches deep were used under laboratory conditions to measure the distance water flowed with respect to time and flow rate. Three pressure levels were used: 1/4, 1/2, and 1 psi, and four orifice sizes: 1/30, 1/16, 3/32, and 1/8 inch diameter. Wetting patterns in the soil were found to be an almost perfect sphere. The radius of the sphere was also found to be a function of orifice size and pressure. One psi and 1/16 inch orifice were found to be the maximum which could be used under conditions of the experiment without channeling occurring.

The soil profile also affects movement of water in a soil. Using subirrigation, Whitney, et al. [34] determined the effect this had. Silt loam, loam, or loamy sand were used as the top soil with subsoils of either sand or pea size stone gravel. Results indicated that the water did not readily move out of the top soil into the subsoil except in the case of the loamy sand top soil with sand subsoil. This occurred because particle size of the loamy sand and sand were similar.

Goldberg, et al. [16] studied the effect of irrigation intervals on distribution of soil moisture in a vineyard. Irrigation intervals were either daily, 7.5, 15, or 30 days. Equal amounts of water were applied for each treatment. Soil type was classed as sandy clay 80 centimeters deep over a clay subsoil. The diameter of the wetted soil surface was 40 centimeters in the daily and 7.5 day treatments, 45 centimeters in the 15 day treatment, and 95 centimeters in the 30 day treatment. A considerable loss of water by deep percolation occurred the first few days following irrigation. If the rate of application were sufficiently low, and irrigation frequent, most of the gravitational water would be available for consumptive use, and the moisture content of the root zone remains at a consistent high level.

Distribution of Salt Concentration

Goldberg, et al. [14] used a fertilizer injector with a trickle irrigation system. The fertilizer solution used was a 20-20-20 ratio of N, P_2O_5, and K_2O. The injector was set to apply the equivalent of 20 kg/ha or 400 grams of nitrogen. Nitrate, phosphate, soluble salts, and chloride content of the soil were measured to determine where the concentrations occurred. Nitrate concentration was low in the upper layer near the emitter and increased at the edges of the wetting pattern. High nitrate concentrations were found under the emitter at the lower soil depths and a decrease in nitrate content at the edges of the wetting pattern. Phosphate distribution was unlike that of nitrogen. Phosphate concentration at all depths tended to be higher near the emitter and decrease to the edge. Soluble salts were highest in the top three centimeters of soil at all locations across the bed. The highest concentration occurred at the edge of the wetting pattern. Chloride distribution was identical to that of the soluble salts.

Goldberg, et al. [16] also studied the effect that irrigation intervals have on moisture and salt concentration. Salt accumulation was found to follow the general pattern of water flux, described earlier. Isolated pockets of salt accumulation were found adjoining part of the surface and a second deep level accumulation with an elipsoidal shaped leach zone between them. The position of the surface and deep level accumulations were found to be related to the radius of the wetted surface. Measurements were taken the next spring after winter rains (average rainfall 630 mm) to determine if salt accumulations were still present.

Readings indicated the upper 120 centimeters were sufficiently leached by rains to prevent salinization.

Water Quality

Irrigation with saline water using trickle, sprinkler, and furrow application were studied on peppers. Sprinkler irrigation severely injured pepper plants. This was attributed to absorption of salt by the leaves. Using brackish water caused only a 14 percent reduction in yield with trickle irrigation, but 54 and 94 percent reductions in yield with furrow and sprinkler irrigation, respectively [4].

Tomatoes and cucumbers also responded well to trickle irrigation using water with a high soluble salt content. Water used contained 800 mg Cl/1 with equal quantities of water applied by either trickling or sprinkling. The yield by trickling was more than double that obtained by sprinkling. Sprinkling also produced higher soluble and diffusible ions, free ammonia, and free amino acids in the leaves, and reduced starch, protein, pigments, and relative turgidity [15].

Crop Response and Water Use Efficiency

Crop response and water use efficiency are very good with trickle irrigation. A test using non-irrigated, subirrigated, and trickle irrigated treatments revealed that both trickle and subirrigation increased soybean plant height and seed yield. Water use efficiency was much better for trickle irrigation than for subsurface irrigation [11].

Hiler and Howell [20] used subsurface, trickle, subsurface plus mist, mist, and surface irrigation treatments. Conclusions indicated that both plant height and leaf area index were greater in the trickle and mist treatments than in either the subsurface or surface irrigation treatments.

Yields of potatoes and corn irrigated by trickle, subsurface, and sprinkler irrigation systems gave significantly higher yields with trickle and subsurface irrigation. A 20 percent reduction in water use also was recorded with trickle and subsurface irrigation [8]. Increase in yield and water use efficiency have also been reported with onions (<u>Allium cepa</u>) and lady fingers (<u>Hibiscus esculentum</u>) [1].

Goldberg, et al. [16] reported water use efficiency could be improved by applying water at short intervals. This also increased the production and weight of grapes.

CHAPTER III

MATERIALS AND METHODS

A trickle irrigation system was installed using 3/4 inch PVC main line, 1/2 inch polyethylene submain line, and 1/4 inch polyethylene lateral line (Figures 1 and 2). The lateral lines were used to encircle the tree with emitters in the lines. Both main and submain lines were buried below the freeze line with lateral lines above ground. In-line type emitters[1] were used in the lateral lines. Four emitters were spaced equidistance around the tree on a ten foot radius circle. Pressure in the main line was maintained at 15 psi pressure. The research plots were located at the Oklahoma State University Research Station at Sparks, Oklahoma. The water used for irrigation was from Sparks Municipal Lake. The analysis of the water was pH 7.1, 13 ppm calcium, and 12 ppm sodium.

Two areas were used for the trickle system. The first area contained trees of the "Western" cultivar 23 years of age of uniform size and vigor. Trees were spaced 49.5 feet apart with 18 trees per acre. Soil type was a Port silty clay loam with zero to one percent slope. Treatments

[1]Controlled Water Emission Systems, 585 Vernon Way, El Cajon, California 92020.

