THE PERSISTENCE OF PROMETRYNE AND TRIFLURALIN

IN TWO OKLAHOMA SOILS

By

WILDON RAY SCHMIDT

Bachelor of Science

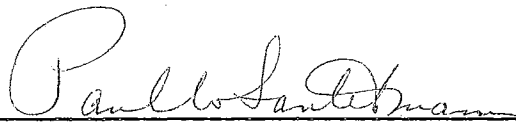Oklahoma State University

Stillwater, Oklahoma

1961

Submitted to the faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
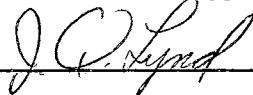for the degree of
MASTER OF SCIENCE
May, 1967

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Thesis Approved:

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Thesis Adviser

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Dean of the Graduate College

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ACKNOWLEDGEMENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

With the large number of herbicides now in use, the persistence of herbicides in soils is of great importance to agriculture. The combined influence of numerous factors determine the longevity of herbicide activity in soil. These include the amount and nature of the compound applied, climatic and edaphic factors, and differences in methods of application.

An ideal herbicide would selectively control undesirable species during the life of the crop plant but become totally inactive immediately after harvest. Unfortunately, some herbicides have the potential of persisting in the soil, particularly under repeated use, to the extent that subsequent crops may be injured. Therefore, a detailed evaluation of new herbicides is necessary to discover any such prolonged toxic properties. This particular study involved the field testing of two widely used herbicides in Oklahoma. It was conducted on two different soil types, with each experiment having a two-year duration. Valuable information concerning the rate of loss of herbicide toxicity may be obtained from field studies but the major modes of dissipation are difficult to determine. Phytotoxic behavior and persistence of soil-applied herbicides may be altered by leaching, adsorption, plant uptake or volatilization; or they may be broken down by microorganisms, chemical reactions or photo-decomposition.

1

The objectives of this study were: (1) to investigate the persistence and downward movement of the selected herbicides in two widely different soil types, and (2) to determine if residues were additive with repeated applications, providing such accumulations did exist.

CHAPTER II

LITERATURE REVIEW

As soil-applied herbicides, the major uptake of triazines and
toluidines by plants is by absorption through the roots. Plant selec-
tivity to soil-applied herbicides could involve three factors: (1) dif-
ferential absorption and placement, (2) absorbed but no action on the
biochemical systems, or (3) the ability of the species to metabolize or
detoxify the herbicide. Crafts (16) indicates that the rate of absorp-
tion may be a selectivity mechanism. He found that absorption rates in
barley decreased in the order of simazine, monuron, amitrole, and
dalapon. Therefore, roots must in some way discriminate between dif-
ferent organic molecules in much the same way as between inorganic ions
(17). Upchurch (56) feels that herbicide placement in relation to the
sensitive seed or plant organ greatly influences the selectivity of the
compound. In addition to affecting selectivity by its proximity to the
site of uptake, placement may also modify sensitivity by its influence
on leaching, photo-decomposition and volatility.

Simazine C^{14} is readily absorbed from nutrient solutions and moves
with the transpiration stream to the leaves where accumulations first
appear at the tips of oats leaves or the margins of cucumber (18, 48).
Atrazine has been shown by Ashton (3) to cause numerous cell disturb-
ances in red kidney beans, including the destruction of chloroplasts.
Photosynthesis is probably the most sensitive physiological system to

3

the phytotoxic action of triazines. Ashton (4) found a direct correlation between plant injury from atrazine and light intensity. Photosynthetic CO_2 fixation and sucrose formation were inhibited in the light but not in the dark (61). Moreland et al. (34) found that glucose nullified the reduced growth of barley seedlings caused by simazine. The activity on the Hill reaction in chloroplasts of susceptible and non-susceptible species is affected equally; consequently, the mechanism controlling selectivity apparently is located outside the chloroplasts (34, 35). Rudenburg et al. (46) found mitotic disturbances 24 hours after treatment in cells maintained in darkness, thus suggesting an explanation of the rapid killing action of triazines since the starvation from photosynthetic inhibition does not seem likely.

Probably the predominant factor in the selectivity of triazine herbicides is the ability of resistant species to metabolize or detoxify the chemical within the plant (13, 33, 38). Negi et al. (38) found that undegraded atrazine in plants roughly correlates with the degree of susceptibility. Atrazine and simazine are converted to nontoxic hydroxy analogs by corn and maize (13, 23, 38). The conversion of methylmercapto triazines to the 2-hydroxy compounds is less than with chloro-triazines (33, 36). Prometryne oxidizes to the sulphoxy and sulphono analogs which readily hydrolyze to 2-hydroxy propazine (36). Cotton, being tolerant to prometryne at relatively low rates, apparently does not detoxify the herbicide but accumulates the material in the lysigenous glands of roots, stems and leaves (59). Foy and Bisalputra (21), comparing glanded and glandless cotton, found the effects of lethal rates of prometryne were slightly reduced or their onset delayed in glanded cotton.

The use of trifluralin as a pre-emergence herbicide was first re-
ported by Aler et al. (1). Rizk et al. (44) found trifluralin to be
more effective when incorporated; as a result, its prominence has been
as a pre-plant herbicide. The toxic activity of this compound is sig-
nificantly greater when the susceptible species have germinated or are
in the process of germination (6). Apparently trifluralin inhibits
cell division in root tissue, but the precise mechanisms involved are
not known (53). Talbert (53) detected increases in the proportion of
cell nuclei during cell division two hours after treatment. After 24
hours, numerous large polynucleate cells were noted. He theorized the
principal mode of action of trifluralin as being interference in the
function of spindle fibers during the prophase stage of cell division.

Abnormal root growth in tolerant species is common. Initial tri-
fluralin damage to cotton begins with increased size and number of root
lesions which eventually causes the cortical tissue to be softened and
discolored (55). Increased susceptibly to soil-borne pathogens as a
result of trifluralin treatment has been suggested, although such an
interaction has not been established (51, 55). Injury symptoms in cot-
ton may be stunting, root pruning, especially lateral roots, leaf
chlorosis and occasional stem swelling in the crown area (55). Adverse
weather conditions tend to increase cotton injury from trifluralin (26,
51).

Oliver and Frans (39) concluded that only minimal root damage
occurred to cotton and soybeans if recommended rates were used. Stunt-
ing may result during the seedling stage but ultimate plant height and
yield of cotton does not appear to be influenced (52).

All of the organic compounds used as herbicides ultimately decompose in soils, but the time required for breakdown varies, thus influencing their relative degrees of safety for selective weed control. Decomposition involves not only the nature and amount of the compound added to the soil, but also the properties of the soil and environmental conditions. The several pathways which influence the persistence of triazines and toluidine herbicides are discussed as follows:

Adsorption

Adsorption implies the physical or chemical bonding of the herbicide to the colloidal surfaces, thus directly influencing the amount of herbicide in the soil solution. The adsorption of herbicides has been correlated with several soil factors, organic matter and clay content being the most important (9, 57). Talbert and Fletchall (54) found the order of increasing adsorption of five triazines as being propazine, atrazine, simazine, prometone and prometryne. Prometone and prometryne adsorption appeared to be related, although a correlation with water solubility was not apparent (54). Weber et al. (58) found that prometone was adsorbed within the clay lattice of montmorillonite but not of kaolinite. The bonding appeared to be of a physical nature since it was temperature dependent. As temperature increased, adsorption decreased (58). Talbert and Fletchall (54) have suggested that simazine adsorption is greatest in acid soils but data presented by Nearpass (37) does not indicate such a relationship (9, 27, 54).

Bardsley et al. (5) found that trifluralin toxicity increased as soil organic matter increased from 1.5% to 6%. They concluded that

trifluralin was retained in the vapor phase by the adsorption sites. Therefore, as the amount of exchange sites increase, so does the adsorption of trifluralin.

