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EXPERIMENTS ON DEFOLIATION OF CLOVER SEED CROPS

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Summary

1. The technique of pre-harvest spraying of clover seed crops to facilitate harvesting is described and its advantages explained.

2. The results of five experiments on defoliation of clover seed crops in 1954 in the East Midland Province are summarised and three experiments in 1955 more fully reported and discussed.

3. The experiments, together with experience gained from field scale spraying by farmers in the province, show that the technique of defoliating clover seed crops is both practicable under English weather conditions and likely to prove of great value for red clover seed crops.

Introduction

Of our agricultural crops there are few so dependent on favourable weather conditions for harvesting as the clover seed crop. Owing to the vagaries of our climate the taking and harvesting of clover seed is of an opportunist nature, which results in wide fluctuations of supplies and prices from year to year. Supply shortages have to be made good from importations, often of strains of plants less suited to our conditions. Any method by which harvesting can be simplified, hastened and thereby rendered less of a risk in bad weather will help to ensure a more level supply of home-grown seed at a reasonable price. Such a technique has been tried out experimentally and on a field scale in this country during the past few years, namely the pre-harvest defoliation of the seed crop. The purpose of defoliation is to kill off the green leaf and stem of the clover and any weeds instead of allowing them to wither naturally, so that harvesting may be carried out earlier and in more favourable weather and so that crops may be combined direct instead of using more laborious and less efficient methods. The process would perhaps be more correctly described as desiccation, for the essence of it is the withering and drying of both stem and leaves so that the threshing drum is not clogged with green-stuff. Spraying is carried out when the seed has reached the normal stage of maturity for direct combining, and combining may begin from two to seven days afterwards depending on the chemical used and the weather after spraying.

The technique of defoliating legume seed crops to facilitate harvesting has been practised on a wide scale in the U.S.A. for some years, but has only been tried out in this country during the past year or two. Acid spraying of clover seed crops was tried successfully from 1953 onwards by at least two East Midland farmers, and is now used by many more. The first experiment in this country was carried out in 1953 by the A.R.C. Unit Oxford in conjunction with Mr. John Davies, N.A.A.S. Grassland Officer, West Midland Province and gave very promising results on a crop of Late flowering red clover.

1954 Experiments

In 1954 and 1955 experiments were carried out by several N.A.A.S. provinces in conjunction with the A.R.C. Unit, Oxford. Five experiments, including two with large plots for combine harvesting, were laid down in the East Midland Province in 1954 on two crops of Late Flowering Red Clover and one crop of White Clover. The conclusions drawn from these were -

(a) that all the chemicals used (DNC, endothal, sulphuric acid and sodium arsenite) would act successfully as defoliants,

(b) that defoliation of Late Flowering Red Clover seed crops was very promising, one of the two large plot trials being successfully combined despite almost continuously wet weather,

(c) that in very wet season the direct combining of White Clover could still be impracticable after defoliation because of the speed of re-growth.

1955 Experiments

Experimental method

Three large plot trials were laid out for combine harvesting on two crops of Late Flowering Red Clover and one of Broad Red Clover in the East Midland Province. Single plots 40 yd x 5 yd were sprayed with the following chemicals.

1. Sulphuric acid (sprayed as neat B.O.V.) 20 gal/ac (12 gal only on one site)

2. DNC oil emulsion 4 lb/ac a.e. sprayed at 30 gal/ac.

3. Sodium arsenite 10 lb/ac As_2O_3 equivalent sprayed at 30 gal/ac.

4. PCP (pentachlorophenol) in diesel oil 5 lb PCP in a total of 15 gal/ac oil.

5. (1 site only) sulphuric acid 8 gal/ac BOV.

A control plot (unsprayed) was included in each trial.

Assessments were made by observations, scoring on degree of desiccation of leaf and stem separately and on ease of combining, and by moisture, germination and seed size tests on samples from the combine.

Results

The main results are summarised below.

Degree of desiccation

The following table gives the final scorings made from 4 to 11 days after spraying:

(10 = maximum desiccation, 0 = no desiccation)

Centre	Sulphuric acid	DNC	PCP	Arsenite	Control (natural desiccation)
LEAF					
A	9	8½	8	7½	2½
B	10	10	10	10	6
C	* 6	8	9	9	1
Means	8.3	8.8	9.0	8.8	3.2
STEM					
A	8½	4	5	3	1
B	9	5	7	7	0
C	* 3	5	8½	9	1½
Means	6.8	4.7	6.8	6.3	0.8

* Only 12 gal of acid was sprayed at this centre and coverage was insufficient.

