TOLERANCE OF KOREAN LESPEDEZA TO VARIOUS HERBICIDES AT DIFFERENT STAGES OF GROWTH

By

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Bachelor of Science

University of Wisconsin

Madison, Wisconsin

1952

Submitted to the faculty of the Graduate School of
the Oklahoma Agricultural and Mechanical College
in partial fulfillment of the requirements
for the degree of
MASTER OF SCIENCE
May, 1955

TOLERANCE OF KOREAN LESPEDEZA TO VARIOUS

HERBICIDES AT DIFFERENT STAGES OF GROWTH

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ACKNOWLEDGEMENTS

Sincere appreciation is extended to Mr. W. C. Elder and Dr. Wayne W. Huffine for their help in planning this study and for their counsel throughout this experiment.

Grateful acknowledgement is made to Mr. Charles E. Denman for his help in the analysis of this study and to other members of the Committee for their constructive criticism.

Appreciation is also extended to the Agronomy Department for providing the facilities which made this work possible.

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INTRODUCTION

It has been estimated that losses caused by weeds on farms have now reached 5 billion dollars annually. At present well over 30 million pounds of the phenoxy compounds, 2,4-D (2,4-dichlorophenoxy acetic acid), 2,4,5-T (2,4,5-trichlorophenoxy acetic acid) and M.C.P. (2 methyl, 4 chlorophenoxy acetic acid) are being used for herbicidal purposes to combat these losses.

The introduction of new chemicals and new weed control techniques, such as pre-emergent treatment, post-emergence and low gallonage applications ranks among the more important recent developments in weed control.

Previous research has shown that different species of legumes, and to some extent varieties, vary in their tolerance to these herbicides. The species not only vary in their response to the different herbicides used, to the concentration of the material, but also the stage of plant growth is a factor. The cause of these differences in tolerance of species to herbicides is as yet unknown. Environmental conditions such as shading, temperature, or competition for moisture are undoubtedly factors which must be considered.

Large acreages in eastern Oklahoma have been and are being planted to Korean lespedeza, Lespedeza stipulacea (Maxim) in permanent pastures and meadows. One of the major problems involved, with the rapidly increasing acreage, is finding the most economical and efficient method of controlling troublesome weeds such as perennial ragweed, Ambrosia psilostachya, Lance-leaved ragweed, Ambrosia bidentata, and Bitterweed, Helenium tenuifolium with the least reduction in yield of lespedeza.

Because of the widespread use of lespedeza as a summer annual legume in our permanent pastures this study was conducted to determine at which physiological stage of growth various herbicides could be applied with the least reduction in seed and forage production.

REVIEW OF LITERATURE

Many factors which are involved in the use of organic herbicides for weed control are not yet fully understood. For best results one must know the tolerance of the different species and also what effect a companion crop has on a legume plant or weed treated with herbicides. Before we can answer this question we must know how shading, competition for nutrients and water alter a plant's physiological make-up.

Recent research indicates that translocation takes place most rapidly when the carbohydrate content of the leaves is at a peak. No difference in the mode of translocation of different forms of 2,4-D has been found, regardless of the concentration of the 2,4-D or the carrier involved.

More recently much investigation has been done to determine what effect the carrier may have in inhibiting plant growth. Gertsch (9) /1 found that kidney bean growth was inhibited to a greater extent when an oil or 5% oil emulsion was used as a carrier for 2,4-D or 2,4,5-T, than when water alone was used. He concluded that the primary reason for greater effectiveness of commercially prepared 2,4-D was the presence of surface active agents and oil in these formulations.

