SOME EFFECTS OF SELECTED HERBICIDES ON YOUNG PEACH (*Prunus persica*, Sieb. and Zucc.) TREES

by

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INTRODUCTION

The successful establishment of a peach orchard is closely associated with the growth of the trees during their first few years in the orchard. After the trees have been planted, one of the most important factors in stimulating growth is adequate control of weeds around the young trees. The use of chemicals for this purpose offers considerable promise and several advantages over the tedious and expensive methods of hand hoeing in areas where machine hoeing is impossible or difficult.

The value of practicing thorough weed control in commercial peach orchards has been recognized and appreciated from the earliest years of peach production. Although many cultural methods have been employed, the same end result is to decrease weed competition and allow for more tree vigor and optimum growth.

As proposed by Klingman (16), the following methods of weed control are of practical importance in commercial peach orchards: (1) mechanical, (2) crop competition, (3) crop rotation, (4) biological predators and diseases, and (5) chemical control. Mechanical methods include the practices of hand pulling, hoeing and spudding, tillage, mowing, flooding, and in the use of non-living smothering materials, such as plastics (28).

In past years, cultivation has been the most effective and economical weed control practice in tree-fruits, just as for other tilled crops. Cultivation is valuable as an aid to control troublesome perennial weeds before the new orchard is established.

Along with the many advantages of using cultivation are some of the following disadvantages which accompany them in orchard practice: (a) cultivation tends to tear up shallow feeder-roots cutting down on nutrient and water uptake by the trees, (b) cultivation, over a period of time, can change the structure of the topsoil so as to become undesirable, and (c) continuous cultivation can powder the topsoil and increase erosion by wind or change the structure to increase water erosion. This is particularly evident in many orchards on hillside sites (26).

Commercial growers are depending less and less on cultivation alone, but rather on the use of chemicals to supplement cultivation treatments. Sods, mulches, non-cultivation, plastics and soil sterilants have also been utilized by many growers with correspondingly wide variations in weed control results (8, 10, 16).

Not until within the last ten to twelve years has the control of weeds in commercial fruit orchards been practiced by the use of herbicides. Since then, much time and labor has been eliminated in the production of fruit as well as the benefit from monetary savings.

In the past, chemical weed control in fruit crops has received less attention than for most other crops. The author proposes that there are at least two reasons for this cleavage: (1) most orchard owners had not recognized the possible savings they could have made and (2) the commercial companies were developing herbicides for the more lucrative markets rather than for the smaller acreages of fruit crops.

Weed growth between tree rows and between trees in the rows can be effectively controlled by cultivation or mowing, but weeds in the areas near the trees are difficult to control. This is probably the most important area of weed control as the competition level between tree roots and weed growth is at the highest peak. Since cultivation is difficult near the base of trees and since it does severely prune the shallow feeder-roots of the trees, this is where herbicides will show the most promising effects (15).

The purpose of this study was to evaluate the effectiveness of several selective herbicides in controlling weed growth in young peach orchards and to determine their effect on the vegetative growth of the trees. Since peach trees are considered to be highly sensitive to herbicides, the effects of these chemicals on the growth of trees, whether stimulating or phytotoxic, were considered to be extremely important.

REVIEW OF LITERATURE

In many weed control studies with fruit crops, workers use two or more fruit crops in their research program (2, 11, 17, 20, 21, 22, 25). As in many previous weed control studies with fruit crops, young apple trees were used in this study along with the young peach trees.

In 1955, Hemphill (12) tested several chemicals as to their effectiveness in controlling weeds around young apple trees of the varieties Delicious, Golden Delicious and Jonathan. Of the chemicals tested, CPCPC (1-chloro-propyl-2) N-(3 chlorophenyl) carbamate at the rate of 14 pounds-per-acre gave excellent control of most weeds for the entire season without any detectable injury to the trees.

Studies conducted by Schubert and Amato (25) indicated that dalapon (2,2-dichloropropionic acid), monuron (N'- (4-chlorophenyl)-NN-dimethylurea), and amitrole (3-amino-1,2,4-triazole) were effective in killing or greatly reducing weed growth in young peach and apple orchards when used at higher rates of application. Dalapon and monuron were too phytotoxic for safe use around young peach trees in that area.

On June 20, 1963, Hemphill (13) sprayed simazine (2-chloro-4,6-bis (ethylamino)-1,3,5-triazine) and casoron (2,6-dichlorobenzonitrile) at the rates of 3 and 6 pounds-per-acre in an area 8 feet by 8 feet beneath the limb-spread of 4-year-old July Elberta peach trees. All vegetation was previously destroyed with a mechanical tree cultivator. Casoron was worked into the soil to a depth of approximately two inches by the use of the mechanical tree cultivator, while simazine was left on the soil surface.

The areas treated with casoron remained weed-free for the remainder of the season, whereas crabgrass (Digitaria spp.) was abundant in the simazine treated plots by mid-July. There was no appreciable rainfall after treatment. No visible injury was observed on the trees.

Saidak and Rutherford (23) observed that the growth of young apple trees was reduced by the application of 24 pounds-per-acre of either simazine or diuron (N'-(3,4-dichlorophenyl)-N-N-dimethylurea) over a two-year period. In the same period, the application of 30 pounds of amitrole had no effect on tree growth although some leaf chlorosis was observed. Adequate weed control was obtained for the growing season with a spring application of amitrole at 5 pounds-per-acre and diuron or simazine at 4 pounds-per-acre. These workers reported that application rates of diuron or simazine should not exceed 6 pounds per acre in order to avoid injury to the trees.

One-year-old apple trees were not injured by two 8 pound-per-acre applications of simazine (17). In addition, no symptoms of foliage injury were observed after a 6 pound-per-acre simazine application to two-year-old apple trees grown in sand culture.

In recent investigations under young apple trees, it was found that the mixtures of two herbicides provided longer-lasting control of weeds than the single herbicide applications (7, 14, 17). The most successful of these mixtures has consisted of a fast acting contact herbicide such as amitrole, amitrole-T (amitrole-ammonium thiocyanate) plus a herbicide with longer soil residual activity such as simazine or diuron.

