Vegetable & Fruit News

UNIVERSITY OF MARYLAND EXTENSION · AgFS Agriculture & Food Systems · University of Maryland Eastern Shore

The University of Maryland Extension Agriculture and Food Systems and Environment and Natural Resources Focus Teams proudly present this publication for commercial vegetable and fruit industries.

Special Alert Edition: IWM Article VIII CPWC May 6, 2021

The Critical Period of Weed Control (CPWC): An Underutilized Concept

Cerruti R[2] Hooks[$*], Alan W. Leslie[#] and Dwayne Joseph[^*]

[$]Associate Professor and Extension Specialist, Post-Doctoral Fellow[^], *CMNS, Department of Entomology, [#] Extension Educator - Agriculture and Food Systems, AGNR UME - Charles County

INTRODUCTION

There is a great need for designing integrated weed management (IWM) programs largely because of an increase in herbicide-resistant weeds. An IWM program involves using a combination of tools (cultural, mechanical, biological, genetic, and chemical) to deploy a holistic and synergistic weed suppression system. An important component of IWM is basing weed management decisions on the critical period of weed control (CPWC). The CPWC is defined as the period within a crop's growth cycle during which weeds must be controlled to prevent perceptible yield loss. Knowing the CPWC of specific crops is useful for 1) helping decide whether weed control measures are needed and 2) timing weed control interventions. The CPWC signifies the time period in which crops are most vulnerable to yield loss due to competition with weeds. As such, identifying the CPWC is essential for planning a weed management program and precisely timing herbicide applications and/or other weed control tactics. This is the eighth article of a series on IWM. Initial articles can be found within the Vegetable and Fruit News newsletter (March, April, May and June 2020 Special Editions).

WEED COMPETITION AND THE CPWC

Weeds lower crop yields primarily by competing for essential resources such as light, water and nutrients. It has been suggested that key factors determining a plant's competitive capacity include 1) its ability to capture space at the beginning of the season, 2) speed of growth and associated capability to expand within the space, and 3) competitive edge for a limiting resource. Generally, very early during the season, resource requirements by crops and weeds are small enough that they can co-exist without impairing each other's growth. Howbeit, as the growing season progresses and weed size increases, they begin to compete with and deprive crops of essential resources. Timing of crop and weed emergence is vital to determining the potential yield loss due to competition. The time at which this competition initiates is known as the critical period, and during this time, crop yield can be negatively impacted. Generally, the first plant system (weed or crop) out of the ground will have the competitive advantage over the other; and in a competitive situation, the plant that initially captures an important resource will maintain the competitive edge for the remainder of the growing season. Thus, weeds that emerge earlier than crops commonly have greater access to soil and spatial resources. Relative to this, weed size is partly influenced by emergence time as weeds that emerge before the crop or with the crop are frequently larger and better established than those that germinate after. Thus, late-emerging weeds tend to be less harmful to crops and less likely to impact yield unless present at very high densities. Consequently, controlling weeds at or before the critical period will protect crops and their associated yields from early-season competition which should be a goal of all IWM systems.

THE CPWC CONCEPT

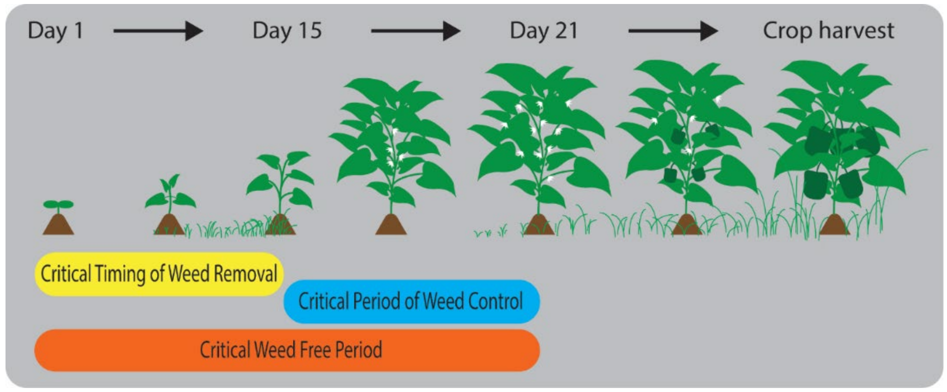


Fig. 1. In this hypothetical example, the critical timing of weed removal (CTWR) is from crop planting (day 1) to 15 days after planting (DAP) and the critical weed free period (CWFP) is from crop planting until 21 DAP. Thus, the critical period of weed control (CPWC) was determined to be between 15 and 21 DAP.