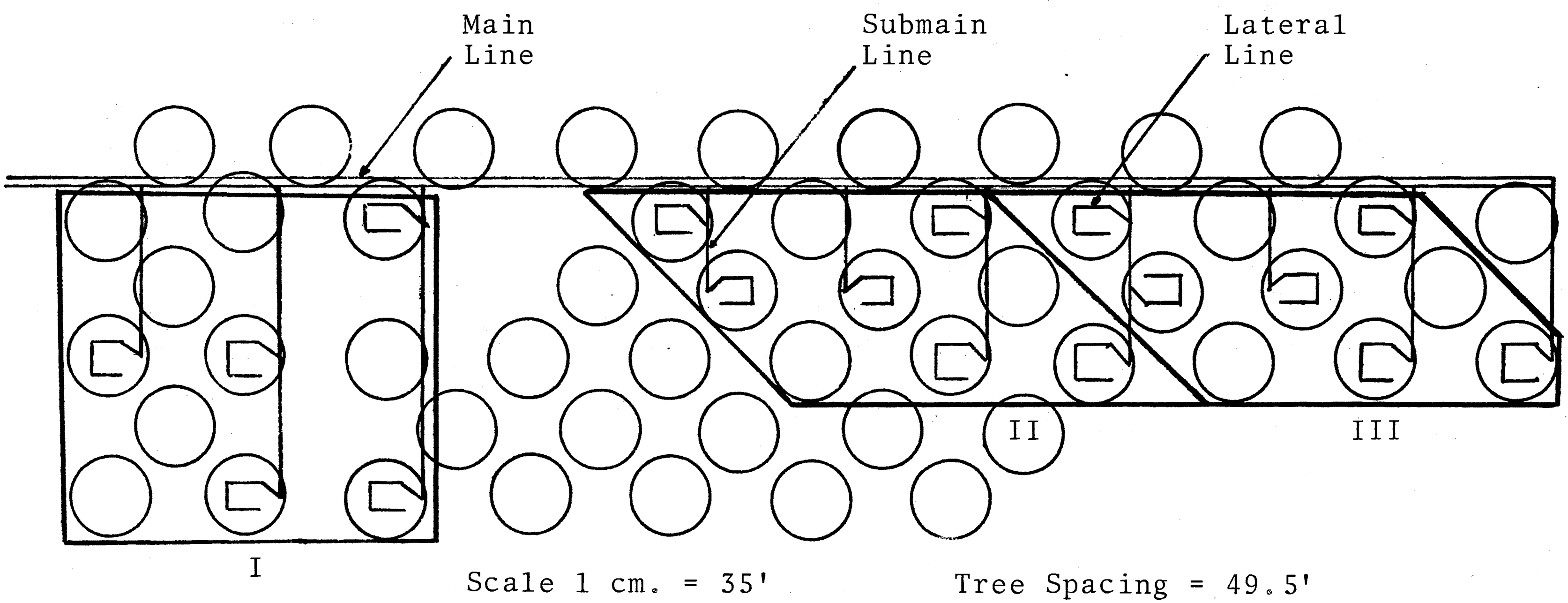
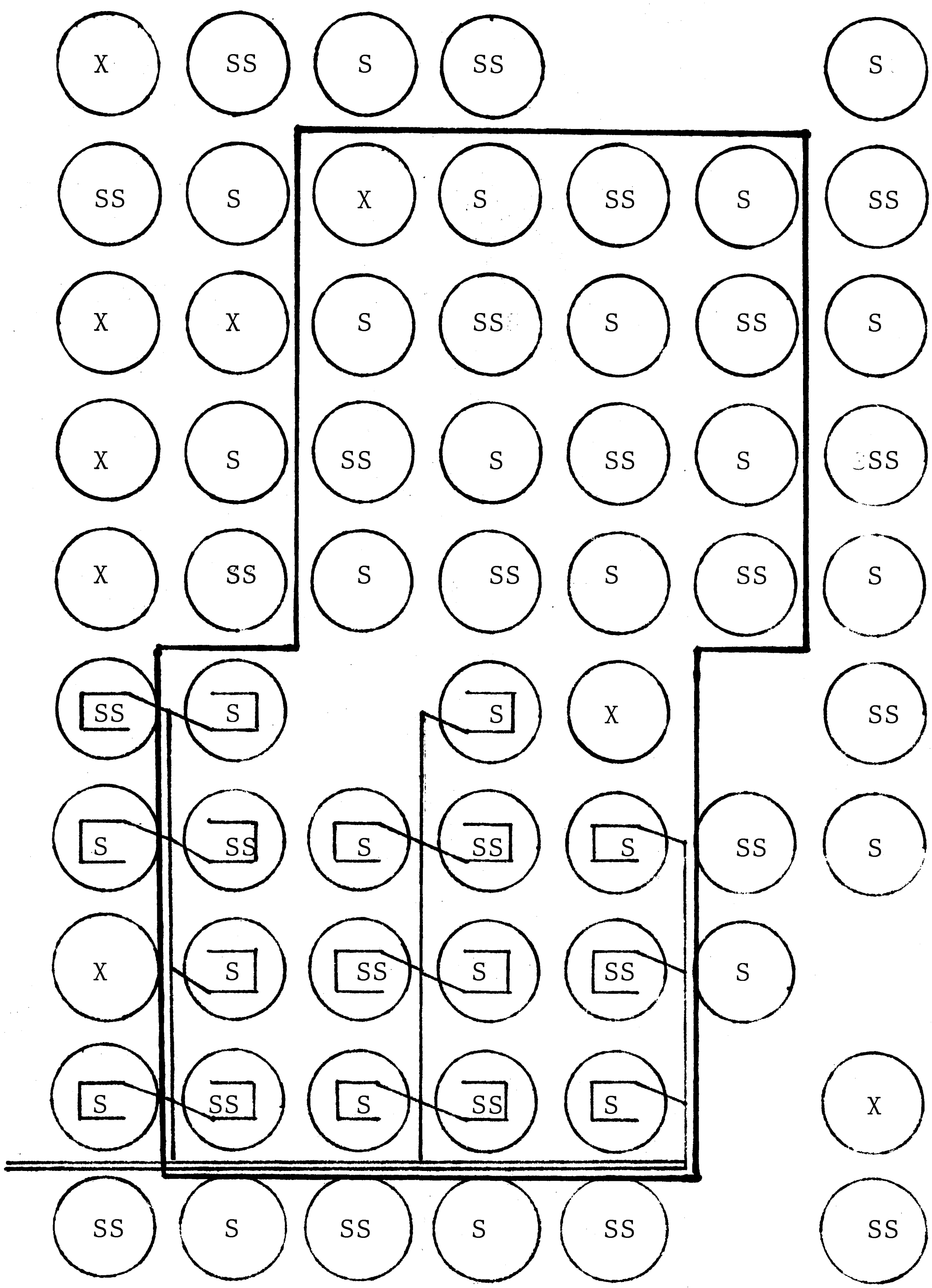


Figure 1. Latin Square Statistical Design for Western Cultivar Experimental Plot



S = Success   SS = San Saba Improved   X = Seedling
Scale 1 cm. = 17.5'   Tree Spacing = 35'

Figure 2. Split Plot Design for San Saba Improved and Success Cultivars

were zero, four, and eight gallons of water per hour. The four gph treatment was supplied by four 1 gph emitters, and the eight gph with four 2 gph emitters. Each treatment was randomized in a 3 x 3 latin square, with three different latin squares. The F-test and Duncan's New Multiple Range test were used in analysis of data.

