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THE ECONOMICS OF CROP SPRAYING

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FOREWORD

The rapid increase in the popularity of crop spraying in recent years - particularly the use of weed-killers in cereal crops - has been one of the notable features in British farming. Materials have now been developed which are safe and dependable and there can be no doubt as to their effectiveness.

There is less information, however, on the economics of this operation. When a contractor is hired, the cost is known beforehand. Many farmers, however, have purchased spraying machines of their own and others are considering whether it would be to their advantage to do so. Even when he has decided to buy a machine, the farmer may wonder which type he should choose for the size of farm and kind of work which he has in mind. In this report, presented by J.S. Nix, an attempt is made to give the answers to these questions in a simple form. As will be seen, the cost of spraying is low and can be covered in most cases by a very modest increase in yields.

The present writer would like to take this opportunity of thanking the farmers who assisted this department in carrying out the investigation, and the manufacturers who supplied data on spraying materials and machines. Our thanks are also due to the Provincial N.A.A.S., notably to Mr. C.V. Dadd for advice on the technical aspects of spraying and to Mr. H.R. Smith for assistance in obtaining the sample.

F.G. STURROCK.

Provincial Agricultural Economist.

THE ECONOMICS OF CROP SPRAYING

CHAPTER I

INTRODUCTION

1. The Present Position of Crop Spraying in this Country

While the first of the growth-regulating weed-killers was discovered in 1940 and the first low volume sprayer introduced in 1942, it is only within the last five years that weed spraying has reached considerable proportions. Between January 1950 and January 1952, the number of "wheeled and tractor-mounted ground crop sprayers" in England and Wales rose by 123 percent, from 4,188 to 9,326, and it is certain that the 1954 machinery census will show an even greater increase.

It has in fact been estimated that nearly $2\frac{1}{2}$ million acres were sprayed for weed control in this country in 1952, compared with less than 300 acres in 1931. A separate survey recently carried out by this department indicates that some 55 percent of the wheat and barley grown in East Anglia in 1953 was sprayed.

This minor revolution in crop husbandry has by no means run its course, for new spray substances and new techniques are constantly being devised. At the present time, the bulk of the spraying against weeds is low volume work using MCPA or 2,4-D, the growth-regulating selective herbicides popularly known as "hormones". Although the former is more expensive, it is the more widely used of the two in this country and on the Continent, since it is considered to have a wider margin of safety and to give better control of certain weeds. DNOC (first introduced in the 1930's) is more expensive than either, but it controls a wider range of annual weeds than the "hormones", including cleavers and poppies, and can be safely used on crops to be undersown, where the farmer does not wish to risk damaging his seeds by using a dilute solution of MCPA.

2. Types of Sprayer: High and Low Volume Work

There are many types of sprayer on the market, but most of them can be conveniently classified under two headings: low volume (L/V) and high/low volume (HL/V) machines, although it is becoming increasingly difficult to draw an exact line between the two groups.

L/V sprayers work on the hydraulic syatem, the liquid being fed by a gear pump at relatively low pressures to small-orifice atomising jets which apply chemicals in a concentrated form in minute droplets at 5 to 25 gallons per acre. Water requirements are low and the rate of work can be rapid.

HL/V machines are able to do both low volume spraying and work which purely L/V machines cannot perform, notably the application of substances such as Bordeaux Mixture which cannot be readily dissolved or suspended. These require effective agitation in the tank and must be applied as a "drench" type of spray at 70-100 gallons per acre, instead of in fine droplets. Apart from the need for adequate agitation, a suspension of coarse particles could not be applied through small-orifice jets without frequent blockages.

There are also cases where high volume application is necessary for biological reasons. For instance, "hormone" weed-killers used on flax or linseed must be applied in 100 gallons of water per acre since the spray would damage the crop if applied in a concentrated form. Again, some insecticides must be applied as high volume sprays to give effective control of certain pests, e.g. the use of D.D.T. against pea moth.

High volume spraying has two further noteworthy advantages. Firstly, owing to the larger droplet size, there is less danger of the wind carrying the spray on to neighbouring fields, where it might cause considerable damage. The strength and direction of the wind is therefore less of a limitation than it is to low volume spraying. Secondly, high volume spraying is safer in that if by accident too much spray is applied, the excess runs off the plant, whereas a concentrated spray would adhere to the plant and might cause serious damage. Overlapping is a common example of where this might occur.

3. The Sample

For the purposes of this report, data was obtained from forty owners of L/V sprayers and twenty-four owners of HL/V sprayers. Most of these farmers were primarily concerned with spraying on their own farms; some did spraying for neighbours, but none could be called a professional contractor.

All but two of the L/V machines were tractor-mounted and power-driven with tank capacities of 40, 45 or 50 gallons. The HL/V machines were more varied and ranged in tank capacity from 100 to 300 gallons; eleven were power-driven, the remainder having separate engines.

To obtain a picture of spraying requirements under varying conditions, the sample of farms was drawn from a variety of soil types. One-third were situated on light land, one-third on medium to heavy land, and one-third on fenland. As costs were not found to differ significantly between these areas, all farms were grouped together in the analysis.

Further details of the crops sprayed and chemicals used on the sample farms are given in Appendix I. While the original data for this report was obtained in 1952, and the figures given in Appendix I refer to the spraying season of that year, all cost data has been brought up to date and refers to the 1954 spraying season.

CHAPTER II

THE COSTS OF OPERATING A SPRAYING MACHINE

1. Average Costs

The average costs per acre (excluding materials) are given in Table I; they totalled 6s.5d. per acre for the L/V sprayers and 9s.6d. per acre for the HL/V machines. Of these totals, depreciation and interest on capital accounted for over 50 percent in each case(1).

TABLE I. Average Costs per acre (Excluding Materials).

