CEREALS

ENVIRONMENTAL FACTORS AFFECTING THE RESPONSE OF BARLEY TO GROWTH REGULATORS

by

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Summary

Large differences in toxicity of growth regulators are found when plants having the same stage of development are sprayed at different times. A large effect is found when the weather is cold and cloudy, with rain before spraying and warm and sunny after. A small effect is found when the weather is warm before spraying and cold after.

A theory of effect of frost, which was advanced earlier, is not confirmed.

Introduction

Earlier investigations have shown the greatest effect of growth regulators has taken place when the temperature was high (2, 3, 4) in sunshine, (3) or in greenhouse experiments with high light intensity (2).

In Danish experiments a different toxicity to cereals is often found, even if plants are sprayed at the same stage of development. Therefore, in some experiments carried out from 1951 to 1954, barley was sown at different times, but sprayed at a fixed stage of development.

Method

Each year barley was sown at 10 different dates in the course of a month, and in each sowing, spraying was carried out at three dates, when the number of leaves was 2.0, 2.5, and 3.0. Earlier investigations have shown that the susceptibility of the plants depends on the stage of development of the ear; but due to shortage of time the development of the ear was not determined before spraying. Later analyses have shown that differences in the stage of development of the ear did not appreciably affect the results.

A section of the plan for 1951 is shown in table 1. The dates of sowing were so chosen that 3 sowings could be sprayed at the same date; e.g. on May 20th, the sowing of April 23rd had 3.0 leaves, the sowing of April 27th 2.5, and the sowing of May 2nd 2.0 leaves. When sprayed on May 22nd, the sowing of April 27th had grown to the 3-leaf stage, the sowing of May 2nd to the 2.5-leaf stage, and so on.

The dose was 1 kg sodium salt of 2,4-D per hectare, (c.116 per acre); in 1953 MCPA was tried as well. The degree of toxicity was judged by counting abnormal kernels, and in 1952 and 1953 also by yield determination.

Effect of night frost

Based on the experiments in 1951, the theory was advanced that the effect of 2,4-D could be increased by night frost (1). In this way, some results from 1951 and 1949 could be explained. However, that theory must now be rejected in part. In 1953 we had frost on April 21st, 23rd, 26th, and 28th, but no great damage was done by spraying on April 21st, 23rd, and 25th. On the other hand there was considerable damage done on May 17th (figure 1), but the minimum temperature was not below 1.5°C in a week before and a week after that date.

Other experiments from 1952 and 1953, indicate a small effect of frost, but the very large differences found in 1953 cannot be explained by the effect of frost.

Effect of temperature, sunshine, and rain

In 1953 the effect of spraying on May 6th and 23rd was small, but on April 29th and May 17th was large. A section of the results and weather conditions is shown in figure 1, where the 3rd to the 10th sowings are shown. Due to rain in late March and early April, the 3rd sowing was not sown until the second had emerged. The second sowing was therefore sprayed at the 2.5 and the 3-leaf stage on April 25th and 29th, but the 3rd sowing was not sprayed until May 4th and May 6th.

In the days before spraying on May 17th the weather was cold, with rain and little sunshine. In the days after spraying, it changed to warm and sunny weather. On May 6th and May 23rd reverse conditions were found, the weather was changing from warm to cold.

No relation was found between the effect of spraying and the weather on the day of spraying, but it seems that the weather of several days must be taken into consideration. Average data was therefore calculated for 5 days before and after spraying, and a summary is given in table 2. In this table a survey of weather conditions is shown for the days when the effect of spraying was judged to be at its largest or smallest.

In all 3 examples of large effect, the number of abnormal kernels showed a definite peak on one day. In each case spraying was done after heavy rain, and the days after spraying were warm and sunny.

When the effect has been small, it is more difficult to point to a single day. In 1951, the effect of spraying was small both on May 20th and May 22nd, and in 1951, on May 4th and May 6th; table 2 shows the weather conditions for the last two dates. If the first ones were chosen, smaller differences would be found between the weather before and after spraying.

Pot experiments

In 1954 two experiments were made, when plants in pots were placed at different places before and after spraying. Four days before spraying, 20 pots were placed at each of the following places:

(a) In a greenhouse (G)
(b) In the garden in sunshine (S)
(c) " " " " " , watered heavily the day before spraying (SW)
(d) Close to the north wall of a house (N)

18 pots in each place were sprayed; after spraying, 6 pots from each place were placed in the greenhouse, 6 in sunshine in the garden, and 6 in the shadow of the north wall. 4 days later all pots were moved to the garden.

In the unsprayed pots the stage of development of the ear was determined. The ear was at the most advanced stage in the greenhouse, and at the least by the north wall. This difference probably has slightly affected the susceptibility of the plants, but cannot explain the whole difference of the effect of spraying.

Exp. 1 shows an effect of watering before spraying (table 3). This agrees with the field experiments, but a similar effect is not found in exp. 2. The soil in exp. 2 was not so dried up as the soil in exp. 1, and that may explain the difference.

For treatment after spraying, the same results are found in both experiments. Plants placed in the sun show the highest response to spraying, and plants from the greenhouse the lowest. The temperature in the greenhouse was higher than that outside, and the light intensity lower. The results would therefore suggest that the high effect in warm, sunny weather, is due rather to high light intensity than to high temperature.

Discussion

The 6 dates shown in table 2 are the only instances of large weather changes in the 4 experimental periods. For a large effect of spraying, rain followed by a rise in both temperature and light intensity seems to be a deciding factor. In 1952 we had 15 mm of rain on one day during the experimental period, but the temperature was falling slightly, and so the effect of spraying was the same during the whole experiment. In 1952 the number of hours of sunshine also varied, but without a corresponding rise or fall in the temperature.

Supposing that the effect of growth regulators increases when the weather changes from a cold, cloudy period with rain, to a period with warm and sunny weather, some strange results from 1948 and 1949 could likewise be explained.

Whether the theory is right or not, the experiments have shown that weather conditions are of considerable importance to the response of the plants. In future experiments it will be useful to draw more attention to the weather.

Table 1. Plan of the experiment 1951

Date of sowing	Date of spraying		
23.4	<u>12.5</u>	15.5	20.5
27.4	22.5	<u>15.5</u>	20.5
2.5	22.5	24.5	<u>20.5</u>
5.5	<u>22.5</u>	24.5	26.5
8.5	30.5	<u>24.5</u>	26.5
continued			

Table 2. Climatic conditions before and after days, when the effect of spraying was very small or very large. Average figures for 5 days before and 5 days after spraying.

Date of spraying	Temperature deviation from normal *) °C		Sunshine hours daily		Rain mm in 5 days	
	before	after	before	after	before	after
The effect small:						
May 22 1951	1.3	-1.5	13	9	0	2
May 6 1953	5.0	-1.9	9	5	0	2
May 23 1953	5.3	2.7	11	8	1	8
The effect large:						
May 30 1951	-4.4	0.9	6	14	37	0
May 29 1953	0.3	4.0	7	10	11	0
May 17 1953	-2.0	4.5	3	10	20	2

* The daily normal temperature calculated as an average of 30 years observations.

Table 3. Pot experiments 1954. Number of abnormal kernels.

Before spraying	G	S	SW	N	G	S	SW	N	G	S	SW	N
After spraying	Greenhouse				Sunshine in the garden				Shadow at a north wall			
Exp. 1	8	18	88	40	40	44	126	83	31	34	95	45
Exp. 2	153	116	143	86	238	391	354	212	268	259	273	242
Exp. 1	154				293				205			
Exp. 2	498				1195				1042			

		Exp. 1	Exp. 2
Totals for	G	79	659
treatment	S	96	766
before	SW	309	770
spraying	N	168	540

(22394)

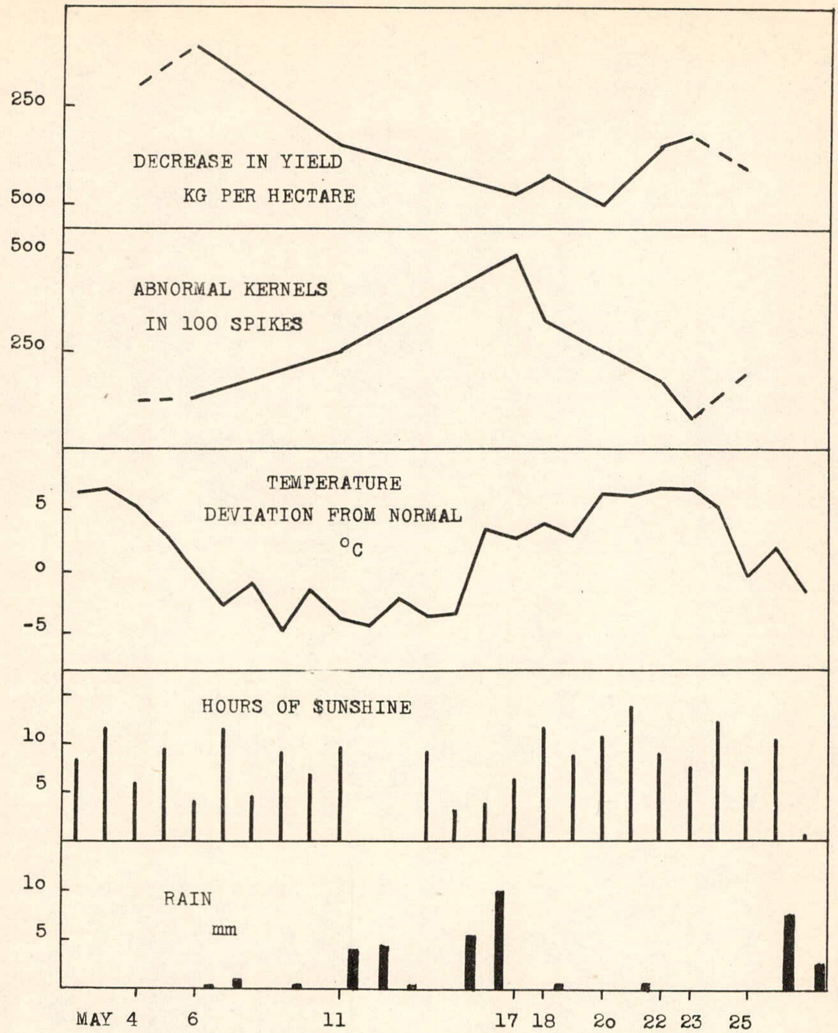

Fig. 1. Weather conditions and effect of spraying in the 1953 experiment, Yield decrease and number of abnormal kernels, average of spraying with 2,4-D at the 2.5 and the 3-leaf stage.

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CONCERNING THE INFLUENCE OF COLD PERIODS ON THE EFFECT OF 2,4-D AND MCPA ON OATS

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Summary

If 2,4-D is applied to oats during or immediately after a frost period or night frosts at the time of tillering, a decrease in yield is to be expected (in the experiments in question 9 - 15 per cent.). Treatment with MCPA does not cause these losses. Despite the appearance of leaf - and spicule deformation on oats on account of 2,4-D influence the yield may be undiminished. On the other hand heavy losses in yield may occur without the presence of any deformation externally visible. 2,4-D injuries are regionally very different. They are frequent in the north (Scandinavia) and decline more and more toward the south (Southern Germany and Italy).

Introduction

It is in the nature of herbicides on the basis of hormone like substances, that their effect cannot be kept under control as safely as those of the usual contact herbicides.

Especially the depressions of yield in cereal crops which sometimes occur although the hormone - herbicides were applied according to the instructions are rather disagreeable. These depressions are more frequent with the application of 2,4-D than with MCPA. We therefore must try to explore the causes of such injuries. It is a striking fact that in the Scandinavian countries as well as in Denmark and Holland 2,4-D was replaced very soon in cereal crops by MCPA.

Also in northern Germany 2,4-D was vastly replaced by MCPA because of repeated injuries after 2,4-D treatment. However no serious injuries in cereal crops by 2,4-D are known in southern Germany. In about 900 experiments with cereals which were carried out in 1952 in the two southern German countries Bavaria and Württemberg no single case of 2,4-D injury was known whilst in the same year in the northern German countries Lower Saxony and Sleswick-Holstein many cases of injuries were reported. Southward the Alps in Italy up to now no reason at all was seen to replace 2,4-D by MCPA (3,4).

These regional differences in the injuries of cereal crops by 2,4-D gave reason to suppose, that the cooler and particularly more changeable spring weather of the northern regions plays a decisive part in the appearance of these injuries. Hanf indeed could ascertain for the year 1953 that injuries of cereals occur especially in those regions of northern Germany which suffer from night frosts and cold in May.

These statistical conclusions of Hanf confirmed our own experimental investigations in 1953 in Hohenheim.

Experimental Results

A pot- and a field experiment were made with oats as the most susceptible sort of grain.

On April, 24. 1953 40 Mitscherlich pots were sown with the particular susceptible oat variety Carstens VI.

Until May, 17. all pots stood together outdoors and developed equally till the beginning of tillering. On May, 18. 24 pots were placed in a refrigerator exposed to light.

There they were exposed for 6 days to the influence of fluctuating temperatures which dropped to -5° C (23° F) (night frost period). The remaining 16 pots were kept outdoors under conditions of rather warm weather. On May, 24. all pots were reunited and remained outdoors until the time of the harvest. Before, during and after treatment with various temperatures the different groups of pots were treated at a distance of 1 to 2 days with 1,5 kg/ha 2,4-D sodium. The amount applied was 1,5 times greater than the normal dosage and the time during the tillering was unfavourable. Therefore injuries were to be expected. The intensity of the injuries was entirely different and therefore very interesting (Tab. 1).

Oatplants which had remained in the vessels kept under warm conditions showed a reduction of the leaves up to 60 per cent. and deformations of the spicules up to 26 per cent., but no decrease in the yield of straw and grains.

The pots exposed to a night frost period behaved quite differently. It is true that in this case deformations of the spicules were not more frequent but the reduction of the leaves was more intensive and the panicles showed the well known signs of contraction.

The yield of straw was unchanged. In contrast to the grain yield which was distinctly affected.

The untreated check pots showed the same grain yield as those kept under warm conditions, so that the period of night frost alone did not cause any damage.

Also the 2,4-D treatment before the cold period did not show any harmful influence. On the other hand treatments during or immediately after the cold period showed definite reductions of yield up to 10 per cent.

