# Spring- and Fall-Tillage System Effects on Hessian Fly (Diptera: Cecidomyiidae) Emergence from a Coastal Plain Soil[1,2]

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**ABSTRACT** Fall emergence of Hessian fly, (HF) *Mayetiola destructor* (Say), was measured from wheat stubble subjected to combinations of spring burning and tillage, and fall tillage in the South Carolina Coastal Plain. In a split-plot experiment, the main-plot effect was a spring treatment, consisting of either: no-tillage, burning, disking, burning and disking or bottom-plowing. The subplot effect was fall tillage (either disking or no-tillage). Among the spring treatments, burning alone gave no reduction in HF emergence. Spring disking reduced HF emergence 54%. Spring burning plus disking reduced emergence 70-96%. No emergence was detected from the bottom-plowed treatments. Fall disking reduced emergence 48-50% in plots that had no spring tillage. Plots disked in both the fall and spring had the same level of HF emergence as plots disked only in the spring or only in the fall. Fall disking greatly increased emergence (up to 23X) from plots where HF had been effectively buried in the spring (previously burned and disked). The disk harrow is the primary tillage implement in the southeastern Coastal Plain, and disking wheat stubble substantially reduced HF emergence. However, repetitive disking can be of limited value or detrimental, in reducing HF emergence from some Coastal Plain soils, in that previously buried puparia might be returned to the soil surface. There was no apparent effect of tillage on emergence timing.

**KEY WORDS** burn, disk, wheat, *Mayetiola destructor, Triticum aestivum,* tillage system.

The Hessian fly, (HF) *Mayetiola destructor* (Say), is the major economic insect pest of wheat, *Triticum aestivum* L., in the southeastern United States (Johnson et al. 1984, Chapin et al. 1989). Cultural control through burial of wheat stubble harboring the oversummering puparia, has been a standard recommended management practice for this pest (Headlee & Parker 1913, McColloch 1923, Chapin & Sullivan 1989). Stubble burning alone is regarded as ineffective because many puparia are located below the soil surface (Headlee & Parker 1913, McColloch 1923). In the Southeast, wheat is typically double-cropped with soybean and rotated with other row crops such as corn and cotton. This cropping system typically includes burning and tillage treatment combinations during the spring and fall, that affect fall emergence of HF. The objective of this study was to measure the effects of these spring and fall tillage systems on HF emergence from a southeastern Coastal Plains soil.

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## Materials and Methods

**1990.** The study was conducted on a Clarendon loamy sand (Plinthaquic Paleudult) at the Edisto Research and Education Center in Barnwell County, SC. The experimental design was a split-plot randomized complete block with four replicates. The whole-plot effects were four spring-tillage treatments of wheat stubble: no-till, burned, disked, and burned and disked. The subplot effects were two fall tillage treatments of soybean stubble: no-till and disked. The main plot experimental unit was 30 × 17 m. Subplots were 30 × 8.5 m. Spring tillage treatments were applied to 'Coker 983' wheat planted with a 10-cm row spacing on 26 October 1989 and harvested with a commercial combine (New Holland TR-70) on 30 May 1990. Wheat was grown with standard management practices, except that no insecticide was used on this HF-susceptible variety. Spring tillage treatments were applied to the wheat stubble on 31 May 1990. Burning conditions were excellent, resulting in rapid combustion of all straw above the soil surface. Burned plots were contained by disked borders ca. 4.5 m wide. Disk treatments were applied to appropriate plots immediately after burning. Plots were disked to a depth of ca. 12 cm using a tandem disk harrow with 56-cm diameter disks and a 4.7-m cutting width. On 13 June "Bragg' soybean was planted in all plots with a United Farm Tools Model 5000 no-till drill using a 60-cm row spacing. On 7 September, soybean plants were hand-scythed and removed from an area large enough to accommodate each emergence trap. Traps were removed for several hours on 7 November to harvest soybean, apply fall-disking treatments, and plant wheat with the previously described no-till drill, using a 20-cm row spacing. Each emergence trap consisted of a polyester fabric cone attached to a galvanized metal frame with a basal area of 0.5 m (as described by Zeiss 1989). Traps were examined approximately weekly from 14 September to 1 February. Traps counts were transformed ($\sqrt{x + 0.5}$) prior to analysis of variance (GLM Procedure, SAS Institute 1985). Main-plot and subplot tillage effect comparisons were made with a pair-wise least-squares means *t*-test (LSMEANS, GLM Procedure; SAS Institute 1985). Total capture over the entire trapping interval was used to compare spring tillage treatments. Fall-tillage effects on the spring treatments were determined by comparing trap capture over the 7 November to 1 February interval.

