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CHEMICAL CONTROL OF WEEDS IN FIELD CROPS

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AGRICULTURAL EXPERIMENT STATION
KNOXVILLE

This bulletin gives the results of chemical weed control experiments conducted by the Tennessee Agricultural Experiment Station, and suggestions for use of the chemicals tested to date. It is not possible for the Experiment Station to test all of the many chemical weed killers under all climatic and soil conditions in Tennessee, even though it is recognized that these factors have a marked influence on the degree of success obtained with most herbicides. Therefore, it is suggested that a person using chemical weed killers for the first time use the best methods, rates, and formulations available, but spray only a small percentage of his total acreage the first year. Then, if the practice proves successful under his conditions, the use can be increased as experience is gained. There is always a chance of crop injury or poor weed control from the use of selective herbicides, but this possibility will be greatly reduced if the farmer will closely follow the recommendation for their use.

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and Troy H. Jones.*

INTRODUCTION

There are many ways to control weeds in crops. These include the use of clean seed, good seed bed preparation, crop rotations, mowing, smother crops, proper cultivation, etc. Most of these methods are necessary to control weeds on all farms. Chemical weed control can be added to this list, not necessarily to replace but to supplement the others.

There are hundreds of herbicidal chemicals on the market today, most of which have been available for only a few years, and many farmers are not familiar with their use. The hundreds of different trade names may be confusing since the active ingredients in many of these commercial products are the same, and many of them can be used in exactly the same way. The easiest way to be certain about what these herbicides will do is to find what the active ingredient will do, and then buy the product which gives the most active ingredient for the least money. The chemical companies are required by federal law to show the name and amount of active ingredient on the labels of their chemical weed killers. The Tennessee Agricultural Experiment Station does not recommend any specific manufacturer's products. All recommendations are based upon the particular active ingredient contained in the commercial product and are given in pounds per acre.

Here is an example: If two different brands of 2,4-D are available, either can be used, but one may be more economical. One might contain 40% active ingredient according to the label, while the other contains 80% active ingredient. To apply a pre-emergence spray (½ pound per acre) to a 20-acre field of corn would require 25 pounds of the first brand, but only 12½ pounds of the second to give the same results. The price per pound would then determine which to use.

Chemical weed control experiments at the Tennessee Experiment Station have been intended to develop selective measures to control weeds in the major crops of the state. The two most

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common procedures of spray application have been carefully tested. They are pre-emergence spraying (spray the ground after a crop is planted and before it comes up), and post-emergence spraying (spray after the crop plants have come up). In most cases the pre-emergence treatments control the annual weeds and grass for a period of from 3 to 6 weeks by killing the young weed seedlings in the upper ½ inch of the soil as they germinate. The post-emergence treatment kills weeds after they have become established.

It is possible to use either or both of these methods on many of our crops. With either method, it is most profitable to kill the weeds while they are young. The crop plants are more easily injured by crowding while they are small, and many weeds which can be killed while they are young cannot be controlled when well established. (Crabgrass seedlings are easily killed by 2,4-D but established plants are not injured at all).

With few exceptions, cultivation is the cheapest way of controlling weeds in crops. However, with continuous expansion of industry in Tennessee, farm labor is becoming more scarce, and consequently labor costs are increasing. The chemical weed killers that can be used to replace hand labor, especially that used for chopping, will have a definite place in our farming program.

CHEMICALS

The chemical compounds (active herbicides) that have been used in experiments by this Station are:

Ammate—ammonium sulfamate

Chlorate—sodium chlorate

Cyanamid—calcium cyanamid

Dinitro—dinitro ortho secondary butyl phenol

E. H. 1—experimental herbicide 1 (2,4-dichlorophenoxy ethyl sulfate)

Herbicidal Oil—petroleum napthas having a boiling range of 300° to 400° F. and containing about 22 percent aromatic hydrocarbons by weight.

IPC—isopropyl-N-phenyl carbamate

MH—maleic hydrazide

P. C.—potassium cyanate

PCP—pentachlorophenol
sodium pentachlorophenate

TCA—sodium trichloroacetate
ammonium trichloroacetate

2,4,5-T—2,4,5-trichlorophenoxyacetic acid

2,4-D—2,4-dichlorophenoxyacetic acid
Ester, amine salt and sodium salt formulations

Further reference to these chemicals in this publication will be by their abbreviated names.