The results of this pot experiment were confirmed by a field experiment with two varieties of oats with 6 replicates carried out in 1953 on heavy loamy soil at Hohenheim. The sowing took place on March, 18., but the seed germinated very irregularly because of the drought. Two applications were made: the first at the beginning of tillering on April, 25. with favourable warm weather; the second on May, 11. immediately after a frosty night with a minimum temperature at the soil of -4·6° C (23,7° F). 2,4-D and MCPA were compared with each other in form of triethanolamine salt. The dose was 1,5 kg/ha. During the vegetation period none of the two compounds showed any injuries. Neither the time of treatment nor the variety of the oat had any influence in this respect.

The more surprising were the yields obtained. The field was practically free of weeds and therefore all differences of yields must be attributed to the different herbicide treatment. On an average of both varieties of oats the different treatments showed the following relative yields in grain (untreated = 100).

2,4-D amine	April, 25.	without frost	102,9
	May, 5.	after frost	86,7
MCPA amine	April, 25.	without frost	102,1
	May, 11.	after frost	101,4

The result of this experiment is very clear: (Tab. 2).

Despite the early treatment and 50 per cent. overdosage no injuries on oats neither by 2,4-D nor by MCPA could be noticed when the treatment was carried out in warm weather. The application of MCPA immediately after a frosty night during the stage of tillering did not have an unfavourable influence on oats whilst treatment with 2,4-D showed a decrease of 13,3 per cent. in average of both oat varieties.

DISCUSSION AND CONCLUSIONS

Both experiments agree in their results. They are confirmed by the above mentioned statistical data obtained by Hanf and recently by several cases of injuries in 1954 in Sleswick-Holstein, where again the application of 2,4-D during a cold period in May caused injuries on oats. It is shown that it is dangerous to apply 2,4-D to oats or other cereals during or after a frost or cold period. Therefore it is safer to apply MCPA instead of 2,4-D in regions where we know from experience that the month of May has frequently cold days with dropping temperatures.

However, the experiments have shown that with the presence of deformaties on account of applications of herbicidal growth-substances no decline in yield is necessarily to be expected. It is possible on the other hand that losses in yield may occur without the appearance of injuries in the form of deformaties.

In experiments concerning a possible injurious effect of herbicides on crops it is therefore necessary to make yield computations even if there are externally no differences in relation to the check plots to be seen.

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TABLE 1

Pot Experiment concerning the Question of the Influence of Cold Periods on the Effect of 2,4-D on Oats

Series	Group of temperature	Day of treatment with 1,5 kg/ha 2,4-D sodium	Appearance of deformations: spicules in total	diminuition of leaves	contracted panicles	Average yields grm. per vessel: in total	± m	corn	± m
1	warmth	check (without treatment)	0,75	none	none	109,9	1,81	55,3	1,56
2	warmth	May, 18.1953	3,50	70 %	single	109,2	2,63	53,1	1,33
3	warmth	May, 25.1953	11,75	50 %	few	110,8	2,04	56,6	1,19
4	warmth	May, 24.1953	26,00	60 %	few	108,4	1,51	54,0	1,07
5	cold	check	1,00	none	none	109,8	0,75	54,4	1,11
6	before cold	before cold May, 18.1953	6,75	90 %		109,8	2,75	53,9	1,21
7	before cold	begin of cold May, 19.1953	8,00	95 %	majority of panicles slightly contracted	105,8	1,61	49,5	0,61
8	before cold	middle of cold May, 21.1953	9,00	90 %		108,8	1,71	52,7	0,64
9	before cold	end of cold May, 22.1953	7,00	85 %		105,1	1,93	50,4	0,83
10	before cold	after cold May, 24.1953	16,25	85 %	numerous	107,0	1,26	49,5	0,95

TABLE 2

Effect of a 2,4-D and MCPA Treatment on two Oat Varieties during a Weather Period without Frost and during a Period with Night Frosts

Series	Treatment Herbicide	Date	Weather	Carstens II yield of grain kg/ha	Carstens II relative yield	Hohenheimer V yield of grain kg/ha	Hohenheimer V relative yield
1	untreated	-	-	3110	100	2960	100
2	2,4-D (amine)	April, 25.	without frost	3240	103,1	3010	101,7
3	2,4-D (amine)	May, 11.	frost	2630	84,7	2620	88,5
4	MCPA (amine)	April, 25.	without frost	3010	98,8	3110	105,0
5	MCPA (amine)	May, 11.	frost	3170	102,0	2980	100,7
6	DNC (Raphatox)	April, 25.	without frost	3250	104,5	2970	100,3

THE EFFECTS OF MCPA (SODIUM) AND 2,4-D (AMINE) APPLIED TO SPRING OATS AT THE 1 TO 3 LEAF STAGE

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Summary

1. This report contains the results of five 1954 experiments and one 1953 experiment in which rates of 2,4-D (amine) and MCPA (sodium) are compared on spring oats at the 1-3 leaf and at the 6 leaf stages of growth, the latter being the normally recommended time of spraying. In five of the experiments ¼ and ¾ lb per acre 2,4-D (amine) and ¾ and 1½ lb per acre MCPA (sodium) were applied, and in the sixth 1 and 2 lb per acre of both chemicals were sprayed.

2. Eye observations made three to four weeks after the second date of spraying indicated that for equivalent chemical applications, the weed control obtained by early spraying was superior in the great majority of cases to that obtained at the normally recommended spraying time. By applying relatively light doses of MCPA at the early stage, a good control was obtained of such weeds as Redshank *Polygonum persicaria*, Mayweed *Matricaria sp.*, Speedwell *Veronica sp.*, which are normally classified as resistant or moderately resistant to MCPA.

3. Some mild straw and panicle deformity was visible on ¾ lb per acre 2,4-D (amine) plots but not on the MCPA (sodium) plots.

4. The yield results for the 1954 experiments showed neither substantial increases or decreases in yield from applications at either time of spraying. One experiment in 1953 produced significant yield increase on the plots sprayed at the two leaf stage: the maximum being 17.4 per cent. above control for applications of 1 lb/acre MCPA (sodium). The absence of yield increases in the 1954 experiments is thought to be due to the cold spring weather delaying weed growth with the result that serious competition between crop and weeds did not occur.

Introduction

During the years 1951-3 the A.R.C. Unit of Experimental Agronomy in co-operation with the National Agricultural Advisory Service carried out an extensive investigation into the effects of growth regulator herbicides applied to clean crops of spring cereals. The results of the work on oats were summarised in a research report by J. D. Fryer to the first British Weed Control Conference in November, 1953.

One of the interesting features of the results was the apparent resistance of spring oats to MCPA, and to a lesser extent 2,4-D, when in the 1 to 3 leaf stage of growth. It was considered that spraying at this stage might have commercial possibilities for the control of weeds such as Redshank *Polygonum persicaria* and Mayweed *Matricaria sp.* that are moderately resistant to MCPA and 2,4-D at the normal spraying time. For more susceptible weeds a smaller than normal dose might become permissible on account of their greater sensitivity at the early growth stages.

The experiments summarised in this report were designed to compare MCPA and 2,4-D applied at the 1-3 leaf stage with similar applications at the normally recommended time of application (6 leaf stage) on weed infested crops of spring oats.

Table No. 1

Scorings by a different observer at each experiment three to four weeks after the second date of spraying

Points awarded for kill or check of weeds: Means for each treatment (to the nearest whole number). In brackets: arc Sin L transformation after conversion to percentage

WEED	Ex. No.	Early Spraying				Normal Spraying				SE% of mean	GD between treat-ments
		lb/acre 2,4-D		lb/acre MCPA		lb/acre 2,4-D		lb/acre MCPA			
		$\frac{1}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$1\frac{1}{2}$	$\frac{1}{4}$	$\frac{3}{4}$	$\frac{3}{4}$	$1\frac{1}{2}$		
Speedwell *Veronica sp.*	124 117	3 (35.0) 6 (50.9)	7 (59.2) 8 (66.4)	5 (54.0) 8 (66.1)	8 (66.1) 8 (66.7)	2 (16.9) 1 (21.1)	2 (21.9) 2 (23.9)	5 (45.0) 3 (32.7)	5 (45.0) 3 (35.0)	18.7 8.5	10.9 11.5
Knotgrass *Polygonum aviculare*	124 117 107	4 (41.1) 8 (63.4) 3 (35.2)	7 (59.2) 9 (75.0) 7 (59.0)	4 (39.2) 9 (77.7) 7 (57.3)	6 (51.1) 10 (83.9) 8 (66.1)	2 (16.9) 4 (40.9) 1 (17.3)	3 (36.8) 5 (45.0) 3 (32.7)	3 (30.0) 5 (43.1) 1* -	4 (38.9) 6 (50.8) 2* -	20.4 9.5 12.0	23.6 17.1 7.6
Chickweed *Stellaria media*	124 107	3 (30.0) 4 (37.2)	3 (26.6) 7 (57.3)	5 (43.1) 3 (28.0)	8 (61.9) 7 (59.2)	1 (13.1) 0 (0)	1 (17.7) 1 (17.7)	5 (43.1) 0* -	3 (35.2) 2* -	20.8 24.1	21.5 11.3
Redshank *Polygonum persicaria*	107	3 (31.0)	5 (46.9)	5 (46.9)	7 (52.0)	0 (0)	2 (21.9)	0* -	1* -	15.7	16.8
Mayweed *Matricaria sp.*	124	3 (30.0)	7 (60.0)	6 (49.2)	8 (66.1)	2 (16.9)	3 (31.8)	4 (34.2)	6 (49.2)	21.2	26.2
Fathen *Chenopodium album*	117	9 (68.9)	9 (77.7)	9 (71.6)	10 (90.0)	5 (45.1)	5 (45.0)	6 (50.9)	7 (54.8)	5.8	11.0
Heartsease *Viola tricolor*	117	6 (50.9)	8 (66.1)	7 (59.2)	9 (68.9)	2 (28.1)	1 (21.1)	2 (32.3)	4 (36.9)	9.9	23.5
Spurrey *Spergula arvensis*	117	7 (57.0)	9 (81.1)	9 (77.7)	9 (76.9)	4 (41.1)	4 (37.1)	6 (48.9)	5 (47.2)	13.2	23.2

* Figures unreliable owing to rain immediately after spraying.

No. of points

0 .... No effect.
2 .... Slight Check.
4 .... Severe Check but no mortality.
6 .... Severe check and 50% kill.
8 .... Severe check and 75% kill.
10 .... 100% kill.

It was intended to place the experiments on fields that contained dense infestations of annual weeds, but the cold dry weather in 1954 at the time of corn emergense did not favour weed growth and resulted in only light weed competition in some experiments. The late and difficult harvest conditions have allowed only a short time for writing this paper and it should therefore be regarded as a progress report.

Methods

The series of experiments were part of the joint N.A.A.S./A.R.C. co-operation programme for 1954 which was organised on similar lines to previous years. A full description of the organisation and division of responsibilities was included in Mr. Fryer's (1) paper in 1953. Chemical application was carried out by special Land Rover sprayers on selected fields at two growth stages; at the time of the second spraying observations were made on the crop and weeds on the plots that received the first application. Further observations were made on crop and weeds after heading and the plots were individually harvested with pusher type combine harvesters, grain samples being taken for nitrogen and dry matter tests.

Details of Experiments

1953 (one experiment). 2,4-D triethanolamine and MCPA sodium salt at 1 and 2 lb acid equivalent per acre applied at three growth stages between the 1 leaf and 6 leaves (on the main stem) stages of growth. 12 treatments and three controls replicated three times - 45 plots.

1954 (five experiments). 2,4-D triethanolamine at ¼ and ¾ lb acid equivalent per acre and MCPA sodium salt at ¾ and 1½ lb acid equivalent per acre applied at the 1-3 leaves stage of growth, and at the 6 leaves (on the main stem) stage of growth.
Eight treatments and four controls, replicated three times - 36 plots.
Volume rate: 7.2 gallons per acre.
Plot size: Sprayed - 40 yards x 5 or 6 yards.
Harvested - 40 yards x 8 feet 6 inches or 12 feet.

In the 1954 experiments two control plots were wheel-marked at each spraying.

Abbreviations

2,4-D .... 2,4-D triethanolamine salt.
MCPA .... MCPA sodium salt.
lb per acre .... Pounds acid equivalent per acre.
Early stage .... 1-3 leaf stage of growth.
Normal stage .... Normally recommended stage of growth for spraying spring oats (6 leaves on the main stem).

Results

A total of eleven experiments were originally sprayed in 1954, but four had to be abandoned because of adverse weather conditions, and yield results are at present available for only five of the remaining seven. The results of an experiment carried out in 1953 are included. The details of the individual experiments are given in the Table 3 at the end of the report.

Weed Control

The assessment of the effects of the early spraying was by means of quadrat counts of weeds, made at the time of the second spraying; in addition three to four weeks after the second spraying points were awarded for weed control for all species present on all plots, the observations were by the eye estimate of a single observer on each experiment since the height of the crop prohibited quadrat counts. The latter method provided a direct comparison of weed control between the two dates of spraying.

The collected results of the eye observations on three experiments after the second spraying are given in Table No. 1.

Applications of 2,4-D and MCPA have usually produced some effect on the weeds listed in Table No. 1, except when light doses of both chemicals were applied to Chickweed Stellaria media and Redshank Polygonum persicaria and Wild Vetch Vicia sativa at the normal spraying time. Of the forty-four possible comparisons (Table No. 1) between similar rates of the same chemicals, the weed check or kill obtained by early spraying was in forty-two cases superior to that obtained at the normal spraying time. In fact in the majority of comparisons the low doses of both MCPA and 2,4-D at the early stage have given better weed control than the high doses at the normal spraying time although the latter contained twice the weight of chemical per acre. In experiments Nos. 123/54, 124/54 and 122/54 quadrat counts, made three to four weeks after the early spraying, indicated that while some kill of weeds had occurred particularly as a result of the heavier doses, a fresh germination of seedlings, which was encouraged by the weather conditions, had made up for those plants killed by spraying; and as a result no worthwhile numerical differences were obtained; later observations showed that this late germination produced plants that were dwarfed by the crop. In contrast, quadrat counts of mayweed Matricaria sp. in experiment No. 94/53 (under different weather conditions) showed that 2 lb per acre of 2,4-D and MCPA had produced 58 per cent. and 66 per cent. reductions respectively in the number of mayweed plants present on early sprayed plots, and without any subsequent germination taking place.