**1991.** In 1991, there were five whole-plot treatments for spring tillage: no-till, burned, disked, burned and disked, and bottom-plowed. The bottom-plowed treatment was applied with a Harrell Switchplow. Spring tillage and burning treatments were applied to wheat stubble on 10 June. Traps were placed on 6 September and removed briefly on 17 October when fall-disking treatments were applied. Unlike 1990, the plots remained fallow rather than being planted with soybean after spring tillage and with wheat after fall tillage. All plots were oversprayed with glyphosate (3.4 kg/ha) plus metolachlor (1.7 kg/ha) on 10 June and glyphosate (2.2 kg/ha) on 23 July for weed control. Traps were closely inspected for the presence of volunteer wheat, to ensure that all captured adults eclosed from oversummering puparia, rather than from an additional fall generation. The depth to the tillage hardpan was measured by probing with a wooden ruler on 30 January 1992. It was assumed that by this date, the soil had settled adequately to determine tillage depth.

## Results

**Spring Tillage.** The effects of spring tillage and burning of wheat stubble are shown in Fig. 1. Burning alone resulted in no measurable reduction of HF emergence. Spring disking caused a 54% reduction in emergence in 1990. In 1991, emergence from disked plots was 36% lower than no-till plots, but this difference was not statistically significant. The burned and disked treatment reduced emergence by 70% in 1990 and 96% in 1991. Bottom-plowing resulted in complete elimination of emergence. Spring disking depth was 10.9 ± 0.3 cm ($\bar{x}$ ± SEM) in the burned and disked plots vs. 9.6 ± 0.3 cm in plots that were only disked ($t$ = 3.46, df = 116, $P$ = 0.001). The bottom-plow depth was 32 ± 0.4 cm.

**Fall Disking.** The effects of fall disking on HF emergence from previous spring tillage treatments are shown in Fig. 2. For 1990 data, spring treatment trap captures are greater in Fig. 1 than Fig. 2, because some emergence occurred prior to fall tillage treatments. Following a spring no-till treatment, fall disking reduced HF emergence 50% in 1990 and 48% in 1991. However, only the latter reduction was statistically significant. Fall disking caused numerical but non-significant reductions following spring stubble burning in both years. HF emergence from plots disked both in the spring and in the fall was nearly identical to emergence from plots disked only in the spring. In 1990, fall disking increased HF emergence by 167% where the stubble had been burned and disked the previous spring. In 1991, fall disking caused a 23× emergence increase over the spring-burned and -disked plots. Fall disking depth was 11.4 ± 0.3 cm in the previously untilled plots versus 12.3 ± 0.3 cm in plots previously disked in the spring ($t$= 1.58, df = 116, $P$ = 0.07).

**Emergence Timing.** In both years, initial emergence from no-till plots was detected earlier than any other spring treatment except the burned treatment in 1990 (Fig. 3). There were no other apparent differences in emergence timing among tillage treatments. Emergence timing varied greatly between years, however. In 1990, there was only one emergence peak, which occurred between 7 and 14 November. In 1991, there were two distinct emergences of oversummering HF; one peaking between 24 and 30 October, and another on approximately 2 December.

