## SESSION 2.

## PRINCIPLES OF WEED CONTROL

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Man's use of land almost invariably creates a weed problem and indeed a weed may be defined as any plant which interferes with man's utilization of land for a specific purpose. This means that any plant may be a weed under a particular set of circumstances although under other conditions it may be a plant of economic value.

The utilization of land involves disturbance of the original environment. Clearing of timber, grazing, trampling, cultivation and fire all tend to upset the equilibrium between the environment and the pre-settlement communities of plants so that changes of ecological nature are induced. The magnitude and nature of these changes depend upon the kind, intensity and duration of the disturbance factor. If we could have imposed, say grazing by sheep on the Australian environment without the accidental or purposeful introduction of alien plants, we would have altered the environment and produced changes in the botanical composition of our plant communities. We would have created, in fact, weed problems. Under such circumstances the weeds would have been found among the native plants of pioneer communities.

The introduction, whether by accident or design, of plants from abroad has intensified the weed problem. The Australian continent is particularly vulnerable to invasion by alien weeds because of its relatively small human and herbiverous populations prior to white settlement. The species of its plant communities were not adapted to the heavy defoliation and trampling which followed the introduction of sheep and cattle. Thus the new ecological niches formed as a result of disturbance tended to be occupied by alien plants pre-adapted to such conditions.

With increasing ease and frequency of communication with other countries the number of introduced species has steadily increased so that to-day in South Australia alone there are about 381 alien plant species. The figure for New South Wales in 1939 was 415 species excluding the Gramineae. Not all these are regarded as weeds, but practically all of them, even those normally regarded as pasture plants, have potentialities as weeds under special circumstances. Of some 39 weeds classed as the most important by the Australian State Weeds Co-ordination Committees, 33 are introduced species.

These plants are almost invariably pioneer plants

characteristic in their countries of origin of disturbed and denuded surfaces such as dunes, sand bars, cultivated fields and overgrazed areas. The characteristics of pioneer plants are precisely those which make them noxious as weeds or valuable as pasture or crop plants. Some of these characteristics are high seed production, rapidity of germination and establishment, longevity of seeds or fruits, delayed germination of a proportion of seeds, efficient methods of fruit or seed dispersal (pappi, spines, burrs, etc.), in annuals and efficient storage of reserves, capacity to form stem shoots from roots in perennials.

The position is that to utilize land native communities must be disturbed. This disturbance alters the environment making it more favourable to pioneer plants which as we have seen embrace those plants most likely to be weeds.

Weeds are therefore an inevitable and ever present problem which are essentially ecological in nature. Consequently their control involves an understanding of ecological principles, particularly of the successional relations of the plants concerned and of their autecology.

There are two principal methods of approach to the control of weeds. One is the direct destruction of a particular species by chemical or mechanical methods and the other is an indirect method involving an alteration of the environment by cultural or ecological methods in order to make it less favourable for a particular weed species. The former is usually but a temporary expedient unless it is combined with the latter. Methods of weed control may be classed broadly as (1)ecological; (2) biological; (3) cultural; (4) mechanical and (5) chemical. The first two might well be classed together, however, biological control has by custom been applied almost exclusively to control methods involving the introduction of insects and since it may or may not have an ecological background it is perhaps best dealt with separately.

(1) Ecological Methods - Since a particular weed is the result of a particular form of land use it follows that a change in land use might either lead to the disappearance of the weed species or to the plant concerned no longer being regarded as a weed. The change in land use however must alter the environment sufficiently at some critical stage or stages of the life cycle of the plant to result in its elimination. In the case of annuals germination and establishment appear to be most critical.

