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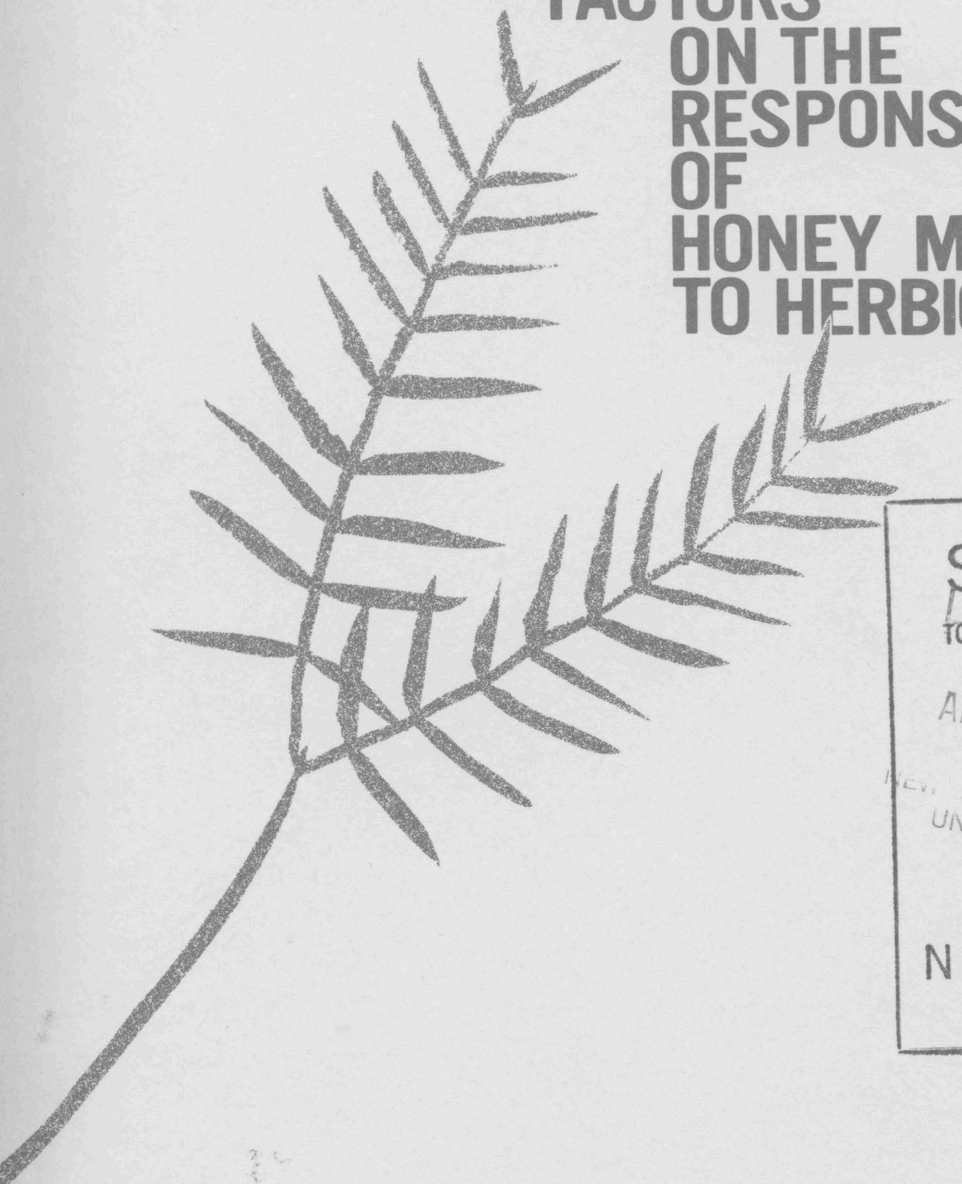
INFLUENCE OF PLANT GROWTH STAGE AND ENVIRONMENTAL FACTORS ON THE RESPONSE OF HONEY MESQUITE TO HERBICIDES



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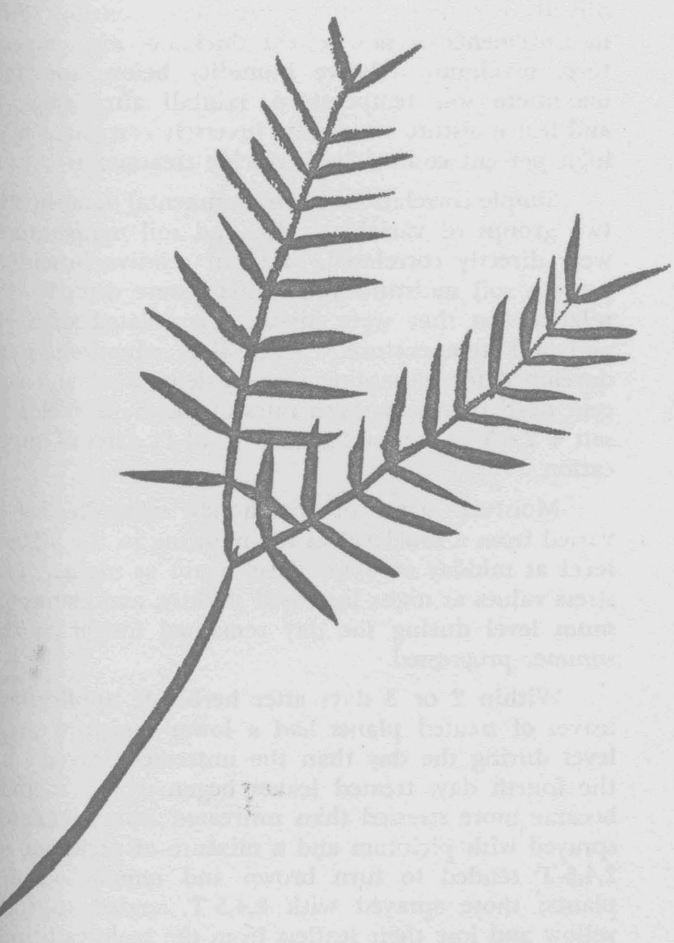

Summary

Honey mesquite [*Prosopis juliflora* (Swartz) DC. var. *glandulosa* (Torr.) Cockerell] plants 4 to 6 feet tall grown on an upland, clay loam site near Bryan, Texas, were sprayed with three herbicides at 14 dates during 1969 and 1970. Herbicide treatments consisted of 0.5- and 1-pound per acre rates of the potassium salt of 4-amino-3,5,6-trichloropicolinic acid (picloram) and the butoxyethanol ester of 2,4,5-trichlorophenoxy)acetic acid (2,4,5-T) alone and in 1:1 mixtures. Mixtures of the two herbicides as the triethylamine salts were applied at six dates at application rate of 0.25 + 0.25 and 0.5 + 0.5 pound per acre.

Plant factors measured were new stem elongation growth, transectional stem dimensions, upward dye movement rate in the xylem, total available stem carbohydrates and leaf moisture stress. Environmental factors included were air temperature, percent relative humidity, soil temperature, soil moisture, rainfall and total daily solar radiation.

Picloram and a mixture of picloram + 2,4,5-T caused 53 and 54, and 62 and 63 percent defoliation 1 year after treatment at the 0.5- and 1-pound per acre rates, respectively, whereas 2,4,5-T caused 44 and 48 percent defoliation. Picloram at 0.5 and 1 pound per acre and picloram + 2,4,5-T at the 0.25 + 0.25- and 0.5 + 0.5-pound per acre rates killed 11 and 12 percent and 23 and 27 percent of the plants, whereas 2,4,5-T alone killed only 2 percent of the plants at both rates. Control by the triethylamine salts of picloram + 2,4,5-T was equal to that of the mixture of potassium salt of picloram + the 2,4,5-T ester.

Most effective control of honey mesquite occurred from treatments applied between April 30 and July 6. Plant characteristics most closely associated with control were widest translocating phloem thickness, most rapid rate of new xylem ring radial growth and lowest predawn leaf moisture stress. Environmental variables most closely associated with honey mesquite control were lower maximum air temperatures of 77° to 96° F 1 week before treatment, maximum soil temperatures at 63° to 79° F at a depth of 3 feet 1 week before treatment and decreasing percent soil moisture from 25 to 18 percent at a depth of 2–3 feet 1 week before treatment.

The higher percent defoliation and percent dead plant ratings were most closely associated in order of effectiveness with herbicidal treatments of picloram, mixture of picloram + 2,4,5-T, and 2,4,5-T. The defoliation correlations were higher than those for the percent of dead plants. Generally, thickness of translocating phloem, rate of upward dye movement in the xylem, lower minimum relative humidity, high soil moisture and higher rainfall before spraying were directly correlated with higher plant control, while measurements of new xylem thickness, air temperature, maximum relative humidity before spraying, maximum soil temperature, rainfall after spraying and leaf moisture stress were inversely correlated with high percent control by herbicide treatments.

