STUDIES ON THE EFFECT OF CONTACT HERBICIDES AS TOP-KILLERS OF ALFALFA

by

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INTRODUCTION

The production of alfalfa seed provides an important contribution to the farm income of many Kansas farmers, and it is the most important legume seed crop in the state. Unfavorable weather during 1950 and 1951 severely reduced the state's alfalfa seed production; however, for the 1939-48 ten year average, Kansas produced an annual crop of 206,000 bushels valued at $3,456,000. The average yield during this period was only 1.3 bushels per acre which is considerably below the 4 to 6 bushel yields obtained in some production areas. In the entire state in 1947 and 1948, only four counties averaged as high as 2 bushels of seed per acre. Several reasons for these low yields are apparent such as lack of sufficient numbers of pollinating insects, unadapted or poorly adjusted threshing machinery, and excessive losses resulting from handling and movement of the ripened seed.

The purpose of these studies was to investigate the possibilities of increasing the yields of harvested seed through the application of contact herbicides to top-kill or defoliate the alfalfa stands, thereby permitting direct combining of the standing crop in preference to the customary method of mowing and windrowing, followed by pick-up combining after the growth had dried. The seed ripening sequence in alfalfa is such that the early seed pods ripen and dry while the later pods are still in the yellow maturing stage. Excessive vibration and turning, such as occurs in mowing and windrowing, causes much of this ripened seed to shatter, resulting in many instances, in losses of over half of the seed yield. Further losses result from strong winds rolling the drying windrows. In some seasons, ground moisture conditions are not conducive to rapid drying of a mature seed crop, but pre-harvest top-killing affords an opportunity to harvest such a crop because the drying seed is not lying on the ground. Alfalfa seed crops which contain rank growth cannot be combined directly because green growth in the rollers and separators of a combine cause heating of the harvested seed, poor seed separation, and binding of the rollers and separators. Properly top-killed foliage is dry, eliminating these moisture problems.

Since contact herbicides kill only those plant parts actually covered, there is a good possibility that some of these herbicides may be employed in the pre-harvest top-killing of alfalfa and other legumes, permitting direct combining of the standing crop, thus preventing the excessive loss through handling and shattering. Legumes are perennial crops, therefore, chemicals must be carefully selected to prevent damage to crowns and roots, and also to the seed in the pods.

REVIEW OF LITERATURE

Top-killing and defoliation experiments have been conducted by various experiment stations on numerous crops for a number of years through the use of non-selective contact herbicides; however, only during the past five years has attention been focused on the possible use of top-killers for legume seed production. The various herbicides used on cotton, flax and weeds, and the rates of application may give good indications as to what results can be expected in legume crops.

Experiments were conducted as early as 1927, using dilute solutions of sulphuric acid. Ashlander (5) reported that when using sulphuric acid as a contact herbicide for general weed control, the acid penetrated the cuticle rapidly and caused all contacted cells to die, yet, no translocations occurred. Humidity and temperature changes had varying effects upon the severity of top-killing. Crafts (10) found that concentrations of N sulphuric acid or stronger were needed to kill plant vegetation, and that sufficient volumes of solution were needed to thoroughly wet the foliage. Ball and French (7) reported that field trials showed greater wetting of and injury to grasses when wetting agents were added to sulphuric acid sprays. Evans and Martin (11) define a wetting agent or spreader as, "a substance which, like soap, assists in the wetting of the sprayed surface". Wetting ability is a property due to surface activity and is associated with the molecular structure of the material. Wetting is the ability of the liquid to form a persistent liquid-solid interface when the excess liquid is drained from the surface. Crafts (9) reported that if water spray solutions are used, their wetting power can be increased by the addition of a wetting agent such as Dreft, Vel, Triton B1956 or other agents, usually used at a concentration of .1 percent by weight.

Robbins et al. (24) found that some herbicides of an organic nature have naturally low surface tensions so that they spread well on all vegetation. Among these are petroleum oils, residues from sulphuric acid refining of lubricating oils, and creosote and tar oils from the destructive distillation process. Aqueous solutions of inorganic acids, bases and salts have a higher surface tension than pure water. Such solutions do not wet and spread on a waxy or otherwise unwettable plant surface. The surface tension of such solutions may be lowered by the addition of wetting agents or spreaders until they wet the most resistant of plant surfaces. Evans and Martin (11) and Hoskins and Ben-Amotz (16) found that excessive use of wetting agents actually lowered the amount of spray retained on the leaf surface, indicating that a particular range of concentration provides the best wetting power for each individual wetting agent.

Crafts (10) discovered that younger leaves are less pervious to the penetration of sprays than are older leaves, even though they are thinner. Young leaf surfaces are more waxy and much more difficult to wet so that quality of the surface layer as well as its thickness must be considered. Robbins et al. (24) reported that cultivated legumes are covered with a thick waxy bloom and therefore shed most of the spray if the concentration is not too high, unless wetting agents are used.

Fogg (12), Crafts (10), and Silversides (25) found that contact herbicides do not enter the leaf through the stomata, but that penetration was effected by diffusion through the cuticle and epidermal cells. They found that turgid leaves were damaged to a greater extent than wilted leaves because the slightly corrugated surface of wilted leaves provided some degree of protection. Cooper (8) studied the penetration of potassium cyanate and sodium cyanamide solutions and found that rapid and severe plasmolysis occurred followed by a disintegration of the protoplast. The stomata did not permit the solution to enter, but death of the guard cells permitted diffusion through them and into the adjacent cells.

Stiver and Johnston (26) reported excellent cotton defoliation following the application of 25 pounds of sodium cyanamide (X5) as a spray per acre. Dusts proved to be of doubtful value as defoliants because of low humidity. Dews are essential for satisfactory results following dust treatments. Thaxton and Jones (27) reported high leaf killing following applications of 12 pounds of potassium cyanate (X1) per acre, or 20 pounds of sodium cyanamide (X5) per acre in 12.5 gallons of water. As low as 1 percent of Vatsol greatly increased the efficiency of the chemicals. At higher concentrations, no differences between different varieties appeared; however, sprays were consistently superior to dusts. Hygroscopic dusts such as sodium cyanamide

(X10) were not dependable during periods of low humidity. Sodium cyanamide (X5) applied as a spray at 15 pounds with 1 percent Vatsol yielded practically the same results as 20 pounds without the wetting agent. Use of the spreader reduced leaf spot burning and increased defoliation. Leaf burning results from the lack of even coverage. They found a narrow margin in rates for both ammonium thiocyanate and potassium cyanate (X1) to produce good defoliation. An over dosage resulted in freezing the leaves on the plant and an underdosage resulted in poor defoliation. Chipman's defoliant gave fair results as a defoliant at a rate of 7.9 pounds of active ingredient per acre, however, spot burning was more pronounced than from potassium cyanate. Guy (14) reported the use of calcium cyanamide on thousands of acres of cotton. Better grades of cotton were produced and definite cotton picking schedules could be established. Regardless of the defoliant used, uniform and complete coverage of all foliage is absolutely essential. When sprays are used, a fine mist is not desirable because mists do not provide sufficient penetration, whereas, a coarse spray results in uneven coverage, unless excessive amounts are applied. Morris and Cowley (20) reported a definite association of climatic conditions and use of herbicides as cotton defoliators. They reported that potassium cyanate (X1) spray at 11.25 pounds and Sharples E. C. 3740 (25 percent) at 2 gallons in 30 gallons of water per acre were very efficient leaf killers of cotton when applied at a pressure of 60 P.S.I. Airplane dusting of cotton proved satisfactory when heavy early morning dews were present.

