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EXAMINATION OF PRODUCTION AND COTMAN RECORDS ON A LARGE ARKANSAS FARM: A FOUNDATION FOR AREA-WIDE INSECT MANAGEMENT

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Abstract

A detailed database of cotton production inputs, insect management histories, and COTMAN records for Wildy Farms was organized in a spatial format to explore entire-farm or area-wide approaches to insect management. Refinement of the database required significant interaction with the farmer and agricultural consultant and active cooperation among several agricultural research disciplines. The process used to organize the database and structure application in an ArcView spatially descriptive format is described. A preliminary application of the database for analysis of 2002 insecticide use patterns is also presented. This data management system is intended as a prototype for expanded use in other area-wide or community management programs in Arkansas. Relevance to current information management and data mining technologies are briefly explored.

Introduction

Arkansas has a long history of innovate cotton insect management programs. Community-wide management systems conceived by J. R. Phillips and colleagues in the 1970s and 1980s (Cochran 1996, Henneberry and Phillips 1996, Phillips et al. 1980, Sterling et al. 1989) clearly founded the concept of entire farm or community cooperation in targeted insect management strategies. More recent advances in management capabilities, especially the ability to monitor crop stress through the COTMAN system (Danforth and O'Leary 1998) and availability of spatially descriptive information-management systems have created new opportunities to refine these entire farm or community management approaches.

Data mining and KDD (Knowledge Discovery in Databases) approaches to information collection are extremely popular concepts (see http://www.kdnuggets.com, http://www.the-data-mine.com, http://data-miners.com). Frawley et al. (1992) defined data mining as "the nontrivial extraction of implicit, previously unknown, and potentially useful information from data". This contemporary application of data management has academic foundations in descriptive statistics, expert systems, neural networks, artificial intelligence, data processing, and information management systems. Numerous business groups, including a wide range of agricultural firms, are actively marketing new management systems at the farm level. Concepts of precision farming and geographic information management are practical, relevant components of today's cotton production environment.

Our historical involvement with simulation models (Luttrell et al. 1998), expert systems (Bowden et al. 1990, Bowden et al. 1991, Luttrell et al. 1991, Danforth and O'Leary 1998), and the COTMAN management systems (Danforth and O'Leary 1998) influenced our interest in the data mining concept and its potential use in refined approaches to community management of insect pests. More important, however, was our long-standing cooperation with Wildy Farms and their elaborate historical records of cotton production and COTMAN information. Wildy Farms has one of the most elaborate crop management systems in Arkansas and the Midsouth. COTMAN and production records have been maintained in a structured database for more than seven years. This unique organization of quality production data, biologically registered with COTMAN stress indices, provided an unprecedented opportunity to examine real world insect management decisions via the data mining concept. The high-level of management and the emphasis on data collection at the farm also provide an important conceptual benchmark for comparisons to other systems. We hope that the prototype example of Wildy Farms will allow us to sophisticate and expand future management systems, especially our proposed community-wide management concepts at other locations in Arkansas.

Described in this preliminary report of first year activities are our data management approaches, a preliminary application of the data management system to exploratory study of insecticide use patterns, and a general assessment of our progress and future plans.

Methods

Organization of the Spatially Descriptive Database

The current database includes seven years of production records, insect scouting information, and COTMAN archives. Wildy Farms created the original database in a Q&A format. The Department of Agricultural Economics and Agribusiness of the University of Arkansas has been working to get these data organized in an Access form for several years. We started our study with these original data sources and worked closely with the farmer and consultant to fill in data gaps and test general accuracy of information in the existing files. Information collected during 2002 was immediately incorporated into the system as a prototype example of data management capabilities and efficiency of "real time" data processing.

Analysis of 2002 Insecticide Use Patterns on Wildy Farms

Insecticide spray histories for 107 different fields of Wildy Farms (Figure 1) were studied relative to proximity to boll weevil overwintering sites (Figure 2) and perceived quality of the overwintering sites. Each field was classified by an index of boll weevil hazard based on the product of the proximity index times the quality index (Figure 3). Fields with higher hazard index rating were fields closer to high quality overwintering sites. Fields with lower hazard index ratings were fields further from the high quality overwintering sites. Proximity was grouped from 0-3 based on ¼ mile distances from the identified overwintering sites (Figure 2). Habitat quality was a general rating of abundance of leaf litter, exposure and general ground cover. Higher quality habitats were those with an abundance of ground litter and hardwood vegetation.