Simple correlations of environmental data showed two groups of variables. Air and soil temperatures were directly correlated. Percent relative humidity, percent soil moisture and rainfall were directly correlated, but they were inversely correlated with air and soil temperature. Regression equations were developed for estimating percent defoliation and percent dead plants for both rates of picloram, picloram salt + 2,4,5-T ester and 2,4,5-T at all 14 dates of application.

Moisture stress of the honey mesquite leaves varied from a low level in the morning to the highest level at midday to a low level again at night. The stress values at night increased slightly, and the maximum level during the day remained longer as the summer progressed.

Within 2 or 3 days after herbicide application, leaves of treated plants had a lower moisture stress level during the day than the untreated leaves. By the fourth day, treated leaves began dying, so they became more stressed than untreated leaves. Leaves sprayed with picloram and a mixture of picloram + 2,4,5-T tended to turn brown and remain on the plants; those sprayed with 2,4,5-T tended to turn yellow and lose their leaflets from the rachises before either dying on the plant or abscising.

Influence of Plant Growth Stage and Environmental Factors on the RESPONSE of HONEY MESQUITE to HERBICIDES

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Honey mesquite [*Prosopis juliflora* (Swartz) DC. var. *glandulosa* (Torr.) Cockerell] varies widely in its response to herbicides. In some cases almost all plants are killed by a given treatment; at other times very few plants are killed. In West Texas, when growing conditions are favorable, 0.5 pound per acre of (2,4,5-trichlorophenoxy)acetic acid (2,4,5-T) generally destroys most top growth and kills about 20 to 30 percent of the plants (5). The most effective treatments occurred 50 to 80 days after the first leaves appeared in the spring and leaves were fully formed and dark green. Treatments were ineffective when applied before this time or during summer and fall when the plant was not actively growing.

Dahl et al. (2) reviewed the literature on variations of plant response to herbicides. They found that soil temperature of 80° F and above at the 18-inch depth was the most important factor affecting the response of honey mesquite to 2,4,5-T. No plants were killed when soil temperature was in the low 70's or below. The easiest plants to kill were those having mature, dark green foliage and mature legumes. Trees on upland and sandy soils were apparently more susceptible to 2,4,5-T than those on bottomland and clay sites because of the difference in soil temperature.

Robison, Fisher and Cross (15) and Fisher et al. (6) have shown that honey mesquite is more susceptible to mixtures of 2,4,5-T + 4-amino-3,5,6-trichloropicolinic acid (picloram) than to 2,4,5-T. In six ranch tests, picloram + 2,4,5-T at 0.25 + 0.25 pound per acre killed an average of 52 percent of the plants as compared to 21 percent for 0.5 pound per acre of 2,4,5-T alone. Thus, factors that prevented the death of all plants were present.

Meyer et al. (11) showed that the toxic agent from 2,4,5-T, picloram and picloram + 2,4,5-T sprays was translocated from the leaves to the stem of honey mesquite within 4 days after application. Brady (1)

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found herbicide applications in May to be more effective than those made later in the growing season on sweetgum (*Liquidambar styraciflua* L.), green ash (*Fraxinus pennsylvanica* Marsh.) and water oak (*Quercus nigra* L.). Effective killing of plant tops was attributed to the high rates of absorption and translocation of the herbicide. A 4-day absorption period was closely correlated with the control of top growth 1 year later. Davis et al. (3) sprayed honey mesquite with 0.5- and 1-pound per acre rates of 2,4,5-T, picloram and a mixture of picloram + 2,4,5-T. After 48 hours, highest concentrations of herbicides occurred in the phloem of those plants sprayed in June and lowest in those sprayed in August. Similar levels of 2,4,5-T occurred in the phloem from applications of either 0.5 or 1 pound per acre, but more than three times as much picloram occurred in plants sprayed with 1 pound per acre as in those sprayed with 0.5 pound per acre.

At College Station, Texas, honey mesquite leaves begin emerging about the end of March (14). Emergence is probably controlled by environmental conditions of high temperatures (10). The new stems elongate during approximately a month beginning about the first of April until tip abortion occurs (14). Then the plant enlarges radially in May and June, producing new translocating phloem and a new xylem growth ring. Fisher, Fults and Hopp (4) and Meyer, Haas and Morton (12) showed that upward translocation of dye occurred in the new, outermost xylem ring of honey mesquite; the dye streak widened from about 0.16 inches at the point of injection to about a 2-inch width at 4 feet and moved about 1.7 feet per hour.

Meyer, Haas and Wendt (13) using greenhouse plants under controlled conditions showed that either low soil temperature (55° F) or cool aerial environment (52° to 77° F) retarded shoot growth; however, maximum shoot growth occurred as a result of an interaction of optimum soil temperature (84° F) and an aerial environment of 20.9 millimeters of mercury (mm Hg) vapor pressure deficit (74° to 105° F). Soil-moisture regimes from −0.5 to −15 bars soil water potential did not impede growth.

Fisher et al. (5) and Robison et al. (16) studied the total available carbohydrate level in honey mesquite stems. That carbohydrate level was low in May could reflect the partial drain of food reserves for foliage production and radial enlargement of stems.

Haas and Dodd (8) studied water stress of the honey mesquite leaf petiole. They showed a diurnal pattern of low stress at predawn and postsunset periods and high stress during the day. A gradual increase in stress occurred at all three periods throughout the season when leaves were present.

The objectives of this study were to develop a reliable means of estimating the ultimate response of honey mesquite to herbicides, to determine the interrelationships of various plant and environmental variables and to observe the seasonal response of honey mesquite to various herbicide treatments.

Materials and Methods

Experimental Site and Plot Layout

A 30-acre site near Bryan, Texas, with a dense stand of honey mesquite plants 4 to 6 feet tall was selected as the experimental site. Most honey mesquite plants had three to five stems that had emerged near the base of the stem. The plants had been mowed about 3 years before the initiation of the study.

The area was an upland site with about a 1-percent slope. The soil was a poorly drained clay loam.

In 1969, about half the area was divided into plots containing five plants each. The plots were arranged in rows 20 to 40 feet long depending on plant density and width sufficient to contain at least five plants with at least a 2-foot space between plants from the adjoining plot. In 1970, the remaining half of the plants were tagged in groups of six for the last five sprayings. Four replications were used for each treatment at each of 14 dates. Four untreated plots were also included at each date, but the results were not included in statistical analyses.

Chemical Applications and Control Ratings

The chemicals were sprayed at 0.5- and 1-pound per acre acid equivalent rates at 14 dates. The potassium salt of picloram, the butoxy ethanol ester of 2,4,5-T and equal amounts of two herbicides (picloram + 2,4,5-T) were sprayed at all dates. A mixture of equal amounts of triethylene salts of picloram and 2,4,5-T (picloram + 2,4,5-T amine) at equal rates was applied at six dates as a comparison with the potassium salt of picloram and the ester of 2,4,5-T.

The herbicides were applied either in the evening or early morning with a hand-carried, compressed air, 3-nozzle boom sprayer. The herbicides were applied to the plots or individual plants at a spray volume of 20 gallons per acre.

Visual ratings of percent defoliation, which measures the amount of stem tissue killed, and percent dead plants were made the season following spraying October 3, 1970, and May 17, 1971.

Plant Characteristics

Plant characteristics measured at each date of treatment included new stem length, transectional dimensions of stem tissue, rate of upward movement of dye in the xylem, total available carbohydrates in the stem and leaf moisture stress. Data, except for some moisture stress readings, were collected on unsprayed plants at the site.

New stem length growth was recorded by tagging five new stems on each of five plants. The stems were measured weekly until growth ceased and the tip aborted in May. They were observed periodically thereafter to determine whether further elongation occurred.

Stem transectional dimensions were measured from stem samples collected from untreated trees the day after spraying. A piece of stem 6 to 12 inches above the ground was collected from each of 10 trees. The stem piece was cut into smaller cylinders, fixed in a Craf killing solution (14) and ultimately stored in 70 percent ethanol. Sections, 15 to 25 microns thick, were cut either from blocks embedded in Paraplast or from unembedded blocks mounted directly in the microtome. The transections were stained with safranin and fast green. Tissue measurements were made at three places equidistant around the circumference of each stem transection. Measurements were made of periderm, translocating and nontranslocating phloem and xylem ring thickness. Pith diameter was also recorded.

Upward movement of methylene blue dye in the xylem was followed by infusing the dye into unsprayed plants that were about 5 feet tall with reasonably straight, unforked stems. The tip of a 1-inch long No. 16 needle, attached to a medical transfusion apparatus, was inserted just under the stem bark about 6 inches above the ground. A 0.1 percent aqueous solution of the dye was allowed to infuse into the stem from 9 to 9:30 or 10 a.m. After the allotted time for infusion and translocation, the bark was peeled off and the length of dye streak measured.

The percent total available carbohydrates was determined on stem samples collected the morning following spraying. A 6-inch long stem sample was collected beginning 6 inches above the ground from each of five plants. The bark was peeled off. The stems then were dried at 158° F and subsequently ground to pass through a 60-mesh screen. The samples were bulked, and at least one pair of duplicate samples were run at each date.

