CLOVER TOLERANCE

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A 19th century proverb states that "When you can tread on nine daisies at once spring has come." But in this, the 20th century, we hope to show that with the aid of chemical weed control by selective herbicides spring will be noticed by the conspicuous absence of these intruders, for they will be replaced by an even more luscious new growth of grass and clovers, which characterises this season of the year.

In any selective weed control work in pastures we have to know the effect of weedkillers on the weeds, clovers, and grasses. Clover is an essential constituent of grazing pastures. Results of trial work on problem weeds indicated that clovers were being damaged to varying degrees by different weedkillers. This led to the need for special field experiments to examine more accurately the comparative effect of weedkillers on the three main clover species used in our pastures—white, red, and subterranean clovers.

DETAILS OF TRIALS

Twenty-one trials (9 are still in progress) have been put down to date to test the tolerance of clovers to various types of weedkillers. Trials were on a small plot scale, and pure sowings of clovers were made, with the exception of one trial. Heavy rates of clover seed were sown to enable the clover plants to establish with sufficient density to obtain good comparative figures of the effects of weedkillers.

METHODS OF ASSESSMENT

Initially, trials included weedkillers differing markedly in their effects, and only big differences in the susceptibility of the clovers could be discovered. Our latest trials, which are well replicated, are designed to examine smaller differences between treatments by grouping the less severe preparations together in one set of trials and the more toxic preparations together in another set of trials.

Differences in clover density are assessed by regular field observations and quadrat counts of seedling and young established plants both before spraying and 2 months after spraying. Once plants are mature counting of individual plants is difficult and the point analysis technique is used to measure differences in clover density. "Before" counts are used as a check on the uniformity of the plots, and these figures clearly show differences in the density of clover establishment before they are sprayed. We are trying to reduce this initial variation by improving experimental technique.

For the earlier trials the degree of damage is shown as a percentage of the control, which equals 100 per cent. For the later trials an area in the centre of each plot was pegged out, and all plants within this area were counted before spraying. The same area was counted again 2 months after spraying. These results are quoted as the percentage survival of plants. Clover sown in pure stands is usually more tolerant and recovers more rapidly than when it is competing with grasses in a pasture. It is likely, therefore, that the degree of damage measured in these trials is actually less than would occur in the normal grazing pasture.

RESULTS

In trials all hormone preparations were applied at 1lb. acid equivalent per acre unless specifically stated. DNBP was usually applied at 1.7lb.

DNBP ammonium salt
DNOC ammonium salt

IPC prophan
CIPC prophan

phenol equivalent. DNOC was applied at 4.83lb. phenol equivalent. MH was applied at MH equivalent. Dalapon and TCA are given as the sodium salt equivalent. Rates of 1 to 4lb. (based on carbamate equivalent) were used for IPC and CIPC. TCA was applied at rates of 5 to 20lb.

WHITE CLOVER

Pre-emergence: Applied at this stage rates of 1 to 4lb. of IPC and CIPC caused no damage to white clover, but it was very susceptible to TCA. The effect of TCA increased in severity as rates increased from 5 to 20lb.

When hormone preparations have been applied as pre-emergence treatment in crop trials all clover that germinated during the period that the weedkillers were effective in the soil were killed. This does not apply in the case of Oktone applied at this stage.

Seedling stage (2 to 3 true leaves): The effect of various weedkillers is shown in Table 1.

White clover was most tolerant to ammonium salt of DNBP and the density of these plots was only slightly less than the control. Plants were equally as large and vigorous as those on the control plots. Amine salt of DNOC was more toxic than ammonium salt of DNBP at this stage.

Sodium salt of MCP (not based only on the 2,4 isomer content) was most severe. Although not statistically significant, it seems likely that the ethyl ester of 2,4-D was more selective than sodium salt of MCP. Ethyl ester of 2,4-D caused a 50 per cent. reduction in plant numbers, whereas sodium salt of MCP caused a 75 per cent. reduction. When similar oil based formulations were compared (for example, butyl ester of MCP and ethyl ester of 2,4-D), MCP was still more severe than 2,4-D, even though the butyl ester of MCP was based on a non-aromatic oil.