In 1963, Ries, et al. (21) observed that in 3-5 year old apple, peach and cherry trees grown in Michigan, that the combination of simazine and amitrole-T at 4 and 2 pounds-per-acre and diuron and amitrole-T at 3 and 2 pounds-per-acre gave satisfactory weed control. In their testing of new chemicals they observed that the combination of linuron (N-(3,4-dichlorophenyl)-N'-methoxy-N'-methyl urea) and amitrole-T and prometryne (4,6-bis(isopropylamino)-2-methyl-thio-1,3,5-triazine) at 4 and 2 pounds-per-acre was as effective as the former chemical combinations when the July rating was made. All Herbicides tested were less effective in the apple orchard when worked into the soil. No crop injury was observed with any of the chemicals used.

Amling, et al. (2) concluded from tests in 1963 that paraquat (1,1'-dimethyl-4,4'-dipyridylium dichloride) treatments of 2 and 4 pounds of cation per acre applied in 200 gallons of water at 2-, 4-, and 6-week intervals gave satisfactory post-emergent weed control around two and four-year-old apple trees on Malling VII rootstocks and in two-year-old peach trees.

Diquat (1,1'-ethylene-2,2'-dipyridylium dichloride) treatment of the same dosage and time intervals were not as effective in controlling perennials (both grassy and broadleaved) and Dewberry (Rubus spp.) as paraquat. The combination of 3 pounds of paraquat and one pound of diquat gave equally good control as did paraquat alone. There appeared to be no beneficial effect from mixing the two chemicals at the rates used. No observable symptoms of injury were recorded during the growing season.

In 1963, Ries et al. (20) observed that simazine apparently influenced nitrogen nutrition of five-year-old peach trees of the varieties, Redhaven and Richaven, and of two-year-old apple trees of the varieties, Northern Spy, Golden Delicious on East Malling VII rootstock and Jonathan on EM II. The peach trees treated with simazine and amitrole-T had higher leaf nitrogen and more growth than trees where the weeds were controlled by hand hoeing or black plastic mulch. Apple trees had higher leaf nitrogen and more growth when treated with simazine and amitrole-T than with no weed control. In both peaches and apples, more growth (longer terminal growth and more lateral branches) and higher leaf nitrogen resulted from the herbicide treatments than from supplemental nitrogen treatments, indicating that the herbicide influenced the nitrogen metabolism of the trees. The nitrogen level in the soil was not measureably increased by the herbicide application.

Evidence is offered that the increased growth of peaches and apples observed in the past where herbicides have been applied, may do more than weed control. For this reason it appears that in Michigan fruit orchards, treated with herbicides, may need to be modified to take care of this apparent influence of herbicide treatments on nitrogen absorption and metabolism.

MATERIALS AND METHODS

On April 20, 1963, fifty one-year-old peach tree whips, of the variety Golden Jubilee, were planted at the Horticultural farm near Manhattan, Kansas. One tree was used in each plot. These whips were then trimmed back to a height of 30 inches. Rows in the young orchard were spaced 20 feet apart with a distance of 15 feet between each tree in the row.

The young orchard site is located in the Kansas River Valley and the soil is a sandy silt loam. No fertilizer applications were made in either 1963 or 1964. Irrigation water was applied on June 15 and August 2 in 1963, and on June 12 in 1964. A total of three inches of water was applied to the soil at each irrigation. All areas between the tree rows and between the trees in the rows were clean-cultivated, except for the treatment areas around each tree.

A total of eleven treatments was used, including the check, with four replications per treatment. A randomized complete block design was used in this study.

The treatments in the present study consisted of the following herbicides: dimethyl tetrachloroterephthalate (DCPA), NN-dimethyl-$\alpha\alpha$-diphenylacetamide (diphenamid), 2,6-dinitro-NN-di-n-propyl-$\alpha\alpha\alpha$-trifluroro-p-toluidine (trifluralin), 2-chloro-4,6-bis(ethylamino)-1,3,5-triazine (simazine), 2,6-dichlorobenzonitrile (casoron), 3-amino-1,2,4-triazole (amitrole), and 1,1'-dimethyl-4,4'-bipyridylium 2A (paraquat). The herbicides which were applied in 1963 and 1964 and their common and chemical names, active ingredients, times of application and rate per acre are listed in (Table 1).

All pre-emergent herbicides were applied in early spring of each of the two years before any weed growth had been initiated, with the exception of the two pre-emergent herbicides applied in the fall of 1963. All vegetation was removed before any of the pre-emergent chemicals were applied. The treatment areas beneath each tree were leveled in early spring for ease in application.

The sprayer used in this experiment was a hand compressed air type with a capacity of three gallons (7). Forty strokes were given to produce a normal spraying pressure of 40 pounds. A teejet nozzle which delivered a flat spray was used. One quart of water in which the actual chemical was dissolved was applied to each treatment area beneath the trees. The treatment area was 25 square feet (5' x 5') around the base of each tree in 1963 but was increased to 36 square feet (6' x 6') in 1964 due to the increased growth of the trees. Polyoxyethylene sorbitan monolaurate (Tween 20) was

Table 1. Herbicides which were applied in 1963 and 1964 to the same plots around young peach trees.

Chemical name	Temporary designations or Common Names	Active ingredient (per cent)	Time of Application	lbs./A
dimethyl tetrachlorotere-phthalate	DCPA	75.0 (Wet. Powd.)	Pre-emergence	12.0
NN-dimethyl-αα-diphenylacet-amide	diphenamid	80.0 (Wet. Powd.)	Pre-emergence	5.0
[1]2,6-dinitro-NN-di-n-propyl--trifluoro-toluidine	trifluralin	4.0 lbs./gal.(liq.)	Pre-emergence	0.5
2,6-dinitro-NN-di-n-propyl-ααα-trifluoro-toluidine	trifluralin	4.0 lbs./gal.(liq.)	Pre-emergence	1.0
2-chloro-4,6-bis(ethylamino)-1,3,5-triazine	simazine	80.0 (Wet. Powd.)	Pre-emergence	2.0
[2]2,6-dichlorobenzonitrile	casoron	4.0 (granular)	Pre-emergence	3.0
3-amino-1,2,4-triazole	amitrole	2.0 lbs./gal.(liq.)	Post-emergence	2.0
1,1'-dimethyl-4,4'-bipyridy-lium 2A	paraquat	2.8 pounds dichl-oride salt/gallon	Post-emergence	1qt.
NN-dimethyl-αα-diphenylacet-amide	diphenamid	5.0 (granular)	Pre-emergence	5.0
NN-dimethyl-αα-diphenylacet-amide	diphenamid	50.0 (Wet. Powd.)	Pre-emergence	7.5

[1]The rate of application was increased to 1.5 lbs./acre after the first application.

