The Reverend T. R. Malthus, in his 1798 essay on the principle of population, said, “The cause to which I allude is the constant tendency in all animated life to increase beyond the nourishment prepared for it.” Malthus’s concern was the increasing human population and consequent poverty and misery he saw in his town, Liverpool, England. The Malthusian apocalypse, when the human population is greater than the ability of the earth to produce food, has been avoided because of developments in food production technology. The apocalyptic possibility, especially in the world’s developing countries, still concerns many.

Crop competitiveness indicates dense, rapid crop seedling emergence and vigorous canopy development relative to that of weeds (Zimdahl 2004). Shading by the crop canopy is an important component of plant competition to inhibit weed seedling germination (Anderson and Nielson 1996), because weed emergence often occurs over an extended period of time (Zimdahl 2004; Spandl *et al.* 1998). The relative timing of crop and weed emergence is an important determinant of competition (Radosevich and Roush 1990; O’Donovan 1992). A number of environmental factors contribute to the germination and emergence of weeds, including soil thermal accumulation and soil water potential (Egley 1986; Forcella *et al.* 2000). Initial weed seedling germination is governed by a temperature or water threshold (Bradford 2002), whereas weed seedling emergence timing is dependent on recruitment depth (du Croix Sissons *et al.* 2000), and thermal accumulation (Forcella et al. 2000; Bullied et al. 2003).

Weeds are considered to compete with crops primarily for soil nutrients, soil moisture, light, and carbon dioxide. The degree of direct competition can be reduced to some extent by certain crop cultural practices based on our knowledge of weed biology and ecology. These methods include planting times, spacing, and herbicide placement. Weeds, as mentioned earlier, are able to compete quite well with crops in the less stressful field environment encountered in agriculture because of their characteristic (Baker, 1974) high seed production, leading to high population numbers, rapid germination, very rapid early growth, and long duration (life cycle). Weed interference can be reduced by altering the environment that a weed is adapted to; however, this can result in shifts in weed composition (Aldrich and Kremer 1997). Reducing weed competitiveness and growth in the current crop also has important implications for the weed seed bank and future weed populations.

The combined effects of particular weed communities, farming systems and environmental conditions will influence competitiveness. A number of agronomic factors including tillage intensity (Derksen *et al.* 1993;McGiffen *et al*. 1997; Blackshaw *et al*. 2001), fertility management (DiTomaso 1995), cultivar type (Harker et al.2003), time of seeding (Mohler 2001a; Bullied *et al*. 2003), and seeding rate (O'Donovan 1994) can be used to enhance crop competitiveness with weeds. Objective of this paper is reviewing on crop-weed competition (general concept, cause of competition and factors that affect competition).

2. CROP WEED COMPETITION

Competition is a question of the reaction of a plant to the physical factors that encompass it and the effect of these on adjacent plants (Clements et al. 1929) . For them, competition was a purely physical process. In the exact sense, two plants no matter how close, do not compete with each other so long as the water content, the nutrient material, the light and heat are in excess of the needs of both.In agriculture, competition is not regarded as simply interaction without any effect on either individual. Competition in agricultural communities has results that are usually negative (Booth *et al*. (2003). The definition according to Clements *et al*. (1929) makes competition different from the broader term interference, which includes competition and allelopathy. The dictionary defines competition as "being for something in limited supply or between agents, as in a rivalry." For physiologists, competition is usually for things. For agronomists and weed scientists, competition is often for things and between individuals (Donald, 1963).

2.1. Types of Competition

Above-ground (Aerial) competition which takes place in the leaves and the growth factors involve are light and carbon dioxide. Below-ground (Subterranean) competition which takes place mainly in the roots while the growth factors involve are water, nutrients and oxygen. The perceived consequence of competition with crop is reduction in the economic yield of affected crop plants.

