BIPYRIDYL HERBICIDES AND THE DIRECT ESTABLISHMENT OF CROPS IN UNCULTIVATED SOIL. 1. CEREALS

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Summary

Field trials were carried out to evaluate methods for the direct establishment of spring-sown wheat and barley and autumn-sown wheat into pastures sprayed mainly with paraquat: other herbicides were included in some trials. The effect of the time and rate of nitrogen application was studied. Highest yields were reached where all components of pasture were completely suppressed. The trials indicate that paraquat at 16 oz controls perennial ryegrass (*Lolium perenne*) and annual grasses to give normal yields of direct-drilled cereals and that the addition of nitrogen generally increases yield. The need for clover suppression and the optimum time and method for achieving this warrant further investigation.

INTRODUCTION

THE STUDY of the use of chemicals for the renewal of pastures without cultivation led to attempts to establish crops by similar methods. To achieve adequate control of vegetation, Barrons and Fitzgerald (1952) and Davidson and Barrons (1954) applied chemicals before drilling, between drilling, and emergence, and after crop emergence. In a large number of trials reviewed by Matthews (1959) and in trials reported by Dawes (1960), 2,2-DPA at 10 lb with amitrole at 2 lb gave good but variable results. Failure of crops to reach normal yields has been attributed to a number of factors. Perennial broad-leaved weeds, such as sorrel (*Rumex acetosella*), buttercups (*Ranunculus* spp.) and yarrow (*Achillea millefolium*), recovered from mixtures of 2,2-DPA and amitrole to compete with the crop. Both chemicals can be taken up by crops from soil, and desiccation of pasture is slow. Difficulties in drilling seed in uncultivated soil have been reported (Dawes, 1960).

The bipyridyl herbicides, paraquat and diquat, were evaluated with tests on grasses, legumes and weeds under New Zealand conditions by Bramley (1961) and shown to have no residual activity in soil, to enter plants quickly, and to desiccate rapidly a wide range of plants. Since then, Bramley (1962) and Thompson (1962) reported trials in which treatment with 2,2-DPA/amitrole mixtures and paraquat were compared with cultivation for the establishment of brassicas.

Satisfactory yields of winter wheat were obtained by Arnott and Clement (1962) following the application of amitrole at 10 lb per acre. Hood *et al.* (1964) have reported the use of paraquat and the successful establishment of cereals in England. The present paper reports the results of trials carried out in New Zealand to study the use of paraquat for the direct establishment of cereals in pasture and to determine the conditions under which direct crop establishment will give acceptable yields. A subsequent paper (Part 2) deals with brassica establishment.

It was not practicable to compare direct establishment with normal methods of cultivation using replicated plots. In most cases direct-drilled plots were laid down adjacent to an area cultivated in the normal manner. Closer comparison will be warranted when the major factors which determine yields have been studied.

EXPERIMENTAL METHODS

All trials were laid down on pasture close-grazed by sheep. Pre-drilling herbicides treatments were applied in 20 to 26 gal of water per acre. Post-emergent herbicides were applied in 12 or 14 gal per acre. Main chemical and fertilizer treatments were arranged in randomized blocks with four or five replicates. All trials were drilled with a Duncan "700 Seedliner" grain and fertilizer drill which has been designed for use on both cultivated and uncultivated soil. In the first trial (C1) the standard coulter point was used. The point was later modified to a V-shape to reduce soil disturbance and to prevent the formation of a soil flap under which seedlings could be trapped. In one trial (C2), seed spilled on to the soil surface at drilling: this was prevented in later trials by lengthening the seed feed tubes.

The area harvested in each plot or sub-plot varied from about 1/20 to 1/40 acre between trials. Yields were measured in pounds weight per plot, corrected for differences in moisture content and expressed as bushels per acre.

Rates of herbicide given in the test or in tables refer to ounces of active ingredient applied per acre.

TRIAL DETAILS AND RESULTS

TRIAL C1: *Direct-drilled spring wheat, Pukemutu clay loam, Winton, Southland*

Paraquat at 16 oz was applied on October 9 to pasture, about one inch high, comprising mainly perennial ryegrass (*Lolium perenne*), sweet vernal (*Anthoxanthum odoratum*) and white clover (*Trifolium repens*) with some cocksfoot (*Dactylis glomerata*) browntop (*Agrostis tenuis*) and red clover (*Trifolium pratense*). A further 16 oz of paraquat was applied after drilling on October 18. Wheat (var. Hilgendorf '61) was drilled on October 14. Different fertilizer and post-emergent herbicide treatments were compared: details of treatments with yield of wheat, bushel weight and baking score are given in Table 1.