Leaching

Research workers generally agree that moisture is one of the major variables which seriously affect the performance of soil applied herbicides. The chemical, without solvation and movement into weed root zones, may be lost by volatization or photodecomposition. Excessive moisture can also result in reduced activity through leaching, especially with soluble compounds (2, 14, 40, 45). Ashton (2) found that downward movement was decreased when the herbicides were incorporated, although lateral movement was more extensive. Leaching studies with triazines showed a correlation between movement and clay and organic matter content (2, 10, 12, 14, 47). Burnside et al. (10) attributed less leaching in heavy soils to increased adsorption. Leaching of triazines according to Burnside et al. (10) is probably a direct function of their water solubility, although this is not in agreement with Talbert and Fletchall (54).

Leaching studies by Parka (40), and Shahied and Andrews (47) indicate very limited movement of trifluralin even in sandy soils. Significant leaching below the six-inch depth did not occur even with large quantities of water.

Volatility

Since the triazine herbicides are solids at room temperature, volatilization would not appear to be a significant pathway of herbicide

loss (10, 11). In contrast, Comes and Timmons (15) found that 65-80 per cent of the soil applied atrazine was non-toxic to oats after 60 days during which time soil temperatures ranged from 140-180° F. A relationship between reduced activity and soil temperature was suggested, although photodecomposition was included as a possible factor (8, 15). Kearney et al. (30) found volatility to be associated with soil type, moisture, and temperature. Greater losses of prometryne occurred at 45° C. from wet soil than dry soil, with the major portion being lost during the first ten hours after treatment. He found that approximately 25 per cent of the amount applied to a loamy sand was lost within 10 hours.

Trifluralin is highly volatile, thus necessitating incorporation (6, 41, 60). It becomes increasingly volatile as temperatures rise (31). Bardsley and others (5) concluded that the most logical mode of trifluralin dissipation was by vaporization which primarily depends on the degree of herbicide adsorption.

Plant Removal

Numerous workers have implied the removal of herbicides from the soil by plant uptake, including those reporting on the metabolic degradation of such compounds (21, 33, 38, 48, 59). The loss of simazine was much more rapid where Cirsium arvense infestation occurred (19). Ercegovich (20) reported similar findings when comparing quackgrass infested corn fields with bare ground.

Apart from the evidence that significant amounts of herbicides are taken up and metabolized by resistant and moderately resistant species, the amount of herbicide taken up by weeds which are killed must not be

overlooked (20). Ercegovich (20) concluded that herbicides are un-
doubtedly destroyed by whatever reactions in plants which are respon-
sible for their herbicidal action.

Photodecomposition

Sunlight, especially ultraviolet rays, has some deleterious effect
on a number of triazines, but the quantitative influence in relation to
temperature, moisture and air movement has not been established (15,
28). Jordon et al. (28) found an apparent decrease in the decomposition
rate of triazines with increased light exposure, thus providing the
basis for the theory that decomposition products may serve as a pro-
tective mechanism against further photodecomposition.

Incorporation has been shown to enhance the activity of triflura-
lin, thus indicating losses occurred from either volatilization or
photodecomposition. With a two-hour exposure to sunlight, Wright and
Warren (60) found a shift in the absorbence peak from 275 mμ to 270 mμ,
thus confirming losses from light rays. A gradual decrease in absorb-
ence was noted with time in both the unirradiated and exposed triflura-
lin. This phenomenon was attributed to volatilization (60).

Microbial Decomposition

The variation of microorganisms in soils is mostly quantitative
rather than qualitative. With few exceptions, the same types of soil
organisms, both morphological and physiological, occur in all soils,
with their activity and numbers being controlled by environment (7).

Although results are highly variable, slow micro-biological de-
composition of triazine herbicides has been reported by several

researchers (11, 12, 42, 43, 50). Hauck and Stephenson (24) found that thiomethoxy-s-triazines were degraded more rapidly than corresponding chloro-s-triazines, while results by Sheets (49) indicated approximately equal decomposition rates of both types of triazines under greenhouse conditions. Almost complete degradation of simazine within 12 days has been reported with the use of culture solutions of Aspergillus fumigatus (29). Other soil organisms reacted similarly except greater time periods were required. C^{14} chain labelled simazine was found largely in lipids, proteins and CO_2, whereas only insignificant amounts of ring-labelled simazine were incorporated into tissue and no C^{14}_2 was evolved (29). Only small amounts of $C^{14}O_2$ were detected by Macrae and Alexander (32) from simazine, atrazine and propazine treated soils after 16 weeks. Ipazine breakdown was recorded within 8 weeks (32). During the first 91 hours after treatment simazine degradation to $C^{14}O_2$ was rapid, followed by a sharp decline, suggesting that microbial activity was impaired, but not after a considerable delay (42). Burnside and co-workers (11) reported that soil microorganisms may require more than 30 days to adapt to simazine substrate depending on environmental conditions. The simazine side chains were decomposed by dealkylation, deamination, or both (11). It was also concluded that 2-hydroxysimazine was not an intermediate product (29). Harris (29) found the 2-hydroxy analog to be an important degradation product of 2-chloro-s-triazines.

