QUANTITATIVE METHODS OF EVALUATING WEEDICIDES APPLIED TO PASTURES

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I AM going to say why I believe quantitative methods of evaluating weedicides applied to pastures are important, and where their place is.

As an example I will give one method which has been used at Grasslands Division and will discuss its advantages and disadvantages.

For the destruction and reduction of weed populations cultivation, spraying with hormone weedkillers, crop management, mowing, chipping, etc., all have their place. But correctly used spraying is gaining favour.

As a rule there are three interdependent objects in spraying:—

First, to kill weeds.

Second, to increase production.

Third, to decrease maintenance costs.

Convincing demonstrations have shown that production can increase after destruction of weeds by spraying, particularly where the initial weed infestation is severe. This success is conditioned by various things, principally plant tolerance to hormone weedkiller. Frequently, weed tolerance differs from crop tolerance sufficiently to allow reasonable latitude in rate and time of application. Cereal crops are cases in point.

Pasture is an association of plants, the tolerance of the most susceptible species being the basis for a comparison with weed tolerance. The difference in tolerance can be large in mature pastures, but is small in juvenile pastures. Thus the choice of material shifts from DNBP to MCPA to 2,4-D and rate of application from low to relatively high. It is important to remember that disturbance of one pasture component will be reflected by a disturbance throughout the others. Of the pasture species the clovers are least tolerant of hormone weedkillers, white clover being more susceptible to MCPA and red clover to 2,4-D. The caution needed when spraying pasture has given rise to compromise rates of applying hormones, which in their turn imply a need for repeated sprayings.

There is urgent need to define the circumstances when spraying is justified. Over the whole range, that is, all weeds—all crop, it is obvious that somewhere between the two extremes lies a range within which the need for spraying is marginal—on production and cost grounds. The spread and positioning of this range will vary from crop to crop and from time to time. At present lack of information renders the accurate positioning of this range speculative.

FIG.1. SPRAY RANGE.

One extreme of the spray range, point A, is clearly defined, but the other extreme, an unknown, will vary between B and C. For my purpose I assume that the unknown and point C are the same. The range A B contains pastures sufficiently weedy to eliminate doubt about the wisdom of spraying. Subjective data will give sound indications for this. The range B C is more uncertain. The combined effects of season, stage of growth, comparative tolerance, and compromise spray rate can give variable results. Personal opinion, with its greater inclination to unconditional weedkilling on the one hand or to increased production on the other, can influence markedly the location of the critical point C, beyond which spraying should not be used. There is an obvious need for quantitative data within this range B C. When this data is available, differences in personal opinion will become less great and the emphasis placed more firmly on actuality.

Although the points B and C may approach each other relatively closely, as with cereals, it seems to me that there will always be a few cases where yield measurements must be made to clarify the position. For pasture B C may always be wide. By quantitative measurements point C will be more accurately located and a number of pastures, which have been sprayed on the toss of a coin, will be left unsprayed and the weeds tackled in a different way. Spraying to kill weeds disregarding other considerations is foolish.

It is fortunate that the collection of quantitative data from weedy pasture is practicable using methods currently employed for measuring pasture production. The usual approach must be modified, because palatability as shown by stock preferences is of greater importance here. Because of this, simulation of grazing is hard, rendering fair and reasonable sampling difficult. Further, grazing by stock is itself a weedkilling influence of notable importance.

THE METHOD USED AT GRASSLANDS DIVISION

Early successful clover establishment is especially important where the seeding has been light. Accordingly, concern was expressed when an autumn sown dairy farm pasture had become infested by weeds in its first spring. Weeds present composed up to 50 per cent. of the total herbage on offer. They were *Rumex obtusifolius*, *Rumex crispus*, *Ranunculus parviflorus*, *Ranunculus repens*, *Ranunculus sardous*, *Sisymbrium officinale*, *Cerastium glomeratum*, *Cirsium arvense*, *Sonchus oleraceus*, *Juncus* spp., *Poa* spp., and *Holcus lanatus*.

With the clovers at the 4 to 5 trifoliate leaf stage of development it was decided to spray, after grazing, with $\frac{3}{4}$ lb. ac. eq. MCP as sodium salt; 13 gallons of water per acre were used as spreader.

It was decided to compare spraying with protection from spraying and grazing with protection from grazing. Thus four treatments evolved:—

- A. Protected from spray and from grazing.
- B. Protected from spray and grazed.
- C. Sprayed and protected from grazing.
- D. Sprayed and grazed.

The variability of the pasture was not known, but it is common for weedy pasture to be more variable than weed-free pasture. A high degree of replication was desirable, but considerations of labour and area enforced a compromise, nine replications being used. For ease of management the replicates were arranged across the pasture in three separate rows of three.

Protection from spraying was effected by laying tarpaulins on the selected 5yd. by 10yd. sites before spraying. Protection from grazing was effected by using permanently sited frames (4ft. x 10ft.), while grazed treatments were sampled using frames moved within the treatment area after each grazing. In this way the influence of the previous grazing could be assessed.

