previously untreated plots was to increase the loss of leaf by scorching by an average of about ten per cent on all varieties. No data was obtained on effect on yield.

Effect on rate of maturation - Tenderometer readings revealed that none of the herbicide treatments had any significant effect on ripening. Differences recorded did not represent more than one day since at around the "practical canning stage", tenderometer readings advance, on average, about 7 - 8 points per day.

On the basis of the results of these experiments, provided the correct recommended dose is used it would appear safe to treat all varieties tested with propham (pre-sowing) or mixtures of chlorpropham/fenuron or chlorpropham/diuron (pre-emergence). So far as the other herbicide treatments employed in peas are concerned, it seems that the varieties may be classified provisionally as below.

Variety	TCA	MCPB	Dinoseb ammonium	Dinoseb amine
Used for vining green				
Dark Skin Perfection	A	C	B	A
Gregory's Surprise	A	B	D	C
Kelvedon Wonder	C	C	C	B
Lincoln	C	B	B	A
Meteor	B	C	B	A
Onward	B	B	B	A
Perfected Freezer	D	C	B	A
Thomas Laxton	C	B	D	C
Victory Freezer	B	B	B	A
Witham Wonder (tall)	A	B	B	A
Used for harvesting dry				
Big Ben	D	A	A	A
Pauli	D	A	B	A
Rondo	A	A	A	A
Zelka	D	A	A	A

Key

A = Tolerant
B = Inclined to be slightly sensitive
C = Moderately susceptible
D = Susceptible

It is suggested that varieties placed in categories C and D should be treated with circumspection, reducing the dose of the herbicide chosen by 10-20 per cent.

In the case of TCA, the dose should remain at the recommended 7.5 lb/ac but only be applied if other factors favour its use rather than propham (Reynolds 1960). Where dinoseb is applied on TCA - treated land, the dose of the former should be reduced by about half; with the less tolerant varieties the dose should be cut by at least a half.

Acknowledgments

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CHLORPROPHAM/DIURON MIXTURES FOR PRE-EMERGENCE WEED CONTROL IN PEAS, BEANS AND BULBS.

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Summary. The results of one year's commercial experience with a proprietary formulation of a CIPC/diuron mixture* applied as a selective residual pre-emergence weed control treatment in ornamental bulbs and spring sown peas and beans are reviewed. Crop safety, weed control, and residual toxicity are discussed in relation to soil and agronomic factors, rainfall, and the crop and weeds present. Results were highly satisfactory on bulbs, and largely so on peas and beans. Crop damage occurred only with faulty application. Where unsatisfactory weed control occurred on peas and beans low rainfall was the most important factor. The best control was obtained on lighter soils and later-sown crops. Increased dose rates are indicated for heavy soils or those high in organic matter and for early-sown crops, together with more latitude in timing of application relative to sowing.

INTRODUCTION

A proprietary formulation of a mixture of chlorpropham and diuron was introduced to the United Kingdom market in the autumn of 1959 with recommendations for the control of germinating weed seedlings in spring-sown peas, broad beans and tick beans, and on ornamental bulbs. The results of commercial applications are reviewed in relation to the various climatic and agronomic factors affecting performance, of which the two most important appear to be soil type and rainfall.

In recent years chlorpropham/fenuron mixtures have shown considerable promise as residual pre-emergence treatments in relatively deeply-sown large-seeded crops, such as peas and beans, and crops which have underground storage organs, such as bulbs. The selectivity of these mixtures appears to depend partly on the physical properties of the components which govern their movement in the surface layers of various soil types, and partly on the inherent physiological tolerance of the crops to the herbicides.

The suitability for selective uses of the four substituted urea herbicides: fenuron, monuron, diuron and neburon, is largely determined by their ability to resist leaching in the soil. The order of preference for selective uses is neburon, diuron, monuron, fenuron. Table I, which summarises the solubility and soil adsorption characteristics of these herbicides, helps to explain the differences observed in selectivity. (Wolf, D.E. et al 1959)

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* as "Residuren", (Farm Protection Limited).

TABLE I. PHYSICO-CHEMICAL CHARACTERISTICS OF FOUR SUBSTITUTED UREA HERBICIDES.

Compound	Solubility in Water (25° C.)	Adsorption on Keyport Silt Loam*
	ppm	ppm*
Fenuron	3850	0.3
Monuron	230	2.6
Diuron	42	5.2
Neburon	5	16.0

*ppm (active ingredient) present on soil in equilibrium with 1 ppm in soil solution. Studies were conducted at 72°F.

A careful consideration of the combined characteristics of chlorpropham/substituted urea mixtures under the wide variety of factors encountered in practical use, determined the choice of a chlorpropham/diuron mixture as the preferred treatment for development and commercialisation for the above-mentioned uses.

The mixture was formulated as an emulsifiable concentrate, based on 32 ounces of technical chlorpropham and 8 ounces of diuron 80 per cent wettable powder+ per Imperial gallon=.

RESULTS.

Peas and Beans

On spring sown peas, broad beans, and field or tick beans, the mixture was recommended as a pre-emergence treatment, applied at four pints in 100 gallons of water per acre, within 48 hours of sowing or drilling.

Treatment was not recommended on soils where there was any element of doubt as to their ability to retain the herbicide in the surface layers. Such soils are those low in clay or organic matter, for example, light, sandy soils and certain silts.

Growers who practised unusually shallow drilling, at a depth of 1 in. or less, were advised not to use the mixture.

Late treatment, i.e. after mid-May, was not recommended, because of limited experience.

The mixture was applied commercially in all the major pea and bean growing areas of the country, but naturally the predominant use was in East Anglia.

+as "KARMEX" Diuron, Du Pont.

Weed Control

In general, weed control was satisfactory. The best results were obtained on the lighter soils, many of which received only three pints of the mixture per acre. On heavier soils, the results were more variable, and the small proportion of unsatisfactory results occurred mainly on such soils.

Undoubtedly the most important factor influencing weed control was soil moisture, as residual herbicides, which rely on root absorption for their activity, must have moisture to produce lethal concentrations in the top inch of soil where most weed seeds germinate. Following sowing, rainfall was low over most of the principal pea and bean growing areas. Representative data are shown in Table II.

TABLE II. RAINFALL, 1960

(Expressed as a percentage of the long-term average)

	February	March	April	May
Manston, Kent	91	93	43	127
Felixstowe, E.Suffolk	70	146	36	63
W. Raynham, Norfolk	78	65	39	25
Mildenhall, W. Suffolk	79	95	23	34
Finningley, Notts.	114	97	52	50
Scarborough, N. Riding, Yorks.	97	84	37	51

In addition, cold, dry winds blew during much of the early growing season and soil dried out quickly after light rain. The germination of many summer annual weeds was delayed under these conditions, frequently it would appear, until much of the activity of the chemicals had been lost, especially that of chlorpropham which is volatile.

The sowing of peas and beans, however, was not delayed, nor was emergence, but subsequent growth was much slower than one would normally expect. Where weeds germinated late, and were not satisfactorily controlled by the chemical, the crop was often insufficiently well developed to smother them. The period of residual activity was therefore too short in early sown crops, particularly under slow growing conditions. In later sowings, where the weeds germinated soon after application, control was excellent and later germinating weeds could not compete with the crops.

Under marginal conditions, the weeds showing greatest tolerance were: fumitory (Fumaria officinalis), speedwells (Veronica spp.) and groundsel (Senecio vulgaris); but under optimum conditions they were well controlled. Under average conditions, consistently good control was obtained of the following weeds: mayweeds (Matricaria and Anthemis spp.), knotgrass (Polygonum aviculare), black bindweed (Polygonum convolvulus), redshank (Polygonum persicaria), chickweed (Stellaria media), annual meadow grass (Poa annua), poppies (Papaver spp,), shepherd's purse (Capsella bursa-pastoris). Some reductions in population of wild oats (Avena spp.) were observed presumably from kill of seeds near the soil surface. Fathen (Chenopodium album), charlock (Sinapis arvensis), runch (Raphanus raphanistrum) and hempnettle (Caleopsis tetrahit) were well controlled, except where germination took place long after application.

Crop Safety

There was no suggestion of crop damage where a satisfactory spray mixture was applied according to the recommendations. No damage was reported at any time from overlap of the spray swathes. Occasionally in beans, but not peas, small areas of damage were observed, which clearly could be attributed to spraying while turning on headlands.

Although excluded from the recommendations, a considerable area of light sandy soil in the East Midlands was sprayed at the reduced rate of three pints of the product per acre, without apparent damage. Nevertheless, a wider range of experience is required before making firm recommendations for treatment on such soils.

Residual toxicity was suspected in three fields sown to susceptible catch crops, two of kale and one of mustard, immediately after harvesting preceding pea crops treated with the mixture about sixteen weeks earlier. The damage symptoms were slight chlorosis, particularly of the cotyledons, and a temporary check to growth. A careful search of catch crops with a similar history revealed no further evidence of damage. In the suspect fields the soil was exceedingly dry following the pea harvest and, ploughing being considered impracticable, the cultivations employed prior to sowing were rotavations and harrowing. There were no obvious factors peculiar to these sites to explain the implied persistence of phytotoxic residues in the soil for so long a period after such small initial applications of the chemicals.