Very little data has been published on the metabolism of trifluralin by soil microorganisms. Funderburk and co-workers (22) did not detect any decomposition products from soil treated with labelled trifluralin. Four species of fungi: Sclerotium rolfsii, Aspergillus niger,
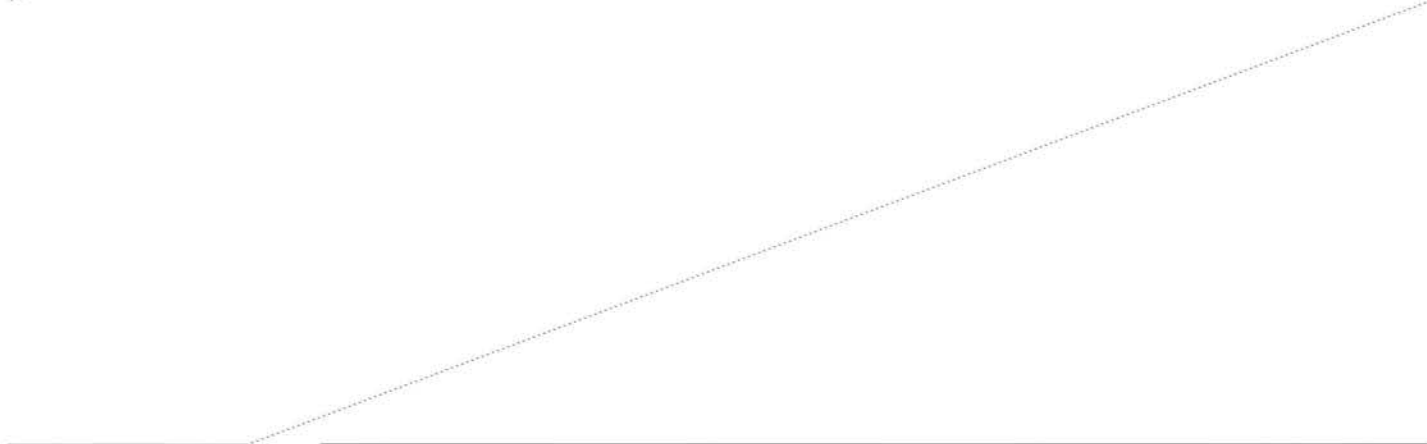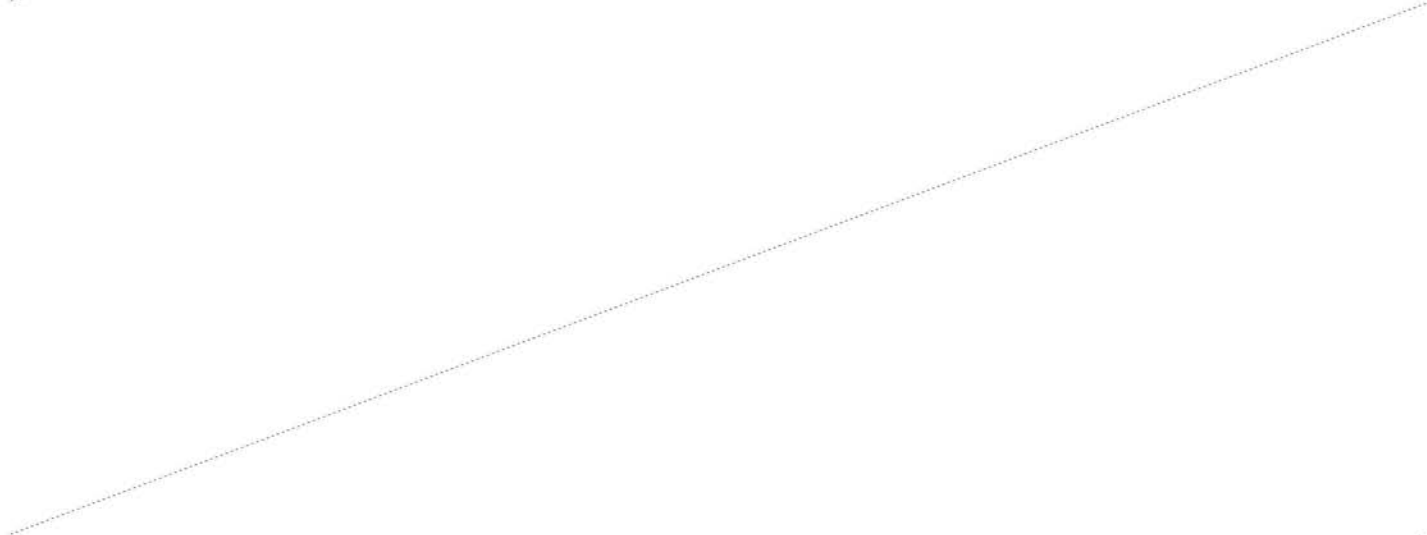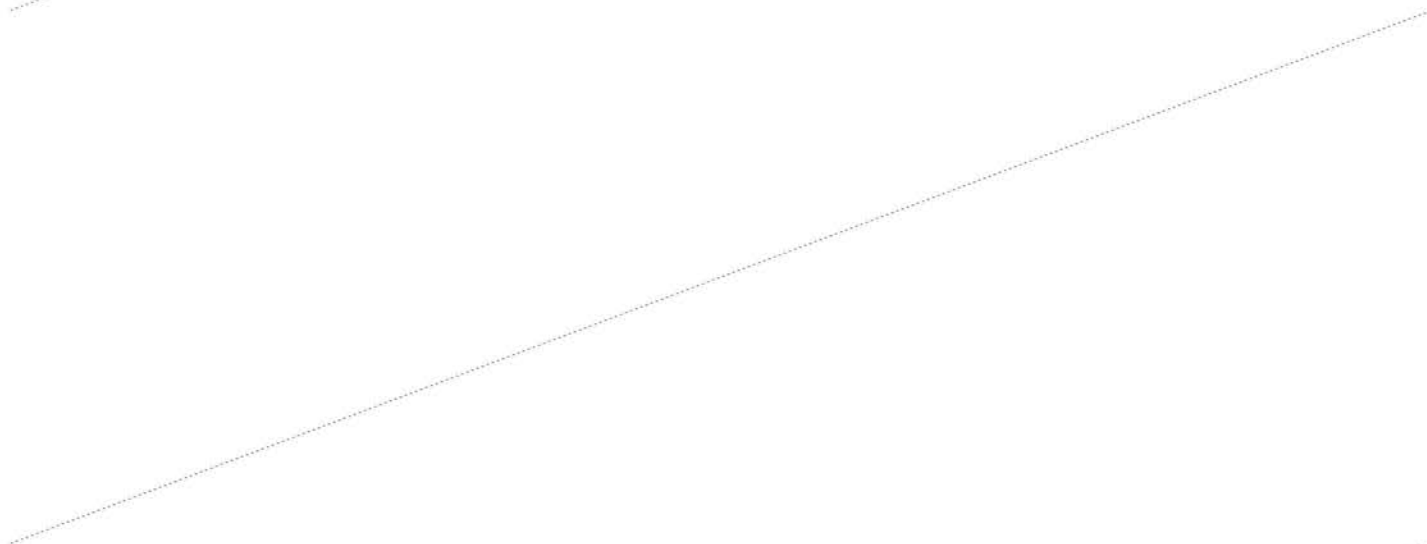
CHAPTER III

METHODS AND PROCEDURES

Research was conducted with prometryne {2-methyl-mercapto-4, 6-bis (isopropylamino)-s-triazine} and trifluralin (a, a, a,-trifluoro-2, 6-dinitro-N-N-dipropyl-p-toluidine). The rates of each herbicide are reported in pounds of active ingredient per treated acre, based on the rate used for weed control in cotton. The recommended rate of prometryne was 2 pounds per acre at Fort Cobb and 4 pounds per acre at Altus. The relative rates of trifluralin were 1/2 and 1 pound per acre, respectively. The higher clay and organic matter content in the Altus soil necessitated such variation for satisfactory weed control (Table I).

Field plots were established at Fort Cobb on a Cobb loamy sand soil and on a Tillman-Hollister silty clay loam soil at Altus. Each location was arranged in a split plot design with four replicates, with each subplot being 14 x 40 feet. Seven treatments, including the control, were used for each herbicide. The recommended rate, plus two and three times that amount, was applied in the spring, with three of the seven treatments receiving an additional application in late summer. Identical treatments were made the following season.

The plots at Altus received cumulative treatments the second year, but due to severe erosion at Fort Cobb near the end of the first year, the experiment was relocated. Therefore, the data presented from the

TABLE I

SOIL FERTILITY AND MECHANICAL ANALYSES

Fort Cobb

Organic Matter	.76%		meq/100 gm.			C. E. C.
Phosphorus	39.60 lb/A		Exchangeable Bases			meq/100 gm.
Potassium	460.00 lb/A	Ca	Mg	K	Na	5.28
PH KCL	5.6	2.3	1.52	0.64	0.23	
Paste	6.35					

Mechanical Analysis: % Sand 81.5   % Silt 7.5   % Clay 11.0   Loamy Sand

Altus

Organic Matter	1.5 %		meq/100 gm.			C. E. C.
Phosphorus	160.2 lb/A		Exchangeable Bases			meq/100 gm.
Potassium	1390.0 lb/A	Ca	Mg	K	Na	20.42
PH KCL	6.2	11.7	5.48	2.21	0.30	
Paste	6.9					

Mechanical Analysis: % Sand 15   % Silt 50   % Clay 35   Silty Clay Loam

Fort Cobb station is a comparison of two first-year studies with the initial test being under sprinkler irrigation.

All treatments were applied with an experimental-plot tractor sprayer with an output of 30 gallons per acre. A tandem disk was used to incorporate the trifluralin treatments at a depth of approximately 3 inches immediately after application. The disk was set between 4 and 5 inches deep to achieve the desired incorporation. The plots were not tilled again except just prior to subsequent treatments of prometryne or just after applications of trifluralin.

All plots were kept reasonably free of vegetation to eliminate un-equal herbicide removal by plant uptake, except during the fall and winter months. In September all plots were seeded to oats as a field bioassay in addition to providing ground cover.

