IMPACT OF SOYBEAN CONSERVATION SYSTEMS ON BOBWHITE QUAIL HABITAT AND MORTALITY

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ABSTRACT

Conservation-tillage systems on the Southeastern Coastal Plain now utilize practices such as minimum surface tillage, narrow row widths, and planting of herbicide-tolerant varieties. These systems can result in many economical, environmental, and ecological benefits, including providing a more suitable habitat for wildlife such as the northern bobwhite quail (*Colinus virginianus*). Our research objectives were to assess the possible ecological impacts of both an innovative soybean (*Glycine max* L. Merr) tillage system (no-till) and traditional soybean system (tilled) on quail habitat and preference. Variables measured were insect abundance, canopy closure and pen-raised quail habitat use. No-till soybean fields were found to have the greatest abundance of orthopteran (crickets/grasshoppers), arachnid (spiders), and coleopteran/hemipteran (centipedes/beetles) insects. Insect numbers were higher in the no-till system than in the tilled system, field borders, and forested areas. The tilled system generally had the second highest number of insects, followed by field borders and forested areas. Canopy closure as estimated by light transmittance through the canopy, was faster and more complete in the no-till system than the tilled system due to the narrower row width used with the no-till system. Pen-raised quail were found more frequently in the no-till system than the tilled system a majority of the time. Greater quail use of the tilled system only occurred at one field. Field borders and forested areas were used less than either tillage systems. Averaged over treatments and release days, the greatest cause of mortality was due to mammals. These results indicate that no-till systems are more beneficial to quail than traditional systems in terms of habitat quality.

INTRODUCTION

Methods used by farmers to produce agronomic crops have changed dramatically in recent years. Practices such as conservation tillage, use of narrow row widths, and herbicide-tolerant varieties enhance yields, as well as provide environment benefits. Planting using narrow row widths and the use of glyphosate-tolerant varieties can be a tremendous aid for controlling weeds in no-till systems where cultivation is not feasible. The ease of weed control and the potential environmental benefits from using glyphosate-tolerant varieties has resulted in a majority of South Carolina's soybean acres being planted in these varieties. Because of the increased popularity, more information is needed about the benefits or problems that can occur when these practices are used collectively as one integrated soybean production system, especially with respect to impact on non-targeted species. For example, no-till systems utilizing narrow row widths and herbicide-tolerant varieties may influence the number and type of insects in a field due to the presence of plant residues, the rapid canopy closure that occurs with narrow row widths, and differences in weed species (compared to traditional tillage). These changes, in return, can affect quail which feed upon these insects. Information on the positive aspects of new technologies is needed due to the negative publicity these advances have received in recent years.

Quail numbers in South Carolina have declined in recent decades. Current estimates put the decline at about 4.5% per year in the Southeast (Sauer et al., 2001). This reduction has partially been attributed to the use of "clean farming practices" and the application of ecologically unfriendly pesticides. Leaving residues on the soil surface should enhance the number and diversity of soil insects and, with the addition of narrow row spacing, provide a better habitat in terms of protection from predators. The switch to Roundup-Ready® programs should be less detrimental to wildlife with respect to toxicology and nest disturbance, compared to traditional systems. Therefore, the use of newer, integrated pest management practices aimed at weed control in soybean should improve the habitat of quail, a non-targeted species. More wildlife-friendly cropping systems are needed on the Coastal Plain because of the dramatic rise in ecotourism industries in the region in recent years. In many cases, leasing of land for hunting purposes provides more income to farmers than can be obtained from crop production. In this study, we plan to test an innovative soybean conservation tillage system that utilizes narrow row widths and Roundup Ready® technologies to determine its impact on quail habitat ecology and habitat preference.