The CPWC concept was introduced many years ago and assumes that weeds are not equally harmful to a crop during the entire season, and that there is a period in crop development where weeds have the greatest impact on yield. This concept suggests that any weeds that germinate within the CPWC window must be controlled soon after germination to prevent them from reducing crop yield. However, once the crop has passed this window, it will out-compete any new weeds that germinate, and these "new weeds" will have minimum impact on crop yield. This period is also known as the *critical period of weed competition* or *critical period of weed interference*. The CPWC is determined by two separately measured crop-weed interference factors. These include 1) the critical timing of weed removal (CTWR) which is the maximum amount of early-season weed interference that the crop can tolerate before it suffers irreversible yield loss, and 2) the critical weed-free period (CWFP) which is the minimum weed-free period required from the time of planting to prevent unacceptable yield loss (typically 5% or greater). If weeds are controlled during the early stages of crop growth, losses from weed competition should be minimized (< 5%). To decide when weed control intervention is economically feasible, it helps to know what period during a weed incursion is it likely to reduce yield below the acceptable limit. Weeds that emerge before the CTWR or after the CWFP may not impact crop yields; and though additional weed control measures may be required before or after these times to produce season-long weed-free conditions, yields should be similar if weeds are controlled only during the CPWC. It's important to note that the critical timing of weed removal (CTWR) and critical weed free period (CWFP) are experimentally determined periods that help researchers calculate the beginning and end of the CPWC (Fig. 1).

PROTOCOL FOR CPWC

Though, the CPWC concept is straightforward, determining it, especially with accuracy can be an arduous undertaking. This is because there are many factors and interactions involved which may cause it to vary. Depending on conditions, the critical period has been suggested to occur as early as 2 to 10 weeks or later after planting and may occur when weeds reach a height of 2 to 10 inches or larger. The inability to precisely predict the critical period requires that conservative decisions be used in declaring when weeds should be removed to prevent yield loss. Two protocols commonly used to determine the CPWC include: 1) keeping the crop free of weeds until a certain period, after which weeds are allowed to grow; and 2) allowing weeds to grow from crop planting to a certain time, after which they are removed until the end of the crop's cycle. Experiments conducted on multiple crops (e.g., corn, soybean, tomato, carrot, pepper, eggplant) worldwide have shown that their susceptibility to weed interference varies at different times and that several factors influence the

CPWC. Therefore, understanding how different factors impact the CPWC provides a basis for planning effective weed management strategies for specific crops.

FACTORS IMPACTING CPWC

The CPWC may be influenced by weed species composition, location relative to the crop, emergence time, pattern and density. Some weeds can be allowed to compete with crops for longer periods when occurring at low densities. Cultural and mechanical practices (e.g., crop cultivars, fertilization, seeding rate, tillage practices and row spacing) may also impact the CPWC as these practices can alter the competitive advantage of the crop or weed. Reducing row spacing is an effective way to increase the competitiveness of some crops. The CPWC can be shortened with narrow rows. Narrow row spacing generally leads to faster canopy closure, thus increasing weed suppression. Early crop canopy formation blocks sunlight, decreases weed seedling emergence, and suppresses the growth of emerged weed seedlings (Fig. 2).

Fig. 2. Tight rows of romaine lettuce with limited sunlight between plants, Fronteras Desk (CC).

The CPWC can be influenced by conservation farming practices such as minimum tillage and cover cropping (Fig. 3). Research has shown that the critical period for corn under no-till conditions tended to start and end earlier than under conventional tillage practices. In a study involving cotton, rye cover crop suppressed early season weed biomass and extended the start of the CPWC. The presence of rye delayed the critical timing of weed removal (CTWR) ~ 8 days compared to the fallow treatment. Other factors including crop genetics and environmental conditions (e.g., temperature, soil moisture) may influence the CPWC. For example, a study conducted in Italy found that the CPWC for corn was longer under dry compared to irrigated soil conditions. This occurred because weed competition started earlier under dry soil conditions tentatively due to water being a limited resource. Further, under dry conditions crop canopy closure may be delayed. In addition, weed species composition, timing of weed emergence relative to the crop, and crop-weed growth will influence the critical period. Weed and crop size at the timing of weed control intervention is important. For example, if weeds are at a height taller than the crop, they may shade it suggesting that control measures should have been initiated earlier. Contrary to this, if weeds emerge several days after the crop is planted, especially transplanted crops, they will have not had an opportunity to shade the crop. These conditions suggest control measures can be initiated at a later time. Relative to this, late emerging weeds will have a more difficult time outcompeting and overtaking a crop, and transplanted crops may have an early season advantage over weeds for space.