Total available carbohydrates were analyzed by a modification of methods described by Hall and Hacskaylo (9) and Wildman and Hansen (17). Duplicate 0.5-gram samples were refluxed in distilled water and hydrolyzed at 131° F for 2 hours with Takadiastase. The mixture was cleared with lead subacetate, which was subsequently precipitated with sodium oxalate and then neutralized. Carbohydrates were oxidized with the concomitant reduction of copper sulfate to copper oxide which was titrated with potassium permanganate after the addition of ferric ammonium sulfate.

Moisture stress in the leaves was determined with a Scholander pressure apparatus (8). Ten trees were tagged in each treatment at each date, except the first two dates. Moisture stress was determined in one leaf from each of five plants in each treatment, predawn (4-5 a.m.), 8-10 a.m., 12-2 p.m., 3-5 p.m. and 6-7 p.m. Central Standard Time. Pressure readings were made 1 to 7 days after spraying. Leaves were removed from half the trees at each time period to minimize the effect of leaf removal on plant response. Data presented show the predawn and daily maximum for each spraying date, the daily stress cycles at several dates, the seasonal stress cycles at several times of day and the cycle of stress in leaves of plants treated with herbicides in the 4-day period following spraying.

Environmental Variables

Environmental variables measured included maximum and minimum air temperatures; maximum and minimum percent relative humidities; maximum soil temperatures at 1- and 3-foot depths; percent soil moisture at depths of 0-1, 1-2 and 2-3 feet; rainfall; and total solar radiation. All except solar radiation were recorded as the mean for the 7-day period prior to spraying.

Maximum and minimum air temperatures and percent relative humidity were recorded at the site with a hygrothermograph. Soil temperature was recorded at the site with a recording thermograph having probes set at 1- and 3-foot depths. The mean daily maximum and minimum soil temperatures were computed.

Soil moisture was determined weekly using gravimetric analysis. Samples were taken from soil depths of 0–1, 1–2 and 2–3 feet either with a bucket auger or a screw-type auger (7). Most samples were collected on Mondays. Five cores were dug at each date. Rainfall data were collected weekly at the site with a rain gauge.

Total solar radiation on the day of spraying was extrapolated from weather records taken by the Department of Meteorology at Texas A&M University at College Station, Texas, about 5 miles from the experimental site. The data are presented as Langleys.

Statistical Analyses

Data on percent defoliation and percent dead plants were analyzed as a split plot analysis with subplots as a factorial of three chemicals at two rates. Four replications were used. Untreated plots also were included at each date but not analyzed with the other treatments.

An attempt was made to develop a predictive indicator for correlating plant response to herbicides at any given date with plant characters and environmental factors. Two multiple regression models were used to predict percent defoliation and percent dead plants. The independent plant variables included new stem length, translocating phloem thickness, total and rate of new xylem ring development, rate of upward dye movement, total available carbohydrates and predawn and maximum leaf moisture stress. Environmental variables during the week prior to spraying included maximum and minimum air temperatures and percent relative humidity; soil temperatures at 1 and 3 feet; soil moisture at depths of 0–1, 1-2 and 2-3 feet; and rainfall. Also, total radiation the day of spraying was included. Several data analyses were made with different combinations to derive the best equations since all variables could not be run in a single analysis. All regression equations presented had F values significant at the 1-percent level with independent variables significant at least at the 5-percent level.

The first regression developed the best equation for the combination of all treatments over all 14 dates. All treatments were fixed into the model which required the line to be drawn through the origin. Time and time[2] factors were fixed into the equation to fit the parabolic curve of the data with time; time counting was begun January 1. Ten independent variables were placed in a pool. The best eight equations for one to nine independent variables were calculated.

The second regression model was used to develop the best equation for each treatment individually over all 14 dates. The time and time[2] variables were placed in a pool with 10 other independent variables. The eight best equations were then calculated having one to six independent variables.

Simple correlations of all dependent and independent variables were calculated for the best 11 dates. March 24, April 14 and October 9, 1969, were omitted. Selected correlations are presented to show the interrelationships of these variables.

Results

Plant Response to Herbicides

The day following spraying, the elongating stem tips curled in all treatments. By the second day, different plant responses among treatments were observable. Leaves of plants sprayed with picloram or picloram + 2,4,5-T had darkened water-soaked spots by the end of the second day. Within 4 days most leaves remained intact, turned brown and died, and by 7 days all leaves were dead. Leaves of plants sprayed with 2,4,5-T turned yellowish-green and became detached from the plants by the end of the third day. Defoliation most frequently began with the leaflets detaching from the rachises. By the end of 7 days the remaining dead portions of the leaves either remained on the plant or became detached. Death of the foliage generally occurred a day or two sooner when the plant was sprayed in late summer rather than in April.

Differences in percent defoliation occurred among treatments averaged for all 14 dates (Table 1). Picloram and a mixture of picloram + 2,4,5-T were equally

TABLE 1. PERCENT DEFOLIATION AND PERCENT DEAD HONEY MESQUITE PLANTS AT A FIELD SITE NEAR BRYAN, TEXAS, SPRAYED IN 1969 AND 1970 AND RATED ABOUT 1 YEAR AFTER TREATMENT

		Year sprayed														
		1969								1970						
	Rate	3/24	4/14	4/30	5/20	6/9	7/1	8/25	10/9	5/4	5/20	6/19	7/6	7/30	8/10	Mean[1]
	lb./acre	Defoliation, %														
Picloram	0.5	2	14	82	78	92	74	32	4	65	76	62	66	48	41	53^{b}
Picloram	1	1	18	96	86	96	88	34	2	84	94	85	77	76	45	63^{a}
Picloram salt + 2,4,5-2 ester	0.25+ 0.25	0	12	86	73	69	86	27	4	62	79	88	75	48	47	54^{b}
Picloram salt + 2,4,5-T ester	0.5 + 0.5	1	16	80	77	91	96	44	4	62	86	96	94	60	64	62^{a}
2,4,5-T	0.5	0	8	71	62	46	72	20	2	49	72	66	63	48	32	44^{d}
2,4,5-T	1	0	25	71	50	65	78	24	2	56	70	61	61	59	51	48^{c}
Untreated		12	12	12	13	13	14	18	16	32	21	10	0	11	0	13
Mean[1]		2^{h}	15^{g}	71^{a}	63^{bc}	67^{ab}	73^{a}	28^{f}	5^{h}	59^{c}	71^{a}	67^{ab}	62^{bc}	50^{d}	40^{e}	
Picloram + 2,4,5-T amine salts	0.25+[2] 0.25				68	74	80		17		86	78				
Picloram + 2,4,5-T amine salts	0.5 +[2] 0.5				75	88	84		13		91	93				
		Dead plants														
Picloram	0.5	0	0	30	18	60	5	5	0	5	10	4	17	5	0	11^{b}
Picloram	1	0	0	75	22	75	35	0	0	15	55	46	33	20	0	27^{a}
Picloram salt + 2,4,5-T ester	0.25+ 0.25	0	0	30	15	15	25	0	0	5	20	29	12	10	8	12^{b}
Picloram salt + 2,4,5-T ester	0.5 + 0.5	0	0	35	15	40	65	5	0	5	30	66	54	0	8	23^{a}
2,4,5-T	0.5	0	0	5	0	0	12	0	0	0	0	0	4	0	0	2^{c}
2,4,5-T	1	0	0	0	0	10	15	0	0	5	0	0	0	0	0	2^{c}
Untreated		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mean[1]		0^{f}	0^{f}	25^{ab}	10^{de}	29^{a}	22^{abc}	1^{f}	0^{f}	5^{ef}	16^{cd}	21^{bc}	17^{c}	5^{ef}	2^{f}	
Picloram + 2,4,5-T amine salts	0.25+[2] 0.25				10	30	10		0		30	17				
Picloram + 2,4,5-T amine salts	0.5 +[2] 0.5				20	50	35		0		45	58				

[1]Values on the same line or column followed by the same letter are not significantly different at the 5% level using Duncan's Multiple Range Test.

[2]Values for picloram + 2,4,5-T as the triethylamine salts were not subjected to statistical analysis.

effective, causing more than 50- and 60-percent defoliation at the 0.5- and 1-pound per acre rates, respectively. The 2,4,5-T treatments were less effective than either picloram or picloram + 2,4,5-T.

Defoliation varied markedly among the 14 dates. Means for all chemicals show that the most effective treatments occurred from April 30 to July 1 in 1969 and from May 20 to July 6 in 1970. At some dates, picloram and a mixture of picloram + 2,4,5-T treatments caused more than 90-percent defoliation. No significant differences occurred between the mixture containing the potassium salt of picloram and the ester of 2,4,5-T and the mixture containing triethylamine salts of picloram and 2,4,5-T.

The data for percent dead plants were lower than for percent defoliation but showed the same trends (Table 1). Averaged over 14 dates, picloram and a mixture of picloram + 2,4,5-T were about equally effective, killing about 11 and 25 percent of the plants, respectively, for the 0.5- and 1-pound per acre rates, whereas 2,4,5-T treatments killed only 2 percent of the plants. At some dates, 1 pound per acre of picloram and the mixture of picloram + 2,4,5-T killed as many as 75 and 66 percent of the plants, respectively, whereas the highest percentage killed by 2,4,5-T was 15 percent.