With potato harvesting, heavy green vines are often a complicating factor, especially when mechanized diggers are used, since they tend to clog the digger and interfere with the harvesting operation. Kraus and Dietz (19) reported excellent top killing of Bliss Triumph potatoes from applications of 1 pound of ammonium sulfate per gallon of water, applied at 100 to 200 gallons per acre. Poor results were obtained from Netted Gem potatoes, indicating varietal differences. Dow General spray applied at a rate of 1 gallon in 99 gallons of water plus 5 pounds of ammonium sulfate, or, 1 gallon of sinox, 15 gallons of diesel oil and 100 gallons of water per acre also gave excellent results. Maturity was not hastened unless all foliage was completely covered and killed. Other results (1) indicated that dinitro-ortho-secondary-butyl-phenol, applied at 6 pounds per 100 gallons of water at 125 gallons per acre and carried in an emulsifiable oil and sold as Dow Spray 66 Improved, produced 100 percent kill (plant parts drooping and discolored) after 4 hours, and most of the leaves were dead after 24 hours. In effect, this herbicide acts as an artificial frost, since "it accomplishes chemically under controlled conditions what nature does haphazardly". Later experiments (4) recommend the use of 2 gallons of Dow Spray 66 Improved plus 2 pounds of aluminum sulfate in 100 gallons of water at a rate of 125 gallons per acre. The temperature at the time and soon after application is extremely important. Seventy to 80 degree temperatures favor action and reduce the amount of spray needed. They found that fan shaped sprays gave better coverage than other spray patterns. Rich (23) reported considerable injury to the xylem and phloem in potato tubers when fast acting chemical herbicides were used. When calcium cyanamide was used, very little damage occurred because several days were required for the completion of the chemical action.

Experimental work conducted in Arizona and the Imperial Valley of California (2) on alfalfa and flax included various combinations of oil and fortifying compounds and various oil, water, and chemical mixes, but a mixture of 2 pints of Dow General Spray and 15 gallons of diesel oil per acre, applied by airplane gave the most satisfactory results. Reducing rates below 2 pints of Dow General or below 7 gallons of diesel oil produced insufficient drying to permit direct combining. Several special aromatic weed oils can be substituted for the diesel oil, however, no advantage over straight diesel oil can be claimed, and also, some oils, when combined with sinox sprays, produce a gummy residue which clogs the nozzels.

Ball et al. (6) found that diesel oil was strictly a contact killer, spreads well on all vegetation, and if properly applied, will destroy all vegetation down to the ground level. Diesel oil, furthermore, has little cumulative effect in the soil. They also found that oils which penetrate the seed coat often kill the seed. Excessive applications of diesel oil in top-killing sprays may be detrimental. Crafts (9) found that diesel oil is a better carrier than water because it has a low surface tension and a high wetting ability. This permits better absorption and killing of the tissues.

Fowler (13) reported excellent top-killing of alfalfa and clovers in Oregon by flying on 1½ to 2 pints of Dow General in 8 gallons of diesel oil per acre. A pre-harvest spray demonstration by John E. Swift, farm advisor, Imperial County, California, yielded a 50 pound alfalfa seed increase per acre following the application of top-killing herbicides and direct combining, compared to conventional mowing and windrowing methods.

Jones (18) obtained excellent results by flying on one to 3 pints of Dow General spray in 10 to 15 gallons of diesel oil per acre. Ground application required 1½ to twice the amount of spray. Water-oil emulsion sprays required from 25 to 65 gallons of solution to produce equal degrees of top-killing. He reported that pre-harvest sprays were used on over one fourth of the 24 million pounds of alfalfa seed harvested in California in 1951, without a single case of impaired germination.

The current practice (3) in the west coast flax areas is to direct combine flax seed. Heavy weed stands often force the grower to resort to mowing and windrowing. Flying on 2 to 3 pints of a dinitro fortifier such as Dow General Weed Killer in 10 to 15 gallons of diesel oil per acre permitted direct combining in one operation and secured a better recovery of seed. Losses of 2 to 3 bushels per acre are common following windrowing.

Birdsfoot trefoil is difficult to harvest because of shattering, both before and during the harvest process. Jones (17) found that 1 to 2 pints of dinitro defoliant in 10 gallons of diesel oil caused birdsfoot trefoil to dry out and toughen sufficiently to permit harvesting before the pods dried enough to shatter. When the temperature was 100° F. or above, harvesting could be started the same day the herbicide was applied.

Cooper (8) reported that large losses often result when wind carries away the swathed material. Wind losses are materially reduced when the plants remain standing. Plot trials showed that 25 pounds of potassium cyanate (X1) or 80 pounds of sodium cyanamide (X5) in 40 gallons of water per acre produced a 90 percent top-kill which was satisfactory for direct combining. Applications of 100 to 150 pounds of calcium cyanamide, monosodium cyanamide (X5) and sodium cyanamide (X10) as dusts were unsatisfactory, producing only 10 to 25 percent top-killing. Younger vegetation was not killed, making this material unsatisfactory for direct combining. He tested various spreading agents and found that the addition of Dreft to potassium cyanate resulted in 50 percent reduction in the amount of chemical needed to give an equal top-kill. At lower rates, the addition of a spreader was much more important than at higher rates. His observations showed that complete top-killing was not necessary. If the seed head and top growth were killed, the stems could remain partially green and still be dry enough for direct combining.

Hoffman (15), by means of field counts, definitely established a need for top-killing and direct combining by reporting that 4 to 6 bushels of alfalfa seed per acre was lost due to mowing, windrowing, and rolling of windrows by the wind. Three years' results show that 1 quart of Dow General Sinox Spray in 10 to 20 gallons of fuel oil per acre, applied at pressures of 30 to 40 P.S.I. resulted in excellent top-killing. Reduction of oil below 10 gallons of oil, resulted in decreasing degrees of top-killing, while above 10 gallons of oil, there appeared to be no additional desirable effects. When water sprays were used, doubling the concentrate rate increased the killing effectiveness. Dinitro treated alfalfa was dry enough for direct combining 2 to 3 days after spraying. Pentachlorophenol also gave reasonably good results.

Several workers (2, 8, 13, 15, 18) reported neither germination nor viability of the seed was affected by the dinitro spray or the water or oil carrier.