The amount of water or oil used to reduce the concentration of an herbicide is generally not important as long as the correct amount of the active chemical in the herbicide is distributed evenly over the area sprayed. If a concentrated solution (5 gallons or less per acre) is used, one must have equipment that can be calibrated accurately, and this machinery must be carefully operated, because a major error in rates may be disastrous. It is suggested that enough diluent be used to insure good coverage without runoff and to reduce the chance of severe injury to the crop in case an error in calibration or operation occurs. Below 5 gallons per acre is extremely difficult to spread evenly, while above 50 gallons per acre generally results in waste through excessive runoff.

EQUIPMENT

Any type of spray equipment which will develop a minimum of 20 lbs. per square inch pressure will deliver a satisfactory spray if proper nozzles are used. This may be any type of equipment from the small 3-gallon pack sprayers to large power operated trailer type rigs. Power operated rigs should be equipped with two sets of screens or strainers (one on either side of the pump), a pressure gauge, a pressure regulator, and a quick-acting shut off valve.

For field scale spraying, gear or impeller type low pressure pump sprayers (20-40 lbs. p.s.i.) have proven to be very satisfactory. These may be either trailer or tractor mounted, and driven by belt drive or from power take-off.

Spray booms of almost any desired length can be bought or may be constructed in the farm shop if pipe cutting and threading tools are available. The length of the boom depends on the capacity of the pump and the character of the land. In areas of Tennessee where the land is rough and rolling, a 12-15 ft. boom is the maximum length that should be used. In the more level areas, considerably longer booms may be used. Special nozzles are available which will spray a 50-foot fan with uniform coverage. This makes a boom unnecessary if this particular nozzle is used.

Low pressure nozzles that deliver a fan-shaped spray pattern are more satisfactory for spraying herbicides than the insecticide nozzles that produce a cone-shaped spray pattern, because they deliver a much more uniform spray. The fan type nozzles can be purchased in many sizes. In order to determine which size nozzle to buy, one must take into consideration three factors. These are (1) speed at which the equipment will run, (2) pressure to be used, and (3) gallons per acre to be applied. With these three factors known, the proper size nozzle can be selected. The Experiment Station has found that it is most economical to use the types of nozzles equipped with interchangeable tips. Extra tips with dif-

ferent spray capacities are relatively cheap, and the equipment can be changed from one spray capacity to another very quickly and easily.

Table 1 gives the amount of spray material applied per acre with various tip sizes operated at different speeds under different pressures.

Table 1. Gallons per acre of spray material applied with nozzles spaced 20 inches apart.

Tip Number	Height in inches	Pressure in pounds	Miles per hour		
			2 mph	3 mph	4 mph
650067 or 65.067	22	20	7.0	4.7	3.5
		30	8.6	5.7	4.3
6501 or 65.1	22	20	10.5	7.1	5.3
		30	12.9	8.6	6.4
65015 or 65.15	22	20	15.7	10.5	7.8
		30	19.2	12.9	9.7
6502 or 65.2	22	20	20.9	14.0	10.5
		30	25.6	17.2	12.9
730116	21	20	12.1	8.0	6.0
		30	15.0	10.0	7.5
730154	21	20	16.1	10.7	8.1
		30	20.0	13.3	10.0
8001 or 80.1	18	20	10.5	7.1	5.3
		30	12.9	8.6	6.4
8002 or 80.2	18	20	20.9	14.0	10.5
		30	25.6	17.2	12.9
8003 or 80.3	18	20	31.5	20.9	15.7
		30	38.4	25.8	19.3

Spray equipment should be thoroughly cleaned after using to insure longer life and less trouble in operation. This can best be done by rinsing the pump, hose, boom, and tank two or three times with clean water. A rinse of this type will satisfactorily clean out all insecticides, fungicides or herbicides except 2,4-D or 2,4,5-T. If either of these herbicides have been used in the equipment, it is almost impossible to clean it sufficiently to be used for any other purpose on susceptible crops.