Item	L/V Machines		HL/V Machines	
	s.	d.	s.	d.
Depreciation	2	11	4	8
Interest on Capital		6		10
Repairs		1		4
Maintenance		2		1
Fuel (excluding tractors)		-		3
Labour	1	2	1	6
Tractor(2)	1	7	1	10
TOTAL	6	5	9	6
Average acreage sprayed	160		361	
Number of machines	40		24	

Repair costs were low, averaging only 1d. and 4d. per acre for the L/V and HL/V machines respectively. While the majority of the sprayers costed were fairly new, their owners did not think that repairs would be much higher even in later seasons. This is borne out by the

(1) To be exact, L/V: 53 percent; HL/V: 58 percent. For details of depreciation and interest see Appendix III.

(2) Tractor costs includes a charge for trailers, water carts and the like. Lorries used for water carting are also included under this heading.

average repair costs on sprayers over three years old, which were only 3d. per acre for L/V sprayers and 5d. per acre for HL/V sprayers. There is little to go wrong with these machines, especially L/V sprayers used on only small acreages annually.

Maintenance costs were also light, being only 2d. per acre for the L/V sprayers and 1d. per acre for the HL/V machines. This item includes washing the machine through at the end of each day's work, end of season maintenance (removing booms and nozzles, etc.), and mounting and dismounting where necessary.

Fuel (excluding tractors) was a negligible item for L/V sprayers and averaged only 3d. per acre on HL/V machines. It included fuel consumed by sprayers with auxiliary engines, and by small engines driving pumps for filling the tanks.

Labour and tractor(s) together cost 2s.9d. per acre (43 percent of total costs) for the L/V sprayers and 3s.4d. per acre (35 percent of total costs) for the HL/V sprayers.

It can be seen from Table I that three items: (a) depreciation and interest, (b) labour and (c) tractor costs constitute 96 percent and 93 percent of total operating costs for L/V and HL/V sprayers respectively. Over the first of these the farmer has no control once the machine is purchased. He can, however, reduce the two latter items by more efficient organisation of the work, and this is now discussed in detail.

2. Rate of Work and Time Analysis

(a) Low Volume Sprayers

Considering first the L/V sprayers, the average rate of work was 30 acres per $8\frac{1}{2}$ hour day. On exactly half the farms surveyed, a one-man one-tractor team was employed, spraying 5 gallons per acre; the rate of work on these farms was also 30 acres per day. When the same team was used to spray at 10-15 gallons per acre, the rate of work fell slightly but when a second man was employed either part-time or full-time, it was a little higher.

For the purpose of analysis we shall assume an average rate of 32 acres per day, since this allows an exact number of loads (four) at the most common number of acres per tank-load (eight). This amounts to two hours a load, allowing half-an-hour for preparation in the morning.

The actual spraying time, with a tractor speed of 4 m.p.h. and a 20 ft. spraying width, would be 50 minutes per load. Assuming a field 300 yards in length and one minute per turn at each headland, turning would take another twenty minutes, leaving fifty minutes for getting to and from the water supply and for miscellaneous short stoppages.

It is in this last fifty minutes that time can be saved. Use of a clean water supply (as distinct from muddy ponds and the like) will do most to obviate one heavy time-loser - blocked jets. Travelling to and fro can be cut to the minimum by taking a water cart which can be towed behind the same tractor. If the refilling could be done in ten minutes, including getting to and from a water cart left at the headland, 6 tank-loads, or 48 acres, could be sprayed in an $8\frac{1}{2}$ hour day.

Of the forty L/V machine owners in the survey, only seven averaged over forty acres per $8\frac{1}{2}$ acre day; two averaged fifty acres and one still more. With overtime of course greater acreages than these were sprayed in a day.

Covering a larger acreage per day is, however, less important as a means of reducing costs per acre, which can only be very slight[1], than of making the most of suitable weather conditions and getting the spraying done while the crop is at just the right stage. On small farms, where a continous day's spraying is a rare occurrence, this is obviously less of a problem than on large farms.

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(1) For example, increasing from thirty to fifty acres per day would cut costs by less than 1/- per acre.

Unless there is a larger area to be covered and speed is all-important, one man should be able to carry out low volume spraying single-handed. While an extra man adds less than 1/- per acre to costs and can be usefully employed in carting water, helping to fill, seeing that there is no overlap and that no nozzles are blocked, he can usually be even better employed elsewhere on the farm at that season of the year.

Six farmers used L/V machines to spray materials at 50 gallons per acre (for potato blight, killing potato tops, etc.). The rate of work was then only 9 acres per day and the cost of application increased to 11s.8d. per acre as against 6s.4d. for 5-15 gallon per acre spraying.

(b) High/Low Volume Sprayers

HL/V sprayers vary more than L/V sprayers in tank capacity, boom width, etc. and as their name implies have a wider range of application rates. A working time analysis could be carried out on the same lines as for the L/V sprayers for any particular size of machine spraying any given volume per acre. When high volume work is carried out so much water is needed that an extra man is essential to provide a constant water supply if a reasonable acreage is to be covered in a day. The only exception to this is when clean water is available close to the fields, as is often the case in the fens.

Table II shows how, as the volume rate rises, the rate of work of HL/V sprayers falls and the total cost increases, the result of

TABLE II. Variation in Application Costs with Different Volume Rates (HL/V Machines)

Volume Rate per Acre	10-20 Gallons	25-50 Gallons	70-100 Gallons	Overall average
Rate of work (acres/$8\frac{1}{2}$ hr.)	48	34	21	X
Cost of application per acre	8s. 3d.	9s. 2d.	11s. 7d.	9s. 6d.

higher labour and tractor costs. When applying 70-100 gallons per acre (as for DNOC spraying) these machines averaged 21 acres per $8\frac{1}{2}$ hour day (11s.7d. per acre), and when "hormone" spraying at 10-20 gallons per acre, 48 acres per day (8s.3d. per acre).

3. Average Costs and Contract Charges Compared

So far we have dealt only with the cost of application. To this must be added the cost of materials to give total spraying costs and a figure comparable with contractors' charges.

