USE OF COMBINATION OF WEEDKILLERS IN PEAS AND MAIZE CROPS

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SUMMARY

TRIALS are described which showed that canning peas sprayed from the 4th to 9th node stages inclusive tolerated a mixture of 8.4 lb a.i. per acre of SMCA and $\frac{1}{4}$ lb a.i. per acre of the sodium salt of MCPB. This mixture applied up to the 6th pea node stage gave effective control of the broad-leaved weeds. The main weeds were willow weed (*Polygonum persicaria*) and fathen (*Chenopodium album*).

With maize, atrazine gave better control of the broad-leaved weeds than simazine, in a very dry season. Neither material controlled the annual grasses. The yields of shelled grain from atrazine and simazine treated plots were not significantly greater than those from plots treated with the amine salt of 2,4-D.

It was previously reported (1) that a combination of SMCA and MCPB gave a more satisfactory control of a wider range of weed species than either chemical alone. This paper gives the results of detailed trials conducted during the 1960-61 season in which various combinations of rates of SMCA and MCPB were applied at various stages of pea growth. Results are also given from a maize trial where two chemicals of the triazine group were compared.

EXPERIMENTAL

All trials were conducted at the Rukuhia Soil Research Station on Horotiu sandy loam. In the pea trials, a composite design layout designed by G. E. P. Box (2) was used. There were six replications of treatments applied in the maize trial, which was of a randomised block design. All yields were taken from the centre rows of each plot and are expressed in the subsequent tables as bushels of the shelled material per acre. All treatments were applied in 30 gallons of water per acre by the Oxford Precision Sprayer at 30 lb pressure. The pea variety sown was Kelvedon Monarch, and Wisconsin hybrid 643 maize seed was used.

PEAS

The differences between the two pea trials are indicated in the following tabulation:

	<i>Trial A</i>	<i>Trial B</i>
Sown	1/10/60	16/12/60
Stages at spraying	3 to 7 nodes	5 to 9 nodes
Date harvested	20/12/60	20/2/61
Sowing to harvest	80 days	65 days

Weather: (A) Generally sunny after each spraying except for 13 points of rain that fell soon after the 4th node spraying. (B) Fine and sunny, except for 125 points of rain in the two days following the 9th node spraying.

The weed infestation in both trials was moderately heavy, and consisted mainly of willow weed (*Polygonum persicaria*), redroot (*Amaranthus hybridus* previously *A. retroflexus*), fathen (*Chenopodium album*), nightshade (*Solanum nigrum*), and *Chenopodium pumilio*. There was also some spurrey (*Spergula arvensis*) and purslane (*Portulaca oleracea*) present in

the second trial. The rates of the two materials combined in trial A at the various pea node stages of growth were as follows:

Pea nodes	SMCA (lb a.i. per acre)	plus MCPB (lb a.i. per acre)
3	8.4	0.75
4	7.35	0.45
	7.35	1.05
	9.45	0.45
	9.45	1.05
5	6.72	0.75
	8.4	0.25
	8.4	0.75
	8.4	1.25
	10.08	0.75
6	7.35	0.45
	7.35	1.05
	9.45	0.45
	9.45	1.05
7	8.4	0.75

The odd quantities stated are due to the requirement of the composite design layout.

The soil was dry when trial B was sown, and only 58 points of rain fell before the peas had reached the 8th node stage. Consequently, because of the dry weather there was an uneven germination of both peas and weeds which were slow in growing. For this reason the first spraying was delayed until the 5th pea node stage. The treatments were the same as in trial A, except that they were applied when the peas had 5 to 9 nodes instead of 3 to 7 nodes.

Weed Control

It is commonly known that willow weed and fathen are largely controlled by SMCA and MCPB respectively, and in the tabulations these two weeds have been separated.

Willow weed: Table 1 shows the control obtained of willow weed by various rates of SMCA when applied at different stages of weed growth.

TABLE 1—CONTROL OF WILLOW WEED BY SMCA

	(lb a.i. per acre)				
Size when treated	6.72	7.35	8.4	9.45	10.08
1 to 2 leaves, 1 to 2 in. diam.	VG		EX		EX
3 to 4 leaves, 2 to 3 in. diam.		G	VG	VG	
4 to 5 leaves, 3 to 5 in. diam.	Fair	G	G	G	VG

The minimum rate required for very good control of willow weed is 8.4 lb a.i. per acre. This rate gave 100 per cent control of willow weed that had up to four leaves and 3 in. in diameter. Therefore under normal weed conditions 8.4 lb a.i. per acre would be sufficient to give satisfactory control, if applied before the 6th node stage, but if there were a very heavy weed infestation, 10.08 lb a.i. per acre would probably be advantageous.