The mode of action of the halogenated phenoxy acetic acids is not fully understood. Indications for the mechanism involved in plant utilization of some 2,4-D derivatives have been obtained by the synthesis and testing of a number of amino acid derivatives. It has been demonstrated that the N-(dichlorophenoxy acetyl) L-amino acid type appears to possess

/1 Figures in parenthesis refer to "Literature Cited," page 21.

growth modifying activity of the same magnitude as 2,4-dichlorophenoxy acetic acid. Plants affected by this type of growth modifier appear to have cellular hydrolytic enzymes capable of splitting the amide linkage of the L-amino acid to liberate the free carboxyl group of the substituted phenoxy acetic acid. Earlier investigations indicate the D-amino acid derivatives appear to have little or no growth modifying activity, suggesting that the plants were incapable of splitting the D-amide linkage.

Kreuson, Newfeld, Drake and Fontaine (14) found that the D-, L-, and D-L forms of 2 methyl 4-chlorophenoxy acetyl alanine were about equally effective, and possessed moderate to strong growth modifying properties. The D form appeared to have little or no growth modifying effect because of a small amount of a hydrolytic enzyme in the plant capable of splitting the D-amino acid derivatives.

Work done by Crafts (5) indicates that 2,4-D derivatives all have anionic groups as their active principle. The activity of these compounds increases in the following sequence; sodium salt, ammonium salt, and the amine salt. Short chain aliphatic esters are two to three times as active as the salts because they are fat soluble and do not dissociate. Evidently any factor tending to lower dissociation of a water soluble form of 2,4-D increases its activity.

Legumes such as beans, peas, red clover, and alfalfa were demonstrated by Carlyle and Thorpe (4) to be extremely sensitive to low concentrations of the ammonium and sodium 2,4-D salts present in the soil solutions. Rates of $\frac{1}{4}$ pound per acre were shown to seriously restrict germination, growth and nodule formation in these legumes. Bacteria were found to be tolerant to 2,4-D at a concentration of 0.3%, indicating that the deleterious effect on the symbiotic relationship was a reduction or inhibition of nodulation caused largely by action of the herbicide through the plant.

Mitchell and Linder (17) have shown that herbicides were most easily absorbed and translocated when they were applied to young rapidly growing stems or full grown leaves. Little or no translocation of 2,4-D occurred when it was applied to partially expanded leaves or buds.

Highly concentrated 2,4-D solutions in small amounts were found by McDonald (15) to be fully as effective in eradicating troublesome weeds as the same amount of chemical in large gallonage applications. Results which he obtained indicated that two gallons of 2,4-D were effective in killing wild buckwheat, sunflower, and field bindweed, provided a uniform application of material was applied. Slightly more drift was noted at low applications because of the small droplet size. Under most field conditions this slight drift was found to be non-significant.

The type of preparation used when applying various herbicides was shown by Buchholtz (3) to be important. Sodium and amine salt preparations of 2,4-D were found to be less toxic to legumes than an equivalent amount of 2,4-D ester. In numerous trials he found $\frac{1}{4}$ pound of 2,4-D ester per acre would result in a severe reduction in an alfalfa stand. Three-fourths pound per acre of the amine and sodium preparations of 2,4-D were required to produce an equivalent amount of damage. Legumes also vary in their tolerance to different preparations of M.C.P. and 2,4,5-T.

Rain, shortly after spraying was found by Knowles (13) to have little effect on the effectiveness of 2,4-D. Results which he obtained indicated that 2,4-D was to a large extent absorbed within 2 to 5 hours after spraying.

In 1946 Wallen (21) was able to demonstrate the differences in volatility of numerous 2,4-D preparations. Honeysuckle plants grown near an open container of butyl, ethyl, methyl, and isopropyl esters of 2,4-D were killed several feet away from the preparation. The acid and salt forms of 2,4-D allowed the honeysuckle to grow over the container indicating a preparation of low volatility. Low molecular weight straight chain alkyl esters were found to have a greater phytotoxic volatility than the high molecular weight carbon straight chain esters.

In an established grass legume pasture, Hauser and Shaw (11) have shown that Ladino clover was more tolerant to 2,4-D and M.C.P. at different seasons of the year. A direct relationship was observed to exist between the overall degree of injury and the vigor and growth rate of Ladino clover at the time of treatment. No reduction in yield occurred at rates up to one pound of 2,4-D applied during June and August. When as little as 1/8 to 1/4 pound was applied in April or October severe reduction in clover yields occurred.