Plant Characteristics

New stems were initiated about March 15 to April 1, and they elongated rapidly until about April 30 (Table 2). Then the stem tips died and aborted. Measurements made into August showed no further elongation after April 30. These and older stems produced very few inflorescences and no legumes ("pods").

Stem transections measured at each spraying date were 13 to 18 millimeters in diameter. Annual radial stem growth occurs largely in the phloem and xylem. Thicknesses of translocating phloem and total and 2-week growth (rate of growth) of the new xylem ring are presented in Table 2. The translocating phloem was thickest between mid-May and mid-June. The new translocating phloem was initiated in late March. After the rapid growth period, some of the translocating phloem sieve elements were crushed against the phloem fibers. This crushing action reduced the translocating phloem thickness by July. The new xylem ring began radial enlargement the early part of April, and growth was minimal after July (Table 2).

The other tissue thicknesses varied somewhat in size; however, they fell in the following ranges: periderm – 0.13 to 0.20 millimeter; nontranslocating phloem—0.26 to 0.72 millimeter; and means of xylem rings produced in 1969, 1968, 1967 and 1966 – 1.75, 2.26, 1.86 and 1.53 millimeters, respectively. Pith diameter was 0.82 to 1.12 millimeters.

Upward movement of moisture and dye occurred almost entirely in the outermost xylem ring. Although the rate varied widely, a trend showed that the most rapid movement occurred between April 30 and June 9 (Table 2). Warm mornings with full sunlight and adequate soil moisture seemed to promote the most rapid dye translocation.

Changes in total available carbohydrates were small (Table 2). However, the lowest level for the year occurred largely before the best time for spraying in April, May and June.

Moisture stress levels in leaves have a daily cycle. Stress ratings of untreated plant leaves at several dates in 1969 are shown in Figure 1. Moisture stress was at a minimum during the night when moisture uptake surpassed transpiration and the plant cells became turgid. Moisture stress levels in the leaves increased to a high of about 30 atmospheres in the afternoon and subsequently receded toward evening. The April 30 stress levels were lower than those later in the growing season. Differences in moisture stress among

TABLE 2. PLANT CHARACTERISTICS AT 14 DATES OF SPRAYING HONEY MESQUITE AT BRYAN, TEXAS

Date sprayed	New stem length	Translocating phloem thickness	Xylem ring thickness: Total for year	Xylem ring thickness: Rate of growth	Rate of upward dye movement	Total available stem carbohydrates	Leaf moisture stress: Predawn	Leaf moisture stress: Midday maximum
	cm	mm	mm	mm/2 wk	cm/hr	%	atm	atm
				1969				
March 24	1	0.08	0.00	0.00	8	9.0	6.2	6.2
April 14	27	.11	.11	.07	85	2.0	6.2	6.2
April 30	31	.13	.23	.10	114	4.6	7.1	13.4
May 20	31	.18	.76	.36	110	6.0	6.4	25.1
June 9	31	.18	1.21	.32	101	5.5	8.0	27.6
July 1	31	.08	1.59	.24	59	6.9	9.7	29.7
August 25	33	.07	1.77	.04	78	6.5	11.2	26.1
October 9	29	.06	1.72	.00	78	7.4	15.8	28.7
				1970				
May 4	28	.16	.23	.14	102	4.0	7.1	20.7
May 20	28	.15	.46	.20	153	4.0	7.2	29.1
June 19	28	.18	1.09	.29	60	5.0	8.4	25.9
July 6	27	.13	1.30	.17	28	6.1	10.1	29.8
July 30	27	.07	1.24	.00	28	6.1	11.7	25.8
August 10	27	.03	1.31	.01	18	6.0	13.8	29.5

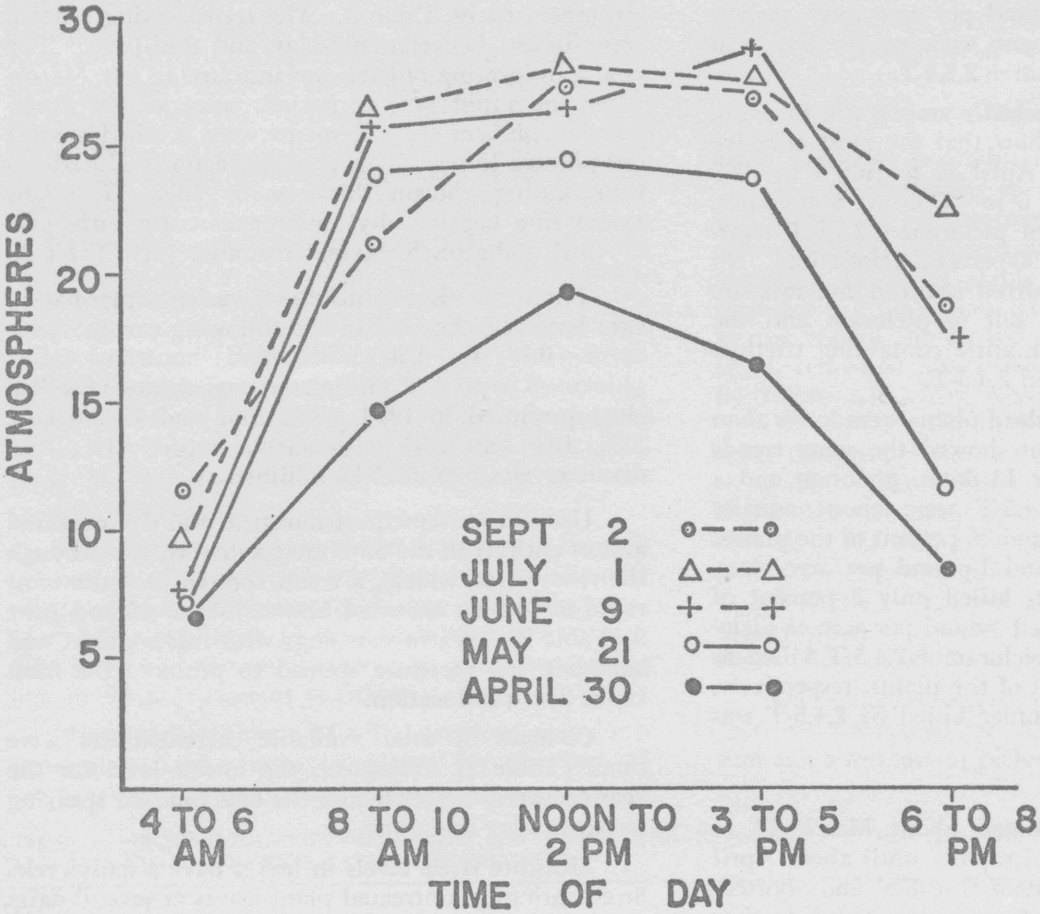

Figure 1. Moisture stress levels in leaves of honey mesquite plants at five intervals during the day at five periods in 1969. Data are means for 1 to 4 days beginning on the day listed.

dates from June 9 through October 9, 1969, were small except for the daily extremes.

The seasonal stress levels of untreated leaves at various times of the day in 1969 and 1970 are presented in Figure 2. The predawn stress level increased during the year and probably reflected the progressive decrease in soil moisture through the season. The readings made at 8-10 a.m., noon-2 p.m. and 3-5 p.m. were similar and are averaged in Figure 2. They were all much higher than the predawn reading. Moisture stress readings made at 6-8 p.m. were intermediate between the predawn and the other readings; the readings at 6-8 p.m. were low on April 30, reached a maximum in June and gradually decreased through the remainder of the growing season. The decreasing values may have resulted from the shortening of the days in the fall. Predawn, the minimum, and the midday maximum stress level data from untreated plant leaves used for regression analysis are presented in Table 2.

Moisture stress levels in leaves of untreated plants and those sprayed with 0.5 pound per acre of picloram or 2,4,5-T were studied in the 4-day period following spraying on June 9, 1969. At dawn all leaves had the same low value (Figure 3). Maximum stress values occurred at noon. However, by 6 p.m. the treated plants had much lower moisture stress than untreated plants. At night, leaves of no treatments were under moisture stress.

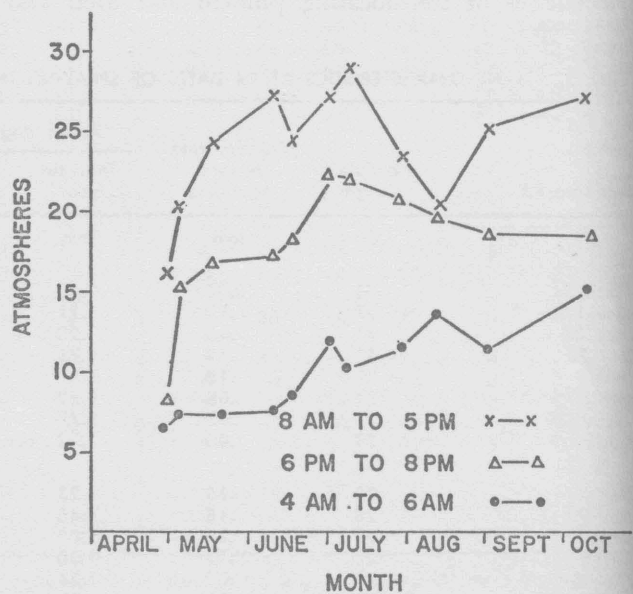

Figure 2. Seasonal moisture stress levels in leaves of honey mesquite at three intervals during the day in 1969 and 1970.