Jones (18) found that harvesting operations could begin from 4 to 24 hours after application when temperatures were 90 degrees or above, and good threshing weather prevailed. Cooper (8) concluded that killing of the seed pod temporarily delayed the mechanism of dehiscence, making harvesting possible before the occurrence of shattering. He reported a best time of application for maximum control. If the seed pod had reached the advanced stage of maturity, the delay in dehiscence was very short, while the killing of an immature pod might affect the seeds' viability.

Cooper (8) and Jones (18) found that where conditions warrant the expense, two applications of sprays are possible and often desirable. Where excessively heavy foliage prevails, the first spray will kill the external growth permitting the second spray several days later to more thoroughly penetrate and cover the lower and protected foliage. When two sprays are used, applications of 1 quart of dinitro in 8 gallons of oil are satisfactory.

Complete coverage and penetration are essential to preparation for combining. Jones (18), reporting operations on over one thousand acres of treated ladino clover, found that ladino is quick to start regrowth after spraying, and as soon as the young leaves appear, the effectiveness of the defoliant decreases. Sprayed fields must be harvested as soon as possible to prevent the addition of moisture from new leaves to the harvested seed.

Hoffman and Sylvester (15) reported that the shock to the established alfalfa crown was not as severe following the top-killing as from mowing. Quicker recovery followed spraying which might make it possible to gain a period of from 4 to 7 days for the production of new growth. This would increase the period of accumulating organic reserves in the roots in the event that the seed crop was removed late in the season, shortly before killing frosts occurred. Cooper (8) concluded that pre-harvest treatment of top growth with herbicides was no more detrimental to root reserves of alfalfa than other practices which were currently used.

MATERIALS AND METHODS

Preliminary top-killing and defoliation tests were conducted in the greenhouse during June and July of 1951 in order to determine which herbicides and what concentrations would provide the highest degree of defoliation and top-killing. Potted alfalfa plants were treated in pairs with various concentrations of 13 herbicides, in order to determine the extent of defoliation, crown injury, and killing effect of each chemical. A small hand insecticide sprayer was used to apply the sprays. The sprayer was thoroughly washed between each application to prevent mixtures of the chemicals.

In order to determine whether complete leaf coverage was better than spotted coverage, various chemicals were applied to individual leaves, the outer leaflets being completely covered by means of a small brush, and the center leaflet spotted with the solution by means of a medicine dropper. This would give indications as to whether a fine mist as supplied by high pressures and small nozzles would provide a more satisfactory defoliation than would larger and fewer droplets as obtained from lower pressures and larger nozzles.

Data were collected from all plants on extent of leaf and stem drying, percent defoliation, and height of new growth. Detrimental effects resulting from the application of any treatment would produce differences in the height of the new shoots arising from the crowns of the top-killed plants.

Field Plot Experiments, 1951

Field plots were laid out in two well established Buffalo alfalfa fields located on the Agronomy farm. The upper field was well drained and covered with a good dense stand of alfalfa, while the lower field was considerably wetter than is desirable for seed setting, due to excessive summer rainfall. The stand of the lower field consisted of rank top growth with considerable weed growth, mainly foxtail spp., scattered throughout the field.

Two blocks of 180 randomized plots each were staked out in the lower field and one similar block was established on the upper field. Yard square plots were staked out with a two foot alley running between adjacent rows of plots so that each plot could be sprayed without walking on adjacent plots. Five chemical treatments, Dupont Copper Sulfamate, Sharples Experimental Chemicals ME 3000, ME 3001, and EC 3321, and Standard Agricultural Chemicals, Inc. Sinox General, and a check plot were randomized 5 times at 3 different concentrations and 2 rates of application in each block. In order to assure good leaf penetration of the herbicides, a Sharples' wetting agent, Nonic #218, was added to all solutions at a concentration of .001 percent by volume.

In order to determine whether the various treatments or concentrations would have any effect on the number of seed pods dropped between the time of application of spray and harvest, 5 racemes in each plot were tagged and the number of pods in each raceme counted and recorded.

Four of the chemicals chosen for this experiment were known to produce a high degree of actual defoliation, as shown by greenhouse experiments. In order to determine the extent of defoliation, five alfalfa stalks were selected at random from each plot, inserted in paper bags, and dried in the greenhouse. These samples were later compared with similar samples collected after the application of the top-killing herbicides.

Equipment consisted of a compressed air sprayer, modeled similarly to one used by Raleigh and Patterson (22). A 500 cubic inch war surplus oxygen tank served as the pressure reservoir, to which was attached a pressure guage and a pressure regulator. An air valve was fitted into the end of the tank to permit filling. A small portable air compressor was used to fill the oxygen tank in the field. The pressure regulator was set to maintain a pressure of 40 P.S.I. at the nozzle. The herbicide container was either a 2 quart glass mason jar, graduated for 300 cc applications, or a 1 quart oil jar, graduated for 150 cc applications, depending on the volume of spray required. The herbicide container was attached to the air line of the sprayer by means of a supporting framework around the bottom of the container which screwed up tightly against a rubber seal on the container cap by means of two wing nuts. Glass jars of the type used were able to withstand the internal pressure of 40 P.S.I. used in these experiments, however, if higher pressures were to be used, a metal shield around the glass container would be desirable to prevent injury to the operator in case one of the jars should burst. Glass jars were used in preference to metal containers so that the operator could regulate the volume applied to each plot, thereby eliminating the need for refilling the container after spraying each plot. Five randomized plots in each block received the same rate and concentration of spray. The calibrated herbicide container necessitated only one filling in order to treat all five identical plots. The spray boom consisted of an ordinary knapsack sprayer boom with an F50u cone shaped nozzle.

The nearness of adjacent plots necessitated the use of drift preventative measures. Five completely enclosed screens were constructed of a lath framework covered by heavy muslin cloth. These screens were one yard square and one yard high, with the muslin extending to within 10 inches of the ground. During the spraying operation, one screen was placed around each of the five identical plots, the desired volume of top-killing herbicide was applied within each screen, and then, while the spraying equipment was being rinsed out and the container refilled with the next spray, an assistant moved the screens to the next set of five identical plots. This permitted application of the herbicides as rapidly as the spraying equipment could be washed and refilled. All herbicide solutions were prepared in the laboratory and taken to the field in a form ready to apply. All plots in one block were treated before starting on another block in order to prevent interplot variations due to different times of application. Plate I shows the spraying equipment and one of the screens used for the application of these sprays.

Harvesting operations commenced 2½ days after the first spray application. The five tagged racemes of each plot were removed and inserted in small coin envelopes. The number of pods in each envelope was later counted and compared to the number of pods counted prior to spray application. The percent of pod dropping was calculated from these data.

Five more stalks were picked at random from each plot, bagged, and dried in the greenhouse. Assuming that a fairly accurate ratio existed between the air dry weight of leaves and stems of all stalks, a determination of the percent of defoliation was computed from the difference between the percent of leaf to stem ratio of the samples collected before and after application of the top-killing herbicides.