## Discussion

The failure of stubble burning to reduce HF emergence may be partially due to higher rates of parasitism for puparia found above the soil line (McColloch 1923). Predation, pathogens or other environmental mortality factors may also contribute to reduced survival of puparia oversummering on the soil surface. High natural mortality of these surface puparia would tend to negate any benefits of burning. It is also unknown how stubble burning modifies these mortality factors.

The efficacy of bottom-plowing is consistent with early studies emphasizing the importance of tillage. Headlee & Parker (1913) and McColloch (1923) reported reduced emergence when stubble was bottom-plowed to a depth of only 15-17 cm. However, other than for peanut production, disking rather than bottom-plowing is the primary tillage operation in the southeastern Coastal Plain. It is important to distinguish between the control efficacy of these implements. Our

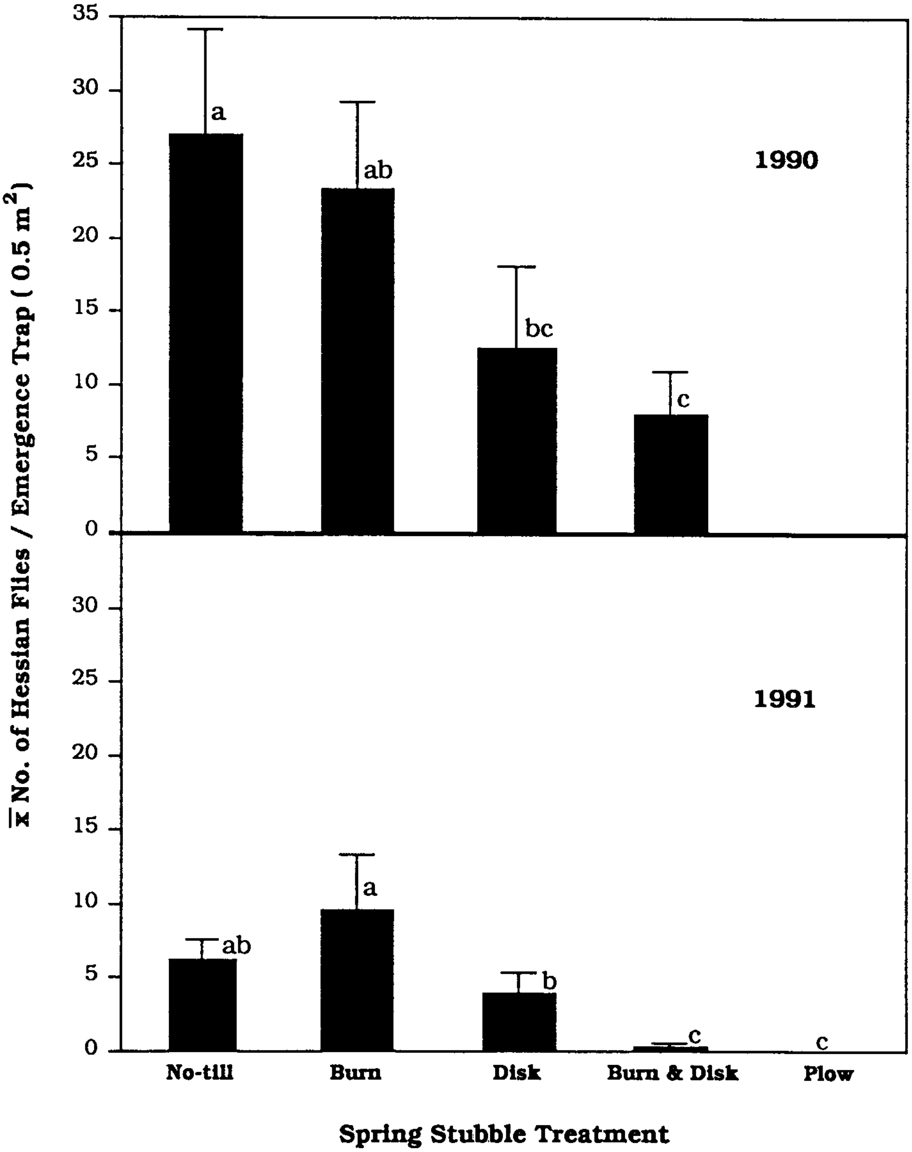


Fig. 1. Effects of spring tillage and burning on Hessian fly emergence from wheat stubble on a Coastal Plain soil. Vertical lines indicate SEM. Means sharing the same letter are not significantly different ($P$ = 0.05; pair-wise LSMEANS $t$-test).