There are a number of ways in which the environment may be changed to make it unfavourable for a particular weed

species. In some circumstances it may be sufficient to limit the intensity of utilization, as for example in the grazing of native pastures. The objective being to hold or regenerate the pasture to a successional stage which has a relatively stable composition in terms of useful perennial species. Biddiscombe found, for example, that severe grazing in the Trangie district was associated with high densities of saffron thistle and maltese cockspur. In cases where degeneration has proceeded far it may be necessary or advisable, where possible, to adopt a more positive approach than mere reduction in grazing intensity. In the Tumbarumba district of New South Wales, for example, the native kangaroo grass will eliminate St. John's Wort if animals are excluded for about 14 years, but, since kangaroo grass will not withstand grazing, the control of the weed is temporary under stocking. However, by sowing subterranean clover and applying superphosphate, it is possible to virtually eradicate St. John's Wort in four years and, at the same time, increase the intensity of utilization of the area. In essence, the system adopted at Tumbarumba was to introduce one pioneer plant, the clover, to compete with another (the St. John's Wort) and to ensure that the clover would have a satisfactory environment for vigorous growth by applying phosphate in quantities sufficient for its requirements. Similar results were obtained in experiments conducted by the Lands Department in Victoria on the control of blackberry, Watsonia, ragwort and bracken. In the case of the bracken, the competing pasture had to be assisted by mechanical treatment of the regenerating fronds. Since mature perennial plants are less susceptible to changes in environment than germinating seeds and seedlings it often may be advisable to hasten and assist the process of control by chemical or mechanical methods.

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In improved pastures the control of weeds may be assisted by correct use of fertilisers; the aim being to maintain a balance between the grass, clover components of the sward. The evidence is that capeweed, for example, may dominate subterranean clover pastures which have low proportions of grass because of the low phosphate status of the soil.

(b) Biological Control - In biological control the objective is to eradicate an alien weed by introducing insect enemies from its country of origin. The method when successful is spectacular and from the farmers' viewpoint easy and inexpensive. It is, however, important to know just what will happen when one weed species is eliminated by an insect. It may be replaced by another weed equally or even more

noxious. Biological control should, theoretically at least, be most successful when the weed is in a mixed community containing useful plants. In such instances the work of the insect may be aided materially by competition from the other plants of the community. Control by insects is least likely to be successful when the weed species is a pioneer community forming pure or almost pure stands. Denudation of such communities by insects may be followed by recolonization by the same or a different weed species. It is highly desirable, therefore, that following insect attack the plant environment is changed in some way.

(c) Cultural Control - This method which is essentially one of crop rotation aims at changing the environment at regular intervals to prevent the build up of any particular weed species. Many weeds are associated with particular crops and others are commonly found in improved pastures. For example, annual crucifers are commonly found in cereal crops. We are all familiar with the fate of the continuously cropped plots on the Broadbalk field at Rothamsted where Alopecurus agrestis became so prevalent that a rotation had to be introduced. Deep rooted herbaceous perennial weeds are frequently associated with monocultural practices. By introducing a different culture such as a different type crop or a pasture ley into a cropping system or by ploughing and cropping pasture land it is possible to control weeds associated with any particular phase of the system. The method has been little employed in Australia, but is deserving of much wide usuage.

(d) Mechanical Control - This is the oldest method of weed control and includes hoeing, mowing, cultivating, crushing and latterly bull-dozing and chaining. Mechanical methods are often of use as a starting point in weed control for removing tall growth and woody species for the purpose of effecting a change in the environment. In crops, particularly row crops, the method is employed regularly for temporary control of weeds during the growing period of the crop.

When the ecological life history of a particular weed species is known, mechanical treatment may be an extremely useful method of control. The best known examples are cape tulip and soursob, the life histories of which were investigated by Cashmore and Clarke respectively. By ploughing these species when carbohydrate reserves were at a minimum and prior to the formation of new bulbils, Trumble and his coworkers at the Waite Institute were able to reduce markedly the densities of these two troublesome weeds.

(e) Chemical Control - Control of weeds by the application of chemicals may be accomplished in a number of ways.

Application may be made on the weeds themselves or on the soil and it may be made before or after the planting of the crop.

