GENERAL AND PHYSIOLOGICAL EFFECTS OF
CYANAMID PRODUCTS AND PETROLEUM OILS AS HERBICIDES
OR AS PRE-HARVEST TOP-KILLERS FOR LEGUMES

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GENERAL AND PHYSIOLOGICAL EFFECTS OF
CYANAMID PRODUCTS AND PETROLEUM OILS AS HERBICIDES
OR AS PRE-HARVEST TOP-KILLERS FOR LEGUMES

A DISSERTATION

SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES
IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF SCIENCE

FACULTY OF AGRICULTURE
DEPARTMENT OF PLANT SCIENCE

by

George S. Cooper

EDMONTON, ALBERTA

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SYNOPSIS

P A R T I

Under the conditions of this investigation, first year stands of legume crops for seed were successfully weeded with Cyanamid contact herbicides. Some promising results from treatment of young annual weeds in cereal crops were also obtained but the results in this regard, are not yet conclusive.

P A R T II

Cyanamid contact herbicides were successfully used in pre-harvest treatment of legume seed crops and in some instances increased the yield of seed. Petroleum oils were successfully used for the same purpose. Relative efficiency, availability and costs of chemicals require additional study.

P A R T III

There was no apparent translocation of the contact herbicide used in this investigation. No apparent damage resulted to seed germination or crowns of treated perennial legume plants.

Sodium cyanamid (X 5) spray apparently has the same physiological effects on plant root reserves as those following lowered temperatures and top-killing frosts.

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GENERAL AND PHYSIOLOGICAL EFFECTS OF CYANAMID PRODUCTS
AND PETROLEUM OILS AS HERBICIDES OR AS PRE-HARVEST
TOP-KILLERS FOR LEGUMES

G. S. Cooper

P A R T I

WEED CONTROL USING CYANAMID CONTACT-KILLING HERBICIDES

INTRODUCTION

The purpose of this section of the study was to investigate the possibilities of using Cyanamid contact-killing herbicides for the control of weeds in legumes and cereal crops.

At the present time herbicidal chemicals may be divided into two general classifications. These are translocated herbicides and contact herbicides, and it is with the latter class that this portion of the study deals.

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Contact herbicides kill only the organ of the plant covered, and therefore are limited mainly to the control of annual weeds, but may be employed ~~for use~~ on perennial weeds where starving or retarding effect is desired.

In northern Alberta the growing of legume crops such as alfalfa and clovers for seed production has become a very important industry, and the control of annual weeds in first year stands of legumes without permanent injury to the crop would be highly desirable. The perennial nature of such legume crops and their susceptibility to existing translocated herbicides makes it seem more advisable to use a contact-killing herbicide for weed control.

In certain localized areas Tartary buckwheat has become a serious problem and threatens to spread over a wide area unless a control can be found. To date this weed in an advanced stage has proved to be resistant to concentrations of translocated herbicides which may safely be used on cereal crops. For this reason it was thought useful to experiment with contact-killers on Tartary buckwheat and certain other annual weeds which have shown partial or complete resistance to translocated herbicides.

Controlled conditions will only be those of the plant

covered, and therefore the limited range of the control of
annual weeds, but not the depth of the control of weeds
which extend to the surface of the soil.

In various places the control of weeds is

as slight and always for seed destruction has been a very in-
complete measure, and the control of annual weeds in first year
crops of legumes without permanent injury to the crop would be
highly desirable. The permanent damage of such legume crops and
their susceptibility to various diseases and insects makes
it seem very desirable to use a contact-killing herbicide for
weed control.

In certain localized cases spraying has been used
a surface spray and sprayers are spread over a wide area and
a control can be made. The data show that in an average situation
proved to be practical to control weeds in the first year
which may easily be used on annual crops. For this reason it was
thought desirable to experiment with contact-killing on various crops
and certain other annual weeds which have been killed or
control resistance in the first year.

LITERATURE REVIEW

The principle of general contact herbicides and of selective weed killing with herbicidal sprays has been known for the past 50 years. One of the first substances to be employed for this use was sulfuric acid, as long ago as 1897 it was reported that dilute sulfuric acid would control such broad leaved weeds as mustard and wild radish without injury to the crop plants. Ball and French (4) and Newhall et al (26) reported that up to 95% of such broad leaved weeds may be killed by the application of dilute sulfuric acid to fields of onions, the onions being unharmed because of their vertical growth habit, waxy bloom and concealed growing point. Aslander (3) reported that sulfuric acid kills only the cells it comes in contact with and is not translocated. He reported that during his experiments, humidity and temperature changes had varying effects upon the results obtained. Crafts (8) stated that 1.0 N sulfuric acid or stronger is necessary to kill plants and even at these concentrations the volume of solution used must be sufficient to wet the foliage thoroughly, before favorable results are obtained. The thickness of the cuticle and the age of the leaves treated caused a great variation in the final results obtained. The younger the leaves the more difficult it was to get satisfactory results.

EXPERIMENTAL PROCEDURE

The objective of the present investigation was to determine the effect of the concentration of the solution on the rate of the reaction. The reaction was carried out in a closed system at a constant temperature of 25°C. The rate of the reaction was determined by measuring the volume of gas evolved at regular intervals of time. The results of the experiment are shown in Table I. It can be seen from the table that the rate of the reaction increases with increasing concentration of the solution. This is in agreement with the theoretical expectation that the rate of a reaction should increase with increasing concentration of the reactants. The results of the experiment are also in agreement with the results of other workers who have found that the rate of the reaction increases with increasing concentration of the solution.

Blackman and Templeman (5) found that the efficiency of sulfuric acid in killing corn, chrysanthemum was improved by a wetting agent. Evans and Martin (11) have shown that the addition of an excess of wetting agent to sprays may lower the amounts of spray retained by the leaf surface. If the toxicant can be readily increased in concentration however, the use of a wetting agent with the same amount of toxicant in a reduced volume of water may save time and labor.

Newhall et al (26) and Crafts (9) reported that the following essentials must be considered when a contact-killer is being used:

- (a) age of crop,
- (b) temperature,
- (c) size of weeds,
- (d) sufficient toxicant must be applied to kill the bulk of vegetation desired to be killed, and allow considerable excess for unevenness of application and differences in plant thickness,
- (e) spray solution must be distributed so that growing parts of weeds are covered completely,
- (f) where vigorous weeds, or grassy weeds are present, the solution must creep down into the crowns to prevent renewal of growth by tillers.

Newhall et al (26) reported that sodium chlorate and Atlacide, two contact herbicides, were very good for control of all growing vegetation, but were unsatisfactory because they

Aluminum and Teflon (2) found that the efficiency of

relatives with in killing more, approximately 100 percent of a
within 1000. Some and within (11) have shown that the relation
of an excess of wetting agent to spray and lower the resistance of
wax, treated by the last surface. In the contact can be used
if treated in concentration, however, the use of a wetting
agent with the same amount of herbicide is a reduced volume of
water and save time and labor.

Newell et al (26) and Trefe (27) reported that the

following essential oils can be considered as contact-killers
in being used:

- (1) age of crop,
- (2) temperature,
- (3) size of weeds,
- (4) sufficient contact must be applied to kill the plant or
vegetation exposed to the oil, and also contact must be
made for a period of 24 hours and afterwards in
the morning,
- (5) spray solution must be distributed so that growing parts
of weeds are covered completely,
- (6) where various weeds are present, the
solution must be applied to the weeds to prevent the
spread of growth by tillage.

Newell et al (26) reported that certain oils are

essential, two contact herbicides, very good for control of
all growing vegetation, but were unsatisfactory against many

remained in the soil for a long period and stunted the growth of subsequent crops. Sinox, one of the dinitro contact herbicides, was successfully used to control annual weeds in onions, but the margin of safety was very narrow and its use was not recommended.

Litzenberger (22) reports successful use of borax for control of certain weeds in stands of grass or related plants and that this chemical is more effective on light, porous soils.

Newhall et al (26) stated that if calcium cyanamid were applied to wet foliage at the rate of 35 - 80 pounds per acre annual weeds were controlled. Erratic results were obtained however, unless wet foliage was treated. Temporary damage to onion plants often occurred, but full recovery was made in a short time. Lee and Ellis (21) reported that sodium arsenite sprays and calcium cyanamid dusts were effective herbicides in many crops. When sodium arsenite was applied as a spray, very fine droplets gave excessive coverage resulting in considerable damage to the crop plant which, however, showed considerable tolerance when the liquid was applied in larger droplets. They stated that cyanamid dust to be effective, must remain on the plant several days without disturbance by rain or heavy dew. Rain or dew following closely after application of the herbicide resulted in a decrease in the effectiveness of the herbicide. Carew (6) stated that excellent weed control in peas was obtained with calcium cyanamid dust and potassium cyanate (X 1) spray, and that no

remained in the soil for a long period and caused the growth of
subsequent crops. Hence, one of the chiefest causes of soil
was undoubtedly due to the fact that the soil was not
properly of itself was very much and the soil was not
improved (17) reports suggested use of cover for
control of certain weeds in states of some of related plants and
this also showed in some respects on the soil, known soils.
Hence, it is (18) stated that if certain operations were
applied to the soil at the rate of 15 - 20 pounds per acre
annual weeds were controlled. Specific results were obtained from
over, which are listed as follows. The results were in some
plants often better, but still showing the same in a small time.
Lee and Allen (19) reported that sodium arsenite was very effective
in some systems where the plants were in many cases.
When sodium arsenite was applied as a spray, very fine results
were obtained. The results in some cases were in some cases
very good, however, showed considerable difference when the
liquid was applied in some cases. The results were in some
cases to be effective, but some on the plants were in some
the distance by rain or heavy dew. When the soil was
closely after application on the plants was in some
cases in the thickness of the plants. When (20) stated
that excellent weed control in some was obtained with sodium
arsenite and potassium arsenite (21) stated, and that no

harmful residue remained. No approximate rates were quoted. Rademacher (29) reported the use of calcium cyanamid for weed control in both summer and winter cereals at the rates of 135 to 270 pounds per acre.

Robins ^bet al (32) reported that many cultivated legumes have a thick cuticle and are covered with a waxy bloom and therefore shed most of the spray and are not seriously injured by contact herbicides if concentrations are not too high. It seems therefore that certain of the Cyanamid contact herbicides may be useful in the control of weeds in alfalfa, red clover and alsike clover fields in Alberta. The following tests were carried out to investigate this possibility.

MATERIALS AND METHODS

Both sprays and dusts containing contact-killing herbicides were employed in this preliminary study. Potassium cyanate (X 1) and sodium cyanamid (X 5) were used. The Tables indicate the rate, form of chemical and gallonage of water used with sprays. The sprays were applied from a knapsack sprayer fitted with a fan nozzle; the dusts spread using a hand pump insecticide duster.

chemical analysis was made. The specimens were found to be
Keweenaw (25) reported the use of similar specimens for
control in each case and their results of the test of 100 to
200 percent per year.
Fishes at 25 (25) reported that they collected specimens
from a fish which was not reported with a very high and low
from the rest of the group and was not reported in the
control specimens. It was stated that the fish was not
therefore was not a part of the specimens collected in the
be useful in the control of the fish in the fish, but they were
also found in the fish in the fish. The specimens were found
but as they were not reported.

RESULTS AND DISCUSSION

Both groups and were reported in the fish in the fish
fish were reported in the fish in the fish. The fish in the fish
(25) and (25) were found. The fish in the fish
the fish, they are reported and reported of the fish in the fish.
The fish were reported from a number of fish in the fish
fish; the fish were found in the fish in the fish.

Alfalfa, alsike clover and barley were chosen as experimental material in this study. Weed seeds were sown in fields where it was necessary to ensure an adequate weed growth.

Alfalfa

Plots of alfalfa 12 ft. x 12 ft., seeded in 1949, were treated in the spring of 1950. Weed seeds were broadcast and raked into the soil before spring germination commenced. Table I, 1, gives the chemicals selected for this experiment.

Table I, 1

Chemical	Form applied	Rate, lb. per acre	Gallonage/acre where H ₂ O used
Potassium cyanate (X 1)	Spray	5-10-15	40
Potassium cyanate (X 1)	Dust	60-80-100	--
Sodium cyanamid (X 5)	Spray	40-60-80	40
Sodium cyanamid (X 10)	Dust	60-80-100	--
Granular cyanamid	Granules	90-120-150	--
Special grade cyanamid	Dust	90-120-150	--

With the exception of granular and special grade cyanamid, the above chemicals were applied to two replicated sets of plots at two different dates. As granular and special grade cyanamid are recommended for pre-emergence weed control only, it is practicable to apply these chemicals at one date only, unless cultivation is carried out just prior to application. In this experiment no cultivation was used, so when the second replicate was treated at a later date, potassium cyanate (X 1) blend was substituted for granular and special grade cyanamid.

The chemicals were applied to Rep. 1 on May 5, 1950, during initial stages of plant growth: Rep. 2 was treated June 15, 1950, when the weeds and alfalfa were commencing to flower.

Growth was very slow because of the extremely adverse conditions experienced during the spring of 1950. At the date of the first application the soil moisture was very low. Temperatures for the week following application remained relatively low, averaging a daily high of about 58°F.

At the second date of application the reserve soil moisture was still very low. For ten days following application the average daily high was approximately 76°F. Growth of weeds and alfalfa was below normal for this time of year.

Alsike Clover

In 1949 plots of alsike clover 9 ft. x 9 ft. were selected from a field of alsike clover sown in 1948 at the University of Alberta. A simple randomized block design consisting of four replicates was used.

Table I, 2, gives the chemicals, rates and gallonages of water used in this test.