Straw and Panicle Deformities

Samples of straw and panicles from each plot have been taken by N.A.A.S. officers in charge of experiments and despatched to Oxford for detailed inspection, but owing to the late season no time has been available for their examination. Field observations made on the crops after heading give an indication of the appearance of the straw and panicles. Applications of MCPA at both growth stages produced no visible signs of deformity but the ¾ lb per acre rates of 2,4-D at both growth stages produced very mild deformity that might well have been missed had there been no control plots to allow comparison. There were four main effects: a small reduction in the length of straw, the panicles were rather more erect than normal, the crop tended to be darker green, and the wheel marks were more easily visible.

Yield

The mean yield results for six experiments are shown in Table No. 2. It was anticipated, during the planning of the experiments, that the presence of weeds would cause some variation in yields and for this reason four control plots were placed in each replicate. The standard errors expressed as percentages of means indicate that reasonable accuracy has been obtained in all but one experiment (123/54); this trial was on Lancashire peat land, a soil type that is often very uneven in fertility.

The yield results for the 1954 experiments are on the whole negative: only one (No. 117/54) of the five trials was significant at the P = 0.05 level and in this experiment ¾ lb per acre MCPA sprayed at the 2 leaf stage yielded significantly higher than any of the other MCPA treatments; it was also significantly higher than control. On the other hand 1½ lb per acre MCPA at the first spraying and ¾ lb per acre MCPA at the second spraying were significantly lower than control. The overall means for each treatment of four of the 1954

(22394)

411

Table No. 2

Mean yields for each treatment in cwt/acre - uncorrected for moisture content

Ex. No.	Control	Sprayed at Early Stage of Growth					Sprayed at Normal Stage of Growth					Significance	S.E. % of mean	Treatment S.D.
		lb/acre 2,4-D		lb/acre MCPA		Mean	lb/acre 2,4-D		lb/acre MCPA		Mean			
		¼	¾	¾	1½		¼	¾	¾	1½				
107/54	12.8	12.7	12.6	13.3	13.5	13.0	12.8	13.5	13.3*	11.7*	12.8	Non sig.	6.7	2.5
117/54	37.8	37.5	37.0	40.3	34.2	37.2	37.6	36.7	35.4	36.4	36.5	Significant	2.7	3.1
122/54	21.9	21.7	22.5	22.0	21.0	21.8	22.0	21.2	25.3	22.2	22.7	Non sig.	5.8	4.0
123/54	20.3	21.5	22.6	22.6	22.1	22.2	21.8	18.1	24.4	22.5	21.7	Non sig.	7.9	5.0
124/54	22.6	23.4	21.5	22.2	22.6	22.4	23.7	23.7	23.4	23.4	23.5	Non sig.	4.9	3.3
Mean for excpts. 117,122 123,124	25.7	26.0	25.9	26.3	25.0	25.9	26.3	24.9	27.1	26.1	26.1			
% of control	100.0	101.4	101.0	104.5	97.5	101.0	102.5	97.1	105.7	101.8	101.8			

Ex. No.	Control	Sprayed at Early Stage				Sprayed at Intermediate Stage				Sprayed at Normal Stage				Significance	S.E. % of mean	Treatment S.D.
		lb/acre 2,4-D		lb/acre MCPA		lb/acre 2,4-D		lb/acre MCPA		lb/acre 2,4-D		lb/acre MCPA				
		1	2	1	2	1	2	1	2	1	2	1	2			
94/53	25.9	28.5	29.0	30.4	29.9	26.3	25.3	25.5	29.2	23.7	23.8	24.8	24.4	Significant	4.9	1.7
% of control	100.0	110.0	111.9	117.4	115.4	101.6	97.7	93.4	112.7	91.5	92.0	95.8	94.2			

* results unreliable owing to rain immediately after spraying. Treatment S.D. is between means of any two chemical treatments.

experiments are shown as percentages of control in Table 2, all differences appear to be extremely small and are in contrast with the single experiment of this type carried out in 1953 (No. 94/53). In this trial highly significant increases in yield occurred as a result of spraying 1 and 2 lb per acre MCPA and 2 lb per acre 2,4-D at the 2 leaf stage, whereas spraying the same rates at the 6 leaf stage produced small decreases. The optimum yield was an increase of 17.4% over control as a result of applying 1 lb per acre MCPA at the 2 leaf

DISCUSSION

An interesting feature of the results is the check obtained on resistant or semi-resistant weed species by applications at the cotyledon or first leaf stage; that the treatments have not always resulted in complete kill is probably due to the relatively small quantities of chemical applied. The effect of the chemical applied at the cotyledon stage was usually to cause some distortion and to slow down further growth, almost complete stoppage of further growth being caused by the higher doses. The appearance of the experimental areas after heading suggests that a severe check of the weeds would be sufficient to prevent competition, if the chemical is applied when the weeds are young; but if the weeds are more mature, a complete kill may be necessary to ensure the removal of competition.

Previous research work on spring oats summarised in Mr. Fryer's paper (1) in 1953 had indicated that deformity of straw and panicle might be appreciable after applications of 2,4-D, but insignificant after MCPA application. The observations on these experiments support this information, and suggest that the commercial use of 2,4-D on spring oats might lead to complaint on the part of the farmer but that would not be the case with MCPA; the oats in the six experiments in the report showed no appreciable damage at heading on the plots sprayed with MCPA.

It is interesting that although the weeds in the 1954 experiments were checked and in some cases killed, this did not produce substantial yield increases either at the early or the normal spraying time; a possible reason is that although weeds were present, their late germination due to the weather conditions prevented them from competing seriously with the oat crop on the control plots. This is in contrast with the results of the 1953 experiment, in which yields were substantially increased by the early treatments and where weather conditions favoured early and vigorous weed growth.

Conclusion

During the years 1951-54, twenty-two fully replicated experiments have been carried out by the A.R.C. Unit of Experimental Agronomy, in which spring oats at the 1-3 leaf stage of growth have been sprayed with MCPA (sodium). Some of the crops were weed free and some were weed infested. In no case have doses of up to 1 lb acid equivalent per acre caused a significant yield reduction; while in only one case (experiment No. 117/54 in this report) has a significant reduction been caused by 1½ lb per acre. Crop deformity has been negligible.

It is concluded that MCPA (sodium) may be used on spring oats at the 1-3 leaf stage of growth without harm to the yield or appearance of the crop.

It has also been demonstrated that weed control as a result of spraying at the early stage can be superior to that obtained by spraying at the normal stage at equivalent doses. Several annual weeds such as Redshank Polygonum persicaria, Mayweed Matricaria sp. and Speedwell Veronica sp., normally moderately resistant to MCPA, can be adequately controlled by early spraying. It is

Table 3

Ex. No.	Location	The Crop: Stage of Growth				Degree of Weed Competition	Weed	Dominant Weeds. Stage of Growth		Plants per sq. ft.
		First Spraying		Second Spraying				First Spraying	Second Spraying	
		Leaves	Height	Leaves	Height					
107/54	Bridgend (Glam.)	1-3	-	6-6½	-	Medium	Redshank Knotgrass Chickweed	Cotyledon " "	Max. 6" high " 6" " Up to 4" high	5 4 4
117/54	Skelton (Yorks.)	2-2½	3-4"	6-6½	13½"	Light	Fathen Knotgrass Spurrey Heartsease	Max. 1 leaf Cotyledon " Max. 1 leaf	Max. 6 leaves " 8 " " 8" high " 8 leaves	3 2 2 3
122/54	Penrith (Cumberland)	1-1½	2-3"	6-7	10-11"	Light	Spurrey Redshank	Cotyledon "	Not recorded " "	16 6
123/54	Astley (Lancashire)	1-1½	3"	5-6	12"	Intense	Hempnettle Redshank Fathen Heartsease	Cotyledon - 1 leaf Cotyledon " "	)) 8-12") high))	5 2 23 8
124/54	Shefford (Beds.)	2-2½	3-4"	5	22"	Light	Speedwell Chickweed Knotgrass Mayweed	2-4 leaves 1" high 2-3 branches ½" high Cotyledon 4 leaves	6" high 6-12" high - 12" high	7 4 occ. 4
94/53	Nuneham Courtenay (Oxon)	2 (Third Spraying: 6-7 leaves 14-18" high)	-	4½-5	12-14"	Intense	Mayweed Knotgrass Charlock	Cotyledon " "	6-7 leaves 5 leaves 2" high 5 leaves 4" high	6 2 2

The figures for leaves in the Crop stages of growth refer to leaves on the main stem.

concluded that under conditions favouring weed competition, treatment at the early stage of growth is likely to result in greater yield increases than spraying at the conventional time.

Although satisfactory control of weeds has been obtained by early spraying of light doses of 2,4-D (amine), the deformity that appears in the crop is likely to limit its use on spring oats.

Acknowledgements

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References

1. J. D. Fryer. Proceedings British Weed Control Conference, November 1953, pp. 37-43.

EARLY SPRAYING OF SPRING OATS WITH MCPA (POTASSIUM)

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Summary

The results reported in this paper deal with a series of trials designed to investigate the effects of spraying MCPA (potassium) at growth stages earlier than those normally recommended.

The incidence of malformities, weed control and its subsequent effect on yield are considered in relation to the stage of growth at spraying.

Introduction

Spring oats at all stages of growth are very much less susceptible to MCPA than to 2,4-D. This applies both to the production of malformities and to yield depression (1), (2).

Recent work has indicated that at the 0 - 3 leaf stage of growth oats are resistant to MCPA (sodium). Further, up to 32 oz. MCPA (sodium) per acre at any stage of growth from emergence to the beginning of shooting has not normally caused any appreciable yield reduction (3).

Malformities have been found following spraying at all stages of growth but in all cases the percentage is exceedingly low and the type of damage observed is considered to be of no commercial importance (3), (4).

It has been suggested that under certain conditions early spraying may give superior results on the more resistant annual weeds and lead to greater yield increases by the earlier removal of weed competition (3).

This paper describes a series of trials laid down in 1954 to investigate the effects of MCPA (potassium) on clean and weedy crops of spring oats sprayed at three stages of growth, with reference to crop damage, yield increase or decrease and weed control. Statistical analysis of these trials is incomplete and this paper should be regarded as a progress report.

Experimental Results

Fourteen large-scale trials on spring oats were sprayed in 1954. Seven of these trials, on sites where yellow charlock (*Sinapis arvensis*) had germinated early, were sprayed with MCPA (potassium) at 4, 6 and 12 oz. The remaining seven trials were sprayed at 12, 16 and 24 oz. MCPA (potassium). All doses are expressed in terms of active acid equivalent per acre.

Sprays were applied with a Land Rover mounted sprayer calibrated at 12 gallons per acre.

Each trial comprised 40 plots, arranged in four randomised blocks of ten treatments made up of an untreated control and three rates of MCPA (potassium) applied at three successive growth stages as follows:

I	0 - 3	main shoot leaves per plant
II	3 - 5	" " " " "
III	5+	" " " " "

N.B. Spraying is now normally recommended at stage III.

TABLE I

OCCURRENCE OF MALFORMITIES IN SPRING OATS AFTER SPRAYING WITH MCPA (POTASSIUM)

Expressed as a percentage of total culms in the sample and arranged according to the stage of growth at spraying

B54 1	Spring Oats		First Spraying							Second Spraying							Third Spraying							Control
			Growth Stage				Malformities			Growth Stage				Malformities			Growth Stage				Malformities			
No.	Variety	Sown	Date	L	T	H	12	16	24	Date	L	T	H	12	16	24	Date	L	T	H	12	16	24	0
2	Forward	17/3	20/4	2.3	0	3.4"	4.5	3.8	8.3	7/5	4.7	1.7	5.1"	2.5	2.8	10.3	28/5	7.4	2.2	13.8"	1.3	2.8	2.8	1.3
4	S225	30/3	23/4	1.2	0	2.7"	2.1	2.9	3.1	12/5	3.9	1.1	5.2"	2.7	1.9	2.9	27/5	5.9	2.3	10.6"	2.3	2.7	1.0	2.1
5	Eagle	5/4	7/5	2.0	0	3.5"	0.6	1.2	2.3	20/5	4.2	0.4	6.4"	0.6	1.5	1.0	3/6	6.0	0.6	11.3"	0.8	0.6	0.6	0.8
8	S225	6/4	9/5	2.4	0	3.9"	4.4	4.4	2.7	26/5	4.9	2.3	7.1"	3.8	3.5	5.0	4/6	6.3	3.3	12.7"	4.2	5.0	3.3	5.2
9	Blenda	9/4	10/5	2.0	0	3.4"	3.1	2.1	1.3	25/5	4.4	0.9	7.9"	1.9	3.8	4.0	16/6	6.2	1.6	15.7"	1.3	2.3	2.7	2.5
10	Eagle	10/4	10/5	1.9	0	3.8"	7.5	8.1	5.8	26/5	4.3	0.9	8.4"	9.0	7.1	4.4	4/6	5.9	1.3	15.1"	2.5	5.6	5.6	6.5
11	Eagle	12/4	11/5	2.0	0	3.8"	0.2	0.4	0.8	26/5	4.1	0.5	7.2"	1.3	2.9	1.3	22/6	6.8	1.3	21.1"	0.2	0.8	0.4	0.4
B54 1	Spring Oats		First Spraying							Second Spraying							Third Spraying							Control
			Growth Stage				Malformities			Growth Stage				Malformities			Growth Stage				Malformities			
No.	Variety	Sown	Date	L	T	H	4	6	12	Date	L	T	H	4	6	12	Date	L	T	H	4	6	12	0
3	Marvellous	25/3	23/4	2.3	0	3.4"	4.2	4.4	5.0	7/5	4.7	1.7	5.1"	3.1	4.2	2.9	28/5	7.4	2.2	13.8"	5.0	4.0	4.2	3.3
14	Star	21/4	19/5	2.2	0	4.1"	3.8	3.1	2.5	1/6	4.2	1.1	6.6"	6.0	5.0	7.5	14/6	6.2	4.4	14.9"	3.1	3.8	3.1	3.1
7	Sun II	7/4	9/5	2.2	0	3.6"	4.0	7.1	4.0	25/5	5.0	1.6	10.0"	2.5	3.8	1.0	3/6	6.2	1.7	15.6"	2.7	2.1	1.3	3.3
12	Eagle	15/4	12/5	1.5	0	2.4"	1.5	2.3	4.4	27/5	3.0	0.1	6.0"	1.7	2.3	3.8	14/6	5.2	1.3	14.7"	1.3	2.1	2.7	0.8
1	Blenda	15/3	20/4	2.7	0	3.2"	0.8	0.8	1.3	7/5	4.7	1.8	5.7"	2.0	1.8	3.3	21/5	6.4	2.3	11.3"	0.5	0.8	0.8	1.0
13	Sun II	15/4	13/5	1.9	0	3.0"	2.1	2.9	4.6	28/5	3.6	0.4	5.9"	3.1	3.3	4.4	11/6	5.7	0.8	12.3"	2.1	2.9	4.8	2.3
6	S147	7/4	8/5	1.8	0	2.7"	1.0	1.2	3.1	26/5	4.2	0.9	4.3"	1.7	1.7	1.7	11/6	6.1	1.8	9.5"	1.0	1.7	1.2	1.0

Notes: Malformities are arranged according to the dose of MCPA (Potassium) applied; 12,16 and 24 oz. and 4, 6 and 12 oz. active acid equivalent per acre respectively.