On the basis of their effects on weeds and crops, chemicals may be classed as -

(i) Contact herbicides - This group of chemicals kill plants by direct contact with the foliage and they may be selective or non-selective in their action. Non-selective contact herbicides include certain petroleum oils, oil-water emulsions, dilute sodium arsenite, dilute sodium chlorate, etc. They are mainly used for killing unwanted vegetation near buildings, etc., and for pre-emergence control of weeds in crops. Selective contact herbicides function through differential wetting of plant surfaces, e.g. sulphuric acid for the control of crucifers in cereals, or through biochemical selectivity, e.g. oils in carrot crops and salts of dinitro-o-cresylate and di-nitro-o-sec-butyl phenol for the control of certain annual dicotyledonous weeds in cereals, flax and onions.

(ii) Translocated herbicides - These herbicides penetrate the leaf surface and move through the phloem or xylem to the roots. They are of particular value for controlling perennial dicotyledonous weeds. The best known are the hormone-like substances MCPA, 2,4-D and 2,4,5-T which are selective in their action.

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(iii) Soil Sterilants - Chemicals of this group are applied usually in heavy dosages, the aim being to kill existing plants and to prevent all plant growth for a long period. Such sterilants include arsenic, chlorates, common salts, borates and thiocyanates; they are absorbed principally by the roots of plants. Salts of trichloroacetic acid (TCA) have recently been used for temporary soil sterilization particularly for the control of perennial grass weeds. More recently 3,p-chlorophenyl-1, 1-dimethyl urea (CMU) has received some prominence; it is non-poisonous and effective at much lower dosages than the more commonly used sterilants.

Soil sterilants which persist for long periods in the soil have little use in agriculture except for the eradication of localized infestations of perennial weeds. Fumigants (volatile liquids) such as chloropicrin, methyl bromide, carbon disulphide and Shell D-D have been used with some success on nutgrass and other perennial weeds. Since all plants growing in the volume of soil penetrated by the gases are killed and there is no residual action these compounds are ideal soil sterilants. However, the high cost

and difficulty of handling restricts their use.

There are two types of pre-emergence weed control. In the one, a contact weed-killer with no residual effect in the soil is used after the weeds have emerged but before the crop is through. In the other, the chemical is applied to the soil surface immediately after sowing. In the latter, the chemicals used have selective properties, e.g. 2,4-D or MCPA; isopropyl phenyl carbamate (IPC) and ammonium-di-nitro-o-sec-phenate.

Chemicals are extremely useful for controlling weeds, particularly annuals, in crops. Here the aim should be to apply a selective herbicide in amounts just sufficient to enable the crop to over-top the weeds. It is not necessary in all instances to apply as much chemical as is necessary to kill the weeds without the aid of the crop. Areas which are regularly cropped may need applications of herbicides every time a crop is sown, the herbicides being used for the same reason as fertilizers, viz. to increase production. In such instances, weed control is the aim rather than eradication and the smallest amount of herbicide which will accomplish this end is all that is necessary.

In controlling deep-rooted perennials, a pasture phase would appear to be a highly desirable adjunct to chemical treatment. Attempts to eradicate such weeds under a mono-cultural system are wasteful of chemicals because of the higher concentrations necessary and the doubtful efficiency. It is almost invariably better to attack a weed in a mixed population of plants, some of which have relative resistance to the selective herbicide used so that in addition to the effect of the chemical on the weed there is also a competition effect.

The fundamental principles of weed control may be summarized as follows :

(i) Plant quarantine, seed inspection and seed certification to prevent the introduction of plants likely to be weeds.

(ii) Eradication of localized infestations of weeds known to be serious problems in other areas.

(iii) Control of grazing to prevent the formation of bare or semi-denuded areas suitable for colonization of pioneer plants.

(iv) The revegetation of areas already denuded by the sowing of species or through natural plant succession and the assistance of the competition of native and sown pasture species with weeds by fertilizers, herbicides, grazing practices, etc.

(v) The use of rotations in farming practices so that environments suitable for particular weeds are not maintained uninterrupted for long periods.

(vi) The use of chemicals or cultivation to remove competition from weeds during the growing period of annual farm crops.