2.1.1. Competition for nutrients

It is an important aspect of crop weed competition. Weeds usually absorb mineral nutrients faster than crop plants. Usually, weeds accumulate relatively larger amounts of nutrients than crop plant Nutrient removal by weeds leads to huge loss of nutrients in each crop season, which is often twice that of crop plants. Nitrogen, phosphorus, and potassium are primary plant nutrients. Success in gaining nutrients may lead to more rapid growth and successful competition for light and water. Fertilization is used to improve crop growth but may worsen the weed problem. Consumption of nitrogen and phosphorus for weeds and crops is very similar. The point is weeds require the same nutrients, at the same time, and are often, because of early emergence, more successful in obtaining them.

In a crop heavily infested with weeds, it seems logical that more fertilizer should reduce nutrient competition. If competition does not occur until the immediate supply falls below combined demand, when supply increases, competition should decrease. Actually, although this seems logical, it is wrong. Fertilizer usually stimulates weed growth to the crop's detriment. With low fertility, competition is primarily for nutrients however, with high fertility, competition is just as vigorous, and primarily for light. Yields in unwedded, fertilized plots are usually equal to those in weeded, unfertilized plots.

The influence of fertility treatments for 47 years on weed types and populations was evaluated in Oklahoma (Banks et al., 1976). Plots with the lowest weed density were those that had received no fertilizer for 47 years. Highest weed density occurred on plots that received complete fertilizer (N, P, K) and lime (CaCO3). Grass weeds were most abundant with complete fertility while broadleaved species declined. In general, weeds have a large nutrient requirement and will absorb as much or more than crops. Nitrogen is the first nutrient to become limiting in most instances of weed-crop competition. The nitrate ion is not held strongly in soil and is highly mobile. Nitrogen depletion zones are likely to be quite large and similar to those for water. Therefore, rooting depth and root area of plants determine the ability to obtain resources and relative competitiveness for nitrogen is largely determined by the soil volume occupied by roots of competing species.

Movement of phosphorus and potassium is slow compared to nitrogen, and they move over shorter distances. Smaller depletion zones minimize interplant competition. Competition for phosphorus and potassium is therefore most likely to occur after plants are mature and have extensive, overlapping root development. It is reasonable to assume that competition for phosphorus will be more apparent in perennial crops. Competitiveness of barley cultivars with wild oats varied in response to potassium (Siddiqi *et al.*, 1985) or phosphorus (Konesky *et al.*,

1989) supply. There are few studies of weed-crop competition for phosphorus or potassium. While competition for nitrogen can sometimes be overcome by nitrogen fertilization, this is rarely true for phosphorus and potassium. It may be possible to prevent or delay weed invasion of perennial crops by maintaining a vigorous crop with fertilizer.

2.1.2. Competition for soil moisture

Crop weed competition becomes critical with increasing soil moisture stress. In general, for producing equal amount of dry matter weeds transpire more water than field crops. Therefore, the actual evapotranspiration from the weedy crop fields is much more than the evapotranspiration from a weed free crop field. Water, or its lack, is often the primary environmental factor limiting crop production, and it is probably the most critical of all plant growth requirements (King, 1966). Without irrigation, rainfall determines the geographic limit of crops. The classic work on water requirements of plants was done in Akron, Colorado, in the early 20th century (Briggs and Shantz, 1914; Dillman, 1931; Shantz *et al*., 1927). Individual crop and weed plants were grown in separate pots, and the grams of water required to produce a gram of plant dry matter were determined.

Weeds compete for water, reduce water availability, and contribute to crop water stress. They require just as much, and often more, water than crops and are often more successful in acquiring it. Stomata in some weeds are less sensitive to declining leaf water potential than those of crops with which they compete (Patterson, 1995a). When this is combined with a larger root system or better drought tolerance, weeds are formidable competitors for water. High water use by weeds may be ecologically advantageous to weeds in weed-crop competition, especially when soil moisture is limiting (Patterson, 1995a). Water as a variable and found a slight tendency for decreased water availability to favor crops by reducing weed competition (Patterson, 1995a). This reasonable generalization may not always be true because it will be affected by each crop-weed combination and the cultural and environmental conditions in each crop season or over several seasons.

