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THE POSSIBILITY OF INCORPORATING HERBICIDE RESISTANCE INTO OILSEED RAPE

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INTRODUCTION

When a crop and its most aggressive weed competitors are closely related, a lack of selectivity in the herbicides may preclude the use of this form of weed control. The search for more selective herbicides with which to solve this problem is both laborious and now very expensive, and present economic pressures require that existing chemicals are utilised to control weeds in the most effective way. An alternative approach has been advocated in recent years. This has been to modify crops to suit existing herbicides by harnessing the natural variability enhibited by them in response to herbicides. An example being the recently developed strain of a paraquat tolerant ryegrass (Faulkner, 1976) which is now in national list trials prior to release as an amenity variety.

The problem of selectivity is highlighted where Brassicae compete with Cruciferous weeds. If in such cases an effective chemical weed control is attempted then considerable crop damage may result (Cassidy, 1972). Therefore as stated by Salter (1972), there is a need for a safe and effective selective herbicide for pre-emergence, or even early post-emergence, application in direct drilled Brassica crops.

It is for this reason that an investigation is in progress to investigate the possibility of incorporating resistance to simazine (2-Chloro-4, 6-bis-ethylamino-s-triazine) into oilseed rape. Simazine was chosen because, although its low cost and high effectiveness make it a superior herbicide, its selectivity is low and its range of usefulness is limited to those crops showing a natural resistance. The agronomic value of simazine resistance in oilseed rape becomes apparent when we consider two aspects of the weed problem in this crop. The first is apparent at establishment. At this stage of development despite relatively vigorous growth which tends to smother weeds, it is sensitive to competition (Procter and Finch, 1976). The second is that control of its close relatives, for example Sinapis arvensis L., Raphanus raphanistrum L. or self sown Brassica nigra (L.) Koch., is often poor with excessive admixture of weed seed in the crop, leading to its rejection at the crushing mill (Warwick, 1973).

EVIDENCE INDICATING THE POSSIBILITY OF INCORPORATING SIMAZINE RESISTANCE IN RAPE

While examples of varietal differences in response to herbicides are quite common in weed and crop science literature, there are very few examples of deliberate selection and exploitation of outstanding varietal tolerances. A survey of the period 1953-1972 (W.R.O., 1972) revealed only 21 such references to cereals, 6 to grasses and 10 to other crops. There is however clear evidence that genes for s-triazine resistance exist in a variety of species. For example susceptibility to atrazine and simazine by maize is known to behave as a simply inherited character (Grogan et al., 1963). However, further examples where crop species enhibit a simply inherited resistance to herbicides are comparatively rare. This is probably one of the reasons why deliberate attempts at breeding herbicide resistant crops have not occurred in the past.

Examples where resistance is governed by more complex genetic systems are greater in number. For example, Andersen and Behrens (1967) selected varieties of flax that showed varying levels of resistance to atrazine. Further work by Comstock and Andersen (1968) showed that the tolerance of the more resistant variety behaved as a quantitative character.

It is the utilisation of resistance that behaves as a quantitative character that may be of value in the case of simazine resistance in the Brassicae and oilseed rape in particular. It is, however, very rare for selection to have been undertaken to improve a cultivar in such a character. One exemple is that of Faulkner (1976).

Karim and Bradshaw (1968) were the first to show that in Cruciferous crops such as oilseed rape and Sinapis alba L. (white mustard) there is an appreciable variation in response to simazine both between and within varieties which probably had a genetic basis. Warwick (1973) showed that this continuous variation may be readily selected and that tolerance could be enhanced in a few generations.

The suggestion that herbicide resistance can be increased significantly in a few generations of artificial selection has been given a considerable boost by recent evidence of genetically-determined resistance to herbicides in weed populations. The possibility that weed species would become resistant to repeated treatment with herbicides was suggested by Harper (1956). Some of the most striking examples in the literature concern resistance to s-triazines. Examples include resistance to simazine in Senecio vulgaris L. (Holliday and Putwain, 1977; Ryan, 1970) and in Chenopodium album L. (Bandeen and McLaren, 1976).

THE CHOICE OF SCREENING TECHNIQUE

The possibility of incorporating simazine resistance into oilseed rape depends first on the genetic variation that exists within the crop; second on that within its close relatives; and third on the facility with which resistance can be transferred to commercially acceptable material (Warwick, 1973). In addition the efficiency of selection for simazine resistance depends on the ability of the screening technique to locate and select superior genotypes. It is important that the technique employed is simple and repeatable to ensure uniformity over successive experiments. During the screening process all the plants should be exposed equally to the selective dose and thus the technique must be accurate, especially if herbicide resistance in Brassica crops resembles metal tolerance in grasses where tolerant plants occur sporadically in normal populations (Bradshaw et al., 1965).

Potential variables such as climate and growth medium should be controlled as far as possible. This is particularly important and there is evidence (Jordan et al., 1960) that controlled growing conditions are essential. Thus marked seasonal changes in mortality may be expected if work is carried out in a glasshouse.

It is also desirable that the screening technique simulates field conditions. This therefore indicates the need for field experiments to test the efficiency of the screening process. The need for this was shown by Jacobsohn and Andersen (1968) who admitted that the large differences observed in lines of wild oat treated with carbamate insecticides in the glasshouse might not be apparent under field conditions. Thus it would seem logical to screen in the field. However, field screening is unsatisfactory due mainly to the unpredictable nature of climate and soil.