MATERIALS AND METHODS

Treatment Arrangement:

This project was conducted at the Pee Dee Research and Education Center in Florence, South Carolina during the 2001/2002 and 2002/2003 growing seasons. Seven fields (minimum of 12 acres each) were selected that were at least 500 yards apart, contained similar soil types and had consistent surrounding habitat. The number of fields used was dependent upon the variable measured. Each field was split in half, with one half planted using conservation tillage and the other using traditional surface tillage for doublecropped wheat and soybean. On the traditional side of the field, the soil was disked twice prior to planting each crop and the soybean was planted using 30-inch row widths and a conventional variety. On the conservation tillage side of the field, Roundup Ready® soybean was planted no-till using 7.5 inch row widths. Herbicides were applied based upon field-scouting results and Clemson University Extension Service recommendations. Fertilizer was applied at rates based upon soil test results. Details on the equipment and specific agronomic practices used have previously been described (Frederick, et al., 1998; Busscher et al., 2001).

Movement Patterns/Habitat-Use:

Flight-conditioned, pen-raised bobwhites were purchased which were certified and disease free. Upon arrival, quail were fitted with a 4-g, necklace-style radio transmitter, each quail having a unique tracking frequency. The first quail release was conducted on 23 July 2003, the second on 5 August 2003, and the third on 19 August 2003. Three female and three male quail were released on each side of the field at each site. All quail were tracked using homing techniques discussed by White and Garrott (1993) where the observers used a "dialing down" procedure to approach birds within 30 ft. Tracking equipment included a 3-element yagi antenna and ATS receiver. Daily locations were classified as being within four prominent habitat groups: no-till crop production system, tilled crop production system, field borders and woods (forested areas).

Food Supply (Insects):

Tillage systems may also impact quail food supply in direct or indirect ways such as altering insect species diversity, and/or causing population shifts or fluctuations of insects during the growing season. To test how these tillage systems affect insect prey of quail, insects were sampled within four main types of habitat over the breeding season: conservation tillage, traditional tillage, the strip-disked buffer zone and the forested area. Two pitfall insect traps were randomly placed within each of the four habitats and collected weekly for insect identification to genus or lowest level possible.

Cover and Edge Management:
Canopy closure was estimated by canopy light interception measured using a LiCor light rod. Measurements were taken at 12:00 noon approximately every 10 days. Data was used and compared temporally to movement and mortality rates of all radio-tagged quail.

Predation Indices:
All radio-tagged transmitters were equipped with a mortality signal that could be identified by simply scanning with the radio receiver. The mortality signal was activated when movement ceased for a continuous 12 h period. Quail were located and post-mortem inspections were used to record the type of mortality. If killed by a predator, the kill was classified as either avian, mammalian, reptile, or unknown. Data were analyzed to determine cause of mortality for each treatment.

RESULTS AND DISCUSSION

The orders Orthoptera (crickets and grasshoppers), Arachnida (spiders), and Coleoptera/Hemiptera (centipedes and beetles) were the most common insects found in this study (Fig. 1 and Table 1). Previous research has shown that 84% of a quail chick's diet is comprised of macroinvertebrates including beetles, grasshoppers, crickets, caterpillars, and moths (Jackson et al. 1987; Handley, 1931). Palmer (1995), using human-imprinted, pen-raised birds as surrogate wild chicks, reported that Orthoptera, Coleoptera, Heteroptera, Arachnida, and Lepidoptera were the most commonly ingested insects by quail. In our studies, insect numbers were usually highest in the no-till system, followed by the tilled system, field borders, and forested areas (Fig. 1). These results indicate that the supply of important food insects for quail should be greatest in no-till systems.

The amount of canopy provided by a crop has been reported to be very important for determining bobwhite habitat use (Puckett et al., 1995; Palmer, 1995). Ideal brood habitat usually includes at least 50% overhead cover for protection from predators (DeVos and Muellar, 1993). Use of crop fields for nesting and brooding purposes generally increases during the growing season as the crop develops, with at least 60% canopy closure needed for sufficient brooding to occur (Palmer, 1995). In our study, canopy closure, as estimated by light interception (Fig. 2), was much more rapid and complete for the no-till system which included the use of narrow row widths (7.5 inch). Canopy development in the tilled system which used a 30-inch row width was later to occur than in the no-till system and 60% light interception was not achieved in either year.