Scientists in arid areas have developed fallow cropping systems. Many arid areas have sufficient rainfall to support crop growth only every other year. Competition for water is determined by the relative root volume occupied by competing plants and will be greatest when roots closely intermingle and crops and weeds try to obtain water from the same volume of soil.

2.1.3. Competition for light (solar energy)

The total supply of light is the most reliable of the several environmental resources required for plant growth. But in contrast to water and nutrients, light cannot be stored for later use; it must be used when received, or it is lost forever (Donald, 1963). Although it varies in duration, intensity, and quality, light regulates many aspects of plant growth and development. Neighboring plants may reduce light supply by direct interception: shading. Leaves are the site of light competition. Leaves that first intercept light may reflect it, absorb it, convert it to photosynthetic products, convert it to heat, or transmit it. If transmitted, light is filtered so that it reaches lower leaves dimmer and spectrally altered.

Light competition is most severe when there is high fertility and adequate moisture because plants grow vigorously and have larger foliar areas. Plants with large leaf area indices (LAI) have a competitive advantage with plants with smaller leaf areas. Leaf area index, a measure of the photosynthetic surface over a given area, is correlated with potential light interception. Successful competitors do not necessarily have more foliage, but have their foliage in the most advantageous position for light interception. Thus, a plant's ability to intercept light is influenced by its angle of leaf inclination and leaf arrangement. Plants with leaves disposed horizontal to the earth's surface are more competitive for light than those with upright leaves disposed more or less competitive than those with alternate leaves. Plants that are tall or erect have a competitive advantage for light over short, prostrate plants.

A heavily shaded plant suffers reduced photosynthesis, leading to poor growth, a smaller root system, and a reduced capacity for water or mineral uptake. The effect of shading is independent of direct competition for water or nutrients and entirely under the influence of light (Donald, 1963). Current cropping practices used, at least partially, to manage weeds, such as smother crops and narrow row spacing exploit plant responses to light (Holt, 1995). Most weeds and crops respond to shading in similar ways via morphological and physiological adaptations (Patterson, 1995a). This is not surprising because these plants evolved in disturbed habitats where shade adaptation has few selective advantages (Patterson, 1995a). Reports that crops are physiologically and genetically capable of higher productivity and photosynthetic efficiency than obtainable in the field confirm that intercepted light is a limiting factor in crop canopies (Holt, 1995).

Crops and weeds differ in shade tolerance. Soybean and several of its associated weeds (e.g., eastern black nightshade, tumble pigweed, and common cocklebur) were most photosynthetically efficient under low growth irradiance (Regnier et al., 1988; Stoller and Myers, 1989). Many other weeds acclimate to low growth irradiance by plastic responses that reduce the growth-limiting effects of shading and allow restoration of high rates of photosynthesis when the plant is exposed to high irradiance (Dall'Armellina and Zimdahl, 1988; Patterson, 1979). Bazzaz and Carlson (1982) generated photosynthetic response curves for 14 early, mid, and late successional species grown in full sunlight and 1% of full sunlight. Early successional species, all common annual weeds, had the highest difference in response between sun and shade grown plants.

The magnitude of photosynthetic flexibility decreased in plants from later successional stages. All species studied were able to change their photosynthetic output in response to light, but the change was larger for early successional annuals (Bazzaz and Carlson, 1982). These findings suggest that weeds are not only adapted to high light but are more capable of adapting to extreme variation in light, particularly deep shade. Thus, managing the light environment in a crop field to deter weed growth is difficult and not likely to be effective (Holt, 1995).

Studies in India (Shetty et al., 1982) showed that dicots are less shade sensitive than monocots and help explain why monocots are often important tropical weeds. Broadleaved weeds usually do not appear until after tropical crops are well established. It seems that manipulation of tropical crop canopies could suppress weeds via shading. Plant height and vertical leaf area distribution are the important elements of crop weed competition. When moisture and nutrients in soil are plentiful, weeds have an edge over crop plants and grow taller. Competition for light occurs during early crop growth season if a dense weed growth smothers the crop seedlings. Crop plants suffer badly due to shading effect of weeds. Cotton, potato several vegetables and sugarcane are subjected to heavy weed growth during seedling stage. Unlike competition for nutrients and moisture once weeds shade a crop plant, increased light intensity cannot benefit it.