Tillage practices on Wildy Farms are evolving. As with many locations across the Midsouth, reduced and minimum tillage practices are becoming more common. In 2002, Wildy Farms had tillage patterns ranging from conventional to no till. Ridge tillage was no till and a cover crop of wheat. The distribution of the different tillage practices across the farm (Figure 4) was captured in our spatial descriptions and used as an independent variable to study insecticide use patterns. Date of planting and crop physiological cutout (NAWF 5) were also obtained from the elaborate COTMAN records collected for each field on the farm and were used to explore relationships with insecticide use patterns.

Dependent variables included in the preliminary analyses were number of border sprays for boll weevil early in the season, total number of border and within season sprays for boll weevil, number of sprays for thrips, number of sprays for plant bugs, number of sprays for spider mites, number of sprays for bollworm, number of sprays for tobacco budworm, number of sprays for fall armyworm, total number of insecticide sprays and days to crop cutout as measured by COTMAN (NAWF 5). A descriptive analysis of the different independent variables was conducted with information spatially registered on detailed maps of Wildy Farms. Correlation analyses were conducted to measure relationships among the different independent and dependent variables.

Results

Organization of the Spatially Descriptive Database

All of the growers production and COTMAN data have been incorporated into our Access based system called COTBASE. With COTBASE we can accumulate and access crop monitoring data from previous years and use that information to help synthesize information for decision making in the future. Previous COTMAN information, actual yields, yield monitoring data, cost data, insect population numbers and many other production records can now be studied in a data mining atmosphere to identify major impacts on production efficiency and formulate new management strategies. We have proposed an exploratory "strategy" session with the farmer, the agricultural consultant, involved agricultural scientists, and Cotton Incorporated scientists later this year. Organization of this rich data set is generating many ideas about potential use of the information.

Analysis of 2002 Insecticide Use Patterns on Wildy Farms

Correlation coefficients (r) observed in the analyses of 2002 data are listed in Table 2. Interestingly, days to cutout (DTC) was not generally related to insecticide use patterns. A significant negative correlation was observed between DTC and tillage category (TIL). Tillage categories were 1 = conventional tillage, 2 = no tillage, and 3 = ridge tillage (no till plus cover crop). Date of planting (DOP) was negatively correlated with proximity to overwintering sites (DOS), habitat categories (HAB), number of border sprays (WEB), and total sprays (TOT). Later planted fields tended to receive more insecticide sprays (Figure 5, but the relationship was relatively weak and significant variability existed in the data. DOP was highly correlated with proximity to overwintering sites (POS), HAB, and WEB. Earlier planted fields tended to be those closer to preferred overwintering sites and those more likely to receive early season border sprays for boll weevil suppression. POS was highly correlated with IOS, HAB, quality of the overwintering site (QOS), and WEB. Similarly, HAB was highly correlated with QOS and IOS. HAB was also correlated with number of sprays for spider mites (SMI) and number of sprays for fall armyworm (FAW) suggesting a possible linkage between the border sprays for boll weevil and subsequent problems with these polyphagous pests.

Tillage (TIL) had a major influence on the spectrum of insecticide sprays (Figure 6), Lower tillage rankings (no tillage or minimum tillage practices) were associated with lower numbers of total insecticide sprays (TOT), especially those associated with boll weevil (WEB and WEE) and tobacco budworm (TBW). Conversely, more sprays for thrips (THP) were associated with fields with conventional tillage fields.

Total number of insecticide sprays (TOT) was associated with the number of sprays for all pest species except fall armyworm (FAW), which tended to be isolated cases associated with fields treated for plant bugs (TPB) and tobacco budworm (TBW). Sprays for boll weevils, especially the border sprays early in the year (WEB), tended to be the most influential sprays in terms of influence on total insecticide usage (Figure 7). Of the 107 fields managed in 2002, 40 received two early season border sprays and averaged 2.8 more sprays than the 67 fields not receiving early season border sprays.