Table I, 2

Chemical	Form applied	Rate, lb. per acre	Gallonage/acre where H ₂ O used
Potassium cyanate (X 1)	Spray	10-20-25	40
Potassium cyanate (X 1)	Dust	60-80-100	--
Potassium cyanate (X 1) + Vatsol K	Spray	10-20-25	40
Sodium cyanamid (X 5)	Spray	60-80-100	40

In the experiments where Vatsol K (2 g.) was added, it was used as a spreader to test the possibilities of applying a spreader or wetting agent in order to reduce the amount of chemical needed to achieve the desired results.

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The chemicals were applied August 26, 1949. The weather was sunny, clear and dry. The average daily temperature for the following seven days was 72°F. No rain or dew fell during this period. The first seed set of clover was ripe and the second seed set was just maturing. The weeds were in all stages of growth.

Barley

Two fields of Olli barley were sown May 5, 1950. To the barley seed for one field, Tartary and wild buckwheat seeds were added. Plots 10 ft. x 10 ft. were marked out in these fields as soon as the barley appeared. The plots without the added Tartary and wild buckwheat were included to permit investigation of possible delay in maturity and reduction in yield resulting from the application of a contact herbicide.

Table I, 3, gives the chemicals, rates and gallonages applied where sprays were used.

Table I, 3

Chemical	Form applied	Rate, lb. per acre	Volume applied per acre
Potassium cyanate (X 1)	spray	8-12	40
Sodium cyanamid (X 5)	spray	40-60	40
Pot. cyanate (X 1) + 2 gals. per acre, 2,2,4 trimethylpentane*	fine mist	4-8	40
Pot. cyanate (X 1) + 4 gals. per acre, 2,2,4 trimethylpentane*	fine mist	4-8	40
Pot. cyanate (X 1) + 2 gals. per acre, 2,2 Dimethyl Butane*	fine mist	4-8	40
Pot. cyanate (X 1) + 4 gals. per acre, 2,2 Dimethyl Butane*	fine mist	4-8	40
Sod. cyanamid (X 5) + 2 gals. per acre 2,2,4 trimethylpentane *	fine mist	4-8	40
Sod. cyanamid (X 5) + 4 gals. per acre, 2,2,4 trimethylpentane*	fine mist	4-8	40
Sod. cyanamid (X 5) + 2 gals. per acre, 2,2 Dimethyl Butane*	fine mist	4-8	40
Sod. cyanamid (X 5) + 4 gals. per acre, 2,2 Dimethyl Butane*	fine mist	4-8	40

* One gram of Dreft added as an emulsifying agent.

TABLE 1

Station	Depth, m	Soil	Remarks
10	0-10	Grass	Topsoil (10)
10	10-20	Grass	Subsoil (10)
10	20-30	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel
10	30-40	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel
10	40-50	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel
10	50-60	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel
10	60-70	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel
10	70-80	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel
10	80-90	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel
10	90-100	Thin soil	Topsoil (10) + 10% clay, 10% sand, 10% gravel

Two sets of data were added to the
original data.

The 2,2,4 trimethylpentane has a B.P. of 99.3°C . and is considered as a heavy oil fraction. It contained few aromatic hydrocarbons. The 2,2 dimethyl butane has a B.P. of 49.7°C . and is considered a light oil fraction. It contained a high percentage of aromatic hydrocarbons.

The chemicals were applied June 12, 1950. The sprays were applied with a knapsack sprayer, while the fine mists were applied with a paint spray gun attached to a knapsack sprayer tank used as the source of compressed air.

The weather conditions were extremely adverse resulting in the germination of very little buckwheat. The daily high for the following week was approximately 85°F .

EXPERIMENTAL RESULTS

Alfalfa

The combined results of the treatments of Reps. 1 and 2 are shown in Table I, 4. Table I, 5, gives the actual weed counts per square foot.

The 2,2,4-trimethylpentane has a b.p. of 100.1° and is considered as a heavy oil fraction. It contained few aromatic hydrocarbons. The 2,2,4-trimethylpentane has a b.p. of 100.1° and is considered a light oil fraction. It contained a high percentage of aromatic hydrocarbons.

The compounds were separated into 12, 13, 14, and 15 fractions. The 12 and 13 fractions were separated by a vacuum column, while the 14 and 15 fractions were separated with a light oil column. The 12 and 13 fractions were separated with a light oil column. The 14 and 15 fractions were separated with a vacuum column.

The vacuum column was used to separate the 12 and 13 fractions. The light oil column was used to separate the 14 and 15 fractions. The vacuum column was used to separate the 12 and 13 fractions. The light oil column was used to separate the 14 and 15 fractions.

EXPERIMENTAL

ANALYSIS

The compounds were separated by the treatment of 100.1 and 100.1 are shown in Table I. The 12 and 13 fractions were separated by a vacuum column. The 14 and 15 fractions were separated by a light oil column.

The following tables I, 4 to I, 6, illustrate results of yearly trials of 1949 in which various chemicals used in various ways for weed control purposes.

Table I, 4

Chemical	Rate, lb./ acre	Weed control*	Alfalfa damage	Comments
Pot. cyanate (X 1) dust	60	Poor	Nil	Little promise
	80	Fair	Nil	Control of two leaf weeds
	100	Good	Nil	50% weed control
Pot. cyanate (X 1) spray	5	Poor	Nil	Rate is too low
	10	Very good	Some chlorosis	Has promise
	15	Excellent	Heavy chlorosis	Very good here
Sod. cyanamid (X 5) dust	60	Poor	Nil	Not heavy enough rate
	80	Very good	Leaf spotting	Shows promise
	100	Excellent	Heavy damage	Some top damage noted
Sod. cyanamid (X 5) spray	40	Fair	Basal leaf damage	Good
	60	Excellent	Tip yellowing	May delay flowering
	80	Excellent	Heavy damage	Too much damage
Granular cyanamid	90	Poor	Nil	Not high enough rate
	120	Poor	Nil	Not high enough rate
	150	Fair	Nil	" heavy enough rate
Special grade cyanamid	90	Poor	Nil	Not heavy enough rate
	120	Fair	Nil	Not heavy enough rate
	150	Very good	Nil	Need more uniform appl
Pot. cyanate (X 1) blend dust	60	Fair	Nil	Need more uniform appl
	80	Very good	Leaf spotting	Need more uniform appl
	100	Excellent	Heavy damage	Need more uniform appl

* Weeds controlled included red root pigweed, lamb's quarters, common plantain, purslane, common groundsel, spear-leaf goosefoot, hawksbeard, night-flowering catchfly, wild mustard and ball mustard.

Table I, 5

Chemical	Rate	Total weeds killed		Total weeds		Remarks
		Rep.1	Rep.2	Rep.1	Rep.2	
Potassium cyanate (X 1) dust	1	12	16	49	56	Poor results
	2	29	32	33	39	Good results
	3	31	28	35	32	Very good results
Potassium cyanate (X 1) spray	1	17	21	39	45	Poor results
	2	22	31	43	39	Good results
	3	43	39	43	41	Excellent results
Sodium cyanamid (X 5) dust	1	19	14	36	42	Poor results
	2	46	26	56	43	Very good results
	3	37	45	37	45	Excellent results
Sodium cyanamid (X 5) spray	1	32	24	52	43	Fair results
	2	29	37	29	37	Excellent results
	3	33	23	33	23	Excellent results
Granular cyanamid	1	--	--	42	54	Poor results
	2	--	--	63	29	Poor results
	3	--	--	21	19	Good results
Special grade cyanamid	1	--	--	37	28	Poor results
	2	16	19	42	35	Fair results
	3	28	32	30	35	Very good results
Potassium cyanate (X 1) dust + sticker	1	--	29	--	43	Fair results
	2	--	23	--	29	Very good result
	3	--	41	--	44	Excellent result
CHECK				55	51	

2

The results show that in general the sprays appear to be more effective than the dusts for weed control. The method of applying dusts resulted in a very uneven application so the contrast in results may have been partially attributable to the better coverage from sprays.

The chemical applied at an excessive rate retarded the growth of the alfalfa but even at this very high rate no apparent injury resulted. Potassium cyanate (X 1) spray at 10 and 15 pounds per acre and sodium cyanamid (X 5) spray at 60 pounds per acre effectively controlled young weeds, including common groundsel, red root pigweed, lamb's quarters, spear-leaf goosefoot, hawksbeard, night-flowering catchfly, ball mustard and wild mustard, without apparent damage to the alfalfa crop.

Alsike Clover

The results of this test as shown in Table I, 6, again indicate that in general sprays were more effective than dusts. It is apparent however, that in controlling weeds in alsike clover, application by either means should be made before the weeds reach the flowering stage.

The results were that in general the species groups to be most affected by the disease were those of the lowest of ecological status. This is a very general statement as the results in general may have been differently distributed to the different groups of species.

The results showed that the species groups to be most affected by the disease were those of the lowest of ecological status. This is a very general statement as the results in general may have been differently distributed to the different groups of species.

The results showed that the species groups to be most affected by the disease were those of the lowest of ecological status. This is a very general statement as the results in general may have been differently distributed to the different groups of species.

Results of the study

The results of this study are shown in Table 1, which indicates that in general species were more affected than those of higher ecological status. This is apparent, however, that in certain species of higher ecological status there was a high degree of resistance to the disease.

Table I, 6

Chemical	Rate, lb./ acre	Weed control*				Comments
		Rep. 1	Rep. 2	Rep. 3	Rep. 4	
Potassium cyanate (X 1) spray	10 20 25	Good V.good Ex.	Good V.good Ex.	Good V.good Ex.	F.good Good Ex.	Older weeds only partially killed. Very good. This rate excessive.
Potassium cyanate (X 1) dust	60 80 100	Poor Poor Fair	Poor Poor Poor	Poor Fair Fair	Poor Poor Poor	Of little value here. Generally poor. Very spotty killing.
Potassium cyanate (X 1) blend dust	60 80 100	Poor Fair V.good	Poor Good Good	Poor Fair V.good	Poor Good V.good	This rate is too low. Little use for older weeds. Very good young weed control. An evener coverage would help.
Sodium cyanamid (X 5) spray	60 80 100	Ex. Ex. Ex.	Ex. Ex. Ex.	Ex. Ex. Ex.	Ex. Ex. Ex.	Not too effective on older weeds. Too heavy a rate here.
Sodium cyanamid (X 5) spray + Vatsol K	60 80 100	Ex. Ex. Ex.	Ex. Ex. Ex.	Ex. Ex. Ex.	Ex. Ex. Ex.	Too heavy a rate here.

Date	Time	Location	Remarks	Total
1941	10:00	1000	1000	1000
1941	10:00	1000	1000	1000
1941	10:00	1000	1000	1000
1941	10:00	1000	1000	1000
1941	10:00	1000	1000	1000
1941	10:00	1000	1000	1000

Table I, 6 (Continued)

Chemical	Rate, lb./ acre	Weed control*				Comments
		Rep. 1	Rep. 2	Rep. 3	Rep. 4	
Sodium cyanamid (X 10) dust	80	Poor	Poor	Poor	Poor	Of little value here.
	100	Fair	Good	Good	Good	Poor, large weed control.
	120	V.good	Good	V.good	V.good	Very good on younger weeds.
Sodium cyanamid (X 10) dust + Vatsol K	40	Fair-	Fair	Fair	Fair	Poor, older weed control.
	60	Good	Good	Good	V.good	Good, young weed control.
	100	V.good	V.good	V.good	V.good	
Potassium cyanate (X 1) spray + Vatsol K	10	V.good	V.good	V.good	V.good	Very good weed control
	20	Ex.	Ex.	Ex.	Ex.	
	25	Ex.	Ex.	Ex.	Ex.	

* Weeds encountered were: lamb's quarters, red root pigweed, common plantain, purslane, common groundsel, spear-leaf goosefoot, hawksbeard, night-flowering catchfly, wild mustard, ball mustard.

 

Potassium cyanate (X 1) spray at 20 pounds per acre and sodium cyanamid (X 5) spray at 60 pounds per acre gave excellent control of young weeds with very little apparent permanent injury to the alsike clover. The weeds encountered were the same as those listed previously in alfalfa experiments. The addition of one gram of Vatsol K increased the efficiency of potassium cyanate (X 1) spray, thus indicating that a reduction in the amounts of this chemical needed may prove to be feasible when used as a spray.

The rates of sodium cyanamid (X 5) spray were too high to show differences when Vatsol K was added.

Barley and Buckwheat

Observations Five Days After Treatment

Potassium cyanate (X 1) spray at eight and 12 pounds per acre resulted in very good control of all young annual weeds present. The 12 pound rate resulted in a complete top-killing of Tartary and wild buckwheat in the two-leaf stage. Older plants

showed only upper leaf necrosis. There was also some evidence of leaf burning on the lower barley leaves.

The compound X 5 at 40 and 60 pounds per acre gave complete control of young annual weeds. The buckwheat in the 2-4 leaf stage showed extensive leaf-killing. The 60 pound rate resulted in a great deal of necrosis in the barley.

Potassium cyanate and sodium cyanamid, with the addition of oil, showed a great deal of injury to the barley as well as to the weeds. In the tests where oil was used, the addition of one gram of Dreft per plot may have been partially responsible for the increased injury observed.

Observations 14 Days After Treatment

Potassium cyanate (X 1) spray at eight pounds per acre resulted in a complete kill of the very young annual weeds except buckwheat. The buckwheat showed evidence of leafing from the lower nodes. The barley had apparently made complete recovery from the initial damage observed. Potassium cyanate at the 12 pound rate gave complete control of the young annual weeds including buckwheat in the 2-4 leaf stage. Older buckwheat plants were budding from the lower nodes. The leaf edges of the barley were necrotic, while many of the lower leaves showed chlorotic spotting.

Sodium cyanamid (X 5) spray at 40 pounds per acre caused a general yellow cast to the entire plots treated. There were no signs of recovery of the buckwheat treated in the two-leaf stage. Older plants were stunted, but had commenced leafing from the lower nodes.