Experimental Results

Several different chemicals have been used in weed control experiments with corn, cotton, soybeans, peanuts, strawberries, small grains, and sod crops. Various rates and times of application have been used in an attempt to determine the best procedures for chemical weed control.

Corn

Experiments at Knoxville and Jackson have consistently shown very good results with 2,4-D as both a pre-emergence and post-emergence spray on corn. It can be used either as a pre-emergence spray in a planned weed control program, or a post-emergence spray as an emergency measure if weeds get out of hand.

The results of the 1949 tests (as shown in Table 2) show that while chemical methods alone were not equal to clean cultivation plus chopping, treatment just before emergence was far superior to treatment at planting time, and not much below conventional cultural methods in yield. In 1950, all treatments were cultivated, but the plots receiving chemical treatment were not hoed. These results show that chemical treatment can supplement standard cultural practices to good advantage. The treated plots required no hoeing, and less cultivation, yet yielded almost as much as plots cultivated and hoed. Again, treatment just before emergence was superior to treatment at planting.

TABLE 2—CHEMICAL WEED CONTROL IN CORN

WEST TENNESSEE EXPERIMENT STATION, JACKSON

Average of Four Replications

Treatment	Av. Yield Bu. per Acre
1949 Test	
Standard, clean cultivation and chopping	109.2 [1]
Pre-emergence, at planting, 1.5 lbs./A 2,4-D amine—[2] no cultivation or chopping	28.9
Pre-emergence, at planting, 2.5 lbs. /A 2,4-D amine— no cultivation or chopping	40.7
Pre-emergence, just before emergence 1.5 lbs. /A 2,4-D amine—no cultivation or chopping	62.1
Pre-emergence, just before emergence, 2.5 lbs./A 2,4-D amine—no cultivation or chopping	74.3
L.s.d. (5%)	20.7
1950 Test	
Standard, clean cultivation and chopping	102.1
Pre-emergence, at planting, 2 lbs./A, 2,4-D amine— cultivation, but no chopping	80.3
Pre-emergence, just before emergence, 2 lbs./A 2,4-D amine—cultivation, but no chopping	95.9
Pre-emergence, at planting, 2 lbs./A E.H.1— cultivation, but no chopping	89.1
Pre-emergence, just before emergence, 2 lbs./A E.H.1—cultivation, but no chopping	99.5
L.s.d. (5%)	12.3

[1] Not included in the analysis.

[2] Rates given are for complete coverage of both row and middles.

A pre-emergence spray of 2,4-D will control most of the annual broadleaf weeds and grasses. Crabgrass has been controlled almost 100 percent in several experiments during the past 4 years by this method of spraying. Established perennial weeds, however, were not controlled. If it is known that a field is apt to be excessively weedy, or if one wishes to insure against wet weather which might prevent needed early cultivation, then the pre-emergence spray with 2,4-D should be used. When properly applied, weeds will be kept under control for from 3 to 6 weeks after planting. This method of using 2,4-D has been most successful on clay and silt loam soils. Tests on sandy soils and soils with poor internal drainage where heavy rainfall was encountered have sometimes given very poor weed control, and in some cases have resulted in poor germination of the corn seed.

The following recommendations are made for pre-emergence spraying of corn:

(1) **Rate**—Use 1¼ to 1½ pounds per acre of 2,4-D acid (amine salt formulations) for complete coverage. Mix with enough water to give a uniform distribution of the 2,4-D over the area.This may require from as little as 5 gallons per acre up to 50 gallons per acre, depending on the spray equipment used.

(2) **Time**—2,4-D can be applied as a pre-emergence spray to the soil any time after planting and before the corn emerges from the soil; however, best results have been obtained when the spray was applied just before emergence.

(3) **Cultivation**—The corn should be cultivated if and when weeds begin to appear (one cultivation should be sufficient and under favorable conditions no chopping should be necessary except for perennial weeds).

(4) **Caution**—Do not use this method of spraying 2,4-D on corn that is planted in sandy soils or in soils with poor internal drainage. Do not use 2,4-D near cotton, tomatoes, or other susceptible crops.