[2]The rate of application was increased to 6.0 lbs./acre after the first application.

added as an emulsifier to the contact herbicide--pre-emergent spray mixtures.

A composite sample, consisting of ten leaves per tree, was collected on October 25, 1963. Leaves were selected at random from the mid portion of primary and secondary branches. No leaves with damaged areas caused by insects or disease were selected for the composite samples. Individual leaves of each sample were measured in centimeters and weighed on the fresh weight basis. They were then immediately dried in an oven at 80°C. for 48 hours and the dry weights were then determined. Each composite sample was then thoroughly powdered by grinding in a Wiley mill with a 20 mesh sieve.

The total nitrogen content of the leaf samples was then determined by the Gunning modification of the Kjeldahl method (3) using boric acid in the receiving flask (24). Growth in total linear inches per tree, including both primary and secondary branches, was determined in February, 1964. Measurements were made after leaf abscission for easier determination. The diameters of the tree trunks were determined in centimeters at a height of 3 inches above the level of the soil. A similar composite sample was collected on July 10, 1964, but total nitrogen was the only determination made for the second growing season. Determination of terminal growth was made on July 25, 1964. The six uppermost primary branches were measured in centimeters and the averages of the six measurements was used in each tree sample.

All data was statistically analyzed as described by Snedecor (27).

EXPERIMENTAL RESULTS

Tree-Growth Studies

Since peach trees are considered to be highly sensitive to herbicides, the effect of these chemicals on the vegetative growth of the trees is important. Optimum vegetative growth is essential in newly established peach trees in order for fruit productiveness in later years.

Composite samples of leaves were collected on October 25, 1963, consisting of ten leaves per sample from each tree. These composite leaf samples were then used in the determination of differences in vegetative growth as influenced by the chemical herbicide treatments.

No significant differences were observed in fresh weights of the samples, as influenced by the various herbicide treatments although the differences between replications were significant, at the (0.05) level (Table 2).

Similarly, the dry weights of the composite samples were not significantly influenced by the herbicide treatments but the differences between replications were significant at the (0.01) level (Table 3).

Each leaf in the composite sample was measured in length and width and expressed in centimeters. No significant differences were observed in leaf-length as influenced by the herbicide treatments (Table 4). Leaf-widths, in centimeters, were also not significantly influenced by the herbicide treatments (Table 5).

Each tree in the test orchard was measured for growth in total linear inches during the month of February, 1964. Measurements included all primary and secondary branches. Growth in total linear inches per tree was significantly influenced by the application of herbicides at both the (0.05) and (0.01) levels of confidence (Table 6). The L.S.D. value was calculated and the average mean differences are given for each treatment (Table 7). All treatment mean values within the same bar did not differ significantly.

Tree plots which had been treated with simazine at 2 lbs./acre, diphenamid at 5 lbs./acre 5G, and the combination of DCPA + paraquat 12 lbs.,

Table 2. Analysis of variance of the fresh weights of composite peach leaf samples collected October 25, 1963, consisting of 10 leaves per sample.

Sources of variation	Df	Ss	Ms	F
Treatments	10	7.34	0.73	1.40 ns
Replications	3	4.90	1.63	3.13 *
Error	30	15.46	0.52	
Total	43	27.70		

* = Pr (F Computed F) .05
** = Pr (F Computed F) .01
ns = non-significant

Table 3. Analysis of variance of the dry weights of composite peach leaf samples collected October 25, 1963, consisting of 10 leaves per sample.

Sources of variation	Df	Ss	Ms	F
Treatments	10	1.17	0.117	0.56 ns
Replications	3	4.99	1.66	7.90 **
Error	30	6.22	0.21	
Total	43	12.38		

For explanation of *, **, see footnote of Table 2.
ns = non-significant

Table 4. Analysis of variance of peach leaf-length, measured in centimeters, for composite samples of 10 leaves collected from each tree on October 25, 1963.

Sources of variation	Df	Ss	Ms	F
Treatments	10	12.58	1.26	1.20 ns
Replications	3	8.49	2.83	2.69 ns
Error	30	31.48	1.05	
Total	43	53.55		

ns = non-significant

Table 5. Analysis of variance of peach leaf-widths, measured in centimeters, for composite samples of 10 leaves collected from each tree on October 25, 1963.

Sources of variation	Df	Ss	Ms	F
Treatments	10	0.69	0.069	0.19 ns
Replications	3	0.13	0.04	0.11 ns
Error	30	10.66	0.36	
Total	43	11.48		

ns = non-significant

Table 6. Analysis of variance of the total linear inch growth per tree including all primary and secondary branches measured at the end of the 1963 growing season.

Sources of variation	Df	Ss	Ms	F
Treatments	10	1809055.00	180905.50	7.24 **
Replications	3	498731.00	166243.60	6.60 **
Error	30	749407.20	24980.20	
Total	43	3057193.20		

For explanation of ** see footnote of Table 2.
L.S.D. at 0.05 level......... 224.0

Table 7. The average mean differences between four replications per treatment for the total linear inch growth per peach tree.

Treatments	total linear inches per tree*
Simazine 2 lbs./acre	1835
Diphenamid 5 lbs./acre 5G	1831
DCPA + paraquat 12 lbs., 1 qt./acre	1655
Simazine + Amitrole 2 lbs., 2 lbs./acre	1609
Diphenamid 5 lbs./acre 80w	1592
Diphenamid 7.5 lbs./acre 50w	1571
DCPA 12 lbs./acre	1466
Trifluralin 1.0 lb./acre	1399
Casoron 3 lbs./acre	1356
Check	1333
Trifluralin 0.5 lb./acre	1141

F = 7.24 significant at both (0.05) and (0.01) levels.
L.S.D. = 224
*All treatments within the same bar do not differ significantly.

1 qt./acre showed more linear growth than any tree plots receiving the other herbicide treatments. Weed growth had been permitted throughout the 1963 growing season in the check plots.

