

TILLAGE AND WEED MANAGEMENT

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Introduction

Tillage is the most important factor influencing weed management in row crops. Any tillage treatment can be considered as a weed management strategy; the primary function of tillage is to manage weeds. The effects of tillage on weed management can be direct or indirect. Examples of the direct effects of tillage on weed management would be the physical destruction of weeds by cultivation or the dilution of the soil weed seed reservoir. Indirect effects include the relative placement of herbicides in the soil and the impact on herbicide degradation. Another factor that must be considered is the affect of tillage on plant residue on the soil surface. Residue management impacts weed management, but is the critical component for soil erosion potential. These factors must be evaluated when developing a tillage system; the positive effects of tillage on weed management weighed against the negative impact on soil erosion potential.

Discussion

Herbicides and Tillage

Traditionally, fall tillage followed in the spring with several tillage operations was thought necessary for acceptable herbicide performance. This became increasingly important as Iowa growers shifted to the use of herbicides requiring physical incorporation. An estimated 65% to 70% of the corn and 75% to 85% of the soybean acres in Iowa are currently treated with a preplant incorporated (PPI) herbicide. The average amount of plant residue left on the soil surface is usually not sufficient to deter soil erosion. However, research would suggest that herbicides can be successfully incorporated with a significant amount of residue remaining on the soil surface.

The interest in single pass herbicide incorporation also reflects concerns for residue management. However, when herbicides are incorporated with a single, shallow tillage treatment, the importance of soil condition increases. If soils are wet, or if residue coverage is greater than 45%, herbicide performance will likely decline.

The depth of tillage used for herbicide incorporation is also an important consideration. If a incorporation tillage treatment is too shallow, poor soil/herbicide mixing occurs and herbicide distribution does not allow for effective weed management. A deep incorporation tillage treatment may dilute the herbicide below the effective amount needed for weed control. Generally, the first tillage treatment influences the vertical distribution of the herbicide, while the second incorporation tillage treatment improves the horizontal herbicide distribution. The physical properties of the herbicide affect whether or not a single incorporation

tillage treatment is sufficient to provide the necessary distribution for effective weed management and dictates the depth that incorporation should be conducted.

Tillage and resultant residue also affect the distribution of preemergence (PRE) herbicides. Tillage systems that result in greater residue amounts on the soil surface potentially interfere with herbicide coverage. More surface residue reduces the amount of herbicide that directly reaches the soil surface. While timely rainfall removes much of this herbicide, thus improving the potential weed control, the longer the herbicide remains on the residue the stronger the adsorptive bond is. Repeated wetting/drying cycles, the result of dew formation, also strengthen the adsorption of the herbicide on the plant residue. Generally, with moderate amounts of plant residue, the effect on PRE herbicide distribution and resultant negative impact on weed management is not a major tillage consideration.

Tillage also potentially affects herbicide degradation. Logically, more tillage should dilute the herbicide thus reducing the effective herbicide rate and increasing the possibility that the herbicide will find a degradative site. Research by Hartzler et al. (Table 1) demonstrates the effect of tillage on trifluralin degradation and placement in the soil. A significant rate and tillage response is illustrated. Any reduction in the severity of tillage increases the amount of trifluralin in the soil. Further, as tillage is reduced, the amount of trifluralin reported in the top 7.5 cm increases. This is significant as this area represents the planting zone for the rotational crop. Thus, with more herbicide residues in the planting zone, the greater is the potential injury on the rotational crop.

While there is an impact of tillage on herbicide degradation, if a herbicide has extremely high specific activity on the rotational crop, a potentially positive effect of tillage may not significantly reduce rotational crop injury. Imazaquin (Scepter) carryover to corn was not consistently reduced with increased tillage. Significant corn yield reductions were reported by growers who moldboard plowed soybean residue, used reduced tillage systems, and planted no-till. Other growers who used the same tillage systems reported no carryover injury, thus demonstrating the lack of consistent tillage response on imazaquin degradation. Tillage that is conducted to reduce herbicide residues must be considered only after determining the actual risk of significant yield reductions and the negative impact on soil erosion. Generally, tillage practices should not be modified if the intention is to reduce herbicide carryover potential. The negative impact on soil erosion will likely outweigh the positive influence, if any, on herbicide degradation.