Pasture sage (Artemisia frigida) was found by Friesen (8) to be effectively killed with applications of 1 to 2 pounds of 2,4-D amine or ester, while 2,4,5-T was found to be ineffective at all rates.

Fertilization, with plowing and reseeding to adapted forage species, accompanied by annual applications of 2,4-D was found by Klingman and McCarty (12) to be the most effective means of controlling weeds in pastures.

Mowing weeds in June and July was generally found to be ineffective for weed control. Annual weeds mowed in early June gave comparable results as a means of control when compared to weeds sprayed in June with 2,4-D. Weeds sprayed in July gave considerably better control than weeds mowed in the same period.

Elder (6) found that ragweeds in a Korean lespedeza pasture could be killed by applying ½ pound of 2,4-D amine per acre when the weeds and lespedeza were six inches tall. Reduction in the yield of lespedeza was no more severe after spraying than when no attempt was made to control the weeds.

On an established mixed legume stand of Ladino clover, alsike clover, red clover, and alfalfa, Waywell (20) showed that rates of 4, 6 and 8 ounces per acre of 2,4-D butyl ester, and M.C.P. sodium salt reduced the yield of forage to such an extent that recovery was not complete within the following year.

Experimental work done by Miller and Dunham (16) indicated that species of legumes vary in their tolerance to herbicides. Species of legumes such as Grimm and Ladak alfalfa; Evergreen and yellow sweet clover; Midland and northern commercial red clover, when sprayed with ½ pound acid equivalent of the amine salt of 2,4-D or M.C.P. showed a slight varietal response to these treatments in 1951. In 1952 there was no indication of varietal difference.

Miller and Dunham (16) found an established stand of alfalfa, red, and alsike clover to be more tolerant to the amine salt of 2,4-D and M.C.P. in the spring shortly after growth began, than when the stand was sprayed after removing the first hay crop. The alfalfa forage yield in this instance was reduced 20% by 2,4-D and 7% by M.C.P. when the herbicide was applied after the first hay cutting. At a rate of ½ pound of M.C.P. or 2,4-D however, all legume stands were reduced with the exception of ½ pound M.C.P. on red clover.

At the Minnesota Experiment Station, Olson, Burrows and Friesen (18) found Grimm alfalfa and White Blossom sweet clover sown with wheat and flax to be relatively tolerant to 2 ounces of 2,4-D butyl ester or 4 ounces of 2,4-D amine, when sprayed at a plant height of 3 to 5 inches. At a rate of 4 ounces of either M.C.P. sodium salt, M.C.P. ester, or 2,4-D butyl ester intermediate injury to the legume occurred. An 8 to 12 ounce rate of M.C.P. ester and 12 ounce rate of M.C.P. sodium salt produced severe curling of the leaves and stems. Sweet clover was found to be less tolerant to these rates than alfalfa.

Elder and Gassaway (7) reported annaul lespedeza in the seedling stage was killed by 2,4-D at rates per acre of $\frac{1}{4}$, $\frac{1}{2}$ and 1 pound of M.C.P. or 2,4,5-T amine respectively. At a plant height of 4 to 6 inches $\frac{1}{4}$ to $\frac{1}{2}$ pound of 2,4-D amine reduced forage yield moderately. As the plant neared maturity spray applications at these rates resulted in dropping of leaves. No difference in plant tolerance was found when rates of 1 pound per acre of 2,4-D or M.C.P. were applied. 2,4,5-T was found to kill the plant in all stages of growth.

Korean lespedeza and red clover were shown by Hansen and Freeman (10) to be less affected by 2,4-D ester and amine, when sown in a clipped blue grass sod which had been sprayed previously, as compared to being sown in a small grain stand given the same treatment. Yields of the sprayed plots indicated that the residual effect of 2,4-D had twice the duration in the small grain stand as in the blue grass sod.