In Table III average total costs, including materials, of farmer-owned machines are given for various types of corn spraying, along with typical charges of large-scale and small-scale contractors for spraying 10-49 acres. Most quotations made by contractors will lie somewhere between these two.

The cost of materials in 1954 will be as follows[1]:-

MCPA: Single Strength Application:

$2\frac{1}{2}$ pints @ 30/- per gallon
or $1\frac{1}{2}$ " " 50/- " " = 9s. 5d.[2].

Double Strength Application:

5 pints @ 30/- per gallon
or 3 " " 50/- " " = 18s.10d.

Single strength is sufficient to kill susceptible weeds such as charlock, but it is necessary to use double strength when dealing with more resistant species such as docks and thistles.

2,4-D: The general recommendation of one well-known proprietary brand for corn spraying is 1 pint (low volume) or 2 pints (high volume). The costs of these quantities, at 32/- per gallon, are 4/- and 8/- per acre respectively, and these are the costs in Table III. For complete control of some arable weeds, however, anything up to 2-$2\frac{1}{2}$ pints

(1) Prices vary according to the amount bought. The prices given are for medium quantities.

(2) The two sets of application rates and prices given apply to two proprietary brands of differing concentrations. The costs of "hormones" in 1954 are some 20 percent lower than in 1953 and previous seasons.

would be necessary even with low volume application. Other brands have different strengths, recommended rates and prices, but the cost per unit of acid equivalent is approximately the same.

DNOC: 36/- per acre (2-gallon tin).

Table III shows the average costs of farmer-owned machines to be substantially lower than contractors' charges. It is to be noted, however, that the average acreage sprayed per machine surveyed was large (see further Chapter III). Also, it must not be inferred that the charges made by contractors are unreasonably high or their profits

TABLE III. Contract Charges and the Cost of Farmer-owned Machines Compared : Corn Spraying.

A. LOW VOLUME

	Farmer-Owned Machines	Large-Scale Contractors	Small * Farmer-Contractors
	£ s. d.	£ s. d.	£ s. d.
MCPA: Single Strength	15 9	1 15 0	1 5 0
" : Double Strength	1 5 0	2 4 0	1 14 0
2,4-D	10 6	-	1 0 0

* Estimated at approximately 15/- per acre plus cost of materials (1)

B. HIGH VOLUME

	Farmer-Owned Machines	Large-Scale Contractors	Small-Scale Contractors
	£ s. d.	£ s. d.	£ s. d.
MCPA: Single Strength	19 0	2 6 0	1 12 6
" : Double Strength	1 8 3	2 15 0	2 0 0
DNOC	2 7 7	3 8 0	2 18 0

(1) The recommended charges per acre of the British Contractors' Association for 1953 were as follows (plus cost of materials in each case): low volume, 25/-; high volume, 30/- (non-toxic sprays) and 45/- (toxic sprays).

excessive, for the larger concerns in particular have heavy overhead costs to bear. They must carry staffs of men sufficient to carry out spraying whenever it is required, and during the off season these men must still be paid at least a retaining fee. Furthermore, some have large research organisations whose work is of great benefit to the farming industry. The farmer who sprays only a few acres for his neighbours, on the other hand, is often able to quote a lower price. His overhead costs have already been covered by work on his own farm and as soon as spraying is completed the men employed are moved to other work on the farm.

These points, however, do not alter the fact that a farmer with a fair acreage to spray can make a considerable saving by buying his own machine and doing the work himself.

CHAPTER III

WOULD IT PAY TO BUY A SPRAYER ?

1. Low Volume Machines

So far we have been concerned with average costs, but to a farmer considering whether or not to buy a sprayer these can only be of limited value, for the cost per acre depends largely on the number of acres to be treated annually. It is proposed, therefore, to consider here the minimum acreage which would justify the purchase of a sprayer.

The costs of operating such a machine are of two kinds. Firstly, there are the so-called "fixed" or overhead costs - depreciation and interest on capital - which decrease (per acre) as the acreage on which the machine is used increases(1). Secondly, there are the "variable" costs - materials, repairs, maintenance, fuel, labour and tractor costs - which are constant per acre regardless of the acreage sprayed. The

TABLE IV. The Decrease in Costs as Acreage Sprayed Increases. (L/V).

Acres Sprayed per annum	10	20	30	40	50	100	200
	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.	s. d.
Fixed Costs per acre	32 10	16 5	10 11	8 2	6 7	3 3	1 10
Variable Costs per acre*	2 11	2 11	2 11	2 11	2 11	2 11	2 11
TOTAL COST per acre*	35 9	19 4	13 10	11 1	9 6	6 2	4 9

* Excluding materials. The variable costs assumed are the averages obtained in the survey.

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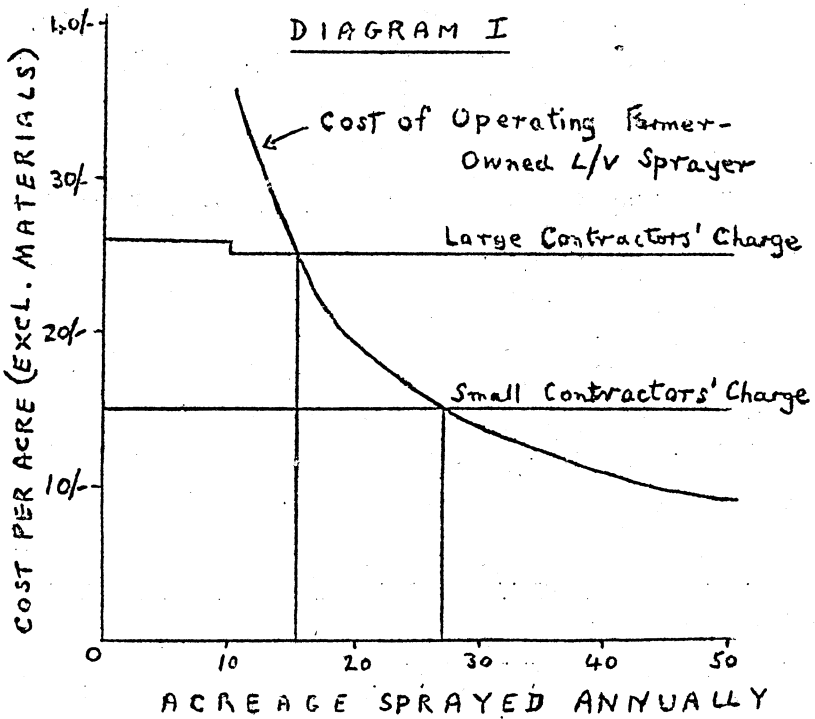
(1) This is assuming, as is reasonable with sprayers applying non-corrosive sprays, that obsolescence and gradual rust and decay with age are more important in restricting the useful life of the machine than what is called "use depreciation". Some allowance is, however, made in this report for a faster rate of depreciation where large acreages are sprayed annually. (See Appendix III).

