USE OF A COTTON STALK PULLER FOR CONSERVATION TILLAGE COTTON

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Abstract

Conservation tillage is important in reducing wind and water erosion as well as reducing soil compaction due to tillage operations. Loss of soil moisture which evaporates with each tillage operation is reduced with conservation tillage when a crop residue mulch is retained on the soil surface. This study compared the use of a moldboard plow system with either a rotary mower plus a stalk puller or a flail shredder plus a stalk puller for effectiveness in controlling regrowth cotton and in reducing weed (especially volunteer cotton) and boll weevil populations. The use of a cotton stalk puller is a quick and efficient way to destroy cotton stalks and to leave boll weevil pupae or larvae and cotton seed within the top 2 cm of the soil surface where soil temperatures can reach 54° C or more. High soil temperatures combined with dry conditions can desiccate immature boll weevils and reduce the germination and establishment of volunteer cotton. Plowing the cotton stalk residue places the boll weevil larvae and pupae in a dark, generally moist environment which may be conducive for over-wintering in south Texas and northeastern Mexico. Using the stalk puller reduced fall seedling cotton populations in 2 of 3 years when compared with the moldboard plow system. Stalk puller treatments exposed weevil infested cotton squares and bolls to higher soil temperatures and lower soil moisture than did the moldboard tillage system.

Introduction

Wind and water erosion are major problems in south Texas and northeastern Mexico. Conservation tillage reduces wind and water erosion and reduces water evaporation which occurs with each tillage operation (4). Maintaining crop residue on the soil surface can mulch the soil, retaining moisture and insulating the soil surface from temperature extremes (4). Texas state law mandates the destruction of cotton stalks in south Texas by September 1. Cotton stalks are destroyed to prevent regrowth and subsequent production of a boll weevil food supply which enhances the overwintering capacity of the boll weevil (7).

In a conservation tillage or no-tillage cotton production system, deep plowing of cotton stalks is not feasible. Crop residue is managed so it remains on the soil surface to protect the soil from wind and water erosion. Recent work performed in the Rio Grande Valley of Texas has shown that cotton production in a conservation tillage system produces lint yields which are equivalent to lint yields of cotton produced in conventional moldboard plowing systems (4). Cotton production costs can be reduced by as much as 50 dollars per acre when tillage is reduced in the system (4). Thus, by reducing input costs of tillage and soil preparation for planting and achieving equivalent lint yields, profitability increases (3, 4) and soil is protected from wind and water erosion with conservation tillage practices. Typical cotton stalk destruction is done by deep tillage or moldboard plowing. This tillage would prevent conservation tillage practices from being a viable option for area producers of cotton. Deep plowing is not advisable in some areas due to the thin top-soil layer.

The stalk puller consists of two large disk plow blades mounted with concave sides opposed to one another which overlap to pinch and uproot cotton stalks. Operation of a cotton stalk puller is much more economical than conventional moldboard plowing (3, 4), or other primary tillage methods of stalk destruction. The use of the stalk puller or undercutting sweeps which are commonly used in conservation tillage systems leaves most of the cotton stalk residue within 2 cm of the soil surface (4). Cotton stalk destruction in Texas Pest Management Zone I (Lower Rio Grande Valley) is required to be completed on or before September 1. Current Texas Department of Agriculture regulations require mechanical stalk destruction which is defined as: plowing, shredding, disking, or any other cultivation practice that destroys the cotton plants, and prevents regrowth of stalks, bolls, squares, blooms, foliage, terminals and root system.

Conventional stalk destruction in the Lower Rio Grande Valley normally consists of shredding cotton stalks, one pass with a heavy disk, and one pass with a moldboard plow, generally operated to a depth of 13 to 30 cm. At least two disk operations are then made over the field, prior to forming and shaping beds for the following year's crop. Estimated costs for conventional stalk destruction and reshaping beds for the following crop are about $140/ha compared with only $42/ha when using a stalk puller and then reshaping beds (Table 1.). Stalk puller costs are reduced even further in dryland areas. When cotton plant height is limited, the stalk shredding operation is not be needed, thus reducing costs to only $32/ha. By using the stalk puller to replace primary tillage, reductions in tillage costs can increase profitability of cotton production, and protect the land from wind and water erosion.