Soil samples, taken at monthly intervals throughout the summer, were transferred to the greenhouse for bioassay residue analysis. Soil samples at three depths were obtained from three sites located at ran-dom within each subplot. The different depths were 0-3, 3-6, and 6-9 inches. The three samples taken from like depths within each subplot were consolidated, then subdivided after being mixed into three homo-geneous portions, thus eliminating sampling error and subplot variation. Therefore, at each sampling date, nine individual subsamples were taken from each subplot or 504 per location.

Six-ounce styrofoam cups, with small holes in the bottom, were used for sample containers during the bioassay period. Cucumber, Straight-8 variety, was used as the indicator species for prometryne, while German millet served as the measure for trifluralin residues. In preliminary studies, these species were effective in detecting the desired toxicity

range for each herbicide (Figure 5). Initially, each cup was planted
with excess seed, then thinned after one week of growth to either three
cucumber or five millet plants per cup. All cups were randomized with-
in each replicate, and surface watered as needed.

During the first season, bioassays were conducted in a greenhouse
with limited cooling facilities, which allowed some maximum day tempera-
tures to exceed 100° F., even with partial overhead shade. The follow-
ing summer, all bioassay determinations were made indoors with continu-
ous artificial light near 220 foot candles. The daily temperature
ranged from 79 to 82° F.

After three weeks of growth the above ground portion of the indi-
cator plants was harvested and after being oven-dried at 90° C. for 24
hours, dry weights in grams were recorded. As before, the three like
samples were consolidated prior to weighing to eliminate sample vari-
ation.

During the analysis, a large interaction was apparent between dates
and locations. Because of this, each location was analyzed separately.
In order to obtain orthogonality in the analysis, the check responses
were removed. Mean treatment weights are shown in the Appendix (Tables
III, IV, V, and VI). By doing this, independent comparisons between
treatments were possible. Then to assist in clarity, each treatment
was compared to the check response. These values are represented
graphically as a per cent of check and will be discussed in the follow-
ing section.

CHAPTER IV

RESULTS AND DISCUSSION

The Dissipation of Prometryne in Soils

at Fort Cobb and Altus

Two consecutive first-year prometryne studies were conducted on a
loamy sand at Fort Cobb. The results are shown in Figure 1. The bio-
assay response obtained from the first and second sampling dates were
averaged since the second application was not applied until after their
removal. Prometryne activity was shown to be extensive throughout the
top three inches of the profile. At the 2 pound rate there was little
persistence two months after application in both 1965 and 1966. A
slower rate of dissipation occurred in the upper soil layer during
1965. During the first year, all second application bioassays were
killed, while in 1966 only the 8 pound rate obtained equal toxic levels.
Irrigation of the 1965 study may have caused increased movement of this
unincorporated herbicide deeper into the soil profile. This could have
reduced its vulnerability to volatility and photodecomposition, if
volatilization does occur as reported by Kearney et al. (30). More
rainfall was also received in May and June of 1965 than during the
same period in 1966 (Table II). Prometryne movement into the 3 to 6
inch depth was greater in 1965 than 1966. The second application did
not have a significant effect on displacement into the second and third
depths during the sampling seasons. In fact, movement into the 6 to 9

1965   1966

0 - 3" Depth

3 - 6" Depth

6 - 9" Depth

Days after treatment   Days after treatment
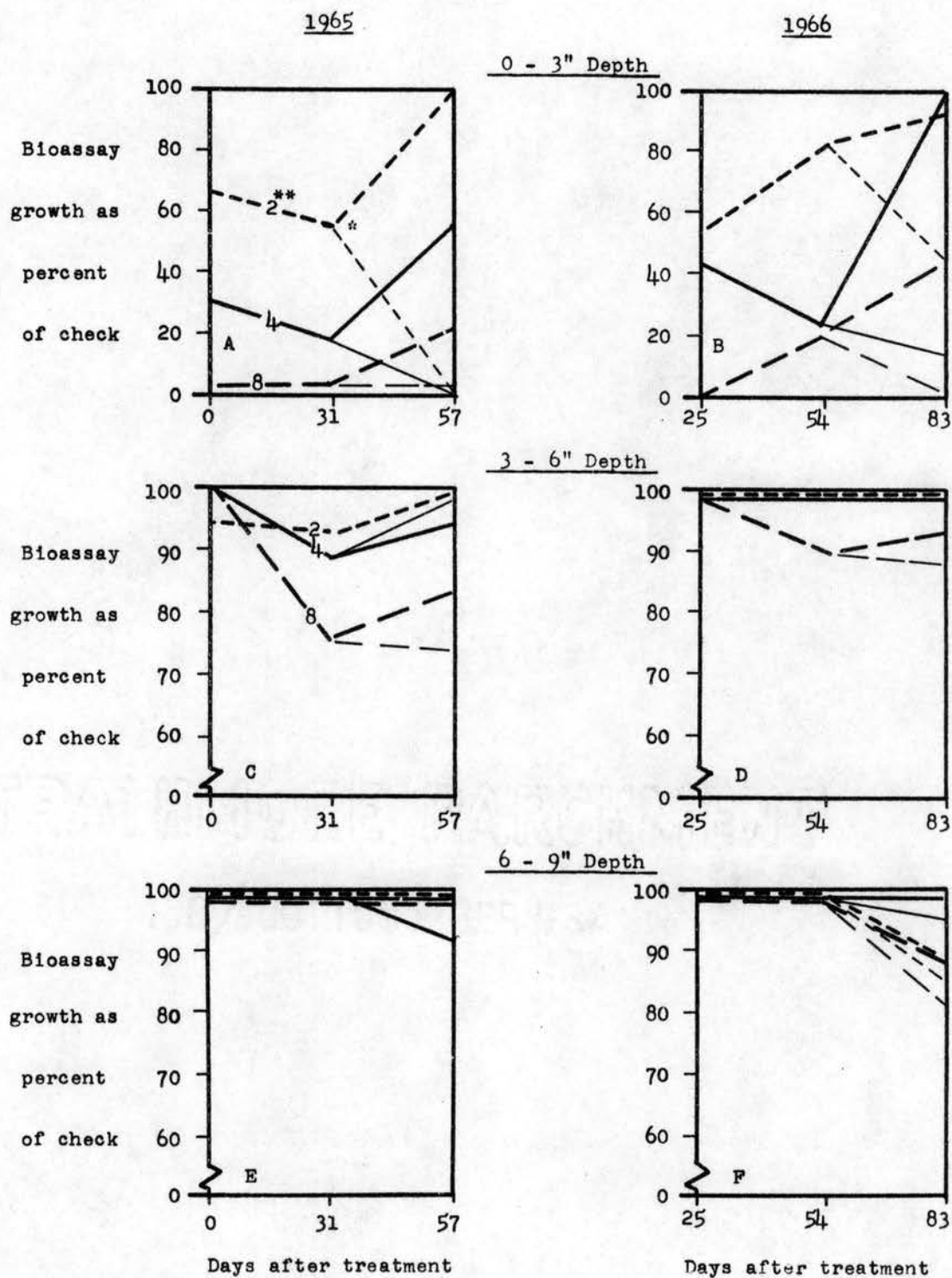
* Where line splits, the lighter portion indicated the second application.

** Figures in the graph represent pounds of herbicide per acre.

Figure 1. The Presence of Prometryne in Different Soil Layers at Varying Intervals After Treatment at Fort Cobb

TABLE II

MONTHLY PRECIPITATION TOTALS FOR 1965 AND 1966 AT FORT COBB AND ALTUS

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Total
						1965							
Fort Cobb*	0.81	0.78	1.02	4.24	4.06	4.90	0.25	2.93	5.13	1.74	0.01	2.97	28.84
Altus	0.52	0.57	0.41	1.16	4.43	2.78	1.24	5.27	9.00	4.53	T	1.77	29.91
						1966							
Fort Cobb*	0.50	2.45	0.84	2.76	0.79	2.82	0.04	7.41	2.98	0.45	0.16	0.67	21.87
Altus	0.51	0.74	0.87	1.80	0.15	0.54	1.26	5.81	3.47	0.57	0.09	0.19	16.00

*Rainfall measurements taken approximately 3 miles from study

inch depth was relatively minor during both sampling periods. Figure 1F does indicate some herbicide activity at the 6 to 9 inch level, although it is felt that this response resulted from an extremely high check value and not herbicide phytotoxicity. This is confirmed by the limited amount of prometryne detected in the layer immediately above this depth.