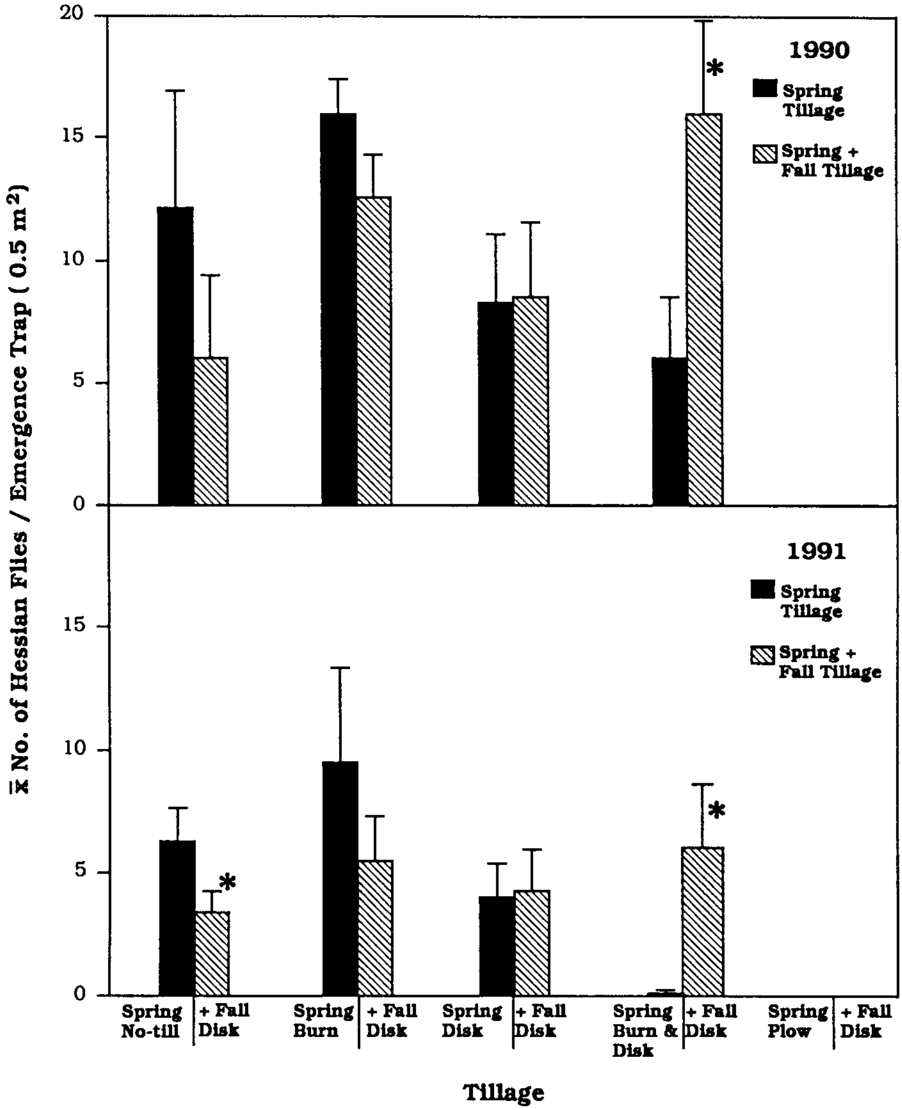


Fig. 2. Effects of fall disking on Hessian fly emergence from wheat stubble previously subjected to spring tillage and/or burning. Vertical lines indicate SEM. An asterisk indicates a significant effect of fall disking. ($P = 0.05$; pair-wise LSMEANS $t$-test).

