Using Crop Competitiveness as a Component of Integrated Weed Management

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Introduction

This is the second article of a series on integrated weed management (IWM). The inaugural article entitled “An introduction to integrated weed management and tools of prevention” can be accessed at the following link: Click Here The emphasis of this edition is cultural practices, specifically tactics that can be used to enhance crop competitiveness. These cultural tactics are generally compatible with chemical, biological, genetic and physical tools, and in most instances, there is little to no economic cost associated with incorporating them. A crop’s competitiveness can be determined by its ability to maintain yield projections in the presence of weeds (tolerant) and/or its ability to reduce weed establishment or growth (suppress) through allelopathy or direct competition. In this article, we will discuss various ways to manipulate competitive interactions between crops and weeds to provide crops the upper hand.

Crops and weeds are primary producers, and as such, compete for similar resources (sunlight, water, nutrients and space). To guarantee high yields, farmers try to make these resources available to their crops. However, these resources are concurrently being utilized by weeds. A truly competitive crop will dominate the weed community by exploiting these resources at the detriment of weeds. This allows the crop to produce desirable yields in the presence of weeds. Some crops compete well with weeds with limited assistance, while others require growers to adopt practices that enable them to compete better with weeds. Integrated weed management strategies that modify the crop-weed competitive relationship to benefit and give crops a competitive edge over weeds are among the least expensive IWM tools and are often broadly compatible with existing weed management practices. Competitive management tactics may fit into three categories. Tactics that ensure: 1) vigorous early season growth of the crop, 2) that the crop covers and shades as much of the soil as possible and 3) crops are fed and watered but not weeds. Any husbandry practices that can provide crops a competitive edge over weeds will better ensure their ability to acquire resources that would otherwise be commandeered by weeds.
Ensure early crop vigor

*Seed features* - Planting seedlings that germinate quickly, homogeneously and grow vigorously is the first step towards establishing a crop that competes well with weeds. In general, seed vigor describes the ability of seeds to emerge rapidly and uniformly under a wide range of environmental conditions. Seeds with low physiological potential or vigor generally have slow irregular growth and are more susceptible to environmental stresses. Using vigorous seeds is especially important if crops are planted when conditions for germination and seedling establishment are less than optimal. Seed size has been shown to be a valid measure of seed vigor and is associated with greater seedling growth and plant height. For example, planting larger soybean seeds improved soybean competitiveness with weeds by increasing its petiole length and plant height. Subsequently, these increases resulted in exceptional weed control in organic soybean production. For direct-seeded vegetable crops, seed weight is often advertised by seed companies, and can be used as a criterion for choosing varieties.

In addition to planting varieties with larger seeds, priming seeds before planting is an additional measure that may help with rapid germination and early seedling growth. Priming seeds involves soaking seeds in water to initiate the germination process ahead of planting. In doing so, primed seeds exhibit a faster and more synchronized germination, and young seedlings are often more vigorous and resistant to abiotic stresses than seedlings obtained from unprimed seeds. Some vegetable seeds are available to buy pre-primed by seed companies, but it is also possible to prime seeds on your own. However, in most cases those seeds should be planted immediately after priming. Moreover, some seeds such as edamame should not be pre-soaked. Using vigorous seeds, selecting the largest seeds for planting, priming seeds and using transplants as opposed to direct seeding are all methods to create favorable initial size differences between crops and weeds.

*Competitive traits* - Enhanced weed suppression may be achieved by growing cultivars that contain specific traits that make them more competitive with weeds. Farmers often select crop cultivars or varieties based on traits such as yield, fruit quality and marketability, timing of maturity, and disease resistance. Traits associated with competitive ability may include rapid growth, high biomass production, elevated plant height and large leaf area; all of which would help the crop to intercept light, uptake nutrients, and occupy space better than weeds. Other plant parameters associated with plant competitiveness include high tiller density, early canopy cover, and vertical and horizontal leaf orientation. The use of competitive crops or cultivars can be an important and cost-effective tool to enhance weed suppression and optimize crop yield, especially in cereal crops. Weeds are highly susceptible to the negative influences of shade. For example, shading greatly reduces the number and size of tubers produced by nutsedge (*Cyperus* spp.). As such, crop cultivars that rapidly shade the soil surface are more competitive in suppressing weed growth than slow growing cultivars.

Crop species and/or cultivars that are well adapted to specific environmental conditions of the field tend to be better competitors as they tend to grow more vigorously as environmental stress is minimized. As such, optimal planting date, which may vary among years, is an important consideration for crop competitiveness. For example, if a warm season crop is planted in cool soil, it will likely grow slowly and not compete well with weeds, especially if the field contains weeds that germinate under cool soil conditions. If crops must be sown in soils at temperatures that are not conducive to rapid growth, it may be helpful to adjust the planting date or locate cultivars that are more tolerant or adapted to those conditions. Using transplants over direct seeding may also provide the crop an initial advantage over weeds if weeds have yet to germinate. This is because transplants enter the field larger and more developed than weeds. Further, transplanted crops have a shorter critical weed-free period compared to direct seeded crops. Critical weed free period (CWFP) also known as the critical period for weed control (CPWC) is the time period that weeds must be
controlled to prevent an unacceptable yield reduction. Use of transplants may increase production costs over direct seeding, so the economic benefit should outweigh the additional cost.