Post-emergence spraying of corn with 2,4-D is suggested when weeds such as wild morning glory, bindweed, cocklebur, ragweed, or other broadleaf weeds threaten the corn crop. None of the grass weeds will be killed, except those just germinating. Controlling weeds does not necessarily mean complete killing. Many perennial weeds are stunted when sprayed with 2,4-D; they are not killed, but never grow well, and often do not produce seed. This, of course, reduces competition with the crop and can cut down the stand of weeds during the following year.

The following recommendations are made for post-emergence spraying:

TABLE 3—CHEMICAL WEED CONTROL IN COTTON

WEST TENNESSEE EXPERIMENT STATION, JACKSON
U. S. COTTON FIELD STATION, KNOXVILLE

Average of Four Replications

Treatment	Lbs. of Seed Cotton per Acre	
	Jackson [1]	Knoxville
1950 Tests		
Standard cultivation and chopping	1620	1042
Pre-emergence, 6 lbs./A water soluble dinitro	1344	829
Pre-emergence, 6 lbs./A oil soluble dinitro	1485	------
Pre-emergence, 6 lbs./A water soluble dinitro and two 5 gal./A post-emergence treatments of herbicidal oil	1572	988
Pre-emergence, 6 lbs./A oil soluble dinitro and two 5 gal./A post-emergence treatments of herbicidal oil	1641	------
L.s.d. (5%)	362	286
1951 Tests[2]		
Standard cultivation and chopping	2080	1856
Pre-emergence, 4 lbs./A water soluble dinitro	1755	1279
Pre-emergence, 4 lbs./A oil soluble dinitro	1989	1201
Pre-emergence, 6 lbs./A water soluble dinitro	1443	1295
Pre-emergence, 6 lbs./A oil soluble dinitro	2067	1482
Pre-emergence, 8 lbs./A water soluble dinitro	1482	1513
Pre-emergence, 8 lbs./A oil soluble dinitro	1781	1466
Post-emergence, 3 applications of herbicidal oil at 5 gal./A sprayed on 8" band centering on row	1482	1030
L.s.d. (5%)	494	187

[1] The 1951 test at Jackson had poor stands caused by dry weather early in the season.

[2] All pre-emergence applications in the 1951 tests were followed in 6 weeks and again 10 days later by post-emergence herbicidal oil applications at 5 gal./A sprayed on 8" band centering on the row.

ever weeds begin to grow, and before they are 1½ inches tall. These treatments should be at least 5 days apart. If no pre-emergence spray has been used, post-emergence treatment with herbicidal oil can be used as necessary, starting about one week after the cotton comes up. Timeliness of this post-emergence oil treatment is extremely important. The oil acts as a contact killer only, and affects only those plants or plant parts which are covered. Weed growth too dense to be completely covered by the oil spray will not be killed.



Top—No chemical treatment for weed control—no cultivation.

Below—Treated, pre-emergence, with 6 pounds water soluble dinitro per acre—no cultivation.

The cost of spraying is an important consideration. It is practical to spray only the row area, and to keep the middles clean by cultivation. If a band 14 inches wide (centered on the row) is sprayed, this makes it necessary to use only 2 to 2.6 pounds per

acre of active ingredient and gives satisfactory control at one-third the cost of spraying the entire field.

At current prices, this method of spraying a band along the row would cost $3.50 to $4.50 per acre for the water soluble dinitro and $4.40 to $5.75 per acre for the oil soluble dinitro. Note that this is the cost of the active chemical only and does not include other materials, equipment, or labor. A single post-emergence herbicidal treatment will require about $1.25 per acre for the herbicidal oil.

Approximate cost of these materials is as follows:

(1) Water soluble dinitro—$1.75 per pound of active ingredient

(2) Oil soluble dinitro—$2.20 per pound of active ingredient

(3) Herbicidal oil—$0.25 per gallon

(4) Fuel oil diluent for oil soluble dinitro—$0.13 per gallon

Cost of machinery is also a factor to be considered. The basic machinery will be the same to apply either dinitro or herbicidal oil. The dinitro can be applied and the cotton planted in one operation by rigging spray nozzles so that the spray is applied just behind the planter packwheels. It can also be applied in a separate operation, but care must be exercised to keep the treated band centered on the row. On small acreages where tractor equipment is not available, compressed air sprayers can be used to apply the dinitro to the rows. It should be remembered that a smooth surface for the treatment is essential for the best results.