Bulbs

Narcissus, Iris, Tulips

On narcissus, daffodils, bulbous iris and tulips, two applications, each at one gallon of the mixture in 100 gal of water/ac, were recommended. The first application was advised immediately after planting on new beds, or after late summer cleaning on established beds, to control autumn and winter germinating weeds. The second application was advised as near to crop emergence as possible to obtain optimum control of winter and spring germinating weeds.

Generally, a single application just prior to emergence was employed, as many growers used contact herbicides, for example sodium arsenite, to kill weeds which were already established.

The residual treatments gave consistently good weed control and there was no evidence of damage to crops. Many treated beds were maintained in a clean state for six months after treatment. Excellent control was obtained of mayweeds (Matricaria and Anthemis spp.) which are not well controlled by pre- or post-emergence treatments of chlorpropham alone.

Gladiolus

On gladiolus, treatment was recommended immediately after planting, with a second application after emergence, provided the crop plants were not more than 4 in. high. For each treatment, the recommended application rate was one gallon of the mixture in 100 gal of water/ac.

Weed control treatments based on these recommendations were highly satisfactory.

There was only one report of damage, which took the form of severe scorch to the leaves. This resulted from a late post-emergence application to a crop 18 in. to 24 in. high. Very high temperatures followed immediately after spraying.

DISCUSSION

The successful use of selective residual pre-emergence weed control depends on certain basic requirements: consistent control of weeds, a wide margin of safety to crops, a rate of disappearance from soils that permits the normal growth of subsequent crops, and use-cost competitive with existing control methods. Commercial experience with a chlorpropham/diuron mixture during the past year suggests that these requirements are met in bulbs.

They are met in peas and beans, except for some inconsistencies in weed control. Accordingly, our recommendations for peas and beans for 1961 will be modified to improve weed control over a wider variety of soil and weather conditions. For soils high in clay or organic matter, the rate of application will be raised to six pints per acre throughout the season. The six pint rate will also apply to crops sown early, i.e. before March 15th. The restrictions on the interval of two days between sowing or drilling and application will also be relaxed to allow spraying up to seven days before the expected time of emergence of the crop, provided weeds have not emerged. This will often allow up to three weeks delay in the application to slow-growing early sown crops providing an additional period of residual herbicidal activity. Commercial and experimental work has indicated that both peas and beans have an adequate margin of tolerance to the increased rate of application.

While retaining the same concentration of active ingredients the chlorpropham/diuron mixture has been formulated to withstand water hardness corresponding with a maximum of 450 ppm of calcium as $CaCO_3$ and 1,600 ppm of magnesium as $MgCO_3$. This should confer adequate tolerance to the great range of water hardness encountered.

Despite the apparent tolerance of peas and beans to doses of the mixtures in excess of those recommended, there should be strict observance of all precautions designed to prevent possible damage to crops. The depth of sowing should be carefully controlled and never less than one inch below the soil surface. For this reason, broadcast sowing followed by harrowing is unsuited to residual pre-emergence treatment. The seedbed should be left with a fine, even tilth and it is advisable to roll before treatment to ensure moderate consolidation of the soil. Uniform application with properly agitated spray equipment is important, and over-dosing particularly at headlands and by generous overlapping of spray swathes must be avoided.

Limited commercial experience has shown that medium and low volume application can give satisfactory results; but further investigations are required before a reduction in the volume rate can be recommended.

The development of reliable methods of residual pre-emergence weed control in row crops eliminates the need for post-emergence spraying and post planting cultivations which unavoidably cause crop damage. Rows are generally spaced to facilitate cultivations; but plant population studies have shown that such spacing may limit maximum growth and yield per acre. The new technique of weed control should help to promote the development for practical use of research findings on seedbed preparation and plant spacing.

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PRE-EMERGENCE AND POST-EMERGENCE WEED CONTROL IN MAIZE

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Summary. Weeds, not birds, are the worst enemies of maize. Inter-row cultivation is of limited value and hitherto only tentative recommendations have been issued for the use of herbicides for weed control in maize in this country. During 1959-60 experiments carried out in the South East Region have tested the value of (i) simazine as a pre-emergence herbicide and (ii) three substituted phenoxy-acetic acids for post-emergence application.

A classification of weeds, commonly found in maize crops, is presented, based on their susceptibility to simazine. There are indications that simazine benefits maize other than by mere removal of weeds. The stage of growth of the crop, at the time of spraying, appears to be of greater importance than the choice of herbicide when MCPA or 2,4-D is used for post-emergence weed control. Crop yield data indicate the likely responses following the application of herbicides in the maize crop.

INTRODUCTION

The acreage of maize (Zea mais) grown for ensilage in this country is growing rapidly. It has been estimated that 5,000 acres of maize, as a fodder crop, were grown in the south of England in 1960. The impetus for this sudden increase in crop acreage is derived, no doubt, from (i) improved methods of harvesting and (ii) the introduction of double-cross hybrid varieties. These new varieties are capable of producing, in terms of dry matter, from 4-5 tons per acre of a high-energy value fodder crop that is comparatively easy to conserve by ensiling.

There are many problems of crop production, under conditions in this country, remaining unsolved. Paramount amongst these are the means of attaining (1) freedom from bird damage and (2) freedom from weed competition. The increase in maize acreage in any one locality (10-20 acre units) has tended to reduce the intensity of bird damage to any one crop. This, coupled with combinations of bird-scaring methods, has done much to remove one of the greatest obstacles in maize production in this country. Maize, in its young stages of growth, cannot tolerate competition from weeds. Down-the-row cultivations can eliminate weeds in the inter-row area but leave undisturbed the weeds in the maize drill where they are least desired. Some doubts still exist about the wisdom of moving soil in the vicinity of the spreading roots of maize. There is wide scope, therefore, for the use of herbicides to attain early control of weeds in the maize crop.

An experiment, laid down in Berkshire during 1959 alongside variety and manuring trials, tested the value of simazine as a pre-emergence herbicide in maize. Despite the very dry conditions that prevailed during the immediate post-spraying period a successful control of weeds coupled with increased crop yield was attained. The experiment has been repeated at the same site during 1960.

In order to have a comparison, under equal conditions, post-emergence treatments were also applied in 1960 in an adjoining area at two crop growth stages. It was realised however that many of the weed species present at this site were likely to show varying degrees of resistance to the substituted phenoxy-acetic acids used for post-emergence weed control. In view of this, another site in Hampshire, where the dominant weed was Chenopodium album (fat hen - 25 plants sq ft) was also sprayed with the same post-emergence treatments at a single crop-growth stage in June 1960.

METHODS AND MATERIALS

For the 1959 trial, testing simazine for pre-emergence weed control, a logarithmic spraying machine (Hartley et al 1956) mounted on a vehicle equipped with a rear power-take-off was used. Thus a logarithmically decreasing concentration of simazine was sprayed in each plot as the vehicle moved along a length of 20 yd and covering an effective width of 5 yd equal to 6 drills of maize sown at 32 in. width. Each plot also allowed for a 5 yd run-in required to accelerate to the operating speed and for concentrate solution to reach each independently fed nozzle. At the other end of the plot a length of 5 yd and width 5 yd was left un-sprayed. This plot-pattern and technique was used in all the experiments reported upon. The half-dosage distance for the machine, as used in this series of experiments, was 6.7 yd.

It should be noted that over-all spray, not band-application, was applied at all sites.

Treatments:- - all application at 28 gal/ac.

Pre-emergence spray (replication x 4) - 1959 and 1960 - 3 lb/ac simazine reducing to 3/8 lb/ac.
(using a 50 per cent wettable powder.)

Post-emergence spray (replication x 3) - 1960 only - 3 lb/ac reducing to 3/8 lb/ac.

(i) MCPA - potassium salt
(ii) 2,4-D - Triethanol amine
(iii) 2,4-D - butoxy-ethyl ester

each applied at two crop growth stages in Berks. - one stage in Hants.

Simazine applications were tested on Warwick 277 only but post-applications relate to both Warwick 277 and Pioneer 395 - two of the most widely distributed varieties grown during 1959-60.

(78178)

TABLE I. DETAILS OF SOIL AND CROP AT EACH SITE

Detail	Berks 1959 and 1960 Pre- and Post-emergence application	Hants 1960 Post-emergence application
Soil type	Upper Greensand - bordering gault clay	Clay with flints - overlying chalk
Aspect	Rural, gentle slope well drained - at 190 ft above sea level	Rural, level site, well drained at 450 ft above sea level
Previous crop	Spring Oats	Long ley
Maize variety sown	Warwick 277 1959 - 40 lb/ac - 7th May 1960 - 35 lb/ac - 5th May	Pioneer 395 40 lb/as - 7th May

Berks site	per cent		per cent			
Mechanical analysis of soil	Coarse sand	11.6	Organic matter	5.4	pH	7.3
	Fine sand	31.7	Free $CaCO_3$	7.5		
	Silt	9.3				
	Clay	35.5				

In the pre-emergence trials the application of simazine was made directly post-drilling of the crop after using spring-tine weeders for covering-in seed, and fertiliser. Rolling with a ring-roller was carried out within two days of sowing and spraying. No further cultivations were carried out during the period of the trials.