Sodium cyanamid (X 5) spray at 60 pounds per acre resulted in a very definite yellow cast of the plots treated. There was considerable killing of the lower leaves of the barley and chlorosis of the upper leaves. Young buckwheat plants were severely burned and showed no signs of recovery. The older buckwheat plants developed a marked thickening and stunting of the basal parts of the stem. At this time there was a definite indication of a retarding effect on the growth of the barley.

As judged by the definite retardation and severe damage to the barley, potassium cyanate (X 1) and sodium cyanamid (X 5) with the addition of Dreft and oil apparently are insufficiently selective for this type of weed control.

Observations 21 Days After Treatment

Heavy rainfalls 16 and 17 days after application of the chemicals resulted in a new growth of weeds, buckwheat and a second growth of barley, thus rendering further observations and results of very little value.

stains appearing in the form of the brown and were caused
a general yellow stain on the white stone blocks. These were in
form of traces of the material washed in the two-level areas.
Other stains were observed, the red brownish staining from the
lower basins.

Below specimens (1-2) there is the brown and the
yellow is a very delicate yellow stain of the lower basins. This
was considerably filling in the lower basins of the water and
reforms of the upper basins. Some basins were on
very green and brown in form of the water. The other basins
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General Notes on the Staining

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DISCUSSION AND CONCLUSIONS

From the results obtained in the experimental trials for control of weeds in alfalfa and alsike clover using Cyanamid contact-killing herbicides, sprays appear to be more efficient for this purpose than do dusts. Because of the relatively inefficient method of applying dusts however, it is very difficult to evaluate fully their potential values in this type of work.

Potassium cyanate (X 1) blend dust, and sodium cyanamid (X 10) dust show promise for control of young annual weeds if even coverage can be obtained. Granular cyanamid, special grade cyanamid and potassium cyanate (X 1) dust show very little promise for this work. Potassium cyanate (X 1) spray at 10 and 15 pounds per acre resulted in very good control of annual weeds. Sodium cyanamid (X 5) spray at 60 pounds per acre applied in 40 gallons of water per acre, resulted in complete control of all annual weeds provided they had not reached the flowering stage. In spite of a definite yellowing of the alfalfa and alsike clover following treatment, no apparent permanent damage occurred and full recovery of the crop was noted within a few days. It is therefore thought that this method of weed control should be very satisfactory in controlling annual weeds in first year stands of legume crops in northern Alberta.

The use of contact-killing herbicides for the control of Tartary buckwheat and other annual weeds needs further experimental trials. Sodium cyanamid at 40 and 60 pounds per acre shows some promise for selectively controlling Tartary buckwheat and purslane if treated in the 2-4 leaf stage. However, quantitative final yield determinations on the barley must be determined before any definite decisions can be reached.

P A R T I I

CHEMICAL TOP-KILLING OF LEGUMES WITH CYANAMID CONTACT
HERBICIDES AND CERTAIN PETROLEUM OILS

INTRODUCTION

The purpose of this phase of the work was to investigate the possibilities of using Cyanamid contact herbicides and certain petroleum oils containing a high percentage of aromatic hydrocarbons for top-killing of legumes and for delaying the dehiscence of birdsfoot trefoil pods.

Since contact herbicides kill only the organ of the plant covered, there is a possibility that some of these herbicides may be employed for the pre-harvest top-killing of legumes, thus assisting in the harvesting of such crops as alfalfa, red clover, alsike clover and birdsfoot trefoil. If enough of the top growth of the legume plant could be killed without damage to the crown or root, direct combining could be carried out, thus preventing loss through

excessive handling and shattering. The chemical used for this purpose must not cause injury to the crown or root or to the seeds within the pods.

By application of a contact herbicide to prepare the crop for combining, the farmer should be able to control to some extent the time of harvest and thus aid in the planning of harvest operations during the busy season. Because such herbicides act by direct contact only, attention has been given to the supplementary use of stickers and spreaders in attempts to obtain greater foliage coverage and therefore a more thorough top-killing.

LITERATURE REVIEW

The perennial habit of alfalfa, red clover, alsike clover and birdsfoot trefoil makes it preferable that the top-killing chemical used be of the contact type rather than the translocated type. Any translocation of the chemical may cause death of crown or root of the plant. It is necessary, however, that the herbicide reach the parts of the plant that must be killed.

excessive heating and charring. The chemical used for this purpose may not cause injury to the tissue or even to the cells within the body.

By application of a chemical substance to remove the excess fat deposits, the chemical should be able to combat its action except the time of removal and also all in the planning of various operations during the busy season. Chemicals such as sodium hydroxide, by direct contact with, absorption and used given to the subject, very few of them will experience in efforts to obtain results. Various sources and literature have shown the following:

Chemical Agents

The chemical used for this purpose, sodium hydroxide, and sodium hydroxide is still used in practice for the removal of excess fat. The chemical used for this purpose is the same as the chemical used for the removal of excess fat. The chemical used for this purpose is the same as the chemical used for the removal of excess fat. It is necessary, however, that the chemical be used in the form of a solution of the chemical in water and be used in the form of a solution of the chemical in water and be used in the form of a solution of the chemical in water.

Aslander (3), using sulfuric acid as a contact herbicide for general weed control, reported that the acid penetrated the cuticle rapidly and caused death to the cells contacted, yet no translocation was evident. In this work humidity and temperature changes had varying effects upon the results obtained. Crafts (7) stated that 1.0 N sulfuric acid or stronger concentrations were needed to kill plants and even at these strengths the volume of solution used must be sufficient to wet the foliage thoroughly before favorable results were obtained. Guy (16) reported successful defoliation of thousands of acres of cotton by the application of calcium cyanamid resulting in a better grade of cotton and a definite schedule of cotton picking. Guy stated however, that a uniform and complete coverage of all foliage is absolutely essential with all known defoliants, either when used as dry dusts or as liquid sprays. Efficient machines and careful operators are also essential. Where sprays are used a true mist is not desirable because mists do not provide sufficient penetration whereas too coarse a spray results in uneven coverage.

Stiver and Johnson (34) reported excellent cotton leaf killing using 25 pounds sodium cyanamid (X 5) spray at 25 pounds per acre. Morris and Cowley (25) reported that climatic conditions are a very important factor in the use of contact herbicides. In very dry areas where no dews occur, sprays are more efficient

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than dusts. They reported that potassium cyanate (X 1) spray at 11.25 pounds per acre was a very efficient killer of cotton leaves.

Thaxton and Jones (35) reported that in experimental trials on cotton defoliation, potassium cyanate (X 1) spray at 12 pounds per acre and sodium cyanamid (X 5) spray at 50 pounds per acre gave excellent kills of cotton leaves. They also reported that the addition of 1% Vatsol as a wetting agent greatly increased the efficiency of the chemical. Results of their tests in 1948 indicate that in drouthy years when no dew is present, sprays are needed, and that sodium cyanamid (X 5) spray consistently gave the best results. Where high concentrations of sprays were needed there was little difference in varietal response to the chemical, and a uniform killing was achieved. Although promising when applied at times of heavy dew, the hygroscopic dusts, sodium cyanamid (X 10), were not dependable during periods of low humidity.

Rich (30) reported that in the top-killing of potato-vines, there was a marked difference in the rapidity and extent of the top-killing which took place following the application of the many commercial chemicals available at the time of experimentation. There was considerable injury to the xylem and phloem in the tubers when fast acting chemical herbicides were used. It was suggested that the damage to the tuber was not caused by the

that these. They showed that the effect of the
at 11.85 hours per day was a very significant effect of water
level.

Ward and Green (1961) conducted a series of experiments
initially on a single fish, and then on a group of 10 fish. It
is possible that the results of the experiments on the group of 10 fish
may have been different from those of the single fish. The results
showed that the effect of the water level was significant, and that
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These results are similar to those of the other experiments. The results
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was significant. The results showed that the effect of the water level
was significant, and that the effect of the water level was significant.

herbicide, but by a substance already present in the plant and induced to migrate to the tubers. On the other hand, calcium cyanamid, which required several days for completion of action, resulted in very little tuber damage. Kraus and Dietz (19) reported that the use of one pound of ammonium sulfate in one gallon of water applied at 100 gallons per acre gave satisfactory top-killing of Bliss Triumph vines but not of Netted Gem vines. Apparently there are varietal differences in the response of potatoes to such treatments.

There is very little literature with reference to the pre-harvest top-killing of grain and legume seed crops. Available reports from south eastern United States (2), however, indicate that dinitro-compounds with diesel oil have been applied from the air with considerable success on flax and alfalfa during the past three years.

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SUMMARY OF PROCEDURE AND RESULTS

The cyanamid products used in this part of the study were applied as sprays or dusts. Knapsack sprayers were used to apply sprays to experimental plots, while a high gallonage Green Cross sprayer was used for field application. A hand pump insecticide duster was used to apply dusts to experimental plots while a T & T "Electronic" duster was used to apply dusts in field work. Plots 10 ft. by 10 ft. were used in small scale trials and the field tests involved 0.6 acre plots. In 1948 alfalfa and red clover were used as experimental material while in 1949 alfalfa and alsike clover were treated. In 1950 alfalfa, alsike clover, red clover and birdsfoot trefoil were included in the experimental trials. The birdsfoot trefoil was treated in an effort to find a method whereby the mechanism controlling dehiscence of the pod could be controlled, thus preventing the shattering of the seed prior to harvesting. At the present time there is no satisfactory method of harvesting this seed crop because of the explosive nature of the pods.

Alfalfa, 1948

The following tables II, 1 to II, 13, indicate the results of yearly trials in which various chemicals used in various ways as preharvest top-killers for species indicated.

Table II, 1

Plot Trials

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top- killing
<u>Sprays</u>			
Potassium cyanate (X 1)	40 40	200 400	80 80
Potassium cyanate + 1 g. soap	40 40	200 400	95 95
Potassium cyanate + 1 g. casein	40 40	200 400	100 100
Potassium cyanate (X 1)	60 60	200 400	100 100
Potassium cyanate + 1 g. soap	60 60	200 400	100 100
Potassium cyanate + 1 g. casein	60 60	200 400	100 100
Sodium cyanamid (X 5)	60 60	200 400	90 90
Sodium cyanamid + 1 g. soap	60 60	200 400	95 95
Sodium cyanamid (X 5)	100 100	200 400	100 100
Sodium cyanamid + 1 g. soap	100 100	200 400	100 100

Table 1

The following table shows the results of the tests conducted on the various types of material used in the construction of the various types of structures.

Table 1

Table 1

Material	Weight (lb.)	Volume (cu. ft.)	Specific Gravity
Potassium cyanide (1)	100	100	1.00
Potassium cyanide + 1 g. water	100	100	1.00
Potassium cyanide + 1 g. water	100	100	1.00
Potassium cyanide (1)	100	100	1.00
Potassium cyanide + 1 g. water	100	100	1.00
Potassium cyanide + 1 g. water	100	100	1.00
Sodium cyanide (2)	100	100	1.00
Sodium cyanide + 1 g. water	100	100	1.00
Sodium cyanide (2)	100	100	1.00
Sodium cyanide + 1 g. water	100	100	1.00

Table II, 1 (Continued). Plot Trials

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top- killing
<u>Dusts</u>			
Calcium cyanamid	150	-	5
	200	-	10
Monosodium cyanamid	75	-	5
	100	-	5
	150	-	10
Sodium cyanamid (X 10)	50	-	10
	75	-	15
	100	-	25

Red Clover, 1948

Table II, 2

Field Trials

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top- killing
<u>Sprays</u>			
Potassium cyanate (X 1)	20	$4\frac{1}{2}$	65
Potassium cyanate + soap, 1 lb./acre	20	9	90
Sodium cyanamid (X 5)	80	40	100
Sodium cyanamid + soap, 1 lb./acre	100	60	100
<u>Dusts</u>			
Potassium cyanate (X 1)	80	-	10
Sodium cyanamid (X 10)	40	-	5

Table II, I (continued).

Country	Year	Population (millions)	Per capita income (US\$)
Colombia	1950	10.0	100
Colombia	1955	10.5	100
Colombia	1960	11.0	100
Colombia	1965	11.5	100
Colombia	1970	12.0	100
Colombia	1975	12.5	100
Colombia	1980	13.0	100
Colombia	1985	13.5	100
Colombia	1990	14.0	100
Colombia	1995	14.5	100
Colombia	2000	15.0	100
Colombia	2005	15.5	100
Colombia	2010	16.0	100
Colombia	2015	16.5	100
Colombia	2020	17.0	100

Table II, I

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Country	Year	Population (millions)	Per capita income (US\$)
Colombia	1950	10.0	100
Colombia	1955	10.5	100
Colombia	1960	11.0	100
Colombia	1965	11.5	100
Colombia	1970	12.0	100
Colombia	1975	12.5	100
Colombia	1980	13.0	100
Colombia	1985	13.5	100
Colombia	1990	14.0	100
Colombia	1995	14.5	100
Colombia	2000	15.0	100
Colombia	2005	15.5	100
Colombia	2010	16.0	100
Colombia	2015	16.5	100
Colombia	2020	17.0	100

Discussion

In the top-killing of alfalfa, potassium cyanate (X 1) spray applied at 40 pounds per acre gave satisfactory results and the addition of soap and casein improved the herbicidal action. It is evident that the rate of 20 pounds per acre is in excess of that actually needed to obtain satisfactory results. Similarly the 60 pound rate was higher than necessary, consequently the addition of soap and casein to such treatments did not visibly affect the amount of top-killing obtained.

Sodium cyanamid (X 5) spray at 60 pounds per acre resulted in a satisfactory kill whose efficiency was only slightly increased by the addition of soap. The 100 pound rate resulted in a complete top-killing and the addition of casein and soap was superfluous in this case.

The dusts used in this experiment did not give satisfactory results.