Plot yields were obtained by hand harvesting with a sickle an area of one ten-thousandth acre from the center of each plot. A tubular aluminum pipe, bent to form a square 24.9 in. on a side and open on one side was pushed at ground level into each plot. All plants growing within this form were carefully cut and inserted into a paper bag. These samples were dried in the greenhouse, then, each sample was threshed with a small portable threshing

EXPLANATION OF PLATE I

Equipment used for applying the top-killing herbicides, showing the air tank, guage and pressure regulator on the operator's back, the calibrated herbicide container, and a muslin screen used for preventing drift of the spray.

PLATE I

machine. This seed was recleaned on a South Dakota Seed Blower on which the intensity of the air blast and the time of running was equally adjusted for all samples. Seed yields for each plot were weighed separately.

Seed from the five plots receiving identical treatment in each block was then bulked and a germination test run on the composite sample. All germination tests were made by the Kansas State Seed Laboratory at a temperature of 68° F for 7 days. The percents of germination and of hard seed were recorded for each sample. All data were subjected to statistical treatment to determine whether different herbicides and concentrations had produced significantly different results.

In order to assimilate field conditions, two adjacent one-third acre plot yields were compared. One plot was mowed; the other plot was preharvest sprayed with a tractor drawn field sprayer using a concentration of 58 lbs. of copper sulfamate in 60 gallons of water per acre, applied at a pressure of 40 P.S.I.

Three days later, when the material was dry enough to thresh, the top-killed plot was direct combined, using a six foot model 12A John Deere combine, while the other plot was threshed with the same combine, using a pickup attachment to remove the mown material from the swath. The combine was adjusted to reduce seed losses to a minimum and no attempt was made to obtain clean seed. All seed was later recleaned on a small hand operated Clipper cleaner in the laboratory.

Preliminary Field Experiments, 1952

Results of the previous season were highly satisfactory and warranted additional investigation before field scale operations could be started. A series of two-hundredth acre plots was laid out in a field of first growth alfalfa late in May. Various concentrations and rates of 5 herbicides, Dow General, Sinox, Endothol, potassium cyanate, and penta-chlorophenol, were applied, using various combinations of diesel oil or diesel oil-water emulsions. Triton B 1956, an emulsifier and wetting agent was added at a rate of 4 ounces per hundred gallons to assure adequate penetration of the spray into the leaf tissues and a thorough mixing of the oil-water mixtures.

The spraying equipment was essentially the same as that used the previous season except that a three nozzled boom, covering a five foot strip replaced the single nozzle. Tee Jet flat spray nozzles were utilized to obtain an even distribution of the herbicide. Various capacity nozzles were used to apply different volumes of spray. A constant rate of travel of approximately 3 M.P.H. was maintained. Observations regarding the top-killing effectiveness of the various sprays were recorded.

EXPERIMENTAL RESULTS

The results herein reported are concerned with the effects of various contact herbicides on the top-killing, germination, and seed yield of alfalfa. These results are applicable for the conditions under which the experiments were conducted and may not coincide with results from similar experiments conducted under different circumstances.

Leaf Coverage Experiment

Low spraying pressures provide fewer and larger droplets than do higher pressures, the nozzle orifice remaining constant. In this experiment, spot treated leaflets represented lower pressures and less complete leaf coverage.

Actual leaf defoliation counts following these treatments showed that better defoliation occurred following the spotted treatment than following complete coverage. The data in Table 1 show that in every instance, spot treatment gave equal or better defoliation than did the complete coverage treatment. This indicates that better leaf defoliation and top-killing can be expected by applying top-killing chemicals at relatively low pressures in preference to higher pressures which break the spray into much finer droplets. Larger droplets have a better chance of being absorbed into the leaf tissues before evaporation materially reduces the droplets' liquid content. Larger droplets are less likely to drift excessively when applications occur during windy conditions.

Leaf Defoliation and Pod Dropping Experiments

Some of the contact herbicides which are useful as top-killers for alfalfa also produce a high degree of defoliation. Copper sulfamate and Sharples experimental chemicals, ME 3000, ME 3001, and EC 3321, produce up to 70 percent actual leaf defoliation. No particular value can be claimed for leaf shedding in small seeded legumes, as the dead leaves offer no problem in the harvesting procedure. It was necessary, however, to include defoliation studies as part of the experiment in order to determine whether defoliating chemicals would cause an increase of pod dropping with a resulting decrease in yield. Table 2 presents the summary of the analysis of variance of the percent defoliation produced by the various chemicals. A highly significant difference occurred between the various treatments. This was expected on the basis of field and greenhouse observations. It can be observed from Table 3 that sinox produced considerably lower extent of

Table 1. Comparative top-killing and percent defoliation of contact herbicides in greenhouse experiments.

Herbicide	Conc. per acre in lbs.	Leaf kill*	Stem kill*	Percent defoliation Total	Brushed on leaves	Spotted on leaves
EC 3504	5.3	5	9	66	33	100
	10.7	0	9	100	100	100
	21.4	0	9	75	37	100
EC 3321	5.3	5	9	33	00	100
	13.3	0	9	100	100	100
	21.4	0	9	100	100	100
EC 3301	7.7	5	9	100	0	16
	8.1	0	9	80	50	100
	9.1	0	9	100	100	100
Copper sulfamate	21.0	2	9	22	0	67
	42.0	0	9	90	33	100
	63.0	0	9	44	33	64
Sodium nitrite	21.0	0	9	11	8	16
	32.0	0	5	0	0	0
	53.0	0	0	0	0	0
Trichlor-acetic acid	21.0	0	9	100	100	100
	42.0	5	9	46	25	80
	63.0	2	9	33	0	50
Ammate	21.0	5	9	22	0	67
	42.0	0	9	8	0	25
	63.0	2	9	0	0	0
Potassium cyanate	26.0	0	5	50	25	100
	42.0	0	9	0	0	0
	53.0	0	7	0	0	0
Sinox	5 pts.	2	9	50	25	100
	7 "	2	9	44	33	67
	10 "	0	9	25	12	50
Pentachloro-phenol	4 pts.	7	9	33	33	33
	6 "	7	9	44	33	67
	10 "	2	9	33	11	75

* 0 - completely dead
9 - no injury

defoliation than the other herbicides. A least significant difference of 8.6 shows that all untreated check plots and all but several of the sinox treated plots produced a significantly lower extent of defoliation than did the other herbicides. Sinox treated plants produced unnoticeable defoliation in the field while copper sulfamate treated plants shed most of their leaves. Plate II illustrates the difference in extent of leaf defoliation for these two herbicides.

Table 2. Summary of analysis of variance for the percent defoliation produced by various herbicides in field experiments.