All herbicide treatments, with the exception of trifluralin at 0.5 lb./acre, resulted in more total linear growth than the check plots, however, many of the mean differences between herbicide treatments and the check plots were not significant.

Simazine at 2 lbs./acre indirectly influenced total linear growth of treated trees significantly more than the combination of simazine + amitrole applied at 2 lbs. each/acre. No significant differences were observed in linear growth of trees between the combination of DCPA at 12 lbs./acre and trees treated with the combination of DCPA + paraquat at 12 lbs./acre, and 1 qt./acre.

Trees receiving diphenamid at the rate of 5 lbs./acre 5G, had significantly more total linear growth than trees receiving diphenamid at the rates of 5 lbs./acre 80w, or diphenamid at 7.5 lbs./acre 50w. DCPA applied at 12 lbs./acre, trifluralin at 1.0 lb./acre, and casoron at 3 lbs./acre did not significantly influence total linear growth of the trees more than the tree plots which served as checks.

Trunk diameters of each tree were also measured in centimeters during the month of February, 1964. Trunk diameters were not significantly influenced by the herbicide treatments (Table 8).

Terminal growth measured in centimeters was taken on July 25, 1964. The six uppermost primary branches were measured and the average of these was used as total terminal growth per tree. Terminal growth was not significantly influenced by the herbicide treatments (Table 9).

Table 8. Analysis of variance of trunk diameters in centimeters per each tree measured at a height of 3 inches above the level of the soil.

Sources of variation	Df	Ss	Ms	F
Treatments	10	6.49	0.65	1.25 ns
Replications	3	2.95	0.98	1.88 ns
Error	30	15.50	0.52	
Total	43	24.94		

ns = non-significant

Table 9. Analysis of variance of the terminal growth in centimeters per tree of the six uppermost primary branches. Data collected on July 25, 1964.

Sources of variation	Df	Ss	Ms	F
Treatments	10	3564.9	356.5	0.870 ns
Replications	3	101.2	33.7	0.082 ns
Error	30	1230.6	410.2	
Total	43	4896.7		

ns = non-significant

Similarly, no significant differences were observed in the terminal growth of trees between the applications of simazine at 2 lbs./acre and diphenamid at 7.5 lbs./acre 50w, on November 5, 1963 (Table 10). These were the only two herbicides applied in the fall of 1963.

Table 10. Analysis of variance of the terminal growth in centimeters per tree of the six uppermost primary branches on trees receiving the fall application of simazine at 2 lbs./acre and diphenamid at 7.5 lbs./acre on November 5,1963.

Sources of variation	Df	Ss	Ms	F
Treatments	1	41.10	41.10	1.08 ns
Replications	2	51.70	25.80	0.67 ns
Error	2	76.40	38.20	
Total	5	169.20		

ns = non-significant

As observed from data collected, the only significant influence on the vegetative growth of the trees by the herbicide treatments was on the total linear growth per tree. Total growth is important and there is a close correlation between tree vigor and vegetative growth associated with the total linear growth of the trees.

Total Nitrogen Studies

The total nitrogen content of leaf tissue is another valuable means of evaluating the vegetative growth and vigor of young peach trees. This study was conducted to observe differences in the percent total nitrogen of leaf samples due to the influence of herbicide treatments.

Total nitrogen content was calculated from the composite leaf samples which were collected on October 25, 1963, at the end of the first growing season. None of the herbicide treatments significantly influenced the differences in total nitrogen content of the trees (Table 11).

Composite leaf samples were collected again on July 15, 1964, near the middle of the second growing season. The percent total nitrogen was then calculated and expressed as the percent nitrogen in a one gram sample of ground leaf tissue. The total nitrogen content of the trees was significantly influenced by the herbicide treatments (Table 12). Treatment means were significant at both the (0.05) and (0.01) levels of confidence. The L.S.D. was calculated to be 0.16 and the average mean differences are given for each treatment (Table 13). All treatment means within the same bar do not differ significantly.

Trees on plots treated with trifluralin at 1.5 lbs./acre, simazine at 2 lbs./acre, and diphenamid at 5 lbs./acre 5G, contained the most total nitrogen per sample, but the differences between the treatment means of these chemicals were not significant.

Tree plots to which simazine had been applied at 2 lbs./acre contained more total nitrogen than the combination treatment of simazine + amitrole applied at 2 lbs. each/acre. The differences were significant. Tree plots to which casoron had been applied at 6 lbs./acre contained significantly more total nitrogen than either DCPA at 12 lbs./acre or diphenamid at 5 lbs./acre 80w. Tree plots receiving the combination of DCPA at 12 lbs./acre + paraquat at 1 qt./acre contained significantly higher total nitrogen content than the single application of DCPA at 12 lbs./acre.

Table 11. Analysis of variance of the percent total nitrogen expressed as mg./1 gm. sample of the total composite sample of peach leaves collected on October 25, 1963, and consisting of 10 leaves per sample per tree.

Sources of variation	Df	Ss	Ms	F
Treatments	10	0.22	0.02	0.57 ns
Replications	3	0.21	0.07	2.00 ns
Error	30	1.04	0.035	
Total	43	1.47		

ns = non-significant

Table 12. Analysis of variance of the percent total nitrogen expressed as mg./1 gm. sample of the total composite sample of peach leaves collected on July 15, 1964, consisting of 10 leaves per sample.

Sources of variation	Df	Ss	Ms	F
Treatments	10	0.58	0.058	4.83 **
Replications	3	0.06	0.020	1.66 **
Error	30	0.36	0.012	
Total	43	1.00		

For explanation of ** see footnote of Table 2.

L.S.D. at (0.05) level......... 0.16.

Table 13. The average mean differences between four replications per treatment of percent total nitrogen expressed as mg. N/1 gm sample of the total composite sample consisting of 10 leaves per tree. Samples were collected on July 15, 1964.

Treatments	Total nitrogen (per cent)*
Trifluralin 1.5 lbs./acre	3.71
Simazine 2 lbs./acre	3.70
Diphenamid 5 lbs./acre 5G	3.56
Casoron 6 lbs./acre	3.53
DCPA + Paraquat 12 lbs., 1 qt./acre	3.51
Simazine + Amitrole 2 lbs., 2 lbs./acre	3.47
Check	3.44
Diphenamid 7.5 lbs./acre 50w	3.44
Trifluralin 1.0 lb./acre	3.41
DCPA 12 lbs./acre	3.36
Diphenamid 5 lbs./acre 80w	3.36

F = 4.83 significant at both (0.05) and (0.01) levels.
L.S.D. = 0.16
*All treatments within the same bar do not differ significantly.