Conclusions and Relevance to Expanded Community Management Programs

This compilation of production and COTMAN records for Wildy Farms and the initial use of 2002 data for studying insect use patterns represent a data mining application to real-world production agriculture. More efficient management of historical information will foster creative management approaches at the farm level. Our experiences with this project illustrate an "end of the season" analysis of production efficiency that will allow farm managers to develop site-specific management practices. A more refined system will eventually facilitate "real time" decision-making through rapid turn around of the collected data. Our progress would not have been possible without the open cooperation and support of David Wildy, the farmer, and Dale Wells, the agricultural consultant. Physically housing our data manager at the farm site and emphasizing the critical transfer of information from farm or crop manager to data manager was an extremely important element of this project

The meticulous compilation of historical information on Wildy Farms has been a long-term investment, one that will soon yield important management possibilities through the practical application of these data mining concepts and our evolving ability to describe spatial and temporal patterns in the data. Site-specific management strategies will increasingly depend upon site-specific historical data and evolving spatial descriptive capabilities. Our rather simplistic example of the application of these management systems clearly illustrates a potential for "higher level" management systems rich in spatial and temporal records.

We are pleased with our ability to generate a practical, usable system, and we intend to continue to build community management systems around the concept of detailed field management. As precision agriculture becomes more refined and manageable, our prototype system designed around field-level resolution should be adaptable to within field units. Our preliminary use of the data base clearly indicates that economic efficiencies can still be obtained at the field and farm level of resolutions…in fact strategic allocation of resources to target weak links in the seasonal histories and host selection processes of polyphagous insects seems to be a useful benefit of these management systems.

In 2003, we hope to more fully examine the seven-year data set with a detailed analysis of COTMAN information and distribution of crop stresses across years as associated with the various spatial environments of the farm. We also intend to develop initial maps for two or three additional study sites in Arkansas. Eventually, we intend to use the data mining concept to postulate and study innovate insect management approaches not limited by individual field borders or traditional treat as needed philosophies. The cooperation of highly organized, data-rich management units, like Wildy Farms, is the critical component of this research.

Acknowledgements

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Table 1. Independent and dependent variables included in 2002 data analyses of insecticide use patterns.

DTC – days to crop cutout
DOP – date of planting
POS – proximity to overwintering sites (0-4 based on ¼ mile intervals)
QOS – quality of overwintering sites (categories of 1-3 based on perceived ground cover)
IOS – index scale of overwintering sites (product of POS and QOS)
HAB – habitat scale of overwintering sites (Mandy list scale)
TRP – number of sprays for thrips
SDM – number of sprays for spider mites
WEB – number of early season border sprays for boll weevil
WEE – total number of sprays for weevils including border and within season sprays
TPB – number of sprays for plant bugs (tarnished plant bugs and cotton fleahoppers)
SDM – number of sprays for spider mites
BLW – number of sprays for bollworm
FAW – number of sprays for fall armyworm
TBW – number of sprays for tobacco budworm
TOT – total number of foliar sprays

Table 2. Correlation coefficients (r) observed in analyses of relationships between dependent and independent variables in 2002 data.

	DTC	DOP	POS	QOS	IOS
DTC	1.000				
DOP	-.117	1.000			
POS	.012	-.374***	1.000		
QOS	-.056	-.072	.477***	1.000	
IOS	-.094	-.130	.689***	.818***	1.000
TIL	-.203*	.038	.059	.226*	.107
HAB	.003	-.368***	.933***	.513***	.643***
THP	.176	-.100	.132	-.109	-.109
WEB	.055	-.281**	.233*	.032	.188
WEE	-.018	-.099	.045	.173	.298**
TPB	-.068	-.132	.000	-.114	-.112
SDM	.082	.059	-.147	-.254**	-.189
BLW	-.029	-.023	-.013	.129	.126
FAW	.098	-.042	-.139	-.192*	-.158
TBW	.087	.036	-.034	-.122	-.069
TOT	.069	-.245*	.120	.013	.178

	TIL	HAB	THP	WEB	WEE
TIL	1.000				
HAB	.104	1.000			
THP	-.433***	.074	1.000		
WEB	-.294*	.206*	.124	1.000	
WEE	-.227*	.020	-.134	.318***	1.000
TPB	.005	-.035	.098	.051	.020
SDM	-.189	-.146	-.032	.299**	.032
BLW	.084	-.054	.016	-.109	-.292**
FAW	-.058	-.138	.000	.013	-.071
TBW	-.243**	-.031	.114	.013	-.124
TOT	-.412**	.053	.278**	.692***	.477***

	TPB	SDM	BLW	FAW	TBW
TPB	1.000				
SDM	.163	1.000			
BLW	-.171	-.135	1.000		
FAW	-.217*	-.064	.195*	1.000	
TBW	-.204*	-.027	.573***	.380***	1.000
TOT	.222*	.267***	.315***	.183	.434***

Significant correlations * P=0.05, ** P=0.01, *** P=0.001 (n=107).