Tillage and Weeds

Effect on Weed Seed Distribution

Tillage has a profound effect on the physical distribution of weed seeds. Most annual weeds do not have specific adaptations for distribution. If the natural yearly distribution of these weeds is observed, the infestation appears to move radially from the mother plant as a "creeping" front. The distance that seeds are dispersed from the mother plant is dependent on the weight of the seeds and the height of the plant. However, the likelihood of a seed successfully germinating, maturing, and reproducing increases as the distance from the mother plant increases. Thus, a weed infestation will "creep". When tillage artificially moves weed seed, the rate and manner of distribution changes dramatically. Observations

suggest that a small infestation of an annual weed can be spread to cover an entire field in 3 to 5 years after the initial infestation. Tillage therefore can be seen as the major mechanism of weed seed dispersement.

Weed seed distribution also occurs vertically. Again, tillage has a significant effect on the vertical placement of weed seeds. Pareja demonstrated significant differences between reduced and conventional tillage on the distribution of weed seeds in the spring (Figure 1). However, when weed seed distribution was evaluated shortly after the fall seed drop, the differences attributable to tillage system were not significant (Figure 2). The vertical distribution has profound implications with regard to the apparent weed population, the severity of weed infestations, and the life of the population.

Weed seeds have specific requirements for successful germination and emergence. These requirements include favorable light, temperature, moisture, and nutrient conditions. Generally, annual weeds will germinate and emerge from the top 1/2 to 1 inch of soil. This germination area can be considered relatively stable and thus represents a "safe site" for the seedling weed to develop. Further, the probability of any particular weed seed germinating must be considered. Obviously, the more weed seeds in the germination area, the greater the likelihood of weed seeds successfully germinating. When the data by Pareja is considered, it becomes apparent that the likelihood of weed infestations in reduced tillage systems is better than in conventional tillage systems.

Research by Oyarzabal (Figure 3) demonstrates the placement of shattercane (*Sorghum bicolor* [L.] Moench.) seeds and the relative germination depths. Note that shattercane has the ability to germinate deeper than many annual weeds. There is a significant effect of tillage system on the depth of shattercane emergence. This difference reflects the relative seed population at a particular depth, but also suggests that the environmental conditions necessary for successful germination also are affected by tillage systems. Given that seeds have specific germination requirements, it becomes obvious that as the tillage system becomes less aggressive, the location of the favorable germination requirements moves upward in the soil profile. It is likely that the primary germination requirements affected are soil temperature and moisture.

Effect on Weed Population

Oyarzabal also demonstrated that tillage system had a significant effect on shattercane populations. Shattercane populations evaluated early after crop emergence demonstrated a significant tillage response (Figure 4). The shattercane population in the no tillage treatment was considerably greater than either the conventional or reduced tillage treatment. There was an interaction between tillage and planting date. Early planting date and no tillage had a greater initial shattercane population than any other treatment. The differences between tillage systems were minimal for the late planting date. The lack of population response for the late planting date no tillage treatment likely reflects the depletion of the shattercane seed from the soil seed reservoir. No significant differences were observed between conventional and reduced tillage system.

Shattercane populations evaluated late in the growing season reflected initial populations, although considerable "self-thinning" occurred for the no tillage

treatments (Figure 5). Significant differences were not observed between conventional and reduced tillage treatments. The only planting date response was observed for the no tillage treatment.

Similar weed population trends relative to tillage system are reported by Owen et al. Foxtail (*Setaria* spp.) populations were significantly greater for no tillage treatments compared to reduced and conventional tillage systems when evaluated on June 9, 1989 (Figure 6). Pigweed (*Amaranthus* spp.) populations were greater for reduced and no tillage treatments (Figure 7). Foxtail and pigweed populations were significantly reduced at later evaluations due to row cultivations. When the interaction of weed control strategy and tillage treatment is determined, significant differences are found between no herbicide treatment (untreated) and no tillage treatment for foxtail (Figure 8), and no herbicide treatment and reduced tillage treatment for pigweed (Figure 9). No differences, regardless of tillage or herbicide treatment, were observed for other interactions. The lack of effect for the untreated herbicide controls is the result of effective cultivation and drought conditions that reduced weed development. Further, these data do not reflect rotational strategy that is also included in the research.