2.1.4. Competition for space (CO2)

Crop-weed competition for space is the requirement for CO2 and the competition may occur under extremely crowded plant community condition. A more efficient utilization of CO_2 by C_4 type weeds may contribute to their rapid growth over C_3 type of crops.

2.2. Critical Period of Crop-Weed Competition

The period at which maximum crop weed competition occurs called critical period. It is the shortest time span in the ontogeny of crop when weeding results in highest economic returns.

Factors affecting weed-crop interference or critical period of crop weed competition:

2.2.1. Period of weed growth

Weeds interfere with crops at any time they are present in the crop. Thus, weeds that germinate along with crops are more competitive. Sugarcane takes about one month to complete its germination phase while weeds require very less time to complete its germination. By that time crop plants are usually smothered by the weeds completely. In general, for most of the annual crops first 20-30 days weed free period is very important.

2.2.2. Weed - crop density

Increasing weed density decreasing the crop yields. The relationship between the yield and weed competition is sigmoidal. Increase in plant population decreases weed growth and reduce competition until they are self-competitive for soil moisture and other nutrients. In wheat reduced row spacing from 20 to 15 cm reduced the dry matter yield of lolium and phalaris spp by 11.8% and 18.3% respectively.

2.2.3. Plant species effects

Weed species: Weeds differ in their ability to compete with crops at similar density levels. This is because of differences in their growth habits and to some extent due to allelopathic effects.

Crop species and varietal effects: They differ in their competing ability with weeds. Among winter grains the decreasing order of weed competing ability is barley > rye > wheat > oat

Fast canopy forming and tall crops are more competitive than slow growing short stature crops (sorghum, maize, soybean and cowpea) because of their slow initial growth. Late sown dwarf wheat is affected by the late germinating weeds like Canada thistle and wild safflower.

2.2.4. Soil condition

Soil fertility: Under limited nutrient conditions, competition exists between the crop and the weed. Soil type, soil fertility, soil moisture and soil reaction influence the crop weed competition. Elevated soil fertility usually stimulates weeds more than the crop, reducing thus crop yields. Method and time of application of fertilizers to crop determining whether added fertilizer will suppress or invigorate weed growth in fields. Application of fertilizers during early crop growth season when weed growth is negligible was more beneficial. Band application of fertilizers to the crop will be inaccessible to inter row weeds.

Soil moisture status: Weeds differ in their response to available moisture in soil. Russian thistle Salsola kalishowed similar growth in both dry soils and wet soils; whereas large crab grass Digitaria sanguinalis produce more growth on wet soil. When fields are irrigated immediately after planting then weeds attain more competitive advantage over crops. If the weeds were already present at the time of irrigation, they would grow so luxuriantly as to completely over cover the crops. In water logged soils weeds are more competitive than crop plants. In submerged conditions in rice, weeds are put to disadvantage to start with. But if there is a break in submergence, the weeds may germinate and grow more vigorously than the crop, even if fields were submerged later.

Soil reaction: Abnormal soil reactions (very high or very low pH) often aggravate weed competition. Weeds offer intense competition to crops on abnormal pH soils than on normal pH soils. In acid soils Rumex acetosella and pteridium spp, saline alkaline soils Taraxacum stricta, Agropyron repens are the dominant weeds.

2.2.5. Climatic influences

Adverse weather conditions like drought, floods and extreme of temperature intensify weed-crop interference since most of our crop varieties are highly susceptible to such climatic influences whereas the weeds are tolerant to their stresses

2.2.6. Cropping practices

Time of planting crops: If the time of planting of a crop is such that its germination coincides with the emergence of first flush of weeds, it leads to intense weed-crop interference. Usually longer the interval between emergence of crop and weeds, lesser will be the weed-crop interference.

