Selectivity against weeds of phenoxyacetic acid herbicides applied in association with a liquid fertilizer*

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COMPENDIO

Se realizaron estudios sobre la posibilidad de aplicación de herbicidas en asociación con fertilizantes líquidos.

Se aplicaron dos fórmulas de ácidos fenoxiacéticos, a saber "Banlene plus" (A) y "Cambilene plus" (B), como herbicidas selectivos contra la mostaza silvestre (Sinapis arvensis) *y la presea* (Galium aparine) *en dos estados del crecimiento de cebada de primavera. Los herbicidas fueron aplicados individualmente en dosis de 2, 4, 6 kg/ha, y en forma combinada con un fertilizante nitrogenado (26 por ciento N) en dosis de 224 kg/ha*

El tratamiento aplicado cuando la cebada había completado su macolla fue más beneficioso que el aplicado en la etapa temprana del macollaje. Las pruebas que recibieron los tratamientos herbicidas combinados mostraron el rendimiento más alto de materia seca de cebada y el más bajo rendimiento de malezas, lo que sugiere una interacción favorable entre los herbicidas. Cuando los herbicidas se usaron individualmente, fue necesaria una dosis de 4 kg/ha para un control eficaz de las malezas, pero en las parcelas donde se había usado aplicación combinada, fueron suficientes las dosis de 2 kg/ha de herbicidas para un efecto similar. — El autor.

Introduction

THE use of herbicides such as MCPA (2,4-D) on a commercial basis began nearly two decades ago, since when they have been used extensively with a variety of crops. Nevertheless, some weeds which were formerly highly sensitive now show a considerable tolerance of these herbicides. For example, *Galium aparine*, effectively controlled by MCPA in the 1950's, has shown progressive resistance. The addition of 2,3, 6-TBA (trichlorobenzoic acid) has been recommended. This compound is highly persistent and may remain in the soil for more than one season; hence a particular hazard arises when the straw of sprayed cereals is used subsequently as a mulch for susceptible glasshouse crops (2).

Slight changes in formulation have been shown to increase the selectivity of some herbicides. For example, "Banlene plus" (MCPA + dicamba + mecoprop) controlled chickweed *(Stellaria meria)* up to 13 cm high, while "Cambilene plus" (MCPA + dicamba + mecoprop + 2,3,6-TBA) is recommended for controlling weed species up to 20 cm (3). Within the limited range available, emphasis has been placed on the mixing of various types of closely related herbicides and it is desirable to study the effectiveness of such mixtures in association with a fertilizer. With this objective, the work reported here was designed to look into the feasibility of the application of a nitrogen fertilizer in association with herbicides, either individually or in combination, as a post-emergence spray to a greenhouse-grown barley. An attempt has been made to examine some growth characteristics of the crop plants, the extent of weed control, and the relevant changes induced in the crop due to weed competition.

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Materials and methods

The experiments were performed at the University of Leeds, England, Experimental Station, on a sandy loam soil containing sand 58 per cent, silt 25 per cent and clay 17 per cent, with 2 per cent organic matter. The treatments were arranged in a completely randomized design with two replications. The nitrogen fertilizer* was a 26 per cent solution containing ammonium nitrate and urea and was applied at a constant rate of 224 kg/ha. "Banlene plus" (MCPA + dicamba + mecoprop)** and "Cambilene plus" (MCPA + dicamba + mecoprop + 2,3,6-TBA)** were used as selective herbicides against charlock *(Sinapis arvensis)* and cleavers *(Galium aparine)*. Each was applied at rates equivalent to 2, 4 and 6 kg/ha. Where these were applied together, the volume of each was reduced to half, so that the total rate of the mixture remained 2, 4 and 6 kg/ha. The chemicals were applied through a chromatographic spray (Quickfit 19/26) on plots consisting of horticultural trays 15 x 10 x 5 in. The spray was connected to an air pump and the amount of liquid applied was calculated on a weight basis as a function of time. The spray produced uniform droplets of less than 275 μm diameter and enabled the experimental plots to be covered very precisely. Barley (c.v. *'Julia')* seedlings were transplanted on January 15th 1970 at 8 seedlings per plot, and at the same time 6 seedlings of each weed species per plot. Details of the treatments are shown in Table 1.

