WHEAT TOLERANCE TO HORMONE WEEDKILLERS

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THE many investigations that have been carried out on this subject in the United States and Canada have yielded much valuable data relating to American wheat varieties grown under those climatic and soil conditions. Most of that work has pertained to comparisons between the effects of various 2,4-D formulations, MCP not being of great importance in North America. On the other hand, both here in New Zealand and in Europe, on the basis of evidence available, it has been held that MCP is more selective and is more tolerated by wheat than is 2,4-D.

It is unfortunate, however, that in the case of such MCP formulations as have been available until recent times, specifications have been based upon a determination of the total content of all the isomers of MCP present, and not on the content of the most actively phytotoxic isomer, 4-chloro, 2-methyl-phenoxyacetic acid. Consequently these older type products well may have been of variable composition in respect of the quantity of the 4-chloro, 2-methyl isomer present. Considerable doubt is thrown on the validity of the results of comparative experiments conducted with these older MCP materials.

Recent advances in technique have enabled manufacturers to market an accurately standardised MCP containing 40 per cent. of the 4-chloro, 2-methyl isomer. In the work now to be described it was this MCP type of product that was compared against two 2,4-D types of product.

OBJECTS OF THE EXPERIMENT

1. To establish the tolerance of our most important wheat variety, Cross 7, to MCP and 2,4-D formulations.
2. To discover what variations in tolerance this variety of wheat exhibits toward MCP and 2,4-D formulations in relation to stage of growth at treatment.

MATERIALS AND METHODS

The following materials and rates of application were used:—

1. Diethanolamine MCP 0.75.
2. Diethanolamine MCP 1.5.
3. Diethanolamine 2,4-D 0.75.
4. Diethanolamine 2,4-D 1.5.
5. Ethyl 2,4-D 0.75.
6. Ethyl 2,4-D 1.5.

Treatments were applied in lb. acid equivalent per acre, all being applied with water at a volume rate of 30 gallons per acre.

On 28 September, 1954, 18 seeds of Cross 7 wheat were sown in each of 124 5in. tins which previously had been filled to standard weight with a uniform and carefully prepared mixture of Horotiu sandy loam and complete fertiliser together with "Krilium" at 1 to 1000. After emergence and prior to the first spraying date the seedlings were thinned out, leaving four uniform plants in each pot.

All pots were rotated 180 degrees daily until the end of the experiment. Soil moisture content was maintained at a uniform level by means

of frequent check weighings, and nitrogen losses were replenished periodically. The pot cultures were grown outside on benches, protected by wire-netting from birds and vermin.

Cultures were sprayed by a small power spray outfit mounted on rails to ensure uniform coverage of each of the four replicate pots. These were carefully positioned in a single file so that the same spray pattern passed over each of the pot cultures in succession.

The calculated spray application rate of 30 gal. per acre was secured by passing the spray over the cultures twice, using F25 nozzles, at 14in. centres, 20in. height, 40lb. per sq. in. at 2 ml. per hour. Spray pattern records were taken on graph paper and were compared for uniformity at each spray application date. The droplet size was small, with 5 to 7 droplets per 1/100 sq. in. square with no squares missed, and giving a coverage of approximately 20 per cent. of total surface. This type of spray was considered ideal for securing maximum uniformity of coverage compatible with minimal losses through run-off or rebound of spray droplets. It was noted that sprays containing the ester of 2,4-D gave the best apparent coverage through fusion of droplets on the plant surfaces.

STAGES OF GROWTH AT SPRAYING

The following are particulars of the respective stages of growth at the various spraying dates, which occurred virtually at weekly intervals:—

Date sown: 28/9/54. Emergence commenced: 5/10/54.
1st spraying: 15/10/54 (10 days) 2 leaf stage.
2nd spraying: 22/10/54 (17 days) early tillering; 4 leaf.
3rd spraying: 28/10/54 (23 days) later 4 to 6 leaf.
4th spraying: 5/11/54 (31 days) 6 to 8 leaf: tillering complete.
5th spraying: 12/11/54 (38 days) 10 leaf.

In designing the experiment it was intended that the wheat cultures should be sprayed at intervals corresponding to the 2, 4, 6, 8, and 10 leaf stages. Because of some lack of information on the growth habits of pot-grown wheat, incorrect criteria were used in determining the times for spraying, and as a result this was carried out at closer intervals than planned. Thus the final spraying occurred at an earlier stage of growth than had been intended—much too early for the study of the effects of spray applications made at "shot-blade," "boot," or later stages of growth. On the other hand, had the intervals between sprayings been more extended, the results actually obtained indicate that probably much less clear-cut figures might have been secured.