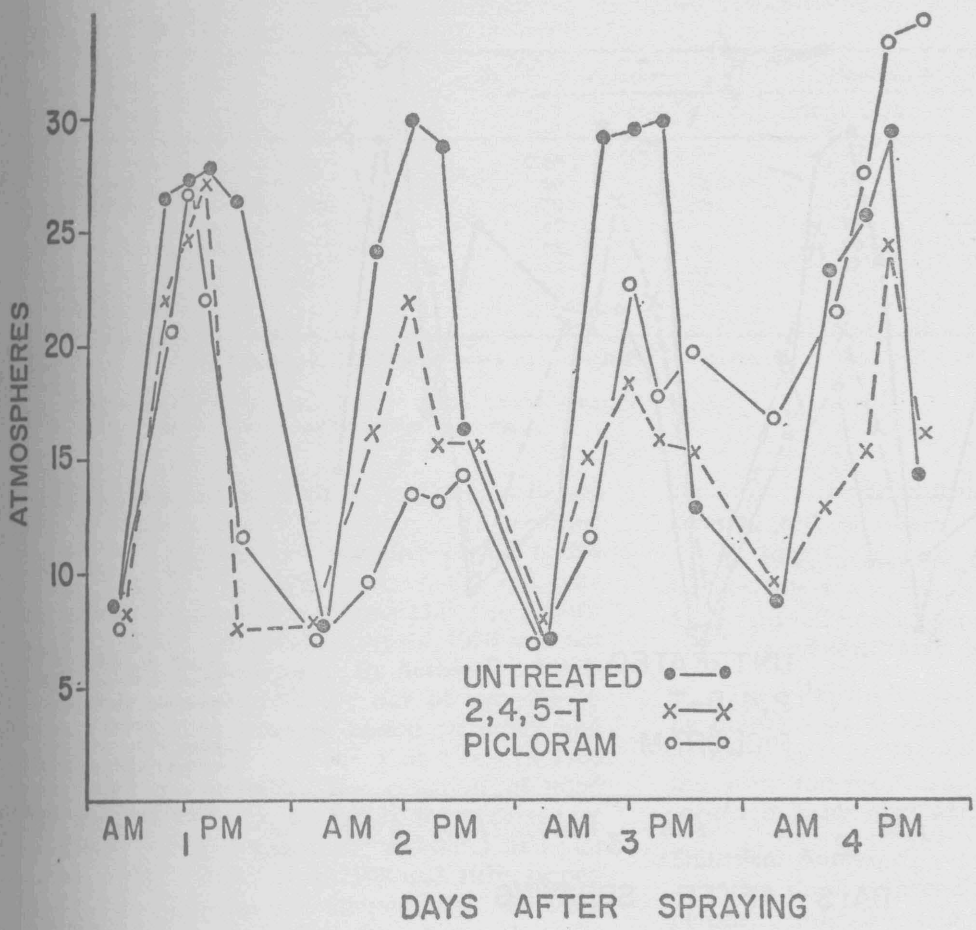

Figure 3. Moisture stress levels in leaves of honey mesquite plants during a 4-day period which had been either unsprayed or sprayed on June 9, 1969, with a 0.5-pound per acre rate of 2,4,5-T or picloram.

After the second and third day, however, the leaves of plants treated with herbicides failed to become as stressed during the midday as the unsprayed leaves. The difference between herbicide treatments was probably not significant at this stage.

On the fourth day, the treatments differed markedly. The untreated leaves had about the usual daily stress cycle. Almost all leaves sprayed with picloram, however, had died and had begun drying up. The essentially infinite values recorded on the pressure apparatus were indicative of the dried state of the leaves at 4 days.

Leaflets of leaves sprayed with 2,4,5-T began to abscise on the third day after spraying. By the fourth day, mostly only petioles and rachises remained. The moisture level in the petioles was regained by the fourth evening. The petioles yellowed and abscised after the fifth through the seventh day. The leaves sprayed with the mixture of picloram + 2,4,5-T reacted essentially like those sprayed with picloram alone.

The stress levels in untreated plant leaves and those sprayed with the 1-pound per acre rate of either picloram or 2,4,5-T are compared in Figure 4. At this rate, leaves in the plants treated with herbicides did not become as stressed as the untreated leaves the first 3 days after spraying. The depression in stress at this rate occurred earlier than at the 0.5-pound per acre rate. The leaves were not stressed on the night they were sprayed nor on the following two nights.

As in the 0.5-pound per acre rate, the ratings in the sprayed leaves were abnormally high the fourth day. The leaves sprayed with picloram remained intact and turned brown when they died. The leaflets of the leaves sprayed with 2,4,5-T abscised. The remaining petioles and rachises had yellowed somewhat and either died on the plant or abscised by the seventh day. The leaves sprayed with the 0.5 + 0.5-pound per acre rate of picloram + 2,4,5-T reacted essentially the same as those sprayed with picloram alone.

Pressure readings of treated plants taken at other times of the year gave similar results to those of June 9, 1969. However, the leaves seemed to die about a day earlier as the season progressed into periods of lower soil moisture.

Environmental Variables

The mean maximum and minimum air temperatures for the 1-week period prior to spraying are presented in Table 3. The range of temperatures during spraying dates of April 30 to July 1, 1969, and

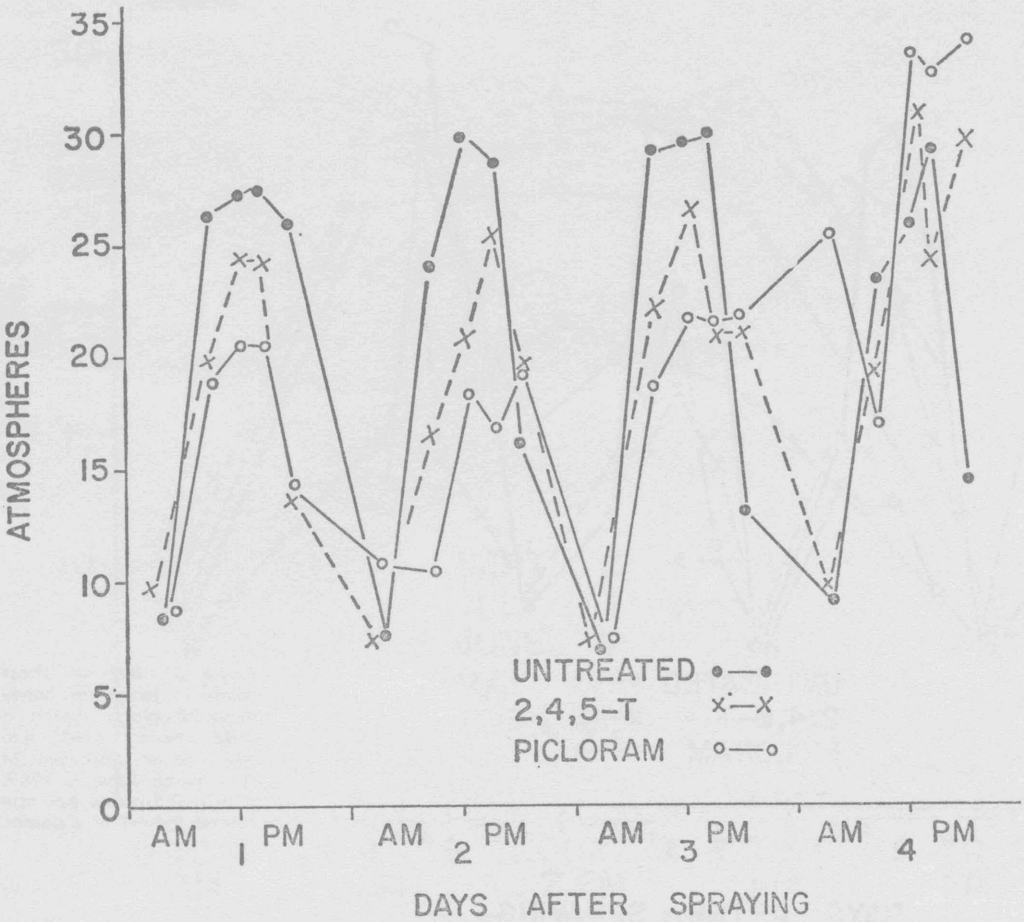

Figure 4. Moisture stress levels in leaves of honey mesquite plants during a 4-day period which had been either unsprayed or sprayed on June 9, 1969, with a 1-pound per acre rate of 2,4,5-T or picloram.