Table 1.—The experimental details

Experimental code	Date of spraying	Growth stages					
		Barley		Charlock		Cleaver	
		L.S.	H (cm)	L.S.	H (cm)	L.S.	H (cm)
T_1	18-5-1970	5-7	23	11-14	20	—	15
T_2	29-5-1970	T.C.	33	F	42	—	28

Transplanting date = January 15, 1970

L.S. = Leaf stage

H = Height

T.C. = Tillering completed

F = Flowering completed

Results

Vegetative growth and weed control

Treatments with "Cambilene plus" or combined herbicidal application at the rate of 4 or 6 kg/ha checked charlock growth markedly. The majority of plants showed abnormal growth in the form of curled leaves; the apex or growing point was distorted and showed a ring like structure. Individual herbicides at 2 kg/ha were considered inadequate for charlock: complete check was not observed and re-growth was frequent. However, charlock showed a high susceptibility to the combined herbicidal treatment at this rate, comparable to the treatments with individual herbicides at 4 kg/ha.

Delaying the spraying time did not show visible resistance of charlock to any herbicidal treatment. Cleavers *(Galium aparine)* did not show any differential effects of the herbicide rates, but there was a significant effect with the time of application: this weed was completely checked at the spraying time T_1. Even the lowest rate (2 kg/ha) gave control comparable to that of a higher rate (4 kg/ha) at this spraying time. When the spraying was carried out at time T_2 re-growth was noticed, especially in plots where "Banlene plus" was used up to the rate of 4 kg/ha. In general, "Cambilene plus" was more effective against charlock and "Banlene plus" against cleaver. The combined application was effective against both the weed species.

The actual number of weeds killed due to a particular treatment was not counted. Instead, the dry-matter yield of weeds in grams per plot (including their seeds and dead leaves) was estimated at the final harvest. From Table 2 it is apparent that the combined application of herbicides had the most consistent effects, and the weed yield was lowest. There was a significant increase in weed yield with the delay in spraying time, particularly at the lower herbicide rates.

Growth analysis of barley

This was performed immediately after harvesting, with the results shown in Table 2.

Number of ears per plant. In general the combined herbicidal treatments resulted in higher ear numbers per plant than when the herbicides were applied singly. Increasing the herbicide rates did not show any specific effect on ear number. Delaying the spraying time caused, in general, a decrease in ear number when the herbicides were used up to the rate of 4 kg/ha, but an increase was noted with the delay in spraying time at highest herbicidal levels (6 kg/ha). There was a significant interaction between herbicides and their rates of application ($p < 0.05$), but the interaction between herbicides and time of application was non-significant ($p > 0.05$). Table 2 also reveals that control plots had significantly lower ear numbers per plant.

Number of fertile spikelets per ear. The herbicides individually did not influence spikelet number significantly ($p > 0.05$). However, there was a significant effect with their rates of application ($p < 0.01$), and a much more pronounced one in plots which received the combined herbicides. Spraying times were significant ($p < 0.01$): in general, delay resulted in decreased spikelet numbers. In spite of the insignificant effects of the herbicides, the effect of spraying times was very marked ($p < 0.01$), which suggested that herbicides react differently at different spraying times.

* Sample courtesy Fisons Ltd., Cambridge, England.

** Samples of commercial products courtesy Schafers Ltd., Doncaster, England.

Table 2.—The effect of herbicide/fertilizer application on the yield of weeds and spring barley.

Herbicides	Rates of applications kg/ha	Weed yield (g/plot)		Nº of ears		Fertile spikelets/ear		Grain yield (g/plant)		Kernel yield (g/plant)		Chaff yield (g/plant)	
		T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2	T_1	T_2
Banlene plus (A)	2	3.45	4.92	4.1	3.2	21.2	21.2	1.85	2.13	1.36	1.42	0.25	0.18
	4	3.40	4.86	3.2	3.2	22.6	23.2	2.53	2.43	2.13	1.21	0.25	0.33
	6	0.45	1.76	3.2	3.2	21.9	23.2	2.20	2.36	1.92	2.02	0.29	0.35
Cambilene plus (B)	2	2.58	5.16	2.0	2.6	23.2	20.2	2.12	1.94	1.21	1.16	0.33	0.21
	4	0.90	1.96	2.1	2.4	23.2	21.4	1.73	1.40	2.11	2.32	0.42	0.42
	6	1.68	1.92	2.0	2.4	21.5	23.1	1.94	2.20	1.77	1.42	0.34	0.36
(A+B)	2	2.87	4.18	3.1	2.1	21.7	20.9	1.37	1.90	2.78	1.38	0.25	0.18
	4	2.54	3.20	3.4	3.6	22.5	20.6	2.47	2.31	1.70	1.41	0.33	0.30
	6	0.78	1.25	3.9	3.4	25.7	23.9	1.36	2.07	2.55	1.46	0.18	0.18
	Control	9.44		1.1		12.2		0.46		0.41		0.21	
L.S.D.	5%	0.28		0.12		1.34		0.58		0.20		0.11	
	1%	0.39		0.17		1.84		0.72		0.28		0.15	

It is also worth mentioning that the control plots showed a considerable decrease in spikelet numbers, amounting to just over 50 per cent of the average of the rest of the treatments. From this, the extent of weed competition in the control plots can be easily assessed.