The recommended rate of 4 pounds per acre on the silty clay loam soil at Altus expressed considerably more herbicide phytotoxicity than the same relative rate of 2 pounds per acre at Fort Cobb (Figure 2). Prometryne was too active in the top three inches of soil to permit the detection of a possible variation with time over the two-year period. One year after treatment herbicide residues totally inhibited the growth of the bioassay species in the surface layer. These data reflect the toxic carry-over from the previous year's treatments.

The time of herbicide movement into the middle sampling layer at Altus was equal that found at Fort Cobb. The first evidence of herbicide toxicity in this portion of the profile was one month after treatment with the 16 pound rate. Subsequent sampling in 1965 from the 3 to 6 inch depth points out the presence of prometryne in relatively large amounts with some indication of dissipation at 88 days. Apparently, detoxification was minor since the June 1966 results do not confirm any sizeable degree of dissipation. The strong expression of prometryne toxicity in 1965, two months after treatment, may be the influence of 3.8 inches of rain 4 days prior to sampling (Table II). The first and second samplings in 1966 showed a response to both rate and application at the 3 to 6 inch level with definite evidence of dissipation. As in 1965, strong herbicide movement into this depth
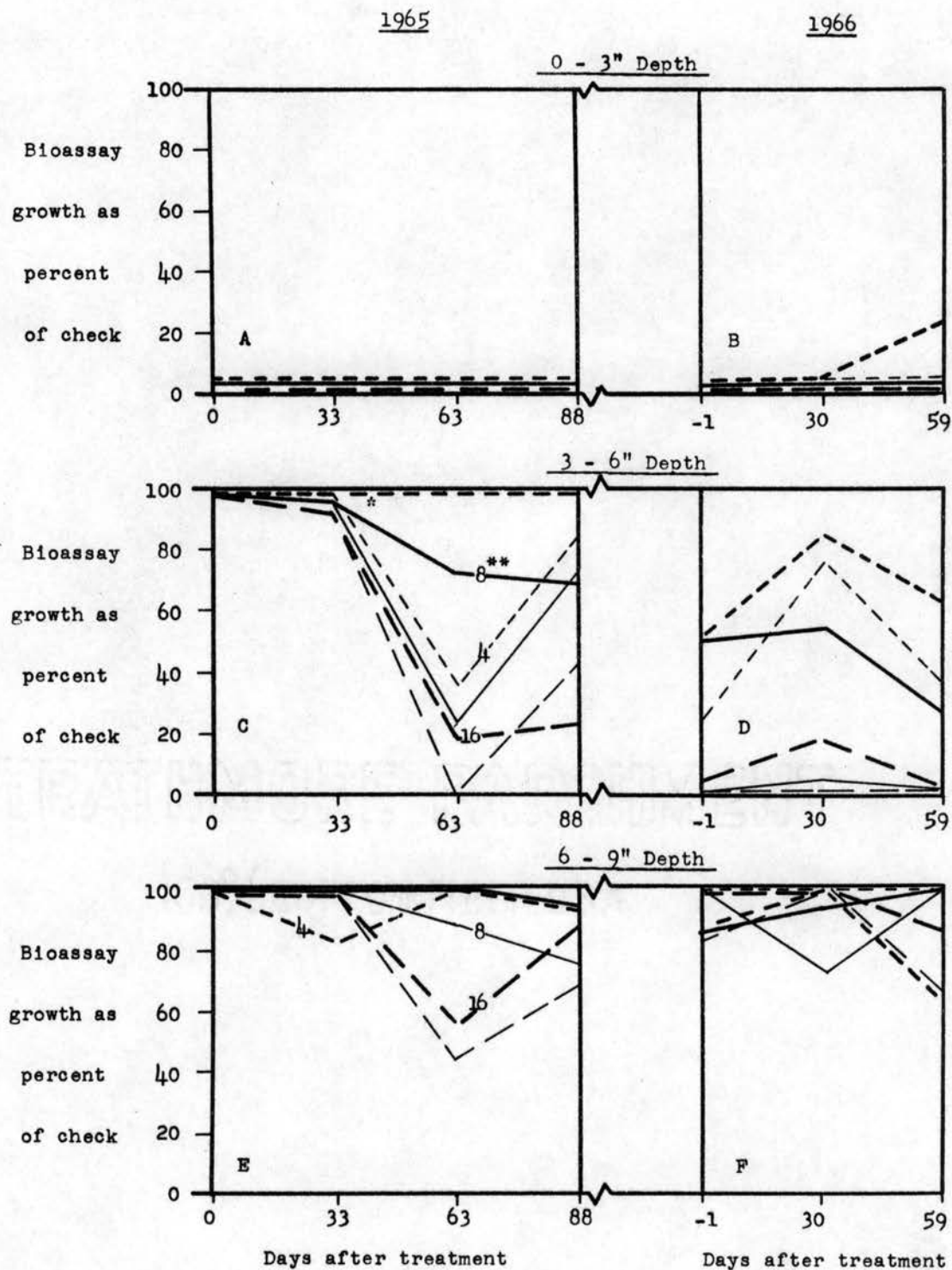
Figure 2. The Presence of Prometryne in Different Soil Layers at Varying Intervals After Treatment at Altus

occurred within two months after the first yearly treatment. Figure 2D
shows the prometryne accumulation in the center depth after two seasons'
treatments.

Prometryne movement into the 6 to 9 inch depth apparently was quite
inconsistent. The lack of uniformity throughout the study at this
depth is believed to be from the irregular maximum penetration depth
of prometryne. Figures 2E and 2F indicate the highest herbicide con-
centration at this level in the profile occurred two months after the
initial application during both sampling seasons. No appreciable resi-
due was present at the onset of the second summer.

The Dissipation of Trifluralin in Soils
at Fort Cobb and Altus

The 1966 trifluralin study at Fort Cobb was a separate experiment
and not a continuation of the 1965 plots. Therefore, the analysis will
be primarily a comparison of two first-year studies. The only pro-
cedural difference was the 1965 plots were irrigated while the follow-
ing year's study received only natural precipitation.

In the upper portion of the sampled profile, the plotted fluctu-
ations within each sampling season generally coincided with that of the
following year, except trifluralin seemed to be more lethal during 1966
(Figure 3). Persistence of the 1/2 pound rate was almost non-existent
one month after application in 1965 as compared to approximately 50 per
cent of the check at the same period the second season. There was al-
most total dissipation of the 2 pound rate three months after appli-
cation under irrigated conditions. During both sampling seasons, the
1/2 pound showed a decrease in trifluralin activity 30 days after

* Where line splits, the lighter portion indicates the second application.