The double application of paraquat killed virtually all grasses and severely checked clovers. Red and white clover eventually recovered in undrilled discard areas and, to a much lesser extent, in plots not sprayed with MCPA/dicamba. The wheat was harvested on April 14. The results given in Table 1 show that the application of MCPA/dicamba to suppress the few clovers recovering in the crop did not significantly affect yield. Ammonium sulphate at 2 cwt increased yield by 14 bushels per acre and the value for treatment 3 suggests that the effect in treatment 4 was obtained from the first cwt of ammonium sulphate. Baking score and bushel weights were similar for all treatments.

The following year, on the same farm, non-replicated treatments were sprayed on September 2 and wheat (Hilgendorf '61) drilled on September 8 with 2 cwt superphosphate and 2 cwt ammonium sulphate per acre. Yields were as follows:

<i>Treatment</i>	<i>Yield (bu/acre)</i>
1. Paraquat 8 oz	42
2. Paraquat (8 oz) with MCPA (9 oz) and dicamba (1.5 oz)	30
3. Paraquat (16 oz) with MCPA (9 oz) and dicamba (1.5 oz)	73

MCPA with dicamba was applied to all treatments after tillering and this suppressed clovers which recovered quickly following paraquat at 8 oz. Grasses, mainly perennial ryegrass, recovered in treatment 2. Paraquat at 16 oz with MCPA and dicamba controlled clover and most grasses except some browntop and cocksfoot. Hilgendorf '61 wheat on the cultivated area of the field, drilled with nitrogenous fertilizer and harvested at the same time, yielded 59 bushels per acre. The relatively low yield is attributed mainly to powdery mildew which severely affected wheat on the cultivated area but which was not present on the direct-drilled crop.

TRIAL C2: *Direct-drilled barley, Templeton silt loam, Ashburton.*

Paraquat at 16 oz per acre was applied on October 5, 1965 to pasture comprising perennial ryegrass, sweet vernal, red and white clover, and subterranean clover (*Trifolium subterraneum*). Barley (var. Research) was drilled on October 21. Grain, spilt on to the soil surface at drilling, was removed by birds, leaving a very low plant population. Clovers recovered quickly to grow in association with the barley. Table 2 gives details of treatments and results. The low rate of fertilizer application in treatment 4 was caused by the uneven flow of the mixed fertilizer through the drill.

TABLE 1: TRIAL C1: YIELD, BUSHEL WEIGHT AND BAKING SCORE OF WHEAT

<i>Treatment (cwt per acre)</i>	<i>Yield (bu/acre)</i>	<i>lb wt/bu</i>	<i>Baking Score</i>
1. Serpentine superphosphate 3	64bB	57	40
2.*Serpentine superphosphate 3	65bB	57	39
3. Serpentine superphosphate 2 with ammonium sulphate 1	(80) omitted	56	40
4. Serpentine superphosphate 2 with ammonium sulphate 2	78aA	56	40
†Cultivated with superphosphate 2	66 omitted	56	41

*Treatment 2 differed from treatments 1, 3 and 4 in that MCPA/dicamba mixture (9 and 1.5 oz, respectively) was not applied after tillering.

†The mean yield of cultivated wheat was estimated from four plots adjacent to, but not randomized with, the trial. This value could therefore not be included in the statistical analysis.

In treatment 3 excessive rates of fertilizer were applied at drilling to half of each plot in three blocks: edge effects at the time of harvesting have probably given the relatively high yield for this treatment. The value was excluded from the statistical analysis of results.

TABLE 2: TRIAL C2: TREATMENT DETAILS AND YIELD OF BARLEY

<i>Treatment (cwt/acre)</i>	<i>Yield (bu/acre)</i>
1. Superphosphate 1½	15bB
2. Superphosphate (drilled) 1½, ammonium sulphate (broadcast) 1	25aA
3.* Superphosphate 1½	11bB
4. Superphosphate 1, ammonium sulphate ½ (drilled)	24aA

*MCPA/dicamba was applied to suppress clovers after tillering to all treatments except treatment 3.

Yields were, in general, less than half the average for the area. The suppression of clovers did not significantly increase yield. The addition of nitrogen as 1 cwt S/A broadcast or ½ cwt S/A drilled with the seed markedly increased yield.

TRIAL C3: *Direct-drilled wheat, Hatfield silt loam, Darfield.*

A perennial ryegrass/white clover pasture with patches of browntop was grazed short and paraquat at 16 oz per acre applied on May 26, 1966. Arawa wheat was drilled on June 20 and the following treatments compared:

1. No nitrogen applied.
2. 1½ cwt calcium ammonium nitrate (30 units N) applied 30 June.
3. 3 cwt calcium ammonium nitrate (60 units N) applied 30 June.
4. 1½ cwt calcium ammonium nitrate (30 units N) applied 21 Sept.
5. 3 cwt calcium ammonium nitrate (60 units N) applied 21 Sept.