The second area contained "San Saba Improved" and "Success" cultivars 23 years old. Trees were spaced 35 feet apart with 36 trees per acre. Soil type was a Port silt loam with a zero to one percent slope. Treatments were zero and four gph arranged in a split plot design. The four gph rate per tree was delivered by four 1 gph emitters operating at 15 psi. Single tree plots were replicated six times for San Saba Improved and eight times for Success cultivars. The two-tailed T-test was used for data analysis.

Irrigation began on April 9, 1974. Each line was, by means of a time clock, operated eight hours per day until June 20, then increased to 12 hours per day. During the eight hour period, the Western cultivar was irrigated from 7:00 a.m. to 3:00 p.m., and San Saba Improved and Success cultivars from 10:30 p.m. to 6:30 a.m. When time was increased to 12 hours per day, Western cultivar was irrigated from 7:00 a.m. to 7:00 p.m., and San Saba Improved and Success cultivars from 7:00 p.m. to 7:00 a.m. During the eight hour per day irrigation, 32 or 64 gallons of water per tree per day was delivered. The 12 hour operation delivered 48 and 96 gallons per day. During this study, both orchards were under clean cultivation.

Following a rain the irrigation system was turned off for a given period. The following schedule was used to determine when the irrigation system should be turned on and off.

Inches of Rainfall	Days Off
>.25	0
.25 to .37	1
.38 to .62	2
.63 to .87	3
.88 to 1.25	4
1.26 to 1.75	5
1.76 to 2.25	6
<2.25	7

Bouyoucos blocks were placed in the soil around one tree of each treatment to monitor moisture at 12 and 30 inch depths in the soil (Figure 3). They were spaced two feet apart in a straight line from each emitter, and in the same pattern around a tree receiving zero gph. These were read at weekly intervals starting July 12 and ending October 11. Samples were collected from latin squares II and III at two, four, and six feet from the emitter at 12 and 30 inch depths on July 10, 17, and 24. Samples were collected July 24 from the San Saba Improved and Success plots at two, four, and six feet from the emitters at 12 and 30 inch depths. The samples were collected, placed in

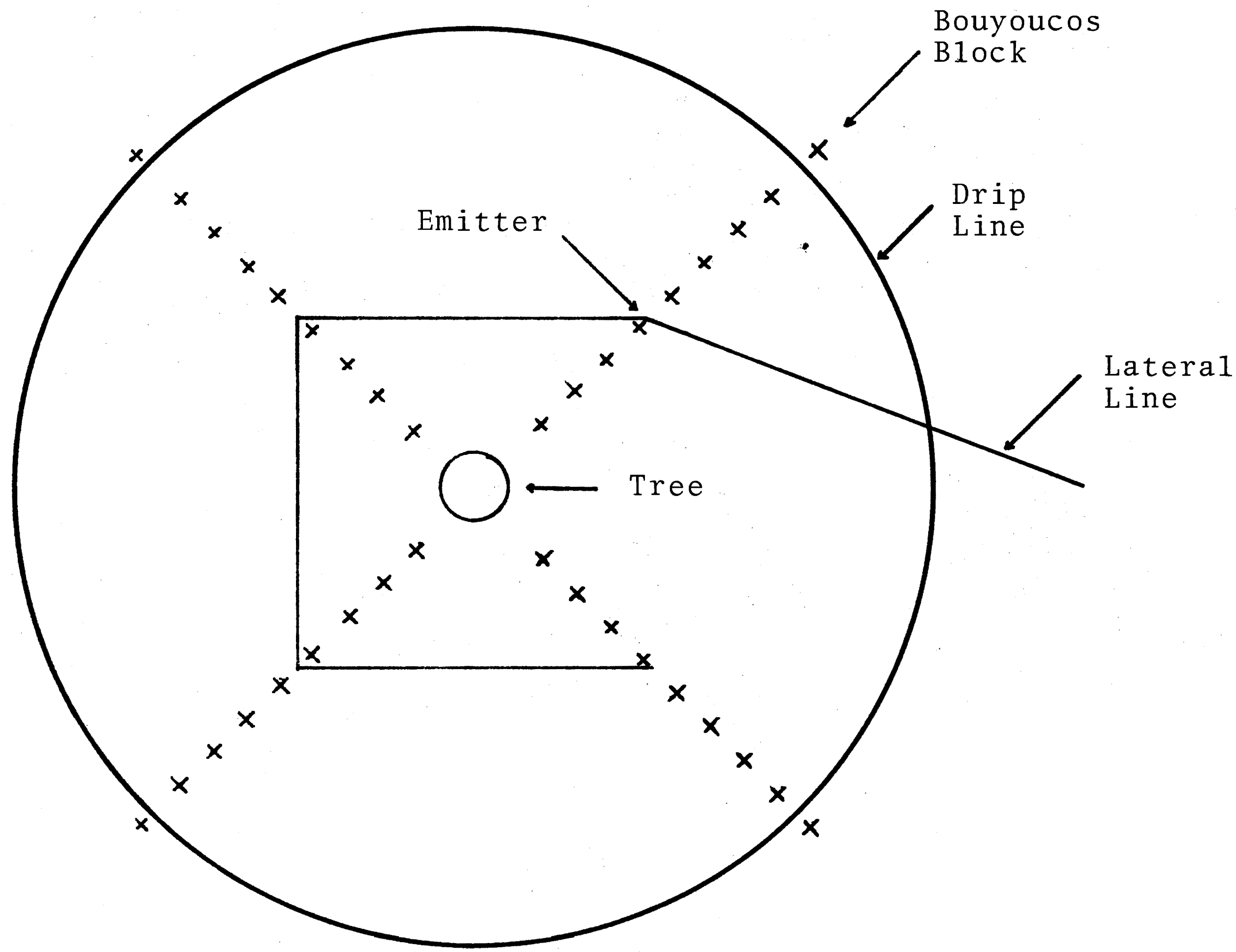


Figure 3. Placement of Emitters and Bouyoucos Blocks

air tight cans, weighed, and oven dried for 24 hours at 100° centigrade.