** Figures in the graph represent pounds of herbicide per acre.

Figure 3. The Presence of Trifluralin in Different Soil Layers at Varying
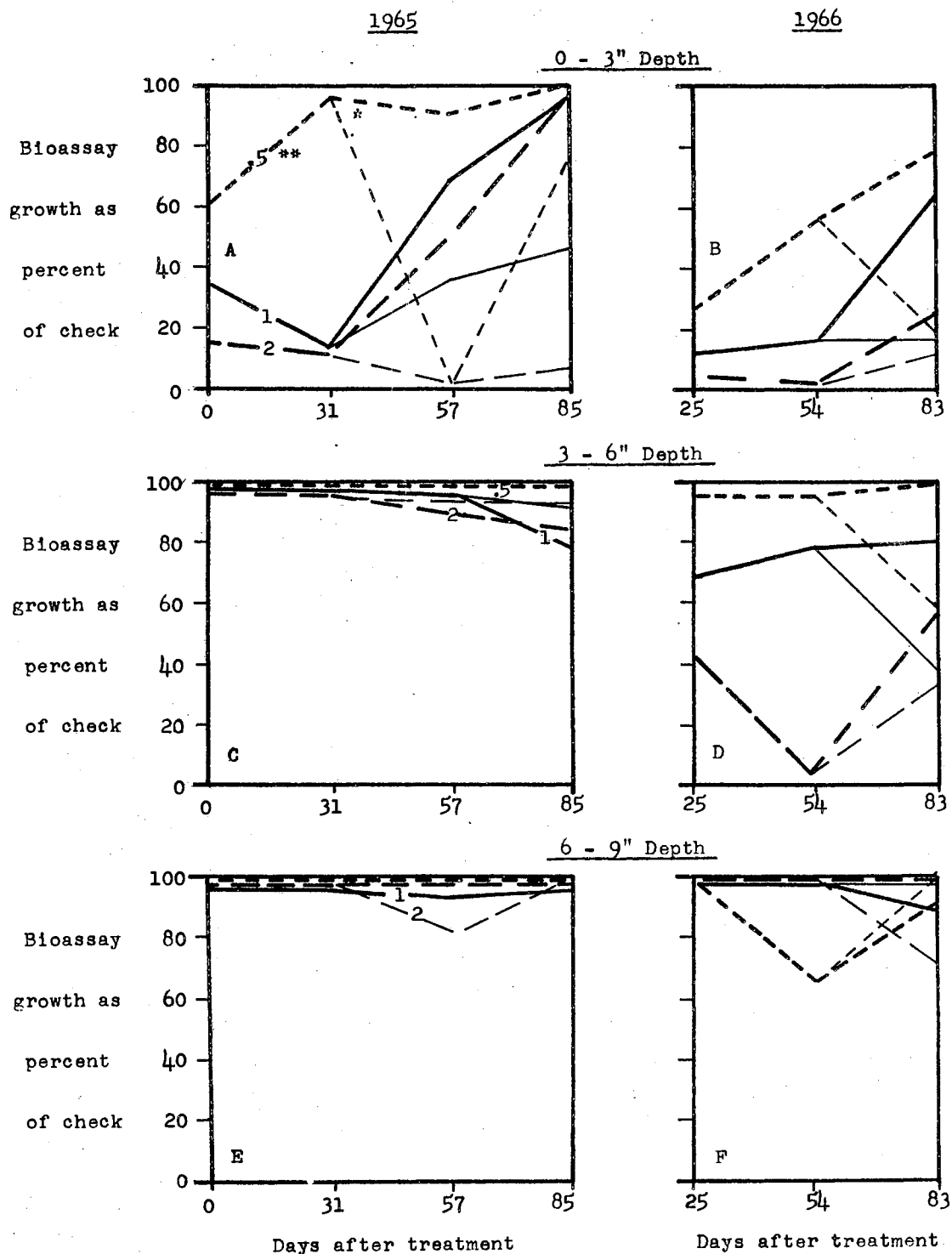Intervals After Treatment at Fort Cobb

treatment. This was not the case when higher rates of herbicide were used. Herbicide displacement into the 3 to 6 inch depth varied widely between years. During 1965, movement was not significant until 60 days after treatment; even then, its existence may have been a result of incorporating the second application. The 1966 data showed a sharp contrast by indicating prominent trifluralin activity two months after treatment, with initial detection being after 25 days. In the 6 to 9 inch depth, trifluralin was detected after 54 and 83 days. From the inconsistent results, it was concluded that the herbicide only penetrated the upper portion of this layer. It is felt that the non-irrigated conditions in 1966, in some way, enhanced trifluralin movement and persistence. Possibly, the increased void space resulting from less soil water during 1966, permitted deeper penetration of the vapor phase of the herbicide. Apparently, high soil water content reduces the downward movement of trifluralin.

Except for overall trends, the 1965 Altus data cannot be analyzed in detail since the coefficient of variation exceeded 50 per cent, thus making minor variations impossible to detect (Figure 4). Even by acknowledging this fact, it is still apparent that dissipation of trifluralin in the silty clay loam soil at Altus proceeded at a very slow pace. In fact, trifluralin residues almost totally inhibited growth of the bioassay species one year after treatment with the recommended rate of 1 pound per acre. Movement into the center portion of the sampled area seemed to be relatively minor in 1965, although some trifluralin activity was detected during the last two samplings. Figure 4 does indicate increased toxicity and drastic downward displacement during the winter months. Herbicide dissipation was not evident during the second

1965   1966

0 - 3" Depth

3 - 6" Depth

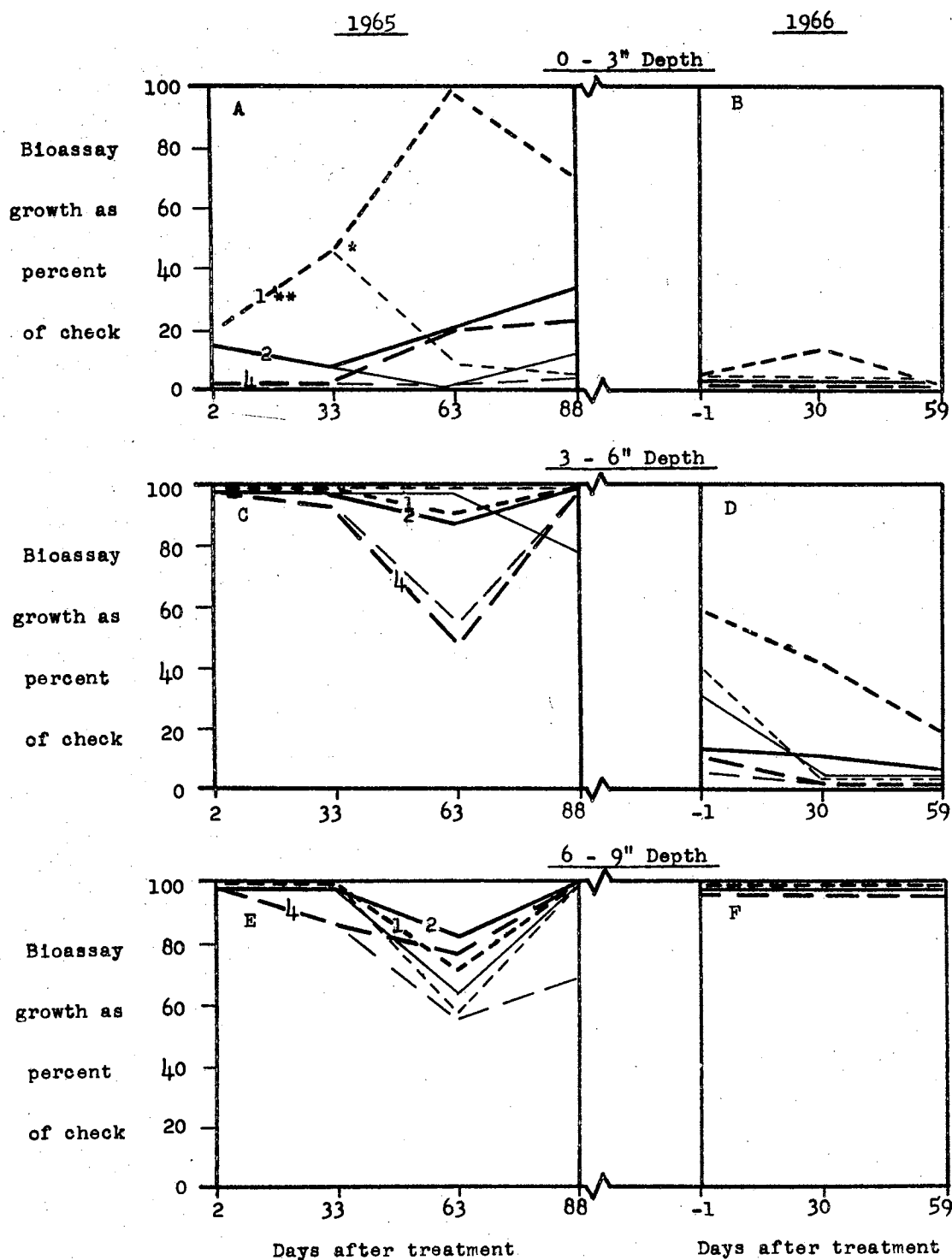6 - 9" Depth

Days after treatment   Days after treatment

* Where line splits, the lighter portion indicates the second application.
** Figures in the graph represent pounds of herbicide per acre.

