ZONE MANAGEMENT - IS IT PRACTICAL FOR INSECT PEST CONTROL IN MIDSOUTH COTTON?

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Abstract

To compete globally, U.S. producers must improve overall system efficiency and work to exploit their comparative advantage in engineering technology, equipment capacity, and use of precision agriculture tools. This includes expanding site-specific management tactics for improving insect pest management. With implementation of spatial technology, crop protection decision-making will grow increasingly complex. Decisions should be made with an understanding of pest insect and plant interrelationships and an appreciation for risk management. Zone management practices for agronomic inputs in Midsouth cotton are prevalent; however, use of site-specific approaches for insect control are lacking. In this paper, a practical guide for setting zones for use in insect control is presented. It includes a summary of field validation of a simple zone approach for insect pest control termination for tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), a key pest of Midsouth cotton.

Introduction

Midsouth cotton production acres have declined in the past decade in response to low commodity prices related to sluggish global demand and to the restructured U.S. government farm program. Low prices have been accompanied by increasingly higher production costs, and maintaining profitability has become a substantial challenge. Pest control inputs contribute significantly to overall production costs, particularly in the Midsouth, and changes in the *business as usual* approach to crop protection are needed.

There has been outstanding progress in cotton insect pest control technology over the past two decades, particularly with regard to control of caterpillar pests. Boll feeding caterpillars are now largely managed through embedded seed technology included in transgenic cottons that can express of as many as five different insecticidal proteins derived from *Bacillus thuringiensis* (Luttrell et al. 2015). No capital-intensive equipment is necessary to benefit from this technology because deployment is seed-based. From smallholder farmers in developing countries who plant by hand, to our highly capitalized, large scale U.S. producers planting with satellite-linked, precision-guided equipment, each has access to these advanced pest management tools. Because U.S. producers no longer have a comparative advantage in access to seed technology, they must work to exploit their engineering technology, equipment capacity, and use of precision agriculture tools.

Under new Farm Bill policies, now, more than ever, U.S. cotton producers recognize that maximum yield and maximum profit are not equivalent, and they must work to improve their input use efficiency to better emphasize profitability rather than yield. Efficiency will advance as producers and their crop advisors improve their recognition, understanding, and management of ***limiting factors*** in crop productivity. This includes a better appreciation of spatial and temporal variability of crop carrying capacity (Hearn and Da Roza 1985). Particular fields and field areas have different levels of crop carrying capacity (Figure 1). Carrying capacity may vary temporally, related to growing conditions, particularly weather, as well as spatially, related to soil properties including texture, fertility, elevation and drainage. A major focus in our Arkansas research program is to develop practical guidelines to increase implementation of site-specific management using spatial technology to improve input efficiency. One approach is to reduce inputs in low performance field areas that have confirmed limited crop carrying capacity. The minimalist approach to zone management in spatially variable fields is contrary to the practice of maintaining or increasing inputs in low yielding areas in an attempt to improve overall uniformity. If landscape features affects insect pest risks, then increased protection may be warranted associated with that risk; however, site-specific actions such as “border sprays” should be considered rather than broadcast field scale approaches (Figure 2).