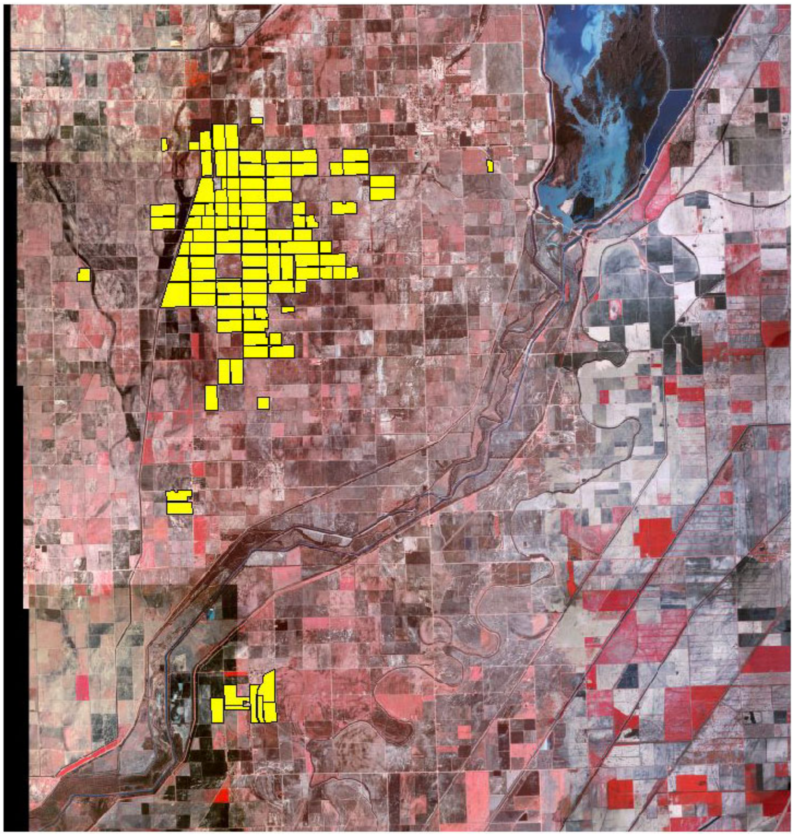

Figure 1. Boundaries of Wildy Farms and individual production fields.