Figure 4. The Presence of Trifluralin in Different Soil Layers at Varying
Intervals After Treatment at Altus

summer. The lack of detectable dissipation during 1966 may have re-
sulted from the extremely low annual rainfall (Table II). Significant
amounts of trifluralin were found in the 6 to 9 inch depth only once
during the two-year period and this was in August 1965. A possible
hypothesis would be the downward filtration of chemically treated sur-
face particles through the loose cloddy structure as a result of a 3.8
inch rain four days before sampling. During 1966, the deepest pene-
tration did not reach the lower level.

Even though a large interaction did exist between dates and lo-
cations, a comparison of the herbicide performance in the two soils can
be made. The rates used were in increments of the recommended rate
for cotton on each soil type. The amounts used for both herbicides at
Altus were double that applied at Fort Cobb for the corresponding rate.

Prometryne was more persistent in the upper portion of the silty
clay loam profile at Altus than the lighter textured Fort Cobb soil.
At both locations, displacement through the soil layers was dependent
to some degree on water movement.

Trifluralin activity in the 1966 dryland plots at Fort Cobb and
in the 1965 Altus study was very similar. Some movement into the 6 to
9 inch layer did occur within 60 days at both locations while decompo-
sition was evident within 80 days. The surface layer results of the
two 1965 trifluralin studies almost coincided for the first 60 days.
After that date, herbicide toxicity decreased rapidly at Fort Cobb but
remained relatively constant at Altus.

The sensitivity of both herbicides used varied greatly with soil
type (Figure 5). Under no conditions did the bioassay species respond
in a linear fashion. Greater concentrations were required to induce
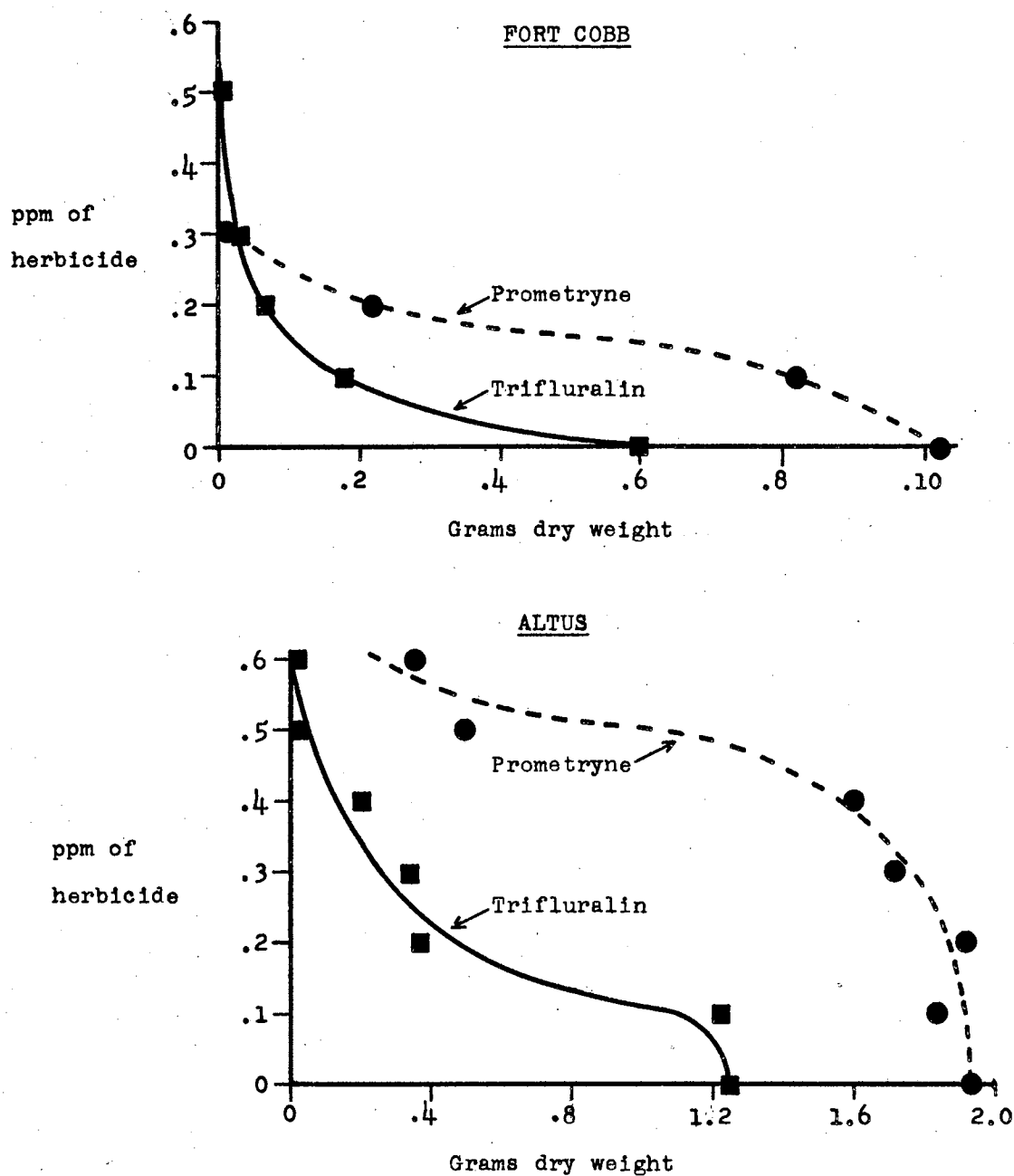
Figure 5. Bioassay Response to Known Rates of Herbicide

cucumber inhibition with the silty clay loam soil from the Altus station than the loamy sand soil at Fort Cobb. Detectable amounts of prometryne ranged from .2 ppm to slightly above .6 ppm at Altus as compared to less than .1 ppm to approximately .35 ppm at Fort Cobb.

Millet responded to a range of .2 ppm to .6 ppm at Altus and from near zero to .5 ppm on the loamy sand soil at Fort Cobb.

Within each response curve, regardless of the herbicide-soil combination, .1 ppm of herbicide resulted in at least 50 per cent of the growth inhibition. This fact may account for some of the wide variation reported in this study.

CHAPTER V

SUMMARY AND CONCLUSION

The dissipation of prometryne in the loamy sand soil at Fort Cobb
appeared to be complete 80 days after a single application of the rec-
ommended rate of 2 pounds per acre. Persistence and movement through
the soil profile were affected by the herbicide rate. As the amount
of herbicide increased, so did the longevity and degree of displacement.
Since prometryne does move with the soil water, the magnitude of herbi-
cide displacement hinged to some extent on the total precipitation.
Prometryne reacted similarly in the silty clay loam soil at Altus, ex-
cept detoxification progressed at a much slower rate. Damaging resi-
dues definitely were present one year after application of the rec-
ommended 4 pounds per acre. Its persistence in excess of one year was
not determined. Prominent movement into the lower sampling depths did
occur. It was equally as persistent at the 3 to 6 inch depth as in the
top three inches.

