LOSSES CAUSED BY WEEDS AND ECONOMIC THRESHOLDS FOR CONTROL

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Weeds have been called the most important of all crop pests (16). Reduction in crop yield results from interference between weeds and crops for water, soil nutrients, space, and light (25). When the supply of any or all of these essentials is not adequate for the optimum growth of the crop and weed, interference or competition occurs. Considerable variation exists among species of crops and weeds in their competitive ability. A strong plant competitor--either crop or weed--retards the growth of other plants growing in association with it. Strong competitors dominate because of faster and taller growth, early emergence and larger embryos (8, 13, 17). Annual losses in crop yield and quality due to weeds, combined with the costs of weed control, are greater in the United States than the costs of insects, plant diseases, and nematodes (4, 20). While maximum yield losses can exceed 90% of the potential yield in many crops, the actual losses in farmers' fields are generally much lower (25).

The important agronomic weeds have many characteristics in common (10). Of the 37 worst soybean weeds in the U.S., 38% are monocots, 32% are perennials, 35% have some form of vegetative reproduction, 19% produce rhizomes, 38% have the C_4 photosynthetic pathway, and 55% are exotic to the U.S. In addition, 55% of the 37 worst soybean weeds have allelopathic properties (24).

Of the world's worst 18 weeds, 72% are monocots, 44% are perennials, 61% reproduce vegetatively, and 33% produce rhizomes (7); 78% of these same weeds have the C_4 pathway (10). Among the most outstanding characteristics are the tremendous overrepresentations of C_4 plants and monocots as important agronomic weeds in proportion to their occurrence in the world's flora (16).

Thomas Pavlychenko did much of the classic studies in plant competition. He observed that competition for water begins in the soil when root systems overlap in their search for water and nutrients, and discovered that weeds were strong competitors for water (18). The amount of water used by a plant during its seasonal growth is called the water requirement. The water requirement for the aerial parts of the plant is the number of pounds of water used to produce a pound of dry matter. A plant of wild mustard (*Brassica kaber* var. *pinnatifida*) requires four times as much water as a well-developed oat plant, and a plant of common ragweed (*Ambrosia artemisiifolia*) requires three times as much water as a corn plant to reach maturity (19). The water requirement per acre is determined by multiplying the production of the plant in pounds of dry matter per acre times the plant's water requirement.

The dominance of a plant is determined by its success in competing for light. Light becomes a factor when the crop plant or weed is tall, the population is high, and the shading of one plant by another occurs.

Losses caused by weeds and economic thresholds for control. Mitich, L. W. Weeds have been called the most important of all crop pests (16). Reduction in crop yield results from interference between weeds and crops for water, soil nutrients, space, and light (25). When the supply of any or all of these essentials is not adequate for the optimum growth of the crop and weed, interference or competition occurs. Considerable variation exists among species of crops and weeds in their competitive ability. A strong plant competitor--either crop or weed--retards the growth of other plants growing in association with it. Strong competitors dominate because of faster and taller growth, early emergence and larger embryos (8, 13, 17). Annual losses in crop yield and quality due to weeds, combined with the costs of weed control, are greater in the United States than the costs of insects, plant diseases, and nematodes (4, 20). While maximum yield losses can exceed 90% of the potential yield in many crops, the actual losses in farmers' fields are generally much lower (25).

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The dominance of a plant is determined by its success in competing for light. Light becomes a factor when the crop plant or weed is tall, the population is high, and the shading of one plant by another occurs.

Some weeds such as green foxtail (Setaria viridis) and redroot pigweed (Amaranthus retroflexus) are intolerant of shade but others like field bindweed (Convolvulus arvensis), common milkweed (Asclepias syrica), spotted spurge (Euphorbia maculata), and Arkansas rose (Rosa arkansana) are shade tolerant. Shading suppresses the growth of several weeds including common lambsquarters (Chenopodium album), common ragweed, and wild buckwheat (Polygonum convolvulus) (14).