Growth Stage
L = Average number of main shoot leaves per plant
T = Average number of tillers per plant
H = Average height of plants in sample (in inches).

Each plot was the width of the sprayer boom (5 yards) and 100 yards in length. The plots were orientated at right angles to the cereal drills.

Malformities

No retardation of growth or loss of vigour as a direct result of spraying was observed in any of the treatments.

In two trials (B54/I/1 and 2) 100 culms per plot taken at random after heading were examined for malformities. In the remaining twelve trials 120 culms per plot were examined. The results are shown in relation to the stage of growth at spraying in Table 1. The stage of growth was determined by examining a total of 160 plants taken at random from the twelve plots about to be sprayed and the four controls. It is described in terms of the average number of main shoot leaves and tillers, and the average height per plant.

The most commonly observed malformities were one or more supernumerary panicles arising from the uppermost node of the culm, twisting of the rachis, partial abortion of the rachis and trapping and partial trapping of the panicle within the leaf sheath. Reduced internodes, split rachides and abnormalities of the spikelets such as multiple glumes and paired spikelets occurred to a much lesser extent. Malformities such as twisting of the rachis, partial abortion of the rachis and trapping and partial trapping of the panicle may occur in oats attacked by frit fly (Oscinella frit). These, together with naturally-occurring abnormalities will account for the relatively high figure in the control of some trials. Where the figure for the treatments does not exceed this level it may be concluded that the malformities are not caused by spraying.

The results show that although malformities may follow spraying with MCPA (potassium) up to 24 oz. at all stages of growth of spring oats from emergence to shooting, the percentage is always low. It is generally negligible at stage III, only exceeding the controls in four trials (B54/1/2, 3, 12 & 13). At Stages I and II malformities tend to reach a maximum exceeding the controls appreciably in 7 trials at stage I (B54/1/2, 5, 3, 7, 12, 13 and 6) and in 7 trials at stage II (B54/1/2, 11, 14, 12, 1, 13 and 6).

Yields

Yield data were obtained from all but two trials where the crop was badly laid at right angles to the plots. Harvesting was carried out by means of the co-operating farmers' pusher-type combine-harvesters, a single width being cut through each plot. The width of the combine was 8' 6" in eleven trials, making the harvested area of each plot approximately 1/17th of an acre. In one trial (B54/1/13) a 10' wide combine was used making the harvested area approximately 1/14th of an acre.

The mean yields for each treatment together with the mean for each stage and dose are tabulated in Table 2.

The three trials labelled "clean" (B54/1/4, 5 and 8) which were relatively free of weeds show no significant yield depression.

In some of the weedy trials it was obvious that in some of the weedier plots there was a higher percentage of weed seeds and green matter in the sample. This factor may have tended to mask the effects of spraying on yield in some trials.

In four of the weedy trials (B54/1/7, 12, 13 and 9) the stage of growth at spraying had no significant effect on yield.

TABLE 2

OAT YIELDS AFTER SPRAYING WITH MCPA (POTASSIUM)

Mean yields for each treatment are expressed in cwt. per acre and arranged according to the dose and stage of growth at spraying. Mean yields for each dose and stage are included and the extent of weed infestation at each site is indicated.

B54 1 No.	Weeds	First Spraying				Second Spraying				Third Spraying				Dose Mean & Control	MCPA oz.
		MCPA(K) oz/acre			Stage	MCPA(K) oz/acre			Stage	MCPA(K) oz/acre			Stage		
		12	16	24	Mean	12	16	24	Mean	12	16	24	Mean		
4	Clean	25.3				26.4				26.0				25.9	(12)
			26.6				25.9				26.3			26.3	(16)
				26.6				25.5				25.9		26.0	(24)
					26.2				25.9				26.1	25.1	(0)
5	Clean	24.4				23.4				25.7				24.5	(12)
			23.7				25.4				24.1			24.4	(16)
				25.0				24.4				24.3		24.6	(24)
					24.4				24.4				24.7	25.2	(0)
8	Clean	15.0				15.1				14.6				14.9	(12)
			14.8				15.0				14.3			14.7	(16)
				14.0				14.5				14.4		14.3	(24)
					14.6				14.9				14.4	15.1	(0)
9	Light	10.7				10.0				10.3				10.3	(12)
			10.6				10.2				9.9			10.2	(16)
				10.3				9.7				10.1		10.1	(24)
					10.6				10.0				10.1	10.4	(0)
10	Mod.	21.8				22.3				26.3				23.5	(12)
			23.5				23.8				25.2			24.2	(16)
				23.6				24.2				26.1		24.6	(24)
					23.0				23.4				25.9	22.0	(0)

11	Heavy	17.8				19.1				17.8				18.2	(12)
			17.4				18.7				17.0			17.7	(16)
				17.7				19.2				16.8		17.9	(24)
					17.7				19.0				17.2	16.3	(0)
	Weeds	4	6	12	Stage Mean	4	6	12	Stage Mean	4	6	12	Stage Mean		
14	Mod.	11.1				11.9				11.9				11.6	(4)
			10.8				11.5				12.0			11.4	(6)
				11.0				12.0				11.4		11.5	(12)
					11.0				11.8				11.7	11.6	(0)
7	Mod.	31.3				32.1				30.1				31.2	(4)
			31.2				31.5				29.5			30.7	(6)
				31.0				32.8				32.2		32.0	(12)
					31.2				32.1				30.6	29.8	(0)
12	Heavy	12.7				13.2				14.2				13.4	(4)
			12.3				12.0				11.9			12.0	(6)
				13.1				14.1				14.3		13.8	(12)
					12.7				13.1				13.5	12.7	(0)
1	Heavy (crop laid)	14.3				16.2				18.2				16.2	(4)
			15.5				16.0				17.4			16.3	(6)
				12.1				16.4				17.6		15.4	(12)
					14.0				16.2				17.7	17.6	(0)
13	Heavy	13.6				16.0				15.0				14.9	(4)
			14.3				15.2				15.5			15.0	(6)
				15.6				14.3				13.6		14.5	(12)
					14.5				15.2				14.7	14.7	(0)
6	Heavy	21.7				21.1				19.4				20.7	(4)
			21.2				21.4				19.8			20.8	(6)
				21.5				22.1				18.9		20.8	(12)
					21.5				21.5				19.4	18.8	(0)

TABLE 3

KILL OF YELLOW CHARLOCK (SINAPIS ARVENSIS)

Based on counts from random quadrats and expressed as a percentage

B54 1 No.	First Spraying MCPA (Potassium) oz/acre)			Second Spraying MCPA (Potassium) oz/acre			Third Spraying MCPA (Potassium) oz/acre		
	4	6	12	4	6	12	4	6	12
14	78.7	87.2	95.7	93.6	91.5	100.0	100.0	100.0	100.0
7	98.6	99.3	100.0	100.0	100.0	100.0	95.9	100.0	99.3
12	69.9	92.9	96.2	99.5	99.5	100.0	3.3[R]	98.9	100.0
1	99.5	99.5	100.0	100.0	100.0	100.0	91.9	96.2	99.2
13	90.0	97.8	97.8	100.0	100.0	100.0	80.0	95.6	98.5
6	67.4	74.5	88.1	93.5	98.2	99.4	77.2	86.4	94.1

R = Rain fell immediately after spraying

TABLE 4

CONTROL OF CREEPING THISTLE (CIRSIUM ARVENSE)

Based on a vigour grading and expressed as a percentage

B54 1 No.	First Spraying MCPA (Potassium) oz/acre			Second Spraying MCPA (Potassium) oz/acre			Third Spraying MCPA (Potassium) oz/acre		
	4	6	12	4	6	12	4	6	12
14	1	11	14	33	37	41	40	66	71
12	20	14	9	42	53	57	27[R]	71	87
B54 1 No.	First Spraying MCPA (Potassium) oz/acre			Second Spraying MCPA (Potassium) oz/acre			Third Spraying MCPA (Potassium) oz/acre		
	12	16	24	12	16	24	12	16	24
9	10	32	22	44	49	48	60	72	73

TABLE 5

CONTROL OF CORN SOWTHISTLE (SONCHUS ARVENSIS)

Based on a vigour grading and expressed as a percentage

B54 1 No.	First Spraying			Second Spraying			Third Spraying		
	MCPA (Potassium) oz/acre			MCPA (Potassium) oz/acre			MCPA (Potassium) oz/acre		
	12	16	24	12	16	24	12	16	24
11	21	40	39	55	56	68	68	74	82

In three of the weedy trials the treatment means were significantly higher than the control (B54/1/6, 10 and 11). In two trials the highest yields were obtained after spraying at stage II and in both cases spraying at stage I gave greater yield increases than spraying at stage III (B54/1/7 and 11). In one trial, spraying at stage I and stage II gave significantly higher yields than spraying at stage III (B54/1/6). In one trial, yields were highest following spraying at stage III (B54/1/10). The weeds were mostly perennials in this trial.

In two weedy trials there was a significant yield depression following spraying at stage I (B54/1/14 and 1). As the crop was badly laid in one trial no great emphasis can be placed on the results obtained from it (B54/1/1).

The effect of the dose of MCPA (potassium) was significant in only one trial (B54/1/12) although it is anomalous the yield following spraying at 6 oz. being lower than that following spraying at 4 oz. as well as following 12 oz. A similar, but insignificant, trend is apparent in another trial (B54/1/7).

Thousand Grain Weight

Samples of 1000 grains per plot were weighed for four trials (B54/1/7, 6, 5 and 8). Two of these (B54/1/5 and 8) sprayed at 12, 16 and 24 oz. MCPA (potassium), were clean and showed no effect on yield, the other two (B54/1/7 and 6) sprayed at 4, 6 and 12 oz. were weedy and showed yield increases due to treatment. No treatment effects were observed.

Weed Control

Of the seven sites where yellow charlock (Sinapis arvensis) was present at the time of the first spraying six were sufficiently well infested for counts to be made some six weeks after the last spraying. Random quadrat samples were counted and the kill of charlock expressed as a percentage is shown in Table 3.

It is clear the best results were obtained at stage II when the majority of the weeds had germinated and the plants were still at a young stage. Although later germination was apparent in some trials sprayed at stage I a pre-emergence effect was indicated by a greater percentage kill with increasing dose. At stage III when many plants had become tough and woody, in one trial regrowth occurred from lateral buds at the bases of incompletely killed plants sprayed at rates of 4 and 6 oz. (B54/1/6).

With perennial weeds such as creeping thistle (Cirsium arvense) and corn sowthistle (Sonchus arvensis) the results of a vigour grading made by three independent observers make it obvious that progressively better weed control was obtained by the later sprayings (Tables 4 and 5).

DISCUSSION

The results obtained from these trials confirm the resistance of spring oats to MCPA up to 24 oz. when in the 0 - 3 leaf stage of growth. They also indicate that they are no more susceptible at the 3 - 5 leaf stage. Few of the abnormalities observed would appear to be of commercial significance and it is extremely doubtful whether those recorded in these trials would be normally noticed in farming practice.

Resistant weeds which are best killed in the cotyledon stage did not develop to a sufficient extent in any of the trials to enable observations to be made on their control after spraying at early stages. There is clear evidence, however, that susceptible weeds such as yellow charlock, may be consistently killed by lower rates by spraying at stage II. There is a danger, however, of spraying too early (stage I) before the majority of annual weeds have germinated or before perennial weeds such as thistle and sowthistle have made sufficient aerial growth to suffer the maximum check.

If the weed infestation develops early the maximum benefit to yield may be expected to follow early spraying. For the majority of annual weeds it would appear that stage II is the best time to spray in order to catch the highest proportion of weeds at their most susceptible stage. Maximum effects on perennial weeds such as thistles are obtained following spraying at stage III.

Conclusions

The results of these trials confirm that the early spraying of spring oats with MCPA shows promise from the point of view of safety to the crop. There are also indications that better control of susceptible annual weeds may be obtained and that yield increases may be greater by removing weed competition earlier.

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DISCUSSION ON FOUR PREVIOUS RESEARCH REPORTS

Professor G. E. Blackman: Can Professor Rademacher tell us first, what the light intensity in the cold cabinet was and second, give some details of how he sprayed his plants?

Professor B. Rademacher: The light intensity was about 60 per cent. of the normal daylight. Spraying was performed at intervals of two days for both plants grown inside and outside. Unfortunately, I could not find a cabinet with the same light intensity as the exterior.

Dr. Daphne Osborne: Mr. Andersen may be interested in some unpublished work that I carried out at the California Institute of Technology in control conditioned greenhouses. The tomato plants were sprayed with 2,4-D following exposure to different light intensities and temperatures. Tomato plants were exposed to a number of different temperature conditions (5-30°C.) combined with a number of different light intensities (50-5,000 f.c.) prior to, and following a spray with 2,4-D. Plants transferred from low to higher temperatures and light intensities following spray were very susceptible to 2,4-D. On the other hand, a transfer to lower light intensities and temperatures following spray applications reduced the effect of 2,4-D.