Bolton and Coupland (1) found in an old established alfalfa seed field, rates up to 16 ounces per acre of M.C.P. amine and M.C.P. butyl ester, or 2,4-D amine and ester could be applied without reduction in seed yield, provided growth had not begun. Previous work indicated that these herbicides seriously affected the seed yield of alfalfa at more mature stages of growth.

Work done by Brown (2) indicated that if alfalfa is sown with a companion crop such as barley, and sprayed with as little as 3 ounces of 2,4-D butyl ester a 50% reduction in yield may be expected.

Results obtained by Pavlychenko (19) indicated 2,4 -D ester, 2,4-D amine ethyl ester or 2,4-D amine may be used as pre-emergent sprays in alfalfa and sweet clover fields at rates of 1, 2, and 3 pounds per acre with reasonably good germination of legume seeds. This method of weed control was found to be agronomically impractical because of an equally good germination of weed seeds. Mixtures of 2,4,5-T and 2,4-D ester likewise allowed equally good germination of the legume and weed seeds.

MATERIALS AND METHODS

This study was conducted on the Oklahoma Agricultural Experiment Station Agronomy farm located at Perkins. The soil was a fairly uniform Teller very fine sandy loam.

A seed bed was prepared by plowing under a stand of weeping lovegrass in the summer of 1953. The field was disked and cultipacked in the spring before planting. Three hundred pounds of 20% superphosphate were broadcast and worked into the soil prior to the seeding.

Commercial Korean lespedeza, with a germination of 80%, was sown March 28th at a rate of 20 pounds per acre. The seeds were sown in one foot rows with a Planet Junior garden seeder. Sowing of the Korean lespedeza was later than usual because of low soil moisture.

The design used in this experiment was a split plot randomized block replicated four times. Each replication consisted of ten plots which was divided into five sub-plots consisting of 4 rows, 24 feet long. The plots and sub-plots were both randomized in each replication. The four herbicides used in this experiment were 2,4-dichlorophenoxy acetic acid (isopropyl ester), dimethylamine 2,4-dichlorophenoxy acetate, 2,4,5-trichlorophenoxy acetic acid, (butyl ether ester), and the diethanolamine salt of 2 methyl 4-chlorophenoxy acetic acid. These herbicides contained 3.34,4 and 2 pounds of acid equivalent per gallon respectively, and were applied at the rate of $\frac{1}{2}$ pound acid equivalent per acre.

A knapsack sprayer equipped with a one foot boom, having two nozzles, number 65015, was used. The spray was applied at the rate of 40 gallons of water per acre. An air pressure of 30 pounds per square inch was maintained throughout the spraying process. Separate sprayers were used for

Fig. 1 - Replicated Plots of Korean Lespedeza being Treated with Various Herbicides at Ten Day Intervals.

M.C.P., 2,4,5-T and 2,4-D, thus eliminating chance for error in evaluating the different spray materials.

The plots were kept free of weeds by hand from time of emergence through harvest so that reduction in yield would be due to variances in spray tolerance and not through weed competition.

Ten spray applications were made at ten day intervals beginning at the 3 to 8 trifoliate stage through the pre-bloom stage. The two center rows of each sub-plot were sprayed. The outer two rows served to control drift and interplot competition. Spraying was done only when the wind was at a minimum so as to assure as uniform an application as possible.

Observations were made twice during each ten day interval, once two to three days after spraying and again immediately before the next spraying.

Forage yield plots were harvested with a hand scythe, beginning the 25th of August and was completed by the 28th of August. Eight feet from each of the two center rows were harvested as close to the ground as possible. The green weight in grams of forage from each plot was taken in the field. Before re-weighing the samples were placed in the dryer, which was set at 160 degrees F., for three days. The samples were weighed immediately after removing from the dryer and the per cent of dry matter calculated.