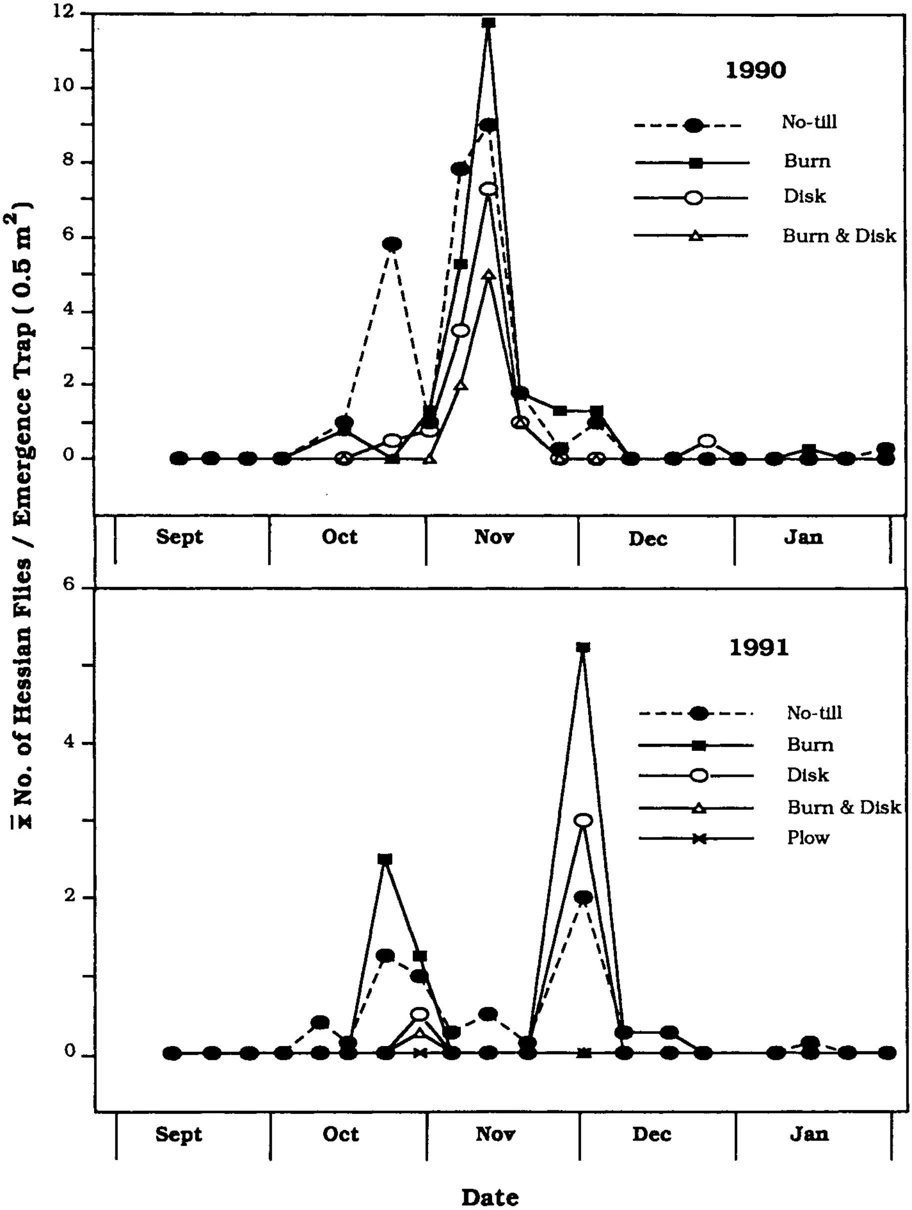


Fig. 3. Timing of Hessian fly emergence from wheat stubble on a Coastal Plain soil subjected to spring tillage and/or burning.