General trends from the Chariton, Iowa, experiments suggest that weed populations increase as tillage severity is reduced. However, row cultivation can minimize these differences unless the initial weed population is extremely severe. Weed control strategy interacts with the tillage treatment. Generally, individual tillage or weed control treatments that result in high populations of weeds will influence the interaction in a similar manner. However, with only 2 exceptions, only slight differences were observed for the interaction between weed control treatment and tillage system. The lack of differences would not likely continue indefinitely. The slight differences will potentially become greater if the treatments are continued.

Conclusion

Tillage systems have a major impact on weed populations and management strategies. Generally, as tillage is reduced, weed populations potentially increase. The population increase reflects the distribution of weed seed in the soil, the resultant soil environmental conditions, and the impact that increased plant residue has on herbicide efficacy. However, it should be noted that the potential increase in weed population is not a certainty; if weed management strategies minimize weed seed production, there will not be a significant change in population. Further, the positive effects of reduced tillage on soil erosion likely warrant the potential negative effects on weed seed population. Similarly, less severe tillage systems potentially affect herbicide in a negative manner. This reflects the ability to successfully incorporate a herbicide with increasing plant residue amounts, the effect of plant residue on PRE herbicide distribution, and the response of herbicide degradation to reduced tillage. Improved management strategies can resolve the distribution problem. Herbicide degradation may not be a consistent concern; yearly environmental conditions may have a greater impact on herbicide degradation than tillage system. Further, many herbicides that have demonstrated a consistent degradation response to tillage system have not consistently caused a yield response, regardless of the degradation pattern.

Table 1. Effects of trifluralin rate and tillage on trifluralin residues 12 months following application.

Treatment (kg/ha)	Trifluralin residue at two locations and two soil depths			
	Ames		Nashua	
	0-7.5 (cm)	7.5-15 (cm)	0-7.5 (cm)	7.5-15 (cm)
	(ppmw)			
Trifluralin ^a :				
0.0	NDR ^b	NDR	NDR	NDR
1.1	0.12	0.04	0.07	0.01
2.2	0.15	0.05	0.14	0.02
4.5	0.36	0.10	0.24	0.05
LSD (0.05)	0.06	0.03	0.06	0.02
Tillage ^c :				
Moldboard	0.13	0.10	0.06	0.06
Chisel	0.14	0.02	0.11	0.00
No-till	0.20	0.02	0.16	0.00
LSD (0.05)	0.05	0.03	0.05	0.01

^aTrifluralin means are pooled values of three tillage systems.

^bNDR = no detectable residue.

^cTillage means are pooled values of four trifluralin rates.