Method of planting: Weed seeds germinate most readily from top 1.25 cm of soil, though it is considered up to 2.5 cm depth. Avena, barnyard grass, Xanthium and Vicia spp may germinate even from 15 cm depth. Therefore, planting method that dries up the top 3-5 cm of soil rapidly to deny weed seeds opportunity to absorb moisture for their germination and usually post pone weed emergence until first irrigation.

Crop density and rectangularity: It determines the quantity and quality of crop environment available to the growth of weeds. Wide row spacing with simultaneous high intra row plant population may induce dense weed growth. But square method of planting is ideal to reduce intra row competition.

2.3. Plant Characteristics and Competitiveness

In general, it is true that plants possessing one or more of the following characteristics are more competitive than plants that lack them. This list is not in rank order, and it cannot be said that a plant with a certain characteristic will always win over a plant with another. Most competitive plants have the following traits:

- Rapid expansion of a tall, foliar canopy
- Horizontal leaves under overcast conditions and obliquely slanting leaves (plagiotropic) under sunny conditions
- Large leaves
- A C4 photosynthetic pathway and low leaf transmissivity of light
- Leaves that form a mosaic leaf arrangement for best light interception
- A climbing habit
- A high allocation of dry matter to build a tall stem
- Rapid stem extension in response to shading

Competition for nutrients and water takes place beneath soil, where it can’t be seen. The most competitive plants also share some of the following root characteristics:

- Early and fast root penetration of a large soil area
- High root density/soil volume
- High root-shoot ratio
- High root length per root weight
- High proportion of actively growing roots
- Long and abundant root hairs
- High uptake potential for nutrients and water

An interpretation of the relationship between crop yield and weed density has been described by the sigmoidal curve (Zimdahl, 1980). At very low weed densities, there is no effect on crop yield, and as weed density increases, while there may be an effect, it is barely discernible. As weed density continues to increase, crop yield drops quickly but never goes completely to zero. For practical purposes, the effect of 1 weed/acre is zero and that weed has no immediate, measurable economic effect. However, that one weed does affect nearby crop plants and produces seed and can, thereby, affect future crops.

When yields are plotted over a range of weed densities, there is no evidence to support a sigmoidal response. The most accurate representation of crop-weed interactions is that created by regression analysis of crop yield and weed density. This is because densities observed in the field and those used in experiments cannot represent the whole range of possible weed densities depicted. Multiple regression models must be chosen carefully so they reflect biological reality and not just mathematical convenience.

Weeds grow quickly to capture sunlight, water, space and nutrients. They often can alter their branching pattern, leaf size and leaf orientation to win the resource battle. Weed root growth can stunt crop roots in moisture-short soil. Sophisticated reproductive strategies Gardeners know that weeds can produce tremendous numbers of seeds. Weeds also have ways to prevent all of their seeds from germinating during years with less favor able weather. Seeds can be buried in undisturbed soil for an amazing length of time and still is able to germinate.

2.4. Factors that Control the Degree of Competition

Factors that determine the degree of competition is encountered by an individual plant. For weeds, density, distribution, and duration or how long weeds are present are important. For crops, density, distribution (including spacing between rows and spacing in the row), and duration (whether or not thinning is required) are important. These factors, modified by soil (edaphic) and climatic conditions, determine the degree of competition encountered by each plant. The primary things plants compete for are nutrients, light, and water. When any one is lessened, others cannot be used as effectively. Plants may compete for heat, but it is difficult to conceptualize how they do so. However, it is well known that accumulation of degree days enhances plant growth.

The threshold temperature differs between species and is the temperature below which the plant doesn't grow. Because they do not grow well at high temperatures, there is a maximum cutoff temperature, in the range of 30°C, for many plants. Plants grow better when it is warm, but no studies have reported competition for heat, perhaps because it is not a resource that exists in a finite reservoir. Yield reductions are generally in proportion to the amount of light, water, or nutrients that weeds use at the expense of a crop. A very general rule is for every unit of weeds grown, there will be one less unit of crop grown. Inconsistent results between weed management experiments in one year or between years are regularly attributed to environmental (i.e., light, water, nutrient, or climatic) variation. In most cases the data are insufficient to define cause and effect.