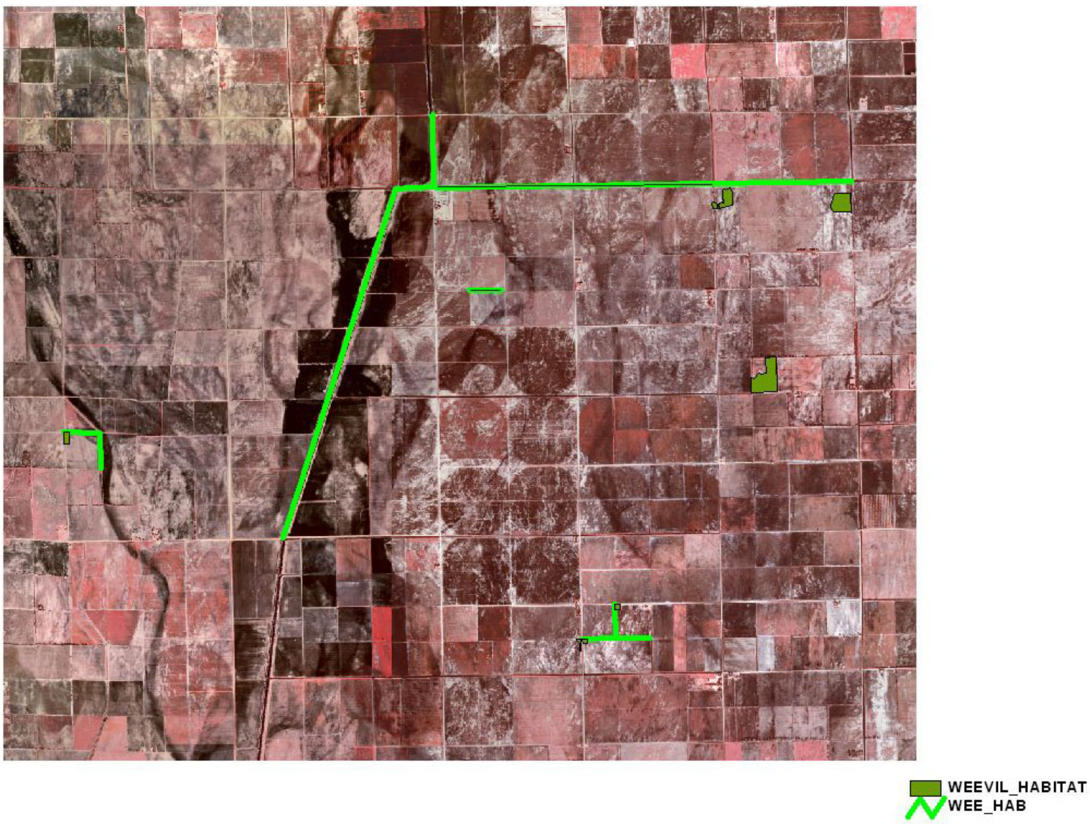

Figure 2. Major overwintering sites for boll weevil on Wildy Farms.

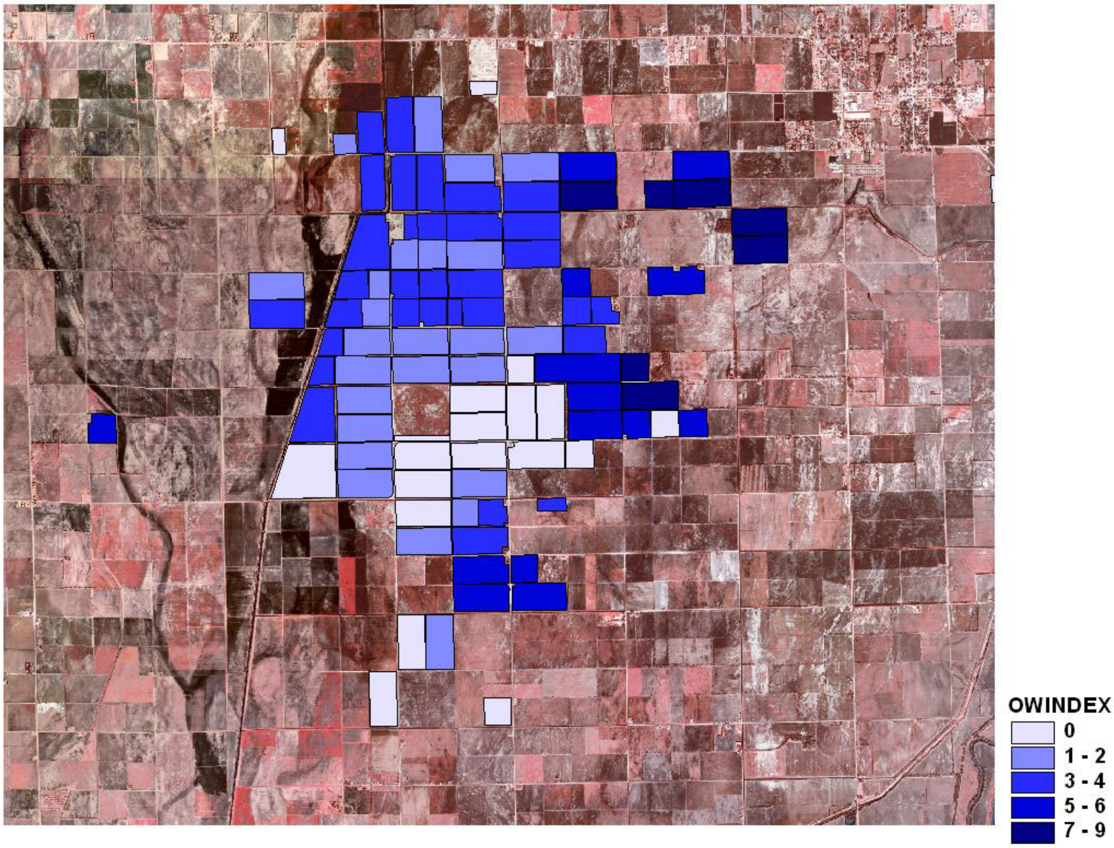

Figure 3. Classification of production fields relative to proximity and quality of boll weevil overwintering sites (index of 0-9 was a product of relative proximity to overwintering and relative quality of the defined habitat).