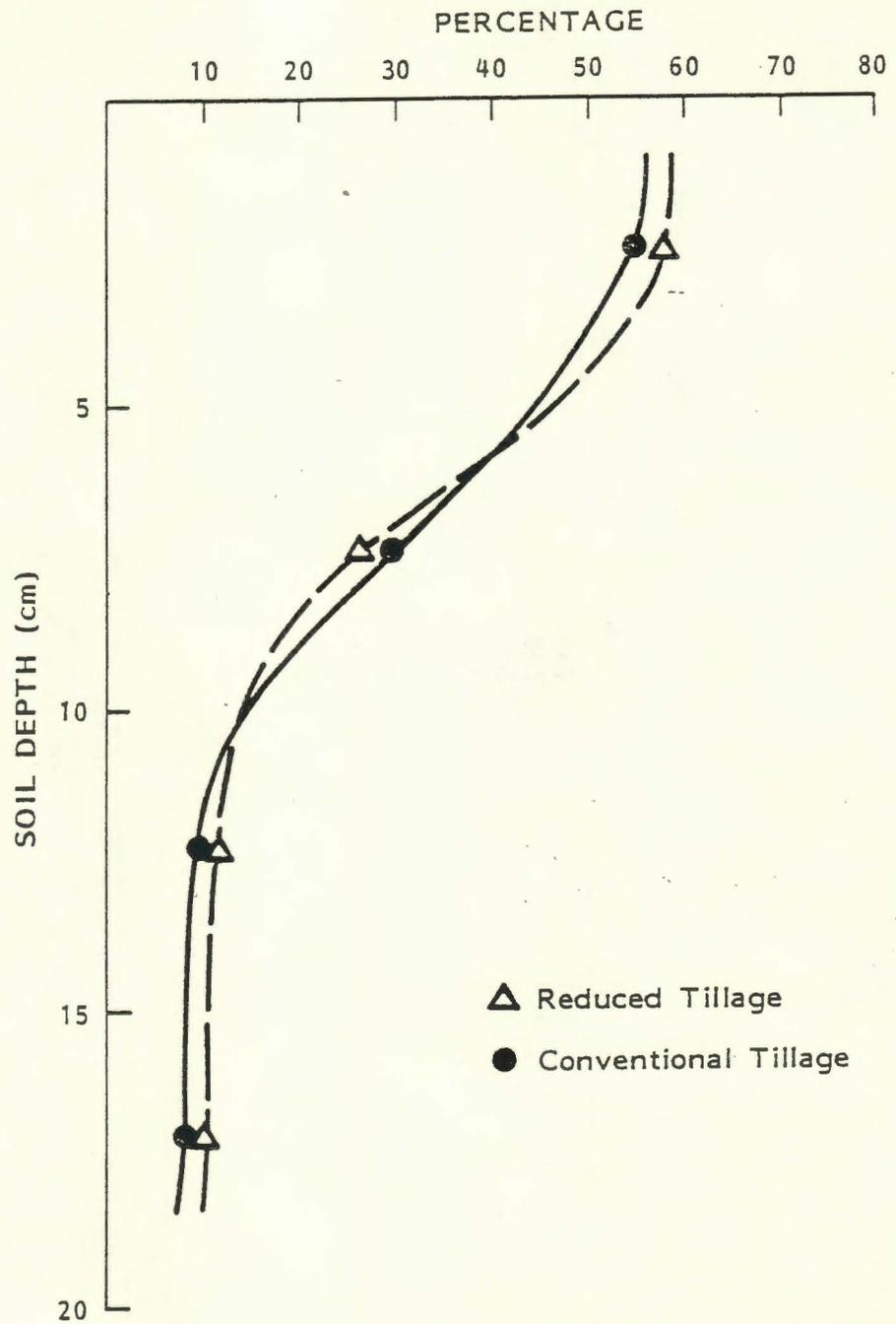


FIGURE 1. Percentage distribution of the weed seed population in the soil as a function of soil depth and tillage regime in the fall