Professor G. E. Blackman: We have some work that is about to be published on the effect of temperature and light on the action of 2,4-D and I think they show how difficult it is to interpret the various environmental factors that may condition spraying in the open. Supposing we consider the effects of light intensity before and after spraying on sunflower; increased light intensity before spraying increases the leaf area so that when you spray plants subjected to high light they receive a different dose to those previously grown in low light intensity. Similarly taking the effects after spraying; - the rate of penetration into the leaf is dependent on the light intensity. With sunflower high light causes a greater penetration than low light. The effect of light intensity after spraying in terms of death is more important than the effects before spraying, but a combination of low light intensity before and after makes a remarkable difference in decreasing the dose required to give 50 per cent. mortality.

Professor Stekhoven: At the time I was a student in Utrecht Boyce and Jansen and later Went were publishing their results. I have been wondering if it would not be possible to link the work of these older investigations with the newer experiments on weedkillers that we are considering. We heard yesterday of Professor Wain's experiments; today Professor Blackman and Professor Rademacher have spoken of the influence of cold and light on dose responses. I would like to ask those people if it is not possible to analyse their problems in the same way as was done by Went and others using agar blocks under carefully controlled conditions so that the exact influence of the environmental factors on different types of plants could be determined.

Mr. Sigurd Andersen: Professor Blackman has said that the leaf area would be larger under high light intensity. This may be the important factor, but does he not think that the carbohydrate metabolism of the leaves may also play an important part?

Professor G. E. Blackman: I think that there is a good deal of evidence from many published papers that the movement of 2,4-D and other synthetic growth regulators out of the leaves is associated with the movement of carbohydrates and, therefore, clearly in the light factor story this has to be considered as well.

Mr. J. D. Fryer: This appears to be the only opportunity I shall have of raising the question of stage of growth of cereals. I do not want to refer to the interesting oat problem which has already been discussed but I would like to record one point about the stage of growth for spraying spring wheat and barley. Following the interesting paper last year by Miss Myers, I think the general feeling of the Conference, as recorded in the proceedings, was that the earliest stage at which spring wheat and barley can be sprayed without damage or deformity is the six leaf stage, in other words when there are six fully expanded leaves on the main stem. This year there has been ample evidence to suggest that this is really too late. When the plants have six leaves on the main stem they may be as high as 20 inches and weed competition will have already taken place.

Miss Myers said last year that deformity might take place up to the six leaf stage while our Oxford experiments carried out over the last three years indicated that deformity in spring wheat and barley could take place up to the four to five leaf stage, but not later. This year's practical experience and experimental evidence indicates that although we might have to put off spraying until the six leaf stage if we are to get absolutely no deformities whatever, this is not really a practical recommendation and that the four to five leaf stage giving perhaps a fortnight's longer spraying season is really a more realistic recommendation, allowing spraying to begin at a reasonable time without risk of crop damage. I cannot go into this in detail now but I would like to record my own views of the subject as I do think that the feeling of last year's Conference was that the six leaf stage was the correct early stage for spraying. I am myself convinced that the six leaf stage is in fact too late for optimum results.

Mr. G. E. Furse: We are rather particularly concerned in Devon and Cornwall with mixed corn crops particularly oats and barley which we refer to as dredge. I do not know whether the last speakers or any of Professor Blackman's team could give us any advice on what might be considered to be the optimum time to spray such mixed corn crops. Following on from what Mr. Fryer has just said, spraying oats at the three and five leaf stage appeared to be best. One of the speakers has indicated that although there may be no deformity in the crop, the yield may be quite appreciably reduced. We are inclined to look for deformities when advising on spraying damage in cereals. Can anybody suggest any other symptoms we should look for in addition to head deformity when we are trying to determine spray damage?

Mr. J. G. Elliott: Mr. Furse has referred to yield reduction. I think we want to be quite clear in our own minds that when you spray the growth regulator herbicides on to clean crops in the absence of weeds and I stress with the absence of weeds, it is possible to produce yield reductions. If you spray at the right time those yield reductions are so insignificant that you only require a very small weed population to result in yield increase. In a dredge corn mixture the only chemical that can be used is MCPA. Although oats are resistant at the 1-3 leaf stage, barley is not; and so it is necessary to wait until the barley is resistant.

THE APPLICATION OF HERBICIDES IN WINTER-RYE AND -WHEAT WITH SPECIAL REFERENCE TO THE YIELD-STIMULATING EFFECT OF DNC

by

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Summary

1. DNC applied at the 4 leaf stage in weed-free autumn-sown cereals results in an increase in yield of about 10%; this is due to an increase of about 3½% of the thousand kernel weight and of about 6½% in the number of kernels per ear.

2. The action of DNC is not due to a Nitrogen-effect.

3. DNC stimulates the yield at all Nitrogen-levels.

4. The action of DNC on the crop cannot be explained by a control of micro-organisms pathogenic to the crop.

5. The yield-stimulating effect of DNC depends on the concentration used.

6. DNC reduces the transpiration shortly after its application and increases it about a month before harvesting.

Introduction:

In the Netherlands the yield depression in cereals due to weeds can be estimated to be about 10% on sandy soils and 5% on clay soils. These figures are derived from field experiments laid out to investigate the productivity level of different soil types and of the influence of weed-growth on the crop yield.

The application of herbicides in crops is only economically feasible if the costs of spraying and the loss of yield due to the action of herbicides are smaller than the advantages obtained by weed control. Therefore the loss in production if any should be very small. In the Netherlands this reasoning led to spraying experiments in clean crops. In all these experiments before and after spraying the weeds are carefully removed by hoeing and hand-weeding. Only in this way is it possible to study the direct reaction of crops on a field application of herbicides. The figures given in this paper bear only on experiments in weed-free crops.

Experimental methods

The basic design involved is a comparison of three herbicides: DNC, MCPA and 2,4-D applied simultaneously at different stages of development of the cereals. The applied quantities of these herbicides, all sprayed with a knapsack sprayer at a standard rate of 1000 l of water per ha,* are:

(a) 5 kg/ha (C.5 lb/acre) of the NH_4-salt of DNC. (Product with 80% act. ingr.)
(b) 1 kg/ha of the Na-salt of MCPA.

* 1000 l per hectare = 89 galls. per acre.

(c) 1 kg/ha of the Na-salt of 2,4 D.

Normally a three fold replication with a random block-arrangement was used. The developmental stage of the cereals at the moment of spraying is indicated by the number of leaves on the main shoot (See table I).

TABLE I

Periods of development of successive leaves in winter-rye (1948/49) at different times of sowing. (The figures in the 2nd till 9th column indicate the first or second half of the month in question) (Data of Van Dobben[3])

Date of sowing	Number of leaves on the main shoot							
	1	2	3	4	5	6	7	8
Sept. 25	Oct.1	Oct.1	Oct.1-2	Oct. 2	Nov. 1	Dec. 1-2	Jan. 2	Mar. 1
Oct. 6	Oct.1-2	Oct.2	Nov.1	Nov. 2	Dec. 1-2	Jan. 2	Febr.2	Mar. 1-2
Oct. 15	Oct.2	Nov.1	Nov.2	Dec. 2	Jan. 1-2	Febr.1-2	Mar. 1	Mar. 2
Oct. 30	Nov.1	Nov.2	Dec.2	Jan.1-2	Febr.1-2	Mar. 1	Mar.1-2	April 1
Nov. 15	Nov.2	Dec.1-2	Jan.1-2	Febr.2	Mar. 1	Mar. 2	Mar. 2-April 1	April 1-2

After the discovery of the yield-stimulating effect of DNC in autumn-sown cereals other experiments were laid out to study the Nitrogen effect of DNC and the effect of this herbicide after manuring of the crop with varying amounts of Nitrogen-fertilisers. Besides, other experiments were laid out, regarding the influence of spraying-technique upon the yield of cereals and on weed control.

Since the data are very numerous, a selection has been made from the most significant experiments.

Experimental results

The effect of herbicides on the yeild of autumn-sown cereals

Tables II and III give the effect of the herbicides on winter-wheat and -rye.

TABLE II

The effect of herbicides on the yield of winter-wheat sprayed at different growth-stages in kg/are. (1 kg/are = 89 lbs/acre)

Exp. CI 1213

Compound \ Treatment	Number of leaves during spraying					Unsprayed	Mean per compound
	2½	3½	4½	5½	6½		
DNC	56.0	59.8	60.6	64.0	53.9	53.5	58.9
MCPA	54.4	57.0	57.0	57.0	58.3	55.0	56.5
2,4-D	48.1	38.5	48.7	48.8	56.9	50.6	48.2
Mean per spraying time	52.8	51.8	55.4	56.6	56.4	53.0	54.5

Sign. difference	P 0.05	P 0.01
Between Compounds	1.2	2.8
Between one treatment and control:	7.6	10.2
Interaction: Spraying time x Compound	10.8	14.5

TABLE III

The effect of herbicides on the yield of winter-rye, sprayed at different stages of development in kg/are.
Exp. CI 1212 (1 kg/are = 89 lbs/acre)

Treatment / Compound	Number of leaves during spraying					Unsprayed	Mean per compound
	1½	2½	3½	4½	5½		
DNC	33.5	35.5	33.4	36.5	34.9	32.6	34.8
MCPA	34.0	31.9	31.5	31.9	30.3	31.1	31.9
2,4-D	32.9	31.8	32.4	28.7	29.8	32.9	31.1
Mean per times of application	33.5	33.1	32.4	32.3	31.7	32.2	32.6

Sign. difference	P 0.05	P 0.01
Between Compounds	1.0	1.7
Interaction: Compound x Time	4.3	

From these tables it is evident, that MCPA does not affect the yield of these cereals, when sprayed during the early growth-stages. When this compound is sprayed during the early tillering-stage, however, the application results in many deformed kernels. It appears that DNC stimulates production, if applied at the early tillering-stage. At the same time 2,4-D decreases the yield of these crops, if applied when they have formed 3½-5 leaves. These data confirm those of other experiments published elsewhere (4).

In order to determine with more accuracy the effect of these compounds on cereals, random samples were taken in order to determine the influence on tillering, number of grains per ear, thousand kernel weight and leaf surface.

Table IV shows the effect of the herbicides on thousand kernel weight.

TABLE IV

The effect of herbicides on thousand kernel weight of winter-wheat
Exp. CI 1213 (in grammes)

Treatment / Compound	Number of leaves during spraying					Unsprayed	Mean per compound
	2½	3½	4½	5½	6½		
DNC	51.0	51.8	52.2	51.7	51.5	50.9	51.6
MCPA	49.4	51.5	51.7	51.4	52.0	51.2	51.2
2,4-D	46.7	46.0	49.3	49.2	50.7	50.9	48.4
Mean per times of application	49.0	49.7	51.1	50.7	51.4	51.0	50.4

Sign. difference	P 0.05	P 0.01
Between Compounds	1.3	
Between times of application:	1.0	1.3
Interaction Compound x Time	2.4	3.2

There exists a significant difference between the various compounds. It appears that DNC increases the seed weight. According to experiments of Van Dobben this should be ascribed to an increase in leaf surface of the last formed leaves.

In pot-experiments with spring-barley the transpiration of DNC-treated plants exceeded that of the untreated checks about a month before ripening. This increase in transpiration shortly before ripening of the crop seems to indicate that the leaf-area is larger, or that the vital parts of the leaves maintain their action over a longer period. The effects of DNC on tillering and on the number of fertile shoots are not significant.

During the experiments it could be observed that about 5 - 6 weeks after application of DNC the colour of the autumn-sown cereals was greener than that of the untreated plants. This observation led to the supposition that DNC could have a Nitrogen-effect upon the crop. Therefore two types of experiments were laid out.

(a) Comparison with other Nitrogen-compounds

The last three years field trials were laid out to compare the effects of different Nitrogen containing compounds. The amount of compound applied is based on the percentage of Nitrogen in the ammonium salt of DNC. These experiments led to the conclusion that the yield stimulating effect of DNC is not due to Nitrogen. (table V)

TABLE V

The effect of Nitrogen compounds on the
yield of winter-rye in kg/are.
(1 kg/are = 89 lbs/acre)

Exp. CI 1406

Compound	Amount applied	Seed yield in kg/are
NH_4-DNC	5 kg/ha	30.8
Orthonitrotoluol	9.6 "	25.3
2,4-dichlorophenol	4 "	23.8
Ammonium nitrate	2.8 "	24.7
Urea	2.1 "	25.5
Untreated		25.2
Sign. difference		
P 0.01		3.2

Only DNC caused an increase of the yield.

(b) Comparison of the effect of DNC on winter-rye after manuring with different amounts of Nitrogen.

(1) From tables VI and VII it is apparent that the yield of rye is increased when more Nitrogen is applied. DNC does increase the yield of winter-rye at all levels of Nitrogen application.

TABLE VI

Effect of DNC on rye at several Nitrogen levels.
Seed-yield in kg/are
(1 kg/are = 89 lbs/acre)

Exp. CI 1405

Treatment	Amount of Nitrogen in kg/ha					Mean per treatment
	0	30	60	90	120	
Untreated	8.2	12.8	20.7	24.7	25.6	18.4
DNC at 3¼ leafstage	9.3	16.1	24.7	26.5	29.3	21.2
DNC at 4 leafstage	8.0	15.1	22.5	26.0	28.5	20.0
Mean per N-level	8.5	14.7	22.6	25.7	27.8	

Sign. difference	P 0.05	P 0.01
Between Nitrogen levels	1.4	1.9
Between Treatments	1.1	1.5

TABLE VII

Effect of DNC on rye at several Nitrogen levels
Seed-yield in kg/are
(1 kg/are = 89 lbs/acre)

Exp. CI 1205

Treatment	Amount of Nitrogen in kg/ha						Mean per treatment
	0	25	50	75	100	125	
Untreated	22.7	23.5	30.3	32.0	36.5	36.4	30.2
DNC at 3½ leafstage	27.8	28.8	27.9	36.0	38.1	31.8	31.7
DNC at 4½ leafstage	22.5	28.8	31.3	35.3	36.5	36.2	31.8
Mean per N-level	24.3	27.0	29.8	34.4	37.0	34.8	

Sign. difference	P 0.05	P 0.01
Between Nitrogen-levels	3.3	5.2
Between Treatments	1.2	
Interaction Treatment x Nitrogen	4.3	5.7

(2) The increase in yield is realised by the thousand kernel weight and the number of grains per ear. The thousand kernel weight is increased by Nitrogen till a certain optimum is reached. Beyond this optimum the seed weight is decreased by Nitrogen

Generally the seed weight is increased by DNC (table VIII). Both Nitrogen and DNC increase the number of grains per ear (table X and XI).

