APHID AND VIRUS RESISTANCE IN CROPS

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Summary

Although breeding for resistance to fungous diseases is a widely adopted and highly successful method of control in crops, there has been some reluctance to adopt this approach for controlling insect and virus attack. This is probably due to the efficient control of insect pests and virus vectors by chemicals. A survey of the achievement to date in crop breeding for insect and virus resistance in New Zealand shows spectacular progress and it is postulated that an even greater range of resistance breeding projects should be undertaken.

INTRODUCTION

BECAUSE variation in susceptibility to pests and diseases is a characteristic of most species of plants, standard breeding techniques enable varieties resistant to diseases and pests to be developed. The main emphasis of this plant breeding work in the past has been directed towards resistance against fungous diseases, but numerous successes in breeding for insect and virus resistance have shown that this is a very profitable method of attack.

A great deal of time can be wasted in arguments about the meanings of "resistance", "susceptibility", "tolerance", "immunity", etc., and to avoid this the terms resistant and susceptible are defined as follows:

A plant population is *resistant* where it suffers much less economic damage than a *susceptible* one under the level of attack normally encountered in commercial crop production.

The advantages of using resistant varieties over other methods of control are summarized below.

- (1) The cost of development of resistant varieties is less than that for the development of insecticides.
- (2) Once resistance is incorporated in control varieties, disease control is automatically achieved without annual charges and application difficulties.
- (3) Resistant varieties can be developed more rapidly than other control systems for many crops.
- (4) There are no residue problems, or likelihood of harmful biological side-effects.
- (5) The use of resistant varieties may be the only possible method of control of some aphid and virus diseases which spread from other host plants and have little secondary spread within the crop.
- (6) The side products of a major resistance breeding programme may be of considerable value.

The main disadvantages of the method are:

- (1) Unlike many broad-spectrum chemicals, the plant resistance is valuable only towards the particular crop in which resistance has been developed (though resistant varieties of one host may reduce greatly the disease incidence in other hosts).
- (2) Resistant varieties may be deficient in yield, quality or other characteristics in disease-free environments when first released.
- (3) Resistance may not be permanent. The insect or virus may overcome the resistance of the host variety.

A recent survey (Smith, 1962) showed quite high annual losses from virus diseases in field crops and a very high potential value of resistance breeding.

VIRUS AND INSECT RESISTANCE BREEDING PROGRAMMES AT CROP RESEARCH DIVISION

The results of several breeding programmes at Crop Research Division are used below to illustrate many advantages arising from resistance breeding.

BRASSICA APHID AND VIRUS RESISTANCE

The aphid and virus disease complex has been prevalent on brassica field crops in Canterbury and North Otago for many years. It has less frequently caused severe damage in the North Island and Southland.

The main aphid pest causing damage has been the cabbage aphid (*Brevicoryne brassicae*) and the main virus diseases have been cauliflower mosaic virus and to a lesser extent turnip mosaic virus, although they frequently occur in combination (Brusse, 1965). Generally the four brassica crops reacted as given in Table 1 before much work was devoted to this problem.

TABLE 1

Crop			Pest Cabbage Aphid	Disease Cauliflower & Turnip Mosaic
Kales			R	R
Turnips			R	V.S.
Swedes			R to S	R to S
Rape			S	S

R = Resistant.

S = Susceptible.

V.S. = Very susceptible.

Rape

In 1947, a programme was started to transfer cabbage aphid resistance from swedes to rape. Swedes and rape are quite interfertile. In 1961, Aphid Resistant rape was released for general use (Palmer, 1960). This variety generally gave lower yields under aphid-free conditions than the available susceptible varieties, but by 1966 the major part of the

area in rape was sown in this variety. In addition to being aphid resistant, this variety also has a high degree of resistance to cauliflower and turnip mosaic virus diseases. In 1968 another resistant variety, "Rangi", will be available for sowings by farmers. This is higher yielding and agronomically better than Aphid Resistant, and equally or more resistant to aphids.

In the summer of 1966-67 several crops of Aphid Resistant rape in Canterbury were severely attacked by the cabbage aphid. Recent glasshouse trials suggest that new populations of aphids have evolved with the capacity to attack severely these "resistant" varieties. If this ability is permanently retained by the field populations then resistance to the cabbage aphid has not been a permanent solution to this problem. However, there is no evidence to suggest that virus resistance has been lost in these new varieties.

