Is Zero Tolerance an Optimal Weed Management Strategy? The Economic Threshold Revisited

Terry W. Griffin, Ph.D.

Spaceplowboy@gmail.com

501.249.6360

Selected Paper prepared for presentation at the Southern Agricultural Economics Association's 2015 Annual Meeting, Atlanta, Georgia, January 31-February 3, 2015

Is Zero Tolerance an Optimal Weed Management Strategy? The Economic Threshold Revisited

Abstract

Economic thresholds (ET) were originally developed and applied to insect management during the 1970s. Traditional ET methodologies have sporadic success in weed management scenarios and are not globally appropriate for weed management especially in presence of herbicide resistant species. Historically, the economic threshold equation has been static and myopic, ignoring any multiple-period impact or the soil seed bank. The evolution of herbicide resistant weed species has prompted scientists to reconsider economic thresholds for weed management; and intuitively have chosen zero-tolerance for potentially herbicide-resistant weed species. The weed science and economics literature addressing resistant weed management supports zero-tolerance, especially when dynamic optimization techniques were applied to the problem. Although dynamic programming techniques do not equate to zero-tolerance recommendations, single-period static cost-benefit analyses tend to support non-zero economic thresholds in scenarios where zero-tolerance was the optimum strategy. The objectives were to revisit ET models suitable for accurately modeling weed control strategies with herbicide resistant species. Preliminary results suggest the multiple-season dynamic framework is the best management practice for weed management.

Keywords: economic threshold, herbicide, resistance, weed, zero tolerance

Introduction and Background

Economic threshold levels have been evaluated since the 1960's. J.C. Headley has been created for developing economic thresholds as applied to entomological pest control. Hall and Norgaard (1973) offered criticism and improvement over Headley's economic threshold. The majority of economic threshold literature focused on entomological pests until the late 1970s when models were first applied to weed control (Harris et al., 1979; Templeton et al., 1979). Even in the earliest years of economic thresholds being applied to weed control strategies, the single time period static models were noted for not being considered as they were useful as for insect control.

Given the ineffectiveness of static models to weed control strategies, multiple time period dynamic models were introduced to both the agricultural economics literature and the weed science literature. Most of these advanced weed control models utilized Hamiltonian equations. Dynamic programming models and zero-tolerance concept usually used for invasive or resistant species. Baxter et al. (YEAR) state "most of the state space nevertheless recommends complete removal of emergent plants" (page 2223), i.e. zero tolerance. They go on to say that "complete eradication is often an unrealistic target and the question becomes one of how much control is enough" (page 2223). As expected, expected crop yields were maximized when dynamic rather than static models were utilized for agricultural weed control (Jones et al., 2006; Baxter et al., YEAR). Early ET models were criticized for several reasons. More recently static ET models have been criticized for inflexibility by entomologists and economists (Harper et al., 1994). The traditional ET model credited to J.C. Headley has received criticism since its inception although remains as the status quo in entomological, pathology, and weed science strategies. The literature discusses in late 1980s to mid 1990s addresses DP superiority over static ET models. Even by the early 1980s multiple period dynamic models were proposed (Hall and Moffitt, 1985) to improve upon single time period models. The concepts of ET evolved into zero-tolerance as the result of price ratios and herbicide resistance or invasive species introduction. Unlike insect pests, weed escapes not only impact current year profitability but long-term land values. Hall and Moffitt (1985) show that inter-seasonal model dominates simpler single period models although improvements may not offset computational requirements.

The economics and weed science literature (Jones and Meed, 2000) explicitly state that the static approach to weed control is not sufficient. Although Jones and Meed (2000) stated goal is to deplete soil seed bank in most economic manner, their process does not always reduce to a zero-tolerance strategy. Jones and Meed (2000) report that a "paradigm shift from thresholds to longer term population management is warranted" (page 337) however their models never reported a zero-tolerance strategy. Jones and Meed (2000) point out that one criticism of ET is the bias toward a single herbicide; a scenario that has been blamed in part on resistance.

References

Baxter, P.W.J., C. Wilcox, M.A. McCarthy, and H.P. Possingham. 2007. Optimal Management of an Annual Weed: A Stochastic Dynamic Programming Approach. MODSIM 2007 International Congress on Modeling and Simulation. Modeling and Simulation Society of Australia and New Zealand.

Bor, Y.J. 1995. Optimal pest management and economic threshold. Agricultural Systems. Volume 49, Issue 2, 1995, Pages 113–133

Bor, Y.J. 2003. Uncertain Control of Dynamic Economic Threshold in Pest Management. Agricultural Systems. Volume 78, Issue 1, October 2003, Pages 105–118

Bor, Y.J., 1997. Some evidence for the existence of dynamic economic thresholds. Agricultural Systems. Volume 53, Issues 2–3, February–March 1997, Pages 143–160

Hall, D.C., and Horgaard, R.B. 1973. On the Timing and Application of Pesticides. Am. J. Agr. Econ. (1973) 55 (2):198-201.doi: 10.2307/1238437

Harris, P., and Cranston, R. 1979. An Economic Evaluation of Control Methods for Diffuse and Spotted Knapweed in Western Canada. *Canadian Journal of Plant Science*, 1979, 59(2): 375-382, 10.4141/cjps79-060

Headley, J.C. 1972. Economics of Agricultural Pest Control. Annual Review of Entomology. Vol. 17: 273-286 (Volume publication date January 1972).
DOI: 10.1146/annurev.en.17.010172.001421

Jones, R., and Cacho, O. 2000. A Dynamic Optimization Model of Weed Control. Working Paper Series in Agricultural and Resource Economics. ISSN 1442 1909. Paper presented to 44th Annual Conference of the Australian Agricultural and Resource Economics Society, Sydney, January 23-25, 2000 http://ageconsearch.umn.edu/bitstream/12902/1/wp000001.pdf

Jones, R.E. and Meed, R.W. 2000. Economic Thresholds and the Case for Longer Term Approaches to Population Management of Weeds. Weed Technology. 14: 337-350

Templeton, G.E., TeBeest, D.O., and Smith, Jr., R.J. 1979. Biological Weed Control with Mycoherbicides. Annual Review of Phytopathology. Vol. 17: 301-310 (Volume publication date September 1979). DOI: 10.1146/annurev.py.17.090179.001505

Talpaz, H. and Borosh, I. Strategy for Pesticide use: Frequency and Applications. American Journal of Agricultural Economics. 56: 769-775.