23. Weeds and Agriculture: Some Problems and Principles

IMPORTANCE OF WEEDS

Earlier we examined the role of weeds in agriculture. Now, in considering control measures, it may be well to reiterate the economic significance of weeds. Losses due to weeds have been estimated in various ways. It has been said that they cost an annual debt of three to five billion dollars, second only to soil erosion. The average cost of tillage of cultivated land has been estimated at 16 per cent of the value of the crop produced. One half of the tillage required is, in general, due to the presence of weeds. Therefore, on each acre of cultivated land, growers are losing, because of weeds, approximately 8 per cent of the value of the products produced.

Weeds compete with crop plants for light, water, and soil nutrients. The chief role they play in affecting agriculture is that of reducing crop yields as a consequence of such competition. There is some evidence that certain weeds may further reduce crop growth and subsequent yield by releasing inhibitory or poisonous substances into the soil; recent attention has been directed towards quackgrass in this regard. Weeds also increase the cost of labor and equipment, reduce quality of agricultural commodities, harbor insects and fungus diseases, render harvesting more difficult, may be poisonous, cause hay fever, etc.

Weeds can reduce the value of the land or even render it essentially useless for agricultural purposes. In the southwestern United States, literally millions of acres of once valuable range land are covered with almost solid stands of woody plants. A small spiny tree, mesquite, predominates. Practically nothing grows under the dense stands of these plants. The mesquite originally occurred largely along watercourses and in low areas. As a consequence of deterioration of the grassland, resulting from continued overgrazing and drought, this woody plant was able to invade higher ground. Mesquite can be eradicated, but if the land is to be put in operation again, re-establishment of the grasses must follow. The total procedure is difficult from the dollars-and-cents standpoint since control measures may cost as much as the land is worth. Similarly, the introduced *Halogeton* has become very abundant in wide areas of poor condition range. This weed is poisonous to animals. As indicated in the previous chapter, its pres-

ence has rendered much semi-arid range dangerous to use.

Another special type of a weed problem occurs in the western states. Water for irrigation is essential to much of agriculture. The weedy vegetation along streams and irrigation canals has the capacity for taking up enormous quantities of water. Estimates place annual water loss in this manner at 25 million acre-feet. Assuming two acre-feet to be required for irrigation purposes per acre during a year, this is enough water to irrigate 12 to 13 million acres of crops.

The exact importance of light, water, and nutrients for which weeds and crop plants compete in a given situation is usually not well known nor, in many instances, how their combined effects result in losses in yields. In instances in which weeds grow rapidly and overshadow crops, it is quite obvious that, aside from other factors, the matter of light is involved. However, weeds reduce yields even though the crop plants are tall enough to obtain sufficient light and there is overabundant moisture and the soil is highly fertile. Possibly water and mineral nutrients become exhausted in an infinite number of small areas in the soil in which root hairs of the weeds and crops are in competition. The following are examples of some of the kinds of observations which have been made regarding the competitive effects of weeds on crops.

Many weeds have a higher water requirement than crops. It has been calculated that 1,000 pounds of cockleburs *(Xanthium)* per acre — not a heavy infestation — require enough water to produce 8 bushels of oats, 7 of barley, 4 of wheat, or 9 of corn. Weeds may have high mineral nutrient requirements. It has been reported that a plant of common mustard *(Brassica)* requires twice as much nitrogen, twice as much phosphorous, four times as much potash, and four times as much water as an oat plant. Work with several weeds has suggested that they are able to absorb potash and nitrogen from the soil better than certain crop plants.

Competition studies with controlled weed stands in carrots, onions, and beets have shown different tolerances on the part of the crop plants to the weeds, and different reactions to specific competition situations. Concentrations as low as 15 per cent of the "normal" stand of weeds were capable of affecting the yield of the crop plants. In fact, in many instances, sparse weed stands caused almost as much damage as denser ones. The period from emergence to four weeks was shown to be a critical stage in competition of weeds with these row crops.