ABNORMALITIES OF POT-GROWN PLANTS

The pot culture technique appears to produce some abnormalities in the growth of wheat, and at any rate some of the conditions associated with pot cultures which vary from field conditions are worth mention.

"It has been stated: 1. That field-grown wheat in Britain commonly produces two or three tillers. Plants in this experiment produced on an average six, but exceptionally up to nine tillers, some of which appeared to be secondary tillers originating from primary tillers. Because of the masses of dead or dying leaf bases at later stages it was impossible exactly to trace the origin of all tillers. Quite a number of tillers aborted, but at harvesting time it was found that the average number of fertile or semi-fertile heads in this experiment was five,

which indicates that the plants produced twice the normal number of fertile tillers. Though this could be a varietal characteristic, it could be due to the increased light caused by the relatively wider spacing of plants by comparison with that found in a field crop.

Two sowings of wheat, supplementary to the main sowing, were made, and studies indicated some variation in the speed of maturation in the three sowings. The earliest sowing required 41 days between emergence and the 9 leaf stage, while in a sowing made 18 days later only 38 days elapsed between emergence and the 10 leaf stage. Ripening of the earliest sown series occurred about one week earlier, relatively, than in the series sown 18 days later. Thus the earlier sown series grew more slowly at earlier stages, but ripened more rapidly than the second series. Finally the grain yields of the first series were uniformly of a lower level than those of the second series, despite identical treatment. These variations in growth-rates are expected to influence the response of plants to hormone spray applications.

The water requirements of these pot cultured plants were fully met at all times by regular watering. Under field conditions it is probable that a deficit of available soil moisture hastens the ripening of a late crop in particular, with consequent reduction in grain yield. Heads arising from late tillers especially might fail to mature. In this experiment due to the lack of alternative reliable criteria harvesting was delayed until all heads were ripe, including those on the shortest straw, although mostly the yields from these were eliminated from the yield results by the method of harvesting adopted by us. None the less, it is believed, taking all into consideration, that there remained some bias in favour of the lower yielding or more slowly ripening cultures, and that a greater practical significance must be attached to those figures indicating reduced yields than the figures alone seem to indicate.

OBSERVATIONAL DATA

Although the yield data later to be presented represents the true results of the trial, some time was devoted to the counting of deformed heads, and measuring heights and dry matter. Time will not permit a survey of all these results. Generally the most marked effects of those treatments which were responsible for the greatest degree of visible damage were:—

(a) Decreases in the average heights of culms, not so much due to a general reduction in maximum height as to wider variations in the heights of individual culms, with increases in the numbers of short ones. Apparently the main stem and first tillers generally were less affected in this way than were later tillers.

(b) Considerable retardation in and spread of the ripening period of ears situated on the shorter tillers. This effect was not confined to, although more marked in, treated cultures, and in the controls, too, harvesting was delayed for a time to permit full ripening of all ears. It appeared probable that in field practice many of these short ears would have aborted earlier, or would have been unobserved or probably disregarded for the purpose of determining harvesting date.

(c) The most marked ear damage was associated with "tubular-leaf" effects and the consequent "bowed-ear" and partial sterility effects.

Application of 2,4-D ester caused some physical damage to sprayed plants, in the form of leaf-tip burn and necrotic spots. Finally there appeared to be only minor damage attributable to hormone effect on embryonic ear development, despite the fact that the close intervals between spraying dates must have resulted in the spraying of plants at this stage of growth.

METHOD OF HARVESTING

Owing to the nature of the trial it was necessary to evolve an artificial method of harvesting. It was decided, therefore, to harvest the yields in two cuts. The first cut was made at a height estimated to eliminate heads situated on the abnormally short straw, many of which were apparently largely sterile, as well as some of the grossly deformed heads, many of which were also sterile. This was due to the fact that the latter were partially enclosed in the sheaths of "tubular-leaves."

A second cut taken at about ground level yielded all the balance of the dry matter, as well as the remaining grain in the above mentioned categories of heads. In actual fact the grain yield from these heads generally was not great on account of much sterility, and most of the grain was of small size, and would have been rejected in threshing. The results indicated that the method adopted was reasonably accurate.