Fathen: Table 2 shows the results of both general plot observations and individual plant peggings:

TABLE 2—CONTROL OF FATHEN BY MCPB

	(lb a.i. per acre)				
Size when treated	0.25	0.45	0.75	1.05	1.25
1 leaf, $\frac{1}{2}$ to 1 in. diam.		VG	EX	EX	
2 leaves, 1 in. diam.	FG		EX		EX
4 leaves, 2 in. diam.	Nil	Poor	VG	EX	EX
4 to 6 leaves, 2 in. diam.	Nil		G	EX	EX
6 to 8 leaves, 2 in. diam.	Nil		F. poor	VG	

Generally, not very good control was obtained with either the 0.25 lb or 0.45 lb a.i. per acre rates of MCPB, unless applied before the fathen had reached the one-leaf stage. However, the 0.75 lb a.i. per acre rate gave very good to excellent control up to the four-leaf stage, but much less control after the six-leaf stage. It was also noted that the control was much better at the four-leaf stage when the fathen was no more than $\frac{3}{4}$ in. high. With 1 lb a.i. per acre of MCPB, very good control was obtained on fathen with six to eight leaves.

Redroot: Table 3 shows the control of red root obtained by the combination of about 0.75 lb a.i. per acre of MCPB with various rates of SMCA. SMCA 8.4 lb a.i. per acre plus MCPB 0.75 lb a.i. gives adequate control when redroot has not more than four leaves. However, by increasing the rate of SMCA to 9.24 lb a.i. per acre or 10.08 lb a.i. per acre or MCPB to 1 or 1.25 lb a.i. per acre the larger redroot should be satisfactorily controlled.

TABLE 3—CONTROL OF REDROOT BY RATES OF SMCA PLUS MCPB AT 0.75 LB A.I. PER ACRE

Size when treated	(lb a.i. per acre)			
	7.35	8.4	9.45	10.08
1 to 2 leaves	FG	EX	FG	
2 to 3 leaves	Fair	EX	EX	EX
3 to 4 leaves		VG		
Over 5 leaves, 2 to 4 in. diam.	FG	G	VG	
6 in. diam.		Poor		

Nightshade: The mixture of SMCA at 8.4 lb a.i. per acre and MCPB at 0.75 lb a.i. per acre was again sufficient for excellent control, if applied when the nightshade was about the one-leaf stage. The rate of MCPB in the mixture may have to be increased to 1 or 1.25 lb a.i. per acre for effective control of larger nightshade plants with up to three leaves.

Other weeds: When *Chenopodium pumilio* was up to four leaves and $1\frac{1}{2}$ in. in diameter very good to excellent control was obtained with the mixture of SMCA 8.4 lb a.i. per acre and MCPB at 0.75 lb a.i. per acre. This mixture gave excellent control of spurrey when 1 in. high but no control of purslane when from $\frac{1}{4}$ to 2 in. long.

From the above tabulations it is concluded that the combination of SMCA at 8.4 lb a.i. per acre and MCPB at 0.75 lb a.i. per acre is sufficient for very good to excellent control of broad-leaved weeds, provided they are not too large. This would mean spraying before the 6th pea node stage. In any normal growing season most of the broad-leaved weeds would be no larger than two to four leaves, and 1 to 2 in. diameter, when the pea crop has no more than 5 or 6 nodes.

Yields

In this composite design layout the effect of the treatments on the yields can best be seen by a number of graphs that separate the various factors and interactions of the trial. In the graphs the average yield from each of a particular material is shown. The figures show the mean of the two replicates, and the yield is shown as bushels of shelled peas per acre. The hand weeded and unweeded controls could not be included in the statistical analysis, and the yields from these are shown in horizontal lines in the figures.

Trial A

The following tabulation shows the yields of the main treatments.

Hand weeded	101.5 bushels/acre
SMCA 8.4 lb a.i. per acre + MCPB $\frac{3}{4}$ lb a.i. per acre, 5 node	97.4 bushels/acre
Unweeded	77.8 bushels/acre

Effect of MCPB: The effect of the various rates of MCPB on pea yields did not approach significance, and are not shown in the figures. This is

probably due to the fact that willow weed, which was dominant in the trial, was not controlled by the rates of MCPB used. However, if fathen were the dominant weed, the control of such by MCPB would no doubt have increased the yield.