In field trials with alsike clover, Table II, 2, the potassium cyanate (X 1) spray at 20 pounds per acre applied at $4\frac{1}{2}$ gallons per acre did not provide sufficient coverage to completely kill the top growth. When 20 pounds of the chemical were applied at nine gallons per acre with the addition of soap, an increase in the amount of killed vegetation was noted, but the lower leaves

Summary

In the following table, the results of the experiments are given. The first column shows the number of subjects, the second column the number of correct responses, the third column the number of errors, the fourth column the number of omissions, and the fifth column the number of commissions. The results show that the subjects were able to discriminate between the two conditions, and that the number of correct responses was significantly higher than the number of errors, omissions, and commissions.

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The results of the experiments are given in the following table. The first column shows the number of subjects, the second column the number of correct responses, the third column the number of errors, the fourth column the number of omissions, and the fifth column the number of commissions. The results show that the subjects were able to discriminate between the two conditions, and that the number of correct responses was significantly higher than the number of errors, omissions, and commissions.

and branches which were not covered resulted in a considerable amount of basal green material.

Sodium cyanamid (X 5) spray at 80 and 100 pounds per acre resulted in a complete top-killing and indicated that the rates used were in excess of the amount of chemical needed to obtain satisfactory results.

Alfalfa, 1949

Table II, 3

Plot Trials

Chemical	Rate, lb. chemical in	% top-killing
	40 gal. H ₂ O/acre	
Potassium cyanate (X 1) spray	10	50
	20	70
	25	90
Sodium cyanamid (X 5) spray	60	90
	80	95
	100	100

and therefore also the number of cases in a considerable amount of detail. The results of the investigation are given in the following table. The results of the investigation are given in the following table. The results of the investigation are given in the following table.

TABLE I

Page 10, 2

Page 10, 2

Case-Number	Age, in years	Sex
10	10	Male
11	10	Male
12	10	Male
13	10	Male
14	10	Male
15	10	Male
16	10	Male
17	10	Male
18	10	Male
19	10	Male
20	10	Male
21	10	Male
22	10	Male
23	10	Male
24	10	Male
25	10	Male
26	10	Male
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89	10	Male
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91	10	Male
92	10	Male
93	10	Male
94	10	Male
95	10	Male
96	10	Male
97	10	Male
98	10	Male
99	10	Male
100	10	Male

Alsike Clover, 1949

Table II, 4

Plot Trials

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top- killing
Potassium cyanate (X 1) spray	10	40	30
	20	40	60
	25	40	80
Potassium cyanate + Vatsol K (1 g.) spray	10	40	60
	20	40	85
	25	40	90
Potassium cyanate (X 1) blend dust	60	--	10
	80	--	30
	100	--	60
Potassium cyanate (X 1) dust	60	--	10
	80	--	12
	100	--	20
Sodium cyanamid (X 5) spray	60	40	60
	80	40	80
	100	40	100
Sodium cyanamid + Vatsol K (1 g.) spray	60	40	80
	80	40	95
	100	40	100
Sodium cyanamid (X 10) dust	80	--	35
	100	--	50
	120	--	65
Sodium cyanamid (X 10) dust + Vatsol K (1 g.)	80	--	40
	100	--	60
	120	--	70

White Clover, 1941

Table 1

1941

Year	White Clover	Red Clover	Alfalfa	Other
1940	10	10	10	10
1941	10	10	10	10
1942	10	10	10	10
1943	10	10	10	10
1944	10	10	10	10
1945	10	10	10	10
1946	10	10	10	10
1947	10	10	10	10
1948	10	10	10	10
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2005	10	10	10	10
2006	10	10	10	10
2007	10	10	10	10
2008	10	10	10	10
2009	10	10	10	10
2010	10	10	10	10
2011	10	10	10	10
2012	10	10	10	10
2013	10	10	10	10
2014	10	10	10	10
2015	10	10	10	10
2016	10	10	10	10
2017	10	10	10	10
2018	10	10	10	10
2019	10	10	10	10
2020	10	10	10	10
2021	10	10	10	10
2022	10	10	10	10
2023	10	10	10	10
2024	10	10	10	10
2025	10	10	10	10

Table II, 5

Field Trials

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top- killing
Potassium cyanate (X 1) spray	12	60	60
Potassium cyanate (X 1) dust	60	--	15
Sodium cyanamid (X 5) spray	60	60	95
Sodium cyanamid (X 10) dust	60	--	20

Discussion

From Tables II, 3 and II, 4, it can be seen that potassium cyanate (X 1) spray at 20 pounds per acre caused sufficient top-killing to permit direct combining. A more complete top-killing resulted from the use of higher rates, but it is doubtful if this increase was great enough to warrant the extra cost of material. The addition of a spreader permitted a reduction in the amount of chemical necessary to achieve desired results.

11-61-3

The saving was one-half the amount of potassium cyanate necessary when no spreader was used.

Sodium cyanamid (X 5) spray at 60 pounds per acre was sufficient to bring about satisfactory results. The addition of a spreader to this compound also greatly increased its efficiency.

Potassium cyanate (X 1) blend dust and sodium cyanamid (X 10) dust at rates of over 100 pounds per acre resulted in satisfactory top-killing of the older growth of alfalfa, but did not control the younger second growth as well as the sprays did.

Analysis of variance carried out on the yields of the plots given in Table II, 3, indicated that there was no significant difference between the yields of the swathed plots and the yields of the treated plots.

The analysis of variance table shown below is for alfalfa seed yield data for the experiment listed in Table II, 3.

Variance due to	D.F.	Sums squares	Mean square	F. value	5% level
Treatment	6	353.85	58.975	0.538	2.7
Reps.	13	224.03	74.676	0.681	3.16
Error	18	1974.03	109.668		
TOTAL	27	2551.91			

$$\text{M.S.D.} = \frac{\sqrt{109.688}}{\sqrt{4}} \times \sqrt{2 \times 2} = 14.77 \text{ g.}$$

The average of the two groups is 10.000.

Each group has 10 members.

Group 1 (A) has 10 members and the

members are 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000.

Group 2 (B) has 10 members and the members are 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000.

Group 3 (C) has 10 members and the members are 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000.

It is clear that the members of the three groups are 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000.

Therefore, the average of the three groups is 10.000.

It is clear that the members of the three groups are 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000.

Therefore, the average of the three groups is 10.000.

It is clear that the members of the three groups are 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000, 10.000.

Therefore, the average of the three groups is 10.000.

The value of the average is 10.000.

The average of the three groups is 10.000. The average of the three groups is 10.000. The average of the three groups is 10.000.

Treatment	Group	Members	Average	Variance
1	1	10.000	10.000	0.000
2	2	10.000	10.000	0.000
3	3	10.000	10.000	0.000
TOTAL		30.000	10.000	0.000

$$10.000 = \frac{10.000 \times 3}{3} = 10.000$$

Under the conditions of these tests there was apparently no significant increase or loss of alfalfa seed resulting from the treatment. The pre-harvest treatment would however permit direct combining and thus reduce the risk of loss which is always present when swathing is employed or when harvesting is postponed until after a killing frost. Large losses often result when high winds carry away swathed material and losses can also occur when the killing frost is followed by heavy snows which may delay harvesting operations indefinitely.

Potassium cyanate (X 1) spray at 12 pounds per acre killed sufficient of the top growth of alsike clover to permit direct combining of the strips treated. This chemical required several days longer for effective action than did the sodium cyanamid (X 5) spray at 60 pounds per acre. The latter was very rapid in its action and resulted in satisfactory top-killing of alsike clover.

The application of dusts, potassium cyanate (X 1) and sodium cyanamid (X 10) did not control the younger vegetation and thus material treated in this way was unsuitable for combining.

In the harvesting of the treated plots, Table II, 5, a misunderstanding which resulted in pooling of the seed from the plots treated with potassium cyanate spray and sodium cyanamid spray prevented recording of individual plot yields. When the combined yields of the two treatments were compared to the yield of the swathed plot however, a 20% increase in yield per acre

was noted. As no material was left until a killing frost, no comparison with this method was possible. It was also noted that a much cleaner sample of seed was obtained from the chemical pre-harvest treatment of alsike clover than from the swathed material.

Alfalfa, 1950

Table II, 6

Plot Trials

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top- killing (Av. of 2 reps)
Potassium cyanate (X 1) spray	10	40	25
	15	40	85
	25	40	100
Potassium cyanate (X 1) spray + 1 g. Drift	10	40	75
	15	40	100
	25	40	100
Potassium cyanate (X 1) dust	40	--	0
	50	--	5
	75	--	20
Potassium cyanate (X 1) blend dust	80	--	10
	100	--	15
	150	--	50
Sodium cyanamid (X 5) spray	60	40	85
	80	40	98
	120	40	100

was noted. It is believed that the A. trilineatus, as
 compared with this species, is also noted. It was also noted
 that a much smaller number of eggs was deposited from the
 biological two-weeks incubation in this case. From the
 two eggs noted.

RESULTS, 1955

Table 1

Table 1

Number of eggs (No. of eggs)	Number of eggs (No. of eggs)	Rate, % (No. of eggs)	Remarks
25	10	40	Incubated (1) (1) eggs
25	10	40	
100	40	40	
25	10	40	Incubated (1) (1) eggs +
100	40	40	
100	40	40	
0	--	0	Incubated (1) (1) eggs
0	--	0	
20	--	20	
10	--	10	Incubated (1) (1) eggs
10	--	10	
20	--	20	
25	10	40	Incubated (1) (1) eggs
10	40	40	
100	40	40	

Table II, 6 (Continued). Plot Trials

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top- killing (Av. of 2 reps)
Sodium cyanamid (X 5) spray + 1 g. Dreft	60 80 120	40 40 40	100 100 100
Sodium cyanamid (X 10) dust	80 100 150	-- -- --	15 25 45
Potassium cyanate (X 1) spray + + + +	5 7 $\frac{1}{2}$ 12 $\frac{1}{2}$ 12 $\frac{1}{2}$	40 40 40 40	-- -- -- --
Sodium cyanamid (X 5) spray three days later	30 40 60	40 40 40	20 60 100
Potassium cyanate (X 1) spray + + +	5 7 $\frac{1}{2}$ 12 $\frac{1}{2}$ 12 $\frac{1}{2}$	40 40 40 40	-- -- -- --
Potassium cyanate (X 1) blend dust three days later	40 50 75	-- -- --	15 50 70
Potassium cyanate (X 1) spray + + +	5 7 $\frac{1}{2}$ 12 $\frac{1}{2}$ 12 $\frac{1}{2}$	40 40 40 40	-- -- -- --
Sodium cyanamid (X 10) dust three days later	30 40 75	-- -- --	12 45 90
Potassium cyanate (X 1) dust + + +	40 50 75 75	-- -- -- --	-- -- -- --
Sodium cyanamid (X 10) dust three days later	40 50 75	-- -- --	10 20 40
Sodium cyanamid (X 5) spray + + +	30 40 60 60	40 40 40 40	-- -- -- --
Sodium cyanamid (X 10) dust three days later	30 40 75	-- -- --	35 75 100

TABLE 2. 3. Summary of results.

Year	Number of plants	Number of leaves	Number of stems	Number of flowers	Number of fruits
1950	100	100	100	100	100
1951	100	100	100	100	100
1952	100	100	100	100	100
1953	100	100	100	100	100
1954	100	100	100	100	100
1955	100	100	100	100	100
1956	100	100	100	100	100
1957	100	100	100	100	100
1958	100	100	100	100	100
1959	100	100	100	100	100
1960	100	100	100	100	100
1961	100	100	100	100	100
1962	100	100	100	100	100
1963	100	100	100	100	100
1964	100	100	100	100	100
1965	100	100	100	100	100
1966	100	100	100	100	100
1967	100	100	100	100	100
1968	100	100	100	100	100
1969	100	100	100	100	100
1970	100	100	100	100	100
1971	100	100	100	100	100
1972	100	100	100	100	100
1973	100	100	100	100	100
1974	100	100	100	100	100
1975	100	100	100	100	100
1976	100	100	100	100	100
1977	100	100	100	100	100
1978	100	100	100	100	100
1979	100	100	100	100	100
1980	100	100	100	100	100
1981	100	100	100	100	100
1982	100	100	100	100	100
1983	100	100	100	100	100
1984	100	100	100	100	100
1985	100	100	100	100	100
1986	100	100	100	100	100
1987	100	100	100	100	100
1988	100	100	100	100	100
1989	100	100	100	100	100
1990	100	100	100	100	100
1991	100	100	100	100	100
1992	100	100	100	100	100
1993	100	100	100	100	100
1994	100	100	100	100	100
1995	100	100	100	100	100
1996	100	100	100	100	100
1997	100	100	100	100	100
1998	100	100	100	100	100
1999	100	100	100	100	100
2000	100	100	100	100	100

Table II, 7

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top-killing 14 days later
Potassium cyanate (X 1) spray	2½	40	0
	5	40	20
	10	40	60
	15	40	90
Potassium cyanate (X 1) spray + 1 g. Drefit	2½	40	15
	5	40	35
	10	40	85
	15	40	95

1941, 1942

Species	No. of specimens	No. of specimens	No. of specimens
Fossilium cynosura (L.) Guss.	10 10 10 10	10 10 10 10	10 10 10 10
Fossilium cynosura (L.) Guss. + F. G. Guss.	10 10 10 10	10 10 10 10	10 10 10 10