All treatments gave reasonably good desiccation of the leaf, but the effect on the stem varied. Taking the effect on the leaf and stem together, sulphuric acid was the most effective, except at one centre where the rate of application was too low. DNC, PCP and arsenite all gave similar results on the leaf, but DNC was less effective on the stem than the other two.

Speed of action

Acid had the quickest action, followed closely by DNC and PCP. Arsenite was considerably slower, taking up to a week to show its full effect.

Ease of combining

Allowing for the anomalous result for acid at Centre C, the treatments were placed in the following order (1) Acid (2) PCP (3) DNC and arsenite (4) Control i.e. the ease of combining corresponded very closely to the observed degree of desiccation. The differences between spray treatments were slight, but all treatments combined much more easily than the controls.

Moisture content

All defoliation treatments tended to reduce the moisture content of the seed slightly; the best treatments did do by 1 - 1.5% on crops with 11 - 14% moisture in seed from control plots.

Germination and seed size

N.I.A.B. have supplied the following figures:

Treatment	Germination + hard seeds %			Hard seed content %		
	Centre A	B	C	Centre A	B	C
Control	87	87	75	16	30	10
Arsenite	86	87	74	17	30	18
Acid 12-20 gal	79	78	80	20	31	15
Acid 8 gal	91	-	-	21	-	-
DNC	86	81	74	19	32	11
PCP	91	80	78	23	30	14

There are no consistent differences between treatments in the total germination figures. In spite of the results from Centre B which are of doubtful value because of special circumstances affecting the trial, there is no reason to suppose that the treatments other than acid have had any effect on germination. Taking these results in conjunction with those for 1954, it seems possible that sulphuric acid applied at rates of about 20 gal/ac may depress germination slightly under some circumstances, as at Centre A. The 8 gal rate at Centre A and the 12 gal applied at Centre C did not affect germination.

The "hard seed" figures for Centre A and C indicate that one effect of spraying for defoliation is to increase slightly the percentage of hard seed, and there is other evidence to the same effect.

N.I.A.B. also determined the proportion of smaller seed in the samples by dividing them into two fractions designated "large seed" and "medium seed" which were those caught by 1.5 mm and 1.0 mm sieves respectively. Small seed passing through the 1 mm sieve was almost nil in all cases. There are no consistent trends to be seen in the proportions of large and medium seed which therefore suggests that the spray treatments have no effect on the proportion of undersized seeds in the sample.

Arsenic content of crop

The herbage of the plots sprayed with sodium arsenite was sampled on the day of harvesting and the arsenic content determined by the Nutrition Chemist's Department, Shardlow as follows -

Centre	Arsenic content of dry matter as parts per million As_2O_3
A	5
B	40
C	40

There was exceptionally heavy rain within a few hours of spraying at Centre A which probably accounts for the low figure. At the concentration quoted for the other two trials, the minimum lethal dose of arsenic as sodium arsenite taken by the mouth for the adult bovine is represented by about 30 lb dry matter intake of the herbage.

Discussion

The experiments carried out in this province and elsewhere, together with knowledge gained from field scale spraying have shown that the defoliation or desiccation of clover seed crops is a practicable technique under English climatic conditions. The two years in which first-hand experience was gained in this province provided two extremes of harvesting weather; the first was exceptionally wet and the other exceptionally dry and sunny. In 1954 very little red clover seed was harvested by any method, yet one of our two experiments was successfully combined direct. The severe drought in the summer of 1955 combined with the hot and dry weather at clover harvest time enabled many crops of red clover to be combined direct without the need for defoliating sprays. Conditions of this kind, however, probably do not occur more often on an average than 1 year in 20 and it is in the normal harvesting weather with wet and dry spells alternating, that chemical defoliation is likely to prove most valuable to the farmer. Under these conditions the spells of fine weather would generally allow of direct combining if the crop were in a fit state, yet there is sufficient moisture to keep the crop green until late in the season.

Of the six crops on which experiments have been carried out, four have been Late Flowering Red Clover, one Broad Red Clover and one S.100 white clover. There has been therefore sufficient experience to show the effectiveness of chemical defoliation of Late Flowering Red Clover but not enough evidence yet to generalise about Broad Red or White. The one experiment on Broad Red did not reveal any appreciable difference from the Late Flowering type nor is there reason to expect any. We therefore expect that the technique will be equally successful with all types of red clover. The position with White Clover is not the same, because of the big difference in growth habit between the two clovers. The one experiment carried out in 1954 was on a dense leafy crop grown with S.23 ryegrass as companion in a wet season and it is doubtful whether the degree of defoliation originally achieved would do. In any case the weather following spraying made combining impossible while encouraging rapid regrowth of the clover. In the exceptionally dry and sunny summer of 1955, however, a crop of white clover was successfully combined on a field scale after defoliation with acid. It is clear that weather conditions are far more important with white than with red clover in determining whether defoliation and direct combining is practicable.