Turnips

In 1957 and 1958, there were severe outbreaks of cauliflower mosaic virus in turnip crops in the South Island. A range of turnip varieties was tested but none possessed any worthwhile degree of resistance. Crosses were made between turnips and resistant swedes, and from the resulting hybrid populations a resistant variety of turnip, "Kapai 66", was produced. This was released for general sowing in 1966 (Palmer, 1965). Under heavy aphid and virus attack at Lincoln this year, Kapai 66 has survived well and given good production where standard varieties have been completely destroyed.

Work on developing cauliflower mosaic resistant turnips has led to an intense effort in turnip breeding in New Zealand, and thus a range of clubroot resistant turnips has also been developed.

CARROT APHID AND VIRUS RESISTANCE

Carrot aphids (*Cavariella aegopodii*) have caused serious damage to early carrot crops in Canterbury and Marlborough for many years, but it was not until about 1955 when carrot motley dwarf virus was identified in crops in New Zealand (Smith *et al.*, 1960) that the full significance of the aphid and virus complex existing in this crop was recognized.

Some trials at Auckland (about 1945) showed that it was possible to control aphids in carrots and it was thought that aphids were wholly responsible for poor development of early crops. However, by controlling the aphids in glasshouse and field trials at Lincoln and recording the incidence of virus at different sowing dates, it was shown that the aphid-borne carrot motley dwarf virus was in great degree responsible for the poor growth. It was also shown that the carrot varieties Top Weight, and Taranaki Strong Top selections such as Egmont Gold and Sweet Crop, were markedly aphid resistant and tolerant to virus infection.

On the basis of this work, a breeding programme aimed at transferring motley dwarf virus resistance into the early Manchester Table type of carrot was commenced at Lincoln. Considerable progress has been made but no new commercial varieties have been released as yet.

PEA VIRUS RESISTANCE

Pea Mosaic Virus

Pea mosaic virus has been present for many years. It has caused serious losses in Marlborough in some years but has generally been a minor

disease in other pea-growing districts. A back-crossing programme to produce standard varieties resistant to this disease was commenced in 1950. In 1966, a more destructive strain of pea mosaic virus became prevalent in the Hawke's Bay processing crops. It was found that all New Zealand mosaic resistant pea varieties were also resistant to the new virulent strain of pea mosaic. This showed that a breeding programme to produce resistance to a minor disease has had far more value than was originally anticipated.

Pea Top Yellow Virus
(Also known as pea leaf roll virus)

Infection with this virus disease is caused mostly by aphids invading pea crops from infected clover seed crops and possibly from lucerne for hay. Secondary spread within the pea crops appears to be less important and consequently, although systemic insecticides kill aphids very effectively within the pea crops in all trials to date, they have not effectively protected crops from damage by pea top yellows virus.

Varieties vary considerably in their reaction to the virus (Crampton, 1966), which is now known to be a prime cause of the poor yield of many otherwise desirable pea varieties. Crossing resistant varieties with these desirable but susceptible varieties has enabled plant breeders to produce varieties combining resistance with good agronomic and processing qualities.

TOBACCO MOSAIC RESISTANT TOMATOES

In 1958, a breeding programme to produce glasshouse tomatoes with resistance to tobacco mosaic virus was commenced at Crop Research Division. In 1966-7, commercial trials of the new variety showed that the resistant strain gave good yields in the absence of virus and up to 40% higher yields than the standard varieties when tobacco mosaic was inoculated into the glasshouse crop. This new variety has two minor defects—the presence of yellow seedlings which must be rejected, and a very strong attachment of the calyx to the fruiting truss. Nevertheless, it is in considerable demand already by the tomato glasshouse industry in New Zealand.