Seed yield plots were harvested with a hand scythe, beginning the 6th of November and was completed by the 13th of November. Eight feet from each of the two center rows were cut and placed in a paper bag. After allowing the seed to dry for a week each sample was threshed with a hammer mill. Each sample was then sieved by hand to remove most of the trash. An aspirator was then used to remove the chaff. The seed yield of each plot was recorded in grams and the pounds per acre of seed calculated.

RESULTS AND DISCUSSION

Environmental conditions produced results which deviated to some extent from the expected. No significant difference was noted in the treatment dates in forage or seed yield, as shown in Tables 1 and 2. A highly significant difference was noted in the various herbicides applied on the yields of seed and forage.

Low soil moisture in early spring delayed planting for three weeks. A relatively loose seed bed and lack of moisture resulted in a non-uniform emergence of the lespedeza.

Extremely low soil moisture and high temperature throughout the growing season reduced the yields of all plots. This may explain in part, at least, the surprisingly small difference in forage and seed yields at the different treatment dates.

The first treatments were delayed until the 3 to 8 trifoliate stage because it was known that all the herbicides used in this study would kill the plants in the earlier stages of growth.

A bluish cast was noted on plots sprayed with 2,4-D ester. This bluish appearance of the plants was particularly noticeable after the first sprays, and occurred in other plots sprayed with 2,4-D ester to a lesser extent as the plants became more mature. Brittleness of the leaves was noted shortly after applying the spray.

Plants sprayed with 2,4,5-T at a rate of ½ pound per acre appeared chlorotic approximately 3 days after spraying and eventually died. Actual death of the plant occurred within 3 to 14 days after spraying, depending upon the stage of maturity.

Forage yields shown in Table 2 indicate a relatively severe reduction in yield in all spray treatments applied when the plants were at the 3 to 8 trifoliate stage until a height of about 5 inches was reached. This was particularly true of plots sprayed with 2,4-D ester.

Yields in Table 2 indicate very little difference in plant tolerance to 2,4-D amine or M.C.P. at all stages of plant growth.

Spray applications made at a plant height of from 7 inches to the pre-bloom stage caused a severe yellowing and drying of the leaves. This was particularly noted in the plots sprayed with 2,4-D ester. No difference in the degree of injury could be distinguished at this time. Low soil moisture at this time caused the leaves of all the plants to dry and shed, making the extent of the damage by the different herbicides difficult to ascertain.

Forage yields of the last two herbicide treatments, as shown in Table 2, does not indicate as striking a reduction in yield as might be expected. This could probably be explained by the slight growth made from the date of application of the herbicides until harvest. Soil moisture was very low and shedding of the leaves could probably account for the slight difference between the treated plots and the check plot.

The effects of the herbicides upon seed and forage yields were significantly different. This was obvious by average mean yields and further substantiated by the statistical analysis. The forage yields ranged from 2,082 pounds per acre for those plots treated with 2,4-D ester to 2,653 pounds per acre on the non-treated or check plots. Seed yields ranged from 43 pounds per acre on 2,4-D ester treated plots to 85 pounds per acre on the check plot.

A slight to severe reduction in seed and forage yield occurred for all stages treated, regardless of the herbicides used. The least reduction in yield occurred when the lespedeza was sprayed at a height of 5 to 7 inches.

The lespedeza was more tolerant to M.C.P. than the amine formulation of 2,4-D, while the ester of 2,4-D was considerably more injurious than either of these herbicides; however, there was no statistical difference in yields of seed or forage at the various treatment dates. This might be expected since all plants were in the 3 to 8 trifoliate stage when the first treatments were applied. Applications of ½ pound of 2,4,5-T killed the plants in all stages of growth.

Table 1

Effect of Various Herbicides on Seed Yield of Korean Lespedeza Treated at 10 Day Intervals Beginning in the 3 - 8 Trifoliate Stage and Ending Just Prior to Blooming.