Effect of SMCA: The effect of rate of SMCA was significant at the 1 per cent level. The yields obtained generally correspond to the degree of weed control given by the various rates of SMCA. The figure indicates that a minimum rate of 8.4 lb a.i. per acre of SMCA is required for effective weed control; otherwise a substantial reduction in yield can be expected from the competition with the remaining uncontrolled weeds.

Time of Application: This was significant at the 5 per cent level only. The 3rd node stage was too early, because of the toxic effects of the treatments, and also there was a later germination of weeds that reinfested the plots, and the combination of these two factors reduced the yield. The yield at the 4th pea node was somewhat low because of rain that fell soon after spraying, reducing the weed control. At the time of the 7th node spraying the weeds may have been slightly too large to be effectively controlled. Thus it appears that good results can be obtained up to the 5th or 6th pea node.

There were no significant interactions in this trial.

Trial B

The following tabulation shows the yields of the main treatments:

Hand weeded	59.1 bushels/acre
SMCA 8.4 lb a.i. per acre + MCPB $\frac{1}{2}$ lb a.i. per acre at 7th node	57.3 bushels/acre
Unweeded	35.0 bushels/acre

The yield differences due to rate of SMCA, rate of MCPB, and number of nodes did not reach significance. However, there was a significant interaction between the rate of SMCA and the time of application, which was significant at the 5 per cent level.

The effect of various rates of SMCA at the 6th, 7th, and 8th node stages was studied. It is apparent that by increasing the rates of SMCA at the 6th node stage, better weed control would be obtained, resulting in increased yields. However, at the 7th node stage there would be little, if any, increase in yield by increasing the rates of SMCA. This result is possibly the effect of competition from the larger weeds that were not controlled. Similarly, at the 8th node stage the weeds would be slightly too large to be adequately controlled by the rates of SMCA used, and there would be no resulting increase in yield. In fact by this stage the pea plant is approaching flower initiation and appears more susceptible to higher rates of SMCA.

In the results of the two pea trials concerning the effect of SMCA, it must be noted that this was always in the presence of MCPB, which was found at the rates used to have caused little difference to the yields.

MAIZE

Pre-emergence treatments of simazine and atrazine at 1.5 lb a.i. per acre and a mixture containing 0.75 lb a.i. per acre of each were applied under dry soil conditions a day after the maize was sown on 22/11/60. There followed 10 days of fine, sunny weather until 120 points of rain fell from 3 to 12 December. The amine salt of 2,4-D at $\frac{1}{2}$ lb a.i. per acre was applied when the maize had four leaves and was 4 in. high, during a period of fine, sunny weather. The weed infestation was a mixture of mainly willow weed at the four-leaf stage, 2 to 3 in. in diameter, and redroot with two to three leaves, 1 in. in diameter. When the trial was laid down there was a soil moisture deficit of about 1 in., and even up to the time of the formation of grain on the cobs, the soil moisture deficit was never offset by normal rainfall. Consequently, the maize crop suffered from a severe lack of moisture which increased with time, with the result that the yield was very poor, even on the plots that had been kept hand weeded.

Weed Control

On the unweeded plots there were heavy infestations of redroot and willow weed, with moderate infestations of annual summer grasses of *Panicum* spp. The following table shows the weed control obtained by the chemical treatments:

Treatment lb a.i. per acre	Redroot	Willow Weed
Atrazine 1.5	EX	VG-EX
Atrazine 0.75 + Sima- zine 0.75	VG-EX	VG
Simazine 1.5	G-VG	Fairly good
Amine 2,4-D $\frac{1}{4}$	EX	VG

With the unusually very dry conditions prevailing in this trial atrazine (70 p.p.m. soluble in water) gave much better broad-leaved weed control than the less soluble simazine (3.5 p.p.m.) and the mixture of the two triazines was intermediate. There was little, if any, control of the annual summer grasses by the chemical treatments. Though simazine gave poor control, it was slightly better than atrazine.

Yields

The amount of annual grasses present varied from a very heavy to a very light infestation from one end of the trial to the other, and yields, though still poor, were better where there were fewer grasses. The following table shows the average yields of shelled grain (at 16 per cent moisture) in bushels (56 lb) per acre; and also the average height of the crop at the time of harvesting.