Cultivations, manuring (without nitrogen top-dressing) and all other cultural factors were equal for the pre-emergence and post-emergence trials at the Berks site. The crop was top-dressed with 2 cwts per acre of a nitrogenous fertiliser (15.5 per cent nitrogen) ten days after spraying at the Hants centre but no method of weed control, other than spraying, was carried out. The details of crop growth stages and weed competition at the time of post-emergence spraying, at both centres, are given in Table II.

TABLE II. CROP AND WEED GROWTH - AT POST-EMERGENCE SPRAYING

Crop and Weed species	Berkshire 1960				Hampshire 1960	
	First stage-30th May		Second stage-13th June		Single stage-16th June	
	Plants /sq yd	Stage of growth and height	Plants /sq yd	Stage of growth and height	Plants /sq yd	Stage of growth and height
MAIZE	8.5	4th leaf appearing 3-4 in.	8.4	mean 6.3 leaves 6-10 in.	6.6	6th leaf appearing 4-6 in.
Chenopodium album (Fathen)	13	1st true leaf 1 in.	18	6-8 leaves 3-4 in.	232	3-6 true leaves 2-4 in.
Cirsium arvense (Creeping Thistle)	10	3-5 leaf 2 in.	11	4-6 leaf 4-5 in.	2	4th leaf 5 in.
Veronica agrestis (Speedwell)	196	cotyledon to 2 true leaf	288	70 per cent - 3rd pair 20 per cent - cotyledon	21	1-2 true leaf 1½ in.
Thlaspi arvense (Pennycross)	-	none present	-	none present	95	2nd whorl 1-2 in.
Matricaria maritima (Mayweed)	-	none present	-	none present	57	3-4th pair leaves 1-2 in.
Stellaria media (Chickweed)	43	1-2 runners 2 in. length	72	2-4 runners 1-4 in.	-	none present
Fumaria officinalis (Fumitory)	13	4-6 leaf 2-3 in.	18	early flower 3-6 in.	-	none present
Urtica urens (Annual nettle)	11	cotyledon	54	2nd pair true leaves ½-1 in.	-	none present
Sonchus arvensis (Sow Thistle)	6	2 leaf rosette	8	2 true-leaves ½ in. postrate	- -	none present

Weather conditions at and following spraying are obviously of some importance where a low-solubility pre-emergence herbicide is used during late spring. In the case of maize weather conditions post-spraying govern to a large extent the recovery of the crop in the event of any initial setback due to spray toxicity. Meteorological data, for each centre, are therefore given in detail in Table III.

TABLE III. WEATHER CONDITIONS AT EACH SITE - DURING AND AFTER SPRAY APPLICATION

Period T=dry temperature RH=Relative Humidity	Pre-emergence applications		Post-emergence applications		
	Berks		Berks - 1960		Hants - 1960
	1959 7th May	1960 5th May	1st stage 30th May	2nd stage 13th June	single stage 16th June
Day of spraying	T - 68°F RH - 58 per cent Soil knobly dry to 2in. depth	T - 70°F RH - 36 per cent Fine seed- bed moist 2 in. deptch	T - 66°F RH - 36 per cent Dry foliage warm sunny	T - 64°F RH - 41 per cent Sunny after heavy rain dry foliage	T - 71°F RH - 77 per cent Dry foliage overcast
For 48 hours post-spray	overcast warm dry	sunny warm dry	very dry sunny	warm showers 0.08 ins.	sunny warm dry
First appreciable rainfall post spray	21st May 0.24 in.	11-12th May 1.14 in.	7-8th June 0.52 in.	22nd June 2.83 in.	22nd June 0.62 in.
Rainfall during one-month post-spray General Conditions	0.56 in. Showers on 4 days otherwise dry and warm	2.13 in. Dull showery then dry warm period	4.36 in. Dry at first then heavy showers warm-with thundery spells	5.36 in. Alternating periods of heavy rain and dry periods	3.68 in. Thundery spells. Wet, cool at end of the period

RESULTS

Pre-emergence

Weed Control. During the dry period following spraying in 1959 no visual effects of the herbicide could be observed 14 days post-sowing. By this time numerous seedlings of Stellaria media (Chickweed) and Veronica agrestis (Speedwell) had become established in all plot areas. Maize had fully emerged by the 26th May. Towards the end of June however visual differences in weed population and vigour were observed in treated areas. A careful record of weed species surviving, with an indication of plant vigour, was made on the 17th July in each yard length of each logarithmic plot.

Conditions post-spraying, in 1960, were much more favourable for a soil-acting herbicide such as simazine. A considerable difference in weed population, within a logarithmic plot, showed clearly during early growth stages. On the 13th June an assessment of species distribution and plant vigour in each yard length of a plot was recorded.

From these observations, in both years, a classification of weed species, according to the degree of control given by simazine at various concentrations per acre, has been compiled in Table IV.

Whereas a dose range of 2.0-2.5 lb/ac simazine was required to give complete eradication of Cirsium arvense (creeping thistle) in both years of tests - 1.5-2.0 lb/ac simazine gave a useful control of the same species and reduced the vigour of the remaining plant. A lower dose range 1.0-1.5 lb/ac simazine whilst not reducing plant population of creeping thistle to any extent, was nevertheless capable of depressing the growth of the weed such as to allow the crop to dominate and eventually crowd out the species. This principle, relating to the effect of reducing doses, could be applied to all the other weed species enumerated in the table.

TABLE IV. WEED SPECIES CLASSIFICATION - COMPLETE ERADICATION BY SIMAZINE APPLIED AS A PRE-EMERGENCE SPRAY TREATMENT

Dose range of simazine	1959 - Berks	1960 - Berks
2.5-3.0 lb/ac	Rumex obtusifolius Agropyron repens	Agropyron repens (patches)
2.0-2.5 lb/ac	Polygonum aviculare; Polygonum convolvulus; Galium aparine Cirsium arvense, Thlaspi arvense Hypochaeris radicata	Polygonum convolulus; (14) Cirsium arvense (patches)
1.5-2.0 lb/ac	Chenopodium alba; Urtica urens, Fumaria officinalis; Solanum nigrum; Ranunculus repens	Sonchus arvensis (6); Galium aparine (occasional) Chenopodium album (10) Fumaria officinalis (11)
1.0-1.5 lb/ac	Sinapis arvensis; Raphanus raphanistrum; Myosotis arvensis	Stellaria media (31) Urtica urens (81) Veronica agrestis (225)

An indication of weed population in control plots Berks 1960 is given in brackets as plants/sq yd

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Post-emergence weed control - doses in oz/ac.

(i) Hants centre:- An assessment one month post-spraying (13th July) recorded Chenopodium album 18 in. high in early flower stage and dominating maize (10-13 in. high) in the control plots. In sprayed plot this weed species was absent or moribund at rates above 12 oz MCPA; 8 oz 2,4-D-amine and 6 oz 2,4-D-ester. Thlaspi arvense (Pennycress) had succ umbed to all treatments above 6 oz level. Veronica agrestis (speedwell) was eradicated by 2,4-D-ester above 16 oz. There was an arrest of growth, resulting in spindly development of Matricaria maritima (scentless mayweed) following treatment with MCPA 24 oz; 2,4-D-amine 16 oz and 2,4-D-ester 12 oz.

(ii) Berks centre:- Here, by mid-July, it was evident that the control obtained by the second stage application was much superior to that resulting from the earlier application. This was due partly to late germination of many weeds. Some indication of the efficiency of treatments at the Berks centre is given in Table V.

TABLE V. BERKS CENTRE. MINIMUM DOSES (OZ/AC) REQUIRED TO GIVE DEGREES OF CONTROL

Post-emergence application	MCPA		2,4-D-amine		2,4-D-ester	
Degrees of control	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
Good overall eradication of weeds	40 oz	36 oz	32 oz	24 oz	20 oz	20 oz
Kill of Chenopodium album and Cirsium arvense. Serious retardation of growth of Veronica agrestis and Urtica urens	32 oz	24 oz	24 oz	20 oz	16 oz	12 oz
Arrest of growth of all weeds causing yellowing of foliage and failure of normal flowering	24 oz	16 oz	16 oz	16 oz	10 oz	8 oz

Note:- Stages of growth of all weed species at time of spraying are given in Table II.

Perhaps the most outstanding features at the Berks centre were (i) the considerable resistance shown by Fumaria officinalis (fumitory) to all spray treatments and (ii) in contrast, the efficiency of the herbicides used in arresting the growth of Veronica agrestis (speedwell) and Urtica urens (annual nettle) - species not generally classified as being very susceptible to the action of substituted phenoxyacetic acids.

Visual effects of Treatments on growth of Maize

There were no visual toxicity symptoms during the growth period of maize at the Berks centre (1959/1960) following pre-emergence application of simazine at doses up to 3 lb/ac. By mid-August maize plants in the simazine treated areas, in particular where doses of active chemical applied exceeded 1½ lb/ac, showed vigorous healthy growth.. Crop foliage in these areas had assumed a dark olive green colour suggestive of heavy nitrogenous top dressing.