Table II, 8

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied / acre	% top-killing (2 reps.) 14 days later
Potassium cyanate (X 1) spray	6 12	40 40	50 90
Potassium cyanate + 1 g. Duz	6 12	40 40	95 100
Potassium cyanate + 1 g. Tide	6 12	40 40	80 90
Potassium cyanate + 1 g. Fab	6 12	40 40	90 100
Potassium cyanate + 1 g. Vel	6 12	40 40	65 90
Sodium cyanamid (X 5) spray	30 60	40 40	80 90
Sodium cyanamid + 1 g. Duz	30 60	40 40	80 90
Sodium cyanamid + 1 g. Tide	30 60	40 40	85 100
Sodium cyanamid + 1 g. Fab	30 60	40 40	100 100
Sodium cyanamid + 1 g. Vel	30 60	40 40	80 90

TABLE II

Concentration of Sodium Cyanide (% w/v)	Concentration of Sodium Cyanide (% w/v)	Concentration of Sodium Cyanide (% w/v)	Concentration of Sodium Cyanide (% w/v)
0.1	0.1	0.1	0.1
0.2	0.2	0.2	0.2
0.5	0.5	0.5	0.5
1.0	1.0	1.0	1.0
2.0	2.0	2.0	2.0
5.0	5.0	5.0	5.0
10.0	10.0	10.0	10.0
20.0	20.0	20.0	20.0
50.0	50.0	50.0	50.0
100.0	100.0	100.0	100.0
200.0	200.0	200.0	200.0
500.0	500.0	500.0	500.0
1000.0	1000.0	1000.0	1000.0

Table II, 9

Chemical	Gals./ acre	Gals. of emulsion /acre	% top- killing
QXS - 16C*	20	-	80
	60	-	95
	80	-	100
QXS - 16C + 1 g. Drefit	10	100	40
	20	100	80
	60	100	95
QXS - 16C + Potassium cyanate $1\frac{1}{2}$ lb./acre	2	100	0
QXS - 16C + Potassium cyanate 3 lb./acre + 1 g. Drefit	2	100	15
QXS - 16C + Potassium cyanate 6 lb./acre + 1 g. Drefit	2	100	25
QXS - 16C + Potassium cyanate $1\frac{1}{2}$ lb./acre + 1 g. Drefit	5	100	10
QXS - 16C + Potassium cyanate 3 lb./acre + 1 g. Drefit	5	100	20
Potassium cyanate 6 lb./acre + 1 g. Drefit	5	100	60
Potassium cyanate (X 1) spray + 1 g. Drefit	$1\frac{1}{2}$ lbs.	100 gal/a.	2
	3 lbs.	100 gal/a.	12
	6 lbs.	100 gal/a.	25

* QXS - 16C contained 76% aromatic hydrocarbons. Courtesy Imperial Oil Company.

Alsike Clover, 1950

Table II, 10

Field Trials (4-acre plots)

Chemical	Rate, lb./ acre	Gallons of H ₂ O applied /acre	% top-killing 14 days later
Potassium cyanate (X 1) spray + 1½ oz. Duz	12	40	50
Sodium cyanamid (X 5) spray + 1½ oz. Duz.	30	40	75
Swath	--	--	100
Frost	--	--	50

Table II, 11

Plot Trials

Chemical	Gals./ acre	Gals. of emulsion /acre	% top-killing
QXS - 16C	40	-	95
	60	-	100
	80	-	100

TABLE 1.1 - 1964

1964, 1965

(1964-1965) (1964-1965)

1964-1965	1964-1965	1964-1965	1964-1965
1964	1964	1964	1964
1965	1965	1965	1965
1966	1966	1966	1966
1967	1967	1967	1967
1968	1968	1968	1968
1969	1969	1969	1969

1964, 1965

1964, 1965

1964-1965	1964-1965	1964-1965	1964-1965
1964	1964	1964	1964
1965	1965	1965	1965
1966	1966	1966	1966
1967	1967	1967	1967
1968	1968	1968	1968
1969	1969	1969	1969

Red Clover, 1950

Table II, 12

Plot Trials

Chemical	Gals./ acre	Gals. of emulsion /acre	% top- killing
QXS - 16C	20 60 100	- - -	45 95 100
QXS - 16C + 1 g. Duz	10 20 60	100 100 100	10 45 90
QXS - 16C + Potassium cyanate 2 lb./acre + 1 g. Duz	2	100	10
QXS - 16C + Potassium cyanate 4 lb./acre + 1 g. Duz	2	100	15
QXS - 16C + Potassium cyanate 6 lb./acre + 1 g. Duz	2	100	45
QXS - 16C + Potassium cyanate 2 lb./acre + 1 g. Duz	5	100	10
QXS - 16C + Potassium cyanate 4 lb./acre	5	100	20
QXS - 16C + Potassium cyanate 6 lb./acre	5	100	50
Potassium cyanate (X 1) spray + 1 g. Duz	2 lbs. 4 lbs. 6 lbs.	100 gal/a. 100 gal/a. 100 gal/a.	5 10 25

See Table 1, 1951

Table 1, 1951

Table 1, 1951

Observations	Year	Value	Unit
1951 - 1952	1951	100	100
1952 - 1953	1952	100	100
1953 - 1954	1953	100	100
1954 - 1955	1954	100	100
1955 - 1956	1955	100	100
1956 - 1957	1956	100	100
1957 - 1958	1957	100	100
1958 - 1959	1958	100	100
1959 - 1960	1959	100	100
1960 - 1961	1960	100	100
1961 - 1962	1961	100	100
1962 - 1963	1962	100	100
1963 - 1964	1963	100	100
1964 - 1965	1964	100	100
1965 - 1966	1965	100	100
1966 - 1967	1966	100	100
1967 - 1968	1967	100	100
1968 - 1969	1968	100	100
1969 - 1970	1969	100	100
1970 - 1971	1970	100	100
1971 - 1972	1971	100	100
1972 - 1973	1972	100	100
1973 - 1974	1973	100	100
1974 - 1975	1974	100	100
1975 - 1976	1975	100	100
1976 - 1977	1976	100	100
1977 - 1978	1977	100	100
1978 - 1979	1978	100	100
1979 - 1980	1979	100	100
1980 - 1981	1980	100	100
1981 - 1982	1981	100	100
1982 - 1983	1982	100	100
1983 - 1984	1983	100	100
1984 - 1985	1984	100	100
1985 - 1986	1985	100	100
1986 - 1987	1986	100	100
1987 - 1988	1987	100	100
1988 - 1989	1988	100	100
1989 - 1990	1989	100	100
1990 - 1991	1990	100	100
1991 - 1992	1991	100	100
1992 - 1993	1992	100	100
1993 - 1994	1993	100	100
1994 - 1995	1994	100	100
1995 - 1996	1995	100	100
1996 - 1997	1996	100	100
1997 - 1998	1997	100	100
1998 - 1999	1998	100	100
1999 - 2000	1999	100	100
2000 - 2001	2000	100	100
2001 - 2002	2001	100	100
2002 - 2003	2002	100	100
2003 - 2004	2003	100	100
2004 - 2005	2004	100	100
2005 - 2006	2005	100	100
2006 - 2007	2006	100	100
2007 - 2008	2007	100	100
2008 - 2009	2008	100	100
2009 - 2010	2009	100	100
2010 - 2011	2010	100	100
2011 - 2012	2011	100	100
2012 - 2013	2012	100	100
2013 - 2014	2013	100	100
2014 - 2015	2014	100	100
2015 - 2016	2015	100	100
2016 - 2017	2016	100	100
2017 - 2018	2017	100	100
2018 - 2019	2018	100	100
2019 - 2020	2019	100	100
2020 - 2021	2020	100	100
2021 - 2022	2021	100	100
2022 - 2023	2022	100	100
2023 - 2024	2023	100	100
2024 - 2025	2024	100	100
2025 - 2026	2025	100	100
2026 - 2027	2026	100	100
2027 - 2028	2027	100	100
2028 - 2029	2028	100	100
2029 - 2030	2029	100	100
2030 - 2031	2030	100	100
2031 - 2032	2031	100	100
2032 - 2033	2032	100	100
2033 - 2034	2033	100	100
2034 - 2035	2034	100	100
2035 - 2036	2035	100	100
2036 - 2037	2036	100	100
2037 - 2038	2037	100	100
2038 - 2039	2038	100	100
2039 - 2040	2039	100	100
2040 - 2041	2040	100	100
2041 - 2042	2041	100	100
2042 - 2043	2042	100	100
2043 - 2044	2043	100	100
2044 - 2045	2044	100	100
2045 - 2046	2045	100	100
2046 - 2047	2046	100	100
2047 - 2048	2047	100	100
2048 - 2049	2048	100	100
2049 - 2050	2049	100	100
2050 - 2051	2050	100	100
2051 - 2052	2051	100	100
2052 - 2053	2052	100	100
2053 - 2054	2053	100	100
2054 - 2055	2054	100	100
2055 - 2056	2055	100	100
2056 - 2057	2056	100	100
2057 - 2058	2057	100	100
2058 - 2059	2058	100	100
2059 - 2060	2059	100	100
2060 - 2061	2060	100	100
2061 - 2062	2061	100	100
2062 - 2063	2062	100	100
2063 - 2064	2063	100	100
2064 - 2065	2064	100	100
2065 - 2066	2065	100	100
2066 - 2067	2066	100	100
2067 - 2068	2067	100	100
2068 - 2069	2068	100	100
2069 - 2070	2069	100	100
2070 - 2071	2070	100	100
2071 - 2072	2071	100	100
2072 - 2073	2072	100	100
2073 - 2074	2073	100	100
2074 - 2075	2074	100	100
2075 - 2076	2075	100	100
2076 - 2077	2076	100	100
2077 - 2078	2077	100	100
2078 - 2079	2078	100	100
2079 - 2080	2079	100	100
2080 - 2081	2080	100	100
2081 - 2082	2081	100	100
2082 - 2083	2082	100	100
2083 - 2084	2083	100	100
2084 - 2085	2084	100	100
2085 - 2086	2085	100	100
2086 - 2087	2086	100	100
2087 - 2088	2087	100	100
2088 - 2089	2088	100	100
2089 - 2090	2089	100	100
2090 - 2091	2090	100	100
2091 - 2092	2091	100	100
2092 - 2093	2092	100	100
2093 - 2094	2093	100	100
2094 - 2095	2094	100	100
2095 - 2096	2095	100	100
2096 - 2097	2096	100	100
2097 - 2098	2097	100	100
2098 - 2099	2098	100	100
2099 - 2100	2099	100	100

Birdsfoot Trefoil, 1950

Table II, 13

Plot Trials

Chemical	Rate, lb./ acre	Gals./ acre	% of maturity at time of treatment	dehiscence following treatment	% top- killing
Potassium cyanate (X 1) spray	12	60	7 days		
			0	0	
			25	0	
			50	0	
			75	75	
			100	100	100
			10 days		
			0	0	
			25	0	
			50	18	
			75	95	
			100	100	100
			14 days		
			0	0	
			25	10	
			50	60	
			75	100	
			100	100	100

Table II, 13 (Continued). Plot Trials

Chemical	Rate, lb./ acre	Gals./ acre	% of maturity at time of treatment	% dehiscence following treatment	% top- killing
Sodium cyanamid (X 5) spray	60	60	7 days		
			0	0	
			25	0	
			50	0	
			75	0	
			100	80	100
			10 days		
			0	0	
			25	0	
			50	10	
			75	15	
			100	90	100
			14 days		
			0	0	
			25	10	
			50	30	
			75	52	
			100	98	100
Sodium cyanamid (X 10) dust	120	--	7 days		
			0	0	
			25	0	
			50	10	
			75	80	
			100	100	5
			10 days		
			0	2	
			25	12	
			50	40	
			75	100	
			100	100	10

Table II, 13 (Continued). Plot Trials

Chemical	Rate, lb./ acre	Gals./ acre	% of maturity at time of treatment	% dehiscence following treatment	% top- killing
				14 days	
			0	68	
			25	85	
			50	95	
			75	95	
			100	100	25
CHECK				14 days	
			0	70	
			25	90	
			50	100	
			75	100	
			100	100	-

Discussion

When alfalfa was treated with one chemical, followed three days later by the application of a second chemical, Table II, 6, there was a general increase in the amount of top-killing obtained. The final results however did not warrant the extra time and labor involved since comparable results could be obtained by the application of a single chemical treatment.

Potassium cyanate (X 1) spray at 10 pounds per acre with the addition of a spreader gave satisfactory results under the conditions of the trials, Fig. 3. Sodium cyanamid (X 5) spray at 60 pounds per acre, with the addition of a spreader, resulted in complete top-killing and it was later found that this chemical would give satisfactory results from applications as low as 30 pounds per acre, Fig. 1.

The dusts alone did not give satisfactory results, and the dusts in combination with sprays did not give an increase in top-killing to warrant this procedure.

When Dreft was added to potassium cyanate (X 1) spray it resulted in a reduction of the amount of chemical needed to obtain satisfactory results, Table II, 7, but the lowest practical rate of potassium cyanate (X 1) was 10-12 pounds per acre. The addition of Dreft to sodium cyanamid (X 5) permitted a reduction of the chemical to 30 pounds per acre.

In trial experiments using various detergents, Table II, 8, it was found that Fab, Duz, Tide and Vel followed in the order mentioned as to their effectiveness in increasing the efficiency of the chemical sprays.

The field trials on alsike clover indicated that potassium cyanate (X 1) spray at 12 pounds per acre plus $1\frac{1}{2}$ oz. of Duz was sufficient to give satisfactory top-killing of the stand

treated, but that a longer period of time was required after the application as compared with sodium cyanamid (X 5) spray. The sodium cyanamid (X 5) at 30 pounds per acre plus $1\frac{1}{2}$ oz. of Duz caused rapid top-killing sufficient to permit combine harvesting within five days.

Yields from each of the four-acre plots of this experiment were:

Swathing	392 lbs.
Potassium cyanate (X 1) spray..	471 lbs.
Sodium cyanamid (X 5) spray....	498 lbs.
Natural freezing	406 lbs.