When herbicidal oil is applied, the spray must be directed so that it will cover the row area without hitting the foliage, because only the stems up to about one inch from the ground level can be sprayed with the oil since there is a waxy "cutin" layer that protects the stem. It is necessary to direct the herbicidal oil on a very narrow area when the plants are small. Fan-shaped nozzles can be mounted on specially designed shoes or shields that mount on the cultivator frame and slide along the ground in such a way as to keep the oil from hitting the leaves. Special shields that hold the nozzles and protect the treated row from new soil thrown by the cultivators can be used. By using the shields, one can spray the row and cultivate the middles at the same time without disturbing the treated band or moving new grass seed onto the band. Small compressed air sprayers can be used by mounting either one nozzle or two nozzles for row treatment. In spraying the row with hand equipment, the nozzles can be placed so they spray across the row and not hit the cotton over one inch above the soil level.

The following recommendations are made for spraying cotton with herbicides:

I. Pre-emergence

1. **Rate:** For spraying row area (⅓ of entire area) with dinitro, use 2 to 2.6 pounds per acre. Use the higher rate for water soluble dinitro and mix with enough water to give at least one gallon of spray for each inch of band sprayed. (Example: if a 12-inch band is sprayed, use 12 gallons of spray mixture.) If oil soluble dinitro is used, mix it with enough fuel oil to give one-half gallon spray mixture per inch of band sprayed on the row. (Example: if a 12-inch band is sprayed, 6 gallons of spray mixture should be used.)

   CAUTION—Some injury was noted in West Tennessee in 1951 and on experimental plots at Knoxville in 1952 when extended periods of dry weather followed treatment.

2. **Time:** Spray as soon after planting as possible, but not more than two days after planting.

3. **Cultivation:** Cultivate the middles when needed, making sure not to disturb or throw dirt on the treated bands. If soil is thrown onto the treated bands or if the soil is disturbed in the treated area, new weed seeds will germinate and some of the value of the chemical will be lost. When weeds begin to appear, post-emergence herbicidal oil can be used or the rows can be cultivated so as to throw soil around the cotton to cover the weeds. It may be necessary to chop the rows to get some weeds that were not controlled by the chemical.

4. **Caution:** Plant the cotton at least ¾ of an inch deep; exposed seed may be damaged. Prepare a clod-free seed bed for best results and use a solid packwheel that is at least as wide as the treated band to smooth the soil ahead of the spray nozzle. There are several types of packwheels that can be used to smooth the surface for the treatment. It should be remembered that much of the success of the treatment will depend on the clod-free surface where the chemical is applied. If ridges and clods are left they tend to weather down when it rains and weed seeds will germinate where untreated soil is exposed. **Do not use dinitro on cotton after it emerges—this will kill the cotton.** Be sure the sprayer is applying the correct amount of material. Check it occasionally.

II. Post-emergence

1. **Rate:** Herbicidal oil should be used at the rate of 5 gallons per acre covering an 8-inch band centering on the row but directed from each side of the row so that the cotton foliage will not be sprayed.

2. **Time:** If a pre-emergence spray is not used, the first oil application should be applied about 7 to 10 days after emergence. The treatment should be repeated as weeds appear, but not more often than 5 days apart. Where post-emergence oil treatments follow pre-emergence treatments, one should apply the oil as soon as weeds begin to appear, which should be from 3 to 6 weeks after emergence of the cotton. Do not spray with herbicidal oil after the main cotton stem has begun to become rough or corky.
3. **Cultivation:** It is important to keep a flat, clod-free, row area where the oil treatment is to be applied to insure the best results. The middles should be cultivated as needed.
4. **Caution:** One should keep a close check on speed and pressure while applying herbicidal oil sprays to insure applying the correct amounts. Cotton stems and leaves should be checked after each spraying to see if there is injury of any kind. An excess amount of oil will cause a gall effect on the stems. Do not spray cotton after the corky layer has begun to form on the main stem.