Any possible detrimental effect of defoliation spraying on the seed itself is obviously of great importance and has been studied in these experiments. The data collected show that for most of the treatments there is no harmful effect on total germination or seed size, though there is a possibility that high rates of sulphuric acid may depress germination by a few per cent. The tendency to a slight increase in the content of hard seed with all the defoliation treatments tested has also been found in other experiments. Since it occurs with several chemicals of widely varying properties and modes of action it is probable that it arises from the effect of defoliation on the plant and not from any chemical effect on the seed itself. A slight increase of hard seed content is, however, unlikely to affect the commercial value of a crop.

The experiments under review have shown relatively small differences in effectiveness between the chemicals tested. Sulphuric acid has proved the most efficient, but DNC, sodium arsenite and PCP in diesel oil are almost as good and other factors than efficiency will generally be more important in deciding choice of materials. There is little to choose in effectiveness between the last three mentioned chemicals at the rates used in the experiments. It should be remembered that the rates of application chosen were to some extent arbitrary

and it may be that slight differences in effectiveness would be eliminated or reversed at optimum rates. Choice between available chemicals will depend mainly on availability, cost, safety and convenience.

The figures quoted for arsenic content of herbage show that there is a real danger of poisoning of stock if animals break into clover seed fields sprayed with sodium arsenite at the rate used in these trials. It would need a full day's grazing of herbage with an arsenic content of 40 p.p.m. for cattle to take in the minimum lethal dose of arsenic of 1 g, but this is by no means impossible with off-lying stock, and it is quite possible that concentrations higher than this may be found in some parts of a field or under different conditions. This, and the possibility of poisoning from careless disposal of empty tins or surplus material, constitutes a serious risk when using sodium arsenite and must be weighed against its cheapness and ease of application.

The most important question to be answered in connection with chemical defoliation is "Will it pay?". The final answer will, of course, have to be worked out on farms under varying circumstances of weather, labour and machinery supply and other relevant factors. Attempting to answer the question resolves itself into weighing the advantages of direct combining plus the extra cost of defoliation against the alternative harvesting methods. The most common method of harvesting red clover seed crops in this province is to cut with a mower and dry out in the swath, turning as necessary, and then either put the crop on tripods or into a stack. The tripoded crop may be threshed in the field if weather permits or stacked when fit. These methods need a lot of labour and are correspondingly expensive and the repeated moving and handling of the crop loses an appreciable amount of seed. There is also the danger of losing the crop because of bad weather while it is lying on the ground. By contrast, direct combining means cheaper harvesting, little or no loss of seed and greater certainty of safely harvesting the seed. Bad weather after spraying will do little harm to a defoliated crop, and being leafless it dries out rapidly during fine spells. The cost of defoliation which is likely to vary between £1 5s and £3 10s/ac according to chemical used, seems a small price to pay for these benefits and is likely to be repaid by saving of harvesting labour alone. Certainly where the farmer already possesses a suitable spraying machine or where profitable use can be made of one for weed control spraying, the cost of defoliation will be low and very well worthwhile.

DISCUSSION ON THE PREVIOUS PAPER

Mr. G. W. G. Briggs (Introduction to discussion)

This interesting, and as far as this country is concerned, relatively recent development needs, I think, to be studied against the general background of clover seed production in the country and of our seed requirements.

Our normal annual requirements are of the order of 700-800 tons for white clover and a little more for Late Flowering red clover. It is difficult to give an accurate figure for Broad Red clover as not all seed passes through the normal trade channels, but it seems to be certainly not less than 3000 tons and we usually prefer to take a figure of 4000 tons.

The variable weather conditions experienced from year to year have their effect on home production. Consequently, deficiencies have to be made up with imports, and it is not always possible to secure what on technical grounds are the strains or types most suited for our conditions.

Any reduction in the supply of home grown seed is due to two factors. First, inadequate pollination due to unfavourable weather conditions affecting pollinator activities adversely. I mention this to emphasise that in considering alternative harvesting methods one wants to be assured that there is seed to harvest. The second factor is inclement weather at harvest time, for instance in 1956 it is estimated that at least 75% of the acreage of white clover put up for seed has had to be written off owing to harvest difficulties in August. The position with red clover has not been quite so serious but has by no means been easy.