**Pest management** - Effective insect and disease management are also important factors in maintaining crop vigor. These additional stresses can reduce growth rates, lower stand counts, and cause the crop to be less competitive and more negatively impacted by weed pressure. Seeds that have been treated with insecticides and/or fungicides may be used in cases where you know soil-borne disease or other pest pressure is high. Alternatively, some pesticides can be applied in-furrow or with transplant water when early season pest (insect, disease) pressure is known to be high. After planting, regular scouting should be performed as a part of an integrated pest management (IPM) approach to managing pests including pathogens. Starting out with healthy, vigorous plants and minimizing stress from other pests will help maintain a competitive crop.

**Shade the soil**

**Crop spacing and density** - The physical arrangement of a crop can help determine how well the crop competes with weeds within a field. Generally, planting crops with narrow row spacing will enhance their competitiveness with weeds, as more of the ground is covered by crop plants. At the extreme end, planting a crop with equal spacing within and between rows provides uniform coverage of the soil, which maximizes the competitive ability of the crop. Under this arrangement, competition among crop plants is minimized by giving each plant equal space to grow, and competition between the crop and weeds in a field is favored by the crop. Equal spacing of crop plants maximizes their ability to take up resources throughout the entire field and most importantly, maximizes the amount of soil surface that becomes shaded as the crop canopy closes. As a result, planting patterns that reduce inter-row spacing and approach a uniform distribution tend to have a shorter CWFP than crops planted in wide-rows. Additionally, increasing the plant population and planting in narrow rows can further reduce weed pressure. For example, an experiment with corn found that narrow row spacing (18-24 in) and higher plant density (33,000-36,000 plants per acre) resulted in significantly more shading and more biomass accumulation by the crop, and lower biomass, density and nutrient uptake by weeds. Increasing planting density and planting crops in narrow rows can maximize the space that crops occupy early in the season and enhance their competitiveness with weeds (Fig. 1).

![Diagram of different cropping layouts](image)

**Fig. 1.** Diagram of different cropping layouts. A. wide row spacing typical of many vegetable crops; B. narrow row spacing, which increases competition with weeds between crop rows; C. increased plant density, which increases competition with weeds within crop rows; D. high density and narrow row maximizes crop competition with weeds. A. and B. have the same number of plants, as do C. and D.; B. and C. have the same per-acre plant density.

Maximizing crop competition by increasing plant density and using narrow row spacing has its limitations, and cannot be effectively used in all types of crops or cropping situations. In fact, these tactics may have limited applicability for many vegetable crops. For example, fruiting crops such as tomato, pepper and eggplant may suffer from reduced fruit size under plant populations that are too high. These crops are also typically harvested repeatedly by hand for multiple weeks, and therefore inter-row spacing must accommodate workers’ foot traffic. Many of the successes from using higher...
plant density to suppress weeds were observed in agronomic crops, especially cereal grains. Several agronomic crops can tolerate narrower row spacing and/or higher-density plantings without any yield reductions, and crops such as soybeans can be planted in narrower rows without increasing the per acreage seeding rate. Further, when more seeds are required per acreage in agronomic cropping systems, the weed suppression benefits of using a higher seeding rate often outweighs the additional cost. However, vegetable seeds and transplants tend to be much costlier. Thus, compared to agronomic crops any increase in weed suppression is less likely to compensate for the additional cost associated with a higher plant density. Still for agronomic and vegetable cropping systems, narrow row spacing may limit the use of mechanical cultivation as a weed management tool, if cultivation equipment on hand is incompatible with narrow row spacing. This could be especially important for organic producers. Thus, several issues must be considered before making the decision to change the spacing and/or density of a crop to maximize its ability to compete with weeds.

**Crop row orientation** - Crop rows can also be oriented relative to the path of the sunlight so that they better shade out weeds located between crop rows. Researchers in Australia have shown a reduction in weed biomass when crops are planted with rows in an east-west compared with a north-south orientation. Crop rows in an east-west direction were oriented at a right angle to the direction of sunlight (within the winter cropping system in Western Australia) which caused greater shading of weeds in the interrow areas. It has been suggested that this row orientation allows crops more uniform access to light, which provides crops a competitive advantage over weeds. This benefit was shown in wheat and barley. However, findings were not consistent in canola, field pea and lupine crops. One of the weeds impacted by differences in crop orientation was annual ryegrass (*Lolium rigidum*). Researchers found that 47% more light was available to annual ryegrass growing between north-south compared to east-west planted crop rows. Likewise, in California, it was found that shoot and root dry biomass as well as seed production of black nightshade (*Solanum nigrum*) were reduced under grapevine rows oriented east-west compared with north-south. It is also important to note that the impact of row orientation varies with latitude and the seasonal tilt of the earth in relation to the sun. For example, near the equator, north-south as opposed to east-west orientation gives crops higher levels of light interception most of the year. The value of using crop row orientation specifically for vegetables is not well known as little research has been conducted in summer crops.