Nut samples were taken from San Saba Improved cultivar trees October 18. Two samples of 50 nuts each from each tree were taken unless this number was not available. Samples were dried at room temperature for two weeks and data on nut diameter, shell thickness, number of nuts per pound, and percent kernel were recorded. Nuts were not available from either Success or Western cultivars.

Shoot growth made in 1974 was measured September 10 for San Saba Improved and Success cultivars and September 27 for Western cultivar. Fifty measurements were made around each tree at a height of 12 to 15 feet. Only terminal shoots were measured, taking 25 from the east and 25 from the west sides of the tree. These were used as subsamples, and their means used in analysis.

Trunk measurements were determined November 11. They were collected at a point approximately three feet above the soil line. They had been measured at this same location prior to spring growth. The growth in square inches of trunk area was determined and analyzed.

Water pressure at the end of each lateral line was measured October 26. This was done by removing the hose end clamp at the end of the lateral and inserting a pressure gauge. Readings were recorded for each lateral line in the Western cultivar research area.

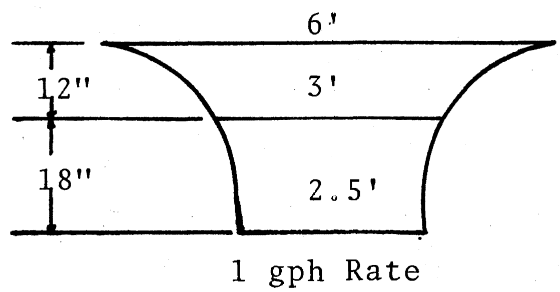
CHAPTER IV

RESULTS AND DISCUSSION

Emitter Wetting Patterns

Wetting patterns and total water content per emitter were determined from surface area measurements, as well as from Bouyoucos block readings, and oven dried samples. Bouyoucos block readings were highly variable from one block to another; however, they were very effective in detecting moisture differences at a particular location. Because of this wetting, drying, and constant moisture conditions could be detected at a particular block location, but it was impossible to determine exactly how much moisture was present. Both oven dried soil and surface area measurements of the wetted area provided uniform readings for a given treatment. With the combination of the three measurements the wetting patterns were found to be funnel shaped for emitters which delivered either one or two gph (Figure 4). Previous reports stated that emitter wetting patterns have a tear shaped design, but this probably was in a soil with a higher percolation rate than was the soil of this experiment.

The wetted surface areas of the one and two gph emitters were not directly proportional. Instead of the two gph



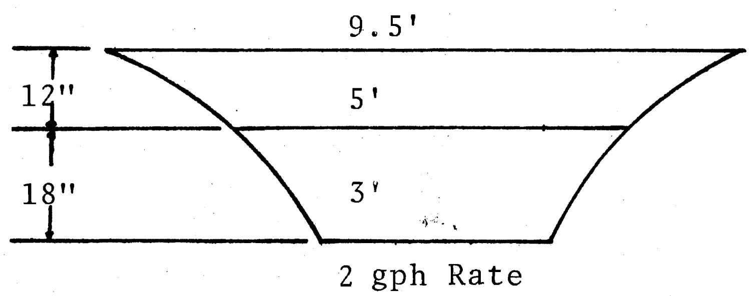


Figure 4. Cross Section View of 1 and 2 gph Emitter Wetting Patterns

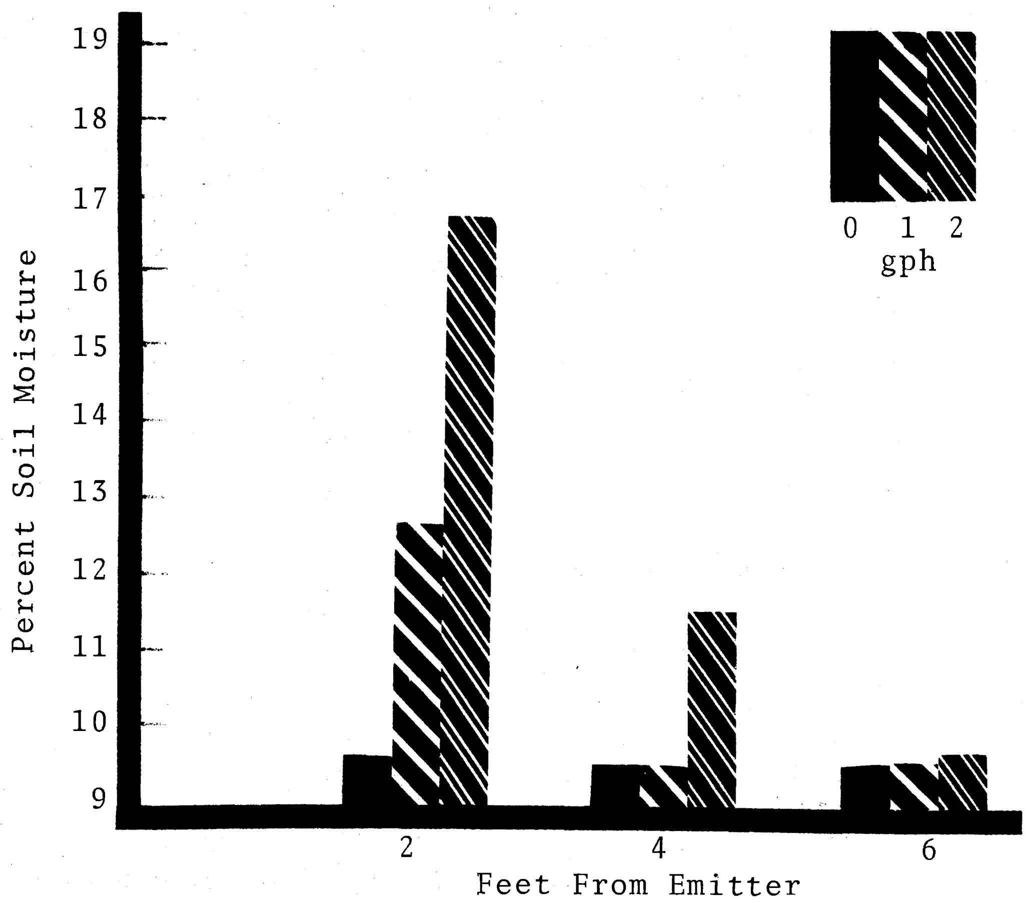


Figure 5. The Percent Soil Moisture on an Oven Dried Basis at a 12 Inch Soil Depth