Material	Spray Periods 1	2	3	4	5	6	7	8	9	10	Mean
	Pounds of Seed per Acre										
Check	80	83	97	88	85	92	89	86	77	79	85.6
M.C.P.	64	67	74	73	70	77	77	71	56	55	68.4
2,4-D Amine	49	52	53	57	55	68	68	55	46	40	54.3
2,4-D Ester	38	35	40	54	43	59	59	41	41	31	44.1

Analysis of Variance from the Above Data.

Source of Variation	df	SS	MS	F
Blocks (Reps)	3	418	139	
Spraying Date	9	8284	920	.80
Error (A)	27	31149	1154	
Plots of Spraying Dates	39	39851	1022	
Sprays	3	38857	12952	212.3**
Sprays X Date	27	821	30	
Error (B)	90	5459	61	
Total	159	84988		
Spray Yields		48956		

** Highly Significant

Table 2

Effect of Various Herbicides on Forage Yield of Korean Lespedeza Treated at 10 Day Intervals Beginning in the 3 - 8 Trifoliate Stage and Ending Just Prior to Blooming.

Materials	Spray Periods 1	2	3	4	5	6	7	8	9	10	Mean
	Pounds of Forage per Acre										
Check	2619	2660	2658	2522	2517	2608	2880	2538	2775	2761	2653
M.C.P.	2294	2330	2477	2282	2343	2462	2776	2168	2582	2453	2416
2,4-D Amine	2292	2205	2300	2163	2268	2400	2443	1958	2476	2313	2281
2,4-D Ester	1923	1881	2073	1916	1933	2144	2407	1793	2478	2331	2086

Analysis of Variance from the Above Data

Source of Variation	df	SS	MS	F
Blocks (Reps)	3	362740	120913	
Spraying Dates	9	3790367	421151	1.70
Error (A)	27	6674526	247204	
Plots of Spraying Dates	39	10827633		
Sprays	3	6887879	2295960	114.8**
Sprays X Date	27	810011	30000	1.48
Error (B)	90	1819100	20212	
Total	159	20344623		
Spray Yields	39	11483257		
C.F. 889706413				

** Highly Significant

SUMMARY

Hot dry weather conditions throughout much of the growing season undoubtedly must be considered while interpreting the results of this study.

Korean lespedeza varied significantly in its tolerance to the herbicide applied. No significant difference was noted in time of application and the herbicide used.

In all stages of growth M.C.P. inhibited plant growth the least, followed by 2,4-D amine and 2,4-D ester. The plants were killed by 2,4,5-T in all stages of growth.

In the early stages of growth all herbicide applications resulted in a temporary twisting of the petiole and severe stunting of the plant. As the growing season progressed no immediate effect of the herbicide on the plant could be noted. Leaflets of young plants sprayed with 2,4-D ester were observed to have a bluish cast and were found to be brittle. This peculiarity of plots sprayed with 2,4-D ester became less noticeable as the plants reached the more advanced stages of growth.

The least reduction in seed and forage yields occurred when the plants were sprayed at a height of from 5 to 7 inches. At this time plants sprayed just prior to the pre-bloom stage became chlorotic shortly after spraying. This was true regardless of the herbicide applied. Lespedeza sprayed at the pre-bloom stage appeared to be particularly sensitive to 2,4-D ester as was indicated by the drying out and shedding of leaves. A severe reduction in yield of all treated plots indicated that Korean lespedeza is not tolerant to rates as high as $\frac{1}{2}$ pound acid equivalent per acre at the pre-bloom stage.

Little difference in the number of blossoms could be noted in plots sprayed at different treatment dates. In each spray period, however, most blossoms were noted in plots sprayed with M.C.P. followed by 2,4-D amine and 2,4-D ester. No difference in the time of blooming was noted regardless of the material used.