The data secured at harvesting included: Net harvestable grain, total grain yield, total weight of straw and grain, number of ears, and estimated mean height (of harvestable ears).

RESULTS

Time will not permit consideration here of all the data secured, and I propose therefore to discuss chiefly the grain yield. Yields of net harvestable grain are presented in Table 1 as percentages of the yield of the unsprayed control series:—

TABLE 1—Grain Yields of Hormone Sprayed Wheat
(Expressed as Percentages of Unsprayed Control Yields)

Treatment	2 leaf	Stage of Growth at Spraying			10 leaf
		4 leaf	4/6 leaf	6/8 leaf	
		Early tiller	Late tiller	Tillering complete	
Control, unsprayed ..	100	100	100	100	100
MCP amine, 0.75 ..	114	102	99	109	99
2,4-D amine 0.75 ..	93	90	106	109	107
2,4-D ethyl ester 0.75	102	86*	90	99	102
MCP amine 1.5 ..	110	72**	82**	107	105
2,4-D amine 1.5 ..	92	77**	95	100	101
2,4-D ethyl ester 1.5	104	84**	79**	99	93

Sig. diff. 5 per cent. *; 1 per cent. **.

1. At the 2 leaf stage all materials are tolerated at both the low and the high rates. The apparent increased yields of MCP treated plants just fail to attain significance at the 5 per cent. level.
2. At the 4 leaf, early tillering stage there are marked decreases in yields from plants sprayed at the higher rate with all three materials (significant at 1 per cent. level) while a decrease in the ethyl ester sprayed at the lower rate is significant only at the 5 per cent. level.
3. At the late tillering stage, 4 to 6 leaf, the wheat appears to have recovered tolerance to amine salt of 2,4-D at the higher rate, while MCP and ethyl ester of 2,4-D still produces highly significant decreases in yield.
4. In the two later stages sprayed, the 6 to 8 leaf and 10 leaf stages, the wheat appears to have fully recovered tolerance to all materials.
5. Visual observations indicate that most of the damage resulted from "tubular-leaf," "bowed ear," reduced fertility, and small

grain size. There was minor evidence of ear damage arising during embryonic development of the inflorescence.

CONCLUSIONS

1. As far as the experiment extended, the results confirm those of overseas workers in demonstrating a susceptible phase in the early stages of the growing wheat plant.

2. It appears to be safe to spray wheat with amine MCP and amine salt of 2,4-D at the rate of 0.75lb. per acre at any time up to the 10 leaf stage of growth, but it is inadvisable to apply ethyl ester of 2,4-D at this rate during the 4-leaf early tillering stage.

3. During the susceptible phase, that is, when tillering is in progress from the 4 to the 6 leaf stage it is inadvisable to apply any of the materials at the rate of 1.5lb. per acre with the exception that amine salt 2,4-D did not cause a significant yield decrease when applied at the late tillering stage.

4. At times other than during this susceptible phase, all materials may be applied at the higher rate with little chance of causing significantly decreased yields.

5. Considerable changes in the tolerance of wheat to hormone sprays occur during the elapse of short periods of time such as a few days. The time for spraying must be determined therefore with considerable accuracy.

REFERENCE

1. Fryer & Elliott: Proc. Br. Weed C. Conf. p. 52, 1953.

APPENDIX

For the information of those interested in statistical results the following is a summary of the wheat yield results prepared by the Biometrician:—

1. The 4 leaf or early tillering stage gives the largest depression, and the 4 to 6 leaf, late tillering stage the next largest. The other three stages are significantly better than these two.
2. The heavy rate of weedkiller depresses significantly more than the light rate.
3. The interaction between rates and times is significant. The rates do not differ significantly at the 2 leaf, 6 to 8 leaf (tillering complete), or the 10 leaf stage, but at the early tillering 4 leaf and the late tillering 4 to 6 leaf stages, the heavy rate gives significantly lower yields than the light rate. That is, the difference due to rates is significant only at the most susceptible times.
4. It is possible that at the earliest stage the plants are somewhat susceptible to amine salt of 2,4-D and not to the other weedkillers, but the result should be treated with reserve.
5. Ethyl ester of 2,4-D is significantly more severe on the average than amine MCP and amine salt of 2,4-D gives yields intermediate between these two.
6. The types of weedkiller by times interaction also reaches significance. This seems to be due to the fact that at the 2 leaf stage amine salt of 2,4-D gives significantly lower yields than either of the other weedkillers, while at the late tillering stage it yields significantly more than them.