Soybeans

Experiments and production results have shown that soybeans grown for beans yield better when planted in rows than when seeded broadcast. When soybeans are planted in the row, they must have some form of weed control for the first few weeks until the fast growing beans can shade out the grass and weeds. This makes the soybean an ideal crop for pre-emergence sprays which will control the weeds for several weeks after emergence.

Soybean weed control experiments have been conducted at the West Tennessee Experiment Station at Jackson since 1948. The following chemicals have been used as pre-emergence sprays: 2,4-D, IPC, PCP, and Dinitro. The amine form of 2,4-D was tried in 1948 in a replicated test at the rates of 1 and 2 pounds of 2,4-D acid per acre; it was applied 7 days before planting, at planting, and 6 days after planting. Poor stands of soybeans resulted in all treatments. 2,4-D cannot be used at high enough concentration for pre-emergence weed control without injuring the soybeans. IPC at 6 pounds per acre did not give weed or grass control. PCP at 30 pounds per acre gave very good weed control but caused a deformity in some of the first leaves which later disappeared. Dinitro at 6 pounds per acre for overall coverage gave very good weed control and no apparent injury to the beans. The more recent experiments have been with different rates of dinitro, and it has been found that the rates and methods of application given under cotton can be applied to soybeans. (See Tables 4 and 5.) Soybeans should be planted at least one inch deep. Dinitro has not been widely tested on soybeans, and it is suggested that it be used on only small areas when it is first used. Some preliminary work has been done with herbicidal oil as a post-emergence spray on soybeans, but not enough information has been obtained to evaluate this herbicide for soybeans.

TABLE 4—CHEMICAL WEED CONTROL IN SOYBEANS

WEST TENNESSEE EXPERIMENT STATION, JACKSON

Average of Four Replications

Treatment [1]	Av. Bu. per Acre
1949 Test	
Standard clean cultivation	37.2
Pre-emergence, 6 lbs./A, water soluble dinitro	35.7
Pre-emergence, 30 lbs./A, PCP	39.3
L.s.d. (5%)	3.9
1950 Test	
Standard clean cultivation	15.1
Pre-emergence, 6 lbs./A, water soluble dinitro	15.5
Pre-emergence, 6 lbs./A, oil soluble dinitro	14.3
Pre-emergence, 6 lbs./A, water soluble dinitro, followed by two 5 gal. per acre herbicidal oil treatments	13.7
Pre-emergence, 6 lbs./A, oil soluble dinitro, followed by two 5 gal. per acre herbicidal oil treatments	14.7
L.s.d. (5%)	2.4
1951 Test	
Standard clean cultivation	38.4
Pre-emergence, 4 lbs./A, water soluble dinitro	42.5
Pre-emergence, 6 lbs./A, water soluble dinitro	41.3
Pre-emergence, 8 lbs./A, water soluble dinitro	42.2
Post-emergence, herbicidal oil applied 5 gal./A at 3 different times	40.1
L.s.d. (5%)	7.6

[1] Rates are given for row and middle coverage. If row area alone is sprayed, the amounts would be approximately ⅓ of those given above. There was a reduction in stand of soybeans in the 2,4-D treated plots.

TABLE 5—CHEMICAL WEED CONTROL IN INTERPLANTED CORN AND SOYBEANS

WEST TENNESSEE EXPERIMENT STATION, JACKSON

Average of Four Replications

Treatment [1]	Av. Yield Bu. per Acre	
1951 Test	**Soybeans**	**Corn**
Standard clean cultivation	22.9	81.8
Pre-emergence, 4 lbs./A water soluble dinitro	19.8	71.8
Pre-emergence, 6 lbs./A water soluble dinitro	22.5	71.4
Pre-emergence, 8 lbs./A water soluble dinitro	23.1	73.3
Pre-emergence, 2 lbs./A, 2,4-D amine	17.8	81.8
L.s.d. (5%)	4.3	17.4

[1] Rates are given for row and middle coverage. If row area alone is sprayed, the amounts would be approximately ⅓ of those given above. There was a reduction in stand of soybeans in the 2,4-D treated plots.



Control of weeds in corn with 2, 4-D.