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APPENDIX

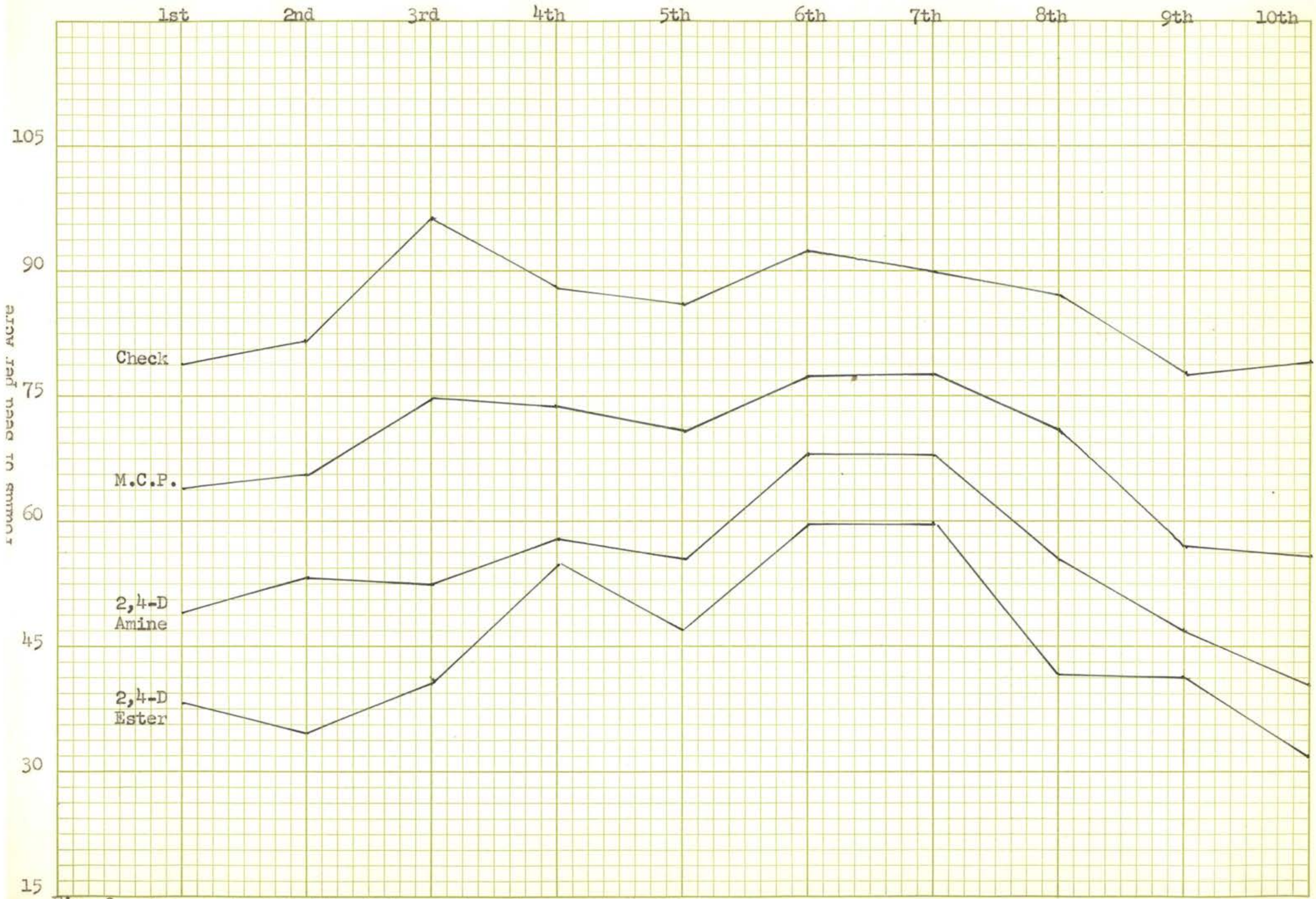

Fig. 2 - Average Seed Yields of Korean Lespedeza Treated with Various Herbicides at Ten Day Intervals Beginning in the