Somewhat the same points are illustrated in an experiment with wheat carried out in South Dakota. Weed-free wheat yielded 42 bushels an acre; wheat infested with 100 mustard plants per square yard yielded 18.4 bushels, and wheat with twice as much mustard yielded 16 bushels per acre. Note that the thin stand of mustard reduced crop yield almost as much as the heavy stand. But wheat that was sprayed in the 4- and 6-leaf stage yielded 40 bushels. However, six days after the 6-leaf stage (wheat in the "flag-leaf" stage and mustard budding), spraying did not materially increase yield. Apparently the principal effect of the mustard occurred before it started to bloom. Spraying after this time facilitated harvesting but did not increase yield.

Recent studies of sorghum (Kansas) have indicated that with moderate rainfall, one weed per two linear feet of row, reduced yield 40 per cent. In a season with very low rainfall, one weed per three feet of row essentially eliminated yield whereas, the weed-free control produced about 20 bushels an acre.

WHAT CHARACTERS MAKE FOR "WORST" WEEDS?

Worst weeds can be defined in several ways. Over-all considerations should probably involve (1) competitive ability, i.e. effect per acre, (2) how widespread, i.e. how many acres does it cover, and (3) how hard it is to get rid of. In the usual definition of worst weeds in which the perennial noxious weeds are considered the major pests, primary emphasis is given to point number three. Total consideration of all three points would probably indicate that some of the abundant, highly competitive annual weeds (e.g. foxtails, *Setaria;* smartweeds, *Polygonum*) have considerably more economic significance than the perennial noxious weeds.

WEED PREVENTION

The cheapest way to control weeds is not to have them in the first place. Weed seeds have been hauled all over the earth with agricultural products and equipment. Most of our weeds are introduced. For instance, in Iowa, only one of the eight primary noxious weeds (horse nettle) in the Agricultural Seed Law is native to the North American continent. The spread of many of the resistant deep-rooted perennials still continues in agricultural seed, manure, feeds, harvesting equipment, nursery stock, and soil. The avoidance of new infestations from such sources is still the farmers' cheapest weed control.

High quality commercial seed which has been recleaned by experienced operators and offered for sale by seedsmen is, in most cases, relatively free of weed seed. But, in certain crops (e.g. oats) much or most of the seed planted never passes through the seedsman's hands. Farmers save their own seed or buy from a neighbor. Such farm seed, as indicated by drill-box surveys, is often fantastically full of weed seeds, containing hundreds or even thousands per pound.

Seed processing equipment used by skilled operators can achieve amazing results in the cleaning of seeds. These are complicated and expensive machines beyond the reach of the ordinary farmer. But many seed companies, elevators, and cooperatives will do custom cleaning for farmers. In general, one or several are within easy hauling distance of any farm.

Weed prevention involves avoiding planting new weeds or replanting hordes of the old ones. It is a basic cornerstone of good farming prac-

tice. The value of subsequent weed control practices may be largely negated by planting weed-polluted seed. Specifically, weed prevention involves the following:

(1) If seed is purchased from a seedsman, the higher priced, higher quality seed is usually to be recommended. Ordinarily, it is cheapest in the long run. The purchaser should examine the analysis tag as well as the price tag.

(2) If seed is purchased from a neighbor, the potential purchaser should insist that the seed be tested before the deal is closed.

(3) If a farmer intends to plant his own seed, it will pay him to have it custom-cleaned and tested for noxious weeds, total weed seed content, and germination before planting.

GROWTH HABITS OF WEEDS AS RELATED TO CONTROL PRINCIPLES

Annuals and Biennials

Annuals and biennials live one or two years respectively and reproduce only by seed. New plants must come from seeds. Control, then, involves the use of clean crop seed, and the prevention of seed production by the weeds. Applicable methods may involve mowing, cultivation, competition (including rotations), or the use of herbicides. Complete prevention of seed production will not mean the absence of annual weeds the following year since weed seeds already in the soil will continue to come up; however, if seed production is prevented for several years in succession, a considerable reduction in weeds will result. True, some weed seeds may be carried in by wind or other natural means, but the number of these is usually small as compared to those produced on the land. A simultaneous program (e.g. preplanting working of the soil; pre-emergence herbicides) to induce germination and destruction of seedlings in the soil will speed the program.