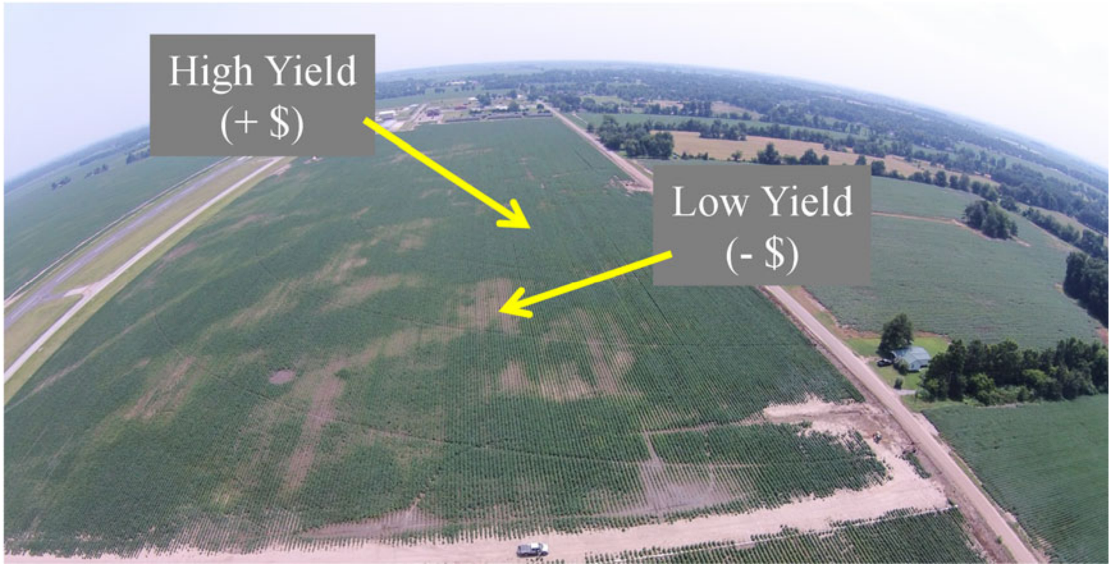

Figure 1. Fields with heterogeneous soils typically have different levels of crop carrying capacity which translates into low to high yield potential. Production inputs are the same, or even higher in what will be the **low profit** areas of the field.

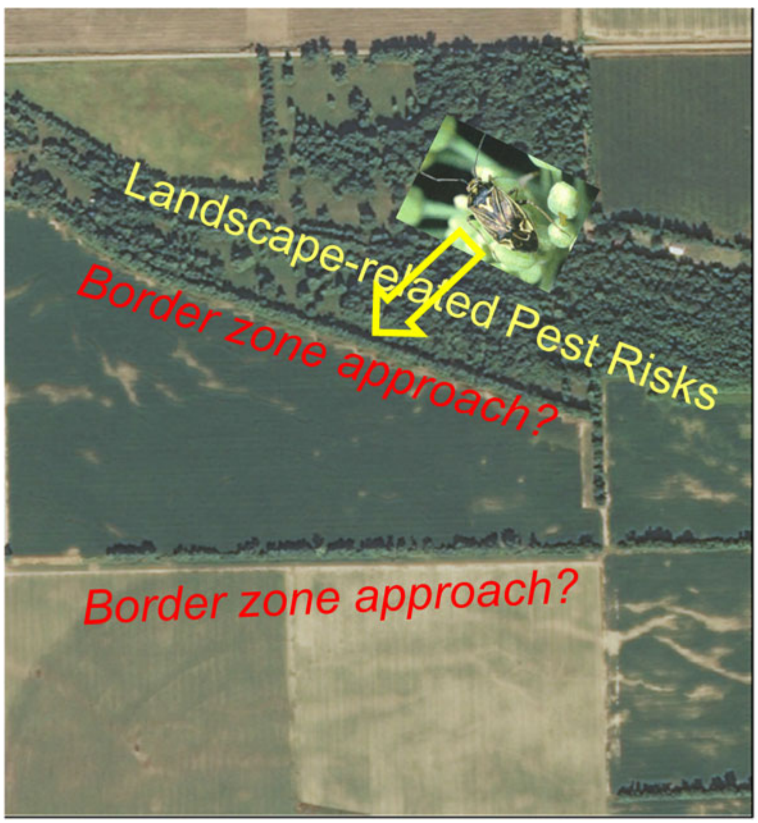

Figure 2. Zone approaches to pest management can include implementing site-specific control practices to address identified pest risks associated with landscape features such as high-quality overwintering habitat for pests or presence of alternative plant hosts including weeds or other crops where pest numbers may increase and then move into cotton.