All treatments, with the exception of trifluralin at 1.5 lbs./acre and simazine at 2 lbs./acre when applied to tree plots, did not differ significantly from the check plots in total nitrogen content. The check plots were kept weed-free by means of hand-hoeing throughout the 1964 growing season.

Simazine at 2 lbs./acre and diphenamid at 7.5 lbs./acre 50w, were applied to tree plots on November 5, 1963. On July 15, 1964, composite leaf samples were collected from these trees and the total nitrogen content was calculated. The total nitrogen content of tree plots treated in the fall with simazine at 2 lbs./acre were not significantly different from the plots treated with diphenamid at 7.5 lbs./acre. (Table 14).

No significant differences in total nitrogen content were observed at the end of the first growing season but differences were significant in samples collected from trees near the middle of the second growing season after the young peach trees had been established.

Table 14. Analysis of variance of the percent total nitrogen of leaf samples collected on July 15, 1964, from trees treated with simazine at 2 lbs./acre and diphenamid at 7.5 lbs./acre 50w, on November 5, 1963.

Sources of variation	Df	Ss	Ms	F
Treatments	1	0.11	0.11	1.57 ns
Replications	2	0.03	0.015	2.14 ns
Error	2	0.14	0.07	
Total	5	0.18		

ns = non-significant

Weed Control Studies

Weeds compete with crops for water, light and mineral nutrients. The greatest loss caused by weeds results from their competition with crops for these three essential requirements. The reduction in yield of all farm, orchard, and garden crops due to weed competition is estimated at about 10 per cent of their total value (10).

The weed species most prevalent in the test orchard were: yellow nutgrass (Cyperus esculentus), goosegrass (Eleusine indica), green foxtail (Setaria viridis), yellow foxtail (Setaria lutescens), lambsquarter (Chenopodium album), kochia (Kochia scoparia), rough pigweed (Amaranthus retroflexus), three-seeded mercury (Acalypha virginica), velvet leaf (Abutilon theophrasti), climbing milkweed (Ampelamus albidus), ivy-leaved morning glory (Ipomoea hederacea), annual morning glory (Ipomoea purpurea), and henbit (Lamium amplexicaule).

Weed species less prevalent in the test orchard were: horsenettle (Solanum carolinense), barnyard grass (Echinochloa crusgalli), and puncture vine (Tribulus terrestris). Two of the tree plots were infested with johnsongrass (Sorghum halepense). This infestation was probably due to wind-borne seed originating from an adjoining field of sudangrass which was heavily infested with johnsongrass.

In 1963, weed counts were made on August 1, by making three counts per tree plot in an area of 4 square feet. The average count was then determined for each tree plot. Consideration in evaluation was also given to height and size of the weed species infesting the plot area. A summary of the 1963 weed control observations are given (Table 15).

Table 15. Weed control observations made on August 1, 1963. Each tree was rated from 1 to 10 with respect to weed control. Lowest rating values denote best weed control. Rating values from 4.0 to 5.0 were considered as fair weed controls.

Treatments	I	II	III	IV	Average	Final Rating
Simazine + Amitrole 2,2 lbs./A	1	4	1	2	2.0	1
Simazine 2 lbs./A	3	1	3	5	3.0	2
Diphenamid 5 lbs./A	3	3	4	3	3.7	3
DCPA + Paraquat 2 lbs., 1 qt./A	4	4	3	4	3.7	3
Diphenamid 7.5 lbs./A 50w	4	4	4	4	4.0	4
Casoron 3 lbs./A	4	4	6	3	4.2	5
DCPA 12 lbs./A	7	4	3	4	4.5	6
Trifluralin 1 lb./A	7	6	5	6	6.0	7
Trifluralin 1/2 lb./A	9	8	9	5	7.7	8

These weed control observations were made sixteen weeks after the application of the pre-emergent herbicides. The two post-emergent herbicides, amitrole and paraquat were applied on June 20, 1963. Each replication of each treatment was rated on a scale ranging from 1.0 to 10.0 with the lowest value representing the best weed control. Values ranging from 4.0 to 5.0 were considered to be fair weed controls.

Of the chemicals tested in 1963, the combination treatment of simazine + amitrole applied at 2 lbs. each/acre gave the best weed control. Simazine applied at 2 lbs./acre also gave excellent weed control. Diphenamid at 5 lbs./acre and the combination treatment of DCPA + paraquat at 12 lbs., 1 qt./acre were rated at equal values in controlling weeds. Diphenamid at 7.5 lbs./acre and casoron at 3 lbs./acre gave fair weed control. DCPA, when applied at the rate of 12 lbs./acre gave poor weed control as did trifluralin at both the 0.5 and 1.5 lbs./acre application rates.

The rate of application for casoron was increased from 3 to 6 lbs./acre, in 1964, as only fair weed control was observed in the 1963 growing season. The application rate for trifluralin was increased from 0.5 to 1.5 lbs./acre in 1964, as it too, gave only fair to poor weed control.

Weed control observations, in 1964, were made on June 25, eight weeks after the pre-emergent herbicides were applied on April 25. The two contact herbicides were applied on June 4, and weed control observations were made on these plots three weeks later.

Weed counts were made in three different areas in each plot and each area consisted of two square feet. The average of these three count areas, selected at random, was then determined in order to rate each of the four replications per treatment as to effective weed control. Weed control ratings for each treatment are summarized (Table 16). Lowest rating values denote

Table 16. Weed control observations made on June 25, 1964. Each tree was rated from 1 to 10 with respect to weed control. Lowest rating values denote best weed control. Rating values from 4.0 to 5.0 were considered as fair weed controls.