Severe leaf rolling and other toxicity symptoms were observed where post-emergence treatments, at certain doses, had been applied at both centres. These symptoms were at their maximum intensity during mid-July when the maize plants were 15-18 in. high and carrying 7-8 leaves. An indication of the severity of the symptoms, at various doses, is given in Table VI. Delaying the application of treatments until maize was in the 6th-7th leaf stage, at the Berks centre, aggravated crop toxicity symptoms compared to those observed following earlier application when maize was showing 4th leaf. These differences far exceeded any differences between types of herbicides at any one dose.

TABLE VI. CROP TOXICITY SYMPTOMS - POST-EMERGENCE APPLICATION (doses in oz)

Centre	Berks - 21st July						Hants - 13th July		
Application	1st Stage			2nd Stage			Single Stage		
Maize stage at spraying	4th leaf - 3 to 4 in.			6-7 leaves 6-10 in.			6 leaves 4-6 in.		
Symptom group	MCPA	2,4-D -amine	2,4-D -ester	MCPA	2,4-D -amine	2,4-D -ester	MCPA	2,4-D -amine	2,4-D -ester
	oz	oz	oz	oz	oz	oz	oz	oz	oz
1. Severe rolling of leaf; Scorch areas on older leaves yellowing of young leaves - very brittle stems	none	none	above 30	above 24	above 27	above 20	above 32	above 26	above 20
2. Slight rolling of leaves - some yellowing and brittle stems	above 40	near 48	22 to 30	20 to 24	22 to 27	12 to 20	24 to 32	20 to 26	16 to 20
3. Occasional young leaf rolling	24 to 40	24 to 48	18 to 22	14 to 20	16 to 22	8 to 12	16 to 24	16 to 20	12 to 16
4. No visual symptoms	below 24	below 24	below 14	below 14	below 16	below 8	below 8	below 16	below 12

At equal doses per acre 2,4-D-ester was much more toxic than 2,4-D-amine, particularly following the second stage application in Berks. At this stage also 2,4-D-amine was less toxic than MCPA but very little difference was observed between these herbicides following their application at an earlier crop stage of growth. In Hampshire MCPA was slightly less toxic than 2,4-D-amine at doses above 16 oz/ac.

Treatment effect on yield of Maize

The fall in concentration in a logarithmic plot is in an exponential manner allowing for a selection of a plot area to represent a desired range of dose application. Thus it is fairly easy to pin-point an area of the crop which was treated with 2-3 lb/ac of active ingredient of any herbicide. Similarly an area treated with 1-1½ lb/ac of the same chemical can be located and these areas would be equal in size. In the experiments reported upon dose range plots, described above, covered an area of 4 rows of maize along 4 yards length of row equal to $\frac{1}{360}$ acre. These areas, using the four centre rows from six sprayed, were harvested from each logarithmic plot at each centre together with a similar harvest area selected in each control plot. Yields of green crop and dry matter per acre of maize, harvested during the last week in September in each year, are given in Table VII.

The plots harvested from inter-row cultivated areas, in Berks, adjoined the post-emergence treated plots but were some distance from the simazine trial. All harvested areas, at this centre, had however been grown under equal cultural conditions apart from different methods of weed control.

Yields from the Hants centre were rather low. Here the trial was sited in a crop that had received no basic manuring but followed a well managed ley. No explanation can be advanced for the reduced yield following the application of 2,4-D-amine at 1-1½ lb/ac at this centre. All three replicate plots gave similar yield of green crop and dry matter per acre.

DISCUSSION

Weather conditions post-application play an important role in the efficiency of simazine. In 1959 0.56 in. rainfall was recorded, at the Berks centre, during one-month period post-spraying whilst rainfall at the same centre during a corresponding period in 1960 was 2.13 in. This difference between seasons is reflected in crop yield responses and accounts for any variation in the susceptibility of some weed species as indicated in Table IV.

Following a dry May-June period the increase from a 1.0-1.5 lb/ac to a 2.0-3.0 lb/ac level of application resulted in a much improved control of some of the more resistant weeds coupled with a crop yield increase of 11 per cent dry matter/ac. In 1960 however yields of maize showed no significant response from a corresponding increase in the rate of simazine applied. Some weed species - Agropyron repens (couch grass), Cirsium arvense (creeping thistle) and the late germinating Polygonum convolulus (black bindweed) - did however succumb more readily to the higher doses. Commercial applications of simazine for weed control in maize have not in all cases met with equal success to that reported in the experiments. Investigation of these failures however indicates that in the majority of cases the herbicide had been applied from 7-14 days post-sowing. In the Berks trials spraying followed immediately on sowing before rolling of the seed-bed and before the latter had dried out excessively. This may be of significance with a crop that is sown during, generally, the driest period of the year. In wet seasons Solanum nigrum (black nightshade) can be a troublesome weed in fodder crops such as maize. Simazine at 1.5 lb/ac gave a complete eradication of this weed in the 1959 trial despite the late germination of the weed as noted in the control plots during June and July. Visual crop toxicity symptoms were not observed in any of the trials following the

TABLE VII. MEAN YIELDS OF MAIZE AS HARVESTED FOR ENSILING - TONS/AC

Centre	Stage of application of spray	Dose range/ac	Number cobs per stem	GREEN CROP				DRY MATTER			
				Cob	Stover	Total		Cob	Stover	Total	
						Ton/ac	per cent control yield			Ton/ac	per cent control yield
Berks 1959	Pre-emergence	Simazine 1-1½ lb	0.9	5.4	6.6	12.0	121	2.23	1.57	3.80	126
		2-3 lb	1.0	5.9	7.8	13.7	138	2.33	1.88	4.21	140
		Control-same blocks	0.8	4.2	5.7	9.9	100	1.66	1.34	3.00	100
Berks 1960	Pre-emergence	Simazine 1-1½ lb	1.1	10.3	15.3	25.6	145	2.20	2.87	5.07	147
		2-3 lb	1.2	10.1	16.2	26.3	149	2.03	3.03	5.06	147
		Control-same blocks	1.0	6.6	11.1	17.7	100(a)	1.31	2.14	3.45	100 (a)
Berks 1960		No herbicide treatment Cultivation Inter-row 27th May	1.2	9.0	12.2	21.2	120(a) 137(b)	1.91	2.32	4.23	123(a) 140(b)
	Post-emergence	Control-same block	1.0	5.8	9.7	15.5	100(b)	1.17	1.85	3.02	100(b)
		MCPA 1-1½ lb 1st Stage	1.1	6.0	9.2	15.2	99	1.29	1.74	3.03	100
		2-3 lb	1.3	7.6	10.1	17.7	114	1.63	1.90	3.53	117

Berks 1960	Post-emergence	MCPA 1-1½ lb	1.1	7.1	10.8	17.9	116	1.54	1.94	3.48	115
		2nd Stage 2-3 lb	1.2	8.1	11.6	19.7	127	1.68	2.13	3.81	126
		2,4-D-amine 1-1½ lb	1.2	6.5	9.8	16.3	105	1.36	1.95	3.31	110
		1st Stage 2-3 lb	1.4	8.4	11.2	19.6	126	1.71	2.22	3.93	130
		2,4-D-amine 1-1½ lb	1.4	8.4	11.1	19.5	126	1.67	2.16	3.83	127
		2nd Stage 2-3 lb	1.2	8.8	11.0	19.8	128	1.75	2.13	3.88	128
		2,4-D-ester 1-1½ lb	1.1	6.6	9.0	15.6	101	1.51	1.73	3.24	107
		1st Stage 2-3 lb	1.3	7.9	10.0	17.9	116	1.67	1.84	3.51	116
		2,4-D-ester 1-1½ lb	1.3	8.2	10.7	18.9	121	1.79	2.10	3.89	129
		2nd Stage 2-3 lb	1.3	7.7	10.1	17.8	115	1.66	1.81	3.47	115
Hants 1960	Post-emergence	MCPA 1-1½ lb	1.7	8.0	10.6	18.6	200	1.04	2.09	3.13	194
		MCPA 2-3 lb	1.8	7.6	11.1	18.7	201	1.37	2.08	3.45	214
		2,4-D-amine 1-1½ lb	1.5	6.1	8.2	14.3	154	0.82	1.59	2.41	150
		2-3 lb	1.8	9.6	11.6	21.2	228	1.41	2.31	3.72	231
		2,4-D-ester 1-1½ lb	1.7	8.9	11.3	20.2	217	1.17	2.12	3.29	204
		2-3 lb	1.7	8.7	11.4	20.1	216	1.16	2.26	3.42	212
		Control same block	1.3	3.7	5.6	9.3	100	0.46	1.15	1.61	100

application of up to 3 lb/ac of simazine. Doses of the chemical exceeding 1.5 lb/ac appeared to give an added boost to the growth of the crop. The vigour of the crop in treated areas compared favourably with that of the farmers crop adjoining which was favoured with a topdressing of 34 units of nitrogen per acre and where weed control was by interrow cultivation. Gysin and Knusli (1958) have suggested that the metabolites of simazine are utilised by the maize plant for its further growth.

The hitherto high cost of simazine products, in this country may be a deterrent to wider usage in the maize crop. The Berks trial in 1960, however, indicates that the cost of chemical for a 1.5 lb/ac application is amply covered by the yield response of 1.6 ton dry matter /ac. [A valuation of £6 per ton dry matter ex-field can be considered low.] The danger, consequent on maize failure, to other crops must be emphasised. A careful survey of other trial centres in the dry year 1959 indicated however that there was no likelihood of damage to cereal crops sown in October after application of doses below 3 lb simazine/ac in the previous May.