May 20 to July 6, 1970, was wide. Maximum temperature during these periods ranged from 77° to 96° F, and the minimum temperature ranged from 58° to 80° F. As expected, the temperatures increased progressively from March until reaching a maximum in July. Temperatures remained high into September but were lower in October.

Percent relative humidity varied widely during the day, frequently as much as 50 percent. Differences among dates, however, were small (data not presented). Maximum percent relative humidity generally reached 90 percent or more at night. The minimum levels of 30 to 50 percent generally occurred in the afternoon.

TABLE 3. AVERAGE ENVIRONMENTAL CONDITIONS ON A CLAY LOAM SOIL DURING THE WEEK PRIOR TO SPRAYING HONEY MESQUITE NEAR BRYAN, TEXAS

Date sprayed	Air temperature		Maximum soil temperature		Soil moisture		
	Maximum	Minimum	1 ft	3 ft	0-1 ft.	1-2 ft	2-3 ft
	°F				%		
				1969			
March 24	69	51	58	52	24	29	26
April 14	76	62	70	58	24	27	23
April 30	77	58	72	63	30	27	25
May 20	79	58	73	64	28	26	24
June 9	80	61	84	74	21	24	22
July 1	96	78	90	79	14	17	18
August 25	88	71	88	83	9	12	15
October 9	87	65	83	76	20	22	21
				1970			
May 4	79	61	76	66	16	25	24
May 20	84	66	78	68	12	21	25
June 19	91	74	82	72	15	22	22
July 6	93	80	86	77	8	18	19
July 30	92	69	88	80	8	13	16
August 10	97	69	93	83	6	13	14

TABLE 4. SIMPLE CORRELATION COEFFICIENTS BETWEEN EIGHT DESIGNATED VARIABLES AND PERCENT DEFOLIATION OF HONEY MESQUITE PLANTS CAUSED BY EACH OF SIX TREATMENTS AT 11 DATES*

	Picloram		Picloram + 2,4,5-T		2,4,5-T	
Variable	0.5	1	0.25 + 0.25	0.5 + 0.5	0.5	1
1. Translocating phloem thickness, μ	0.65	0.67	0.54	0.46	0.39	0.20
2. Rate of xylem radial growth†	.66	.76	.60	.27	.25	.20
3. Predawn leaf moisture stress, atm	— .70	— .73	— .59	— .36	— .49	— .28
4. Maximum soil temperature, ° F, 1 ft‡	— .49	— .50	— .37	— .10	— .35	— .06
5. Maximum soil temperature, ° F, 3 ft‡	— .59	—. 63	— .50	— .23	— .44	— .20
6. Soil moisture, %, 0-1 ft†	.64	.58	.47	.25	.34	.20
7. Soil moisture, %, 1-2 ft‡	.73	.73	.61	.40	.45	.31
8. Soil moisture, %, 2-3 ft‡	.70	.76	.62	.40	.52	.34

*March 24, April 14 and October 9, 1969, dates were not included. Correlation of ± 0.60 and 0.74 are significant at 5 and 1%, respectively.
†Radial enlargement occurring in the 2-week period before spraying.
‡Mean values during the 1-week period before spraying.

Soil temperature at both 1- and 3-foot depths generally increased from the earliest date recorded to early July when the best spraying period ended in 1969 (Table 3). In 1970, however, the soil temperature increased continuously from May 4 to August 10. Consequently, soil temperature in 1970 was not well correlated with response to herbicides. The maximum soil temperatures the day of spraying at the onset of the best spraying period were 72° and 76° F at 1 foot and 63° and 66° F at 3 feet in 1969 and in 1970, respectively. The cessation of good honey mesquite response to herbicides occurred at maximum soil temperatures of 90° and 86° F at 1 foot and 79° and 77° F at 3 feet in 1969 and 1970, respectively. Daily minimum soil temperatures (data not presented) were normally 4° to 6° F lower than the maximum.

Soil moisture 1 week before spraying varied from 6 to 30 percent at the 0-1-foot depth, 12 to 29 percent at the 1-2-foot depth and 14 to 26 percent at the 2-3-foot depth (Table 3). The moisture level was usually highest in March and April and lowest in July, August and September. The best spraying period generally occurred during an overall period of decreasing soil moisture.

In 1969, rainfall was fairly well distributed except for the July 1 spraying, where little rainfall occurred. Most rain fell in early April. In 1970, abundant rainfall occurred until May, but little occurred thereafter.

Total daily solar radiation was markedly affected by the amount of cloud cover and varied from 235 to 656 Langleys. The radiation varied widely during the year; the only consistently low values were recorded in September and October.

Statistical Analyses

The simple correlations along with the sign for percent defoliation data for all herbicide treatments with the eight most important independent variables are presented in Table 4. The 0.5- and 1-pound per acre picloram treatments were directly correlated with translocating phloem thickness, rate of xylem radial growth and percent soil moisture at 1–2 and 2–3 feet depths. They were inversely correlated with predawn moisture stress. Most temperature variables were not significantly correlated with plant control because

TABLE 5. SIMPLE CORRELATIONS OF SELECTED HONEY MESQUITE PLANT VARIABLES WITH 11 OTHER PLANT AND ENVIRONMENTAL VARIABLES AT 11 DATES*

Variable	Translocating phloem thickness	New xylem ring thickness		Moisture stress	
		Total	Rate	Predawn	Maximum
	μ	mm	mm/2wk	Atm	Atm
1. Translocating phloem thickness, μ		—0.54	0.80	—0.86	—0.37
2. Total new xylem ring thickness	—0.54			.74	.87
3. Predawn leaf moisture stress, atm	— .86	.74	— .65		.68
4. Maximum leaf moisture stress, atm	— .37	.87	.69	.68	
5. Maximum air temperature†	— .68	.73	— .35	.84	.75
6. Minimum air temperature†	— .41	.69	— .15	.57	.67
7. Maximum soil temperature, 1 ft, ° F†	— .71	.75	— .50	.86	.65
8. Maximum soil temperature, 3 ft, ° F†	— .76	.83	— .55	.91	.69
9. Soil moisture, 0-1 ft, %†	.62	.57	.55	— .82	— .53
10. Soil moisture, 1-2 ft, %†	.86	— .78	.65	— .93	— .59
11. Soil moisture, 2-3 ft, %†	.86	— .84	.61	— .97	— .71

*March 24, April 14 and October 9, 1969, dates were not included. Correlations of ± 0.60 or ± 0.74 were significant at 5 and 1%, respectively.
†Mean values during the 1-week period before spraying.

TABLE 6. SIMPLE CORRELATIONS OF SELECTED ENVIRONMENTAL VARIABLES DURING THE 1-WEEK PERIOD BEFORE SPRAYING AT 11 DATES[1]

Variable	Minimum air temperature	Maximum soil temperature		Soil moisture		
		1 ft	3 ft	0-1 ft	1-2 ft	2-3 ft
	°F			%		
1. Maximum air temperature, °F	0.87	0.82	0.81	−0.80	− .82	− .80
2. Minimum air temperature, °F		.71	.70	− .72	− .65	− .58
3. Maximum soil temperature, 1 ft, °F			.97	− .82	− .83	− .83
4. Maximum soil temperature, 3 ft, °F				− .83	− .91	− .92
5. Soil moisture, %, 0-1 ft					.86	.74
6. Soil moisture, %, 1-2 ft						.94

[1]March 24, April 14 and October 9, 1969, dates were not included. Correlations of ± 0.60 or ± 0.74 are significant at 5 and 1%, respectively.

temperature was directly correlated in May and June and inversely correlated thereafter.

Of the mixtures, only the 0.25 + 0.25-pound per acre rate of picloram + 2,4,5-T defoliation data were significantly correlated with the rate of xylem growth and soil moisture at 1–2 feet and at 2–3 feet. Other chemical treatments were not significantly correlated with the factors measured.

None of the variables were significantly related to the percentage of plants killed in any of the six treatments (data not presented).

The simple correlations of five plant characters with 11 plant and environmental variables are shown in Table 5. Translocating phloem thickness was inversely correlated with predawn leaf moisture stress and maximum air and soil temperatures and directly correlated with soil moisture.

Total new xylem thickness was directly correlated with predawn and maximum leaf moisture stress, maximum and minimum air temperatures and maximum soil temperature at both depths; it was inversely correlated with soil moisture at the two greater depths. Rate of new xylem radial ring growth was directly correlated with translocating phloem thickness, maximum leaf moisture stress and soil moisture at the two greater depths; it was inversely correlated with predawn leaf moisture stress.