It is simple and neat to separate the elements of competition (nutrients, light, and water). H. L. Mencken (1880–1956) reminded us that "for every human problem, there is a solution that is simple, neat, and wrong." It is not wrong to separate the elements of competition experimentally, but it is wrong to assume that plants do so and it is nearly impossible to separate the elements of competition in nature. Competition will be greatest among similar species that demand the same things from the environment. Those species that best use (grow rapidly) or first capture environmental factors will succeed. Only in recent years has research progressed to consider the spatial distribution or where weeds are in a field. Weed scientists have long been concerned with what weeds (what species) and how many weeds (their density) are present in a field. Control has been directed at the dominant weed or weeds.

Studies of weed biology have emphasized seed production, seed dormancy and survival, and seedling growth and establishment. Results of these good studies have been translated into areas (acres or hectares) without considering the patchiness or non-uniformity of weeds in all fields. Control included the usually unstated assumption that weed distribution and density were uniform over the field. Thus, tillage for weed control and herbicides are nearly always applied uniformly over the field even though most farmers know and weed scientists agree the weeds are not distributed uniformly. Farmers and others who try to manage weeds have long recognized that weed distribution in a field is not uniform and control practices are unnecessary in some places. Biological knowledge to define how the seed bank, seed dispersal, plant demography, and habitat interact to determine the stability of weed or weed seed distribution across fields and across time are not as developed (Cousens and Mortimer, 1995). There is also a poor understanding of how control techniques affect weed and weed seed distribution over time. As this knowledge develops weed managers will be able to manage weeds on less than a whole field basis and that will lead to reduced need for tillage and herbicides (Mortensen, et al. 1998; Johnson et al., 1995).

2.5. Factors for which Plants do not Compete

Plants that emerge at the same time rarely compete for space, even though plant density may be high. When plants emerge at different times, the first plant that occupies an area will tend to exclude all others and have a competitive advantage and, in this sense, plants compete for space by occupying space first. Occupancy or competitive exclusion can be, and among plants should be, regarded as competition for the resources in a space. In general, plants that emerge at the same time and plants that grow together do not compete for space but rather for what space contains. This may not be true in root crops that are planted closely, but in most cases, it is the light, nutrients, and water that space contains for which plants compete.

Booth *et al.* (2003) agree with this assertion but caution that plants whose roots are restricted generally have reduced shoot biomass, height, or growth. Others (Schenk *et al*., 1999, cited by Booth *et al*., 2003) argue the still controversial hypothesis that plants may be regarded as territorial because they defend their space against invasion by others. In other words, a plant may effectively defend its territory by preventing others from using it.

2.6. Magnitude of Competitive loss

Weeds in crops reduce yields by competing for nutrients, moisture, light, and space. Pavlychenko and Harrington (1934) showed that the different growth habits of weed and crop species resulted in different competitive ability. Godel (1935) showed that light seeding rats were as productive as heavier seeding rates on weed-free land, but on weedy fields the higher seeding rates were more productive. Friesen and Shebeski (1960), in a crop-loss study on 142 farm fields over 3 years in Manitoba, found 28 weed species, some with populations up to 2500 per square meter. The average weed count was 270 per square meter with yield reductions ranging from zero to 6l%. Analysis of variance methods were used to determine the number of weeds required to cause a "significant" loss in yield. This was called "critical density." The analytical methods did not quantify the increase in crop loss associated with increasing weed populations.

2.7. Economic Analysis

More economic analysis of weed control is being done. Farmers know weeds reduce yield, and the question they ask is not whether weeds will reduce yield but how many weeds reduce yield how much. Their question is "Should I control weeds and, if so, what method(s) is best? The farmer's definition of best usually means the method that offers the highest profit potential. The study showed that for three potential wheat yields, what the profit or loss would be for spraying, given a certain value of wheat and a defined spraying cost. For example, if a farmer has ½ weed per square foot, the estimated yield loss is 5%. If the wheat yield is estimated to be 15 or 20 bushels per acre, the cost of controlling the weeds will exceed the benefit to be gained. If, on the other hand, yield will be 30 bushels, then the gain will exceed the cost and the weeds should be controlled. A farmer could calculate control costs and value of yield lost to determine whether control should be done. Other studies of decision models have been done (King *et al.,* 1986; Lybecker, 1984), but most decisions about what to do are still made by growers with incomplete information. Weed science needs more information on the efficacy of various weed control techniques and weed management systems in different soils and cropping systems.