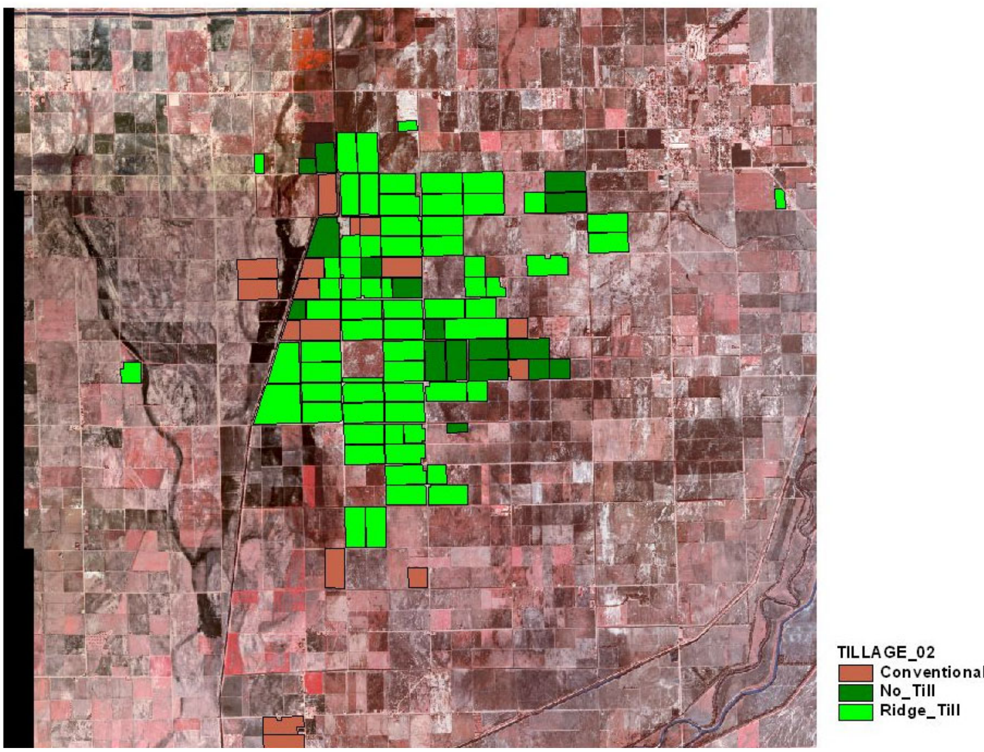

Figure 4. Tillage practices used on Wildy Farms during 2002.