**Feed the crop, not the weeds**

*Fertilizers* - Fertilization is an important component of IWM programs and careful management of soil fertility is essential to allow crops to compete with weeds. Over application of fertilizers may benefit weeds more than crops, because weeds tend to be better at exploiting excess nutrients than crops. On the other hand, if crops are suffering from nutrient deficiencies, they will not be able to grow vigorously and compete with weeds. To this end, applying ideal rates of nutrient will give crops a competitive edge by promoting more vigorous growth. Optimum applications of nitrogen (N), phosphorus and potassium fertilizer promote a closed and uniform crop canopy. This subsequently, reduces the intensity of light available to weed communities positioned below the crop’s canopy. Within most cropping systems, nitrogen is most often the nutrient that limits plant growth. For this reason, fertilization plans to limit weed growth tends to focus on N applications. Managing fertility to benefit crops rather than weeds essentially involves following the four Rs of nutrient management: use the Right source, applied at the Right rate, at the Right time, with the Right placement. The source of N for many farmers may come down to cost. However, the choice of a water-soluble versus slow-release formulation or conventional versus organic fertilizer can impact how that fertilizer is applied and its availability to weeds.
The rate of N fertilizer applications should follow recommendations from nutrient management plans, as these rates are based on expected yields, soil test data and other site-specific characteristics that affect fertility requirements. Excess N will not likely be used by the crop but could be taken up by aggressive weeds. Timing of N application should coincide with peak N demands of the crop. Placement of N fertilizer is also important. Placing N fertilizer within crop rows as opposed to broadcasting it throughout the field will better ensure that the crop takes up the fertilizer and it doesn’t become available to weeds in interrow areas (Figs. 2a, b). Any application method that better guarantees crop access to nutrients over weeds should be considered. For example, methods such as fertigation through drip tape, or banded side-dressing can physically limit the amount of nutrients available to weeds by keeping it in the direct vicinity of crop rows (Fig. 2b). Further, application of N to seeds of certain weed species may “awaken” them from dormancy, stimulating more germination than would otherwise occur. Taken together, any practice that places fertilizer in close proximity of crop plants and away from areas in the field that are conducive for weed uptake will provide crops the competitive edge.

**Water management** - Weeds compete aggressively for water, which is a primary source of crop-weed competition in non-irrigated crops. Water management can be an important IWM tool and key to controlling weeds in vegetable systems. Essentially, irrigation should be confined to crop rows. Overhead irrigation will direct water throughout the entire field including interrow areas where it offers no benefit to the crop but can be utilized by weeds for germination and rapid growth (Fig. 3a). Drip irrigation is the golden standard for getting water directly to the crop while limiting water from entering inter-row areas (Fig. 3b). Another technique, burying the drip tape below the soil surface in the crop row provides moisture to the crop while further minimizing the amount available for weeds near the surface. This method also reduces loss to evaporation and runoff and may result in less water usage. This technique is especially effective during periods of low precipitation when interrow areas remain dry.
Dry surface soil conditions can also be used to help direct-seeded crops germinate ahead of weeds. For example, planting large-seeded crops into deeper soil moisture can provide crops with an initial advantage over weeds by allowing them to germinate without the addition of irrigation, while weed seeds remain dormant in the drier surface layer. Another method that involves planting to moisture involves seeding a crop in the soil as shallow as moisture conditions allow and not applying any irrigation at planting. This earlier emergence provides crops a competitive edge over weed germination and establishment. In addition to tactics discussed above, the stale seedbed is another weed suppression tactic that can provide crops a competitive edge through water management. Stale seedbed is a weed management practice in which weed seeds just below the soil surface are allowed to germinate and then killed prior to planting the cash crop while minimizing soil disturbances. A complete article on the stale seedbed method can be obtained from the following link: Click Here. Optimal application, timing and placement of irrigation will help arrest weed establishment while providing crops the upper hand. Notwithstanding, occurrences of natural precipitation can sometime cause water management tactics designed to provide crops a competitive edge to fail.

Summary
The efficacy of weed control can be improved by adopting crop management practices that promote crop competitiveness. Early crop canopy closure can be achieved by increasing seeding rates of the crop, using narrow row spacing, reducing intra-row spacing of seeds and transplants, planting primed, larger and more vigorous seeds, and planting crop rows at right angles to sunlight direction. These practices result in higher plant populations and/or rapid canopy closure, and greater weed suppression. Weed problems are less likely to occur late season in closed canopy cropping systems. However, any additional cost or inconveniences associated with the deployment of these practices should be weighed against the benefit of greater weed suppression. This will help determine the economic and logistical feasibility of using these tactics in specific cropping situations.

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