From these yield results it is evident that an increase in yield resulted from the application of a contact herbicide as a pre-harvest treatment of alsike clover. So not only can the time of harvest be controlled to a certain extent, but the increase in yield is further justification for pre-harvest treatment of alsike clover with a contact herbicide if the cost of the chemical is not prohibitive.

Sodium cyanamid (X 5) spray at 60 pounds per acre resulted in complete top-killing of birdsfoot trefoil and a delay in the mechanism of dehiscence. This would be an advantage in permitting direct combining before the occurrence of shattering.

Results from trial experiments using oil, QXS - 16C for pre-harvest top-killing of legumes indicated that a minimum of more than 20 gallons per acre is needed to obtain satisfactory results, Fig. 4, but equipment designed to efficiently apply smaller amounts of oil should be tested. The emulsions did not indicate any apparent benefits as compared with oil alone. The addition of potassium cyanate (X 1) as a fortifier gave results inferior to those obtained from lower amounts of oil alone.

Fig. 1

Alfalfa plot treated with sodium cyanamid
(X 5) spray 30 lbs. + 1 g. Drefit in
40 gallons of water per acre.

Fig. 2

Check plot of alfalfa.

Fig. 3

Alfalfa plot treated with potassium cyanate (X 1),
10 pounds per acre + Dreft in 40 gallons of
water per acre.

Fig. 4

Alfalfa plot sprayed with oil QXS - 16C
at 60 gallons per acre.

GENERAL DISCUSSION AND CONCLUSIONS

From the experimental results of three year's trials on the use of contact herbicides as pre-harvest treatment for legume seed crops, it is evident that the application of chemical as a spray resulted in a more satisfactory top-killing than that obtained from the application of the chemical as a dust. A more efficient method of applying the heavy cyanamid dusts may increase the amount of top-killing as compared with that reported in this section of the thesis. Alfalfa was the most resistant of the legumes treated. Red clover, because of its coarser stems, is not as susceptible as alsike clover. Potassium cyanate (X 1) spray at the rate of 15-20 pounds applied in 40 gallons of water per acre was satisfactory as a pre-harvest treatment to permit direct combining. The addition of a detergent permitted the reduction of this rate to 10-12 pounds per acre. Sodium cyanamid (X 5) spray at 60 pounds per acre resulted in sufficient top-killing to permit combining, and the addition of a detergent made feasible the reduction of this rate to 30 pounds per acre. Since sodium cyanamid (X 5) spray is very rapid in its action, this chemical may be useful for the pre-harvest treatment of birdsfoot trefoil. Such treatment by rapid killing of the seed

pod temporarily delays the mechanism of dehiscence making possible harvesting before occurrence of shattering. There is an apparent best time of application for maximum control. If the seed pod has reached the advanced stage of maturity the delay in dehiscence is very short, while the killing of an immature pod may affect the seed's viability. Further studies would establish the most suitable stage of maturity for treatment.

Observations made during the harvesting of legume seed indicated that it was not necessary to kill all of the top growth. If the leaves and seed head are killed, the stems may remain partially green and still be dry enough for direct combining. Figs. 6, 8, and 9, indicate the amount of top-killing satisfactory to permit direct combining. Figs. 5 and 7 show material prior to chemical top-killing.

Unlike the results obtained from pre-harvest top-killing of alsike clover, similar treatment of alfalfa did not increase the amount of seed harvested, but did permit direct combining and a partial control of the time of harvesting.

The use of oil, QXS - 16C as a pre-harvest top-killer was satisfactory at rates greater than 20 gallons per acre. The emulsions used did not bring about an improvement over results obtained with oil alone. Moreover the addition of potassium cyanate (X 1) as a fortifier did not permit a reduction in the amount of oil necessary to obtain satisfactory results.

Fig. 5

Sample from check plot of red clover,
Trifolium pratense.

Fig. 6

Sample from plot of red clover,
Trifolium pratense, treated with
sodium cyanamid (X 5) at 30 pounds
per acre + 1 g. Drest in 40 gallons
of water per acre.

Fig. 7

Sample from check plot of alfalfa,
Medicago media.

7. 10. 19

Sample from each foot of bridge,
along center.

Fig. 8

Sample from plot of alfalfa,
Medicago media, treated with
sodium cyanamid (X 5) at
30 pounds per acre + 1 g. Drest
in 40 gallons of water per acre.

100

Fig. 9

Sample from plot of alfalfa,
Medicago media, treated with
potassium cyanate (X 1) at
10 pounds per acre + 1 g. Drest
in 40 gallons of water per acre.

P A R T I I I

THE EFFECTS OF CHEMICAL TOP-KILLING ON PLANT
PHYSIOLOGICAL PROCESSES

INTRODUCTION

When some of the plant organs are killed by chemical methods or by natural environmental factors such as frost, the responses of the surviving plant parts should be known in order that we may more fully assess the advantages and disadvantages of a particular field treatment. Injury to seed, injury to crown or root, depletion of root reserves, upsetting of physiological processes, changes in gross anatomy and many other problems require consideration.

Many contact herbicides are available for top-killing, but little is known of their effects on crop plants. It is known that when petroleum oils are used as selective herbicides in horticultural crops, off-flavors may result from its use at the wrong time. Excessive use of a contact herbicide may for

example, result in partial crown damage with a resultant decrease in yield of seed and forage.

The studies reported in the following pages were undertaken in an attempt to obtain a better understanding of plant responses to various treatments with herbicides.

LITERATURE REVIEW

Penetration

Fogg (12) reported on the entry of the contact herbicide, 3:5 dinitro-o-cresol into plant tissues. He stated that the poison may enter:

- (a) as a solution or suspension through the stomata
- (b) by diffusion through the cuticle and epidermal walls
- (c) by diffusion as a gas through the stomata

In work with 3:5 dinitro-o-cresol there is very little evidence to show that entry is through the stomata. Fogg reported that

example, result in certain known damage to a building in
which is held of steel and concrete.
The studies reported in the following pages were
undertaken in an effort to obtain a better understanding of
plant responses to various treatments and conditions.

LITERATURE REVIEW

Penetration

Penetration is reported to be the entry of a contact material
into a solid material. The process is usually slow and
the material is often:
(a) as a solution or suspension around the surface
(b) by diffusion through the surface and internal walls
(c) by diffusion as a gas through the surface
In some cases, penetration is very slow and in some cases it is
to some extent, it is through the surface. The material is

Wetzel and Ziegenspeck found that entry as aqueous solutions through the stomata occurred only under abnormal conditions. Crafts' (7) statement that sprays do not normally enter through the stomata was substantiated by Silversides (33).

Fogg considers that diffusion through the cuticle and epidermal cells is the most important method of entry and that this method is dependent upon the concentration of solution and the area contacted. He found that penetration was proportional to the concentration on the outside of the epidermis. Evidently the area covered was important since a reduction in area was noted in wilted leaves which were not damaged to the same extent as turgid leaves. The corrugations caused by the wilting gave some protection against the poison.

Fogg reported that diffusion through the stomata as a gas takes place only when the dust forms of herbicides are used. Some of the 3:5 dinitro-o-cresol may sublime at ordinary temperatures and penetrate as a gas, while at other times the gas may dissolve in the cuticular water and diffuse inward as a liquid.

Aslander (3) reported that the surface tension of sulphuric acid prevented its entry through the stomata, but when this surface tension was reduced, entry through the stomata was facilitated.

Hopp and Linder (17) indicated that a higher water tension inside the plant resulting from low humidity promoted the effectiveness of contact herbicides. At low humidity, however, the herbicide dried rapidly on the surface of the leaf and absorption was decreased. Moisture was needed to facilitate entry through the cuticle.

Translocation

Aslander (3) found that there was no translocation of sulfuric acid when applied as a contact herbicide. Guy (16) and Thaxton and Jones (35) stated that no translocation occurred when Cyanamid contact-herbicides were used. Rich (30), working with potatoes, noted varying degrees of damage to tubers when the tops were killed with a contact herbicide, but stated that this damage resulted from the translocation of a substance already in the plant rather than from a movement of the chemical.

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Translation

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Effects on Cell Constituents

Germination

Ball et al (4) reported that petroleum oils had varying effects on the germination of seeds of different species, also that pre-soaking of the seed before applying the oil resulted in a increase in germination of some seeds, but a depression in others. MacDonald et al (23) stated that the treating of cotton seeds with dilute sulfuric acid resulted in an increase in germination and final yield of cotton. Too strong a concentration used for too long a time kills the seed.

DeFrance, Bell and Odland (10) utilized several fertilizers and chemicals to inhibit germination and weed growth by killing the seeds or by killing the young seedlings as they emerged from the testa. Abbott (1), and Welton and Carroll (41), agreed that cyanamid applied at the rate of one pound per square yard or 20 pounds per 1,000 square feet effectively prohibited the germination of annual weed seeds.

Carbohydrates and Starch

Graber et al (13), working with alfalfa, found that any factor reducing the carbohydrate supply increased the percentage

revised

of winter killing. Greathouse and Stuart (15) reported that in red clover it was not the carbohydrate supply that was so important but the respiration rate of the variety studied. A reduction in the carbohydrate supply however increased the amount of winter killing in all species because the reduced reserves were expended much faster. Mark (24) reported that while the carbohydrate supply is important in winter-hardiness, the genetical constitution of the plant is also a major factor. He stated that the winter hardy alfalfa plants had a higher nitrogen content than the non-hardy plants. Tysdal (38) found that the conversion of starch to soluble sugars resulted in an increase in protected enzymes which indicated an increase in winter hardiness. Kennard (18) reported that the hand picking of leaves from the trees of Montmorency sour cherry trees resulted in a reduction of winter-hardiness and the earlier this was done, the lower the resistance shown. This procedure lowers the amount of available carbohydrates.

Newton and Brown (27) stated that the adaptation of plants to resist frost appeared to depend on seasonal changes which gave the protoplasm stability. Sugar accumulation increased during the fall and a higher concentration was found in hardy varieties of winter wheat.

Grandfield (14) reported that a lowering of the carbohydrate and nitrogen content made the plant more susceptible to winter killing and that late fall cutting was detrimental to winter survival.

MATERIALS AND METHODS

Penetration

In the fall of 1948 plants of alfalfa, red clover and alsike clover were placed in two-gallon crocks and taken into the greenhouse. After the plants had attained complete first growth and had commenced second growth, the individual plants were treated in various ways using potassium cyanate (X 1) and sodium cyanamid (X 5) as sprays. The spray solution for each chemical contained one pound of chemical per gallon of water and where a spreader was included, soap at the rate of one ounce per gallon was added. Where individual leaves and stems were chosen for treatment, a paint brush was used in applying the solutions. An atomizer was used to spray the entire plants and the solution was applied to provide complete coverage.

Individual leaflets were studied under the microscope. The leaflets were first mounted in water and the solution introduced gradually from one side of the slide.

Translocation

In one group of plants terminal leaflets of each leaf on a stem were painted with solutions of potassium cyanate (X 1) and sodium cyanamid (X 5) with and without the addition of soap. Individual plants were used for each treatment. On another group of plants a strip one inch wide was painted around the base of each stem. By means of a hypodermic syringe 0.5 cc. of solution of potassium cyanate (X 1) and sodium cyanamid (X 5) were injected into the stems of individual plants of alfalfa and red clover and into the crowns of healthy normal plants of alfalfa, red clover and alsike clover. Notes were taken on the second, sixth and fifteenth day after treatment.

Effects on Cell Constituents

Germination and Crown Damage

One hundred seeds each, of alfalfa, red clover and alsike clover were used in each of the following tests on the effects of potassium cyanate (X 1) spray on germination of the

Experiment 1

In one group of 10 plants (control) leaves of same leaf
on a stem were painted with solutions of potassium cyanide (1%)
and sodium cyanide (1%) with and without the addition of 10%
Individual plants were used for each treatment. In another
group of plants a strip one inch wide was painted around the
base of each stem. Of course in a typical plant this is
of solution of potassium cyanide (1%) and sodium cyanide (1%)
were injected into the stems of individual plants of alfalfa
and red clover and into the stems of healthy control plants of
alfalfa, red clover and white clover. Notes were taken on
the second, third and fourth days after treatment.

Results on Alfalfa

Individual and Group Results

The number seeds sown, of alfalfa, red clover and
white clover were used in each of the three groups of plants
effects of potassium cyanide (1%) and sodium cyanide (1%) on

treated seeds. The seeds were soaked in a solution containing one pound of chemical dissolved in one gallon water for 1, 6, 12 and 24 hours. They were then carefully washed and placed to germinate in Petri dishes. The check seeds were treated in a similar manner except the potassium cyanate was omitted.

Seeds of alfalfa, red clover and alsike clover were placed on fine mesh screens and sprayed with a solution containing potassium cyanate (X 1), one-half pound in one gallon of water. The seeds of each species were placed in Petri dishes without being washed, and one hundred seeds of each species were placed in a second set of Petri dishes after being carefully washed, and a check of one hundred seeds of each variety which had been sprayed with distilled water only were started in a third set of Petri dishes.

In addition samples of seed from each species were gathered each year from plots and fields treated with the various chemicals used each year. These samples were then forwarded to the Seed Analyst, Division of Plant Products, Calgary, Alberta, for germination tests.

As regards injury to vegetatively reproducing parts of the plant, notes were taken on crown killing resulting from the various treatments.

collected seeds. The seeds were stored in a collection containing
one kind of seedling collected in one collection (see p. 1, 2,
13 and 24). They were then carefully washed and placed in
Gardner's seed oil. The seeds were very small, 1-2
smaller than most of the other seeds collected.
Some of the seeds, one flower and some other seeds
placed on the same surface and covered with a collection of
seeds collected from the same place in the same
of water. The seeds of one species were placed in a small dish
without being washed, and one hundred seeds of each species were
placed in a small dish of water. The seeds were washed in
water, and a small amount of the washed seeds of each species were
and then covered with distilled water and were stored in a
dish of water.
In addition to the seeds from the same place were
gathered and from the same place and from the same place
collected from the same place. Some seeds were collected from
the same place, 1-2, 13 and 24. Some seeds were collected from
for collection seeds.
In addition to the seeds from the same place were
the seeds, which were taken on the same surface and from the
same place.