In the lighter textured soil, trifluralin detoxification was much
faster under irrigation than under dryland conditions. Dissipation of
the 1/2 pound rate seemed complete after 85 days when natural precip-
itation was supplemented. Since residue determinations were not con-
ducted one year after either the 1965 or the 1966 treatments, the
possibility of damaging residues cannot be disregarded. Movement into
the lower sampling depths was much greater during the drier conditions

of 1966. Only traces of trifluralin toxicity were detected below the

0 to 3 inch layer in 1965. At Altus, trifluralin was very persistent;

in fact, toxicity seemed to increase from the last sampling in 1965 to

the first determination in 1966, particularly in the top 6 inches of

the profile. Injury to susceptible crop species would be expected one

year after treatment with the 1 pound rate. The duration of this resi-

due in excess of one year was not determined. Appreciable movement

below 6 inches did not occur during the two sampling periods except in

August of 1965. It was concluded that this was due to the transport of

treated soil particles from the upper level to the lower depth by 3.8

inches of rainfall.

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APPENDIX

TABLE III

MEAN CUCUMBER RESPONSE TO PROMETRYNE TREATMENTS AT FORT COBB

Rate	Applications	1965 Days After Treatment			1966 Days After Treatment		
		0	31	57	25	54	83
		0 - 3" Depth					
0		1.108*	.927	.765	.686	.580	.517
2	1			.870			.477
2	2	.657	.530	.000	.368	.469	.235
4	1			.436			.497
4	2	.305	.175	.000	.311	.141	.082
8	1			.160			.228
8	2	.000	.000	.000	.006	.130	.000
		3 - 6" Depth					
0		.971	.985	.732	.637	.575	.494
2	1			.736			.504
2	2	.910	.911	.726	.628	.592	.504
4	1			.681			.549
4	2	1.104	.868	.690	.578	.621	.539
8	1			.617			.459
8	2	.985	.757	.547	.577	.513	.439
		6 - 9" Depth					
0		1.078	.910	.615	.663	.559	.578
2	1			.669			.514
2	2	1.279	.963	.625	.626	.583	.495
4	1			.565			.579
4	2	1.025	.923	.707	.624	.569	.554
8	1			.663			.513
8	2	.969	.931	.631	.578	.617	.470

*Dry weight in grams

TABLE IV

MEAN CUCUMBER RESPONSE TO PROMETRYNE TREATMENTS AT ALTUS

Rate	Appli-cations	1965 Days After Treatment				1966 Days After Treatment		
		0	33	63	88	0	30	59
				0 - 3" Depth				
0		.254*	.339	.503	.560	.788	.579	.450
4	1			.000	.000	.000	.010	.095
4	2	.006	.000	.000	.000	.000	.000	.000
8	1			.000	.000	.000	.024	.000
8	2	.000	.000	.000	.000	.000	.000	.000
16	1			.000	.000	.000	.000	.000
16	2	.000	.000	.000	.000	.000	.000	.000
				3 - 6" Depth				
0		.331	.374	.608	.670	.633	.664	.355
4	1			.754	.684	.331	.569	.223
4	2	.324	.460	.218	.573	.172	.514	.129
8	1			.435	.457	.327	.358	.099
8	2	.204	.474	.132	.486	.000	.039	.068
16	1			.116	.158	.032	.121	.007
16	2	.275	.344	.000	.295	.013	.000	.004
				6 - 9" Depth				
0		.297	.472	.714	.735	.730	.594	.397
4	1			.785	.686	.651	.638	.241
4	2	.475	.335	.711	.692	.773	.616	.426
8	1			.631	.687	.743	.442	.409
8	2	.328	.601	.714	.557	.647	.558	.456
16	1			.406	.658	.630	.707	.345
16	2	.190	.467	.327	.520	.747	.724	.262

*Dry weight in grams

TABLE V

MEAN MILLET RESPONSE TO TRIFLURALIN TREATMENTS AT FORT COBB

Rate	Appli-cations	1965 Days After Treatment				1966 Days After Treatment		
		0	31	57	85	25	54	83
0 - 3" Depth								
0		.111*	.112	.090	.073	.312	.233	.133
.5	1			.081	.078			.105
.5	2	.067	.108	.000	.056	.081	.130	.025
1	1			.065	.072			.086
1	2	.038	.015	.032	.033	.034	.038	.023
2	1			.046	.077			.034
2	2	.018	.014	.000	.005	.001	.000	.002
3 - 6" Depth								
0		.110	.099	.101	.938	.358	.259	.125
.5	1			.113	.092			.126
.5	2	.149	.113	.097	.087	.342	.244	.173
1	1			.105	.073			.102
1	2	.110	.112	.094	.087	.240	.204	.047
2	1			.089	.079			.076
2	2	.120	.115	.104	.073	.155	.017	.044
6 - 9" Depth								
0		.124	.135	.106	.100	.297	.295	.153
.5	1			.115	.098			.140
.5	2	.152	.150	.110	.094	.350	.194	.173
1	1			.100	.108			.134
1	2	.151	.130	.098	.089	.337	.294	.157
2	1			.086	.105			.156
2	2	.146	.139	.123	.101	.330	.360	.112

*Dry weight in grams

TABLE VI

MEAN MILLET RESPONSE TO TRIFLURALIN TREATMENTS AT ALTUS

Rate	Appli-cations	1965 Days After Treatment				1966 Days After Treatment		
		0	33	63	88	0	30	59
				0 - 3" Depth				
0		.260*	.216	.435	.183	.515	.171	.191
1	1			.447	.138	.026	.023	.000
1	2	.054	.107	.041	.008	.000	.000	.000
2	1			.092	.062	.000	.001	.000
2	2	.041	.018	.000	.023	.000	.000	.000
4	1			.089	.040	.000	.001	.000
4	2	.000	.000	.000	.007	.000	.000	.000
				3 - 6" Depth				
0		.213	.214	.520	.134	.402	.176	.148
1	1			.469	.174	.236	.072	.027
1	2	.175	.369	.524	.159	.154	.004	.000
2	1			.453	.136	.051	.019	.000
2	2	.265	.239	.523	.161	.103	.004	.008
4	1			.255	.137	.039	.000	.004
4	2	.283	.198	.268	.160	.025	.001	.000
				6 - 9" Depth				
0		.231	.231	.588	.166	.285	.116	.094
1	1			.417	.161	.378	.181	.153
1	2	.189	.232	.341	.180	.348	.165	.213
2	1			.481	.159	.346	.193	.220
2	2	.213	.481	.375	.163	.383	.119	.214
4	1			.447	.172	.453	.133	.136
4	2	.196	.195	.335	.115	.383	.196	.123

*Dry weight in grams

VITA

Wildon Ray Schmidt

Candidate for the Degree of

Master of Science

Thesis: THE PERSISTENCE OF PROMETRYNE AND TRIFLURALIN IN TWO
OKLAHOMA SOILS

Major Field: Agronomy

Biographical:

Personal Data: Born near Fort Cobb, Oklahoma, June 3, 1939, the
son of Dave and Lillie Schmidt.

Education: Attended grade school in Broxton, Caddo County,
Oklahoma; graduated from Apache High School, Apache, Oklahoma
in 1957; received the Bachelor of Science degree from
Oklahoma State University, with a major in Agricultural
Education, in May, 1961.

Professional Experience: Reared and worked on a farm near Apache,
Oklahoma, until after high school graduation; farm laborer
during the summers from 1958-1961; lieutenant in the United
States Army from 1962-1965; half-time graduate research
assistant, Department of Agronomy, Oklahoma State University,
1965-1967.

Member: American Society of Agronomy, Weed Society of America,
Phi Sigma and Sigma Xi.