This approach was believed to be better than the difference method, wherein the pasture is sampled immediately before and after grazing. By reasonable shifting of the frames it proved possible to avoid overlapping of frame sites in a 4-month period.

You can deduce that there were four frames, within each replicate, to be sampled at each grazing. A method of sampling which would simulate cow grazing was essential. Possibly in this instance, where weeds were so numerous, a mowing technique may have given satisfactory information, but in most cases this would not have been so. Herbage was cut with shears and scythe, every endeavour being made to simulate grazing. It was difficult to achieve, particularly with regard to the selective neglect by stock of *Ranunculus* spp. The herbage samples secured varied from 1 to 15lb. green weight off $\frac{1}{1089}$ acre, weighed in the paddock. Dry weight varied from 10 to 30 per cent. At least 500gms. of green material was taken by way of sub-sample for dissection. This sub-sample was thoroughly mixed and 100gms. of green weight taken and dissected. Soon after spraying it became possible to reduce the 100gms. to 40gms. green weight. Each dissection sample was broken up into its several component species.

As a necessary adjunct to the yield data, point analysis was performed after some grazings. By its use bare ground, seedling emergence, and changes in habit of growth could be assessed.

THE RESULTS OBTAINED

Distortion and wilting of *Ranunculus* spp. and *Sisymbrium officinale* became apparent within a few hours of spraying. In a matter of days destruction was proceeding apace. *Rumex* spp. (2 to 4 leaved) showed marginal scorch and some plants were killed. Both red and white clovers, originally about 5 per cent. of herbage green weight, showed distortion of petioles and incurling of leaves, the red appearing to be more severely affected. As the trial progressed this observation was proved wrong. In fact, the red clover suffered less severely than did white clover. After a fortnight all sprayed *Ranunculus* spp. showed severe club distortion at the crown with disintegration of the roots. In a subsequent wet period a few plants re-established; otherwise the kill might have been complete.

All sprayed *Sisymbrium officinale* plants withered and disappeared. Other species, sow thistle excepted, appeared to escape the direct effects of spraying. Unsprayed weed and clover plants proceeded as normally, the *Sisymbrium officinale* being characterised by the stiff wiry reproductive growth, which acts as a deterrent to stock grazing.

TABLE 1.—Analyses of Variance for Red and White Clover Dry Weight Yields

Source of variation	d.f.	F reqd. 5% (1%)	F ratios and results of tests		
			Red clover	White clover	Total clover
Blocks ..	8	2.36 (3.36)	1.10 —	1.58 —	1.17 —
Spray (S) ..	1	4.26 (7.82)	3.99 $p=0.06$	26.72 **	12.38 **
Stock (P) ..	1	" "	0.73 —	0.21 —	0.12 —
S x P ..	1	" "	2.29 —	0.67 —	0.36 —
Residual 1 ..	24				
Grazings (G)	3	2.70 (3.98)	10.72 **	10.06 **	13.06 **
G x S ..	3	" "	0.58 —	4.77 **	0.80 —
G x P ..	3	" "	1.75 —	3.69 *	2.31 —
G x S x P ..	3	" "	1.64 —	1.36 —	0.15 —
Residual 2 ..	96				
Coefficients of variation ..			81.5%	98.9%	72.1%

In Table 1 can be seen the gross effect of the experimental treatment over the trial period. The transient nature of the spray effect on red clover can be seen. The delayed recovery of white clover after spraying is indicated by the G x S interaction. There was a gradual reduction in white clover for about 6 weeks and then recovery commenced, slowly at first, but rapidly with the onset of summer. The G x P interaction is difficult to interpret, a likely explanation being that grazing, whether by direct excision or by indirect fertility influence, caused a depression of white clover before the seasonal increase.

TABLE 2.—Analyses of Variance for Desirable Species and Weed Dry Weight Yields

Source of variation	d.f.	F reqd. 5% (1%)	F ratios and results of tests		
			Desirable species	Weeds	Total yield
Blocks ..	8	2.36 (3.36)	1.69 —	1.21 —	1.84 —
Spray (S) ..	1	4.26 (7.82)	0.91 —	38.55 **	7.02 *
Stock (P) ..	1	" "	37.66 **	35.76 **	53.72 **
S x P ..	1	" "	2.82 —	3.72 —	4.36 *
Residual 1 ..	24				
Grazings (G)	3	2.70 (3.98)	7.71 **	31.85 **	13.00 **
G x S ..	3	" "	0.44 —	6.46 **	0.45 —
G x P ..	3	" "	4.76 **	0.90 —	3.64 *
G x S x P ..	3	" "	0.27 —	1.28 —	0.52 —
Residual 2 ..	96				
Coefficients of variation ..			36.8%	56.1%	36.3%

The important influence of grazing on desirable species (ryegrass and clovers) is seen in Table 2. The progressive decline in fertility in permanently protected frames coupled with a rise in grazed frames accounts for much of this influence. Although the effect was not serious in this trial, a longer term would have necessitated the use of a proportional manure return technique.