This information must be combined with information on percent emergence of the weed species in the soil seed bank, expected crop yield, weed control cost, and the farm's current economic situation to make wise weed management decisions.

2.8. Mathematical Models of Competition

A large number of experiments have been done to demonstrate that weeds reduce crop yield (Zimdahl, 1980, 2004). This work has demonstrated that some weeds are more detrimental to one crop than another and the effect is always modified by environmental interactions. Weed scientists don't need more experiments to establish that weeds are detrimental. In fact, the important questions in weed control and weed management cannot be answered by experiments to determine yield loss as a function of weed density. Models can be empirical and describe data or a response to imposed management options. They can also be mechanistic and attempt to incorporate knowledge of processes that determine response (Cousens *et al*., 1987).

Decision aid models are based on the knowledge that weed effects are population dependent and all models attempt to predict the biological (weed density) and economic consequences of management decisions (Coble and Mortensen, 1992). Models incorporate the concept of thresholds or beginning points for weed effects.

Models are increasingly able to fulfill the basic requirements for a good weed crop competition model (Cousens, 1985):

- Without weeds there is no yield reduction.
- At low weed densities, the effect of increasing weed density will be additive.
- Yield loss can never exceed 100%.
- At high weed densities there is a nonlinear response of crop yield to weed density.

3. SUMMARY AND CONCLUSION

Competition is struggle between two organisms for a limited resource that is essential for growth. Water, nutrient, light and space are the major factors for which usually competition occurs. Competition between crop plants and weeds is most severe when they have similar vegetative habit and common demand for available growth factors. Numerous studies have investigated crop-weed competition from a variety of aspects. The results of these studies can be helpful in making decisions about weed management, as guidelines can be prepared indicating, in general, the relative competitive ability of various weeds at various densities in our major crops.

Studies also provide guidelines for duration of weed free conditions needed after crop emergence and for the time when weeds should be removed with post emergence herbicides. Data are somewhat limited, however, on mixtures of several weed species in competition studies. Other types of concerns, such as perception of the producer, neighbors, and landlord, may be as important as yield loss indications from crop weed competition studies in determining the types of weed management systems implemented. Weeds appear much more adapted to agro-ecosystems than our crop plants. Without interference by man, weeds would easily wipe out the crop plants. Weeds have been able to reproduce, survive, and compete for centuries, at least partially due to their diversity. Species of weeds, and sometimes biotypes within species, can vary greatly in various growth habits and ultimately in their ability to compete with crops.

Germination patterns differ markedly and sometimes erratically, causing differences in potential for competition from year to year. Emergence and growth also vary from slow and even, to rapid and almost unpredictable. Different species and biotypes appear to respond differentially to various environmental conditions. Factors that probably contribute more to the variation in results than any others are soil and air temperature, along with soil moisture content and rainfall before, during, and after initiation of competition studies. Even the best planned and conducted studies can vary considerably from location to location and year to year, often because environmental conditions vary. Competition from weeds is the most important of all biological factors that reduce agricultural crop yield. This occurs primarily because weeds use resources that would otherwise be available to the crop.

The magnitude of yield loss is affected by numerous agronomic and environmental factors, most importantly, weed density and time of emergence relative to the crop. Practices that reduce the density of weeds maximize occupation of space or uptake of resources by the crop or establish an early-season size advantage of the crop over the weeds will minimize the competitive effects of weeds on crops. Less competition occurs if roots of crops and weeds are concentrated in different soil areas. More competitive plants have faster-growing, large root systems so they are able to exploit a large volume of soil quickly. If plants have similar root length, those with more widely spreading and less branched root systems will have a comparative advantage in competition for water.

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