Sources of variation	Degrees of freedom	Sum of squares	Variance	Calculated F ratio	F ratio for significance 5%
Total	107	24530.96	229.26		
Between treatments	5	10804.48	2160.89	35.08**	4.74
Between rates	1	75.88	75.88	.32	19.30
Between conc.	2	103.01	51.50	.84	19.39
Between blocks	2	743.66	367.33	4.25	19.48
Interactions					
Treat. X rate	5	1171.74	234.35	2.71	4.74
Treat. X conc.	10	615.99	61.59	.71	2.97
Rate X conc.	2	32.09	16.04	.19	19.39
Treat. X rate X conc.	10	4941.56	494.15	5.72**	2.61
Error	70	6051.55	86.45		

* Significant difference
** Highly significant difference

The various treatments and concentrations did not affect the rate of pod dropping. Table 4 shows that no significant differences exist between the different herbicides or concentrations.

Table 3. Effective top-killing, percent defoliation, and pod dropping of pre-harvest herbicides in field experiments.

Herbicide	Concentration per acre in lbs.	Low volume			High volume		
		Top kill*	Defol. %	Pod drop %	Top kill*	Defol. %	Pod drop %
Copper sulfamate	5.3	7	54	.60	7	55	.67
	32.1	2	52	.24	2	52	.55
	96.3	0	55	.66	0	57	.55
ME 3001	7.1	2	53	.49	5	53	.42
	9.0	2	52	.43	2	55	.62
	11.8	0	61	.36	0	60	.39
ME 3000	2.1	0	53	.60	2	56	.39
	8.0	0	55	.72	0	52	.43
	13.4	0	63	.42	0	60	.39
EC 3321	1.0	5	56	.31	5	56	.60
	2.7	0	57	.43	2	59	.44
	10.7	0	55	.47	0	60	.76
Sinox	2 pts.	5	42	.36	7	50	.69
	4 "	2	45	.49	5	47	.30
	8 "	0	46	.32	0	48	.63
Check		9	26	.50	9	26	.41
		9	25	.48	9	30	.62
		9	32	.71	9	29	.31

* 0 – Completely killed
9 – No effect

EXPLANATION OF PLATE II

Chemically Top-Killed Alfalfa

Fig. 1. Comparison of Sinox (left) and copper sulfamate treated alfalfa, illustrating differences in the extent of leaf defoliation.

Fig. 2. Comparison of Sinox treated (right) with untreated alfalfa showing the high degree of top drying of the treated foliage.

PLATE II

Fig. 1.

Fig. 2.

Table 4. Summary of the analysis of variance of the percent of shattered seed pods in field experiments.

Sources of variation	Degrees of freedom	Sum of squares	Variance	Calculated F ratio	Ratio needed for significance 5%
Total	107	5.19	.05		
Between treatments	5	.09	.02	.22	4.74
Between rates	1	.04	.04	.44	19.30
Between conc.	2	.02	.01	.25	19.39
Between blocks	2	.27	.13	3.25	19.48
Interactions					
Treat X rate	5	.44	.09	2.25	4.74
Treat X conc.	10	.47	.04	1.00	2.97
Rate X conc.	2	.01	.00	.00	19.39
Treat X rate X conc.	10	.90	.09	2.25	2.61
Error	70	2.95	.04		

Increasing the rate of application did not produce an increase in defoliation or pod dropping in all cases. With some herbicides, defoliation accompanies rate increases up to a point, after which, additional rate increases did not produce a corresponding increase in leaf defoliation. A certain range exists for each herbicide within which the best results can be obtained.

In practically all cases, better top-killing resulted from the low volume application than from the high volume application. Decreasing the solution volume while maintaining a constant weight of herbicide increased the concentration of the solution and produced a better top-killing of the herbage.

Germination and Hard Seed

Germination tests were conducted on all lots of seed by the Kansas

Table 5. Percentage of germination and hard seed of top-killed alfalfa plots.

Herbicide	Conc. per acre lbs.	Low volume						High volume					
		Block 1		Block 2		Block 3		Block 1		Block 2		Block 3	
		Germ	Hd Sd	Germ	Hd Sd	Germ	Hd Sd	Germ	Hd Sd	Germ	Hd Sd	Germ	Hd Sd
Copper sulfamate	96.3	62	22	71	25	65	24	61	29	81	14	50	37
	32.1	66	28	64	27	39	36	59	25	80	16	54	26
	5.3	73	17	67	26	37	41	49	36	73	20	40	34
ME 3001	11.8	61	30	59	36	53	40	69	19	75	20	53	40
	9.0	63	24	71	20	47	44	59	27	71	19	60	31
	7.1	69	27	64	26	54	37	78	20	62	26	53	45
ME 3000	13.4	62	32	48	46	55	37	72	22	63	30	63	29
	8.0	66	23	61	32	48	44	45	48	71	23	52	38
	2.1	69	27	81	15	45	43	65	27	58	35	51	41
EC 3321	10.7	60	29	52	37	53	40	64	30	53	33	55	34
	2.7	78	17	72	21	44	46	80	16	76	19	63	26
	1.0	63	24	63	31	57	33	64	26	52	43	53	37
Sinox	8 pts.	65	27	65	27	53	41	69	23	59	28	38	52
	4 "	64	26	67	22	53	39	75	21	59	33	47	43
	2 "	56	39	70	23	47	45	57	38	70	23	53	38
Check		67	25	75	19	58	35	56	36	67	24	51	39
		73	18	53	31	62	29	61	33	68	24	42	52
		63	21	50	46	52	43	65	23	75	20	45	43

State Seed Laboratory at Manhattan, Kansas. All seed was removed from the germinator at the end of seven days and tabulated in terms of percentage of germination, hard seed, and non-viable seed. Table 5 gives the percent germination and hard seed for the various treatments and concentrations. Widespread fluctuations appeared to exist between some of the individual plots; however, an analysis of variance of the percent of seed germinated (Table 6) shows that there are no significant differences in seed germination between rates, concentrations, or herbicides. This indicates that under the conditions of this experiment, no detrimental effects on seed germinations were produced. Over 80 percent of the plot seed samples tested 90 percent or higher germination and hard seed combined, and only one sample dropped as low as 84 percent germination and hard seed. This favorably compares with the germination of commercial lots of seed.

Table 6. Summary of analysis of variance for the percent germination of seed from field experiments.