TABLE VIII

The effect of Nitrogen and DNC upon
the thousand kernel weight of rye
(in grammes)

CI 1405

Treatment	Amount of Nitrogen in kg/ha					Mean per treatment
	0	30	60	90	120	
Untreated	28.6	30.7	30.2	30.6	30.6	30.1
DNC at 3½ leafstage	30.2	31.8	31.5	30.8	29.4	30.7
DNC at 4 leafstage	29.0	31.7	31.3	30.9	30.4	30.6
Mean per N-level	29.2	31.4	31.0	30.8	30.1	

Sign. difference	P 0.05	P 0.01
Between Nitrogen-levels	0.9	1.2

TABLE IX

The effect of Nitrogen and DNC upon
the thousand kernel weight of rye
(in grammes)

CI 1205

Treatment	Amount of Nitrogen in kg/ha						Mean per treatment
	0	25	50	75	100	125	
Untreated	35.4	34.8	33.5	33.8	32.5	31.9	33.6
DNC at 3½ leafstage	35.8	35.2	33.7	32.8	32.8	32.0	33.7
DNC at 4½ leafstage	35.7	35.3	34.1	33.3	32.8	32.5	33.9
Mean per N-level	35.6	35.1	33.8	33.3	32.7	32.1	

Sign. difference	P 0.05	P 0.01
Between Nitrogen-levels	0.6	1.0

TABLE X

The effect of Nitrogen and DNC upon the
number of grains per ear of rye.

Exp. CI 1405

Treatment	Amount of Nitrogen in kg/ha					Mean per treatment
	0	30	60	90	120	
Untreated	16.9	27.4	29.4	36.2	40.4	30.1
DNC at 3½ leafstage	23.8	34.6	39.1	44.1	44.9	37.3
DNC at 4 leafstage	22.9	32.0	38.3	42.3	41.2	35.3
Mean per N-level	21.2	31.3	35.6	40.9	42.2	

Sign. difference	P 0.05	P 0.01
Between Nitrogen-levels	2.6	3.5
Between DNC and untreated	2.0	2.7

TABLE XI

The effect of Nitrogen and DNC upon the number of grains per ear of rye.

Exp. CI 1205

Treatment	Amount of Nitrogen in kg/ha						Mean per treatment
	0	25	50	75	100	125	
Untreated	34.9	35.6	38.8	39.8	39.5	39.5	38.0
DNC at 3½ leafstage	34.9	37.2	39.2	42.1	41.8	43.0	39.7
DNC at 4½ leafstage	34.9	37.2	40.4	40.7	39.9	43.6	39.4
Mean per N-level	34.9	36.7	39.4	40.9	40.4	42.0	

Sign. difference	P 0.01
Between Nitrogen-levels	3.8
Between Treatments and control	1.2

It appears that DNC increases the average seed-yield with about 10%, due to an increase of 3½% in thousand kernel weight and 6½% in the number of grains per ear.

On poorly manured soils the number of fertile shoots may be reduced by spraying with DNC (table XII).

TABLE XII

The effect of Nitrogen and DNC upon the number of fertile shoots of rye per metre.

Exp. CI 1405

Treatment	Amount of Nitrogen in kg/ha					Mean per treatment
	0	30	60	90	120	
Untreated	35.2	36.9	42.6	47.3	45.8	41.6
DNC at 3½ leafstage	29.2	32.3	43.2	42.4	45.9	38.6
DNC at 4 leafstage	34.6	36.5	39.7	47.1	53.6	42.3
Mean per N-level	33.0	35.2	41.9	45.6	48.4	

Sign. difference	P 0.05	P 0.01
Between Nitrogen-levels	3.2	4.3
Between Treatment	2.5	

Discussion

Regarding the yield stimulating effect of DNC many explanations are possible.

1. The action of DNC may reduce the infestation of the cereals by plant- or soil-borne pathogenic micro-organisms.

According to Larose DNC possesses a fungicidal action against mildew. In field-experiments, however, no difference in infestation of cereals with these fungi could be observed between treated and untreated crops. According to experiments of Dijksterhuis (priv. comm.) no difference in infestation with fungi could be observed in peas, if this crop was sprayed with dinoseb before and after inoculation with fungi. Therefore it may be judged unlikely that the effect of DNC is of an antibiotic nature.

2. An influence on plant physiology.

It is imaginable that DNC influences the physiological development of the crop. According to table II at certain developmental stages 2,4-D and DNC have antagonistic effects upon the yield of the crop. This is in agreement with other data (4). If a physiological action is the cause of the stimulating effect, the effect will depend on the concentration of DNC used. In field-experiments it could be shown that the effect depends on the concentration of DNC applied (table XIII).

TABLE XIII

The effect of different amounts of DNC on the yield of winter-rye in kg/are. (1 kg/are = 89 lbs/acre)

Exp. CI 1415

Amount of DNC in kg/ha	Yield of winter-rye in kg/are
0	27.6
1.00	28.7
1.75	29.0
2.50	29.2
5.0	30.3
7.50	27.7

It is remarkable that the data in this table resemble those of the respiration experiments of Blackman, Beevers a.o. (1, 2). It is, however, difficult to explain why an increased respiration should result in an increase in yield. The respiration experiments of Blackman, Beevers etc. were short-time experiments (1 hour to some days) with small objects. In field-experiments, however, there is a great lapse of time between the moment of application of herbicides and the day of harvesting. Therefore pot-experiments were carried out with barley. A mildew resistant variety was used. From this experiment it was evident, that in the beginning the transpiration of barley, sprayed with increasing concentrations of DNC is reduced in comparison to the untreated crop. This may be explained by damage to the leaves. A month before harvesting, however, the transpiration exceeded that of the check. The extended transpiration-time and the increase in transpiration indicates that there might be also a greater rate of assimilation during this period of growth.

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THE USE OF DINITRO WEEDKILLERS ON WINTER CEREALS

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(Pest Control Ltd.)

Summary

1. Spraying winter wheat with DNC (4-6 lb. a.e. per/acre) in the period from December 1953 to February 1954 gave a highly satisfactory control of most autumn germinating annual weeds.

2. The significant yield increases (average of six experiments) were of the same order as those obtained by spraying the same rates of DNC in spring.

3. Only if severe frost occurred within 10 days after spraying did scorch to the wheat exceed the slight scorch which normally occurs after a spring application of the same rates of DNC.

4. Severe scorch (up to 60 percent. of the emerged leaves of wheat) did not result in a measurable reduction in yield except in one case, where the yield was significantly reduced by 10 percent.

5. The results of these experiments do not suggest that the yield increases were due to a stimulating effect of DNC on the wheat for they can be explained almost entirely by the effect of the herbicide on the weed population.

6. An additional spring application of 4-6 lb. DNC on plots already sprayed in winter did not give a further yield increase as a result of control of spring germinating weeds.

7. Dinoseb (triethanolamine), although less selective than DNC as measured by scorch to corn, proved to be safe for winter wheat sprayed during the winter at the rate of approximately 0.75 lbs. a.e. per/acre. The yield increase obtained by this rate of dinoseb was not significantly different from that obtained by 6 lb. a.e. per/acre.

Introduction

The aim of this investigation was to find out whether DNC spraying on winter wheat could be carried out in the late autumn and winter thus leaving less work to be done in the spring. The research work reported in this paper dealt with the following aspects:-

(a) A comparison of the effects of winter and spring applications of DNC on weeds in winter wheat and on the yield of the crop.

(b) The influence of low temperature on the safety of winter spraying on wheat.

(c) The influence of scorch on the yield of winter wheat.

(d) A comparison between DNC and dinoseb (triethanolamine) in winter spraying on wheat.

(e) To determine whether, under the conditions of these experiments, DNC stimulated growth and increased yield of winter wheat as found by P. Riepma (Holland) (1).

The results are based on only one year's experiments. The main conclusions, however, concerning weed control and the safety on corn are based on experience of spraying under 50 different weather-weed-crop conditions.

It appears likely, therefore, that this range of experience will cover most normal conditions as well as abnormal weather such as the prolonged and severe frost which occurred this season.

EXPERIMENTAL RESULTS

I. Comparative Effect of 2 Rates DNC Applied in Winter or Spring on the Weed Population and on the Yield of Winter Wheat

A series of 7 experiments was laid out at 7 different sites in Cambridgeshire and Essex, using the same layout at each site. Each experiment consisted of 12 treatments (including the untreated controls) in 8 replications. Plot size was 16 square yards.

The results of only some of these treatments are included in this report. The others consisted of slightly different formulations of DNC which are not on the market but which in general gave the same results as the standard formulation.

It appears for various reasons to be necessary to include a short description of the conditions under which these experiments (lettered A to G) were carried out. Experiment G could not be harvested owing to irregular and severe lodging due to eye-spot disease.

Description of conditions under which Experiments were carried out

Expt. A: Winter wheat var. Atle, dressed with Agrosan, sown last week of October on light, gravelly, alluvial soil. Fertilizer: 10 tons farmyard manure, 2 cwt. sulphate of ammonia/acre. Average yield: 39.0 cwt./acre. Density of weed population at time of spraying: 65 weeds per square yard consisting of Speedwell 26%, Chickweed 21%, Pimpernel 20%, Shepherds Purse 15%, Pansy 8%, remainder: other weeds. Conditions at time of spraying: wheat not yet tillered; temperature 48° F; humidity very high. Spraying date: 8th December, 1953.

Expt. B: Winter wheat var. Nord Desprez, dressed with Ceresan, sown last week of October on chalky, medium-light soil. Fertilizer: 2½ cwt. mixed fertilizer in autumn; 1 cwt. nitro-chalk in spring. Average yield: 24.4 cwt./acre. Density of weed population at time of spraying: 666 weeds per square yard, consisting of Poppy 61%, Pansy 10%, Speedwell 8%, Trefoil 6% Chickweed 6%, annual grasses 5%, remainder, other weeds. Conditions at time of spraying: wheat 3¼" high, 2 leaves expanded; temperature 51° F., humidity 100%. Spraying date: 16th December, 1953.

Expt. C: Winter wheat var. Eclipse, dressed; sown 2nd week of October on chalky boulder clay, medium-heavy. Fertilizer: 2½ cwt. Fisons 31 in autumn, 2½ cwt. sulphate of ammonia in spring. Average yield: 36.2 cwt. per acre. Density of weed population at time of spraying: 309 weeds per square yard consisting of Poppy and Shepherds Purse 49%, Speedwell 12%, Chickweed 9%, Corn Campanula 9%, Pansy 9%, Pimpernel 3%, Charlock 5%, remainder, Parsley Piert, Mayweed, Dock and annual grasses. Conditions at time of spraying: wheat 2 leaves fully expanded; temperature 46° F; humidity 96%. Spraying date 10th December, 1953.

Expt. D: Winter wheat var. Little Joss, dressed with Agrosan sown 22nd October on medium-light boulder. Fertilizer: 2 cwt. Fisons 31/acre. Average yield: 21.9 cwt./acre. Density of weed population at time of spraying: 425 weeds per square yard consisting of Parsley Piert 25%, Carrot 23%, Speedwell 11%, Chickweed 11%, Galium spp. 8%, Clover 4%, remainder, other weeds. Conditions at time of spraying: wheat tillered once-twice, main shoot 3-4 expanded leaves; air temperature 38° F; humidity 87%. Frost and a little snow the night before spraying. Spraying date: 5th January, 1954.

Expt. E: Winter wheat var. Staring, dressed. Sown 2nd week October on medium boulder clay. Fertilizer: I.C.I. mixed fertilizer and nitro-chalk; quantity unknown. Average yield: 26.2 cwt./acre Density of weed population at time of spraying: 224 weeds per square yard, consisting of Parsley Piert 38%, Speedwell 23%, Poppy 16%, Chickweed 11%, Pansy 11%, remainder, other weeds (mainly ryegrass). Conditions at time of spraying: wheat tillered once, main stem 2-3 expanded leaves. Air temperature 35° F, ground temperature 32-33° F; humidity 86%, hard frost previous night. Snow started falling immediately after spraying. Spraying date: 6th January, 1954.

Expt. F: Winter wheat var. Hybrid 46, dressed, sown last week October on thin boulder over chalk, medium-light soil. Fertilizer: 3 cwt. compound corn fertilizer. Average yield: 21.6 cwt./acre. Density of weed population at time of spraying: 465 weeds per square yard, consisting of Poppy 76%, Parsley Piert 7%, Grass 6%, Chickweed 3%, Pansy 3%, remainder, other weeds. Conditions at time of spraying: wheat, tillered once, main stem 2 leaves expanded. Temperature 35° F., humidity 91%, frost previous night. Spraying date: 1st January, 1954.

Expt. G: Winter wheat var. Hybrid 46. This experiment was not harvested owing to severe lodging of the whole crop. Weed population was assessed as in other experiments. Density of weed population: at time of spraying 319 weeds per square yard, consisting of Chickweed 29%, grass 28%, Poppy 13%, Speedwell 8%, Parsley Piert 8%, Corn Campanula 7%, remainder, other weeds. Conditions at time of spraying: wheat with 2-3 tillers each with 3 leaves fully expanded; temperature 42° F; humidity 92%. Spraying date: 21st December, 1953.

Results of Experiments A - G

Figure 1 shows the composition of the weed population in these seven experiments on the day before spraying and approximately a fortnight after spraying.

Except at one site where annual grasses formed a large proportion of the weed population, the total number of weeds was in all cases reduced by more then 90 percent.