average cost per acre (excluding materials) of using a L/V machine costing £80 is shown in Table IV; it falls from 35s. 9d. when only 10 acres are sprayed annually to 4s. 9d. when 200 acres are treated. This is the result of spreading the overheads over a larger acreage.

These costs, for 10 to 50 acres, are shown as a curve in Diagram I. Beyond 50 acres the curve flattens out considerably. The two horizontal lines on the diagram represent the two contract rates for low volume



MCPA spraying given in Table III, less the cost of materials to the farmer. For less than 15 acres a farmer-owned machine is more expensive than the highest contractors' charge. For more than 28 acres, a farmer-owned machine is cheaper than the lower contract price given. Between these two figures the question is open and depends on the kind of quotation the farmer can obtain in his district. We can, however, safely conclude that if a farmer has more than 30 acres requiring low volume spraying, it would pay him on grounds of cost to buy a machine.

There are, however, other considerations besides costs. The most important of these is timeliness. A farmer owning a machine can spray when the crop is at exactly the right stage and can choose the best weather conditions. A contractor sometimes comes too late or when conditions are poor; he cannot please all of the people all of the time. Indeed, many farmers in the survey considered this point more important than any possible saving in cost.

A contractor, on the other hand, is less likely to make mistakes that cause damage to the crop than a farmer inexperienced in this work - although the application of MCPA and 2,4-D is not difficult. Further, spraying is an added responsibility and the farmer may not be able to spare the tractors and men at the time required. Corn spraying, for example, may clash with beet hoeing. Nevertheless, the amount of labour required is small and this should seldom be a serious difficulty.

2. High/Low Volume Machines

(a) HL/V Sprayers on Low Volume Work

HL/V sprayers on low volume work can work faster than L/V machines since more acres can be covered per tank-load. On average, HL/V machines doing this type of spraying covered 45 acres per day, compared with 30 acres per day for the L/V sprayers. The depreciation cost of a HL/V machine, however, is so much higher that although labour and

TABLE V. Comparison of L/V and HL/V Machines on Low Volume Spraying (Cost excluding materials)

Acreage Sprayed	100	200	300	400	500
	s. d.	s. d.	s. d.	s. d.	s. d.
L/V Machine	6 2	4 9	4 2	3 10	3 8
HL/V Machine	18 4	11 6	8 7	7 1	6 3

tractor costs are less the total cost per acre is greater than for a L/V machine at any acreage (see Table V). It is thus never economic to buy a HL/V sprayer for low volume work alone. If speed were all-important and only low volume spraying were required on the farm, it would generally be a better proposition to buy two L/V sprayers rather than one HL/V machine; a larger acreage could be sprayed per day and costs would be only slightly higher.

If, however, the farmer has enough high volume work to carry the overheads on a HL/V machine (see Section (b) below) he could use it on low volume work for the "variable costs" alone. These, at 2s. 9d. per acre, are lower than the operating costs of a L/V sprayer and a faster rate of work can be achieved. If a farmer has a HL/V machine for high volume spraying, it would therefore pay him to use it also for his low volume work rather than buy a L/V sprayer specially for the purpose. This is assuming the HL/V sprayer can cover the area in time, which should be possible on all but the largest farms.

(b) HL/V Sprayers on High Volume Work

From what has been said above, it follows that the purchase of a HL/V sprayer must be based on the cost of using it for high volume work as compared with contractors' charges for such work. These sprayers are more variable in size and type than L/V machines and the cost varies accordingly. As an example, we will take one of the most popular sizes, a 200-gallon machine costing £380. The types of high volume work such a machine can do also vary widely, but we will take for our example the spraying of DNOC suspensions. Total costs[1] from 0-160 acres are plotted in Diagram II, together with contract charges for DNOC spraying. For an area of 50 acres or more, large contractors charge some £3. 5s. 0d. per acre. To compete with this, a farmer-owned 200-gallon machine would need to cover more than 66 acres. A typical small contractor's charge for 50 acres or more is £2.16s. 0d.; for a farmer-owned machine to operate more cheaply than this it would have to cover 108 acres. Not many farmers, however, have a contractor within call who will spray