Dry-matter yield. In Table 2 this is divided into grain yield, chaff yield (leaves and stem) and kernel yield, each described separately.

Grain yield. The data revealed that the herbicides affected the grain yield significantly ($p < 0.01$) and suggested that "Banlene plus" gave the highest grain yield, followed by the plots which received the combined herbicidal treatments (average of three rates). The statistical analysis also revealed that the rates of herbicide application were not significant ($p > 0.05$). On average, the rate of 4 kg/ha have the maximum yield.

Chaff yield. While the effect of the herbicides was insignificant ($p > 0.05$), in general the rate of 4 kg/ha have the highest yield. It is interesting to note that plants which received the combined application at the rate of 2 kg/ha gave yields closer to the plants which received the "Cambilene plus" at 4 kg/ha. The statistical analysis also revealed that the time of application had a highly significant influence on the yield ($p < 0.01$). In general there was a reduction in yield with a delay in spraying time, most significantly where herbicides had been used at 6 kg/ha. In agreement with the other observations, the yield in the control plots decreased significantly in comparison with the treated plots ($p < 0.01$).

Kernel yield. This was significantly affected by the herbicides ($p < 0.01$), a comparison suggesting that "Cambilene plus" gave the highest dry-matter yield. On average yield was highest where the herbicides had been applied at 4 kg/ha. Any change, e.g. increase or decrease, in the above rate had an unfavourable influence. The spraying times had an insignificant influence ($p > 0.05$). The control plots did not show any comparative decrease in yield.

Total nitrogen uptake by plants (Table 3)

On average, "Banlene plus" resulted in the highest uptake. There was no substantial difference between the plants which received "Cambilene plus" or the combined herbicidal treatment. Of the rates of application, 4 kg/ha gave the maximum uptake; at this rate, combined application gave respectively 10 per cent and 25 per cent higher uptake than with the "Cambilene plus" and "Banlene plus" treated plants. Increasing the rate to 6 kg/ha resulted in reduced uptake.

Discussion

Results of the experiments were satisfactory in that the fertilizer application in association with the herbicides not only increased the dry-matter yield of the

Table 3 —The effect of herbicide/fertilizer application on nitrogen uptake by spring barley (mg per plants)

Herbicides	Rates of applications kg/ha	T_1			T_2			Total	
		Grain	Chaff	Kernel	Grain	Chaff	Kernel	T_1	T_2
Banlene plus (A)	2	29 230	11 152	3 350	40 896	12 212	2 682	43 932	55 790
	4	42 504	17 173	3 025	39 366	12 342	4 257	62 701	55 965
	6	39 160	14 593	3 596	35 164	22 624	4 515	57 348	62 303
Cambilene plus (B)	2	34 344	11 132	4 587	35 114	11 368	2 877	50 063	49 359
	4	32 351	17 302	5 460	27 720	20 416	5 626	55 113	53 762
	6	35 502	16 284	4 624	32 120	10 508	5 256	56 910	47 884
(A+B)	2	21 783	14 456	3 450	37 620	11 868	2 502	39 689	51 990
	4	42 237	17 340	4 257	39 732	14 664	4 140	63 834	58 536
	6	26 112	15 810	2 304	36 088	14 641	2 226	44 226	53 215

Control Grain N uptake 2 121. Chaff N uptake 7 004. Kernel N uptake 2 911. Total N uptake in control plot 12 036.

barley but also progressively reduced the dry-matter yield of the weeds. The principal factor governing effective weed control is correlated to the stage of development of plants, which is of considerable importance for the herbicides of auxin types. There was a significant increase in the dry-matter yield of weeds with the delay in spraying time (Table 2). This may be attributed to the resistance developed by the weeds at T_2.

It is a recognized fact that the growth surroundings of crop plants at the time of tillering and ear initiation play an active role in the development of plants at their later stages. In this experiment, at T_2, the crop plants had completed their tillering stage, and the weeds showed extended growth. In these circumstances a reduction in the grain yield of the crop was expected, since the main factors governing the grain yield, such as fertile spikelets/ear and number of ears/plant (Table 2) showed a significant reduction at T_2. In contrast, as had been expected, the grain yield did not show a significant decrease at T_2. The damage caused by weed competition in the early stages of the crop plants, which was largely responsible for reducing ear number/plant, fertile spikelets etc., was rectified by the combined herbicide-fertilizer application at T_2. It appeared that the combined application at T_2 increased the size considerably. This assumption is in accord with the observation made by Belger (1) and Kopecky (4), who found that fertilizer application at ear initiation of cereals increased the weight of grain.