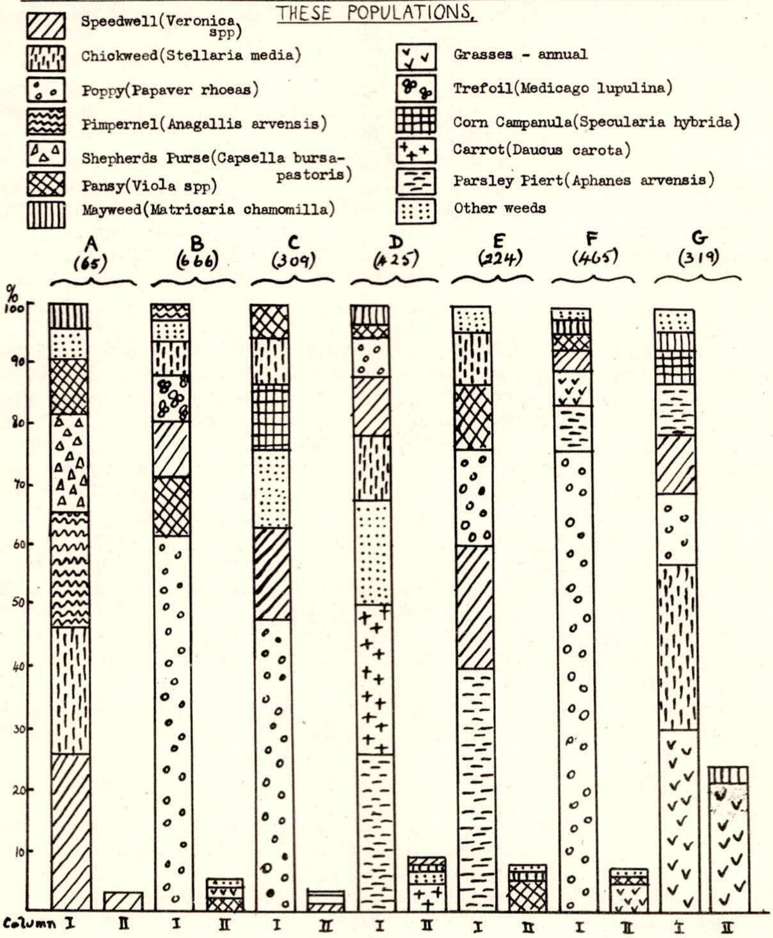
Table 1 shows the percentage kill of the different weeds in each of these seven experiments. It is worth mentioning that even the annual grass seedlings were killed up to 50 percent. by the treatment.

The yield figures of six of the seven standard experiments are shown in Table 2. In this table the following points are worth notice:

(a) Only in one of the six experiments (Expt. D) is the yield from the winter-sprayed plots lower than that of the controls. In this experiment (variety Little Joss), severe frost occurred during the night after spraying.

FIGURE I

ANALYSIS OF THE WEED POPULATIONS ON THE EXPERIMENTS FOR WHICH YIELD FIGURES ARE GIVEN IN TABLE I AND THE EFFECT OF 6 LB. DNC PER ACRE ON THESE POPULATIONS.



EXPLANATION OF THE DIAGRAM:
The different sites are lettered 'A' to 'G'. The figure in brackets under these letters show the average density of weeds per square yard for each site. The total weed population before spraying (column I) is expressed as 100%. The subdivision of the columns shows the percentages of the main weeds. The total number of weeds after spraying (column II) is shown as a percentage of the original population. Sub-division of this column gives an indication of the proportions of the remaining main weeds.

Spring application also failed to increase the yield in this experiment. The conclusion drawn from this and from other experiments is that the natural reduction of the weed population, caused by the exceptional long frost period in January and February, decreased the difference between sprayed and unsprayed plots. This point is discussed later in more detail.

(b) Only in experiment F did both winter and spring treatments give considerable and significant yield increases (28%). In this experiment 76 percent. of the weed population consisted of poppy which was 100 percent. killed by the winter treatment (as well as by the spring application). The severe frost killed about 60 percent. of the poppy on untreated plots but enough remained to cause a considerable yield reduction. At harvest time the large number of poppy plants in untreated plots was very noticeable.

(c) The yield level of the other experiments was determined by the interaction of (i) the density of the weeds (ii) the effect of the herbicide (iii) the effect of severe frost on the weed population, and (iv) the possible influence of slight scorch. Although, owing to the exceptional effect of factor (iii), the yield increases in most individual experiments are too small to be significant, the figures show clearly that winter treatment gave yields at least as high as spring treatment.

(d) A general statistical analysis of the six experiments together showed that all four treatments gave a yield significantly higher than the untreated controls and that there was no significant difference between the effect of winter and spring treatment (see last column, Table 1).

II. Effect of 6 lbs. DNC Sprayed at Different Dates in the Period 3rd December to 11th March, 1954

One field experiment was carried out (latin square 10 x 10) in which 6 lbs. DNC was sprayed at 8 different dates at fortnightly intervals covering nearly the whole winter. Each treatment (time of spraying) was replicated 10 times.

A description of the general conditions under which the experiment was carried out follows:-

Experiment with fortnightly sprays (DNC)	Winter wheat var. Eclipse dressed with Agrosan, sown 24th November on heavy boulder clay. Fertilizer: 14 tons farmyard manure, 3 cwt. mixed fertilizer in autumn, 2 cwt. nitro-chalk in spring. Average yield: 31.7 cwt./acre. Density of weed population at time of 1st treatment: 296 weeds per square yard, consisting of Parsley Piert 49%, Speedwell 18%, Chickweed 12%, Mayweed 8%, remainder, other weeds. Spraying was carried out at fortnightly intervals from 3rd December to 11th March.

Weed counts were made during the whole period on the untreated controls; on treated plots counts were made before and after treatment.

The percentage kill for all treatments was of the same order as that shown in Table 1 for the seven standard experiments.

The weed counts on the untreated controls (shown in Fig. II) clearly shows the changes in the weed population due to natural factors. The sudden and marked decrease after 15th January was due to the exceptional and severe frost period from 18th January to 5th February. Comparison between the air temperatures which were recorded on the experiment with a thermograph and the 50 years temperature data from the Central Meteorological Office showed that such a severe and prolonged frost period can be regarded as exceptional.

TABLE 1

PERCENTAGE KILL OF DIFFERENT WEEDS BY TWO RATES OF DNC IN 7 EXPERIMENTS (WINTER APPLICATION)

EXPERIMENTS (SITES) A-G

	A		B		C		D		E		F		G		Mean	
	lbs. DNC/ac		lbs. DNC/ac		lbs. DNC/ac		lbs. DNC/ac		lbs. DNC/ac		lbs. DNC/ac		lbs. DNC/ac		lbs. DNC/ac	
Weed Species	6	4	6	4	6	4	6	4	6	4	6	4	6	4	6	4
Speedwell	97	95	100	99	97	95	99	99	99	99	98	100	100	98	99	98
Chickweed	100	99	90	85	94	85	91	90	88	88	97	86	95	91	93	89
Poppy	-	-	100	100	100	100	100	97	100	98	100	99	100	100	100	99
Parsley Piert	-	-	-	-	100	98	99	99	97	93	98	98	100	100	99	98
Pansy	99	99	85	76	97	93	56	34	54	39	51	60	-	-	74	67
Pimpernel	100	100	-	-	100	90	-	-	-	-	-	-	-	-	100	95
Charlock	-	-	-	-	100	100	-	-	-	-	-	-	-	-	100	100
Shepherd's Purse	100	100	-	-	100	100	-	-	-	-	-	-	-	-	100	100
Trefoil	-	-	98	96	-	-	-	-	-	-	-	-	-	-	98	96
Grasses	-	-	56	43	-	-	-	-	-	-	-	-	41	39	48	41

TABLE 2

RELATIVE AND ABSOLUTE YIELD FIGURES FOR THE MAIN TREATMENTS AND UNTREATED CONTROLS OF THE SIX STANDARD EXPERIMENTS A-F

EXPERIMENTS (SITES)

		A	B	C	D	E	F	Mean Yield increases %
Autumn Spray	Rel. yield % of control	100.6	101.9	100.4	92.3	111.2	121.6	4.7
6 lb. DNC	Absolute yield cwt./acre	39.0	24.2	36.2	21.5	27.2	21.2	-
Spring Spray	Rel. yield % of control	99.7	102.0	102.1	97.0	106.7	127.3	5.8
6 lb. DNC	Absolute yield cwt./acre	38.6	24.2	36.8	22.5	26.1	22.2	-
Autumn Spray	Rel. yield % of control	106.9	101.1	105.4	87.0	105.9	129.5	6.0
4 lb. DNC	Absolute yield cwt./acre	41.4	24.0	38.0	20.2	26.1	22.5	-
Spring Spray	Rel. yield % of control	95.5	98.6	98.3	102.8	103.2	127.6	4.3
4 lb. DNC	Absolute yield cwt./acre	37.0	23.4	35.5	23.9	25.3	22.2	-
Untreated	Rel. yield % of control	100.0	100.0	100.0	100.0	100.0	100.0	-
Controls	Absolute yield cwt./acre	38.8	23.8	36.1	23.2	24.5	17.4	-
Least Significant Difference $P = 0.05$	for Rel. yield % of control	8.7	12.2	9.6	5.6	10.0	6.98	
	for Absolute yield cwt./acre	3.39	2.95	3.48	1.19	2.72	5.47	

FIGURE II

Natural changes in the density and composition of a weed population in winter wheat from mid December, 1953 to mid March, 1954 (untreated plots)

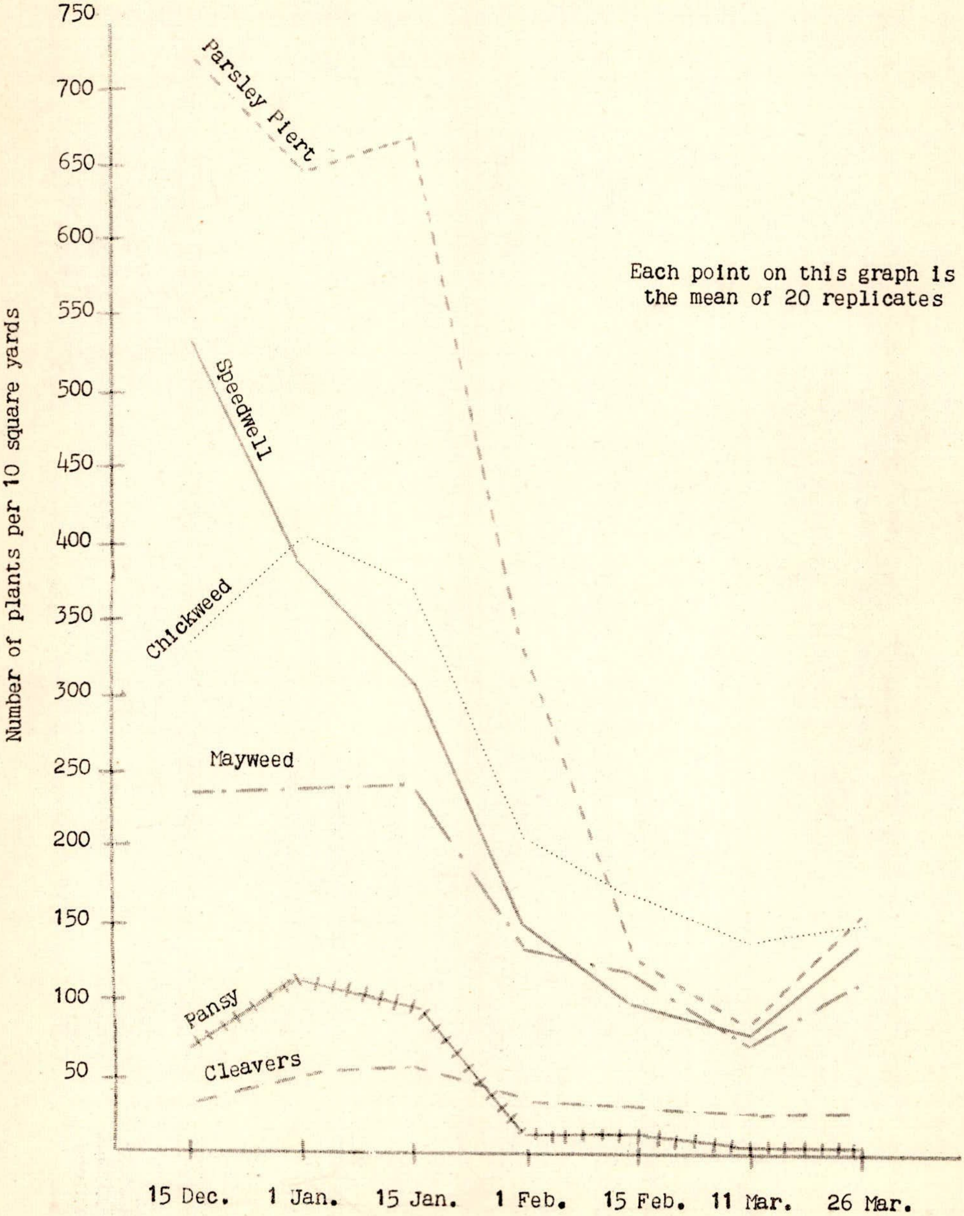


Table 3 shows the relative and absolute yield figures obtained from this experiment.

TABLE 3

RELATIVE AND ABSOLUTE YIELD FIGURES FOR THE FORTNIGHTLY SPRAYING EXPERIMENT

Spraying date	Relative yield % of control	Absolute yield cwt./acre	Remarks on weather conditions
Dec. 3	115.6	34.6	
Dec. 16	106.4	31.9	
Dec. 31	106.0	31.7	Slight frost 29.12.53
Jan. 14	105.7	31.7	Slight frost previous night
Jan. 28	99.9	30.0	(Severe frost before and for 11 days after spraying)
Feb. 17	108.5	32.5	
Feb. 25	106.6	31.9	
Mar. 11	108.1	32.4	
Untreated	100.0	30.0	

Smallest Significant Differences:

P 0.05 7.14% of Untreated; 2.14 cwt./acre
P 0.1 5.97% of Untreated; 1.79 cwt./acre

The first spray gave the highest yield increase (15.6%). All other treatments except one also gave yield increases, which are either significant or very nearly significant at the 5 percent. probability level.

Only the treatment on 28th January did not result in a yield increase. This result is closely correlated with the severe frost period mentioned above. Interaction of the yield increasing factor "weed control" and the decreasing factor "scorch" appear to have compensated each other in this case.

III. Observations on the Question of Correlation Between Frost and Scorch

In one experiment (carried out on the same field as the experiment described above) spraying with 6 lbs. DNC was carried out on small plots (2 sq. yds.) as far as possible every day during the winter.