The trial in Hampshire has shown that, where weeds susceptible to MCPA and 2,4-D dominate in a maize crop, post emergence spraying with these herbicides can lead to worthwhile increases (200 per cent) in dry matter yield. In such a case there is little to choose between MCPA and 2,4-D-amine provided the crop is sprayed at or before the 6-leaf stage. Doses of these two herbicides, below 24 oz/ac, are unlikely to cause any serious effects on the crop when applied during the early crop growth stages. Growth conditions during a 4-6 weeks period post-spraying are likely to have some bearing on the degree of crop damage and the ability of the maize to recover from any temporary setback.

At the Berks centre early application of 2,4-D or MCPA did not give a good control of weeds since some weed species were late germinating. The second stage application of growth regulator herbicides did however arrest the growth of the majority of weeds present and allowed for crop responses of the order of 15-30 per cent dry matter increase over control yield.

Summarising the results of these experiments we find that simazine is an extremely efficient herbicide for weed control in maize provided it is applied soon after the crop is sown. At rates required to give satisfactory control of weeds, normally found in the crop, there is unlikely to be any crop toxicity. Indeed simazine appears to be a stimulant to maize growth. Post-emergence control with MCPA or 2,4-D-amine can also prove satisfactory particularly if supported by inter-row cultivation. Crop damage is likely to increase however if the spraying is delayed much beyond the 5th-6th leaf development of the maize.

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APPLICATION OF HERBICIDES IN CONJUNCTION WITH PRECISION DRILLING IN KALE, TURNIPS AND SWEDES

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Summary. The results of seven experiments using P.C.P. as a pre-emergence weed control material in kale and turnips are discussed. The outcome of the investigations has been the development in practice of a modified technique of application where spraying is the first operation after ridging and drilling carried out soon afterwards. The application of herbicides in conjunction with precision seeding is becoming established as a means of further reducing the costs of root growing and results from general practice are discussed. Preliminary work with diquat suggests that this herbicide may replace P.C.P. in the future.

INTRODUCTION

The use of the precision drill in kale and root growing areas is rapidly replacing the usual cup or brush feed implement. This change means that instead of the usual 4 lb/ac seed rate a ½ lb seeding can be quite adequate provided conditions for growth are near ideal. (Prytherch, E.I. 1959).

The new drill which deposits single seeds at pre-determined spacings, demands that competition from weed growth be kept at a minimum if full advantage is to be taken of its impact in lowering growing costs. A weedy crop requires a heavy input of labour, particularly for inter-plant cleaning if the crop is to flourish. Timely cultural operations, of course, are all important to attain excellent soil conditions as well as a low weed seed population at the time of sowing and very often, under the best husbandry practices, weeds do not present a problem. But cultural difficulties sometimes arise as a result of the place of the crop in the rotation. Where kale or roots follow a one-year ley or a winter cereal crop for spring grazing the period for the preparation of the seed bed often becomes limited so that a satisfactory reduction of the weed population in the soil cannot be accomplished by the traditional methods. Complementary therefore to cultivation in the destruction of weeds for the creation of good conditions for the normal development of the crop, come weed-destroying chemicals.

The usual growth regulator types of herbicide which are at present available are unsuitable for use in brassica crops. The use of residual herbicides is dependent on their quick breakdown in soil if any measure of success is to be achieved and this in turn is greatly influenced by soil and weather conditions which cannot be predicted. The contact herbicide, provided a suitable technique for its application was devised, appeared of potential value.

METHODS AND MATERIALS

In 1955 a pilot study was carried out with PCP (pentachlorphenol) as a pre-emergence weed control agent in a crop of kale. The land was ridged up for drilling 15 days before spraying at which date there was a considerable cover of annual weeds. The kale was drilled in the weedy seed bed three days before spraying. There was a complete kill of weeds with only slight subsequent weed competition with the crop and no apparent loss of vigour in growth of the crop.

Subsequent experimental work in Wales during 1956/8 in association with the ARC followed the same pattern. The technique in the case of brassica crops was essentially a modified pre-emergence system. This was found necessary as brassica seed will germinate simultaneously with the majority of weed seeds. After sowing in the weedy seed bed when weed seedlings were about 1 in. tall, spraying effectively disposed of a large population of weed before the crop seedlings emerged. The technique of drilling in the weedy seed bed just before spraying was followed in each of the trial years.

Seven experiments were conducted in Wales over the period, five in kale and two in turnips. Details of the field operations are given in Table I.

TABLE I. DETAILS OF EXPERIMENTS

YEAR CENTRE	1956			1957			1958
	1	2	3	4	5	6	7
Date of ridging	16 June	8 July	2 July	8 July	4 June	10 June	10 July
Date of drilling	4 July	17 July	14 July	20 July	20 June	30 June	3 Aug.
Date of Spraying	8 July	20 July	17 July	23 July	24 June	2 July	4 Aug.
State of weed growth at spraying	1st leaf	Cotyledon	True leaf emerging	Cotyledon	4th leaf	Cotyledon	2nd leaf

Dry weather conditions retarded the growth of weed after the preparation of the seed bed in 1956, whilst in both 1957 and 1958, June and July were wet months and weeds flourished. Weed densities were assessed at the time of spraying, and also some 14 to 21 days later. This period will be accepted as a critical period in crop establishment, and the experiments were designed to determine the effect of the removal of early weed competition on yield of crop.

Preliminary tests with new herbicides had indicated the possible role of pentachlorphenol PCP as a useful contact herbicide in brassica crops and the trials were designed to determine the value of this chemical at two doses.

The treatments were as follows:-

A - PCP $1\frac{1}{2}$-2 lb a e/ac) Applied in 40 gal/ac at 25 psi
B - PCP 3-4 lb a e/ac)
C - Control, no hand weeding until singling
D - Control, weeds removed by harrowing after sowing

The crop at each centre was precision drilled and singled at the normal time. Cleaning was incidental in the sprayed plots as well as in the control where weeds were removed by harrowing after sowing (D). Control C represented traditional practice where weeds are allowed to compete with the crop until the usual singling time.

The weed population at each centre consisted of a variety of species, the main constituents being Polygonum persicaria (redshank), Sinapis arvensis (charlock), Brassica cleracea (wild cabbage), Spergula arvensis (spurrey) and Chenopodium album (fat hen).

RESULTS

The main results are illustrated in Table II. The effect of the herbicides on each species was very similar and consequently no individual records of herbicidal effect on different species are given in this paper.

The experiment at each centre showed that the herbicide was efficient in destroying weed growth even at a fairly advanced growth stage. The counts for the second crop of weeds which were made 14-21 days after spraying show a substantial reduction in the sprayed plot compared with the unweeded control plots 'C'. The differences were statistically significant at four centres. Moreover, the fresh crop of weeds would be in a very early growth stage at singling time compared with those in the unweeded control plots and this feature would be reflected in considerably lower costs of cleaning and singling in these plots than in those representing traditional practice plots 'C'.

A residual effect was deemed to exist where the increase in the weed population of the unweeded plots was substantially greater than the fresh populations of weed which arose after spraying. This was indicated at three centres viz. centres 1, 2 and 7.

The removal of weeds by surface cultivation soon after drilling did not reduce the weed population at singling time but being in a considerably younger stage of growth they were less competitive.

The effect of the treatments on crop plant vigour is illustrated in the scoring made soon after crop emergence. The higher dose per acre of the herbicide had a greater depressing effect on vigour at each centre than the lower. In general, this adverse effect was less than that occasioned by the competition from weed. The reduction in vigour in the initial growth stages of the crop, however, was not reflected in the total yield of crop. Comparing both sprayed treatments with the control that represents traditional practice, it was noted that yields were generally higher in the former. In fact out of 14 comparisons yields were significantly higher on 7 occasions. It must also be noted that yields per centre were generally low due to a prolonged dry weather period in 1956 which inhibited the growth of weed thus delaying the sowing date for the crop and to adverse conditions in 1957 and 1958 when prolonged rainy weather hindered the drilling and spraying operations.