When comparing habitat use (Fig. 3, Table 2), quail were found in the no-till system an average of 56% of the time, followed by the tilled fields (26%), field borders (2%), and forested areas (16%). Results from release date I were not used in the analysis since soybean crop development was minimal at that time. For release dates II and III, only in one field were quail numbers significantly higher with the tilled system than with the no-till system. Percent mortality was also less with the no-till system (data not shown). Across release dates and sites, mortality was greatest due to mammalian predators (average of 55%), followed by avian (26%), reptilian (1%), and other (18%) predators (Table 3).

CONCLUSIONS

The no-till system had a greater number of insects than the tilled system. The types of insects found were those reported to be important to the diet of quail, especially baby chicks and brooding females. Assuming that insect availability is the same for both no-till and tilled systems, our data would suggest that no-till systems would be a more suitable habitat for insect foraging by quail. In addition, the more rapid and complete canopy closure provided by the narrow row width used in the no-till system should provide more protection from predators. These beneficial aspects in terms of quail habitat for the no-till system would explain the greater quail preference we found for the no-till system.

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Table 1. Insect abundance for different orders of insects as a function of habitat type. Numbers shown are averages across sampling dates and years

Grouping (Order or Class)a	No-Till	Till	Field Border	Forested Area
Orthoptera	40.70	18.98	27.10	9.15
Arachnida	2.90	1.46	0.84	1.05
Coleóptera/ Hemiptera	32.20	23.46	12.45	6.42
Hymenóptera	37.49	15.30	23.04	7.15
Blattaria	0.09	0.10	1.63	1.67
Isopoda	0.09	0.17	5.69	5.30
Chilópoda/Diplopoda	0.41	1.59	4.93	6.63
Diptera	0.72	0.70	0.59	0.26
Dermaptera	0.06	0.08	0.31	0.40

a All groups are orders except for Chilopoda/Diplopoda, which represents class.
b Orders were combined for analysis
c Classes were combined for analysis

Table 2. Habitat use by pen-raised quail during the summer of 2003 by field/release date as a function of release date and habitat type.

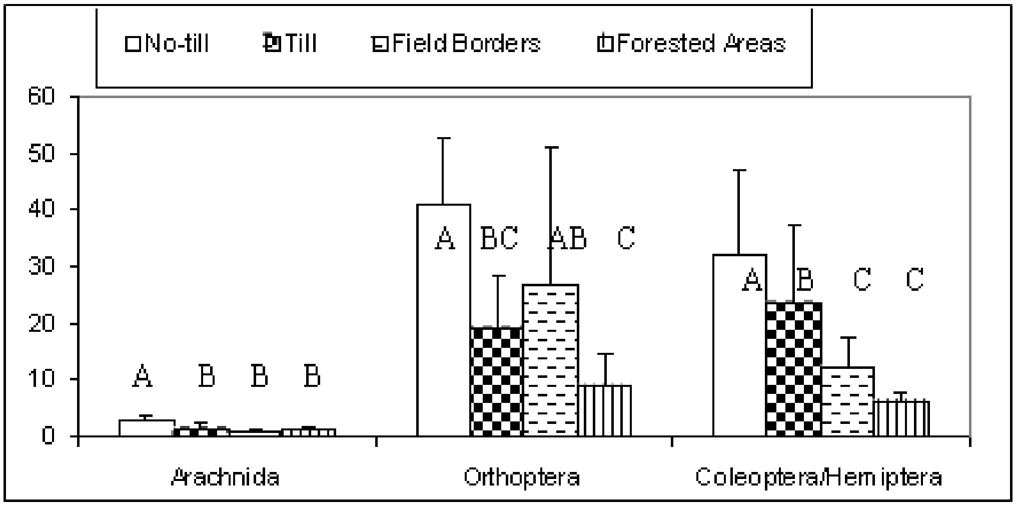
Release Site	Release Date	No-Till	Till	Field Border a	Forested Area
Field A	2	52%	35%	10%	3%
Field B	2	57%	27%	2%	14%
Field C	2	46%	37%	-	17%
Field D	2	62%	23%	0%	15%
Field G	2	84%	0%	-	16%
Field A	3	65%	18%	1%	16%
Field B	3	28%	37%	2%	33%
Field E	3	27%	50%	2%	21%
Field F	3	75%	18%	-	7%
Field H	3	64%	18%	-	18%
Average Use		56%	26%	2%	16%

A dash indicates that habitat type was not available within or surrounding treatment field.