Grid sampling and zone management for fertilizer applications have become common practices on many Midsouth farms; however, use of site-specific approaches for insect control are lacking. Applications of insecticides only serve to protect yield potential within the constraints of carrying capacity, and costly insecticides applied to non-susceptible or non-threatened portions of a variable field are simply wasted dollars for the farming operation. A zone management plan for crop protection ideally will allow managers to protect susceptible plants but will not waste costly control inputs where a) plants are not susceptible, b) pest numbers are low and pose no economic risk, or c) all of the above. Understanding where and when protection is unnecessary is central to managers having confidence in adopting precision practices for insect control, and crop managers require field validated guidelines to move forward with site-specific tactics for zone management of insect pests.

Zone Termination

The decision to segregate a production field into different management zones is not trivial, and producers should be cognizant of the increased management requirements– including expanded scouting – that should accompany stratification. From a practical standpoint, to meet the high standard for zone designation, a potential zones should occur in a predictable spatial pattern plus be large enough to be occupy a crop management-worthy area within a field (e.g. large enough for production-scale equipment). A zone may have a different crop carrying capacity; if so, then production and protection inputs should be gauged to match yield potential. If a field is divided into two or three management zones, the each zone should have an individualized scouting and plant monitoring program as if it were an individual field. In a minimalist approach, management replaces purchased inputs.

Classifying zones can be overly-complicated for many producers, especially when considering differential regimes for protection from pest insects. In the Midsouth, we suggest starting with a zone management structure that is simple, easily predicted, and consistent --setting irrigated and rainfed zones in center pivot irrigated fields (Teague et al 2013, 2014). Plants in the irrigated "circles" or plants in rainfed "corners" comprise the irrigated and rainfed zones (Figure 3). To implement site-specific insect control in these zones, we have proposed using long-established, decision guides for insecticide termination timing (Bourland et al 1992, Danforth and O'Leary 1998). In dry years, plants in rainfed corners will reach physiological cutout earlier than well-irrigated plants, and that maturity differential is the key to a ***zone termination*** tactic. Cutout is defined as the flowering date of last effective bolls-- the latest developing population of bolls that have a high probability of being retained until harvest and which have adequate size and fiber properties to contribute to economic yield (Oosterhuis et al. 1996). Since all other bolls that contribute to economic yield are older, then end-of-season boll protection can be based on susceptibility and tolerance of the last effective bolls. Dates of cutout for a field *or zones in a field* are determined by weekly plant monitoring of nodes above white flower (NAWF)). In the Midsouth, plants attain physiological cutout at NAWF=5 (Bourland et al 1992; Kerby et al. 2010). From that date, maturity of the last effective bolls is gauged using heat unit accumulations. For crop protection from damaging late season populations of tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), Extension recommendations suggest that the crop should be protected from damaging levels of plant bugs until the last effective bolls have accumulated 250 heat units (DD60s) (Studebaker 2014). For zone termination, if damaging levels of plant bugs appear in irrigated zones before the 250 end-point is reached, then they should receive protective sprays, but if plants in rainfed zones which are past the 250 end-point, no protective sprays would be recommended.