Sources of variation	Degrees of freedom	Sum of squares	Variance	Calculated F ratio	F ratio needed for significance 5%
Total	107	1967.00	18.38		
Between treatments	5	294.72	58.94	3.55	4.74
Between rates	1	.46	.46	.03	19.30
Between conc.	2	24.62	12.31	.68	19.39
Between blocks	2	119.42	59.71	3.36	19.48
Interactions					
Treat X rate	5	4.48	.89	.05	4.74
Treat X conc.	10	166.16	16.61	.94	2.97
Rate X conc.	2	36.39	18.19	1.02	19.39
Rate X conc X treat	10	78.17	7.81	.44	2.61
Error	70	1242.58	17.75		

Reduction in the percent of hard seed would be of tremendous value in legumes. It would be highly desirable to be able to find some material which could be sprayed onto the ripening pods which would penetrate the seed coat, and in some manner, reduce the quantity of hard seed. In order to determine whether any of the herbicides used in this experiment had any effect on the amount of hard seed produced, a separate analysis of variance, Table 7, was conducted on the percent of hard seed data. A significant difference between the three replicated blocks occurred at the five percent level, but all other values were insignificant. This significant value between blocks was probably due to different levels of soil fertility or to some other factor, inasmuch as individual treatments or rates failed to show significance. None of the herbicides used in this experiment was found to be of value for the reduction of hard seed.

Table 7. Summary of analysis of variance of the percent of hard seed from field experiments.

Sources of variation	Degrees of freedom	Sum of squares	Variance	Calculated F ratio	F ratio needed for significance 5%
Total	107	8843	82.64		
Between treatments	5	458	91.60	2.37	4.74
Between rates	1	8	8.00	.31	19.30
Between conc.	2	123	61.50	1.58	19.39
Between blocks	2	3337	1168.50	28.30*	19.48
Interactions					
Treat X rate	5	131	26.20	.44	4.74
Treat X conc.	10	387	38.70	.66	2.97
Rate X conc.	2	28	14.00	.24	19.39
Treat X rate X conc.	10	244	24.40	.41	2.61
Error	70	4127	58.95		

* Significant difference.

Visual observation of top-killed and untreated lots of seed, harvested from adjacent areas failed to indicate differences in seed quality. All seed harvested from the experimental plots contained considerable off-color seed; however, seed from the treated and untreated plots could not be distinguished on the basis of plumpness, color, luster or other visual characteristics.

Top-killed plants generally recover more swiftly from the shock of the loss of top growth than where the top growth was removed by cutting non-treated plants. Table 8 shows that only potassium cyanate treated plants recovered more slowly than did the untreated plants. These results indicate that sufficient herbicide can be applied to the foliage to produce a satisfactory top-kill without injury to the crown buds which produce the new growth shoots.

Seed Yields of Top-Killed Plots

Seed yields from each individual plot were collected to determine the effects of various top-killers on seed yield. An analysis of variance of the yield data, Table 9, showed no significant differences in seed yield following the use of any of the treatments or concentrations. No significant differences occurred in the percent of seed pods dropped following the application of the various herbicides, Table 4, and all check plots were as carefully harvested as the treated plots; therefore, no significant differences in seed yield should be expected.

Results from the pre-harvest top-killed one-third acre plots sprayed with copper sulfamate compared to the unsprayed plot indicated that 78.4 percent of the seed was recovered by the top-killing, direct combining

Table 8. Height of new crown growth two weeks after application of top-killing herbicides in greenhouse experiments.

Herbicide	Concentration per acre lbs.	Relative top kill *	New growth in inches
Copper sulfamate	32	2	6
	96	0	$5\frac{1}{2}$
ME 3001	9	2	5
	12	0	8
ME 3000	8	0	5
	13	0	5
EC 3321	3	0	5
	10	0	6
Sinox	4 pts.	2	8
	8 "	0	5
Sodium nitrite	3 lbs.	9	4
	10	9	4
Potassium cyanate	10	7	3
	25	5	4
Check		9	4

* 0 - Completely killed
9 - No effect

method compared to only 44.4 percent following the conventional mowing, windrowing, pick-up combining method. This shows that pre-harvest spraying results in a loss of only 21 percent compared to 55 percent loss for the conventional methods. Both plots were harvested the same day with the same John Deere combine on which no adjustments were made between plots. Therefore, these seed yield differences were due, not to faultiness of harvesting equipment, but to differences in the amount of seed retained by the plants at the time of harvesting.

Yields of adjacent plots were carefully harvested by hand and threshed in a small mobile thrashing machine. These yields were rated in relation to untreated areas as 100 percent yield. Actually, these yields are not 100 percent of the possible yield, but represent the maximum yield that can be retained under the most favorable of harvest conditions and techniques.

Table 9. Summary of the analysis of variance of seed yields of field experiments.

Sources of variation	Degrees of freedom	Sum of squares	Variance	Calculated F ratio	F ratio needed for significance (5%)
Total	107	98.29	.19		
Between treatments	5	4.58	.91	1.82	4.74
Between rates	1	.08	.08	.16	19.30
Between conc.	2	5.98	2.99	4.40	19.39
Between blocks	2	47.32	23.66	20.94*	19.48
Interactions					
Treat X rate	5	2.51	.50	.44	4.74
Treat X conc.	10	1.29	.12	.11	2.97
Rate X conc.	2	1.36	.68	.60	19.39
Treat X rate X conc.	10	3.00	.30	.26	2.61
Error	70	79.49	1.13		

* Significant difference.

A significant difference occurred in the seed yields between blocks of replicated plots. This again was probably due to the effects of a severe thunderstorm which occurred before all blocks were harvested.

A highly significant negative correlation was found between seed yields and percent defoliation. This indicates that as leaf defoliation increases, seed yield decreases, one reason being that as defoliation increases, the number of pods dropped also increases with a resulting loss of seed, hence, increased defoliation results in decreased yields, (Table 10). A correlation between seed yields and pod dropping did not yield a significant value. The results of the experiment, Table 4, showed that the various treatments did not produce a significant pod drop.

Table 10. Seed yields and percent defoliation obtained from top-killed plots in the field experiments.

Herbicide	Conc. per acre in lbs.	Low volume		High volume	
		Seed yield gms.	Defoliation %	Seed yield gms.	Defoliation %
Copper sulfamate	5.3	3.52	54	4.21	55
	32.1	3.64	52	3.11	52
	96.3	3.48	55	3.81	57
ME 3001	7.1	3.63	53	3.91	53
	9.0	2.98	52	3.08	55
	11.8	3.35	61	3.26	60
ME 3000	2.1	3.58	53	3.97	56
	8.0	2.80	55	3.50	52
	13.4	3.02	63	3.95	60
EC 3321	1.0	3.32	56	3.95	56
	2.7	3.21	57	3.11	59
	10.7	3.44	55	3.02	60
Sinox	2 pts.	4.31	42	3.36	50
	4 "	3.83	45	3.06	47
	8 "	3.59	46	3.89	48
Check		3.78	26	4.48	26
		3.82	25	4.00	30
		3.56	32	3.98	29

Top-Killing Results, 1952

Observations on the effectiveness of top-killing of various chemicals on the first growth alfalfa in 1952 are summarized in Table 11. The only effectively top-killed plots were those rated 0 or 2. Sinox, at 2 pints in 40 gallons, or 3 pints in 10, 20, or 40 gallons, and Pentachlorophenol at 1½ gallons of a 40 percent product in 20 gallons of diesel oil-water emulsion, all produced satisfactory top-kills for direct combining. The other applications produced insufficient top drying to permit combining of the seed directly.