Anything that can be done to facilitate harvesting of clover seed, therefore, will help towards a more consistent supply of seed of our own adapted strains.

Traditional methods of harvesting cutting, cocking or tripoding and stacking are generally found under reasonable weather conditions to result in a lower loss of seed and possibly in a better sample of seed than direct combining. But there is always the risk of loss of crop owing to weather and, of course, labour costs can be high.

Direct combining, particularly of Broad Red clover, has been widely practised in recent years, largely to reduce labour costs and to take advantage of breaks of good weather when conditions are difficult. The defoliation investigations were initiated to see how far such a technique would facilitate direct combining, particularly under conditions conducive to leafy growth and how far combining efficiency could be stepped up.

The experiments so far carried out suggest that there is reason to hope that the desiccation may be a useful aid to harvesting, but there are a number of points which still require further study, and I would like to suggest that in the course of discussion it might be profitable to consider some of these. Those which occur to me are:-

1. Efficiency of desiccation as determined by the chemical used, and the penetration of the spray. To some extent penetration is dependent on the condition of the crop. Is it possible for instance that with heavy

laid crops of later flowering red clover two applications of spray will give better results than one, having regard to the cost.

2. Regrowth of white clover after spraying.

3. The importance of correct timing of application to secure not only effective desiccation but also a reasonable seed sample.

4. Disadvantages of certain chemicals under normal farm use despite their efficiency as defoliants, for instance, difficulty of handling and toxicity to man and animals, not forgetting pollinating insects.

5. The necessity to use the combine intelligently in harvesting sprayed crops.

6. Finally the economics of chemical desiccation. The authors of the paper ask the pertinent question "Will it pay?" Obviously this depends on circumstances but equally obviously a reasonable cost per acre is necessary if the technique is to be adopted by seed growers.

Mr. B. H. Bagnall

Would the speakers give some idea of the effects of these compounds on the strength of the red clover stem as there appears to be a tendency to cause the crop to flatten which is disadvantageous in a wet season.

Mr. C. V. Dadd

Reference is frequently made to mixing herbicides in paraffin or diesel oil rather than fuel oil or gas oil - this is rather misleading to the farmer who takes the terms literally and pays exhorbitantly to the Chancellor of the Exchequer. Please may we have a term to define these things.

Mr. J. F. Ormrod

We noticed stem flattening in some of our experiments but did not conclude that any one particular chemical was concerned. We assumed it was caused by a combination of weather conditions, relative vigour of growth and lapse of time after spraying but further information would be welcome.

Mr. B. H. Bagnall

We have found it with endothal at 2 gal/ac but at 1 gal were free of it and where sodium arsenite mixtures were used by local farmers at 10 lb/ac, there have quite frequently been examples of flattening.

Mr. P. F. Le Brocq

Did Mr. Ormrod find that as a result of clover defoliation there was an increase in combine working time per day, since very little dew was present morning and night on the dead foliage.

Mr. J. F. Ormrod

After desiccation the crop consists of bare stems carrying the seed heads, with little or no leaf. Wind is obviously going to dry out such a crop more quickly than a leafy one and one would therefore be able to start combining

correspondingly earlier in the day. However, the real point is that before now direct combining of clover seed crops has usually been impracticable. Without chemical desiccation it is only possible under the most favourable conditions of growth and harvesting weather, and one cannot therefore realistically compare direct combining with and without desiccation.

Mr. Briggs has referred to a possible reduction of yield with the new technique of desiccation followed by direct combine harvesting. This may be true of American conditions, where settled weather allows seed crops to be harvested by the traditional method with a minimum of handling of the crop, but I do not think it applies to this country. Here the crop has to be moved much more in the swath to dry it and the risk of total loss of crop owing to settled bad weather is a very real one. Those of our farmers who have tried the new technique think they are getting more seed rather than less by combining direct after spraying.

Mr. G. W. G. Briggs

Most loss of seed is due to combining too fast with too much seed being thrown out over the back.

Mr. F. R. Stovell

We have had quite a bit of user response to PCP emulsion which does not cause flattening. In the very quick kill obtained by Mr. Ormrod, how much oil was used in DNC emulsion.

Mr. J. F. Ormrod

I think flattening is less likely to occur when the time between spraying and combining is short, so that a quick acting defoliant is desirable. We used 4-5 lb PCP in 10 to 15 gal/ac of gas or fuel oil, no water being included.