Some weeds have an allelopathy affect on crop plants by synthesizing and releasing toxic or inhibitory substances that interfere with the germination of crop seeds or subsequently retard the growth of the plants (9). Allelopathy is clearly related to competition because competition-induced stress may increase the production of allelopathic substances, and growth inhibition caused by allelopathy may reduce the competitive ability of the affected plant (16).

Adding nitrogen to barley plots infested with wild mustard, corn chrysanthemum (Chrysanthemum segetum), and wild radish Raphanus raphanistrum) raised crop yeilds to that of weed-free check plots (2). When high levels of nitrogen were added, competition occurred for other factors since in the weed-free crop there was a linear response to additional nitrogen and in the weedy crop there was a leveling off of response to higher rates of application.

Barley competes more vigorously than wheat for nutrients. While wild oat prevents these crops from fully utilizing soil fertility, it does not affect crop quality. Densities of 70 and 160 wild oat plants per square yard in North Dakota reduced wheat yield 22.1% and 39.1% respectively, compared to a weed free control (12).

The extent to which competition from weeds can reduce crop yields is affected by species, density, and duration. Naturally, species of crops and weeds differ in their competitive ability. In Canadian cereal crops, 600 green foxtail plants per square yard caused less damage than 200 wild oats (Avena fatua), wild mustard, or wild buckwheat plants (21).

When a barley plant was surrounded by varying numbers of pale smartweed (Polygonum lathifolium) plants and vice versa, the barley was not affected by the presence or absence of the smartweed. However, the growth of the smartweed was greatly affected by the presence of the barley. The smartweed did not affect adjacent plants of its own species (1).

In corn there is a consistent and significant difference in tolerance of yellow foxtail (Setaria lutescens) competition between late maturing and early maturing hybrids. Results from a 2-year study indicated that the bushel production per hundred weight of foxtail for a late hybrid may have been subjected to severe foxtail competition at a critical or vulnerable period in its growth pattern, while an early maturing hybrid was past a critical period in its growth before the onset of severe foxtail competition (23).

There is a 35% to 74% yield loss in rice in the United States due to weeds (22), and barnyardgrass (Echinochloa crus-galli) is considered the world's worst rice weed (6). A linear relationship has been found between rice yield and barnyardgrass density (3); when barnyardgrass yielded 100 grans per square meter (dry weight), rice yield decreased to 20% of the control.

How many weed plants per unit of acre can be tolerated before crop yields are reduced? Ten wild mustard plants per square yard in flax, 25 in oats, and 50 in wheat or barley were sufficient to cause significant crop losses in Canada (21). Once the weed population reached 100 to 200 plants per square yard, a further increase in numbers was relatively unimportant. In Michigan, 0.5, 1 and 2 common ragweeds per sugarbeet reduced yields 15% compared to yields from check plots with no weeds present from emergence of the sugarbeets (11).

It is readily apparent that weed competition is capable of reducing the yield and frequently the quality of almost any crop. Past research and research currently underway may reveal the levels of weed population necessary to constitute an economic threshold. Glass (5) defines economic threshold as "that pest population density, or damage level, at which control measures should be taken to prevent an economic injury level from being attained." Controlling the weeds, then, is less costly than the yield loss that would have occurred if the weeds had not been controlled.

Thresholds have not been used for weed control for several reasons. Among them, Norris (15) mentions these: a) low weed densities cause yield loss, b) the population dynamics of weeds are long but explosive, c) weed infestation encompass many species, d) herbicides have to be applied pre-emergence because of the lack of effective postemergence chemicals, e) thresholds refer to numbers of individuals but many weeds are perennials, and f) longevity of the propagules. In addition, there is no way to easily determine weed populations, particularly seeds, and the competitive effects of the same weed species in different crops are not the same. For example, one barnyardgrass per yard of row did not alter the yield of corn but tomato yield was suppressed by 35% (15). Because of these and other factors, the use of population thresholds for weeds has received little attention. However, it is likely that an economic threshold, if determined, will only apply to a specific crop containing specific weeds under specific set of growing and cost/income conditions. Thus, the level of weed competition which is "acceptable" will probably continue to be a matter of individual judgement and the number of weeds acceptable to one individual may be totally unacceptable to another.

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