The gross effect of spraying on weeds can also be seen. Within these figures is a pattern. The elimination of *Ranunculus* spp. and *Sisymbrium officinale* from sprayed areas permitted *Rumex* seedlings

and weed grasses to increase rapidly. It was obvious that desirable species should be encouraged if the full benefits of spraying are to be realised. Where clover has been checked, as here, some further management practice must be used; for instance, oversowing with clover and nitrogenous fertiliser.

In the main, total yield is of academic interest, but the S x P interaction stresses how the spray effect was more marked in grazed than in ungrazed areas.

TABLE 3.—Table of Means for Desirable Species and Weed Dry Weight Yields, with Standard Errors

		Desirable species	Weeds	Total yield
Not sprayed	Not grazed A	281 ± 25	68 ± 8	349 ± 28
	Grazed B	478 "	130 "	608 "
Sprayed	Not grazed C	299 "	34 "	333 "
	Grazed D	412 "	66 "	477 "
Not sprayed		380 ± 18	99 ± 6	478 ± 20
Sprayed		355	50	405
Not grazed		290 ± 18	51 ± 6	340 ± 20
Grazed		445	98	542
General mean		367 ± 13	74 ± 4	441 ± 14

Yield figures in Table 3 show that spraying failed to induce a significant difference in desirable species yield. Further, grazing was associated with a higher yield of desirable species than was protection from grazing. In the sum, grazing coupled with spraying, in this instance, promised to give increased production in time. By extending the trial to 6 months a clearer result would have been achieved.

TO SUMMARISE

This method of assessing the efficiency of spraying appears to be reasonably sound. The facts computed by its use are relatively clear and concrete. Yet there are a number of technical deficiencies.

A more accurate evaluation of the spraying might have been obtained if spray treatments had been located in unsprayed areas as a complement to the unsprayed treatments located in sprayed areas, as here. Ideally—the one pasture should have been used for both tasks. Selective rejection by cows of unsprayed herbage is a powerful reason prompting this opinion.

More replication may have given a clearer picture for the weed species, which were irregularly distributed. The sample size used here for nine replications was adequate for the desirable species but not for each of the minor or weed species, hence it too should have been increased.

The method of sampling, entailing as it did a simulation of grazing, was not completely satisfactory. Repeated sampling of the one spot in the ungrazed plots resulted in any resemblance to grazing being rapidly lost. The non-selective cutting of herbage by shears, etc., meant that weeds were harvested which normally would not be grazed. The net result appeared to be an over-estimate of weed dry weight production, particularly in unsprayed treatments. Further, it was impossible to clip white clover in sprayed treatments as efficiently as did stock. The slump in white clover production which followed spraying was accompanied by a change in habit of growth from large and upright to small and prostrate. Ryegrass became more lax in habit in sprayed treatments, rendering sampling more difficult. In another weed the

prime need for grazing after spraying was made obvious. The failure to return manure to the ungrazed plots caused a rapid decline in fertility. Had the trial been protracted, the comparison between grazed and ungrazed plots might have become invalid.

The measurements proved some observations to have been faulty. It had appeared at first that the spraying was more harmful to red clover than to white clover. The measurements showed that the reverse was true.

It may be seen from the data that this pasture, thought to be reasonably uniform, was of high variability. By the use of the quantitative method personal bias was reduced. Had subjective methods been used, the information derived here could have been obtained only after a large amount of work by many people.

How correct are our ideas of what a pasture should look like? Here are two pastures both sown with the same mixture within the same week after similar preparation, with equally weedy soil, being 100yds. distant from each other. Grazing management has been roughly similar.

Experienced observers judged the unsprayed pasture to be the better. Yet the evidence here presented points to their having been wrong. A weight in a scale pan is more convincing than the eye.

There are numerous difficulties to be overcome before these quantitative methods can approach perfection, but this should be a spur to the quest. Quantitative studies will yield worthwhile information. The killing of weeds is only one aim in spraying, increase in production being equally important. Nor should the important influence of the animal be ignored.

I conclude that the evaluating of a weedicide applied to pasture must be by quantitative means. So-called informed opinions based on questionable subjective data have too often been permitted to exercise undue influence.

DISCUSSION

Chairman. In measuring quantitatively the effect of treatments in reducing or destroying weed infestations it must be realised that some weeds were dealt with in actual practice at a stage when they would not be affecting pasture production to an appreciable extent—yet one knew that if left unchecked, they would affect production seriously. Californian thistle (*Cirsium arvense*), for instance, was in this category. The value of reducing infestations at an early stage would not be obvious in immediate quantitative terms.

In addition, some weeds, for example poisonous weeds, were undesirable in spite of their having little or no effect on pasture production, and the benefit from their removal would not appear in figures obtained in measuring pasture production.

Q.—The main weeds in the trial were buttercups (*Ranunculus* spp.) and docks (*Rumex* spp.), weeds which usually cannot be adequately controlled by grazing management. Buttercup, in particular, could be controlled by spraying. It was surprising that in the trial control was obtained by grazing and not by spraying.

A.—In the trial docks were not controlled by grazing or spraying. There was such a large amount of dock seed in the particular soil that although some of the docks were affected by spraying new seedling plants kept appearing. On the other hand, buttercups were grazed out after some months.