Endothol produced highly unsatisfactory results. Diesel oil-endothol mixtures are not recommended because in our experiments, a heavy, gummy residue was produced which clogged the nozzle strainers and prevented uniform applications of the herbicide.

Potassium cyanate results were also unsatisfactory. These rates of application, in water, produced highly satisfactory results in other experiments on second cutting alfalfa; however, inferior results were obtained in this case, due to the addition of diesel oil. Potassium cyanate is practically insoluble in diesel oil, and in all cases, addition of water was essential for the formation of a true solution.

DISCUSSION

These experiments were conducted in order to determine whether satisfactory pre-harvest top-killing could be obtained by the application of contact herbicides, thus permitting the direct combining of the standing seed crop.

Table 11. The top-killing effectiveness of herbicide-oil solutions and herbicide-oil-water emulsions.

Herbicide	Conc. per acre	Diesel oil in gallons	Water in gallons	Total gallons	Top-kill rating *
Dow General Sinox	2 pts.	5	—	5	5
		10	—	10	5
		5	15	20	5
		5	35	40	2
Dow General Sinox	3 pts.	5	—	5	5
		10	—	10	2
		5	15	20	0
		5	35	40	2
Pentachlorophenol	1 gal.	5	—	5	7
		10	—	10	9
		5	15	20	5
		5	35	40	5
Pentachlorophenol	1½ gal.	5	—	5	7
		10	—	10	7
		5	15	20	2
		5	35	40	7
Potassium cyanate	10 lbs.	5	—	5	9
		10	—	10	9
		5	15	20	9
		5	35	40	9
Potassium cyanate	15 lbs.	5	—	5	9
		10	—	10	7
		5	15	20	7
		5	35	40	7
Endothol	1 gal.	5	—	5	9
		10	—	10	9
		5	15	20	7
		5	35	40	9
Endothol	1½ gal.	5	—	5	9
		10	—	10	9
		5	15	20	7
		5	35	40	9
Check					9

* 0 – complete kill
9 – no effect

Technically, pre-harvest top-killing is not a defoliation process, since in most cases the leaves do not separate from the stem. The treated plants simply die from the tip to the crown, resulting in rapid loss of moisture and drying of the seed pods. The dinitro compounds, pentachlorophenol, and potassium cyanate produce excellent top-killing with little or no defoliation. Several other herbicides, such as copper sulfamate and Sharples' ME 3001, do produce up to fifty percent true defoliation; however, defoliation appears to be of no actual value, since the dead leaf material is readily cleaned from the seed.

The perennial habit of alfalfa and other small seeded legumes prohibits the use of translocated herbicides, since any translocation into the crown and roots would result in severe thinning and death of the stand.

Greenhouse and field experiments gave good indications that satisfactory top-killing could be obtained from the use of 32 pounds of copper sulfamate, 9 pounds of Sharples' Experimental Chemicals ME 3001, 2 pounds of ME 3000, and 3 pounds of EC 3321, or 3 to 6 pints of Sinox (dinitro-ortho-secondary-butyl-phenol) per acre. These chemicals all form true solutions quite readily in water. The substitution of part or all diesel oil for the water greatly reduces the volume of solution needed to provide satisfactory top-killing. Water solutions require from 30 to 60 gallons per acre, while diesel oil solutions of as low as 10 gallons per acre are satisfactory.

Pentachlorophenol, 40 percent, at 1½ gallons per acre in 5 gallons of diesel oil and 15 gallons of water also produced promising results. We found that endothol-diesel oil solutions formed a gummy residue which clogged the nozzle strainers; however, water solutions of endothol may produce satisfactory top-killing.

Sinox chemicals stain contacted foliage varying shades of yellow; however, the chemical does not penetrate the seed pod, hence, seed color is not affected by the chemical. It is difficult to completely remove Sinox from spraying equipment, and it is practically impossible to remove it from clothing, but of the readily available herbicides at the present time, it appears to provide the best degree of top-killing of any of the herbicides used.

Since these chemicals are of the contact type, it is essential that thorough coverage be provided, since leaf and stem tissue are killed only where the chemical contacts the tissues. Alfalfa and other legumes are covered with a waxy bloom which tends to prevent ready penetration of the chemicals. Use of a spreader or wetting agent to induce rapid absorption of the spray droplets by the leaf cells is quite important and it has been shown that use of the correct spreader may result in as high as 50 percent reduction in the amount of herbicide needed to produce a satisfactory killing. Spreaders should not be used indiscriminately since only a narrow range of each spreader will result in maximum wetting. Lower amounts provide insufficient penetration, while too much spreader may cause the spray to roll off the leaf surface more rapidly than if no spreader were used at all. In some cases, the addition of too much spreader will cause leaves to adhere more tenaciously to the plant. This feature may be of value in the harvesting of small seeded legume seed crops, especially sweet clover. Application of excessive quantities of spreading agents may help to hold seed pods on the stalks, thereby reducing the amount of seed loss because of excessive shattering. Wetting agents such as Triton products, Nonic #218, and various detergents such as Dreft or Vel are satisfactory. Diesel oil also exerts some influence on the extent of shattering. The small amount of oil which contacts each pod prevents complete drying for several days, thus decreasing shattering.

Selection of the correct spraying nozzle is necessary to insure good top-killing. Our experiments indicate that the use of mist-like sprays is not as effective as larger droplets, probably because fine droplets evaporate before good penetration is secured.

In selecting top-killing herbicides, several factors must be considered, such as availability, ease of application, cost, dosage and effectiveness, and poison hazards to livestock, humans, and to the viability of the seed. Of the chemicals used in these experiments, Sharples chemicals ME 3000, ME 3001, and EC 3321 are unavailable on the commercial market. Their cost at the present time is relatively high, and these experiments have not shown them to be superior to the dinitro chemicals in any respect.

The dinitro compounds (dinitro-ortho-secondary-butyl-phenol and dinitro-ortho-secondary-amyl-phenol) are readily available, their cost is approximately three to five dollars per acre exclusive of application costs, are readily soluble in water or diesel oil, are highly toxic to contacted plant tissues, form true solutions readily so that no agitation is required, are non-corrosive to spraying equipment, and do not form injurious soil residues. Dinitros are organic compounds which are decomposed in the soil by micro-organisms, thus leaving no toxic residues. Tests have shown that the dinitro groups may be split from the cresol ring and made available to plants, thereby providing a slight fertilizing effect to the new growth. Our experiments showed that dinitro treated plots produced twice the amount of new growth at the end of a two week period as did the untreated plots.

Temperature directly affects the speed of top-killing. Our experiments, conducted under temperatures of 95° F. produced evident collapse of leaf tissue within two hours after the application of sinox. Other herbicides were slower acting and required nearly a day before noticeable damage occurred. Identical treatments as those producing satisfactory results under high summer temperatures were repeated in the greenhouse during winter under cloudy conditions and 70° F temperature. Very poor top-killing resulted. In order to produce satisfactory results under lower temperatures, it was necessary to increase the concentration of the solution used.