DISCUSSION

The results obtained from experiments were very encouraging despite the fact that there was one obvious shortcoming to the method. This was the physical obstruction caused by the weed growth to the efficient operation of the drill. Moreover, under inclement weather conditions the crop would have germinated before spraying could be undertaken. Such experiences led to the

TABLE II. CONTROL OF WEEDS, CROP VIGOUR AND CROP YIELD

	1956				1957		1958	
	1 (Kale)	2 (Kale)	3 (Kale)	4 (Turnips)	5 (Kale)	6 (Turnips)	7 (Kale)	REMARKS
Weeds at spraying time (Range/sq ft)	11.0-19.4	16.8-24.8	23.2-40.8	30.8-97.6	11.2-24.8	10.2-21.3	21.0-30.1	
Weeds at spraying time (Mean count per sq ft)	13.8	20.1	31.5	60.4	17.0	14.0	25.5	
Mean weed count per sq ft 14-21 days after spraying treatment:					±4.0	±2.5	±2.2	
A	16.0	8.3	18.7	6.3	13.7	18.1	5.1	
B	8.7	6.3	8.2	2.5	11.5	16.6	4.1	
C	89.7	31.0	28.3	18.9	20.2	22.5	42.8	
D	83.3	23.7	11.6	10.1	16.2	18.3	13.5	
Sig. Diff.	14.2	12.7	24.5	13.2	-	-	-	
Mean score for plant vigour immediate post emergence treatment: (0-10; 10 = Maximum Vigour)								Mean Scores
A	8.3	8.7	9.3	9.7	5.7	8.0	8.0	8.2
B	6.7	7.0	7.7	8.7	5.0	7.7	7.0	7.1
C	7.3	7.0	6.7	9.7	4.0	7.3	3.0	6.4
D	9.7	10.0	10.0	10.0	7.0	8.0	8.0	8.9
Mean yields (tons/ac) treatments:					±1.2	±0.6	±6.0	Kale Yield at 13 per cent D.M. Turnip Yield at 10 per cent D.M.
A	7.4	6.7	6.9	8.2	11.7	8.8	4.0	
B	7.8	6.6	6.6	9.3	12.8	8.8	4.0	
C	4.4	6.9	5.1	8.4	7.5	7.9	3.4	
D	7.9	7.7	6.9	9.4	12.2	9.6	4.2	
Sig. Diff.	1.8	0.7	0.4	0.5	-	-	-	

practice of spraying the weedy growth as the first operation after ridging, to be followed soon afterwards by drilling. It was found that this period could vary from a matter of hours on a hot sunny day to 1-3 days under cloudy conditions. This pre-sowing spraying technique is now established as a very satisfactory method of weed control in swedes in Breconshire, although as yet, the number of farmers who have adopted the practice is relatively small. At the moment the practice is more or less confined to certain districts and its adoption is a credit to J. W. Hibler, District Advisory Officer, who has been instrumental in furthering its application.

A field survey of the results obtained this year has shown conclusively that spraying weed growth just before precision seeding, is a combined operation of practical importance. It means that the costs of growing kale, swedes and turnips can be substantially reduced by almost complete elimination of hand labour. The experience of a farmer in the Trecastle district may be cited as typical of the kind of result which is being obtained.

A field heavily infested with Polygonum persicaria, (redshank), Spergula arvensis (spurrey) and Stellaria media (chickweed) was sprayed on 10th June, 1960, under ideal weather conditions for spraying. Swedes were precision drilled at 6 in. spacing on the 11th June, 1960. Weed control was excellent and subsequent cleaning was limited to inter row cultivations once only. The contractor's charges for spraying was 15 shillings/ac plus the cost of material used.

Current Pilot Studies

Reference has been made by A. J. Butler (1958) to the commercially acceptable level of control of a number of weeds by diquat. Weeds enumerated included Polygonum convolvulus (black bindweed), Chenopodium album (fat hen), Polygonum persicaria (redshank), Urtica urens (annual nettle), Sonchus oleraceus (annual showthistle), Stellaria media (chickweed) and Galium aparine (cleavers). As this list contains most of the troublesome weeds found in root crops, the chemical was tested in preliminary trial work at two centres in Wales in 1960. Doses/ac were ½ lb, 1 lb and 2 lb in 25 gall of water at 30 psi

At the first centre, under ideal weather conditions, 1 lb/ac affected a complete kill of Brassica oleracea (wild cabbage), Polygonum persicaria (redshank), Fumaria officinalis (fumitory), Galeopsis tetrahit (hemp nettle), Stellaria media (chickweed), Chenopodium album (fat hen) and Atriplex patula (orache) within 2 days of spraying. 75-80 per cent of the weeds were destroyed at the ½ lb rate. The crop was sown two days after spraying.

At the second centre a kale crop failure had resulted in a heavy infestation of fat hen and wild orache. These weeds were at their 4th leaf stage of growth when a trial comprising the following treatments was laid down:-

A diquat - 2 lb/ac
B diquat - 1 lb/ac
C diquat - ½ lb/ac
D PCP - 2 lb/ac
E Control

Conditions for the experiment were unfavourable. Rain had fallen 2 hours prior to spraying and the leaves were still damp at spraying time. Further heavy rain fell within 6 hours of the operation but the efficiency of the product did not appear to have been impaired. A complete kill of weed was achieved at the 1 lb dose and a 65 per cent control obtained at the ½ lb dose. The kale crop was sown a day after spraying. An assessment some 28 days later of the fresh weed population, together with plant population and vigour scores for the kale crop is given in Table III.

TABLE III. WEED CONTROL, PLANT POPULATION AND VIGOUR FOLLOWING THE USE OF DIQUAT AND PCP

Treatment	Weed population/12 in. x 3 in. quadrat	Plant population/ft of drill	Plant vigour 10 = Max
A	0.57	10.7	8.7
B	1.10	10.6	8.0
C	1.90	10.4	7.7
D	1.30	11.8	7.3
E	5.30	8.0	7.0
S.E.	±0.35	±0.11	

The weed flora had undergone a complete change during the period, the dominant weed at the date of assessment being Capsella bursa-pastoris (shepherd's purse). Moreover, this weed was only 2 in.-3 in. high compared with 30 in. high weeds on the control, threatening the existence of the kale.

GENERAL CONCLUSIONS

The experiments have shown that PCP is an effective herbicide for weed control in brassica crops. The improved technique of application which has emerged from the experimental work described has shown without doubt that spraying just in advance of sowing is decidedly more efficient than precision seeding in a weedy seed bed just before spraying. The roll of diquat in conjunction with precision seeding appears highly promising.

Acknowledgments

The writers acknowledge their thanks to the several farmers who made their land available and to others who gave freely of their experience with the new techniques.

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Discussion on all papers in Session 2

A. L. Abel. Have any of the contributors any experience of the use of granular herbicides for controlling weeds in Sugar Beet?

C. Parker. As far as I know very little, if anything, has been done with granular herbicides in this country. Perhaps Dr. Buckholtz or Dr. Warren could tell us what sort of results they have had in the U.S.

G.F. Warren. We have done a great deal with granular materials in the U.S. on a number of crops. Shall I try to summarise this now or should I wait? (until Session 10 - Editor). On sugar beet in particular I am sorry that I cannot give you details except to say that some of the materials which you have been using on sugar beet here have been effective as granular formulations in our trials. I think that is as far as I can go on that one.

G. A. Toulson. It is unfortunate that the endothal/propham mixture has been formulated in such a way as to cause frequent nozzle blockage especially when the tank is nearly empty. Has anything been done to correct this drawback in more recent formulations?

B. H. Bagnall. There will certainly be an improved formulation by 1961. The results to date do not show poorer weed control results than those obtained with the formulations used during 1959.

G. B. Lush. For the record we have during the last two years carried out just under 200 trials with the OMU/BIPC mixture referred to earlier by Mr. Parker. There is, as indicated by Mr. Parker, a rainfall requirement but where this is adequate this mixture does control, very satisfactorily, a wide weed spectrum which includes Chenopodium album and Stellaria media two very important weeds in sugar beet. We have not abandoned this mixture as we are still trying to resolve the rainfall problem.

S. Everest-Todd. Most important is the time between the last rainfall and the application of the herbicide. Provided you can get your herbicide onto a fairly dry soil it does not matter how much rain there is afterwards. If the soil is dry at the time of application there is less damage to the sugar beet and good control of weeds.

G. W. Cussans. The last statement over-simplifies the position regarding the effect of rainfall.

S. Everest-Todd. When using mixtures of two chemicals the solubility of those two chemicals is hardly likely to be the same. We need a lot more experience of mixtures of propham and substituted ureas. Substituted ureas are insoluble in water. Propham is more water soluble. These two chemicals move through the soil at different rates and if you have a wet soil at the time of application then you emphasise the variation in the movement of these chemicals through the soil. One chemical catches the beet at one stage the other chemical at another stage. If both affected the beet at the same stage of growth then there is a fair chance of plant recovery, When the beet gets two knocks it does not stand much chance at all.

J. G. Elliott. Could Mr. West clarify the question of taint in potato tubers? There appears to be some discrepancy on the question of taint, following the use of herbicides, in the two papers presented.

W. J. West. There is no conclusive evidence.

G. W. Cussans. Could it be that moulding-up early will produce a higher percentage of elongated internodes and subsequently of green tubers?

W. J. West. We have not experienced this difficulty in our trials.

M. C. Cade. Sugar beet is grown very successfully in Australia and there good results have been obtained where CDEC is used for weed control.

C. Parker. CDEC certainly has been screened here but has not proved satisfactory in controlling a wide enough spectrum of weeds. Against most of the annual grasses it does not look as promising as propham or endothal.

Dr. Feekes. I see that the mixtures of CIPC have done well in bulbs. Our experience in Holland indicates that they can be extremely dangerous in bulbs, especially tulips.

Chairman. We shall be dealing with flower bulbs during session 7; please raise your query again then.