TABLE 7. REGRESSION EQUATIONS SHOWING THE RESPONSE OF HONEY MESQUITE NEAR BRYAN, TEXAS, TO HERBICIDE SPRAYS APPLIED AT 14 DATES IN 1969 AND 1970

Chemical	Rate	Equation[1]	Standard error	R^2
	lb./acre		%	
1. All chemicals, both rates		(percent defoliation)		
		$\hat{Y} = 4.23(T) - 0.00978(T^2) + 4.32(X1)$	15.2	—
Picloram	0.5	−465		
Picloram	1	−454		
Picloram + 2,4,5-T	0.25 + 0.25	−464 [a]		
Picloram + 2,4,5-T	0.5 + 0.5	−455		
2,4,5-T	0.5	−474		
2,4,5-T	1	−470		
2. Picloram	0.5	(percent defoliation)		
		$\hat{Y} = 27.3 + 180.8(X2)$	20.7	0.54
		$\hat{Y} = 486.0 + 4.20(T) - 0.00964(T^2) + 5.31(X1)$	14.3	.79
		(percent dead plants)		
		$\hat{Y} = -9.37 + 1.81(X3)$	18.8	.18
		$\hat{Y} = -128.3 + 1.64(T) - 0.00395(T^2) - 2.48(X4) + 2.31(X5) + 1.60(X6)$	15.7	.47
3. Picloram	1	(percent defoliation)		
		$\hat{Y} = 35.5 + 198.0(X2)$	25.7	.48
		$\hat{Y} = -502.8 + 4.74(T) - 0.01111(T^2) + 4.48(X1)$	15.7	.81
		$\hat{Y} = -586.1 + 3.79(T) - 0.00931(T^2) + 2.10(X5) + 6.71(X1)$	14.4	.85
		(percent dead plants)		
		$\hat{Y} = -12.7 + 3.45(X3)$	27.0	.29
		$\hat{Y} = -545.6 + 1.63(T) - 0.04419(T^2) + 3.19(X5) + 9.56(X1)$	21.7	.56

TABLE 7. (CONTINUED)

Chemical	Rate	Equation[1]	Standard error	R^2[2]
	lb./acre		%	
4. Picloram +	0.25 +	(percent defoliation)		
2,4,5-T	0.25	$\hat{Y} = 28.8+181.0(X2)$	22.9	.49
		$\hat{Y} = -485.1+4.34(T)-0.01002(T^2)+4.77(X1)$	14.7	.80
		(percent dead plants)		
		$\hat{Y} = 4.87+52.4(X2)$	14.3	.17
		$\hat{Y} = -133.0+1.82(X4)+1.06(X6)-3.03(X7)$	13.1	.32
5. Picloram +	0.5 +	(percent defoliation)		
2,4,5-T	0.5	$\hat{Y} = 35.4+192.3(X2)$	24.2	.50
		$\hat{Y} = 533.3+4.97(T)-0.01140(T^2)+4.32(X1)$	11.6	.89
		(percent dead plants)		
		$\hat{Y} = 4.77+132.7(X2)$	24.1	.32
		$\hat{Y} = -94.0+1.16(X4)+132.5(X2)$	22.3	.43
6. 2,4,5-T	0.5	(percent defoliation)		
		$\hat{Y} = 24.2+141.2(X2)$	23.0	.37
		$\hat{Y} = -444.5+3.80(T)-0.00867(T^2)+4.74(X1)$	16.2	.70
		$\hat{Y} = -740.2+5.95(T)-0.01352(T^2)-4.04(X3)+10.5(X1)$	14.2	.77
		(percent dead plants)		
		$\hat{Y} = 5.37-0.67(X3)+27.6(X2)$	6.2	.09
		$\hat{Y} = -35.3+0.51(X4)+0.75(X8)-1.03(X7)$	6.0	.17
7. 2,4,5-T	1	(percent defoliation)		
		$\hat{Y} = 31.8+117.6(X2)$	23.3	.28
		$\hat{Y} = -330.9+3.34(T)-0.00785(T^2)+2.28(X1)$	15.9	.68
		$\hat{Y} = -601.8+4.42(T)-0.01055(T^2)-3.23(X3)+1.24(X5)+7.93(X1)$	14.0	.76
		(percent dead plants)		
		$\hat{Y} = -0.0633+15.9(X2)$	7.1	.07
		$\hat{Y} = 4.90-0.72(X3)+39.4(X2)$	6.9	.15

[1]Variable abbreviations are the following: T = time in days from January 1 to spraying date; T^2 = time period (T) squared; X1 = percent soil moisture at the depth of 2-3 feet 1 week before spraying; X2 = rate of new xylem ring radial growth in the 2-week period before spraying; X3 = translocating phloem thickness; X4 = average maximum air temperature during 1 week before spraying; X5 = average maximum soil temperature at a depth of 3 feet during 1 week before spraying; X6 = percent soil moisture at the depth of 0-1 foot 1 week before spraying; X7 = predawn leaf moisture stress; and X8 = percent available carbohydrates.

[2]Data for 14 dates were analyzed. Df = 14−(1 for Y +1 for each X variable). Significant R^2 values are the following for 5%/1%: IX = .28/.44, 2X's = .42/.57, 3X's = .53/.66, 4X's = .62/.74.

[3]Add the appropriate negative value of the specific herbicide treatment to the above equation.

Predawn leaf moisture stress was inversely correlated with translocating phloem thickness, rate of new xylem growth and soil moisture, and it was directly correlated with total new xylem ring thickness, maximum leaf moisture stress and air and soil temperatures. Maximum leaf moisture stress was correlated similarly to predawn leaf moisture stress.

Simple correlations of seven environmental variables are shown in Table 6. Maximum and minimum air temperatures are directly correlated with each other and with soil temperature at both depths, and they are inversely correlated with soil moisture. Maximum soil temperature at depths of 1 and 3 feet are directly correlated with each other and inversely correlated with soil moisture. Soil moisture at the three depths are directly correlated.

The other variables measured (data not presented) were not significantly correlated either with plant control or other independent plant or environmental variables.

Regression equations were developed from the data to compute the best estimated value ($\hat{Y}$) for the observed percent defoliation and percent dead plants at any period during the growing season. Hopefully, these equations will closely fit data from other similar treatments showing seasonal honey mesquite responses to picloram and 2,4,5-T throughout the growing season. If reliable equations can be developed, they can be used commercially to predict the amount of honey mesquite control that can be expected from the treatment under any given seasonal and plant growth conditions.

In the first regression analysis, an equation was developed to compare percent defoliation by all treatments at the same time (Table 7). Percent soil moisture 2–3 feet deep was the most important independent variable. The predicted defoliation ($\hat{Y}$) of any treatment can be calculated by adding the appropriate negative treatment constant to the products of the coefficients and their appropriate measurements. The standard error was 15.2 and was not improved appreciably by adding more variables. This equation was approximately as good as any individual treatment equation. The equation for percent dead plants was appreciably less useful because of the large differences among treatments and is therefore not presented.

Regressions for percent defoliation and percent dead plants for each treatment are presented in Table 7. Defoliation caused by both rates of picloram could best be estimated with rate of new xylem ring growth alone. Soil moisture at 2-3 feet was appreciably better upon adding the time-time^2 factor. Percent dead plants was best estimated by translocating phloem thickness as a single variable. The precision was somewhat improved by the four- or five-variable equations including the time variables, maximum air temperature (for 0.5 pound per acre only), maximum soil temperature 3 feet deep and percent soil moisture either at depths of 0-1 or 2-3 feet.

On the basis of a single variable, percent defoliation and percent dead plants at both levels of picloram + 2,4,5-T were best estimated using the rate of new xylem ring growth. For percent defoliation the best equation was obtained using the time-time^2 factor with percent soil moisture at a depth of 2-3 feet. Percent dead plants was best estimated at the 0.25 + 0.25-pound per acre rate with maximum air temperature, soil moisture at a depth of 0-1 foot and predawn leaf moisture stress. Percent dead plants at the 0.5 + 0.5-pound per acre rate was best estimated by maximum air temperature and rate of new xylem ring growth.

On the basis of a single variable, rate of new xylem ring growth gave the best estimate of both percent defoliation and percent dead plants by either rate of 2,4,5-T. Percent defoliation with the 0.5-pound per acre rate was enhanced using the time-time^2 factor plus translocating phloem thickness and percent soil moisture at the depth of 2-3 feet. Percent defoliation at the 1-pound per acre rate was enhanced using the same four variables plus maximum soil temperature at the 3-foot depth.

Only a few plants were killed by either rate of 2,4,5-T. Consequently, none of the variables including the time-time^2 factor contributed appreciably to the equation. Maximum air temperature, percent total available carbohydrates and predawn leaf moisture stress added slightly to the equation for the 0.5-pound per acre rate of 2,4,5-T, and translocating phloem thickness and rate of new xylem growth rate added to the 1-pound per acre rate.

Representative variables during the most effective spraying period from April 30 to July 6 are summarized in Table 8.