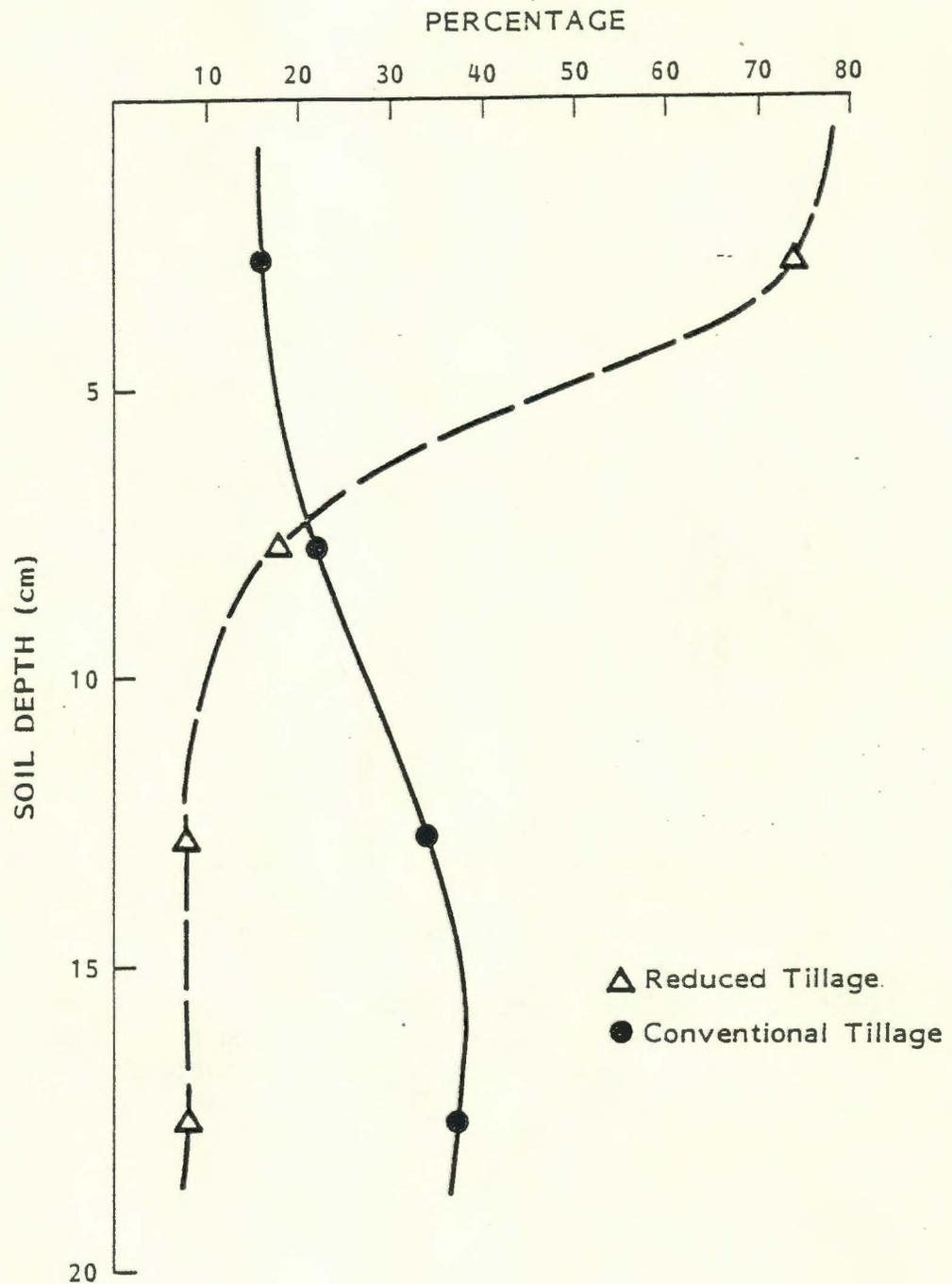


FIGURE 2. Percentage distribution of the weed seed population in the soil as a function of soil depth and tillage regime in the spring

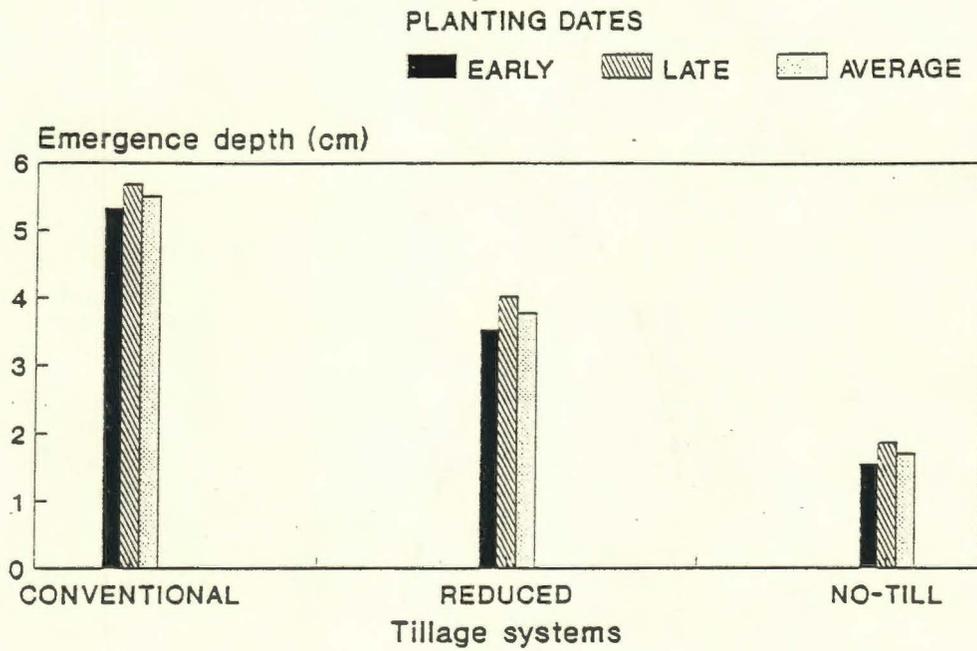


Figure 3. Effect of planting dates and tillage systems on the depth of shattercane seedling emergence. Data are the means of four replications. (LSD ($P < 0.05$) between tillage systems = 0.54)