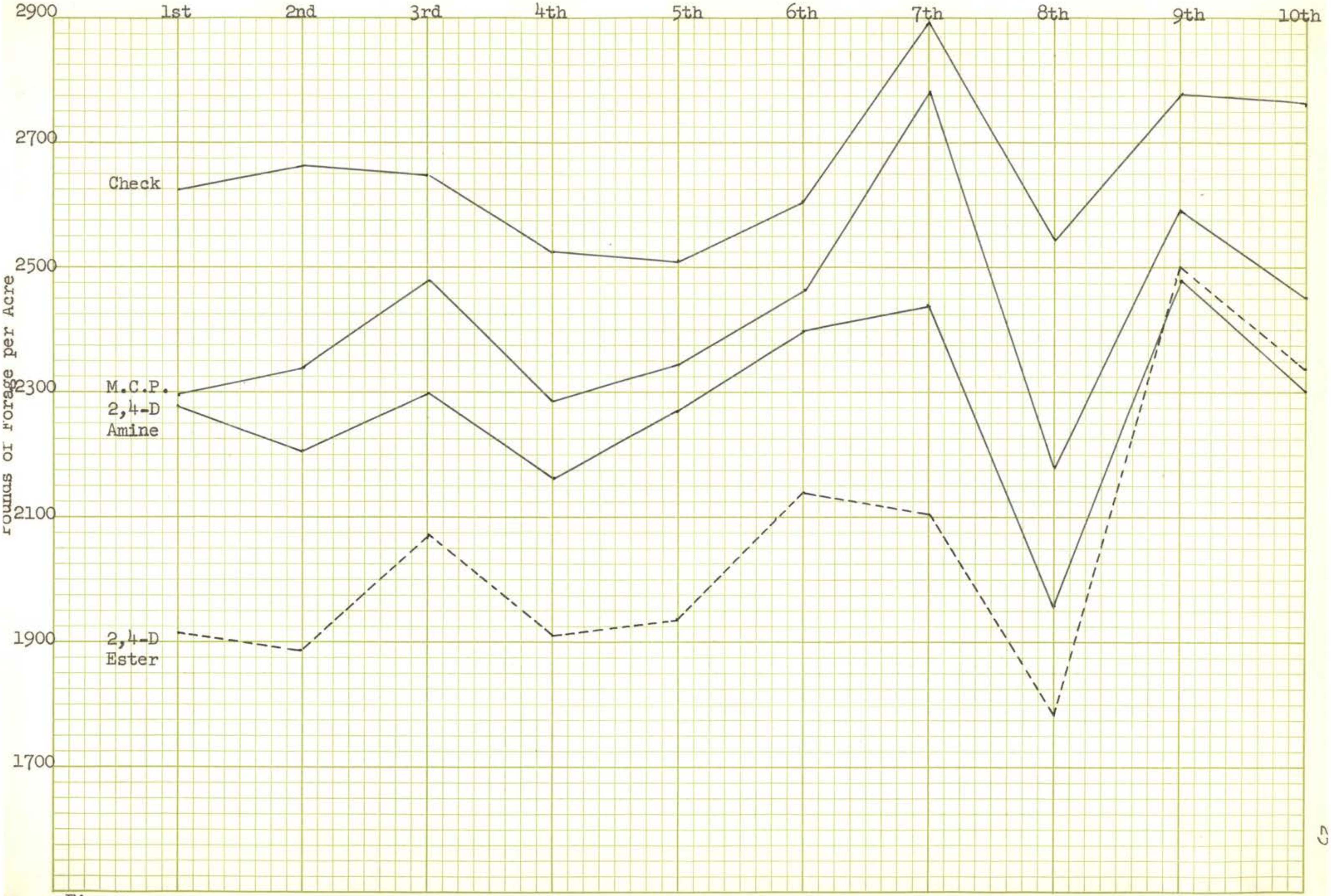

Fig. 3 - Average Forage Yields of Korean Lespedeza Treated with Various Herbicides ...

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