Fig. 3. No-till sweet corn planted into crimson clover (*Trifolium incarnatum*) + rye (*Secale cereale*) residue. Cover crop residue helps suppress early season weed populations during the CPWC.

Crop planting date and the duration of weed emergence may influence the length of the critical weed free period. A study conducted in Canada found that the CWFP for carrot extended up to 930 growing degree days (GDD), when carrot was seeded in late April. In contrast, the CWFP was shortened to 414 to 444 GDD, when carrots were seeded in mid to late May. Based on these findings, growers were recommended to scout early planted carrot fields for weeds until 930 GDD to allow for full yield potential but if planted in mid to late May, weeds emerging after 444 GDD did not reduce yield. The study indicated that a useful strategy to reduce herbicide application, cost and potential herbicide resistance in carrot would be to delay planting until late May. In variance to carrots, findings from a study conducted to determine the critical period for Palmer amaranth (*Amaranthus palmeri*) control in pickling cucumber suggested that planting pickling cucumber as early as possible during the season may help reduce competition with Palmer and delay the beginning of the critical period for Palmer control.

The CPWC may also vary according to the weed species' competitive ability with the crop. For example, the critical period of redroot pigweed (*Amaranthus retroflexus*) control was determined to be 6.6 and 5.1 weeks after snap bean emergence for a 5 and 10% yield loss, respectively. However, the critical duration of interference of common cocklebur (*Xanthium strumarium* L.) was reported to be between snap bean emergence and the full bloom stage. In a separate study, it was reported that the critical period of purple nutsedge (*Cyperus rotundus*) interference occurred at ~ 4 weeks for snap beans. Notwithstanding, most cultivated crop fields have mixed weed populations making determination of CPWC based on mixed weed populations important. It has also been suggested that the CPWC may not be feasible for all weed species. For example, perennial weeds may need to be controlled regardless of crop stage as their vegetative propagules may provide weeds an advantage relative to early season growth and procuring resources.

HOW INFO FROM CPWC CAN BE USED

Understanding when the critical period occurs is essential for maximizing yield potential. For example, corn and soybeans on average can have yield loss of up to ~ 50-60% during the critical period if weed control is not provided; and higher depending on the weed species. Thus, knowing these periods allows growers to be proactive and make better judgement in the timing of management tactics. If farmers want to allow the greatest number of weeds to emerge in a field that will not markedly impact yield before spraying, cultivating and/or controlling them using another tactic, knowing the CPWC is imperative. If control measures are applied too early additional measures will need to be deployed at a later date and if applied too late, weeds present may have already contributed to yield loss. This is important as it suggests that weed management programs that rely on post-emergence herbicides can produce weed-free fields with pleasing aesthetic features by season's end. However, crops in these clean fields may still not reach their full yield potential because of early season competition with weeds. Thus, the CPWC provides a guide as to how long a residual herbicide product (PRE) needs to work to prevent yield loss and/or when a post-emergence herbicide is necessary to sustain a crop's full yield potential. This can aid farmers in determining the best herbicide choice and timing of control measures to achieve maximum yield.

Fig. 4. No-till bell pepper planted into rye (*Secale cereale*) cover crop residue. Photo credit A. Leslie.

Knowledge of the CPWC can also be used to reduce production cost and prevent quality losses due to weeds. If conventional and/or organic farmers can use knowledge of the CPWC to manage weeds with cover crop residue (Fig. 4), well-timed manual weeding, cultivation or herbicide application instead of multiple operations, this could result in lower labor cost, fuel use and/or herbicide applications. For example, an early well-timed application of a post-emergence herbicide may eliminate the need for a pre-emergence application, if conditions are not conducive to vigorous early-season weed growth. As such, the length of the critical weed-free period can identify time required for pre-emergence (PRE) herbicides and cover crop residue to effectively prevent weed seed germination, optimum timing for manual weeding and in-crop cultivation, and timing of PRE and post-emergence (POST) herbicide applications. Moreover, weed management tactics deployed outside the CPWC can lead to additional expenditure without a comparable yield or profit increase. A study conducted to determine the CPWC in hand-weeded corn found that on average 11 hand-weeding activities were needed to keep corn plots weed-free from sowing until harvest. However, four hand-weeding operations were enough to avoid yield loss when conducted during the CPWC (four- to ten-leaf corn stage).