Pre-harvest top-killing of alfalfa affords several advantages over conventional harvest methods. Green weed growth will be killed, and the seed crop can be direct combined. However, the seed crop must be just as ripe for top-killing to be successful as for mowing. When a crop is mowed, some seed may continue to ripen in the pods as long as moisture remains in the stem, while following top-killing, rapid drying occurs and the amount of seed maturing after spraying is negligible. Combining should start as soon as the top growth is dry enough to pass through the rollers and separators without adding moisture to the seed. Excessive shattering will be encountered if more than five days elapse between spraying and harvesting.

For best results, stands should be open and erect to permit complete penetration of the spray. Forty P.S.I. will provide satisfactory coverage and penetration. Increasing the pressure will decrease droplet size, thereby increasing the rate of evaporation before proper leaf penetration could occur.

Our experimental results have shown than no detrimental effects have been produced on seed germination, and visual observations could detect no reduction in quality, i.e. plumpness, luster, or seed color.

Seed yields can be materially increased by means of top-killing. Our tests have shown that 21 percent seed loss occurred following top-killing and direct combining compared to 55 percent loss following mowing and pick-up combining from the swath.

Care must be excercised in the selection and use of these herbicides. Excessive concentrations of some herbicides will permanently injure the stand. Definite injury was evident this spring following an application of 58 pounds of copper sulfamate as a top-killer last fall. Lighter applications of this chemical and also other herbicides used in this experiment produced no injury to the stand.

This method of legume seed harvesting is not to be considered a cure-all for all seed harvesting problems. Its use is applicable only under certain conditions. Where the growth is very thin or short, top-killing, followed by direct combining, would enable larger quantities of seed to be obtained than were this growth to be mowed and windrowed. If most of the early ripening pods were already dry and brittle before harvest could start, direct combining would save much of this dry seed which would shatter if it were mowed and windrowed. Where high winds are encountered during harvest time, shattering caused by the rolling of windrows will be eliminated. However, where temperatures are below 75° F at the time of application, such poor top-killing may result that mowing would be required to permit drying of the seed crop. This would increase shattering losses since the dried seed would shatter during the mowing process.

In cases where excessively heavy stands are encountered, one application of top-killing herbicides would probably not produce sufficient drying to permit combining. In these instances, a second application would be required, which would add considerably to the cost of harvest operations. This method of harvesting is not applicable unless sufficient quantities of additional seed can be obtained to cover the treatment costs. Where greater financial returns can be secured following mowing and windrowing than following top-killing, this method of harvesting is not applicable.

CONCLUSIONS

The following conclusions may be summarized from this experimental work:

1. Sinox produces satisfactory top-killing of alfalfa to permit direct combining when applied at 3 to 5 pints per acre in 10 to 15 gallons of diesel oil, or 30 to 60 gallons of water.

2. Use of diesel oil as the solvent reduces the amount of herbicide required.

3. Highly concentrated applications of some contact herbicides may produce permanent injury to the stand.

4. Seed germination is not affected by application of the herbicides used.

5. Seed yields can be increased by means of top-killing harvesting methods.

6. Additional studies are needed to more accurately determine rates of application under varying field conditions.

Future studies concerning the use of top-killers on alfalfa or other small seeded legumes may well give results which are not comparable with those presented herein. The results which have been presented should be considered valid only for the conditions and application rates used in this experiment.

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STUDIES ON THE EFFECT OF CONTACT HERBICIDES AS TOP-KILLERS OF ALFALFA

by

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ABSTRACT OF THESIS

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1952

Considerable quantities of small seeded legume seed are lost during harvesting operations because of excessive shattering caused by the movement and handling of the dry seed pods during mowing, windrowing and pick-up combining. Strong winds, which are often encountered during the harvest season, considerably increase the shatter losses due to rolling of the windrowed forage. These losses may decrease the seed yield by two bushels or more per acre. The purpose of these studies was to determine whether seed yields could be increased and seed losses decreased through the application of pre-harvest top-killing contact herbicides which would produce a satisfactory top drying of alfalfa foliage to permit direct combining of the seed.

Preliminary experiments were conducted in the greenhouse to determine appropriate herbicides and rates of application for field plot treatments. Yard square replicated and randomized plots were laid out in established alfalfa fields. Five contact herbicides; Copper sulfamate, Sharples' Experimental Chemicals ME 3000, ME 3001, and EC 3321, and Sinox General (dinitro-o-sec.-amyl-phenol) were applied in water solutions at three concentrations of herbicide and two volumes of solution by means of a small portable compressed air sprayer constructed from a war surplus 500 cu. in. oxygen tank, pressure regulator, and 1 and 2 quart calibrated glass jars for holding the spray solutions. Muslin screens were set around each plot during the spraying operations to prevent drifting to adjacent plots.

Seed yield, percent defoliation, and pod dropping data were secured from each treated and untreated check plot.

The various treatments did not significantly affect the extent of pod dropping; therefore, it is assumed seed yields were not decreased by the treatments since seed yield is directly associated with the extent of pod dropping.

Actual defoliation is not required for successful top-killing, since the dry, dead leaves are readily removed from the seed during the cleaning operations. In order to determine the effect of actual defoliation on seed pod dropping, a correlation of these two sets of data was made; however, no significant correlation could be determined for the various treatments.

Seed samples of each plot were tested for germination by the Kansas State Seed Laboratory. No detrimental effects on seed germination were found to exist between the various herbicides. In one instance, an exceptionally high concentration of 58 pounds of copper sulfamate in 60 gallons of water per acre produced permanent injury to the alfalfa stand; however, lower concentrations produced no detrimental effects on the stand, and produced an equal top-killing effect.

Top-killed alfalfa was found to recover more swiftly from the loss of its top growth than did mowed alfalfa.

Herbicide concentrations could be decreased by use of a wetting agent such as Nonic #218 or Triton B1956. Forty P.S.I. provided sufficient coverage and droplet size to produce satisfactory top-killing. Higher pressures reduced droplet size which permitted more drifting and evaporation before adequate penetration into the leaf tissues could be effected.

Temperature directly affected the speed of top-killing and the amount of chemical required. Best top-killing occurred at temperatures above 90° F, while unsatisfactory results were obtained at 70° F or below, unless the concentration was considerably increased.

Seed yields of harvested seed were materially increased by means of top-killing. Twenty-one percent seed loss occurred following top-killing and direct combining, compared to 55 percent loss following mowing and pick-up combining from the swath.

Substitution of diesel oil for part or all of the water materially reduced the volume of spray required to produce a satisfactory top-kill. Sinox produced satisfactory top-killing of alfalfa to permit direct combining when applied at 3 to 5 pints per acre in 10 to 15 gallons of diesel oil, or 30 to 60 gallons of water.