THE EFFECT OF WEEDKILLERS ON SEED GERMINATION

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SUMMARY

THE effect on germination of storing seeds and weedkillers close together is discussed. The germination of rape, lupin, and white clover was affected by ethyl ester of 2,4-D and the butyl ester of 2,4-D. The germination of wheat and perennial ryegrass was unaffected after 11 months. Actual contact with these substances reduced severely the germination of all species.

White clover, sown at a depth of $\frac{1}{2}$ in. and $\frac{1}{4}$ in., was sprayed with CIPC solution at 2lb. and 4lb. carbamate equivalent per acre and germinated under various conditions of temperature and soil moisture. Germination was affected by all treatments, but to the least extent where soil moisture was low, temperatures between 68 degrees F. and 77 degrees F., the seed covered by $\frac{1}{2}$ in. soil and a rate of 2lb. per acre used.

The subject of the possible effect on seed germination of contact with weedkillers is one which has received little attention. It is also a subject which requires investigation, since it is a fact that some weedkillers at least can have a most adverse effect on the viability of seeds with which they come in contact.

This paper will describe the first of a projected series of experiments on the effect of spraying with CIPC the soil in which leguminous seeds have been sown.

Before doing so it may be of interest to mention an experiment concerning storage of seed and 2,4-D in close proximity. This experiment, a failure from most points of view, showed clearly the great care needed in handling seeds and 2,4-D if viability is to be maintained.

Open containers of ethyl ester of 2,4-D and the butyl ester of 2,4-D were stored in closed ammunition boxes in which were cotton bags of seed of white clover (*Trifolium repens*), rape (*Brassica rapa*), blue lupin (*Lupinus hirsutus*), wheat (*Triticum aestivum*), and perennial ryegrass (*Lolium perenne*). The seed was tested for germination at monthly intervals up to 7 months and again after 11 months. Detailed figures from these germination tests cannot be given as many anomalous results appeared which were traced to seed becoming contaminated with minute quantities of weedkiller during testing.

In general the germination capacity of neither wheat nor perennial ryegrass was affected by storage with ethyl ester of 2,4-D or the butyl ester of 2,4-D. Storage with ethyl ester of 2,4-D had an adverse effect on the germination of lupin and rape which fell to 50 per cent. in 7 months and to 15 per cent. in 11 months; that of white clover fell to 70 per cent. after 7 months and to 65 per cent. after 11 months. The effect of the butyl ester of 2,4-D was less marked. The germination of lupin remained unchanged after 7 months and that of rape and white clover fell by 15 per cent. After 11 months' storage these three species had lost 20 to 30 per cent. of their germination capacity.

How lethal to germination is the effect of direct contact with these two substances was discovered when abnormal seedlings of an unusual kind with stubby, truncated roots appeared on germination tests in this experiment.

These appeared usually on the blotters at the ends of the tray, those in the middle being unaffected. It was found that the person who screwed on the cap of the jar containing ethyl ester of 2,4-D or the butyl ester of 2,4-D could retain enough on her fingers to contaminate, where it was touched, the towel which forms the germination substrate, so that seeds in that area germinated abnormally. Only a tiny trace was needed to upset the test.

An accidental spilling of ethyl ester of 2,4-D in one box was immediately wiped up and the seed replaced by fresh seed in clean bags. Within a month rape from this box germinated with an excessive number of abnormal seedlings, in 2 months white clover was affected, and in 3 months germination of lupin fell off markedly. Perennial ryegrass and wheat remained unaffected though both species were susceptible to weedkiller transferred on the fingers.

These results are incomplete, but they do show that it is inadvisable to store white clover, lupin, or rape seed near ethyl ester of 2,4-D or the butyl ester of 2,4-D. Since direct contact with weedkillers has a markedly lethal effect on all the kinds of seed tested it seems a worthwhile precaution to store the weedkillers at a distance from them and to avoid handling weedkillers and seed together.

CIPC

The experiment with CIPC investigated four aspects of the problem:—

1. The effect of rate of application of CIPC (carbamate equivalent per acre).
2. The effect of temperature.
3. The effect of depth of soil cover.
4. The effect of the moisture content of the soil.

White clover was the species tested, a Government Certified line being used with 99.9 per cent. Purity and 95 per cent. Germination. By sieving sterilised potting soil a fine seed-bed was prepared in square tins measuring 8 x 8 square inches. Tins were lined with a double layer of wax paper to prevent contamination. The moisture content of the soil was calculated as a percentage by weight of the air-dry soil. Ten per cent. added water produced a soil which could be squeezed in the hand to a compact mass, but which would fall apart when poked with the finger.

One hundred seeds were counted on to each tin, a mechanical counter being used to ensure even spacing. The seed was covered with the required depth of soil and then sprayed with CIPC dissolved in water at 50 gallons per acre, an ordinary glass scent atomiser being used. The control tins were sprayed with water only. Each treatment was replicated four times. A wrapping of damp blotting paper prevented drying out during the germination period of 10 days. This took place in cabinet-type germinators which were heated to the required temperature during 8 hours of the day and switched off in the afternoon so that they returned to the overnight room temperature of approximately 61 degrees F. Tests made at 58 degrees F. remained at that temperature during the whole 24 hours.

Treatments were as follows:—

1. Rate of application	0, 2lb., and 4lb.
2. Temperature	58 degrees F., 68 degrees F., 77 degrees F., and 86 degrees F. air temperature.
3. Depth of soil cover	$\frac{1}{4}$ in., $\frac{1}{2}$ in.
4. Moisture content of soil	Dry (8 per cent.), medium (10 per cent.), wet (18 per cent.).