SESSION 3

Chairman: Professor W. Ellison

IMPROVEMENT OF PASTURES AND HILL GRAZING

THE CONTROL OF WEEDS BY MCPA IN PERMANENT PASTURE UNDER DIFFERENT MANAGEMENTS AND THE EFFECTS ON HERBAGE PRODUCTIVITY

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Summary: The effects of controlling weeds in permanent pasture by MCPA were studied over a period of years, with and without applied nitrogenous fertiliser. *Ranunculus* species were controlled for at least 3 years by spraying, other weed species were initially controlled but began to recover during the 2nd and 3rd years after spraying. All dicotyledonous species were reduced to negligible quantities by spraying plus nitrogen. Nitrogen without MCPA controlled *Ranunculus* but encouraged the development of other weed species. Herbage yields (particularly of grass plus clover) tended to be reduced by spraying alone. Nitrogen increased total yields, primarily because of the extra grass growth. Nitrogen plus spraying produced very grassy swards.

INTRODUCTION

A recent survey has shown that there are still nearly 7 million acres of permanent grassland in lowland England. Only 20 per cent. of this can be classified botanically as good grassland; 60 per cent consists of inferior *Agrostis*/ryegrass or *Agrostis* swards and 20 per cent of fescue, *Nardus*, *Molinia*, and rush-infested grassland (Baker 1960).

The quickest and surest method of improving permanent grassland is to plough and reseed. However, the permanent grassland includes a large acreage which has remained unploughed because of physical conditions (e.g. topography, high water-tables, etc.). Such swards may be improved by oversowing in conjunction with spraying and/or surface cultivations. (Elliott 1960), and such techniques are particularly appropriate where the swards consist of inferior grasses and dicotyledonous weeds alone. There is, however, a large acreage of unploughed permanent grassland (particularly of the *Agrostis*/ryegrass type) which although infested with dicotyledonous weeds, also contains clover and some of the better grasses, e.g. *Lolium perenne* and *Phleum pratense*. Many of the dicotyledonous weeds in these pastures can be controlled by spraying. Although this spraying may temporarily reduce the clover content it should be possible to improve the sward gradually by encouraging the development of better grasses and clovers, thereby eliminating the blank period of production which follows surface killing and reseeding.

The object of the present series of experiments is to study the long-term effects following the application of MCPA to permanent pasture which is infested with dicotyledonous weeds (particularly Ranunculus repens and R. acris) containing some clover and better grasses. Changes in herbage production and the botanical composition are studied under different nitrogenous and grazing treatments.

This paper presents the final results from a trial already reported (Baker and Evans 1960) together with current results from a second trial.

METHODS AND MATERIALS

The two sites were both in old permanent pastures in the Thames Valley.

Initial botanical composition. Site I (1957 - 1959). The sward contained Lolium perenne, Dactylis glomerata, Festuca rubra, Poa trivialis, Agrostis stolonifera, Holcus lanatus, and Deschampsia caespitosa. Both Trifolium repens and T. pratense were present. The predominant dicotyledonous weeds were Ranunculus repens, R. acris, Taraxacum officinale and Crepis spp.

Site II (1959 - 1960). The same grasses and clovers were present as in Site I except Deschampsia caespitosa. The main dicotyledonous weeds were Ranunculus repens, R. acris, Bellis perennis, Plantago major, P. lanceolata, Circium arvense, and Urtica dioica.

Treatments. Site I: 1) Unsprayed, no nitrogen, 2) Unsprayed + 104 lb. nitrogen/acre/annum, 3) Sprayed, no nitrogen, 4) Sprayed + 104 lb. nitrogen/acre/annum.

Site II: The same treatment as for Site I plus 2 grazing managements: A. Continuous grazing and B. Rotational grazing.

The grazing managements formed the main plots and each was split for the application of spraying and fertiliser treatments.

On Site I each plot measured 30 yd. x 20 yd. Each sub-plot of Site II measure 30 yd. x 15 yd.

Spraying. Both sites were sprayed with 24 oz of MCPA - potassium per acre in 22.4 gal of water, Site I was sprayed on 8th May, 1957 and Site II was sprayed on 29th May, 1959.

Fertilisers. A uniform dressing of 54 lb of P_2O_5 and 54 lb of K_2O was supplied to all treatments at each site at the begining of the experiments.

Nitrogen was applied to the appropriate plots at 52 lb per acre on the following dates:-

Site I	Site II
14 May and 25 July 1957	8 June and 16 July 1959
16 April and 9 July 1958	21 April and 25 July 1960
10 April and 7 August 1959.	

Grazing management. Site I was grazed by beef cattle, which had free access to all plots from May to September. Site II was grazed by both sheep and cattle. Stock had free access to the plots continuously grazed from the commencement of the trial to December, 1959 and from March onwards in 1960 (except for periods during June and August). The rotational plots were grazed four times in 1959 and 1960.

Sampling. Botanical analyses and herbage yields were obtained by methods previously described (Baker and Evans, 1960).

RESULTS

Site I. The detailed yields and botanical assessments for 1957 and 1958 have been given in the previous report. Table I shows the total yields for all years and the yield of individual species in 1959.

The yields in 1959 on the sprayed plots were the same as on the control treatment; a reduced weight of the *Ranunculus* species being accompanied by a corresponding increase in that of grass. The application of nitrogen alone produced the highest yields because of an increase in growth of the grasses and of the other weeds (especially *Taraxacum* and *Crepis* species). On the sprayed plots yields were similar whether or not nitrogen had been applied.

Site II. The specific frequency of weeds both before spraying in May 1959, and twelve months later are given in Table II. Herbage yields during 1959, after spraying on 8th May, are given in Table III, together with herbage production from March to October 1960.

Twelve months after spraying the frequency of both *Ranunculus repens* and *R. acris* was drastically reduced (Table II) and the total yields of *Ranunculus* in the two seasons following spraying were negligible (Table III). The yields of clover were considerably reduced after spraying (Table III - 1959) but in the following spring the frequency of *T. repens* on the sprayed areas was 50 per cent to 70 per cent of the control, whilst the frequency of *T. pratense* was unaffected (Table II). The yields of clover in the second year showed a considerable improvement on the sprayed plots.

The yields of dicotyledonous weeds other than *Ranunculus* were reduced by spraying to negligible levels during the first year, but had increased in both frequency and yield by the second season.

The major effect of applying nitrogen was to increase grass yield, but there was also a cumulative depression of clover, Spraying plus nitrogen produced a very grassy sward, particularly under rotational grazing.

Total herbage yields were reduced by spraying but were considerably increased by nitrogen alone or nitrogen plus spraying.

DISCUSSION

It was evident from both sites that spraying with MCPA provided a good control of *Ranunculus* species throughout the duration of the experiments. The other dicotyledonous weeds (particularly *Compositae*) were initially reduced by spraying, but tended to increase again during the second and third years. The clovers were also reduced by spraying, but they returned more rapidly than the broad-leaved weeds. Jeater (1958) found that spraying weed-infested swards did not alter the total herbage yield, but the proportion of grasses increased at the expense of weeds. In the present trials the total herbage yields of the plots sprayed without the addition of nitrogen, did not normally equal those of the control plots, and only at Site I in 1959 was the reduction in yield of dicotyledonous species matched by a corresponding increase in grass yield.

The application of nitrogen resulted in increased total yields, primarlly due to the extra growth of grasses. Ranunculus and clovers were both reduced by nitrogenous fertilising, but other weeds were encouraged by nitrogen on the continuously grazed plots, particularly Taraxacum officinale on Site I, and Cirsium arvense at Site II. In mid-season 1959 over 20 per cent of the dry matter in the herbage on the nitrogen plots at Site I consisted of Compositae and other weed species. The presence of a high proportion of such weeds would probably lead to the rejection by animals of grasses in the immediate vicinity of the weeds and would eventually lead to sward deterioration.

At Site II the responses to nitrogen were more consistent and greater than on Site I and an average of over 20 lb. of extra herbage was produced per pound of added nitrogen. This was possibly associated with the better utilisation of herbage at Site II where the herbage on all plots was consistently well grazed. As indicated in the previous report, the nitrogen plots at Site I were grazed harder than the non-nitrogen plots. Nevertheless, throughout the duration of the trial at Site I all plots appeared undergrazed.

The combination of nitrogen and spraying always produced a grassy sward with very little clover and few weeds. Generally the total herbage yields were relatively high. There were, however, certain anomalies. At Site I in 1959 the grass yields on plots which were sprayed and which received nitrogen were no higher than those of plots only sprayed and not as high as the plots which received nitrogen alone. Similarly on the rotationally grazed treatment at Site II in 1959, the yields of all species, including grasses, were considerably reduced on the nitrogen plus spray plots when compared with nitrogen alone. The reasons for these differences are not clear, although the dry summer of 1959 may have contributed to them. It should however, be noted that in July, 1959, 12 per cent of the dry matter on the nitrogen plots at Site II consisted of clover and this may have stimulated additional grass growth.

Grazing utilisation on all plots at Site II was good throughout the 2 years under review. On the continuously grazed control plots there was frequently a vigorous growth of Ranunculus spp. within the sampling cages, but outside these species were eaten down to ground level. The rotationally grazed plots responded well to nitrogen, but the yields of all treatments were considerably less during 1959 than those of the continuously grazed plots. This may have been partly due to variations caused by the drought, thus within one block the rotational grazed plots burned badly, whilst the corresponding continuously grazed plots remained green.

On plots which received nitrogen there was a general increase in the percentage of ryegrass and cocksfoot in the swards. At Site II in particular the amount of cocksfoot on the areas rotationally grazed increased considerably, whilst on the uncontrolled grazed plots which received no nitrogen, there was a considerable amount of Agrostis and of fine-leaved fescues.