MCPA (12 oz per acre) and dicamba (2 oz per acre) were applied to one half of each plot at random on October 25. During the early

TABLE 3: TRIAL C3—EFFECT OF TIME AND RATE OF NITROGEN APPLICATION ON YIELD OF DIRECT-DRILLED AUTUMN WHEAT

<i>Treatment</i>	<i>Yield (bu/acre)</i>
1. No N	42dc
2. 30 units N, June 30	51cB
3. 60 units N, June 30	55bAB
4. 30 units N, September 21	52bcB
5. 60 units N, September 21	60aA
Not sprayed with MCPA/dicamba	51aA
Sprayed	53aA
CV	7.0%

stages of growth, the recovery of browntop noticeably reduced the vigour of wheat, particularly where nitrogen had not been applied, whereas wheat growing in association with recovering clovers did not appear to be affected.

The results are summarized in Table 3. The addition of nitrogen at 30 units increased yield by 9 or 10 bushels per acre: an additional 30 units gave a further highly significant increase. The response to the September application was significantly greater than the June application. The differences between the mean of the unsprayed treatments (51 bushels per acre) and those sprayed to suppress clovers (53 bushels per acre) was not significant.

DISCUSSION

For the successful establishment and growth of crops drilled directly into uncultivated soil, a herbicide treatment must control a wide range of plant species with no residual effects on the direct-drilled crop. Under New Zealand conditions, plants in pasture can be conveniently divided into three categories, grasses, clovers, and other species. In the trials reported in this paper, annual grasses and perennial ryegrass were controlled by 16 oz paraquat. Both browntop and cocksfoot recovered to some extent at this rate and, in Trial C3, the recovery of browntop noticeably reduced the vigour of wheat in the early stages. Where stoloniferous or rhizomatous grasses and cocksfoot are dominant, higher rates of paraquat or a combination of chemical treatments are likely to be necessary. The results of Trial C3 suggest competition for nitrogen may be a major factor in the early stages of cereal growth and that addition of nitrogen can markedly increase yields under these conditions.

The application of paraquat at 16 oz to clovers normally causes only a temporary desiccation of the shoot, and regrowth begins within a few days, particularly in spring. However, in Trial C1, the application of 16 oz paraquat before, and again after, drilling suppressed clovers for several weeks. Despite this, the application of nitrogen increased yield by more than one-fifth. As in Trial C3, where the recovery of clovers during winter was limited, the suppression of the few clovers present in the spring did not significantly increase yield. Suppression of the vigorous clover recovery in the trial with spring barley (C2) increased yield but not significantly. However, with the low yields in this trial, it is difficult to draw definite conclusions. The marked response to the relatively low quantities of added nitrogen suggest that clovers in these circumstances compete in the early stages at least for available soil nitrogen.

As clover can be regarded as a potentially useful component of pasture and will grow in association with cereals, three aspects need further study with respect to the effects of clover suppression on the yield of direct-drilled crops: first, the suppression of clovers and the possible release of nitrogen in the soil; second, the value of partial clover recovery for grass and weed suppression; third, the retention of clovers as a basis for permanent pasture following the direct-drilled crop. While investigating the major problems associated with the direct establishment of crops in undisturbed soil, such as machinery and fertilizer requirements, it has not been possible to vary widely the rate of herbicide application. With further information on the susceptibility of grasses to different rates and times of application, it may be possible to reduce rates of application.

The pastures in the trials described above contained few plants other than grasses and clovers. Some perennial weeds in pastures will be controlled by the application of paraquat before drilling, followed by a selective herbicide after crop emergence. Others, such as yarrow, are resistant to both paraquat and many cereal herbicides and must be controlled before drilling. If this is not possible, pastures containing such weeds must be regarded at present as unsuitable for direct-drilled crops.

The few weeds germinating in these trials after spraying and drilling did not warrant special herbicide treatment. If adequate control of vegetation can be achieved before drilling, it appears that subsequent herbicide applications are unnecessary.

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REFERENCES

- Arnott, R. A.; Clement, C. R., 1962: *Nature*, 195: 1277-8.
Barrons, K. C. Fitzgerald, C. D., 1952: *Down to Earth*, 8: 2-3.
Bramley, P., 1961: *Proc. 14th N.Z. Weed Control Conf.*: 41-7.
——— 1962: *Proc. 15th N.Z. Weed Control Conf.*: 97-102.
Davidson, J. H.; Barrons, K. C., 1954: *Down to Earth*, 10: 2-4.
Dawes, S. N., 1958: *Proc. 11th N.Z. Weed Control Conf.*: 109-15.
——— 1960: *Proc. 13th N.Z. Weed Control Conf.*: 102-7.
Hood, A. E. M.; Jameson H. R.; Cotterell, 1964: *Nature*, 201: 1070.
Matthews, L. J., 1959: *Proc. 12th N.Z. Weed Control Conf.*: 43-8.
Thompson, F. B., 1962: *Proc. 15th N.Z. Weed Control Conf.*: 92-6.