The most toxic preparation was 2,4,5-T, whether applied as an alkyl ester or a higher non-volatile ester. When 2,4,5-T was activated with ATA it was significantly more severe than 2,4,5-T alone.

Results from another trial carried out under dry summer conditions showed that potassium salt of MCP (based only on the 2,4 isomer content) was a very selective preparation, and white clover was only slightly reduced in plant numbers. Butyl ester of MCP was more harmful than the water based MCP formulations. (See Table 2).

The butoxy ethanol ester of 4-C caused no damage on white clover.

Dalapon (10lb.) severely damaged the seedling plants. The counts slightly under-estimated this damage, as many plants were present, but appeared lifeless. This chemical was slow in its action, as many of the white clover plants had stolons, and these must have developed after spraying before the foliage started to die.

Seedling white clover was severely checked by TCA at all rates of application, but the heavier rates had a more severe effect. After 8 to 9 months the plants had made nearly full recovery. CIPC and IPC had no effect when applied at either the 2 to 3 true leaf stage of growth or at the semi-mature stage of growth.

The sodium salt of MH at 0.4lb. MH equivalent caused a very slight reduction in plant numbers.

Young Established Plants—Semi-mature (See Table 3)

Both DNBP and DNOC caused no damage.

Sodium salt of MCP (not based on the 2,4 isomer) was very selective by the time white clover had become established. Ethyl ester of 2,4-D appeared in the field to be less selective than sodium salt of MCP, although differences in plant counts were not significant.

Esters of 2,4,5-T were very toxic, and the few plants surviving the application were stunted and distorted.

No information is available on the effect of 4-C, Dalapon, and 2,4,5-T plus ATA on semi-mature clovers.

MH at rates up to 2lb. had no effect.

Semi-mature white clover plants were considerably reduced in plant numbers by TCA at 10 and 20lb.

Mature: White clover was tolerant of all water based hormones, but esters caused a fair amount of damage. The esters of 2,4,5-T and the water based polyethylene glycol ester of 2,4-D caused the most severe checks. Clover growth can be suppressed for 2 to 3 months with polyethylene glycol ester of 2,4-D, and 80 per cent. of the plants were killed with 2,4,5-T. When sprayed at the flowering stage, the flowers were considerably reduced by MCP and 2,4-D esters, but the vigour of the plants seemed to be affected less at this stage.

Once mature, white clover tolerated 2 to 4lb. rates of MH without being damaged.

Although 10lb. of Dalapon almost entirely eliminated seedling white clover, rates up to 10lb. have caused no suppression of mature white clover. TCA caused a slight burning of the foliage, but that was the only effect. CIPC and IPC, as at the early establishment stages, did not damage white clover.

RED CLOVER

Both broad red (early flowering) and Montgomery red (late flowering) strains of red clover have been tested. There was little difference in the tolerance of these two strains to weedkillers.

Pre-emergence: Red clover was most susceptible to light and heavy rates of TCA applied as a pre-emergence treatment. CIPC and IPC did no harm even at rates of 1 to 4lb.

Seedling Stage (2-3 true leaf stage) (See Table 1)

Although ammonium salt of DNBP caused some damage on seedling plants of red clover, there was no significant reduction in plant numbers. Amine salt of DNOC caused a marked reduction in plant numbers.

Sodium salt of MCP (not based only on the 2,4 isomer content) caused a similar amount of damage to ammonium salt of DNBP (25 per cent.) but the reduction in plant density was not significant.

Both ethyl ester of 2,4-D and butyl ester of 2,4,5-T eliminated nearly all seedling red clover. A few twisted and distorted plants remained on these plots. These plants were very brittle and disintegrated when touched. Other formulations, such as the butoxy ethanol ester of 2,4-D have also proved to be as toxic as the ethyl ester of 2,4-D on seedling red clover.