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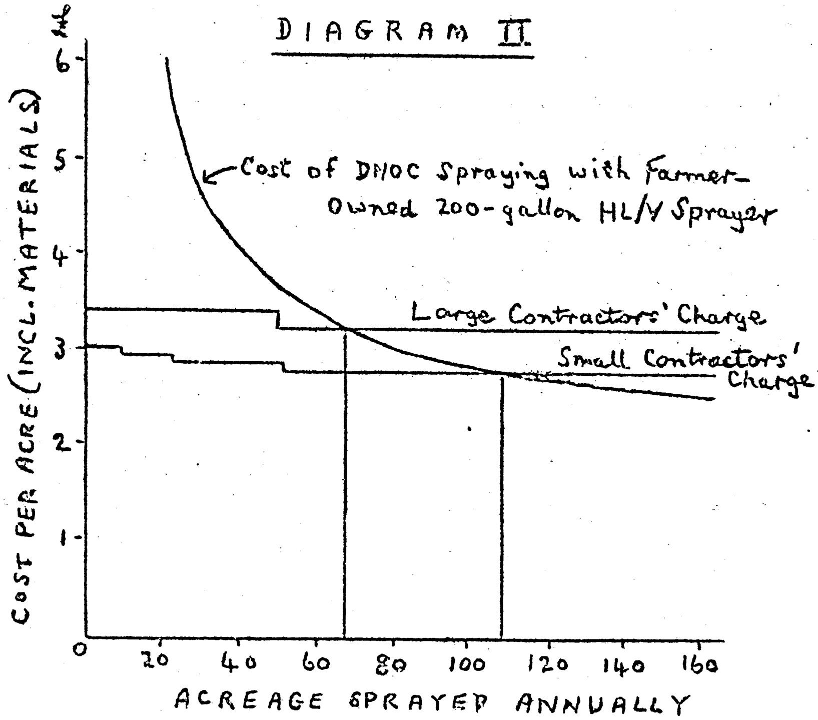
[1] Depreciation and interest total £77.18s. 0d. Variable costs per acre are those averaged by the 200-300 gallon sprayers in the survey when engaged on high volume work: Labour, 2s. 1d., tractors, 2s. 6d., repairs, maintenance and fuel, 11d., total, 5s. 6d. per acre.

DNOC for as little as £2.16s. 0d. per acre.

Another HL/V machine is the 100-gallon sprayer costing about £250. For DNOC spraying, the operation of such a machine becomes



cheaper than £3. 5s. 0d. per acre at 48 acres. Despite higher labour and tractor costs, the total costs of using this machine are lower than the 200-gallon sprayer (up to some 260 acres annually) because of the lower capital charge. It does, however, suffer from the disadvantage that the small tank makes high volume work slow and tedious. On a farm with only a small amount of high volume work this is not a serious matter and the farmer may be glad to have a machine which will make him independent of contractors for high volume work besides doing his low volume spraying. On the large farm, however, speed and timeliness will be the dominant factors and the farmer will therefore prefer a larger machine.

We have seen that, unlike the L/V machine, the HL/V sprayer is an expensive implement and a fairly large acreage is necessary to justify its purchase. It is therefore appropriate to consider the amount of high volume spraying likely to be necessary on a farm. DNOC spraying (one of the main uses of a HL/V machine) is used to control certain annual weeds such as cleavers which are resistant to the "hormones", and it can also be applied with safety to crops to be undersown. The future might well see an increase in the use of this chemical, for the spread of weeds resistant to "hormones" owing to the elimination of competition may become a serious problem[1]. As a result, "rotational spraying", or the alternation of different sprays, is being increasingly advocated. Such an increase might, however, be to some extent counter-balanced if the practice of spraying undersown crops with dilute solutions of MCPA spreads. This is much cheaper and can of course be done with a L/V machine, but involves some risk of damaging the seeds.

In potato and vegetable growing districts, on the other hand, there are a large number of other uses for high volume spraying apart from the application of DNOC, e.g. certain insecticides and fungicides, DNBP on peas, etc.

On balance, the case for buying a high volume machine is less strong than for a low volume machine. There are three main reasons for this. Firstly, it takes a fairly large acreage of high volume work to justify the purchase on grounds of cost. Secondly, even when this acreage exists on the farm, the potential saving is slight (see Diagram II), unless the area to be treated is exceptionally large. Thirdly, DNOC and the organo-phosphorus insecticides are dangerous to human life and therefore require great care in their use. In fact, government regulations are now in force specifying the precautions to be taken when handling these poisonous substances[2]. Apart from these materials, many other types of high volume spraying require rather more specialised knowledge than the spraying of "hormone" weed-killers.

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(1) For example, the recent increase in chickweed infestation of new leys has been attributed to this cause.

(2) The Agriculture (Poisonous Substances) Regulations, 1953.

It is not surprising therefore that in most districts even large farmers usually elect to buy a L/V sprayer and leave high volume work to contractors. In the large scale vegetable growing areas, however, the case for buying a HL/V sprayer is much stronger. If really large acreages of vegetable crops are grown, the saving can be substantial. In addition to this, the application of fungicides and insecticides requires careful timing and even a short delay while waiting for a contractor to come could be disastrous. Consequently, the purchase of a HL/V sprayer is often considered a necessity even on farms with acreages below those which would justify purchase on grounds of cost.

<u>NOTE</u>. From figures given in Appendix II the cost to a farmer of various types of spraying other than for weeds in corn can be quickly deduced. Contract charges for the same work are also given.

CHAPTER IV

WOULD IT PAY TO SPRAY ?

1. Effect on Yield

The purpose of this chapter is to discuss briefly whether or not corn spraying is an economic proposition. To this end we first consider the question of yield. Table VI sets out the increases in yields necessary to cover (a) the average costs of farmer-owned machines[1], (b) the charge of small farmer-contractors and, (c) typical large-scale contractors' charges (see Page 9). The quantities given in the table assume the price of corn to be 30/- per cwt.; yield increases of oats and feeding barley would therefore need to be some 20 percent higher than those shown in order to cover spraying costs.

TABLE VI. Increases in Yield Necessary to Cover Spraying Costs.