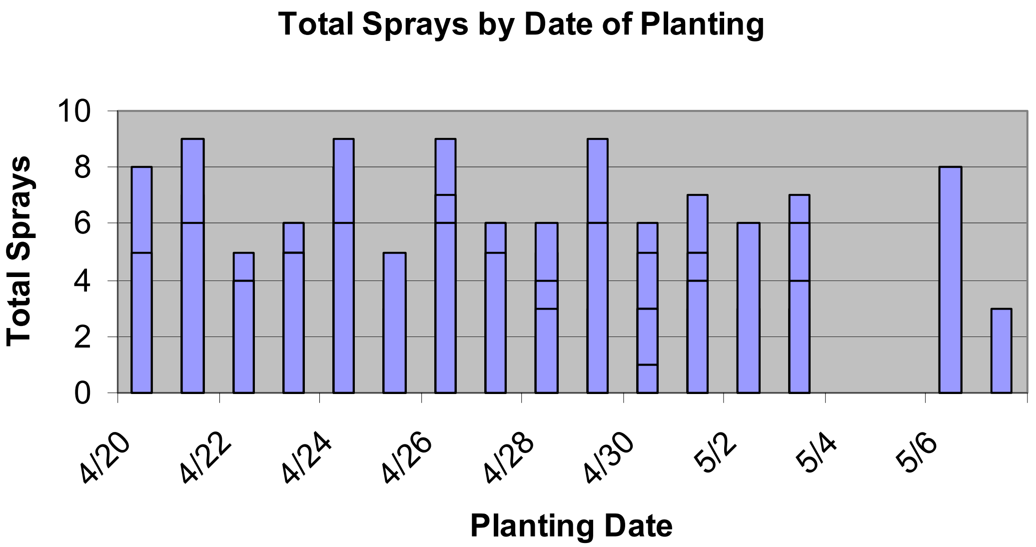

Figure 5. Total number of insecticide sprays as influenced by date of planting.

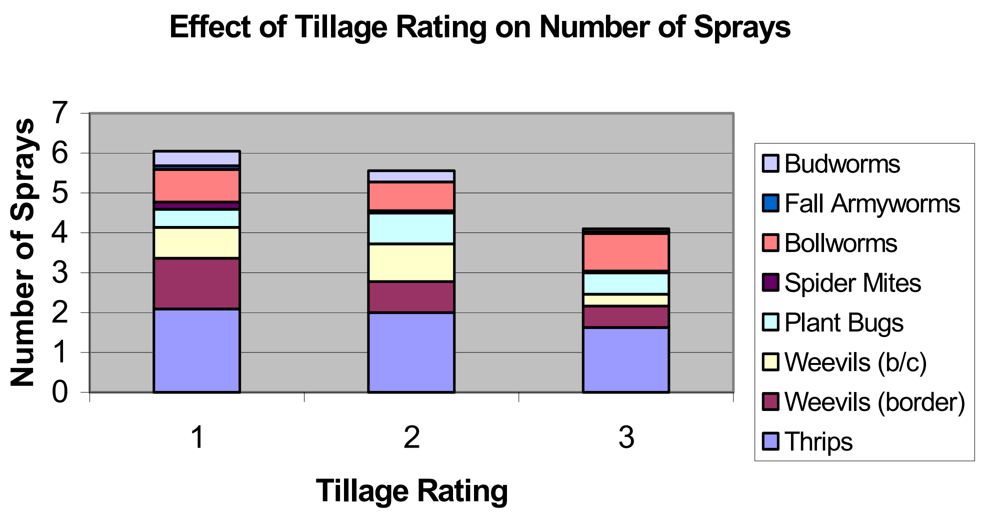

Figure 6. Influence of tillage system on number of insecticide sprays.

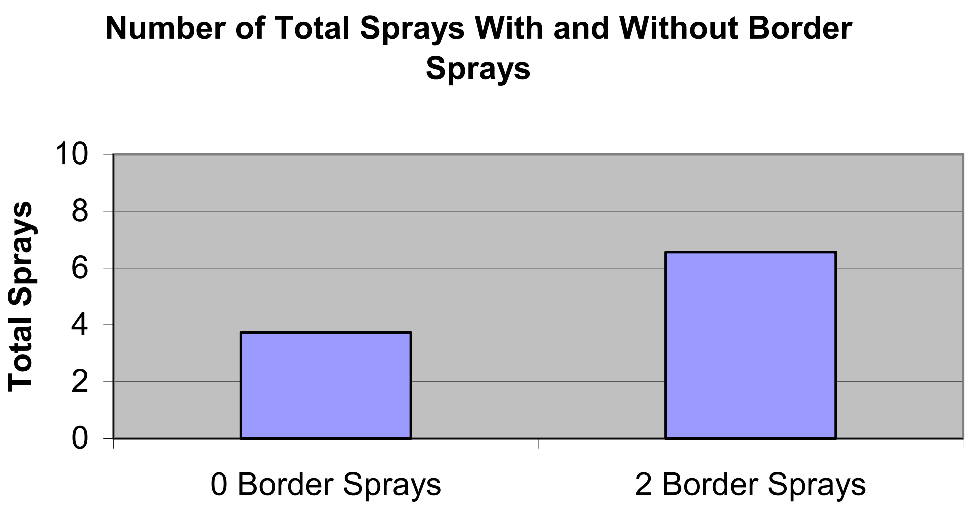

Figure 7. Influence of number of border sprays (0 or 2) on total number of sprays.