Carbohydrates

Total Sugars: -

In 1947, 47 rows of alfalfa were planted. The seed of each row had previously been gathered from individual plants of Ferax alfalfa which had shown a very high degree of self-fertility for several preceding generations. Careful observation during the following three years indicated a great deal of homozygosity between individual plants of each row and the parent line from which the seed had come. There was however a marked variation when comparing plants between rows. Five rows were selected from this group for treatment. It was hoped that there would be little plant variation between plants within rows. Each row was divided into plots containing four plants per plot. The following treatments were repeated in duplicate for the five rows:

- (a) Top growth removed August 4, 1950, and roots harvested August 4, 1950.
- (b) Top growth removed August 4, 1950, and roots harvested August 11, 1950.
- (c) Top growth removed August 4, 1950, and roots harvested October 16, 1950.
- (d) Top growth removed August 11, 1950, and roots harvested August 11, 1950.
- (e) Top growth removed August 11, 1950, and roots harvested August 18, 1950.

Continued

Table 1

In 1947, 15 rows of alfalfa were planted. The seed of each row had previously been followed from initial plantings of 1944 alfalfa which had shown a very high degree of self-fertility and several previous generations. General observations during the following three years indicated a great deal of heterozygosity between individual plants of each row and the seven lines from which the seed had come. There was however a marked variation when comparing plants between rows. Five rows were selected from this group for treatment. It was found that

there would be little effect variation between lines within rows. Each row was divided into plots containing four plants per plot. The following treatment was applied to each plot:

Row and five rows:

- (a) Top growth removed August 1, 1947, and roots harvested August 1, 1950.
- (b) Top growth removed August 1, 1948, and roots harvested August 1, 1950.
- (c) Top growth removed August 1, 1949, and roots harvested October 1, 1950.
- (d) Top growth removed August 1, 1950, and roots harvested August 1, 1950.
- (e) Top growth removed August 1, 1951, and roots harvested August 1, 1950.

The remaining portion of Row 3 received the following treatment beginning August 26, 1950.

- (a) Top growth sprayed with potassium cyanate (X 1) spray at 12 pounds per acre in 40 gallons of water per acre with the addition of one gram of Dreft and roots harvested September 19, 1950.
- (b) Top growth sprayed with sodium cyanamid (X 5) spray at 60 pounds per acre in 40 gallons of water with the addition of one gram of Dreft and roots harvested September 19, 1950.
- (c) Top growth dusted with potassium cyanate (X 1) dust at 75 pounds per acre and roots harvested September 19, 1950.
- (d) Top growth dusted with sodium cyanamid (X 10) dust at 75 pounds per acre and roots harvested September 19, 1950.
- (e) Top growth removed and roots harvested September 19, 1950.
- (f) Top growth removed and roots harvested October 16, 1950.
- (g) Top growth left untouched and roots harvested September 16, 1950.
- (h) Top growth left untouched and roots harvested October 16, 1950, following a killing frost October 15, 1950.

The sprays were applied with a knapsack sprayer and the dusts applied by means of a hand pump insecticide duster.

After harvesting, the roots were carefully washed and the crown removed. Ten inches of the root were then removed and placed in an oven at 100°C. The roots remained at this temperature for one hour and then the temperature was reduced to 60°C. for the next 48 hours. The roots were then removed and ground in a Wiley mill and the material divided into two portions for storage in air-tight containers. The material was later ball-milled for 24 hours.

Total carbohydrate analyses were carried out on the ball-milled material. Weinman's method (40) of preparation utilizing takadiastase for the breakdown of starch, dextrin and maltose to glucose was followed using 0.5 gram samples of air-dried material until final extract volume was reached. The semi-micro method of Underkofler et al (39) was used to measure reducing sugars reported here as glucose according to the graph shown in Fig. 10.

Starch: -

A quantitative method was used to determine what percentage of starch was present in the ball-milled material.

The method used by Pucher, Leavenworth and Vichery (28), for determining starch quantitatively appeared well suited for this purpose. A 0.200 gram sample was used. All determinations were carried out in quadruplicate.

Protein

Nitrogen was determined using Kjeldahl-Gunning-Arnold method, with mercuric oxide as catalyst. Results were expressed as protein ($N \times 6.25$) on a moisture-free basis.

Phosphorous

Phosphorous was determined on the root material by the Truog-fusion method (36, 37). The standard curve, Fig. 11, was established from analytical data on preparations with known phosphorous concentrations.

total suspended matter was determined by the

oil-soluble material. The oil-soluble material

was determined by the difference of weight, and the

oil-soluble material was determined by the difference of weight

of the oil-soluble material and the oil-soluble material

of the oil-soluble material and the oil-soluble material

of the oil-soluble material and the oil-soluble material

Results

The oil-soluble material was determined by the

oil-soluble material and the oil-soluble material

of the oil-soluble material and the oil-soluble material

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of the oil-soluble material and the oil-soluble material

Discussion

The oil-soluble material was determined by the

oil-soluble material and the oil-soluble material

of the oil-soluble material and the oil-soluble material

Conclusions

The oil-soluble material was determined by the

oil-soluble material and the oil-soluble material

of the oil-soluble material and the oil-soluble material

of the oil-soluble material and the oil-soluble material

Fig. 10

Cc. of .05N $\text{Na}_2\text{S}_3\text{O}_3$ equivalent to
copper reduced (W.B.-R).

Fig. 11

Total phosphorous
(Na_2CO_3 - Fusion + Truog colorimetric procedure)
705 mu. - slit about .04 mm.

EXPERIMENTAL RESULTS

Penetration

When the terminal leaflet of alfalfa leaves were painted with the solution of potassium cyanate (X 1) or sodium cyanamid (X 5), the solution tended to concentrate in numerous little globules on the leaflet surface. Penetration through the cuticle took place directly below each globlet regardless of its position on the leaflet. The sodium cyanamid penetrated the cuticle much more rapidly than did the potassium cyanate. The addition of soap to the solution prevented the formation of the globules and resulted in a much more uniform coverage and penetration of the cuticle followed by death to the entire leaflet.

When leaflets were placed under the microscope in a water mount and the solution of potassium cyanate (X 1) or sodium cyanamid (X 5) was introduced singly from one side of the cover slip, rapid and severe cell plasmolysis occurred, the protoplast finally disintegrating. It was noted that the stomata did not allow the solution to enter, but death of the guard cells occurred from diffusion of the chemical through adjoining killed cells. The chloroplasts of the guard cells clumped together rapidly and remained so after death of the tissue. Diffusion

EXPERIMENTAL RESULTS

Penetration

When the cervical leaflet of white leaves were
gained with the solution of potassium permanganate (K₂Cr₂O₇) of 1%
strength (1/2), the solution tended to penetrate in numerous
places, especially on the leaflet surface. Penetration through
the leaflet took place directly below the leaflet regardless
of its position on the leaflet. The solution penetrated
the epidermis more rapidly than did the potassium permanganate.
The addition of soap to the solution prevented the penetration
of the solution and resulted in a much more uniform coverage
and penetration of the leaflet surface of leaflets to the entire
leaflet.

When leaflets were placed under the microscope in a
water spray and the solution of potassium permanganate (K₂Cr₂O₇) of
1% strength (1/2) was introduced directly from one side of
the lower side, veins and various leaf characteristics occurred, the
microscopic findings distinguished. It was noted that the epidermis
did not allow the solution to enter, and that of the guard cells
occurred from diffusion of the solution through adjoining epidermal
cells. The microorganisms of the guard cells showed separation
rapidly and remained as white beads of the solution. Diffusion

from cell to cell was very slow and after a few cells this movement stopped until more solution was added.

The rate of penetration was most rapid in alsike clover, followed by red clover and alfalfa respectively. The pubescent nature of red clover tended to act as a protector against a water solution, but the addition of soap overcame this resistance.

Translocation

Within two days after the application of the chemical solutions to terminal leaflets, death occurred. Six days after the application the two lateral leaflets still remained normal and there was no evidence of chlorosis or necrosis. Fifteen days after treatment the same condition prevailed, there being no evidence of translocation of herbicides from the terminal leaflet to the lateral leaflets or petioles.

On the second day after application of the solutions the one inch strips of treated tissue were necrotic and the material above the strips was showing evidence of wilting. The plants which had been treated with sodium cyanamid showed a more

from call to call was very slow and after a few calls this movement stopped until some activity was noted. The rate of penetration was most rapid in the clover, followed by red clover and alfalfa respectively. The subsequent failure of red clover tended to act as a protection against a water solution, and the addition of soap overcame this resistance.

Translocation

Within two days after the application of the chemical solutions to terminal leaflets, growth resumed. Six days after the application the two lateral leaflets still remained normal and there was no evidence of malformation or necrosis. Fifteen days after treatment the same condition prevailed, there being no evidence of translocation of materials from the terminal leaflet to the lateral leaflets or petioles. On the second day after application of the solutions the one inch strip of treated tissue was necrotic and the material above the strip was showing evidence of wilting. The plants which had been treated with sodium cyanide showed a more

advanced stage of wilting. On the sixth day following the date of application, death of all material above each strip was noted. There was no evidence of death below the point of application. Microscopic studies showed that all phloem and parenchymatous tissues were dead. The cells at point of application showed evidence of protoplasmic destruction while the cells above this area showed symptoms of being cut off from water supply. Apparently the death of the cells at point of contact of the solution prevented movement of water past this area. The cells below the area treated appeared normal and functioning at the time of observation. There was no apparent translocation of the chemical up or down the stem. Studies on the fifteenth day after application confirmed the observations made after the sixth day.

Observations two days after injections into normal crowns showed that all vegetation above the point of injection was dead. Six days after the injections, death had occurred to that part of the crown receiving the solution, but untouched portions still continued normal growth. Fifteen days after injections decay of that portion of root below the point of injection and of that part of the crown receiving the injection was noted. The root, crown and top growth of the remaining part of the plant appeared normal however, thus indicating that no translocation took place.

Effects on Cell Constituents

Tables III, 1 to III, 3, illustrate the effects of various chemical treatments upon seed germination and plant crowns.

Table III, 1

Chemical	Hours of soaking	Al-falfa	Red clover	Alsike clover	Al-falfa	Red clover	Alsike clover
Potassium cyanate (X 1)	24	0	0	0	60	92	87
	12	0	3	4	71	89	90
	6	16	22	26	69	92	84
	1	63	84	86	68	88	91

Table III, 2

Chemical	% germination (unwashed)			% germination (washed)			% germination (check)		
	Alfalfa	Red clover	Alsike clover	Alfalfa	Red clover	Alsike clover	Alfalfa	Red clover	Alsike clover
Potassium cyanate (X 1)	0	0	0	62	81	86	68	88	87

Seeds which were washed following spraying showed no injurious effects of the chemical treatment on germination whereas the chemical retained on the seed coats of the unwashed seeds prohibited germination.

Effect of Salt Stress

Table III, 1 to III, 3. Results are listed in Table III, 1 to III, 3.

Results are listed in Table III, 1 to III, 3.

Table III, 1

Descriptive	Number of Plants	1- 2	3- 4	5- 6	7- 8	9- 10
Plants (1)	24	0	0	0	0	0
Plants (2)	12	0	0	0	0	0
Plants (3)	8	10	20	20	20	20
Plants (4)	1	0	0	0	0	0

Table III, 2

Descriptive	Number of Plants	1- 2	3- 4	5- 6	7- 8	9- 10
Plants (1)	0	0	0	0	0	0
Plants (2)	0	0	0	0	0	0
Plants (3)	0	0	0	0	0	0
Plants (4)	0	0	0	0	0	0

Seeds which were treated with various concentrations of the chemical treatment at the chemical treatment and the chemical treatment on the seed coats of the treated seeds are listed in Table III, 1 to III, 3.

Table III, 3

Chemical	Rate, lb./ acre	% germination			% crown killing		
		Al- falfa	Red clover	Alsike clover	Al- falfa	Red clover	Alsike clover
Check	-	86	91	92	-	-	-
Potassium cyanate (X 1) spray	10	89	92	94	0	0	0
Sodium cyanamid (X 5) spray	60	87	89	90	0	0	0
	100	89	91	92	0	0	0
Potassium cyanate (X 1) dust	80	84	89	94	0	0	0
	120	90	92	93	0	0	0
Sodium cyanamid (X 10) dust	80	88	93	91	0	0	0
	120	87	90	92	0	0	0
Oil QXS-16C	60	86	89	89	0	0	0
	80	--	--	86	0	0	0
	100	89	90	--	0	0	2
Oil QXS-16C + H ₂ O to 100 gals.	60 gals	87	92	--	0	0	0
Oil QXS-16C + 6 lbs. K CnO (X 1)	2gals.	91	94	--	0	0	0
Oil QXS-16C + 6 lbs. K CnO (X 1)	5gals.	89	93	--	0	0	0

Table III, 4 and III, 5, illustrate the effect of contact herbicides upon root constituents.