With the addition of ATA, 2,4,5-T appeared in the field to be even more severe than 2,4,5-T alone, although differences in plant numbers were not statistically significant.

Both potassium salt of MCP (based only on the 2,4 isomer content) and butoxy ethanol ester of 4-C very slightly reduced the number of plants of seedling broad red clover, but with 4-C there was a more noticeable retardation of growth than with potassium salt of MCP (Table 2). Two months after spraying, broad red clover plants on the control plots were flowering, some plants were flowering on the potassium salt of MCP plots, and no plants were flowering on the 4-C plots. Butyl ester of MCP caused at least 15 per cent. more damage than the pure 2,4 isomer of MCP.

Dalapon (10lb.) was very severe, but here again as for white clover, a number of plants appeared to be dying, but were not dead when the counts were made.

Seedling red clovers were very susceptible to TCA, and few plants recovered. CIPC and IPC had no effect at this stage of growth or at any later stages of growth.

The sodium salt of MH, when applied at 0.4lb. MH equivalent to seedling red clover had no adverse effect. All the plots treated with MH were indistinguishable from the control plots.

Preparations of the phenoxypropionic acid series have been included in the trials which are being carried out at present. Interim results have indicated that there was little difference between 2,4-DP and 2,4,5-TP and standard preparations of 2,4-D and 2,4,5-T on red clover. Mixed polypropylene glycol butyl esters of 2,4-D appeared to be more severe than butyl ester of MCP.

Young Established Plants (Semi-mature) See Table 3

Both phenol preparations were very selective on young established plants of red clover.

Sodium salt of MCP (not based only on 2,4 isomer content) was equally as selective as ammonium salt of DNBP.

Even at the semi-mature stage the ethyl ester of 2,4-D caused a marked reduction in plant numbers. All formulations of 2,4-D (water based or oil based) badly damaged red clover.

Esters of 2,4,5-T were also very severe.

MH at rates up to 2lb. was very selective.

TCA applied at the heavier rates reduced the density of semi-mature red clover.

Mature: The water based MCP preparations were very selective on mature red clover. But all preparations of 2,4-D were severe. The polyethylene glycol ester of 2,4-D was more severe than amine salt of 2,4-D. When sprayed at the flowering stage 80 per cent. of the flower heads were reduced and the plants were slightly distorted. Montgomery red clover usually made a better recovery than broad red clover.

MH at rates of 1 to 4lb. was a very selective weedkiller.

TCA slightly retarded the growth of red clover when applied at 20lb. and the foliage was burnt. Lighter rates of TCA had little or no effect.

SUBTERRANEAN CLOVER

Pre-emergence: Treatments of TCA proved to be very toxic on subterranean clover. CIPC and IPC when applied at pre-emergence and at the other stages of growth did no damage.

Seedling Stage (2 to 3 true leaf stage) Table 1

At the seedling stage ammonium salt of DNBP caused some damage (25 per cent.) on subterranean clover. Amine salt of DNOC was more severe than ammonium salt of DNBP.

Sodium salt of MCP (not based only on the 2,4 isomer content) caused a similar reduction in plant numbers to DNBP. Butyl ester of MCP caused slightly more damage than sodium salt of MCP.

The ethyl ester of 2,4-D and all other formulations of 2,4-D appeared in the field to be a little more severe than MCP preparations, although differences in plant counts were not statistically significant.

Esters of 2,4,5-T were very toxic. The combined effect of 2,4,5-T with ATA has not yet been clearly demonstrated in our trials.

Potassium salt of MCP (based only on the 2,4 isomer content) very slightly damaged seedling subterranean clover, when applied in summer (Table 2).