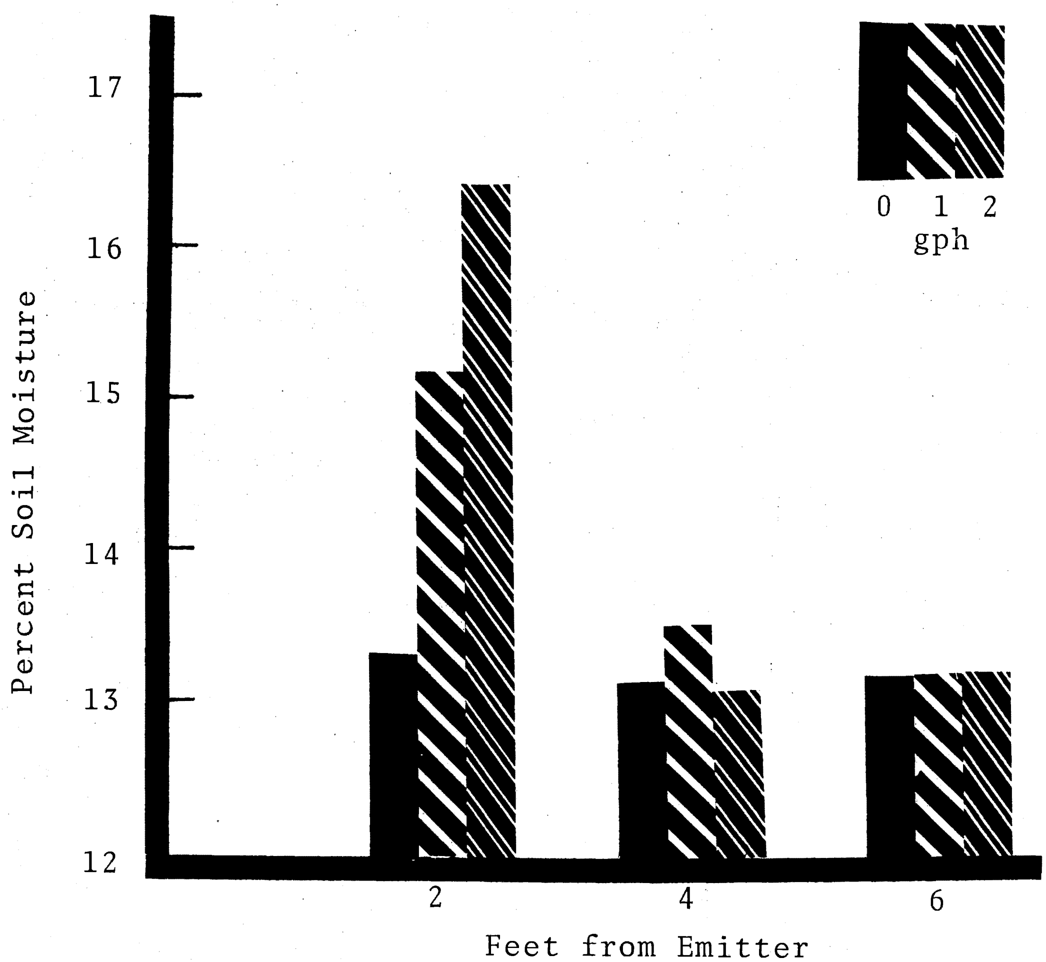


Figure 6. The Percent Soil Moisture on an Oven Dried Basis at a 30 Inch Soil Depth

emitter having twice the wetted surface area of the one gph emitter, it exceeded this. Four 2 gph emitters had a wetted surface area of 283.52 square feet, while four 1 gph emitters had a wetted surface of 113.08 square feet. If the number of 1 gph emitters were increased to eight, they would have a wetted surface area of 226.16 square feet; 57.36 square feet less than four 2 gph emitters. This could be an important factor when utilizing a trickle irrigation system with mature pecan trees. The pecan trees in this experiment had approximately 365 square feet of area under the drip line, with roots extending beyond this zone. Irrigation from four 2 gph emitters covered 77 percent of the area in the drip line, and four 1 gph emitters covered 31 percent of the area in the drip line (Figure 7). Using eight 1 gph emitters 62 percent of the area in the drip line would be covered; 15 percent less than with four 2 gph emitters. With more wetted area a greater number of roots would be involved in uptake of water from the irrigated area limiting the shock of a small area with high available moisture.

Rainfall and Supplemental Water

In Oklahoma, rainfall is usually not distributed evenly throughout the growing season. During nut sizing, moisture is critical [22, 23] and should be maintained at a high level for optimum nut size. From the last week in April through May, and the first two weeks in June, moisture supplied by rainfall was adequate. From the second two