CPWC SHORTCOMINGS

Though the CPWC is a vital component of IWM, the concept has some frailties. Some suggest that the variability associated with the CPWC annuls the practicality of using it. The concept also assumes that 1) weeds are equally controllable at all growth stages, 2) farmers have the ability to control all weeds at the required time and 3) weeds only negatively impact crop yield suggesting that it is not necessary to maintain crops free of weeds throughout the entire season or more specifically beyond the CPWC. Each of these assumptions are not invariably accurate. For instance, weeds that emerge after the critical period can interfere with harvest efficiency and/or produce seeds that contribute to future weed problems (Fig. 5) which is in variance with the principal of IWM which proclaims subsequent crops should be protected from future weed problems by preventing weeds from setting seeds. Relative to this, emphasis should be placed on preventing weed seed production if the goal is to manage and prevent the spread of resistant weeds. This would entail deploying weed control practices outside the critical period required to avoid yield loss. For example, one of the best management practices for growers is to remove all Palmer amaranth plants from the field before they reach reproductive maturity to protect future crop plantings and mitigate the spread of herbicide-resistant biotypes.

Fig. 5. Weed with seed heads in late season soybean. Photo credit: Claudio Rubione, University of Delaware.

Additionally, weed seeds found in harvested crops can increase the risk of spoilage and cause dockage thereby reducing profits. Further, although weeds that begin to grow after the critical period may not affect final yield, under some situations, certain weeds especially those that produce vines such as morningglory (*Ipomoea* spp.) or have fibrous stems growing in the crop at harvest may reduce crop quality and harvesting efficiency. Moreover, weeds remaining after the critical period can harbor insects and diseases that make crop rotation a less effective tool for managing these pests. These concerns suggest that in some cases weed control tactics may require continuity beyond the CPWC.

SUMMARY

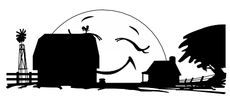
The CPWC is a concept that is not widely endorsed and is often excluded from an IWM system. Yet, it can be useful in determining precisely when weed control intervention is required to avoid yield loss and should be considered a key component of IWM programs. Weeds that germinate and grow outside the CPWC will not impact yield. Further, the CPWC can be used to reduce production cost and increase profits through less chemical use, labor expense and fuel purchase. Despite these benefits, relying strictly on the CPWC to make weed management decisions could prove fatal if it results in the occurrence of weeds that interfere with harvest efficiency or produce seeds that cause dockage, contaminate crop seeds or contribute to the soil seed bank or spread of weeds with herbicide resistance. Primarily, weeds should be removed during the early growth stage of a crop. However, the timing of the CPWC is not an "inherent property of the crop" and varies according to weed species, environmental conditions, year, planting time, field location and farming practices. In general, any farming practice or conditions that increase a crop's competitiveness against weeds will contribute to reducing the CPWC. Moreover, though useful, determining the CPWC is not an easy task. Financial support for the publication of this article is via USDA NIFA NESARE and EIPM grant award numbers LNE20-406R and 2017-70006-27171, respectively.

Vegetable & Fruit News

A timely publication for the commercial vegetable and fruit industry available electronically in 2021 from April through October on the following dates: **April 15, May 13, June 10, July 15, August 12, September 9 and October 28 (Special Research & Meeting Edition).**

Published by the University of Maryland Extension Focus Teams: 1) Agriculture and Food Systems; and 2) Environment and Natural Resources.

Submit Articles to:
Editor,
R. David Myers, Extension Educator
Agriculture and Natural Resources
97 Dairy Lane
Gambrills, MD 21054
410 222-3906
myersrd@umd.edu



Article submission deadlines for 2021 at 4:30 p.m. on: April 14, May 12, June 9, July 14, August 11, September 8 and October 27 (Special Research & Meeting Edition).