Top, pre-emergence treatment, 2½ pounds acid per acre applied six days after planting. Middle, ½ pound acid applied when corn was 8 inches tall. Bottom, no treatment.

Peanuts

Two years' results with chemicals for the control of weeds in peanuts show excellent weed control for a period of 3 to 6 weeks with dinitro at the rate of 6 to 8 pounds per acre overall coverage applied just after the seeds were planted. As in the case of cotton and soybeans, band application is recommended to reduce the cost of treatment. 2,4-D at the rate of 2 pounds per acre gave good weed control with no apparent injury to the peanut plants. While the dinitro costs slightly more than the 2,4-D, it may be preferred because of the danger of applying 2,4-D near susceptible crops like cotton, tomatoes, and others.

Small Grain

A limited amount of work has been done by the Station on the use of chemicals to control weeds in small grain. It is very important to produce weed-free small grain, because small grain growers are penalized heavily each year due to the presence of wild onion or garlic in their grain. There is not enough weed-free Tennessee-grown small grains to supply the demand for seed, and this is encouraging the shipping of unadapted varieties into the state for seed.

2,4-D can be used to control many of the weeds that are common in small grains when they are seeded without legumes.

Following are suggestions for the use of 2,4-D as a post-emergence spray for controlling weeds in small grain:

1. **Rate:** Use the amine salt formulations of 2,4-D at the rate of ½ to 1 lb. of 2,4-D acid per acre if wild onions, garlic, or corn cockle are not present in the small grain. If wild onion, garlic, or corn cockle are present, use the ester formulation at the rate of ½ lb. of 2,4-D acid per acre. The onions and corn cockle are more resistant to 2,4-D than many of the other common weeds in small grain and the 2,4-D may not kill them but will keep them from maturing seed.
2. **Time:** Apply only in spring when the grain is well stooled but before the jointing stage.
3. **Caution:** Spraying at times other than that given above may result in abnormal growth and some reduction in yield. Fall application of 2,4-D may result in serious injury to the grain.

Permanent Pasture

The most desirable type of pasture should have one or more species of legumes and grasses. One of the most troublesome weeds in these pastures of Tennessee is wild garlic (more commonly referred to as wild onion). Experiments have been conducted

at Jackson and Knoxville on controlling wild garlic. The Knoxville test was started in the fall of 1947 and terminated in the spring of 1949. Different formulations and rates of 2,4-D were used, the most effective being the ester form applied at 2 to 2½ pounds of 2,4-D acid per acre. The spray was applied during warm weather in November and again in early March, so that both the fall and spring wild garlic crops were killed before they developed side bulblets underground. Any one spraying killed only the garlic plants that were growing at that time and did not kill dormant bulbs in the ground. The garlic bulbs may live in the soil for two or three years before they emerge. This would make it necessary to spray twice a year for 2 or 3 years to eradicate the garlic. It would probably be cheaper to use a method of cultural control where possible, such as turning the soil in November and March and then using 2,4-D the second year to kill the garlic that escapes the cultural treatment.

2,4-D should not be used on a new pasture seeding because the new seedlings may be killed or injured. At present, mowing of permanent pastures is one of the most effective methods of weed control.

Maleic hydrazide was used on wild garlic in two preliminary tests with promising results but it must be tested more thoroughly before recommendations can be made.

Control of Grass Weeds

Experiments on Johnsongrass using 5 rates of TCA, sodium chlorate, and ammonium sulfamate showed that 75 lbs. per acre of TCA or 250 lbs. per acre of sodium chlorate gave complete kill of the established Johnsongrass plants. Ammonium sulfamate was not completely effective at rates up to 300 lbs. per acre. Suggested rates are 60 to 75 lbs. of TCA acid per acre or 225 to 250 lbs. of sodium chlorate with spot treatment later if there are any escapes. Use about 100 gallons of water per acre as a diluent for these materials. The Johnsongrass should not be cut or burned for a period of three weeks or more after spraying to insure good kill. A crop cannot follow a TCA treatment in less than 60 days unless there has been some heavy rain after treatment to leach the chemical out of the soil. Soil treated with sodium chlorate will remain toxic to plants for a year or more.