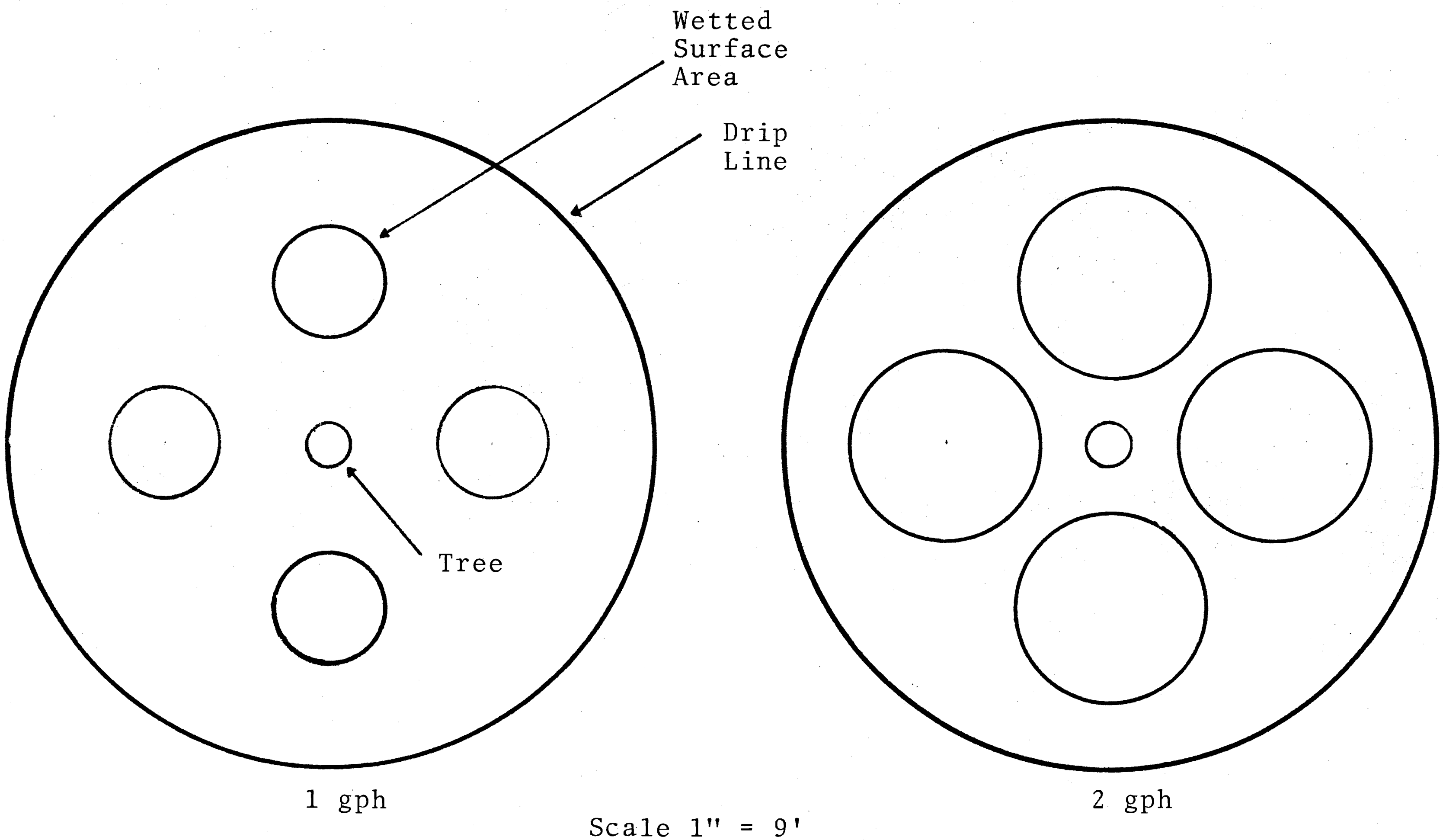


Figure 7. Wetted Area of 1 and 2 gph Emitters with Respect to the Drip Line of the Tree

weeks in June until the third week in August there was little rainfall and droughty conditions occurred. During the remainder of August and September, rainfall was adequate, and in some instances excessive. This situation frequently occurs in Okahoma and stresses the need for irrigation to supplement soil moisture during times when available water is a key factor in nut development.

The stream at the OSU Pecan Research Station overflowed onto the plot of Western cultivar trees April 30, June 10, and September 11. The flooding did not affect the irrigation system, but did lessen the need for as frequent irrigation of the trees. The plot with San Saba Improved and Success cultivars was not flooded.

The amount of supplemental water supplied per month varied according to rainfall. Tables I and II give data on rainfall, supplemental water supplied, and other information regarding the water supplied to the trees. Supplemental water was applied during months when rainfall was both high and low in order to maintain adequate soil moisture. The amount of supplemental water added was regulated by the amount of rainfall and is given on page 15.

At the time the experiment began, the flow rate of water through the main line was checked to determine if the emitters were delivering the correct amount. Data obtained were within one gallon per hour of the total required for all emitters in the orchard. During operation pressure readings were taken from the end of each lateral line

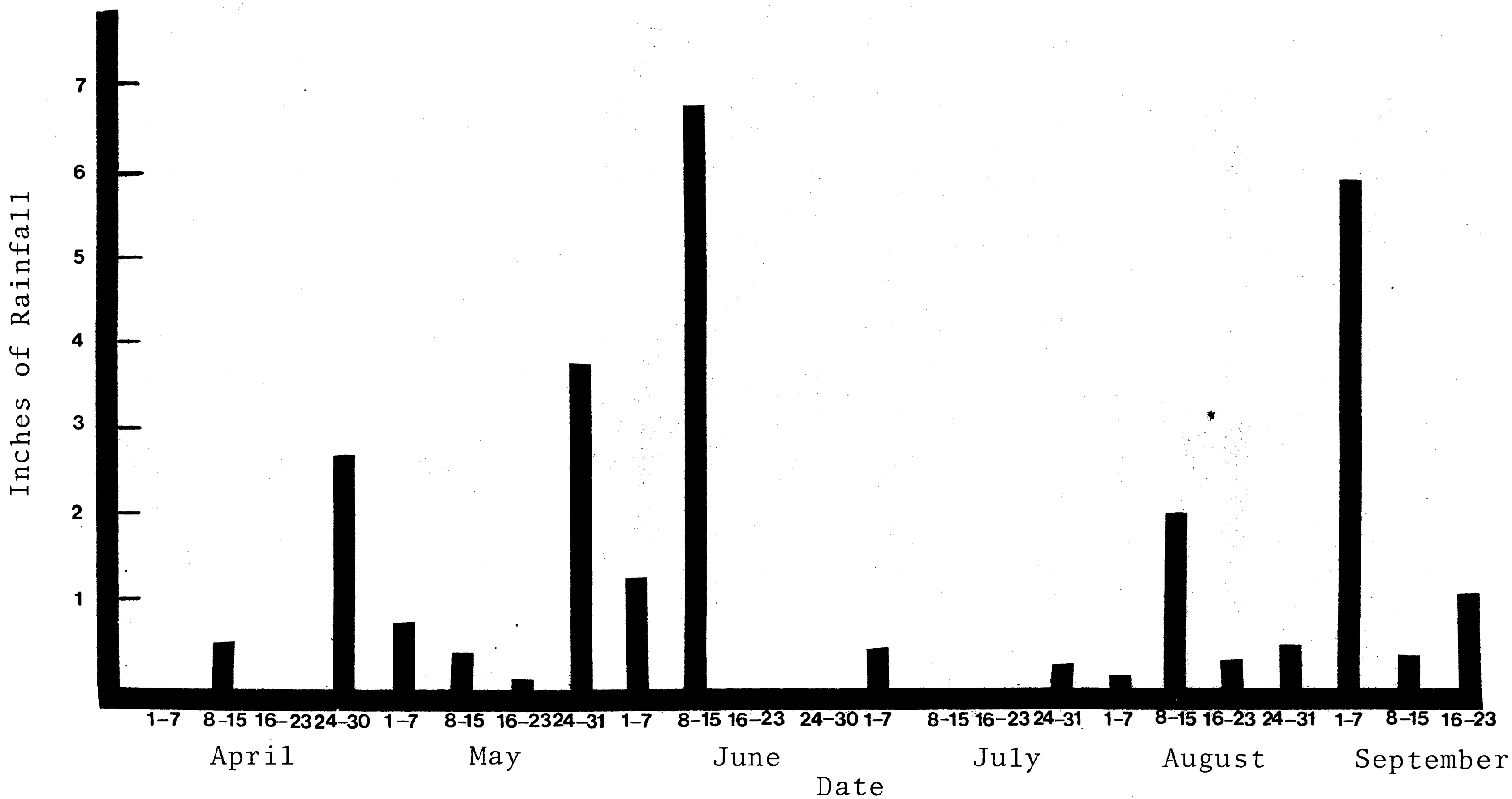


Figure 8. Rainfall Distribution for April through September, 1974, at the Oklahoma State University Agricultural Experiment Station, Sparks, Oklahoma