	(a) Farmer-owned machines		(b) Small Farmer-Contractor		(c) Large-Scale Contractor	
	Cost	Nec.Inc.	Cost	Nec.Inc.	Cost	Nec.Inc.
	£ s. d.	cwts.	£ s. d.	cwts.	£ s. d.	cwts.
MCPA: S.S. (L/V)	15 9	.5	1 5 0	.8	1 12 6	1.1
" : D.S. (L/V)	1 5 0	.8	1 14 0	1.1	2 0 0	1.3
2,4-D: 1pt.p.a.(L/V)	10 6	4	1 0 0	.7	-	-
DNOC	2 7 7	1.6	-	-	3 8 0	2.3

While costs to different farmers using their own machines vary, on average, an increase in yield of only 0.8 cwt., or less than 4 percent,

(1) In point of fact the necessary yields in case (a) are even lower than those shown, since once a farmer has bought a sprayer only his "marginal" costs should be considered, notably the materials, fuel (including tractor), and additional maintenance and repairs. The depreciation and interest charges on both the sprayer and the tractor are overheads and have to be paid whether they are used or not; the same usually applies in practice to the labour.

would pay for spraying MCPA at double strength. Only $\frac{1}{2}$ cwt. would cover the cost of spraying MCPA at single strength, and still less would suffice to pay for treatment with 2,4-D. A greater yield increase would be necessary to pay for contractors' charges, but even the highest (DNOC) would be covered by an extra sack of wheat, or some 10 percent increase in yield.

The important question however is, does spraying increase yield at all? Common sense would lead one to expect that it must do so when a field is full of weeds overshadowing the crop, and experiments bear out this conclusion. Professor Blackman, for example, has reported an average grain increase of 22 percent from three years' experiments with MCPA and 2,4-D, the yield of some barley fields increasing by as much as 90 percent. In practice, however, a farmer can only rely on his own judgement as to how severely weeds are competing with his crop for sunshine, air, moisture and plant nutrients in any particular field. The worst offenders in this respect are the tall and shady weeds such as charlock, the climbers such as cleavers, and the smotherers such as chickweed.

A further point to be considered is the risk of damaging the crop by spraying, quite apart from accidents. DNOC has on occasion harmed S.147 and S.172 oats, and 2,4-D applied to spring oats has sometimes caused damage. Ear malformation, which may spoil the sample and reduce yields, occasionally occurs in cereals which have been sprayed, particularly barley. Most of this damage results from treating the crop too early. Cereals should be sprayed only when fully tillered and about 6-8 inches high, well before heading; oats need more care than wheat and barley. Manufacturers' pamphlets give detailed instructions and these should be closely followed. The best results are undoubtedly obtained by spraying as early as possible within these limits, for not only are annual weeds more easily killed when young, but they are eliminated before they have competed seriously with the crop for food and air. Spraying is most effective in warm, moist conditions when the weeds are growing rapidly, but the effectiveness is reduced if heavy rain falls soon after the work is completed.

If the crop is sprayed late there is the added danger of damage by wheelings. This is particularly true of the large, heavy machines often employed by contractors, and is one of the points which persuades some farmers to buy their own, smaller sprayers. At harvest time green ears can often be seen where the sprayer's wheels have run; these ears may get a chance to ripen in the stook when cut by binder, but when combined they might well spoil the sample.

Among the farmers interviewed there was some conflict of ideas on the effects of spraying on yields. Some believed that it had little effect either way, unless the field was badly infested with weeds. Others thought that apart from yield increase due to the elimination of weed competition, the crop was given a direct stimulus by spraying, especially with DNOC, and still others thought that yields were actually reduced by spraying. Experiments have shown, however, that there will be no yield reduction if the spray is applied properly and at the right time, although damage might occur if the crop is backward for some reason, through, for instance, waterlogging, wireworm attack or deep drilling.

2. Other Considerations

The fact that many farmers spray even when they expect no yield increase shows that other reasons must exist for this work. One of the most important is undoubtedly the natural pride taken by farmers in clean fields.

Another more material consideration is the elimination of green weed seeds which can cause discolouration and heating in stored grain. Drying is less of a problem, dressing is far less difficult, and, in addition, many farmers say they can begin combining earlier in the day. These points have persuaded many farmers to spray every field they intend to combine. Even when corn is cut by binder, the elimination of weeds - particularly thistles - makes the crop easier to handle.

Some farmers believe in routine spraying, even where only very few weeds are present, in the hope that eventually the weeds on their farms will entirely disappear. While a reduction in the weed population from such thoroughness is almost certain, complete elimination is a rather forlorn hope. Some seeds lie dormant for long periods, eventually to germinate and restart an infestation. Others are brought on to the farm from neighbouring fields in a variety of ways. Another point (and one which is attracting an increasing amount of attention) is that according to some authorities species of weeds resistant to all known sprays may be increasing with the elimination of competition from those which have been killed by spraying.

3. <u>Grassland Spraying</u>

The spraying of grassland is most effective where a well managed ley or permanent pasture is spoiled by the presence in large numbers of one or a few species of weeds which are easily controlled by selective weed-killers. For some of these weeds, e.g. creeping buttercup, MCPA is better than 2,4-D and for others, e.g. bindweed, the opposite applies. For effective control, both have to be applied at fairly strong rates. The costs of such spraying (assuming low volume application, and the same cost of application as for cereals) are as follows:-

MCPA (5 pints @ 30/- per gallon): 18s.10d. + 6s.4d. = 25s. 2d. per acre.
2,4-D (2 " " 50/- " "): 12s. 6d. + 6s.4d. = 18s.10d. " "

Contract rates for grassland spraying are about £2 10s.0d per acre for double strength MCPA spraying and £2 4s.0d. for treatment with 2,4-D. For two applications (which are often necessary for the effective control of weeds such as ragwort) reduced charges are made.

With established leys and pastures, spraying can take place any time between April and September, but with new leys and grasses grown for seed more care must be taken, both as to the time of spraying and the quantity of spray substance applied.

The spraying of old, weedy and badly managed pastures is usually a waste of time and money that could be better spent in ploughing up and re-seeding, where this is possible. Even on better quality pastures, spraying must be followed by better grazing management and adequate manurial treatment if the sward is not simply to revert to its former condition.