BARLEY YELLOW DWARF VIRUS RESISTANT CEREALS

Although this virus disease was first identified in 1953, it was not recognized as a major cause of losses in cereals in New Zealand until 1961 when accurate trials showed yield reductions of up to 20 bushels per acre in wheat. Since then many trials comparing numerous varieties of wheat, oats and barley have been completed, and these have confirmed the wide range of differences in resistance and susceptibility. In general, the cereal varieties grown commercially in New Zealand have a good level of resistance compared with many overseas varieties. It has also been well established that the most recently developed varieties of cereals are more resistant to barley yellow dwarf virus than earlier varieties (Wright, 1966) and some of the more recent hybrid selections have even higher levels of resistance. For example, some very susceptible overseas varieties in the tests have been Clintland 60, and Steel Oats and Blackhull-less barley. The older New Zealand varieties have been moderately susceptible—e.g., Onward oats, Cross 7 and Hilgendorf wheat,

TABLE 2: N.Z. CROP VARIETIES RESISTANT TO INSECTS AND VIRUS DISEASES

<i>Crop</i>	<i>Variety</i>	<i>Insect</i>	<i>Resistance to</i>	<i>Virus</i>
Rape—Aphid Resistant*	Rangi*	Grey Cabbage Aphid		Cauliflower & turnip mosaic
Swede—N.Z. Sensation	N.Z. Calder			
	N.Z. Doon Spartan			
Turnip—Kapai 66	Kapai 67			
Carrot—Top Weight	Sweet Crop	Carrot/willow aphid		Motley Dwarf
Pea—Greenfeast 68	Wm. Massey W.R.	—		Pea mosaic & top yellows
	Dark Skinned	—		
	Perfection	—		
Wheat—Aotea†	Gamenya†	—		Barley Yellow Dwarf
Oats—Mapua†	Amuri	—		
Barley—Research†		—		
Potato—Rua		—		Potato Virus X & Y

*Aphid resistance lost in some localities in North Canterbury, 1967.

†Virus resistance still only moderate.

and Proctor barley—while the latest New Zealand varieties—*e.g.*, Mapua and Amuri oats, Aotea wheat, and Research barley—have a reasonable level of resistance. Several plant breeders overseas have shown that barley yellow dwarf virus resistance in oats and barley is relatively simply inherited but that very high levels of resistance are available only in some Abyssinian barleys.

Screening tests on oats and wheat are still being carried out in many countries to identify even higher levels of resistance in these crops than are at present available. However, the fact that the most recent best cereal selections and varieties already possess better levels of BYDV resistance than the earlier or overseas varieties shows that, to some degree, the selection procedure has automatically raised resistance levels. If accurate field screening techniques can be developed, however, even faster progress may be achieved.

POTATO VIRUSES

Accurate seedling screening techniques and useful sources of resistance to Potato Viruses X and Y have enabled a very successful programme of breeding potatoes resistant to these viruses (Driver, 1965). The new varieties released by Crop Research Division—Rua, and Tahī—both have a high degree of resistance and all future selections will be equally

as good. Although potato leaf roll virus still causes considerable losses in many commercial potato crops (particularly in the North Island and in crops at the lower grades of certification) there is a distinct possibility that the high degree of leaf roll resistance in Katahdin can be transferred to new potato varieties also.

CONCLUSION

The examples chosen (see Table 2) from recent crop breeding work in New Zealand show that development of resistant varieties is a useful method of controlling aphid pests and virus diseases of crops.

In many cases resistance breeding is undoubtedly the surest and best method, and acceptance of resistant varieties by growers confirms this. Costs of this development work are usually small because they are undertaken by existing staff as supplementary projects concurrently with the main crop breeding programme. Sometimes, however (as with the brassica aphid and virus project), aphid and virus resistance have been the main projects, and other plant breeding objectives have been supplementary.

There are many advantages for this plant breeding control procedure, and there is every reason to suppose that other insects or insect-borne diseases can also be similarly controlled. Far greater effort should be made to control other major insect pests and diseases by developing varieties resistant to them.

REFERENCES

- Brusse, M. J., 1965: *N.Z. J. Agric. Res.*, 8: 672-80.
Crampton, M. J., 1966: *N.Z. J. Agric. Res.* 9: 152-6.
Driver, C. M., 1965: *N.Z. Agric. Sci.* 1 (7): 13-6.
Palmer, T. P. 1960: *N.Z. J. Agric.*, 101 (4): 375-6.
——— 1965: *N.Z. J. Agric.*, 111: 55.
Smith, H. C., 1962: *Proc. N.Z. Inst. Agric. Sci.*: 55-61.
Smith, H. C.; Giesen, H. J.; Allen, J. D. 1960: *N.Z. Commercial Grower*, 16: 13-4.
Wright, G. M., 1966: *N.Z. J. Agric.*, 113 (1): 38-43.