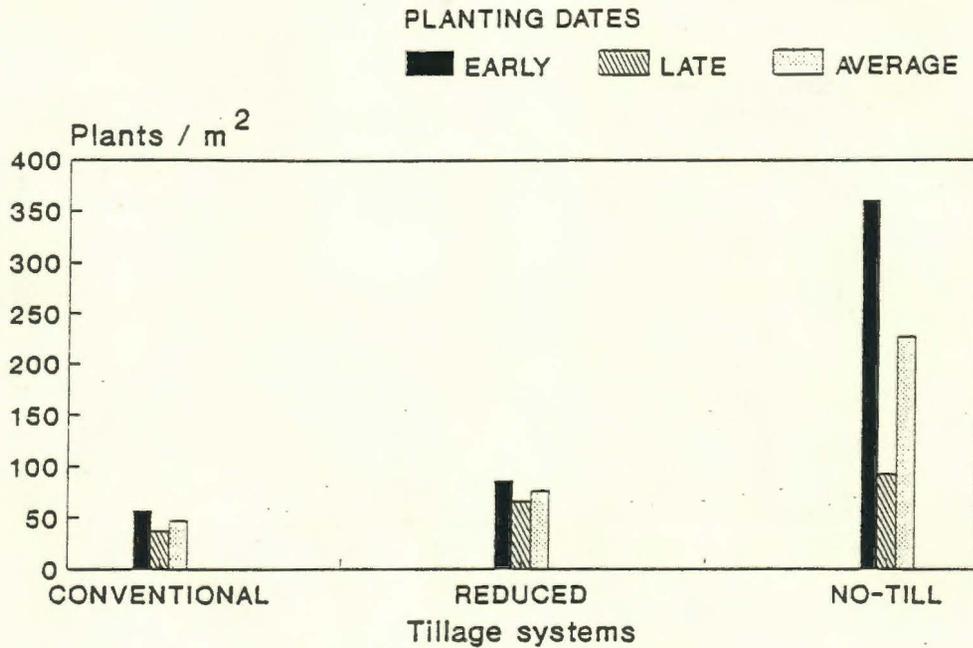


Figure 4. Effect of planting dates and tillage systems on the initial number of shattercane plants. Data are the means of four replications. (LSD ($P < 0.05$) between means of tillage system within a planting date = 55)

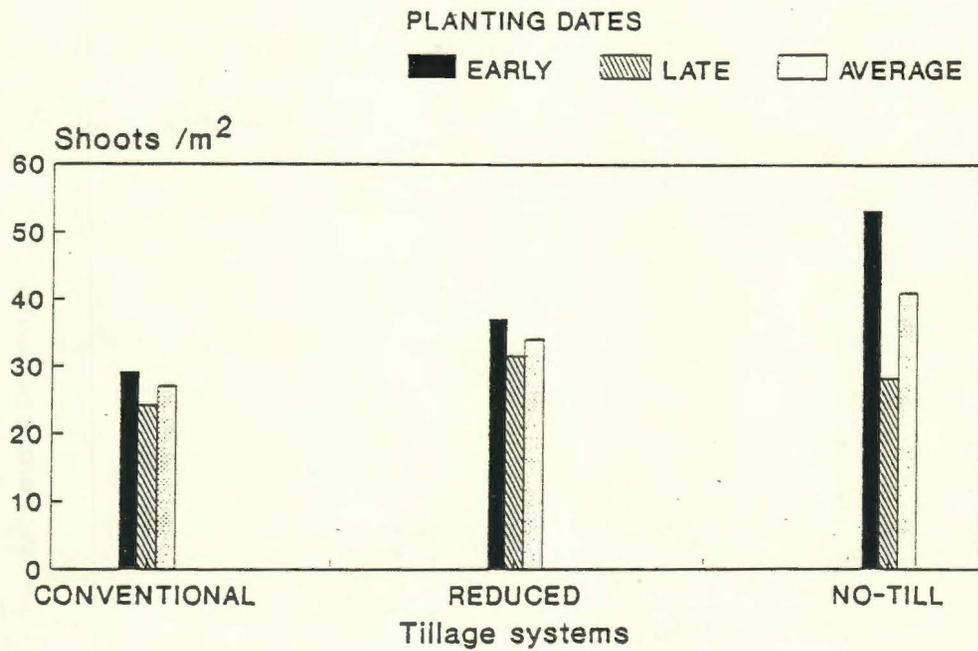


Figure 5. Effect of planting dates and tillage systems on the final number of shattercane shoots. Data are average of four replications. (LSD ($P < 0.05$) within tillage systems for a given planting date = 7.42)