The exact benefits to be obtained from the improved swards in terms of increased milk yields or of greater liveweight increases are not known and most difficult to deduce. Experimental data must be awaited. It is nevertheless certain that spraying could improve many pastures sufficiently either to hold more stock or to release more land for arable production. As was pointed out at the National Weed Control Conference held at Margate in November, 1953, however, grassland spraying is rather more complex in its results than cereal spraying. A substantial change in the farming system, necessitating more capital, more labour, or both, might be required in order to exploit to the full the potential increase in productivity.

SUMMARY AND CONCLUSION

From a survey of forty L/V and twenty-four HL/V sprayers it was found that the average costs of operating these machines, excluding materials, were 6s.5d. and 9s.6d. per acre respectively. Depreciation and interest constituted 53 percent and 58 percent of these sums, and labour and tractor costs 43 percent and 35 percent. Repair costs were very low in both cases.

At the average rate of work of 30 acres per day for L/V sprayers, the actual spraying occupies less than half the total time spent on this operation. HL/V sprayers averaged 21 acres a day (11s.7d. per acre) on high volume work, and 48 acres a day (8s.3d. per acre) on low volume work.

A comparison of these costs with contract charges showed the former to be substantially lower. The cost per acre of using a sprayer falls as the acreage sprayed increases, until at a certain acreage this cost falls below contractors' charges. It was shown that, on a purely cost basis, 30 acres of spraying a year would justify the purchase of a L/V sprayer, though other considerations, such as timeliness, might outweigh a small difference in cost either way.

HL/V sprayers vary in type and size and there is a large variety of work which they can do. An example was taken of a 200-gallon machine spraying DNOC suspensions; 66 acres justified its purchase for this purpose. But above this acreage the difference in costs was small and could be easily outweighed by the danger of using toxic materials and the greater skill required for much high volume work. Regarding the use of HL/V sprayers for low volume spraying, it never pays to buy such a machine for this work alone rather than a L/V sprayer. But if one is bought for high volume work it is cheaper to use this machine for low volume spraying than to buy a L/V sprayer specially for the purpose. 100-gallon machines are popular with some medium-sized farmers with only a small amount of high volume work to do who wish to be independent of contractors.

The increases in yield necessary to cover costs were shown to be quite small, and the likelihood of obtaining them was discussed, along with the possibilities of damaging the crop. Other benefits of spraying were then mentioned and reference made to weed control in grassland.

On a number of occasions during the last few years it has been said that, owing to the rapid increase in the popularity of spraying, corn is replacing roots as the traditional cleaning crop. It is as well to remember, however, that spraying is no universal panacea and that there is still a use for the harrow, the hoe and the plough. No one spray can kill all the weeds and leave the corn unharmed. Resistant weeds have to be kept under control by means of the right cultivations done at the right time, and it is still cheaper to harrow than to spray. While the spraying machine provides a useful and economic method of reducing weed infestation, it cannot be overstressed that spraying is an adjunct of good husbandry and not a substitute for it.

Appendix I

MISCELLANEOUS DATA ON THE SAMPLE FARMS AND SPRAYERS

1. Average Size of Farm, Arable Acreage and Acreage Sprayed

(including work outside own farm)

Type of Machine	Group	Size of farm (acs.)	Arable acreage	Acreage sprayed
A. L/V sprayers	Fens	259	209	161
	S. Cambs.	438	389	195
	S.W. Suffolk	497	381	158
	Miscellaneous*	414	319	125
B. HL/V sprayers	Fens	348	310	303
	S. Cambs.	673	648	472
	S.W. Suffolk	962	810	307

* This group was on a variety of soils within 20 miles of Cambridge.

2. Frequency Distribution of Amount Sprayed by the Sample Sprayers

Acreage sprayed	Number of machines	
	L/V	HL/V
0- 49	4	-
50- 99	12	1
100-199	13	5
200-399	7	10
Over 400	4(a)	8(b)
TOTAL	40	24

(a) The largest acreage sprayed by a single L/V sprayer was 605 acres, 510 of them the farmer's own barley.

(b) The largest acreage sprayed by a single HL/V sprayer was 1,135; the farm where this occurred had a large acreage of brussels sprouts and potatoes which were sprayed two or three times.

3. Distribution of Crops Sprayed by the Sample Sprayers, by Area

(average per farm)

	Crop	Fens	South Cambs.	S.West Suffolk	Miscel-laneous
A. L/V Sprayers	Winter Wheat	59	6	13	14
	Spring Wheat	15	6	4	7
	Barley	16	116	87	74
	Oats	19	7	6	14
	TOTAL CORN	109	135	110	109
	Other crops	14	1	1	-
	2nd or 3rd Spraying(a)	2	-	-	-
	Grass	1	11	21	7
	Contract (b)	35	48	26	9
	TOTAL	161	195	158	125

(a) The spraying of fields a 2nd or 3rd time (as, for example, potatoes usually are for blight) was counted as additional acreage sprayed.

(b) Includes all work done outside the farm, including spraying done for relatives, friends and neighbours.

	Crop	Fens	South Cambs.	S. West Suffolk
B. HL/V Sprayers	Winter Wheat	90	28	78
	Spring Wheat	12	5	3
	Barley	23	228	115
	Oats	13	17	10
	TOTAL CORN	138	278	206
	Other crops	54	46	55
	2nd or 3rd Spraying	28	58	22
	Grass	2	7	8
	Contract	81	83	16
	TOTAL	303	472	307

4. Percentage Sprayed of the Cereals on the Sample Farms*.

	Group	Winter Wheat	Spring Wheat	Barley	Oats
Farms with L/V Machines	Fens	100	100	85	81
	South Cambs	20	75	68	36
	S.W. Suffolk	29	42	59	31
	Miscellaneous	43	43	60	68
Farms with HL/V Machines	Fens	94	100	91	97
	South Cambs.	N.A.	N.A.	76	N.A.
	S.W. Suffolk	73	100	50	32

* These figures include work done by outside contractors.
N.A. = not available.