Although differences in plant density of the control plots and butoxy ethanol ester of 4-C were not significant, field observations showed that growth was retarded, and subterranean clover appeared to suffer more retardation of growth than red and white clovers. As subterranean clover is an annual, its persistency in a pasture relies on its setting of seed each season and retardation of growth is therefore more serious than for the perennial clovers.

Dalapon (10lb.) caused a significant reduction in plant numbers; plants that were present on the plots appeared to be dying.

Seedling subterranean clovers were severely checked by TCA at all rates. Heavier rates had a more severe effect. After 8 to 9 months clover made full recovery.

Seedling subterranean clover was very tolerant to the sodium salt of MH applied at 0.4 MH equivalent.

Interim results have indicated that there was little difference between the mixed esters of 2,4-DP and of 2,4,5-TP and standard preparations of 2,4-D and 2,4,5-T.

Young Established Plants (Semi-mature) Table 3

Phenol preparations (ammonium salt of DNBP and amine salt of DNOC) and sodium salt of MCP (not based only on the 2,4 isomer content) were very selective. Ethyl ester of 2,4-D was less selective. The plants on the ethyl ester of 2,4-D plots were stunted and twisted.

Esters of 2,4,5-T caused severe damage. However, the important observation was made that subterranean clover was significantly less damaged if sprayed when well established than when at the seedling stage. It was possible that late germinating hard seeds might have influenced this result.

Semi-mature subterranean clovers were reduced in plant numbers by 10lb. and 20lb. of TCA.

Mature: Mature subterranean clover was tolerant of all the MCP and 2,4-D preparations employed in the trials. It proved to be particularly tolerant when it was sprayed at the end of its growing season, at a time when the foliage was beginning to die and seed had been set. Esters of 2,4,5-T severely reduced subterranean clover.

RATES OF APPLICATION

When hormone weedkillers were applied at $\frac{1}{2}$ and 1lb. rates there was little difference in clover tolerance. At heavier rates above 1lb. these preparations generally became less selective. A level of toxicity sufficient for killing or considerably reducing clover plants was reached at and above 2lb. As the rates of application were increased recovery after spraying was slower. It was difficult to assess the difference in the degree of damage from light and heavy rates of application of a very toxic preparation such as the esters of 2,4,5-T, as the effect of 1lb. was sufficient to cause such a marked reduction in the number of clover plants.

When considering the effect of rates of application of phenol preparations the weather conditions at the time of spraying must be taken into account. The rate of 1.7lb. phenol equivalent was used in the trials at a temperature of 55 degrees. This rate would have to be lowered at higher temperatures.

COMPARISON OF FORMULATIONS

Salts and amines of all hormone weedkillers were less severe than esters on the three clovers.

When not based on the 2,4 isomer content all formulations of MCP were more toxic to clover than equivalent preparations based only on the 2,4 isomer content. In all cases the butyl ester was more toxic than the salts and amines.

The water based polyethylene glycol ester of 2,4-D was more severe than the oil based esters. Amine salt of 2,4-D applied at 2lb. acid equivalent caused no more suppression of white clover than the polyethylene glycol ester of 2,4-D applied at 1.5lb. acid equivalent.

There has been little difference in the selectivity between the lower alkyl esters and the higher esters, such as the butoxy ethanol and similar esters; for example, both the ethyl ester of 2,4-D and the butoxy ethanol ester of 2,4-D reduced red and subterranean clovers to a similar degree of severity.

When two non-volatile esters of 2,4-D—butoxy ethanol and alkyl cyclo-hexyl—were compared, the density of mature white clover (measured by the point analysis technique) was reduced 73 per cent. by the alkyl cyclo-hexyl, and even more severely (87 per cent.) by the butoxy ethanol ester.

COMPARISON OF TOLERANCE OF WHITE, RED, AND SUBTERRANEAN CLOVERS

When white, red, and subterranean clovers were compared there was little difference in their tolerance to phenol preparations, but they differed in their tolerance to hormone weedkillers.