EFFECT OF TILLAGE ON FOXTAIL
POPULATION, CHARITON, IA 1989

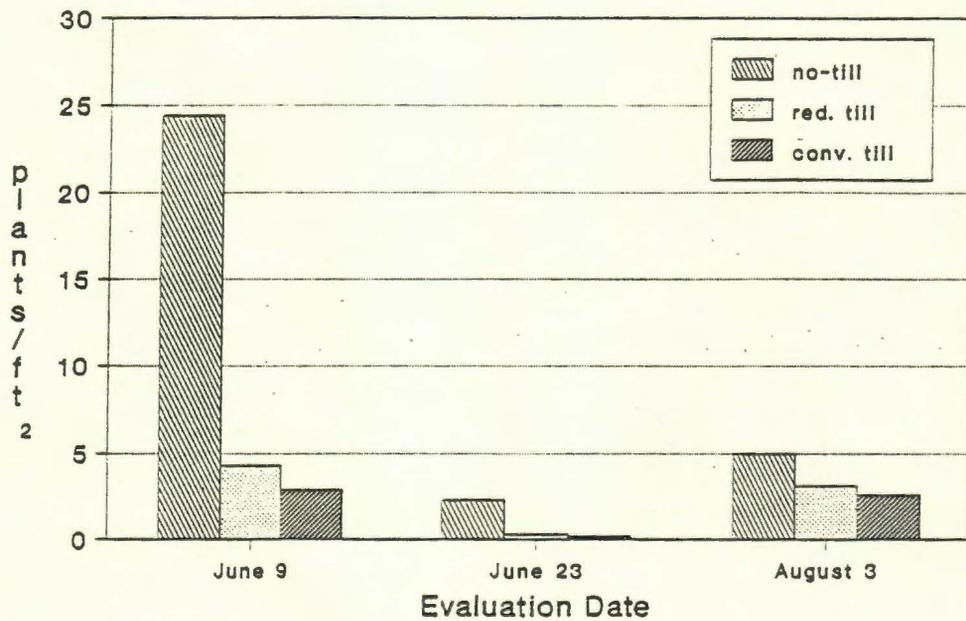


Figure 6.

EFFECT OF TILLAGE ON PIGWEED POPULATION, CHARITON, IA 1989

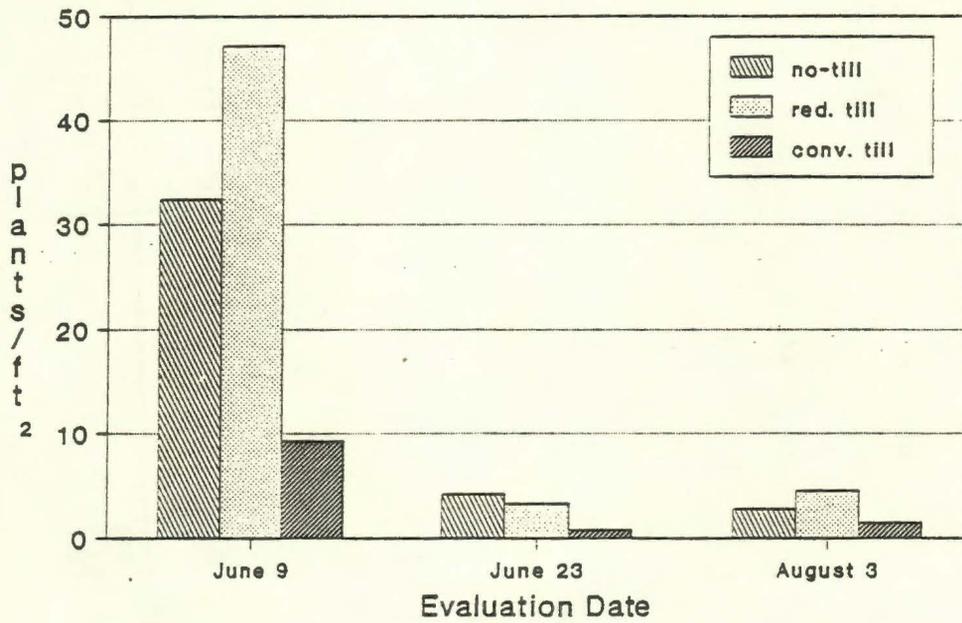


Figure 7.