TABLE 8. A SUMMARY OF HONEY MESQUITE AND ENVIRONMENTAL FACTOR RANGES DURING THE BEST PERIODS FOR SPRAYING IN 1969 AND 1970 NEAR BRYAN, TEXAS

Factor measured	Range
New stem length	27-31 cm
Stem tissue thickness	
Translocating phloem	0.08-0.18 mm
Total xylem ring	0.23-1.59 mm
Rate of radial xylem growth	0.10-0.36 mm/ 2 weeks
Upward xylem methylene dye movement	28-153 cm/hour
Total available carbohydrates	4.0-6.9 %
Leaf moisture stress in untreated leaves the day after spraying	
Predawn	6.4-10.1 atm
Maximum	13.4-29.8
Maximum soil temperature, 1 week before spraying	
1 foot deep	72°-90° F
3 foot deep	62°-82° F
Soil moisture, 1 week before spraying	
0-1 foot	8-30 %
1-2 feet	17-27 %
2-3 feet	18-25 %
Air temperature, 1 week before spraying	
Maximum	77°-96° F
Minimum	58°-80° F
Relative humidity, 1 week before spraying	
Maximum	70-100 %
Minimum	36-50 %
Rainfall, 1 week before spraying	0-3.49 inches
Total solar radiation	238-528 Langleys

Discussion

Little difference occurred in control of honey mesquite among picloram and picloram + 2,4,5-T treatments (Table 1). The mixture is preferred because 2,4,5-T is less persistent, and the mixture is presently less costly than picloram. The formulation of the mixture was not important. Thus, either a tank mix or the formulated herbicides can be used equally well. Both picloram and picloram + 2,4,5-T are superior to 2,4,5-T alone. The latter is presently recommended for the control of honey mesquite. The 2,4,5-T treatments killed very few plants since these plants had regrown after mowing and possessed less leaf area to intercept and translocate herbicide to the lower stem and roots than comparable undisturbed plants. Also, chemical control of plants growing on heavy soils has generally been poorer than for plants growing on lighter soils, even in West Texas (2).

In almost every case, the 1-pound per acre treatment was more effective than the 0.5-pound per acre treatment. Other unpublished results from experiments near Bryan, Texas, have indicated increasing effectiveness with rates up to 2 pounds per acre of 2,4,5-T and/or picloram.

Marked differences in plant response occurred among dates of treatment using the same chemical treatments (Table 1). This finding shows the importance of applying the spray at the date which will give most effective control. Generally the best time to apply herbicides is between April 30 and July 6, which corresponds roughly to the recommended time period 50 to 80 days after bud break. In years with normal rainfall, best results will be obtained by spraying during this period. However, the amount of control obtained from year to year varies markedly. Therefore, a more reliable measurement is needed to quantify the actual amount of control that will be obtained by spraying at any given date.

Stem elongation growth did not occur in the equations presented (Table 7). The end of the stem elongation period essentially marks the beginning of the best time to spray (Table 2). Thus, recognition of cessation of stem elongation growth at spraying time would be useful to show the onset of the spraying season but would be of little value either during the spraying season or to mark the end of the spraying season. A more meaningful measurement might be stem elongation growth per unit time during a period such as 2 or 3 weeks prior to spraying.

Translocating phloem thickness (Table 2) occurred in four regression equations (Table 7). Phloem thickness was directly correlated with percent defoliation (Table 4). The range in thickness during the best spraying season was 0.08 mm to a maximum of 0.18 mm. This measurement is small and varies on different size stems (14) and thus would need to be standardized to be a useful measurement. However, since the translocating phloem is the tissue that conducts the herbicide to the lower stem and roots, the quantity of tissue should have a significant effect on honey mesquite response to herbicides.

The new xylem ring (Table 2) is produced during the best spraying season. The total thickness is highly correlated during the period of best plant control (0.23 to 1.59 mm) but is little correlated at the end of the summer when plant control decreases. The rate of new xylem ring radial growth (Table 2) follows the period of best control more closely. Without the use of a recording dendrograph, measurements were needed at a minimum of 2 weeks. Rate of new xylem ring radial growth occurred as the most important variable where the time-time^2 factor was not used.

Rate of upward methylene dye movement in the xylem (Table 2) failed to occur in any useful regression equation (Table 7). The rate varied from 28 to 153 centimeters (cm) per hour during the best spraying period. Two factors handicap the importance of this measurement. First, only 10 trees were infused at each date. Consequently, the variation from tree to tree reduced the validity of the measurement. Second, it was difficult to infuse trees under exactly the same environmental conditions each time. Changes in day length during the season and cloud cover can affect the radiation and resulting transpiration at time of infusion. Further refinement of the injection procedure may increase the value of this measurement.

Total available carbohydrates varied from 4.0 to 6.9 percent during the best spraying season (Table 2). This variable failed to be included in any equations (Table 7). It generally was lowest just prior to the best spraying season and then increased until about the middle of the spraying season. Determination of total available carbohydrates is expensive and difficult to reproduce. Also, the entire sapwood was sampled. Perhaps only the outermost one or two growth rings would have been a better measure because they are more responsive to seasonal changes in carbohydrates (14).

The leaf moisture stress readings (Table 2 and Figures 1 and 2) were similar to those of Haas and Dodd (8). The values were low in the morning and evening and high during the day. There was a general increase in the predawn value of 6.4 to 10.1 atmospheres during the best spraying period, and a maximum of 13.4 to 29.8 atmospheres at midday. The predawn rating occurred in one regression equation. It might be a useful measurement if it can be correlated with control more closely during the late summer period. The maximum leaf stress value was less well correlated. It rose essentially to a high level early in the season and changed very little thereafter (Table 2 and Figure 1).

The herbicides reduced the moisture stress in honey mesquite plant leaves for several days after treatment (Figures 3 and 4). This reduction in stress may be due to closing of stomata or other changes in the plant's metabolism. The importance of this reduction in leaf moisture stress by herbicides needs to be studied more fully.

Maximum and minimum air temperatures during the 1-week period before spraying were 77° and 58° F, respectively, at the beginning of the best part of the spraying period and increased about 20° F by July 6 (Table 3). Maximum air temperature appeared in one regression equation (Table 7). Air temperature was directly correlated with total xylem thickness, leaf moisture stress (Table 5) and soil temperature (Table 6) and inversely correlated with soil moisture and translocating phloem thickness. As expected, the temperature during the best spraying period was rather warm because honey mesquite was found to grow readily at a minimum average temperature of 65° to 67° F.

Maximum soil temperature at a depth of 3 feet occurred in four regression equations (Table 7); maximum soil temperature at a depth of 1 foot was less correlated with plant control. Maximum soil temperatures at depths of 1 and 3 feet were 58°–93° F and 52°–83° F, respectively (Table 3). Apparently a minimum temperature is required for rapid plant growth. Dahl et al. (2) found that soil temperature above a threshold of 80° F was best for killing honey mesquite. These findings also support their work in the early part of the spraying season. However, soil temperature remains high late in the summer when plant control is not obtained; this gives a final negative correlation (Table 4). Maximum soil temperature was an easy value to measure with a recording thermograph and seems to be a useful one to predict plant control early in the spraying season.

Percent soil moisture was measured during the season at depths of 0-1, 1-2 and 2-3 feet. Percent soil moisture at a depth of 2-3 feet occurred in 11 regression equations (Table 7) and was the most important variable measured particularly where the time-time^2 factor was included. Soil moisture at a depth of 0-1 foot was less correlated with honey mesquite responses than the 2-3-foot measurement. The 1-2-foot depth measurement was not included in the regression equations (Table 7) but presumably could be used almost interchangeably with the 2-3-foot measurement because of the 0.94 correlation (Table 6). The influence of soil moisture needs to be investigated further, particularly at the end of the spraying season. Numerous regression equations were developed, which are not presented here, that included both a soil temperature and a soil moisture variable. As expected, low levels of soil moisture (Table 3) were directly correlated with limited moisture in the plant (high leaf moisture stress) (Table 5).

Maximum and minimum percent relative humidity measurements taken during the week prior to spraying failed to be highly correlated with honey mesquite control. Generally maximum and minimum percent relative humidity ranged between 90 and 100 percent and 36 and 50 percent, respectively. High daily fluctuations and small seasonal trends seem to limit the use of humidity measurements for predicting plant control.

Rainfall the week prior to spraying and total daily solar radiation the day of spraying do not seem to be extremely useful for predicting honey mesquite control because of erratic response to them.

The final decision on the factors to be measured in developing a predicting indicator for the control of honey mesquite depends on (1) the high correlation of measurement with control, (2) the reproducibility of measurement and (3) the cost of measurement. At present, measurements of soil temperature and soil moisture seem to be the most useful. However, a variable that measures the general status of the plant would seem to be the most useful. Phloem thickness, rate of new xylem ring radial growth and predawn leaf moisture stress seem to be the best measured. Measurement of short term daily variables such as rate of dye movement seems to be highly influenced by numerous environmental variables.

Simple correlations of the environmental factors recorded 1 week before spraying can be divided roughly into two groups. Maximum air temperature, minimum air temperature and maximum soil temperatures at 1 and 3 feet were directly correlated in one group. Maximum and minimum relative humidity, percent soil moisture at 0-1, 1-2 and 2-3 feet and rainfall were directly correlated, but inversely correlated with the first group. Generally, the highest direct correlations of the factors recorded 1 week prior to spraying were either the same variables recorded at other time periods or similar variables such as other extremes or depths at the same time period. A number of these variables are correlated closely enough to eliminate the need for collecting data for more than one variable in future studies. The simple correlations with the herbicide treatments decreased as the effectiveness of the treatments decreased.

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