Treatments	I	II	III	IV	Average	Final Rating
Simazine + Amitrole 2,2 lbs./A	1	2	1	3	1.8	1
Simazine 2 lbs./A	2	4	3	1	2.5	2
Simazine 2 lbs./A (Fall Treatment)	2	2	4	-	2.6	3
Casoron 6 lbs./A	1	5	2	4	3.0	4
Trifluralin 1.5 lbs./A	6	4	1	2	3.3	5
DCPA + Paraquat 2 lbs., 1 qt./A	6	3	4	5	4.5	6
Diphenamid 7.5 lbs./A 50w (Fall Treatment)	6	5	3	-	4.6	7
Diphenamid 5 lbs./A	6	5	6	4	5.3	8
Diphenamid 7.5 lbs./A 50w	7	4	8	5	6.0	9
DCPA 12 lbs./A	7	6	7	5	6.3	10
Trifluralin 1 lb./A	9	9	5	8	7.8	11

best weed control and rating values from 4.0 to 5.0 are considered as fair weed controls.

As in 1963, the combination of simazine + amitrole applied at 2 lbs. each/acre gave the best weed control in 1964 (Plate I, Fig. 1). This weed control was evident until August 1, when the last observations were made. The spring application of simazine at 2 lbs./acre gave better weed control than when it was applied in the fall of 1963 at 2 lbs./acre (Plate I, Fig. 2). Casoron, after the rate of application was increased to 6 lbs./acre, gave good weed control (Plate II, Fig. 1). Check plots were kept weed-free throughout the 1964 growing season by means of hand hoeing (Plate II, Fig. 2). Trifluralin also gave good control of weeds after being increased to 1.5 lbs./acre in 1964 (Plate III, Fig. 1).

All formulations of diphenamid at 5 and 7.5 lbs./acre gave fair to poor weed control in 1964, (Plate III, Fig. 2) (Plate IV, Fig. 1 and 2) but the fall application in 1963 of diphenamid at 7.5 lbs./acre, 50w, gave the best weed control on tree plots treated with this chemical (Plate V, Fig. 1). The combination treatment of DCPA + paraquat at 12 lbs., 1 qt./acre gave fair weed control (Plate V, Fig. 2). Not all of the prevalent weeds were controlled and control was erratic. New weed growth began soon after application. DCPA at 12 lbs./acre gave poor weed control (Plate VI, Fig. 1) as did trifluralin at 1.0 lb./acre (Plate VI, Fig. 2).

In 1964, the combination treatment of simazine + amitrole applied at 2 lbs. each/acre gave excellent control of all weed species (prevalent in the tree plots) as did simazine applied at 2 lbs./acre. Casoron gave good control of most weed species. Trifluralin applied at 1.5 lbs./acre gave good control of most weed species with the exception of ivy-leaved morning glory, Pennsylvania smartweed and horsenettle. The combination treatment of DCPA + paraquat

EXPLANATION OF PLATE I

Fig. 1. The combination treatment of simazine + amitrole applied at 2 lbs. each/acre gave the best weed control in 1963 and 1964. Control was evident until August 1, 1964, when the last observations were made. The photograph was taken one week after the treatment was applied on June 4, 1964.

Fig. 2. The spring application of simazine at 2 lbs./acre also gave excellent weed control in 1963 and 1964, and the control was evident throughout the growing seasons. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

PLATE I

EXPLANATION OF PLATE II

Fig. 1. Casoron gave good weed control after the rate of application was increased from 3 lbs./acre in 1963 to 6 lbs./acre in 1964. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

Fig. 2. All check plots were kept weed-free throughout the 1964 growing season by means of hand hoeing. The photograph was taken near the middle of the 1964 growing season.

PLATE II

EXPLANATION OF PLATE III

Fig. 1. Trifluralin also gave good control of weeds after the rate of application was increased from 0.5 lb./acre in 1963 to 1.5 lbs./acre in 1964. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

Fig. 2. Diphenamid applied at the rate of 5 lbs./acre, 5G, gave fair to poor weed control in 1964. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

PLATE III

EXPLANATION OF PLATE IV

Fig. 1. Diphenamid applied at the rate of 5 lbs./acre, 80w, gave fair to poor weed control in 1964. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

Fig. 2. Diphenamid at 7.5 lbs./acre, 50w, also gave fair to poor weed control in 1964. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

PLATE IV

EXPLANATION OF PLATE V

Fig. 1. Diphenamid applied in the fall of 1963 at 7.5 lbs./acre, 50w, in 1964 gave the best weed control on tree plots treated with this chemical. The photograph was taken approximately 7 months after the fall application of this chemical on November 5, 1963.

Fig. 2. The combination treatment of DCPA + paraquat applied at 12 lbs., 1 qt./acre gave fair weed control in 1964. Not all of the prevalent weed species were controlled and control was erratic. New infestations of weeds were observable within 10 days after application. The photograph was taken one week after the treatment was applied on June 4, 1964.

PLATE V

EXPLANATION OF PLATE VI

Fig. 1. DCPA applied at 12 lbs./acre gave fair to poor control of all prevalent weed species in the test plots. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

Fig. 2. Trifluralin applied at 1.0 lb./acre also gave fair to poor weed control in 1964. The photograph was taken approximately 7 weeks after the chemical was applied on April 25, 1964.

PLATE VI

gave good control of most weed species immediately after application but the new infestation of weeds was evident 10 days after application.

Treatments with diphenamid, as well as with DCPA, alone, gave fair to poor weed control of all prevalent weed species in the test orchard. The same results were true with trifluralin at 1.0 lb./acre.

Two tree plots were infested with johnsongrass. One plot was treated with simazine at 2 lbs./acre and the other with trifluralin at 1.0 lb./acre and neither treatment gave any control of this weed species. No other plots were infested so that control by other chemical treatments was not evident.

Herbicide Tolerance Studies

Visual observation was the only criterion used in these studies. None of the pre-emergent herbicides used showed any phytotoxic symptoms on the trees.

In the spring of 1964, following the winter after the first growing season, there was differential injury to trees and parts of individual trees. Some vegetative buds failed to open or the opening was delayed. The author suggests that this differential injury was probably due more to winter injury and to weed competition than to the phytotoxic effects of the chemicals used. Competition with weeds throughout the first growing season, after the young trees were established, would no doubt decrease the vigor and growth rate of the young trees. Vegetative buds may also have been so severely weakened that this was the cause for closure or delayed opening the following spring.

One tree in the test orchard was completely killed. The area around this tree had been treated with the combination of simazine + amitrole at 2 lbs., 2 lbs./acre. All other trees that received the application of this chemical exhibited good to excellent growth. For these reasons, it seems likely that the fatality of the tree was due more to winter injury than to the phytotoxic effects of the chemical.