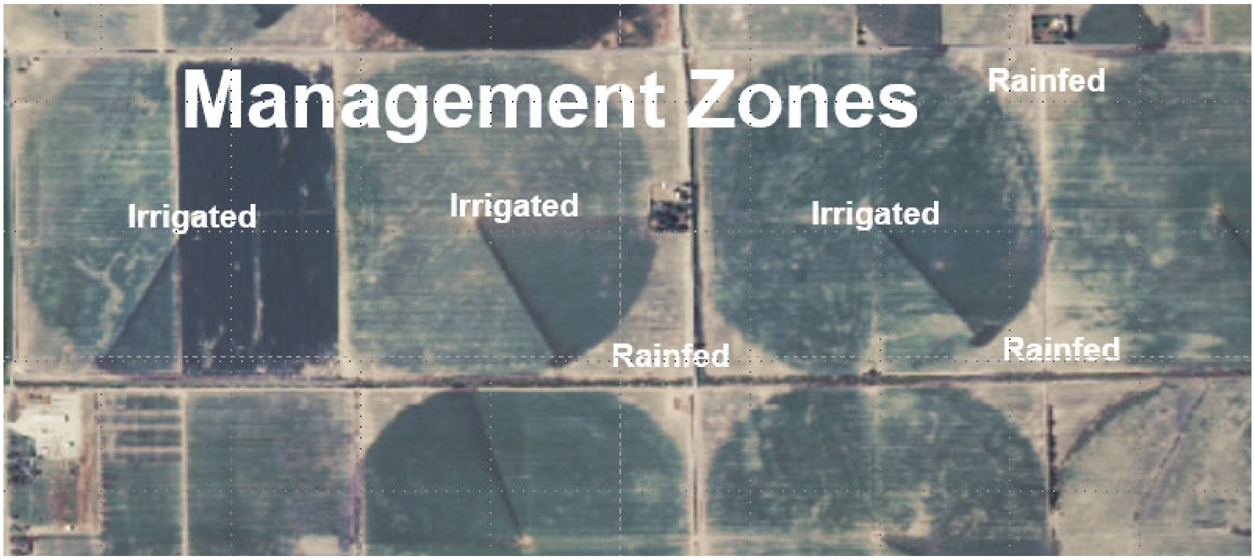

Figure 3. Irrigated and Rainfed Management Zones in center pivot fields are ***easy*** to set up. There are no fancy sensors required. They are zone-worthy because they in occur in predicable patterns, they encompass large areas (e.g. in a center pivot irrigated 150 acre field, 10 to 22 acres typically are rainfed), and, especially in dry years, there is a substantial difference in yield potential between the zones. In dry years, plants in the rainfed areas will reach the final stage of crop susceptibility weeks before irrigated plants, and so late season protection can be suspended earlier for those rainfed plants.

Field studies to validate the zone termination tactic were made over three growing seasons in a commercial field Northeast Arkansas. The on-farm study was a replicated strip trial with three insect control spray treatments (broadcast, zone, or untreated check) across two management zones (plants under center pivot irrigated "circles" or plants in rainfed "corners"). Strips were 28 rows wide across the length of the commercial field (1/2 mile). Weekly measures of NAWF were used to determine date of physiological cutout, and insect monitoring included weekly drop cloth sampling. Final, late-season insecticide applications in broadcast and zone treatments were timed to when last effective bolls had reached the final stage of crop susceptibility (NAWF=5 +250 DD60s). Over the three seasons studied, plants in rainfed zones reached cutout 4 to 21 days earlier than irrigated plants, depending on the year. Once plants in the rainfed zones reached the 250 endpoint, those plants received no further protective sprays. Yield data were acquired with yield monitors on the cooperating farmer's cotton pickers. No yield penalties were associated with following NAWF-based crop termination rules in management zones compared to conventional broadcast control. The results support adoption of a zone termination tactic for late season crop protection from plant bugs.

With zone termination, producers with auto-guidance technology can easily employ map-based applications of crop protectants to control damaging levels of insect pests only in field areas with plants still vulnerable to late season infestations. Adoption of the approach will allow producers to offset rising protection costs. In our validation trials, there was a 13% reduction in control costs for 1 to 2 late season insecticide applications. Zone termination also allows producers to reduce environmental impact of late season insecticide applications at the edge of the field. As with any site-specific application of insecticides, it is important that application rates be made at recommended, labeled rates, and sprayer controls be either ON or OFF with no below label, low-rate applications.

The zone termination approach is also adaptable to spatially variable fields with low yielding areas where plants historically have lower carrying capacity and earlier maturity (e.g. Figure 1). In such field areas, plants likely reach physiological cutout sooner than plants in more productive field areas. If the low yielding areas are zone-worthy (including size and predictability), then crop managers should stratify the field and scout the new zone as a separate unit. Scouting and plant monitoring should be used to document infestations and plant susceptibility, and when plants have reached their final stage of susceptibility (crop protection end-point), managers would terminate insect control. Plants in such low profit zones likely will have lower fertility requirements and require modified rates of harvest aid products, further reducing costs.