TABLE I

RAINFALL AND SUPPLEMENTAL IRRIGATION AMOUNTS ON WESTERN CULTIVAR FOR MONTHS APRIL THROUGH SEPTEMBER, 1974

Month[1]	Treatment gph/tree	No. of Hours on	Rainfall inches	Rainfall gal/tree	Supplemental Water gal/tree	Total Water gal/tree
April	0		3.44	5189		5189
	4	116	3.44	5189	464	5653
	8	116	3.44	5189	928	6117
May	0		4.98	7512		7512
	4	96	4.98	7512	384	7896
	8	96	4.98	7512	768	8280
June	0		7.99	12052		12052
	4	128	7.99	12052	512	12564
	8	128	7.99	12052	1024	13076
July	0		0.90	1357		1357
	4	324	0.90	1357	1296	2653
	8	324	0.90	1357	2592	3949
August	0		2.86	4314		4314
	4	225	2.86	4314	900	5214
	8	225	2.86	4314	1800	6114
September	0		7.62	11494		11494
	4	32	7.62	11494	128	11622
	8	32	7.62	11494	256	11750

[1]Irrigation started April 9 and ended September 30, 1974.

TABLE II

RAINFALL AND SUPPLEMENTAL IRRIGATION AMOUNTS ON SAN SABA IMPROVED AND SUCCESS CULTIVARS FOR MONTHS APRIL THROUGH SEPTEMBER, 1974

Month[1]	Treatment gal/tree	No. of Hours on	Rainfall inches	Rainfall gal/tree	Supplemental Water gal/tree	Total Water gal/tree
April	0		3.44	2594		2594
	4	116	3.44	2594	464	3058
May	0		4.98	3756		3756
	4	96	4.98	3756	384	4140
June	0		7.99	6026		6026
	4	128	7.99	6026	512	6538
July	0		0.90	678		678
	4	324	0.90	678	1296	1974
August	0		2.86	2157		2157
	4	225	2.86	2157	900	3057
September	0		7.62	5747		5747
	4	32	7.62	5747	128	5875

[1]Irrigation started April 9 and ended September 30, 1974.

(Figure 9). Results of this were very uniform with 15 psi main line pressure and 14 to 15 psi pressure at the lateral lines. One line had 13 psi, but had been repaired five times with constricting couplers. This was encountered due to problems with raccoons chewing on the line.

The only other problem encountered was vigorous weed growth in the area wetted by the emitters. These were easily controlled by discing when the lines were rolled up, and had little effect except to cause an unsightly appearance.

Water loss of the tree by transpiration was determined by the "Quick Weight Method." Transpiration loss of 23 year old Western cultivar trees was 91.26 gallons of water per tree per day. Operating 12 hours per day four 1 gph emitters delivered 48 gallons of water per day while four 2 gph emitters delivered 96 gallons of water per day. Not all of the water was available to the tree because of evaporation from the soil surface and deep percolation. It is apparent that neither size emitter would deliver all the water needed for each tree; however, the amount delivered from the 2 gph emitter was very close to the amount needed. With rainfall to build soil moisture reserves, there should be no problem in supplying amounts needed per tree.

Growth Responses

Shoot and trunk growth were measured to determine the influence of supplemental water. The addition of

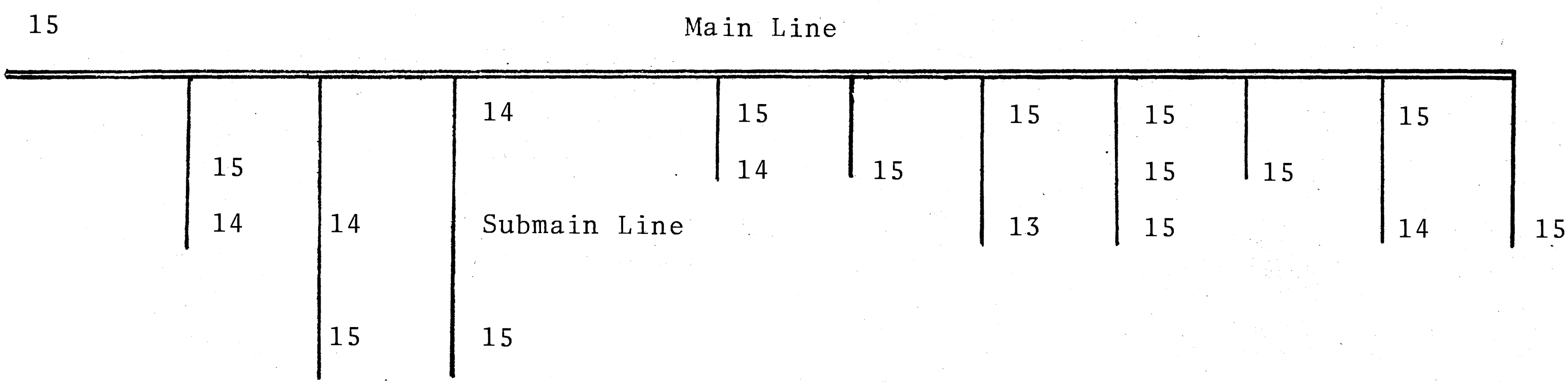


Figure 9. Pressure Readings in psi at the End of Each Lateral Line

supplemental water did not affect shoot growth on San Saba Improved and Western cultivars. Factors which may have affected this are a very light crop on the San Saba Improved cultivar trees, and no crop on the Western cultivar trees. The trees were not under stress conditions that would be present when producing a heavy crop of nuts. The Western cultivar trees were also in poor condition due to an excessively heavy crop the previous year, and had not regained their full vigor. Flooding around the Western cultivar trees also provided a reserve moisture supply which reduced the need for irrigation.

Trees of the Success cultivar were more vigorous than were the San Saba Improved cultivar and were in better condition than those of Western cultivar. For this reason an increase in 1974 shoot growth was obtained from supplemental irrigation. Trees without irrigation had an average of 13.4 centimeters of growth per shoot while trees with irrigation had 15.2 centimeters of growth. This was a significant increase at the ten percent level.