EFFECT OF TILLAGE AND WEED CONTROL STRATEGY ON
FOXTAIL POPULATION, CHARITON, IA AUGUST 1989

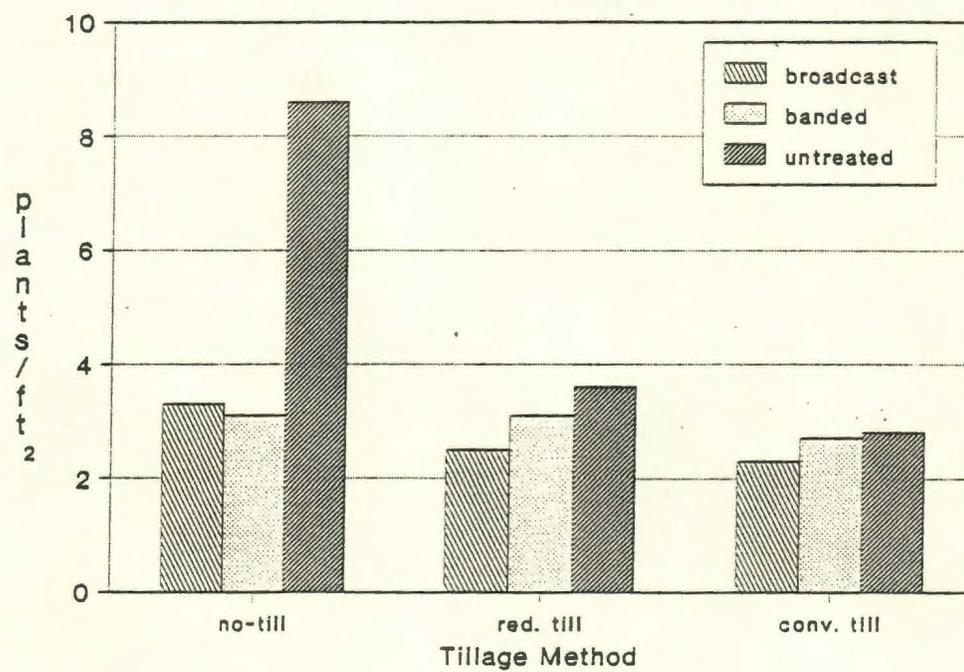


Figure 8.

EFFECT OF TILLAGE AND WEED CONTROL STRATEGY ON
PIGWEEED POPULATION, CHARITON, IA AUGUST 1989

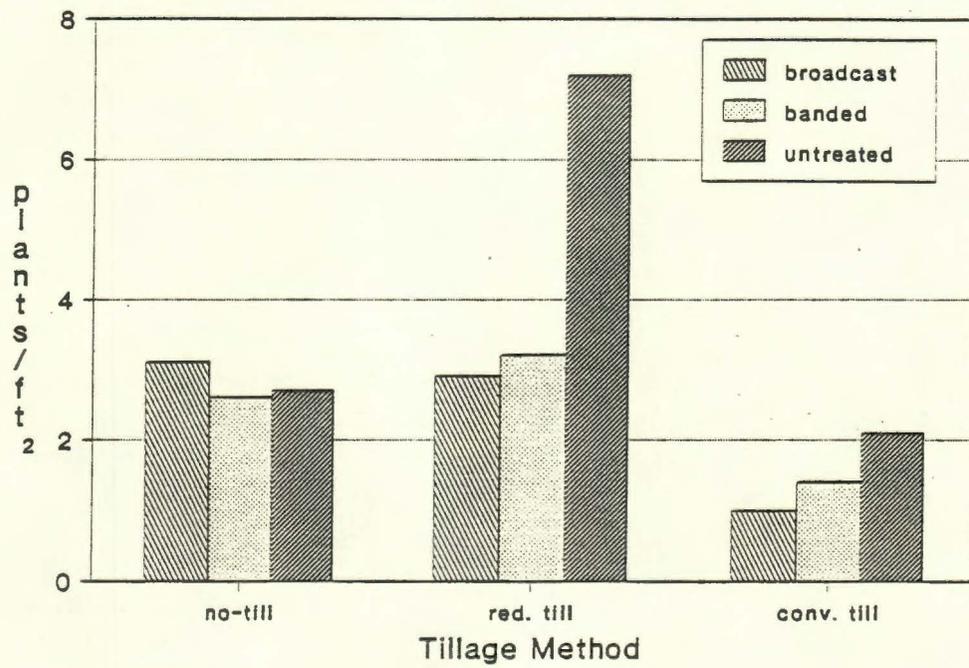


Figure 9.