Planning for Implementation

Any zone management approach requires extensive off-season planning by crop managers to delineate and classify zones. Irrigation zones in center pivot fields are obvious, but implementation of a termination zone management tactic is a simple in-season step only if zones have been defined and prescriptions are prepared before the time-critical cropping season begins. For other production systems, information from yield maps, soil EC maps, and aerial imagery are all important tools for setting zones, but typically the most important input is the direct experience of the producer and crop advisors to validate the management worthiness of establishing the zone. Regardless of zone classification techniques, planning in the off-season is critical. It is especially important for decisions on insect control, because off-season planning allows producers to avoid or reduce decision fatigue and loss aversion behaviors that tend to prompt in-season over spending for crop protection.

With increased adoption of spatial technology and site-specific management, crop protection decision-making in cotton will become increasingly complex. Economic and environmentally sound chemical control decisions should be made with an understanding of pest insect and plant interrelationships plus an appreciation for risk management. Progress toward sustainability of cotton production systems will require an advanced ecological approach to pest management. If producers wish to expand their current pest management programs and reduce their reliance on **costly** foliar insecticide sprays for crop protection, then they should recruit and appropriately compensate dedicated and well-trained, professional crop advisors, who are willing to implement site-specific IPM programs.

Acknowledgements

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References

Bourland, F.M., D.M. Oosterhuis, and N.P. Tugwell. 1992. Concept for monitoring the growth and development of cotton plants using the main-stem node counts. J. Prod. Agric. 5:532-538.

Danforth, D.M. and P.F. O'Leary (Eds.) 1998. COTMAN Expert System 5.0. User's Manual. Univ. of Arkansas Agricultural Experiment Station, Fayetteville, AR.

Hearn, A.B. and G.D. da Roza. 1985. A simple model for crop management applications for cotton (*Gossypium hirsutum* L.). Field Crops Res., 12: 49-69.

Kerby, T. A., F. M. Bourland, and K. D. Hake. 2010. Physiological rationales in plant monitoring and mapping. Pp. 304-317. *In*: J. MacD Stewart, D. M. Oosterhuis, J. J. Heitholt, and J. R. Mauney (Eds.). Physiology of Cotton. Springer, New York.

Luttrell, R.L., T.G. Teague, M.J. Brewer. 2015. Cotton insect pest management. *In:* D. Fang (Ed.), Cotton. (Agronomy Monograph no. 24, 2nd edition). American Society of Agronomy, Inc., Crop Science Society of America, Inc., Soil Science Society of America, Inc., Publishers, Madison, WI, USA.

Oosterhuis D.M. and F.M. Bourland. (Eds.), 2008. COTMAN Crop Management System, University of Arkansas Agricultural Experiment Station, Fayetteville, AR. pp. 107. http://www.cotman.org

Studebaker, G. 2014. 2014 Insecticide Recommendations for Arkansas. MP144, Arkansas Cooperative Extension Service, 300 pp.

Teague, T.G. and D.K. Morris 2015. Zone management of tarnished plant bug (*Lygus lineolaris*) in cotton: Site-specific termination timing for insecticidal control. pp. 149-154 *In:* Derrick M. Oosterhuis (Ed.), Summaries of Arkansas Cotton Research 2014, Arkansas Agricultural Experiment Station Research Series 625.

Teague, T.G., E.J. Kelly, D.M. Danforth, and David Wildy. 2014. Insect control termination decisions across irrigated and rainfed management zones in center pivot irrigated cotton. pp. 741-753 *In:* S. Boyd, M. Huffman, B. Robertson (Eds.), Proc. of the 2014 Beltwide Cotton Conferences, National Cotton Council, Memphis, TN.