Table 3. Cause-specific mortality for pen-raised quail released on three different dates in 2003.

Mortality Agent	**Release Date I 7/22/03**	**Release Date II 8/5/03**	**Release Date III 8/19/03**	**TOTAL**
Mammalian	46 (56%)	28 (42%)	35 (66%)	109 (54%)
Avian	18 (22%)	19 (28%)	16 (30%)	53 (26%)
Reptilian	1 (1%)	1 (2%)	0	2 (1%)
Other	17 (21%)	19 (28%)	2 (4%)	38 (18%)
* Dog	3 (4%)	4 (6%)	0	7 (3%)
* Stress	6 (7%)	4 (6%)	0	10 (5%)
* Unknown	8 (10%)	11 (16%)	2 (4%)	21 (10%)
TOTAL	82	67	53	202
Mammalian vs. Avian (P<0.0001) and Reptilian (P<0.0001)				
Avian vs. Reptilian (P<0.0001)				
Puckett et al. (1995) found higher predation rate for avian than mammalian species				
Groton Plantation Study: pen-raised quail mortality was due to 70% avian, 24% mammalian and 6% other				

Figure 1. Insect abundance in each of the four habitats examined.
Data shown are averages over sampling dates and years



Habitat Type (Soybean Fields Only)	Arachnida	LSD	Orthoptera	LSD	Coleoptera/ Hemiptera	LSD
No-till	2.90	A	40.70	A	32.21	A
Till	1.47	B	18.99	BC	23.46	B
Field Borders	0.84	B	27.10	AB	12.45	C
Forested Areas	1.05	B	9.15	C	6.42	C

LSD: Fischer's Least Squared Differences (0.05 significance level).
Orders Coleoptera / Hemiptera were combined.

Figure 2. Estimated canopy closure during the 2002 (Year 1) and 2003 (Year 2) growing seasons for the tilled and no-till systems.

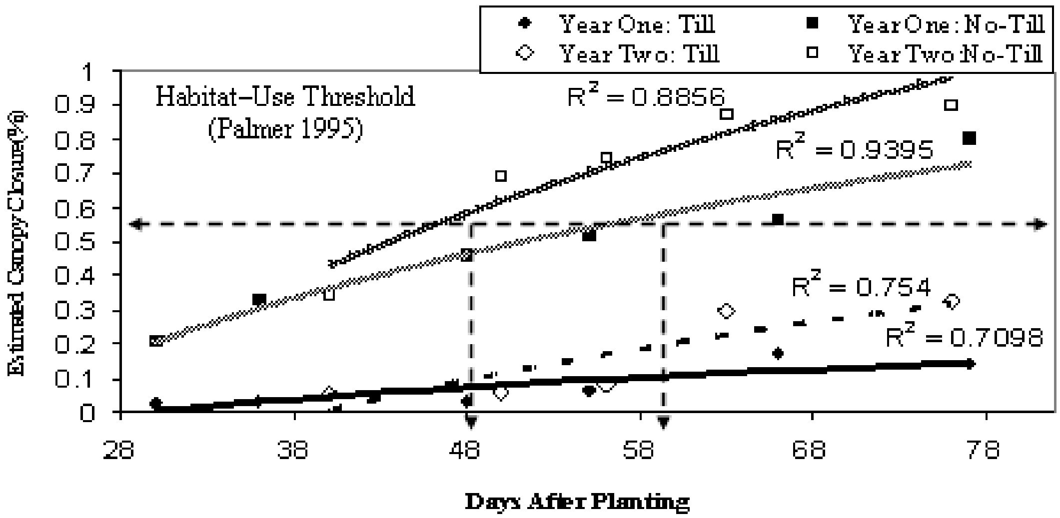


Figure 3. Habitat use of pen-raised quail for the second and third release dates in 2003. Habitats were no-till system (NT), tilled system (Till), field borders (FB) and forested areas (FA)