Perennials

Since perennial weeds are capable of reproducing from year to year from underground roots or stems, even if no seeds are produced, a weed control program must consider both (1) prevention of seed production and (2) the destruction or starving of underground parts. Direct destruction by chemicals or tillage is often feasible with shallow-rooted perennials like quackgrass *(Agropyron)*. On the other hand, with deeper-rooted weeds (e.g. field bindweed, *Convolvulus*), starvation through exhaustion of the root reserves is often the only economic or practical procedure. This may be accomplished by repeated destruction of the tops (mowing, cultivation, chemicals), or by hampering the ability of the plants to replenish the roots (smother crops).

Work with several perennial noxious weeds has demonstrated that plants draw on their food reserves as they initiate growth in the spring, and this continues, in most cases, until flowering time. After flowering, photosynthesis gains the upper hand as active growth diminishes. Stored foods then build up until the end of the season. In other words, food reserves are frequently at their lowest level shortly before flowering.

The above suggests that initiation of control measures (i.e. destruction of tops) when plants come into bud will catch them when they are weakest. An attractive generalization derived therefrom would be that suppression measures should be started at this time, that earlier destruction of tops may not only be superfluous, but may inhibit reduction of root reserves during rapid preflowering growth of the plant.

We do not have sufficient information to formulate definitive conclusions regarding the timing of initial cultivation (or other control measures) with respect to depletion of stored foods in the underground parts. Active work in this area was initiated in the 1930's, but was largely abandoned in the 1940's when major attention was directed towards herbicides. Published conclusions are not in agreement. In any event, it is to be expected that perennial weeds should exhibit considerable variability in this regard.

On the basis of present evidence, it appears probable that weeds which grow vigorously in the spring and come rapidly into bloom (e.g. leafy spruge, *Euphorbia;* Canadian thistle, *Cirsium;* perennial sowthistle, *Sonchus*) are to a large extent drawing upon stored food during this period, and that control measures prior to this time will not materially accelerate an eradication program. On the other hand, slower developing and later flowering kinds (e.g. perennial peppergrass, *Cardaria;* Russian knapweed, *Centaurea;* horsenettle, *Solanum*) develop sufficient photosynthetic capacity to begin restoring carbohydrate and nitrogen reserves well before coming into bloom. Destruction of plant growth should accordingly be initiated considerably earlier for these species.

Subsequent control measures continued throughout the season are calculated not only to prevent the weed from replenishing food reserves but to deplete them further. To this end, regrowth is destroyed as it emerges or shortly thereafter. A slogan once used with respect to combating perennial weeds was "keep the soil black," i.e. destroy new sprouts immediately on emergence. This probably was not the best advice. Perhaps a week will be required for new shoots to appear again above the ground. But the plant is still drawing more food from its roots than it can replace. Another week or so will be required before sufficient leaf surface is expanded so the photosynthetic output will overbalance food utilization. Only then is destruction of the shoot essential. For instance, weekly cultivations of bindweed have been recommended. As good, or better, results (in terms of total length of the program) can be obtained with cultivations spaced at 14-day intervals.

Many considerations with respect to cropping practices may, of

course, affect timing of specific operations. Insofar as possible, however, adherence to the above principles will speed a program to eradicate perennial weeds. Control efforts often fail because: (1) It is not recognized that perennial weeds may possess sufficient food reserves to keep them going for 2 to 3 years, and control practices must be maintained for this length of time. Often efforts are halted just short of success. (2) Control efforts are interrupted for a month in the summer. With even a short period of active growth (and commensurate photosynthetic activity) at this time of the year, the weed stand can do much in a short time to regain lost ground as far as stored food is concerned.

Possibly the above implies that deep-rooted perennials can be controlled only through application of techniques aimed to starve the plants. This is not entirely true. Soil sterilant chemicals and some translocated chemicals are reasonably effective in killing underground parts as well as tops. The number and usefulness of such chemicals can be expected to increase in the future. As yet, sterilants are too expensive to use on large areas and render the soil temporarily unfit for cropping. Weakening or starvation of underground parts still plays an important role in the solution of many perennial weed problems.