5. Spray Substances Used on the Cereals and Grass on the Sample Farms.

(total acres)

Type of Machine	Crop	MCPA		2,4-D	DNOC
		Under 4 pints per acre	4 pints per acre and over		
L/V	Wheat	219	710	319	14
	Barley	1,800	726	399	82
	Oats	145	285	27	-
	Grass	178	149	75	-
HL/V	Wheat	248	644	184	793
	Barley	864	1,342	109	617
	Oats	109	147	-	68
	Grass	7	64	72	-

Notes on this Table.

1. These totals include work done on the sample farms by outside contractors.
2. In the Fens virtually all MCPA spraying was at 4 pints per acre or over, owing to the wide range of weeds present.
3. One farmer accounted for 145 of the 178 acres of grass sprayed by L/V sprayers with single strength MCPA.

Appendix II

COSTS OF SPRAYING WITH FARMER-OWNED MACHINES AND CONTRACT CHARGES FOR CERTAIN TREATMENTS

Below are given the approximate costs of materials to the farmer and typical contract charges for various types of spraying other than those dealt with in the text. To the cost of materials, the farmer doing his own spraying has to add (a) his fixed costs (depreciation and interest) per acre, which are given at various acreages in the following table :-

Annual acreage sprayed	50	100	200	300
L/V Sprayer	6s. 7d.	3s. 3d.	1s.10d.	1s. 3d.
200-gallon HL/V sprayer	31s. 2d.	15s. 7d.	8s. 9d.	5s.10d.

and (b) the variable costs (repairs, maintenance, fuel, labour and tractor costs) which are approximately as follows:

L/V Sprayers	applying	5- 15 gallons	p.a.	3s. 0d. per acre.
	"	50 "	" "	8s. 6d. " "
200-g. HL/V	"	10- 20 "	" "	2s. 6d. " "
Sprayers	"	50 "	" "	4s. 0d. " "
	"	70-100 "	" "	5s. 6d. " "

EXAMPLE: To a farmer owning a 200-gallon machine who sprays 200 acres annually, the cost of spraying DNBP for weed control in peas at 6 pints in 70-100 gallons of water per acre would be as follows:-

Materials:	£1 15s. 0d.	per acre.
Fixed Costs:	8s. 9d.	" "
Variable Costs:	5s. 6d.	" "
TOTAL COST:	£2 9s. 3d.	" "

Weeds in Peas. DNBP costs 46s. 6d. per gallon. Recommended rate is 5-7 pints per acre. 6 pints cost £1 15s. 0d.
Contract charge: £4 7s. 0d. per acre.

TVO on Carrots. The application costs are given above.

Contract charge: £2 2s. 6d. per acre, farmer supplying TVO.

Manganese Deficiency. 10 lbs. manganese sulphate @ 90s. 0d. per cwt. costs 8s. 0d.

Contract charge: £2 13s. 6d. per acre.

Killing Potato Tops. 15 lbs. sodium chlorate @ 131s. 0d. per cwt. costs 18s. 0d. Two sodium arsenite products to be used at 1 gallon per acre cost 24s. 0d. per gallon.
Contract charge: £2 15s. 0d. per acre. Sulphuric acid spraying costs £3 15s. 0d. per acre.

Potato Blight. 5 lbs. of a proprietary copper oxychloride fungicide @ 270s. 6d. = 12s. 0d. per acre. An acre tin of another proprietary copper oxychloride fungicide costs 17s. 6d.
Contract charge: £2 5s. 0d. (1st application), £2 2s. 0d. (2nd), £1 17s. 0d. (3rd).

D.D.T. Spraying for the control of flea beetle. Three proprietary substances with their recommended application rates, prices and costs per acre are as follows:-

1.	16.7 percent	D.D.T.	4 pints	@ 22s. 6d.	per gallon	:	11s. 3d.
2.	18 percent	"	1½-3 "	" 26s. 6d.	" "	:	5s. 0d.- 10s.0d.
3.	25 percent	"	1-3 "	" 30s. 6d.	" "	:	3s.10d.- 11s.6d.

D.D.T. for the control of most pests can be applied either high volume or low volume, but for control of some pests, e.g., pea moth, high volume application is essential.

Contractors' charges for flea beetle control range from £1. 15s.0d. per acre to £3 3s. 0d. per acre.

N.B. The contractors' charges given above are those of a typical large-scale spraying concern for treating 25-49 acres. A farmer, if he wishes to compare his own costs with contract rates for the same work, should substitute the quotations he can obtain in his particular district, where they are different from those given.

Appendix III

COSTING METHODS

Depreciation. A specially contrived form of the diminishing balances method was used to calculate depreciation. The percentage diminished the older the machine, but more gradually than in the constant percentage method, and the machine was totally written off over a period of 8 years. It was felt that with most sprayers obsolescence would be a more potent factor than wear and tear in restricting their useful life but where a machine was used on over 200 acres a year it was written off in 6 years.

Interest on Capital. This was charged at 5 percent compound interest over the life of the machine. With equal payments of interest plus capital each year it amounts to approximately 3 percent of the first cost. It can be regarded as a real cost to a farmer having to borrow the money in order to buy the machine, or as an "opportunity cost", i.e. income from an alternative investment forfeited, in the case of a man drawing from his existing capital for the same purpose.

Repairs, Maintenance and Fuel. Repairs and fuel were charged according to their actual cost. Maintenance was calculated according to the number of man-hours spent maintaining the machine.

Labour. All labour was costed at 2s.10d. per hour. Allowing for insurance contributions, holidays with pay, etc., this is equivalent to a weekly wage of just over £6 per week for 47 hours' work.

Tractors, etc. Light-wheeled tractors were costed at 4s. 0d., medium tractors at 4s. 4d. and heavy tractors at 4s. 8d. per hour. Lorries were charged at 7s. 6d. per hour. If these were employed for carting water and were likely to be stationary most of the time, only half this cost was taken. Water tanks on trailers, water carts, etc., were costed at 1s. 0d. per hour.

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