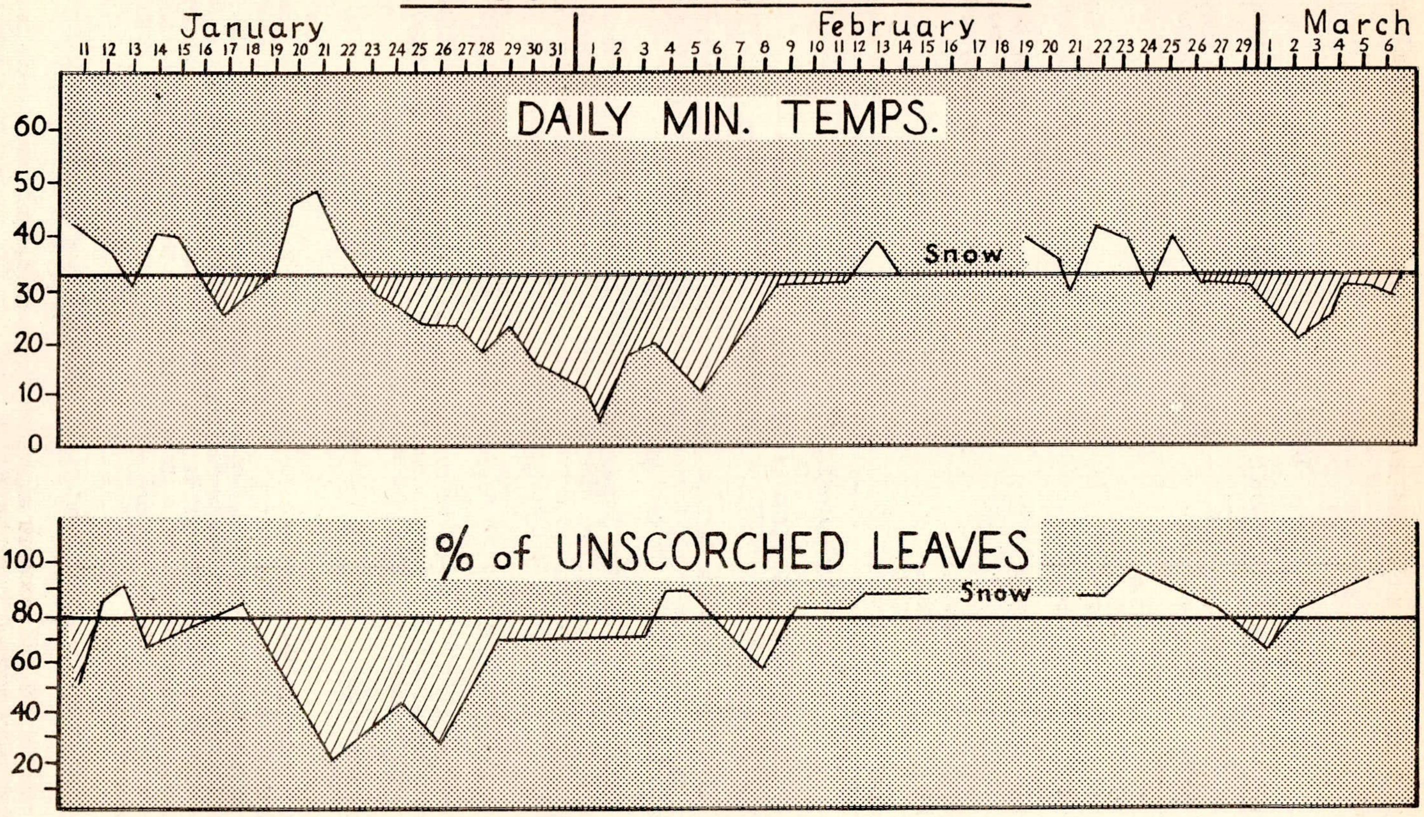
Temperature was recorded during the whole period with a thermograph on the field.

The result of this experiment is shown in Figure 3. This diagram shows a close correlation between the amount of scorch and severe frost occurring within 10 - 14 days after spraying. The amount of scorch (assessed as percentage of remaining unscorched leaves) was assessed approximately a fortnight after spraying and was entered on the graph under the date of spraying. Observations at harvest time showed, as found in the other yield experiments, that the plots which had been scorched (up to 80% of the leaf area) did not look distinctly different from the untreated plots.

IV. Influence of the Spring Germinated Weed Population on the Yield

In four of the six standard experiments described under part I, two treatments which were sprayed in winter with 6 and 4 lbs. DNC respectively were in addition sprayed in spring with the same rates.

FROST AND SCORCH



The following table shows that the yield obtained from these treatments was not significantly different from that of the plots sprayed in winter only. This result suggests that in winter wheat the spring germinating weed population has little influence on the yield, perhaps because the weeds are too small to compete with the established crop. These results however, are only valid for the conditions of the experiments and need further confirmation to be of general value.

TABLE 5

INFLUENCE OF CONTROL OF SPRING GERMINATING WEEDS ON THE YIELD OF WINTER WHEAT

RELATIVE YIELDS % OF CONTROL

	Experiments (Sites)				
	C	D	E	F	Means
6 lb. DNC Winter	100.4	92.3	111.2	121.6	106.4
6 lb. DNC Winter and Spring	100.3	90.5	111.8	128.4	107.7
4 lb. DNC Winter	102.1	97.0	106.7	127.3	108.3
4 lb. DNC Winter and Spring	101.5	94.0	114.3	128.4	109.5
Control	100	100	100	100	100
Smallest significant difference % of control	9.6%	5.57%	10.0%	6.98%	

V. Value of Dinoseb (triethanolamine) in Winter Spraying as Compared with DNC

A number of small preliminary experiments in December 1953 showed that rates above 3 lbs. dinoseb (triethanolamine) are too toxic to the wheat. Therefore a large experiment was laid out in which four lower rates of dinoseb were compared with 6 lbs. DNC at 6 different spraying dates (under otherwise the same crop and field conditions as Standard Experiment B). Lack of space prevents inclusion of all yield and weed count figures in this report. The general yield result however - ignoring the different times of application - is given in the following table.

TABLE 6

YIELD FIGURES FOR THE DINOSEB EXPERIMENT

Treatment	Absolute yield cwt./acre	Relative yield % of control
DNC 6 lb./acre	28.7	105.6
Dinoseb 3 lb./acre	27.2	100.1
" 1½ " "	26.6	97.8
" ¾ " "	28.2	103.8
" ⅜ " "	28.7	105.7
Untreated	27.2	100.0
Smallest Significant Difference P 0.05	1.36 cwt./acre	5.01%

The yield figures can again be explained to some extent by the interaction of scorch and weed control. Three lbs. dinoseb gave approximately 80% scorch. Nevertheless, the yield is not lower than that of the untreated controls.

0.75 - 1 lb. dinoseb/per acre appear to be the best rate.

The general impression from the observations on this experiment however, is - as generally known - that dinoseb is less selective in winter wheat than DNC and therefore has some disadvantages. It can however, be of use where low volume spraying is required.

VI. Direct Yield Stimulating Effect of DNC on Winter Wheat

The yield experiments described above do not indicate the influence of a yield stimulating effect of DNC. They have, however not been carried out on weed-free crops and can therefore not be regarded as a proof that such an effect did not play its part.

DISCUSSION

The application of dinitro herbicides to winter wheat during late autumn and winter instead of spring has the great advantage to the farmer and contractor of allowing more time for spring work.

The results given in this report are based on only one year's experiments and cannot therefore be regarded as a solution to all questions involved in this problem.

Two conclusions, however, based on experience of a wide range of conditions, appear to be valid (a) the highly satisfactory control of the more important autumn germinating weeds and (b) the relatively small influence of scorch on the yield of the crop even when the scorch is considerable as it may be if spraying is followed by a long period of severe frost.

The yield response to the very effective weed control was in general smaller than might be expected. This was probably due to the natural reduction of weeds during the exceptionally cold weather. This effect on yield response to the herbicide is comparable with the effect of natural reduction of the weed population due to drought after spring spraying as described by Blackman (2). The yield increses resulting from winter treatment, although small, were of the same order as those obtained by spring treatment.

An important point for discussion is the effect of spring germinating weeds on the yield of winter wheat. Our results - that the control of the "spring" population in addition to the control of the autumn weeds did not give a further increase in yield - suggests that, under the conditions of our experiments, the spring population did not depress the yield. This result may be due to the inability of the young spring weeds to compete seriously with the established wheat plants. More evidence, however, is necessary before any general conclusions can be drawn regarding this point.

The advantage of weed control cannot of course be expressed only in yield figures. One of the other advantages is that a weed-free crop is much easier to harvest. In this respect no visible differences could be found between autumn and spring-treated plots.

Twelve larger and unreplicated trials of winter spraying of DNC on winter wheat were carried out in addition. The observations on these fully confirm the detailed results described above.

CONCLUSIONS

The conclusions from this year's experiments are that spraying winter wheat with DNC in late autumn or winter appears to be a safe and economic proposition provided that the spraying is not done when there is a high probability of severe and prolonged frost.

REFERENCES

1. RIEPMA, Dr. P., Centraal Instituut Voor Landbouwkundig Onderzoek, Wageningen, Gestencilde Mededelingen Jaargang 11, 1953.

2. Blackman, G. E. and H. A. Roberts: Studies in selective weed control. I. The Control of annual weeds in winter wheat, Journ.Agr.Sci.40 (1950) 62-69.

DISCUSSION ON TWO PREVIOUS RESEARCH REPORTS

Mr. C. V. Dadd: In opening the discussion on these papers there are several questions I would like to ask.

Dr. Pfeiffer has stressed the convenience of winter spraying from the point of view of making more time available in the spring for spraying. He has shown on one year's work that this method is quite as effective as the spring spraying of DNC. A point he did not mention is the advantage of having a clean crop of winter wheat if it is desired to undersow with small seeds.

Does Dr. Riepma think frost after spraying brings about scorch, and if so has he observed loss of yield? The question of yield stimulation is a fascinating one. In this country there is no direct evidence to support Dr. Riepma's work but we agree that there is some circumstantial evidence that the same stimulation does take place. I wonder if Dr. Riepma is entirely satisfied that yield stimulation is not due to a pathogen. I feel that it is unsound to draw evidence from a pea crop and apply it to winter cereals.

Does Dr. Pfeiffer consider that the spray treatment had any effect on the incidence of eye spot disease? Finally, what is the position concerning amine Dinoseb sprayed at low volume? I believe that work is also needed with other substances applied in the autumn, e.g. MCPA and PCP. PCP justifies examination because it is likely to have a residual effect which may control such grasses as blackgrass, an important weed in winter wheat. Does Dr. Pfeiffer believe that there is any residual effect from the DNC?

Dr. P. Riepma: We have found this year, as an exception, that for the first six weeks after spraying the winter wheat and rye were affected, but the damage was not enough to cause the yield to decrease. Concerning low volume spraying, we have found that droplet size has no effect on yield when the same amount of DNC is applied. We mentioned in our paper that we observed no effect of spraying on the incidence of mildew in the cereals.

Dr. R. Pfeiffer: In connection with the effect of scorch on yield. I would mention a case in the Austrian Alps, where a 90 per cent kill of the leaves of winter barley or rye by *Fusarium mivale* under the snow does not result in decreased yield. When the snow melts often no leaves are to be seen in the field but eventually the yield is as high as undamaged crops. I have heard from Norwegian friends that the grazing by geese on winter wheat before the end of February, does not result in decreased yields. Concerning annual grasses, we have heard in Norfolk of 90 per cent of annual grasses being killed. In our experiments about 50 per cent of the grasses including blackgrass were killed. However, there were many plants present, the unkilled ones were able to provide as dense a cover as before.

Further experimental work is necessary before the question of low volume application of dinoseb (triethanolamine) to winter cereals can be answered.

No influence of the DNC spray on the incidence of eye spot has been observed.

I do not expect any important residual effect from DNC treatment, since the rates are too low to prevent germination of weeds.

Mr. P. Gregory: After the eye spot had taken effect it was impossible to tell whether the spraying had had any effect on this disease or not.

Dr. A. J. Lloyd: I do want to stress what Mr. Dadd has said about alternative materials. We appreciate that in time farmers are going to control all the weeds susceptible to 'hormone' weed killers mainly by the use of low volume sprayers which are owned by individual farmers in increasing numbers. This will result ultimately in fields being infested only with the hormone resistant weeds which cannot be controlled without recourse to the high volume spraying of contact herbicides which can only be used with due precautions (e.g. sulphuric acid, DNC etc.). We suggest that P.C.P. properly formulated may be the answer to this problem in providing a material which can be used without special precautions and possibly with low volume applications.

Mr. S. G. Jary: We have tried three varieties of wheat, Hybrid 46, Capelle and YGA and the scorch effect after autumn spraying was negligible for all three varieties. The yield results did not show any suggestion of depression. Another point is that certain weeds i.e. cleavers, mayweed, parsley, piert and chickweed are more easily controlled by autumn spraying than by spring application, even when using a slightly lower dose of about 4½ lb. per acre of DNC.

Under some autumn conditions slugs can cause considerable damage on winter cereals. In one of our trials there was a considerable mortality of slugs immediately following treatment with DNC.

Dr. A. J. Lloyd: PCP is one of the finest molluscicides in the world since it is used very extensively in the tropics, at a few parts per million, in waterways for the control of both aquatic weeds and the snails which are intermediate hosts in the transmission of the human disease Schistosomiasis (Bilharzia). We have also found that it is equally effective for slug control in carrots and other crops.

Mr. T. C. Breese: Concerning Mr. Dadd's query on the possibilities of the winter application of MCPA and 2,4-D, I should like to summarise the results of some trials carried out by my colleagues. Both oats and wheat were damaged, but barley appeared to be unaffected. 2,4-D was more damaging than MCPA, oats being particularly susceptible. Weed control was fairly good but severe frosts appeared to give equally good results. Spring germination of weeds resulted in re-infestation. Our experiences led us to believe that there was little promise in the spraying of hormone weedkillers in the winter.

Mr. J. Wood: I would like to quote the following figures for the effect of DNC and PCP on the lifted weight in daffodils:

Unweeded plots	100.0
DNC	125.9
PCP + 2 cultivations	126.7
Handweeded	123.7

On Tulips

Unweeded	100.0
DNC	113.5
PCP + 2 cultivations	123.9
Handweeded	121.2

(22394)