Many trees exhibiting differential injury were on plots treated with chemicals, such as DCPA, which are usually considered safe enough to be used and registered for a wide variety of deciduous and evergreen trees and shrubs, groundcover plants and herbaceous plants.

Amitrole may exhibit phytotoxic symptoms on fruit leaves as observed by previous workers (23, 25). These symptoms were visible in this study when the combination treatment of simazine + amitrole at 2 lbs. each/acre was applied as a contact herbicide on the area beneath the young trees. If some of the spray material came in contact with the lower tree branches and leaves, symptoms associated with amitrole were visible. Marginal chlorosis of leaves at shoot tips was evident on some of the plots treated with this combination treatment.

From observations made in this study, the author suggests that extreme caution should be exercised so as not to "treat" the lower branches and leaves of the young trees. No phytotoxic symptoms were visible on trees growing on plots treated with the combination of DCPA and paraquat at 12 lbs., and 1 qt./acre.

DISCUSSION

From observations and data obtained in this study, it is clearly evident that herbicides may be effectively used to control weeds in young peach orchards, when used as a supplement to cultivation.

Many of the chemicals tested gave good to excellent weed control while others gave only fair to poor control. The herbicidal properties of these chemicals is very important but the effect of these chemicals on the vegetative growth of the trees is also an important factor to consider. As proposed by Audus (4), the herbicide should have the highest possible toxicity to the weed protoplasm, while the cultivated plant should be much less sensitive to this toxic action.

As previously indicated, significant differences in total growth per tree were observed between different chemical treatments and the check treatment at the end of the 1963 growing season. Optimum growth of the young trees is of maximum importance so chemicals which favorably affect the growth rate show great promise if they do exhibit good weed control properties (9). While some chemicals do possess inferior weed control properties at low application rates, they in turn may be very effective in controlling weeds at increased application rates. This has been shown in this study with the two chemicals, casoron, and trifluralin.

In view of the data and observations obtained in this study, the author suggests that the chemicals, and their respective application rates used, did not severely injury the young peach trees. In most vegetative-growth studies, significant differences were not observed between the various chemical treatments. Significant differences were observed in the percent total nitrogen of peach leaves collected on July 15, 1964, but no significant differences were observed in this test in 1963.

In 1963, Ries, et al. (20) observed that young peach and apple trees treated with simazine and amitrole-T had more growth and higher leaf nitrogen than where weeds were controlled by hand hoeing or black plastic mulch. Higher leaf nitrogen was observed in July, 1964, with the applications of trifluralin at 1.5 lbs./acre and simazine at 2 lbs./acre. Other chemical treatments did not significantly increase the total leaf nitrogen more than the hand-hoed check plots.

Injury was observed on the young peach trees in the spring of 1964, following the winter of the first growing season after the trees were established. Injury ranged from die-back at the tips of branches to complete branch killing. One tree was totally killed. Differential injury occurred on the same tree and injury was not isolated to a specific area in the test orchard.

The author suggests that injury was due to the weakening of the trees prior to cold winter temperatures. This was probably due to competition between the feeder-roots of the young trees and weeds which infested the experimental plots the previous summer.

Winter injury may also have been an important factor. Winter injury is more a factor in weakening peach trees than most growers realize. Such injury tends to be greater in light sandy soils with no cover crop. Trees in a weakened condition seem to be the most susceptible to winter temperatures, whereas those receiving light to moderate applications of fertilizer are more hardy. Golden Jubilee, the variety used in this study, is considered to be medium hardy (8).

Some of the chemicals used in this study, such as DCPA, are considered to be relatively safe for use on many horticultural crops. Trees grown on plots treated with this chemical also exhibited wood and bud injury and death, whereas some trees grown on plots treated with chemicals considered to be more toxic, exhibited no injury whatsoever. This observation supports the proposition that tree injury must have been due to either weed competition and weakening of the trees or to winter injury, or both.

A close correlation was observed, in this study, between weed control and vegetative growth of young trees. Trees which exhibited good to excellent vegetative growth were grown on plots where weeds had been effectively controlled throughout the growing season by various chemical herbicides.

For this reason, herbicides applied to young peach trees must influence vegetative growth of the trees by effectively controlling weeds on the experimental plots. As proposed by Ries, et al. (20), evidence is offered that increased growth of young peach and apple trees, in Michigan, may be due to more than weed control and that there may be an influence of herbicide treatments on nitrogen absorption and translocation. This phenomenon may also influence growth and nitrogen absorption and translocation, here, in Kansas soils, but further testing will be required to fully support this premise.

SUMMARY AND CONCLUSIONS

Data and observations obtained in this study clearly show that herbicides may be a valuable aid in controlling weeds in a newly established peach orchard. Several chemicals exhibited effective weed control while favorably increasing the vegetative growth of the young trees.

Vegetative growth studies were conducted including the following: width, length, fresh weight, dry weight and the percent total nitrogen of composite peach leaf samples. No significant differences were observed between chemical treatments on vegetative growth as exhibited in these composite leaf samples collected in 1963. Significant differences were observed in total growth per tree, being expressed in total linear inches per tree. Chemical treatments did not significantly influence the trunk diameters at the end of the first growing season.

Chemical treatments significantly influenced the percent total nitrogen of composite leaf samples collected in July, 1964. The terminal growth of the six uppermost primary branches was not significantly influenced by the chemical treatments.

Trees grown on plots treated with simazine at 2 lbs./acre, diphenamid at 5 lbs./acre 5G, and the combination treatment of DCPA + paraquat 12 lbs., 1 qt./acre exhibited the most total linear growth at the end of the first growing season. No significant differences were observed between these three chemicals but of the three, simazine at 2 lbs./acre significantly influenced the total growth of the trees more than any of the other chemical treatments.

The percent total nitrogen of composite leaf samples was determined on July 15, 1964. Trifluralin at 1.5 lbs./acre and simazine at 2 lbs./acre significantly influenced the percent total nitrogen more than any other chemical treatment.