Trunk growth was not significantly different for any of the treatments or cultivars. Low crop yield and higher than normal rainfall are the principal factors which reduced the response to supplemental irrigation. Trunk growth also does not respond as rapidly as shoot growth reducing the chance for response due to treatment effect.

TABLE III

THE EFFECT OF SUPPLEMENTAL IRRIGATION ON SHOOT AND TRUNK GROWTH OF SAN SABA IMPROVED, SUCCESS, AND WESTERN CULTIVARS OF PECANS

Cultivar	Treatment gph	Average Shoot Growth in Centimeters	Average Trunk Growth in Centimeters
San Saba Improved	0	13.9_a^z	12.8_a
	4	15.0_a	11.6_a
Success	0	13.4_a	9.3_a
	4	15.2_b	12.0_a
Western	0	8.1_a	12.3_a
	4	8.2_a	10.4_a
	8	8.2_a	10.4_a

[z]Means followed by the same letter are not significant at the .10 level.

Crop Response

Trees of the Western and Success cultivars failed to produce pistillate flowers in 1974. The yield of nuts on San Saba Improved cultivar was low. Nuts of San Saba Improved cultivar were evaluated for diameter, shell thickness, number of nuts per pound, and percent kernel. Nut diameter was 2.12 centimeters from trees receiving no water, and 2.13 centimeters from trees receiving four gph. Difference between the two treatments was not significant.

Shell thickness on trees which were irrigated increased significantly. Average shell thickness for the irrigated and non-irrigated treatments were 7.43 and 7.25 millimeters, respectively. Average number of nuts per pound were significantly less on trees receiving irrigation. Irrigated and non-irrigated trees had 73.8 and 79.4 nuts per pound, respectively. This is a decrease of 5.6 nuts per pound of pecans.

Due to a light crop on the San Saba Improved cultivar, an average yield will be used to predict the increased gross income due to irrigation. Average yield of non-irrigated trees is 60 pounds per tree which is 4,767 nuts if there are 79.4 nuts per pound. If the size of the nuts were increased to 73.8 nuts per pound, as with the irrigated trees, a yield of 64.6 pounds per tree results. This is an increase of 4.6 pounds of pecans per tree or 165.6 pounds per acre. At 70 cents per pound, this is a gross income increase of

TABLE IV

THE EFFECT OF SUPPLEMENTAL IRRIGATION ON NUT SIZE, SHELL THICKNESS, NUT WEIGHT, AND PERCENT KERNEL OF SAN SABA IMPROVED PECAN

Treatment gal/tree/hour	Average Nut Diameter in centimeters	Average Shell Thickness in millimeters	Average Number Nuts/pound	Average Kernel Percent
0	2.12_{a}^{z}	7.25_{a}	79.4_{b}	59.30_{a}
4	2.13_{a}	7.43_{b}	73.8_{a}	59.46_{a}

[z]Means in the same column followed by the same letter are not significant at the .05 level.

$115.92 per acre. The expense of establishing a trickle irrigation system on one acre is given in Table V. Costs were prorated over a ten year period although life expectancy is longer. The water source used in finding the cost per acre is an average figure, and may vary depending on the source of water and the equipment needed to pump the water. Total prorated expenditure for the irrigation system is $64.61. With an increase in gross income of $115.92, this gives an increase in net income of $51.31 per acre. This should be ample to justify the installation of an irrigation system.

Kernel percent was not affected by supplemental water. There are two reasons that contributed to this. The first was due to a very light crop. These trees were not subjected to the normal stress for moisture and nutrients required to mature a crop of nuts. This greatly affects the ability of the nuts to fill [22]. The second reason was associated with higher than normal rainfall during the time when the nuts were maturing. This decreased the need for irrigation, but this is not a normal condition for Oklahoma.

TABLE V

COST PER ACRE OF MATERIALS AND INSTALLATION OF TRICKLE IRRIGATION

Material	Amount	Price	Total
3/4" PVC pipe	500'	.11	55.05
3/4" PVC tees	2	.59	1.05
3/4" PVC ells	1	.48	.48
3/4" Solenoid	1	28.00	28.00
24 hour time clock	1	14.95	14.95
Electric wire	500'	.0676	33.80
Poly drip hose .375"	1800'	.0275	49.50
Poly drip hose .580"	525'	.0475	24.94
1 gph emitters .375"	144	.38	54.72
Filter	1	19.00	19.00
Pressure gauge	1	7.00	7.00
Hose punch	1	4.20	4.20
Hose end clamp .375"	36	.08	2.88
Hose end clamp .580"	3	.08	.24
Ditch Witch	1 day	75.00	75.00
Labor	36 hours	3.00	108.00
Total			496.14
Prorate ten years			49.61
Water source			15.00
Cost/acre/year			64.61

CHAPTER V

CONCLUSIONS

The 2 gph emitter size had a larger wetted surface area than did either four or eight 1 gph emitters. Four 2 gph emitters had a 60 percent larger wetted surface area than four 1 gph emitters and 19 percent larger than eight 1 gph emitters. This is a definite advantage when utilizing trickle irrigation on mature trees. Four 2 gph emitters, operating at 12 hours per day, delivered 96 gallons of water per day. This was more than the average transpiration loss of 91.26 gallons of water per tree per day. With this plus the increased wetting area, the 2 gph emitters were the best of the two sizes used in this experiment.

Percent kernel remained the same in both irrigated and non-irrigated treatments, but shell thickness increased with supplemental irrigation. For the kernel percent to remain the same with an increased shell thickness, the kernel weight must increase with supplemental irrigation. Nut size also increased significantly with supplemental irrigation. This increase can be attributed to both an increased shell thickness and an increased kernel weight.

A definite advantage can be gained by supplemental irrigation above that of no irrigation by increased yields.

Using 36 trees per acre, an increase of 165.9 pounds of nuts per acre would result using 48 gallons of supplemental water per tree per day. This is a significant increase and could result in an increased net profit of $51.31 per acre.

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APPENDIX

THE QUICK WEIGHT METHOD FOR MEASURING TRANSPIRATION

Compound leaves of Western variety pecan trees were cut and sprinkled with water to decrease the transpiration losses. There was an hour delay between the time the leaves were cut and the time transpiration was determined due to transportation time. Fifteen replications were used with all leaves being free of insect and disease damage.

Leaves were placed on a Metler balance and weighed at five minute intervals for thirty minutes to determine weight losses. There was very little variation between replications in loss of weight, and an average weight loss of the replications were used.

Leaves were harvested on a clear day with 85°F and 58 percent relative humidity. All leaves were brought to the laboratory and maintained at 78°F and 52 percent relative humidity while transpiration rates were determined.

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