Therefore a screening technique in controlled conditions has been devised. A comparison of methods (Warwick, 1973) demonstrated certain disadvantages using either water or sand/vermiculite culture techniques. Thus soil has been used as the screening medium. The advantages of using soil with a pre-emergence herbicide are obvious; first, healthy plant growth is ensured; second, the herbicide is presented to the plant in the same way as in the field; and third, screening may be performed in a controlled environment chamber, throughout the year. One problem, however, that does arise using soil as the screening medium is that of uniformity of herbicide application. Any difficulties in achieving uniformity of spraying, especially at the margins of containers, have been overcome by pre-mixing the simazine with a known volume of soil, before sowing the seeds. This method has proved very successful and is easily repeated with precision.

Using this method, a spring variety of rape, Rigo, has been subjected to three generations of simple recurrent selection for simazine resistance (Warwick, 1973). This led to a significant increase in resistance which was also apparent in field trials. The resultant S3 seed has also been tested in comparison with two other varieties, Maris Haplona and Erglu, in the form of a dose response experiment. This resulted in the following L.D.50 values:

Rigo (S3)	0.39 ± 0.02	kg ha^{-1}a.i. simazine
Maris Haplona	0.23 ± 0.01	kg ha^{-1}a.i. simazine
Erglu	0.20 ± 0.01	kg ha^{-1}a.i. simazine

These results suggest that selection of varieties with enhanced tolerance to simazine as well as desirable agronomic characters is feasible.

THE FUTURE

Whilst the selection experiments of Warwick (1973) produced plants which were significantly more resistant to simazine, the degree of resistance obtained was not sufficient to provide adequate selectivity between the crop and weed species. Therefore further investigations of natural and induced variation in response to simazine in Brassica crops and related wild relatives are in progress. Warwick (1973) suggested that resistance to simazine by rape was a characteristic of individuals rather than of varieties. Therefore an intensive screening of large numbers of individuals may result in a small number of plants which exhibit a superior resistance, which, with necessary intercrossing and introgression, could be incorporated into modern oilseed rape cultivars.

Screening experiments have shown that cultivars of _Brassica oleracea_ tend to show a higher level of simazine resistance than other members of the genus.

Since wild relatives of many crop plants have been extensively used as a means of genetically improving disease resistance in crops, we are investigating the response to simazine by wild relatives. A population of wild cabbage (_B. oleracea_ var. sylvestris L.) indicated a higher level of resistance than that inherent in the varieties of oilseed rape tested. An intensive screening of this and other wild cabbage populations may produce plant material possessing a superior resistance.

Finally, while natural variation in crops may provide genes for resistance to herbicides, recent evidence, for example Pinthus et al. (1972), suggests the possibility of inducing mutations in crop plants so that the resultant mutant generations exhibit a greater tolerance to herbicides. Thus a preliminary investigation into the possibility of isolating mutants of oilseed rape exhibiting on increased tolerance to simazine is in progress. While any resistance found by such means may be of value to the breeder, such resistant mutants may also provide suitable material for studies of inheritance and mechanisms of resistance. Such information would obviously be of value in further work concerned with herbicide resistance in rape.

REFERENCES

1. Andersen, R.N. and R. Behrens, 1967. Weeds, 15, 85-87.
2. Bandeen, J.D. and R.D. McLaren, 1976. Canadian J. Plant Sci., 56, 411-412.
3. Bradshaw, A.D., T.S. McNeilly and R.P. Gregory, 1965. Br. Ecol. Soc. Symp., 5, 327-343.
4. Cassidy, J.C., 1972. Proc. 11th Brit. Weed Control Conf., 958-964.
5. Comstock, V.E. and R.N. Andersen, 1968. Crop Science, 8, 508-509.
6. Faulkner, J.S., 1976. Proc. 13th Brit. Weed Control Conf., 485-490.
7. Grogan, C.O., E.F. Easton and R.D. Palmer, 1963. Crop Science, 3, 451.
8. Harper, J.L., 1956. Proc. 3rd Brit.Weed Control Conf., 179-188.
9. Holliday, R.J. and P.D. Putwain, 1977. Weed Res., 17, 291-296.
10. Jacobsohn, R. and R.N. Andersen, 1968. Weed Science, 16, 491-494.
11. Jordan, L.S., R.S. Dunham and A.J. Linck, 1960. Minn. Agr. Exp. Sta. Tech. Bull., 237.
12. Karim, A. and A.D. Bradshaw, 1968. Weed Res., 8, 283-291.
13. Pinthus, M.J., Y. Eshel and Y. Shchori, 1972. Science N.Y., 177, 715-716.
14. Procter, J.M. and R.J. Finch, 1976. Proc. 13th Brit. Weed Control Conf., 509-516.
15. Ryan, G.F., 1970. Weed Science, 18, 614-616.
16. Salter, P.J., 1972. Proc. 11th Brit. Weed Control Conf., 939-942.
17. Warwick, D.D., 1973. Ph.D. Thesis, University of Liverpool.
18. Weed Research Organisation, 1972. Annotated Bibliography, No. 46.