An experiment on a well established stand of Bermuda-grass using these same materials and rates resulted in what appeared to be a perfect kill the first year. The rates of 75 pounds of TCA and 250 pounds per acre of sodium chlorate were most effective. However, the plots were checked the following spring and some new growth was apparent. By the end of the season, the plots had a perfect stand of Bermuda-grass. Apparently, the chemical had not killed all the underground rhizomes, and a stand was easily reestablished from these "escapes".

A preliminary experiment was conducted on the University Agricultural Campus in 1951 using potassium cyanate as a crabgrass killer in a bluegrass and Bermuda-grass lawn. The test was replicated 3 times, and 4 rates of potassium cyanate were tried. The results indicated that this chemical is very effective in killing young crabgrass in Bermuda-grass sods without injury to the latter. However, there were some harmful effects on bluegrass, when sprayed after July 1. Potassium cyanate has the same effect on all grass—it kills the tops and turns them brown within a period of two or three days. However, the perennial grasses are capable of new growth from the root system, where the annual crabgrass is not—unless part of the above ground stems in heavy mats escape spraying. Crabgrass may always reinfest from seed, and more than one spray treatment may be necessary.

Strawberries

Strawberry growers who plan to use chemical weed control methods must understand the limitations of these methods. Even if properly appled, some weeds will not be controlled; and if improperly used, there is considerable chance of injury to the strawberry plants. The best time to use chemicals is when the planting is being established, either applying the material after the bed is prepared but before the plants are set out (preset) or shortly after setting (postset).

Plantings were made in the fall of 1949, using different formulations and different rates of 2,4-D as both preset and postset applications. A combination preset treatment of aero cyanamid followed by a postset application of aero cyanate was also used. The results, given in Table 6, showed that postset treatments were much

TABLE 6—CHEMICAL WEED CONTROL IN STRAWBERRIES

Average of 4 replications

Treatment	Crates per acre
1950 Test	
Aero cyanamid 160 lbs. per acre (Preset)+Aero cyanate 20 lbs. per acre (Postset)	92
2,4-D sodium salt, 3 lbs acid per acre (Preset) Cultivated as needed	77
2,4-D amine salt, 3 lbs. acid per acre (Preset) Cultivated as needed	123
2,4-D amine salt, 2 lbs. acid per acre (Postset) Cultivated as needed	118
2,4-D sodium salt, 2 lbs. acid per acre (Postset) Cultivated as needed	127
2,4-D Isopropyl ester, 3 lbs. acid per acre (Preset) Cultivated as needed	67
Check (Standard cultivation only)	177

better than preset treatments. Of the materials tested, the ester form of 2,4-D resulted in the greatest damage to the plants, while the cyanamid-cyanate combination gave poorest weed control. All plots were hoed and cultivated as necessary, and no results of the treatments were observed after the first cultivation. The chemically treated plots required one less hoeing than the check.

Plantings made in 1950 and harvested in 1951, gave essentially the same results as before. New plantings were made in 1951, and EH-1 was included in the test for the first time. At rates of 2 and 3 pounds per acre, excellent weed control was obtained with no apparent injury to the plants. Yields from this test will not be available until 1952.

Test plots were established in February 1951 to test various chemicals for weed control while the strawberry plants were dormant. The chemicals used were IPC, P. C., 2,4-D, and dinitro. IPC treatment at 10 lbs. per acre severely injured the strawberries, but gave good weed control. The dinitro compounds and P. C. at 30 to 40 lbs. per acre (split applications) gave excellent weed control with little damage to the plants, while 2,4-D did not give satisfactory weed control.

The results to date do not justify standard recommendations for chemical weed control in commercial strawberries. There is sufficient promise to warrant further work and some growers may want to test the better methods in their own fields.

For this purpose, the following suggestions are made:

1. Treat only a few rows until you become familiar with the chemicals and their reactions.
2. Use 2,4-D or EH-1 at 2 or 3 lbs. per acre, applied as a post-set spray in 50 gallons of water.
3. For dormant weed control, use oil soluble dinitro at the rate of 1 quart per acre in 30 gallons of oil and 70 gallons of water, or P. C. at about 30 lbs. (split application) per acre in 100 gallons of water.