The evidence so far accumulated indicates that the control of weeds by the application of sprays alone does little to raise total herbage productivity. Nitrogen increased the quantity of grass present, although it also encouraged the development of undesirable weeds e.g. Cirsium arvense and Taraxacum officinale. A combination of spraying and nitrogen was the best treatment for controlling weeds, although the clovers were depressed. The best responses to nitrogen occurred at Site II where all the plots were well grazed by stock. It thus appears therefore, that the control of weeds by spraying must be accompanied by application of nitrogen and the resulting extra grass adequately utilised.

Acknowledgements

The authors are grateful to the A.R.C. Unit of Experimental Agronomy for applying the spray treatment, to the N.A.A.S. for co-operating in obtaining the sites and to D.R. Lockyer for assistance in the field work.

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TABLE I. THE EFFECT OF SPRAYING AND NITROGEN APPLICATION ON THE YIELDS OF HERBAGE FROM A PERMANENT PASTURE. SITE I.

(Dry Matter, lb/ac)

Year		Control	MCPA	Nitrogen	Nitrogen + MCPA	Standard Error
1957	Total spp.	5310	5020	6590	6800	± 300
1958	Total spp.	7000	6640	8830	8800	± 300
1959	Grasses	3170	3610	3900	3600	± 80
1959	Clovers	80	70	40	30	± 16
1959	*Ranunculus* spp.	400	60	260	20	± 75
1959	Otherwweeds	70	50	380	40	± 67
1959	Total spp.	3720	3790	4586	3690	± 107

TABLE II. SPECIFIC FREQUENCY (PER 30 X 3 IN. QUADRATS) OF THE OCCURENCE OF WEEDS AND CLOVER IN THE SWARD. SITE II

Species	Date	Continuous grazing				Rotational grazing			
		Control	MCPA	Nitrogen	Nitrogen + MCPA	Control	MCPA	Nitrogen	Nitrogen + MCPA
Ranunculus repens	1 May 1959	20	16	16	18	16	19	13	14
	5 May 1960	17	2	8	1	12	1	8	1
Ranunculus acris	1 May 1959	5	7	3	8	10	7	12	8
	5 May 1960	6	1	3	2	10	2	7	1
Trifolium repens	1 May 1959	27	23	26	27	23	22	26	25
	5 May 1960	29	20	25	17	29	18	21	14
Trifolium pratense	1 May 1959	2	3	1	1	4	3	3	5
	5 May 1960	2	3	2	4	5	6	1	5
Various spp.	1 May 1959	11	15	16	8	21	12	19	13
	5 May 1960	17	14	24	4	28	13	12	8

1 May 1959 :- pre-spraying assessment

TABLE III. THE EFFECT OF SPRAYING AND NITROGEN APPLICATION ON THE YIELDS OF HERBAGE FROM A PERMANENT PASTURE UNDER DIFFERENT MANAGEMENTS. SITE II.

(Dry matter, lb/ac)

YEAR		Continuous Grazing				Rotational Grazing				Standard error (approx)
		Control	MCPA	Nitrogen	Nitrogen + MCPA	Control	MCPA	Nitrogen	Nitrogen + MCPA	
1959*	Grasses	2060	1810	3690	4680	1280	870	3280	2620	± 540
	Clovers	750	110	230	60	420	20	310	50	± 178
	Ranunculus spp.	390	tr	90	30	70	10	80	10	± 129
	Other weeds	90	10	120	tr	110	tr	40	10	± 38
	TOTAL	3290	1930	4130	4770	1880	900	3710	2690	± 768
1960	Grasses	5080	5290	8870	8810	6800	6090	9700	9560	
	Clovers	740	460	130	120	380	290	80	60	
	Ranunculus spp.	520	20	100	20	160	tr	40	tr	
	Other weeds	610	270	740	110	330	70	170	70	
	TOTAL	6950	6040	9840	9060	7670	6450	9990	9690	

* Yields from 8th May to end of season.

Discussion on preceding paper

Mr. S. Campbell. At the first British Weed Control Conference (1953) there was considerable discussion on the economic aspects of weed control in grassland. The general feeling then was that at that time weed control in grassland was a doubtful economic proposition. It was not surprising therefore that at intervening conferences grassland aspects of weed control were mainly concerned with the elimination of specific weeds, e.g. rushes, and very few papers dealt with the overall effect on total sward production. It is refreshing therefore to find that a lot of work is now being done from the herbage production point of view. Are we satisfied with the existing herbicides available for pasture weed control? It seems to me that there is a future for a herbicide less damaging to white clover than MCPA and more effective against broad leaved weeds than MCPB. The techniques described in this paper should be of considerable value in improving Dales meadows - these are meadows which are reserved for annual mowing and generally contain a large proportion of broad-leaved weeds - or herbs! - a wide range of grass species and practically no legumes. It has already been shown that the use of a herbicide by itself on such meadows drastically reduces the total yield of dry matter.

Dr. H. K. Baker. I agree with your point regarding damage to clover by spraying with MCPA but, on the other hand, clover can be encouraged to return, after spraying, with proper management.

Dr. J. Stryckers. I am surprised at the time of spraying MCPA on permanent pasture in these experiments. May is a good time to spray *Ranunculus* spp. but it is also a bad time for the clover. We prefer the period from mid-August to early October; *Taraxacum officinale* and other *Compositae* also are susceptible at this time. After application of MCPA or 2, 4-D an initial yield decrease occurs, but at the second cut after spraying it returns to normal; in general, higher yields have occured on the fourth or fifth cuts, especially after an autumn application.

Mr. Lewis Jones. We tried to keep out treatments simple. There is more *Ranunculus* present in May and more time after spraying for damaged clover to re-establish itself.

Discussion on [illegible] paper

Mr. A. Campbell. At the first British Weed Control Conference in 1953 there was considerable discussion on the economic aspects of weed control in grassland. The general feeling then was that at that time weed control in grassland was a [illegible] economic proposition. It was [illegible] that [illegible] grassland [illegible] control [illegible] with the elimination of specific weeds, e.g. thistles, and very few papers dealt with the overall effect on total sward production. It is refreshing therefore to find that a lot of work is now being done from the overall production point of view. [illegible] satisfied with the [illegible] herbage availability for pasture weed control. It seems to me that there is a future for a herbicide [illegible] clover than MCPA and more selective against broad leaved weeds than MCPA. The techniques described in this paper should be of considerable value in [illegible] [illegible] which are required for [illegible] [illegible] and [illegible] a large proportion of broad-leaved weeds - so called [illegible] - [illegible] species and practically no legumes. It has already been shown that the use of a herbicide by itself on such swards drastically reduces the total yield of dry matter.

Mr. R. A. [illegible]. I agree with your point regarding damage to clover by spraying with MCPA but, on the other hand, clover can be encouraged to return, after spraying, with proper management.

Mr. J. [illegible]. I was impressed at the time of spraying MCPA on permanent grass in these experiments, that this [illegible] good time to spray [illegible] [illegible], it is also a bad time for the clover. We prefer the period from [illegible] to early [illegible]. *Taraxacum officinale* and other composites also are susceptible at this time. After application of MCPA at 2 lb an initial yield decrease occurs, but at the second cut after spraying it returns to normal. In general, higher yields have occurred on the fourth or fifth cuts, especially after an autumn application.

Mr. Lewis Jones. We tried to keep our treatments simple. There is more [illegible] in the long term after spraying [illegible] clover is re-establishing itself.

THE USE OF CHEMICALS IN THE RENOVATION OF DIFFICULT SWARDS IN THE EAST MIDLANDS OF ENGLAND

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INTRODUCTION

In a paper given to the Fourth British Weed Control Conference (Ormrod 1958), field experiments on six sites were described, in which dalapon plus 2,4-D-ester was applied as a sward killer and followed by re-seeding after surface cultivations. Cultivations were actually carried out on four sites, two of which were successfully re-seeded. The work described below was designed to answer some of the problems encountered in the six experiments.

METHODS, MATERIALS AND RESULTS

1. Study of time of application of dalapon

As the earlier trials were sprayed in autumn, two experiments were carried out to determine whether spraying at other times of the year would permit the employment of lower doses of dalapon than were found necessary in the autumn. The treatments were:

Dates of spraying - 1958

late spring - 29th May
mid-summer - 19th July
early autumn - 17th September

Chemicals (lb/ac)

7½ lb dalapon)
15 lb ") + 1½ lb 2,4-D-ester.

Both chemical treatments were sprayed at each date at 20 gal/ac volume rate with unsprayed controls arranged in a randomised block design with three replications and a plot size of 20 yd x 5 yd. These small plots were not cultivated or re-seeded.

Two contrasting sward types were chosen:

Hill sward: Altitude 1,350 ft. Low fertility, very wet, thick acid mat. Dominant grasses *Nardus stricta*, *Deschampsia flexuosa*, *Agrostis* spp., *Anthoxanthum odoratum*, *Festuca ovina*. No clover or broadleaved weeds.

Lowland sward: Altitude 350 ft. Moderate fertility, well drained, no acid mat. *Agrostis*/ryegrass type with clover and broadleaved weeds, especially *Ranunculus repens*, *Cirsium arvense* and *Prunella vulgaris*.