results indicate that disking alone results in only about 50% reduction of emergence from a Coastal Plain soil. Zeiss (1989) reported 70-96% emergence reduction from a Piedmont Norfolk loamy sand subjected to two or three spring diskings. The disking depths measured in our study (10-12 cm) are representative of Coastal Plain tillage operations. Although virtually no wheat stubble was visible on the soil surface, plant crowns were readily found within the top 5 cm of soil. The ability of HF adults to emerge from a given depth in various soil types is unknown. In an unreplicated study, Headlee and Parker (1913) found no emergence from depths greater than 7.5 cm. Although stubble burning alone has no value in reducing emergence, it does appear to increase the burial efficacy of disking. Although the disk cut slightly deeper (1.3 cm) after stubble burning, the major difference was probably more uniform soil inversion and improved burial of the plant crowns.

The efficacy of fall disking was very similar to that of spring disking (up to 50% emergence reduction). The nearly identical emergence from spring-disked and spring-disked plus fall-disked treatments indicates that repeated disking is of limited value on some soils. Puparia are in effect "stirred" within perhaps the top 10 cm of the soil profile. Those not initially buried in the spring may be buried by fall disking, but conversely, puparia buried in the spring are moved closer to the surface in the fall. Fall disking could also increase emergence by loosening the soil structure. In our experiments, plots were not subjected to subsoiling during soybean planting, nor cultivation for weed control. Cultivation typically disturbs only the upper 3-5 cm of soil. Thus, cultivation would tend to uncover some puparia and more deeply bury others. In-row subsoiling during soybean planting causes additional surface disturbance, but based on results from our twice disked treatments, it seems unlikely that subsoiling would greatly reduce emergence. The exception might occur where soil beds are thrown up, as commonly practiced in cotton production. Subsequent leveling of these beds during planting might result in significant additional burial of puparia. These results help explain why HF is an annual economic problem in the South Carolina Coastal Plain, even for growers who are conscientious about stubble and volunteer wheat destruction. Disking can significantly reduce, but not eliminate injury to untreated susceptible varieties.

Any recommended tillage system is a compromise of costs and benefits. Bottom-plowing is high efficacious against HF, and stubble burning increases the efficacy of disking, but both practices have environmental costs that make them increasingly undesirable alternatives. Highly resistant varieties (e.g., 'Coker 9766') can be used in reduced-tillage wheat double-cropping systems without sustaining economic injury, but it is unknown to what extent reduced tillage accelerates development of new virulent HF races. As reliance on these resistant varieties increases in the Southeast, it is important to recognize that repetitive disking is not necessarily beneficial.

This study indicates that some additional tillage practices can actually increase HF emergence. If one tillage practice, such as spring burning and disking, is quite effective in burying puparia, than additional disturbance (e.g., fall disking) can eliminate the initial benefits. It is a common practice in many areas of the South to burn wheat stubble, and disk one time prior to planting soybean. After soybean harvest in October or November, some growers disk immediately rather than leaving the crop residue on the surface through the winter. In this case, fall disking could increase HF oviposition in adjacent seedling wheat. The late (1 December) peak emergence of oversummered HF in 1991, demonstrates that tillage immediately after soybean harvest could significantly impact fall emergence. It also demonstrates the futility of relying strictly on delayed planting to avoid economic injury in some areas of the South.

Although initial emergence occurred slightly earlier in untilled plots, this could merely be a sampling variation related to the greater total number of adults emerging from these plots. Fall HF emergence has been correlated with rainfall (McColloch 1923). In 1990, 37 cm of rainfall occurred from 10-23 October, and an additional 5 cm on 9 November. In contrast, during 1991 only 2.5 cm occurred in October and 4 cm during November. Thus, heavy rainfall during late October and early November may have been responsible for the more condensed emergence interval observed in 1990.

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