Temperature: Mention must be made of the effect of temperature on white clover germination (see Table 1). White clover can be germinated successfully at temperatures ranging from 58 degrees F. (and probably lower) to 77 degrees F. Above that temperature the condition termed "freshly swollen seed" is found, in which seeds imbibe water and remain fresh, but are unable to germinate. Because of this condition it was not possible to judge the effect of CIPC at very high temperatures. The slightly lower germination at 77 degrees F. in $\frac{1}{2}$ in. soil may be due to soil temperatures, under the conditions of the experiment, not dropping sufficiently at night so that unfavourably high temperatures were maintained. This would apply to a greater degree at 86 degrees F.

Rate and temperature (see Table 2): In every case there was a decrease in germination and an increase in the number of abnormal seedlings on the sprayed tins. This decrease in germination was greater at 4lb. per acre, though sometimes by only a few per cent. In nearly every case the decrease was significantly different from control at the 1 per cent. level. Seedlings on the sprayed tins were reduced in length both of root and shoot and this was more marked at 4lb. per acre, where the shoots were also somewhat swollen. The conditions of the experiment were not suitable for growing the seedlings to a further stage, so it was not possible to find out whether these differences in size eventually disappear as the seedling matures. It is certain, however, that spraying results in an initial reduction in vigour.

At 68 degrees F. and 77 degrees F. (air temperature) the effect of the spray is very similar. At the lowest temperature (58 degrees F. air temperature), however, there is a more marked decrease in germination percentage and a corresponding increase in the number of abnormal seedlings. The detrimental effect of CIPC to germination therefore appears to be greater at lower temperatures. For reasons given above it is not possible to judge the effect at very high temperatures.

Depth of soil cover: The effect of an increase in depth of soil cover is to reduce the seedling loss. At both 68 degrees F. and 77 degrees F. germination was higher and the number of abnormal seedlings less with $\frac{1}{2}$ in. soil cover than with $\frac{1}{4}$ in. This was true to a less extent at 58 degrees F.

Soil moisture (see Table 3): The soil moisture content in these tests was determined within very broad limits. The dry content (8 per cent. moisture) soil was moist enough to form a compact mass when squeezed in the hand, but fell apart rather easily when the fingers were opened. The wet soil (18 per cent. moisture) remained as a firm ball difficult to break up. In wet soil germination in the control tins was lowered, due possibly to a reduction of available air. Abnormal seedlings on wet and moist tins were rather similar in number. The effect of spraying with 2lb. and 4lb. of CIPC was again to reduce the germination percentage and this reduction was least on dry soil.

DISCUSSION

It has been shown that spraying with CIPC soil in which white clover seed has been sown has a harmful effect on germination. The harmful action may be increased by cool temperatures (58 degrees F.) and heavy rates of application of CIPC (4lb. per acre). The reduction in germination is not so great and may even, for practical purposes, be negligible where seed is covered to a depth of $\frac{1}{2}$ in., is sprayed with 2lb. CIPC per acre, and germinated at temperatures in the region of 65 to 77 degrees F. in moist but not excessively wet soil.

TABLE 1—EFFECT OF TEMPERATURE ON WHITE CLOVER
GERMINATION.
PERCENTAGE GERMINATION OF UNTREATED SEED

Temperature Degrees F.	Laboratory Test		½ in. cover		¾ in. cover	
	Germn.	Abnormal	Germn.	Abnormal	Germn.	Abnormal
58	93	6	83	10	82	8
68	95	4	87	8	83	11
77	95	3	81	9	73	9
86	69	6	19	11	Not tested	

TABLE 2—EFFECT OF RATE, TEMPERATURE, AND SOIL COVER

½ in. cover	Percentage germination					
	58 degrees F.		68 degrees F.		77 degrees F.	
	Germn.	Abnormal	Germn.	Abnormal	Germn.	Abnormal
Control	83	10	87	8	81	9
2lb./acre	21†	69†	64†	30†	61†	26†
4lb./acre	19†	72†	37†	53†	32†	59†
¾ in. cover	58 degrees F.		68 degrees F.		77 degrees F.	
	Germn.	Abnormal	Germn.	Abnormal	Germn.	Abnormal
Control	82	8	83	11	73	9
2lb./acre	66†	25†	72†	17*	66*	15†
4lb./acre	30†	64†	72†	18*	71	17†

*Difference from control significant at 5 per cent. level

†Difference from control significant at 1 per cent. level

TABLE 3—EFFECT OF SOIL MOISTURE
Percentage germination

½ in. cover	68 degrees F.					
	Dry (8 per cent.)		Moist (10 per cent.)		Wet (18 per cent.)	
	Germn.	Abnormal	Germn.	Abnormal	Germn.	Abnormal
Control	86	9	87	8	67	16
2lb./acre	76	17	64	30	54	37
4lb./acre	59	27	37	53	40	41

DISCUSSION

Q.—What are the residual effects of CIPC?

A.—In experiments where 2lb. and 8lb. of CIPC were applied to bare soil 2 months, 1 month, and 2 days before sowing of a ryegrass white clover sward, 2lb. CIPC applied 2 months earlier almost entirely inhibited the germination of white clover on both light and heavy soils in spite of 10in. of rain having fallen in this period.

Q.—Has there been any evaluation of volatile vapours rather than direct contamination?

A.—In the experiment, with the exception of the instance mentioned, effects were due to volatile vapours rather than direct contact.

Q.—Does 2,4-D applied to ragwort in the late-flowering stage affect the viability of the subsequent seed set?

A.—Seed samples at various stages of maturity have been tested. If seed is still dependent on mother plant, germination is reduced. But if the seed has hardened and is dissociated from the plant, it is more resistant.

Q.—Are there any physical or physiological characteristics of the seed which will permit an estimate of its degree of resistance or susceptibility?

A.—Rape seed appeared most susceptible and wheat and ryegrass least, but the basis of resistance is unknown.