Similarly, the chaff yield did not show any significant reduction at time T_2 (Table 2). These observations confirmed the earlier assumption that the application at T_2 not only resulted in higher grain yield, but it also had favourable effects on other plant parts. Applying the combined herbicide-fertilizer at T_1 did not show any increase in the yield of barley, in spite of the reduced weed yield. It is probable that, at this time, the application had also irrecoverably damaged the crop plants.

The plots which received the combined herbicidal treatment showed the highest dry-mater yield of barley. This indicates a favourable interaction between the two herbicides ("Banlene plus" and "Cambilene plus"). When the herbicides were used individually, a minimum rate of 4 kg/ha was found necessary to give satisfactory weed control, but with combined application the rate of 2 kg/ha seems to have sufficed for a comparable effect.

The 4-chloro-2-methylphenoxyacetic acids at the rate of 6 kg/ha were found to increase the percentage of abnormal ears, and despite improvements in weed control had resulted in reduced cereal yields (6). In agreement with the above observation, a significant reduction in crop yield was expected at the higher herbicide rates, but surprisingly this did not occur, in spite of reduced dry-matter yield of weeds. It seems likely that the fertilizer application in association with the herbicides had reduced the toxic effects of the latter, but this needs further investigation.

It appeared that herbicides at higher rates may have had a stimulating effect on crop growth in the combined herbicide-fertilizer application. This is in accordance with Kosovac (5), who reported the same effect of MCPA herbicide in conditions of adequate soil nutrient supply.

The nitrogen uptake by grains was higher at T_2 than at T_1, which was largely due to the increase in dry-matter yield (Table 2). Similarly, nitrogen uptake by other components of the yield (chaff) was also enhanced at T_2 (Table 3). As a result total nitrogen uptake (mg per plant) was higher at T_2 than at T_1. It might be expected that nutrient uptake by the weeds would have continued when the spraying time was delayed. On the contrary, observations did not bear this out, perhaps because the soil was not dressed with fertilizers.

Although a favourable interaction between the herbicides existed, which increased their selectivity against weeds as well as accelerating the nitrogen uptake, the results would have been more satisfactory had the work been done under field conditions. The lethal effects of herbicides on crop plants tend to be increased under glasshouse conditions, since plants show more tender growth and reduced competence. Experiments under field conditions might give more pronounced interaction and hence a more favourable crop yield.

Summary

Experiments studied the feasibility of application of herbicides in association with liquid fertilizers.

Two commercial formulations of phenoxyacetic acids, namely "Banlene plus" (A) and "Cambilene plus" (B), were applied as selective herbicides against charlock *(Sinapis arvensis)* and cleavers *(Galium aparine)* at two growth stages of spring barley. The herbicides were applied individually at rates of 2, 4, 6 kg/ha, and in combined form with a nitrogen (26 per cent N) fertilizer (224 kg/ha).

The treatment applied when the barley had completed its tillering stage was more beneficial than that at the early tillering stage. The plots which received the combined herbicidal treatments showed the highest dry-mater yield of barley and the lowest weed yield, suggesting a favourable interaction between the herbicides. When the herbicides were used individually, a minimum rate of 4 kg/ha was found necessary for effective seed control, but in plots where the combined application had been used, herbicides at the rate of 2 kg/ha seemed to have sufficed for an equal effect.

Literature cited

1. BELGER, U. Investigations on the effects of late application of nitrogen on grain yield and properties of baking quality in winter and spring wheat. Bayerisches Landwirtschaftliches Jahrbuch 42:667-701. 1965.
2. HARTLEY, G. S. Herbicide behaviour in the soil: physical factors and action through the soil. *In* AUDUS, L. J., ed. The physiology and biochemistry of herbicides. London and New York, Academic Press, 1964.
3. FISONS LTD. Agricultural Chemicals. Fison advisory leaflet. London, England. 1961.
4. KOPECKY, M. Effect of time of application of nitrogen on grain yield and nitrogen content of dry matter of winter barley. Rostlinna Vyroba 14(41):533-534. 1968. (Russian)
5. KOSAVAC, Z. Biological and residual effect of herbicides on the basis of triazine and phenoxyacetic acid on weeds in maize on chernozem in South Backa. 1. On the possibility of omitting cultivation on chernozem when using herbicides on the basis of 2,4-dichlorphenoxyacetic acid and chloroaminotriazine. Savremena Poljoprivreda (Sarajevo) 14(9):753-778. 1966. (In Serbo-Croat) Field Crop Abstracts 20:297. 1967.
6. PETERSON, E. J. Chemical control of weeds in winter cereals. Tidsskrift for Planteavl 69(3):410-417. 1965. (Danish). Weed Abstracts 17:407. 1968.