In 1963, weed counts were made on August 1, sixteen weeks after the application of the pre-emergent herbicides. The two post-emergent herbicides, amitrole and paraquat, were applied on June 20, 1963. Of the chemicals tested, the combination treatment of simazine + amitrole applied at 2 lbs. each/acre gave the best weed control. Simazine applied at 2 lbs./acre also gave excellent weed control. DCPA + paraquat 12 lbs., 1 qt./acre and diphenamid at 5 lbs./acre were rated at equal values in controlling weeds. Fair to poor weed control was exhibited by the remaining chemicals. The application rate of casoron was increased from 3 to 6 lbs./acre and that of trifluralin from $\frac{1}{2}$ to $1\frac{1}{2}$ lbs./acre, since both of these treatments did not effectively control weeds at the lower application rates in 1963.

As in 1963, the combination treatment of simazine + amitrole applied at 2 lbs. each/acre gave the best weed control in 1964. Simazine at 2 lbs./acre also gave good to excellent weed control as did casoron and trifluralin after the application rates were increased. All formulations of diphenamid at 5 and 7.5 lbs./acre gave fair to poor weed control in 1964, but the fall, 1963, application of diphenamid at 7.5 lbs./acre gave the best weed control on tree plots treated with different formulations of this chemical. The combination treatment of DCPA + paraquat at 12 lbs., 1 qt./acre gave fair to poor weed control, as did trifluralin at 1.0 lb./acre.

Herbicide tolerance studies were also conducted in 1963 and 1964. Visual observations were the only criteria used in these studies. None of the pre-emergent chemicals exhibited any phytotoxic symptoms on the trees, unless they were not readily visible. Injury did appear on trees following the first winter after the trees were established. It is postulated that this injury was due either to the weakening of the trees prior to cold winter temperatures as a result of weed competition the previous summer, or to winter injury, or both.

A close correlation was observed in this study between weed control and vegetative growth of the trees. Trees which exhibited good to excellent vegetative growth were grown on plots where weeds had been effectively controlled throughout the growing season by various chemical herbicides. It is evident that in order for the trees to reach maximum vegetative growth weed growth beneath the young trees must be effectively controlled. Based on evidence produced by this study, it is apparent that the use of chemicals for this purpose offers considerable promise and several advantages over the tedious and expensive methods of hand hoeing in areas where machine hoeing is impossible or difficult.

From the data collected in this study, it is concluded that a few of the chemicals tested will effectively control weeds around young peach trees and apparently will not injure the trees. Of the chemicals tested, simazine at 2 lbs./acre and the combination treatment of simazine + amitrole 2 lbs., 2 lbs./acre gave the best season-long weed control in the experimental tree plots. Casoron at 6 lbs./acre and trifluralin at 1.5 lbs./acre also gave good to excellent weed control. All formulations of the chemical, diphenamid, exhibited erratic weed control properties in the two-year test period. The combination treatment of DCPA + paraquat 12 lbs., 1 qt./acre gave fair weed control in both years but the control was of short duration as new weed growth began soon after treatment. DCPA at 12 lbs./acre gave fair to poor weed control both years as did trifluralin at 0.5 lb. and 1.0 lb./acre.

Further testing will be required in other areas of commercial peach production as results have varied from location to location. Further experimentation concerning the effect of chemicals on the fruitfulness of the trees in later years may also be necessary and warrant study.

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SOME EFFECTS OF SELECTED HERBICIDES ON YOUNG PEACH (*Prunus persica*, Sieb. and Zucc.) TREES

by

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The successful establishment of a peach orchard is closely associated with the growth of the trees during their first few years in the orchard. After the trees are planted, one of the most important factors in stimulating vegetative growth is adequate control of weeds around the young trees. The use of chemicals for this purpose offers considerable promise and several advantages over the tedious and expensive methods of hand hoeing in areas where machine hoeing is impossible or difficult.

The purpose of this study was to evaluate the effectiveness of several selective herbicides in controlling weed growth in young peach trees and to determine their effect on the vegetative growth of the trees.

Fifty one-year-old peach whips, of the variety Golden Jubilee, were planted at the Horticultural farm near Manhattan, Kansas, on April 20, 1963. The soil was a sandy silt loam. No fertilization was practiced in either year. All data was statistically analyzed as described by Snedecor. A randomized complete block design was utilized in this study.

Tree-growth studies were conducted in 1963, including the following determinations: widths, lengths, fresh weights, dry weights, and the percent total nitrogen of composite leaf samples. Total nitrogen content of leaf samples was determined by the Kjeldahl method. No significant differences were effected by the herbicide treatments, in 1963, but significant differences were observed in the total linear growth. Similarly, the herbicide treatments did not significantly influence the trunk diameters at the end of the first growing season. Significant differences were observed, in 1964, with regard to the percent total nitrogen as influenced by the herbicides. No significant differences were observed in terminal growth of the six uppermost primary branches per tree.

Eight pre-emergent and two post-emergent herbicide treatments were applied to an area 5' x 5' beneath young trees in 1963, and to an area 6' x 6' in 1964. Listed in order of decreasing influence on total linear growth of the trees in 1963 were simazine, diphenamid 5 lbs. 5G, DCPA + paraquat, simazine + amitrole, diphenamid 5 lbs. 80w, diphenamid 7.5 lbs. 50w, DCPA, trifluralin 1.0 lb., casoron 3 lbs., and trifluralin 0.5 lb./acre.

Simazine at 2 lbs./acre, trifluralin at 1.5 lbs./acre, and diphenamid at 5 lbs./acre influenced the percent total nitrogen more than any other chemical treatments in 1964. No significant differences in percent total nitrogen were observed between simazine at 2 lbs./acre and diphenamid at 7.5 lbs./acre when applied to tree plots in the fall of 1963.

Weed counts were made by averaging three random counts per treatment area. Herbicide treatments, in order of decreasing weed control during the two-year test period, are listed as follows: simazine + amitrole, simazine, casoron at 6 lbs., trifluralin at 1.5 lbs., DCPA + paraquat, diphenamid at 7.5 lbs., diphenamid at 5 lbs., DCPA, and trifluralin at 1.0 lb./acre.

From observations in the herbicide tolerance studies, it is evident that no injury resulted in the two-year test, except when amitrole, the post-emergent herbicide, was actually sprayed on the lower leaves of the trees. Some injury occurred following the winter of 1963-1964; but this may have been attributed to either weakening of the trees due to previous weed competition or to winter injury.