The most noticeable differences occurred with similar formulations of MCP (not based only on the 2,4 isomer content) and 2,4-D applied at the seedling and semi-mature stages of growth. These differences are shown by comparing the three clovers in Tables 1 and 3.

On seedling red clover 2,4-D was more toxic than on white or subterranean clovers, but MCP was more damaging on white than on subterranean or red clovers. Although 2,4-D appeared a little more selective than MCP on seedling white clover, it could not be recommended for use in a young pasture, as at least 30 to 50 per cent. of the seedling white clover plants were killed. Subterranean clover was the most tolerant of the three clovers to these two preparations.

Once the clovers had become well established MCP was a very selective preparation on all three clovers. White clover became more tolerant of MCP as it became colder, and at the semi-mature stage of growth MCP now appeared more selective than 2,4-D. When a formulation of MCP, based only on the 2,4 isomer content, was compared with 2,4-D at this stage of growth the difference in selectivity in favour of MCP was more marked.

Red clover was more susceptible to 2,4-D than the white or subterranean clovers. White clover appeared in the field to be the least distorted, and to make the quickest recovery.

SUMMARY

1. In all tolerance studies of clovers to hormone weedkillers the effect of the type of parent acid was greater than the effect of the formulations.

2. Salts and amines should be used wherever possible in preference to oil based formulations.

3. Seedling clovers were more susceptible than established plants to hormone weedkillers, and choice of material is particularly important at the seedling stage of growth.

4. The most selective preparation to use on: (a) Seedling white clover

is ammonium salt of DNBP; (b) seedling red and subterranean clover is MCP (based on the 2,4 isomer) or ammonium salt of DNBP.

5. Phenols and MCP (based on 2,4 isomer) can be used on established clovers. All formulations of 2,4-D can be used on white and subterranean clovers, but not on red clover. At no stage of growth can 2,4-D be used for spraying weeds in red clover pastures.

6. Esters of 4-C are selective preparations on red and white clovers (especially white clover) at all stages of growth, but they cannot be used for subterranean clover, as they retard the growth of this clover. However, the efficiency of 4-C as a weedkiller has still to be proved.

7. Esters of 2,4,5-T are very toxic to all clovers. If these preparations have to be used for woody plants, the pasture should be sprayed in summer, which is the time of the year when clover damage is of less consequence.

8. Carbamates do not damage clovers at any stage of growth, but TCA and Dalapon can only be applied to mature clovers.

9. MH does not harm clovers.

10. Seedling subterranean clover appeared to be the most resistant of the seedling clovers to the widest variety of weedkillers. Once clovers were well established all three were fairly resistant to a variety of weedkillers, except for red clover which was very susceptible to all formulations of 2,4-D.

TABLE 1
EFFECT OF VARIOUS WEEDKILLERS ON CLOVERS APPLIED
AT THE 2 TO 3 TRUE LEAF STAGE

Clover	Control	Ammonium DNBP	Sodium MCP	Ethyl 2,4-D	Butyl 2,4,5-T
White	100	88	26	48	19
Red	100	67	73	4	4
Subterranean	100	76	76	67	12

(Comparison with control = 100)

TABLE 2
EFFECT OF VARIOUS WEEDKILLERS ON CLOVERS APPLIED
AT THE 2 TO 3 TRUE LEAF STAGE

Clover	Control	Potassium MCP	Butoxy Ethanol 4-C	Dalapon
White	69	65	78	35
Red	78	70	74	20
Subterranean	90	91	82	27

(Percentage survival of plants)

TABLE 3
EFFECT OF VARIOUS WEEDKILLERS ON YOUNG
ESTABLISHED CLOVERS

Clover	Control	Ammonium DNBP	Sodium MCP	Ethyl 2,4-D	Butyl 2,4,5-T
White	100	90	90	73	17
Red	100	100	100	50	14
Subterranean	100	86	90	70	41

(Comparison with control = 100)