Table III, 4

Combining Two Replicates

Row	Treatment of top growth	Roots harvested	% total carbohydrate per 0.500 g. sample	% starch	% protein	% phos- phorous
1	Cut Aug. 4	Aug. 4	17.5	5.60	16.6	
	4	11	8.9	1.01	16.3	0.152
	11	11	21.4	4.27	15.6	0.152
	11	18	15.5	2.40	16.1	
2	Aug. 4	Aug. 4	16.7	6.70	16.1	
	4	11	17.5	0.56	16.4	
	11	11	21.6	6.97	16.7	0.140
	11	18	10.1	1.60	16.8	
3	Aug. 4	Aug. 4	22.0	7.20	17.3	
	4	11	14.7	1.30	16.4	
	11	11	20.2	8.60	16.7	0.128
	11	18	10.0	2.25	18.1	
4	Aug. 4	Aug. 4	4.8	8.50	16.9	
	4	11	16.7	0.56	16.8	
	11	11	22.0	7.87	16.5	0.116
	11	18	8.6	0.90	16.1	
5	Aug. 4	Aug. 4	24.2	4.70	16.9	
	4	11	15.5	1.78	16.8	
	11	11	25.5	3.90	16.9	0.116
	11	18	10.1	0.70	17.3	
3	X 5 spray					
	Aug. 26	Sept. 19	22.5	1.70	20.8	0.200
3	X 1 spray					
	Aug. 26	Sept. 19	20.9	5.60	15.7	0.200
3	X 10 dust					
	Aug. 26	Sept. 19	20.6	13.5	16.6	0.160
3	X 1 dust					
	Aug. 26	Sept. 19	24.5	2.70	16.7	0.168
3	Swathed					
	Aug. 26	Sept. 19	12.0	4.50	16.6	0.216
3	Aug. 26					
	swathed	Oct. 16	23.4	1.69	16.3	0.168
3	Frost killed					
	Oct. 15	Oct. 16	22.3	1.10	19.9	1.152
3	Check	Sept. 19	15.5	-	16.1	0.218

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TABLE III, 2

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98	1	1	1	1	1	1
99	1	1	1	1	1	1
100	1	1	1	1	1	1

Table III, 5

Combined Results

Treatment of top growth	Roots harvested	% total carbohydrate per 0.500 g. sample	% starch/ 0.200g. sample	% protein	% phos- phorous
<u>1950</u>					
<u>Cut</u>					
Aug. 4	Aug. 4	20.92	5.6	16.75	
Aug. 4	Aug. 11	14.56	1.04	16.51	.152
Aug. 11	Aug. 11	22.15	6.31	10.52	.130
Aug. 11	Aug. 18	10.86	1.57	16.92	
X 5 spray Aug. 29	Sept. 19	22.5	1.7	20.87	0.20
X 1 spray Aug. 29	Sept. 19	20.9	5.6	15.72	
X 10 dust Aug. 29	Sept. 19	20.6	8.5	16.62	
X 1 dust Aug. 29	Sept. 19	24.5	2.7	16.75	
Swath Aug. 29	Oct. 16	23.4	1.10	16.31	0.168
Swath Aug. 29	Sept. 19	12.0	4.5	16.6	0.216
Check	Sept. 19	15.5	5.4	16.13	0.218
Frost killing	Oct. 16	23.4	1.69	19.91	0.152
<u>1949</u>					
X 5	Afterfrost	21.6	1.1	19.95	.216
Check	After frost	20.6	1.3	19.37	.164

Table 1

Summary of Results

Location	Depth (m)	Temperature (°C)	Salinity (‰)	Density (σ _t)	Speed (cm/s)	Direction (°)
Station 1	0.5	18.5	35.2	1.024	1.2	135
Station 2	1.0	18.2	35.1	1.024	1.1	135
Station 3	1.5	18.0	35.0	1.024	1.0	135
Station 4	2.0	17.8	34.9	1.024	0.9	135
Station 5	2.5	17.5	34.8	1.024	0.8	135
Station 6	3.0	17.2	34.7	1.024	0.7	135
Station 7	3.5	17.0	34.6	1.024	0.6	135
Station 8	4.0	16.8	34.5	1.024	0.5	135
Station 9	4.5	16.5	34.4	1.024	0.4	135
Station 10	5.0	16.2	34.3	1.024	0.3	135
Station 11	5.5	16.0	34.2	1.024	0.2	135
Station 12	6.0	15.8	34.1	1.024	0.1	135
Station 13	6.5	15.5	34.0	1.024	0.0	135
Station 14	7.0	15.2	33.9	1.024	0.0	135
Station 15	7.5	15.0	33.8	1.024	0.0	135
Station 16	8.0	14.8	33.7	1.024	0.0	135
Station 17	8.5	14.5	33.6	1.024	0.0	135
Station 18	9.0	14.2	33.5	1.024	0.0	135
Station 19	9.5	14.0	33.4	1.024	0.0	135
Station 20	10.0	13.8	33.3	1.024	0.0	135

Table 2

Station 1	18.5	35.2	1.024	1.2	135
Station 2	18.2	35.1	1.024	1.1	135

Carbohydrates

There was a marked decrease in the total carbohydrates Table III, 4, following removal of top growth after seed set by the first growth. When the plant remained uncut until September 19, 1950, it was found that the total carbohydrates were also low, this probably being due to support of flowering of the second growth. In four out of the five rows tested, there was a marked difference in the amount of total carbohydrates present at time of harvesting between rows, which indicated an inter-plant variation. Duplicate results, not shown in Table III, 4, indicated no apparent difference between plants within rows.

Swathing of the plants resulted in a decrease in total carbohydrates but when sufficient growing time elapsed before frost, there was a rebuilding of total carbohydrates.

Starch: -

When top growth was removed there was a rapid conversion of starch to soluble carbohydrates, Table III, 5. At time of frost very little reserve starch was found while the total carbohydrates were high. The use of the rapid top-killer sodium cyanamid (X 5) produced results closely paralleling frost treatment. There was a rapid conversion of reserve starch to soluble sugar. The slower

Observations

There was a marked increase in the total population

Table III, following removal of the forest from the area of the first census. The first census was taken in 1950, it was found that the total population was 100.

This probably being due to a report of flowering of the forest. It was one of the first years, there was a marked increase in the number of total population present at the time of the census, which indicated an increase in the population. The increase was 100, and it was found in Table III, that there was no apparent difference between the first and second years.

Removal of the forest resulted in a decrease in total population. It was found that the total population was 100, and there was a reduction of total population.

Discussion

When the forest was removed there was a rapid population of the area by the total population. Table III, it was found that the total population was 100, and it was found that the total population was 100. The use of the total population was 100, and it was found that the total population was 100. The use of the total population was 100, and it was found that the total population was 100.

top-killers did not affect the reserve starch to the same extent. Swathing of the plants resulted in a reduction of total carbohydrates but not a marked reduction in stored starch.

Protein: -

There was little variation in the protein content of the roots except when frost occurred or a rapid top-killer was applied. Both of these treatments resulted in an increased protein content.

Phosphorous: -

There was only a minor variation in phosphorous content of the roots but a slight increase in the per cent of phosphorous was noted, Table III, 5, in treated material as compared with the percentage present when frost-killing occurred.

incubation did not affect the results obtained in the same system.
Owing to the slight variation in a reaction of some samples
there was not a marked reaction in every sample.

- Incubation:

There was little variation in the protein content of
the roots except when there occurred a rapid top-growth was
noticed. Both of these phenomena resulted in an increased
protein content.

- Protein:

There was only a slight variation in phosphorus content
of the roots but a slight increase in the part of phosphorus
was noted, Table III, 2, in treated material as compared with the
physiologic material when frost-killing occurred.

DISCUSSION

It is evident from the results of the experimental trials that penetration of Cyanamid contact herbicides is through the cuticle of the leaf and not through the stomata. As the chemicals used are heat stable, it is very unlikely that there is any penetration by means of vapor. The addition of a spreader increases the area covered by the spray and results in a greater surface being contacted and therefore a larger proportion of killed material. There was no apparent translocation of the chemical. Any movement was the result of very limited diffusion in all directions. Application of the chemical in dust form necessitates the presence of water before the chemical becomes active.

The only plant crown damage that was evident occurred through the application of the oil QXS - 16C at the rate of 100 gallons per acre, Table III, 3. At this rate, only two plants per hundred were killed. Sodium cyanamid (X 5), applied at 100 pounds per acre, retarded some of the crown buds, but these later became active and grew vigorously.

From germination results it was evident that germination of harvested material treated with petroleum oil and Cyanamid contact herbicides was not decreased, Table III, 3. The

RESULTS

It is evident from the results of the experiment

that the treatment of the plants with the chemical
resulted in a marked increase in the yield of the
crop. The plants which were treated with the chemical
gave a much higher yield than those which were not
treated. The yield of the treated plants was about
twice that of the untreated plants. This result is
very significant, especially in view of the fact
that the chemical was applied in a very small
quantity. The results of the experiment are shown
in the following table:

The only plant which was killed was the one
which was treated with the chemical at the rate of
100 g. per acre. This plant was killed because
it was too young to withstand the treatment. The
other plants which were treated with the chemical
at the rate of 100 g. per acre were not killed.
The results of the experiment are shown in the
following table:

From the results of the experiment it was evident
that the chemical was very effective in increasing
the yield of the crop. The yield of the treated
plants was about twice that of the untreated
plants. This result is very significant, especially
in view of the fact that the chemical was applied
in a very small quantity.

seed pods apparently prevent the penetration of the contact herbicide to the seed coat and therefore threshed seed is free from chemical injury. If the Cyanamid is applied to the seed, sufficient of the chemical remains on the testa to prevent germination or kills the radicle as it emerges from the seed coat, Table III, 2. In laboratory tests, washing the seed to remove the chemical, Table III, 2, permitted normal germination. Seeds soaked in a solution of the chemical resulted in a decrease in germination, Table III, 1. The magnitude of the decrease increased with time of soaking and the amount of penetration.

It may safely be concluded that the pre-harvest treatment of the legume seed crops studied did not affect the germination of the harvested seed.

Preliminary studies on total sugars, starch and protein content of alfalfa roots indicated that there was very little variation within closely related plants, but with the exception of protein content, a larger difference did occur when unrelated plants were compared.

There was a marked decrease in the total carbohydrates one week after top growth of alfalfa was removed. This undoubtedly resulted during the initiation of new growth which followed the removal of the original green material. There was also a rapid conversion of stored starch to soluble carbohydrates.

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Following the swath treatment, soluble carbohydrates decreased and had killing frosts been experienced prior to September 19, 1950, the roots would likely have entered the winter with marked diminution of food reserves. Full recovery of available carbohydrates was noted October 16, 1950. This indicates that swath-ing of top material must be carried out early enough in the season to permit replenishment of diminished food reserves before a killing frost occurs.

The application of a rapid acting top-killer, sodium cyanamid (X 5) spray, reacted in a manner resembling that of a killing frost. There was no apparent decrease of total carbohydrates three weeks following treatment and most of the stored starch was converted into soluble sugars during this period. This conversion was also noted following the frost-killing treatments. The use of a slower acting killer did not induce conversion of the reserve starch to soluble sugar. No loss of total carbohydrates was noted three weeks following treatment. In view of the above mentioned results that indicate conversion of stored starch to soluble sugars following the treatment of alfalfa with a fast acting top-killer, there appears to be a possibility of similar achievement with economic advantage in the production of root crops such as sugar beets.

Protein content of the rapidly top-killed alfalfa closely approximated that of the frost killed material while amounts of protein in material from other treatments were relatively lower.

The phosphorous content of the roots of alfalfa treated with sodium cyanamid appeared to be slightly higher than that found in the roots of the frost-killed material.

Continued study of the effects of contact herbicides upon chemical constituents of surviving plant organs appears to be warranted in further efforts to clarify the physiological and practical significance of the changes which take place.

SUMMARY AND CONCLUSIONS

1. There is reason to believe that within the limits of this investigation Cyanamid contact herbicides may be useful for:
 - (1) The weeding of first-year stands of legume seed crops. Potassium cyanate (X 1) spray at 10 - 12 pounds per acre plus a spreader in 40 gallons of water per acre, and sodium cyanamid (X 5) at 30 pounds per acre plus a spreader in 40 gallons of water per acre proved the

most successful. In order to obtain satisfactory results the weeds must not have reached the flowering stage at time of treatment.

- (2) The pre-harvest treatment of legume seed crops to permit direct combining. Sodium cyanamid (X 5) at 60 pounds per acre in 60 gallons of water or at 30 pounds per acre plus a spreader in 60 gallons of water gave satisfactory results. Potassium cyanate (X 1) spray at 10 - 12 pounds per acre plus a spreader in 40 gallons of water also proved satisfactory on alsike clover.
2. Certain petroleum oils used at not less than 20 gallons per acre, were successfully used as a pre-harvest treatment for legume seed crops in preparation for direct combining.
3. No effects on germination were found when Cyanamid contact herbicides or petroleum oils were used as top-killing agents on legume seed crops.
4. Treatment of top growth with Cyanamid contact herbicides is no more detrimental to root reserves of alfalfa than any other practice currently used on legume seed crops.
5. The rapid acting sodium cyanamid (X 5) spray resulted in chemical changes within the alfalfa root which approximated the changes brought about by low temperatures and top-killing frosts.

most susceptible. In order to obtain reliable results the plants must not have received the following amount at time of treatment.

(1) The pre-treatment treatment of lettuce seed crops to be treated directly. Sodium cyanide (K 2) at 10 pounds per acre in 20 gallons of water or 20 pounds per acre plus 2 quarts in 20 gallons of water gave satisfactory results. Potassium cyanide (K 1) spray at 10 - 12 pounds per acre with a sprayer in 20 gallons of water also proved satisfactory in certain cases.

2. Certain potatoes will yield at most less than 20 gallons per acre, with approximately 10 used as a pre-treatment treatment for lettuce seed crops in preparation for direct sowing.

3. No effects on germination were found when cyanide contact herbicides or potatoes are used as top-killing agents on lettuce seed crops.

4. Treatment of top growth with cyanide contact herbicides is no more detrimental to root reserves of lettuce than any other practice currently used on lettuce seed crops.

5. The rapid action sodium cyanide (K 2) spray resulted in chemical changes within the lettuce root which approximated the changes brought about by low temperatures and top-killing.

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