Treatment lb a.i. per acre	Crop height (ft)	Bushels per acre	5%	1%
Hand weeded	5 $\frac{1}{2}$	47.2	a	A
Simazine 0.75 + atrazine 0.75	4	18.2	b	B
Atrazine 1.5	3 $\frac{1}{2}$	15.5	b	BC
Simazine 1.5	4	15.3	b	BC
Amine 2,4-D $\frac{1}{4}$	3 $\frac{1}{2}$	13.2	b	BC
Unweeded	2 $\frac{1}{2}$	2.6	c	C

C.V. 41.4 per cent

The above yields indicate that there is little difference between the chemical treatments, and that the heavy infestation of broad-leaved weeds on the unweeded plots has very severely reduced the yield compared to those of the other treatments. Due to the heavy infestation of grasses, the reduction in yield on the chemically treated plots, compared with the hand weeded plots, was significant at the 1 per cent level. The other slight differences in yield are probably due to the varying amounts of broad-leaved weeds and grasses. The order of treatments according to yield corresponds to the general degree of weed control given by each treatment.

SUMMARY AND CONCLUSIONS

(1) A combination of 8.4 lb a.i. per acre of SMCA plus $\frac{1}{4}$ lb a.i. per acre of MCPB gave adequate broad-leaved weed control in peas when applied no later than the 6th pea node stage. This mixture gave very good to excellent control of the following broad-leaved weeds:

- Willow weed when up to four leaves, but a 10.08 lb a.i. per acre rate of SMCA in the mixture may be necessary for heavy infestations.
- Fathen with up to four leaves, but when the fathen had reached more than the six-leaf stage, a rate of about 1 lb to 1 $\frac{1}{4}$ lb a.i. per acre of MCPB was needed to give very good control.
- Redroot when no more than the four-leaf stage. Larger plants can be controlled by increasing the rate of SMCA to 9.24 or 10.08 lb

Effect of rate of MCA at node stages (trial A).

Effect of rate of MCA at node stages (trial B).

- a.i. per acre, or the MCPB rate to 1 or 1½ lb a.i. per acre, according to the other weeds present.
- (d) Nightshade when about the one-leaf stage; 1 to 1½ lb a.i. per acre of MCPB is needed for plants up to three leaves.
 - (e) *Chenopodium pumilio* when with four leaves, and 1½ in. in diameter.
 - (f) Spurrey when 1 in. high.
 - (g) *Portulaca* spp. when ½ to 2 in. long was not controlled.
- (2) The mixture of SMCA at 8.4 lb a.i. per acre and MCPB at ½ lb a.i. per acre was not toxic to peas after the 4th node. Due to the effective weed control given by this mixture the yield was little different from that obtained from the hand weeded, but far greater than the unweeded. The greatest yield was obtained with these rates at the 5th to 6th node stages. Earlier applications may be somewhat toxic to the peas, and later applications may be poorer because the weeds are too large to be effectively controlled.
- (3) In a maize crop growing under very dry conditions both atrazine at 1.5 lb a.i. per acre and the amine salt of 2,4-D at ½ lb a.i. per acre gave very good to excellent control of redroot and willow weed. Simazine at 1.5 lb a.i. per acre gave only fairly good to very good control of the broad-leaved weeds.
- (4) Under the same dry conditions simazine gave slightly better control of the annual grasses than atrazine.
- (5) The combination of 0.75 lb a.i. per acre of each of the two triazines gave a slightly better overall control of the broad-leaved weeds and grasses than either material alone.
- (6) Due to the dry conditions poor yields were obtained from the trial, even on the hand weeded plots. However, on the chemically treated plots where there were fairly heavy infestations of grasses which were competing with the maize for moisture, the yields, though not significantly different from each other, were significantly (1 per cent) less than the hand weeded, but significantly (5 per cent) greater than the unweeded control.
- (7) Under conditions of adequate moisture the application of simazine would give effective broad-leaved weed control, with possibly better grass control, and this might give yields greater than plots treated with ½ lb a.i. per acre of the amine salt of 2,4-D.

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References

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Statistical Design

The statistical design used in this trial has a somewhat different approach from the ordinary design. It sets out to fit a **response surface** rather than to compare individual treatments. (A response surface is a generalisation of a response curve into three or more dimensions.) Consequently, we do not test significant differences between treatments, but instead test the slope and curvature of the whole response curve. This approach allows a great economy in number of plots used.