A stalk puller leaves boll weevil larvae and pupae and unharvested seed cotton on the soil surface where soil temperatures can exceed 53° C in August, depending on soil type and color and prevailing weather conditions. These high temperatures will desiccate and kill developing boll weevil larvae and pupae in the cotton squares and bolls, and greatly reduce the germination of cotton seed (7). High soil

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temperatures and lack of adequate soil-seed contact may be responsible for low cotton seed germination or seedling desiccation shortly after seed germination occurs. Plowing the cotton stalk residue places the boll weevil larvae and pupae in a dark, generally moist environment which actually protects them from adverse environmental conditions, predator insects, birds, and all insecticides (5, 6, 7). Thus by use of a cotton stalk puller, the boll weevil populations and fall cotton seedling germination and growth may be reduced when compared to conventional moldboard plowing. Timeliness of farm operations is difficult to assign a direct cost, however a stalk puller operated at between 8 and 12 miles per hour provides a producer with a quick and efficient way to eliminate cotton stalks (i.e. approximately 25 acres per hour @ 8 mph with an 8 row stalk puller). Control costs for fall germinated cotton seedlings and wind and water erosion of the soil can be reduced by using the cotton stalk puller. The integrated effects of cotton stalk destruction with a stalk puller system on cotton regrowth, fall cotton seedling growth, and boll weevil populations have not been thoroughly studied or documented, nor has an economic analysis been performed which integrates reduced tillage systems (i.e. use of stalk puller) and the management of fall cotton seed germination and growth and boll weevil populations.

Data obtained from these experiments will be used to develop an effective and efficient boll weevil management system which can be integrated with conservation tillage cotton production. Additionally, costs of controlling fall boll weevil populations may be reduced and production costs of cotton decreased if deep tillage is not used. Cotton is not generally considered a high residue producing crop, but when stalks are left on the soil surface, they can provide soil protection from wind and water erosion.

The long term objective of this research is to increase the overall profitability of cotton production by decreasing expenditures for cotton stalk destruction and for control of fall seedling cotton, and to decrease overwintering boll weevil populations.

The specific objectives of this study were: (1) Conduct a cost/benefit analysis for the cotton stalk destruction systems and conventional moldboard plow system. (2) Establish the relationship between stalk destruction method and cotton seedling germination in the fall; and (3) Determine the effect of cotton stalk destruction methods on immature boll weevil survival, and subsequent season boll weevil populations.

Materials and Methods

The effect of cotton stalk shredding plus deep plowing was compared to stalk shredding plus the use of a cotton stalk puller. Soil surface and ambient temperatures at 5, 10, 20, and 30 cm below the soil were measured on an hourly basis from late August till January the following year. Soil moisture and precipitation were measured and recorded weekly. Cotton regrowth and cotton seedling germination were measured. The experimental design was a randomized complete block with four replications of each treatment. Cotton was planted near 1 March each year in plots 15 m wide and 30 m long. Cotton was harvested in late July and stalk destruction was done in mid-August each year. Three treatments imposed upon the soil were: 1) a conventional cotton production system in which stalks were shredded using a flail-shredder, disced, and deep plowed; 2) no-tillage cotton production in which cotton stalks were shredded using a flail-shredder and a mechanical cotton stalk puller operated at 10 mph; and 3) no-tillage cotton production similar to number 2 except a rotary mower was used instead of a flail shredder.

Cotton squares and bolls were counted in 10 1 m^2 areas in each plot after the cotton was harvested both before and after stalks were pulled or deep plowed in August. Additionally, squares and bolls were collected from each plot and their location relative to soil depth at the time of collection was determined on day one after cotton plant destruction, and weekly thereafter for ten consecutive weeks. Stalk pulling, discing, and plowing were all done on the same day. At 10 weeks after stalk destruction (approximately November 1), cages (1 m^2) were uniformly spaced in each plot (10 cages per plot) over plant residues and examined weekly for emerging weevils until planting time the following spring. Cotton and other weeds were counted from 10 1-m^2 subplots per plot twice each fall, once about 21 days after tillage operations had occurred and again about 21 days later.

Cotton was rotated with grain sorghum each of the two seasons. Data were collected only in the cotton plots and fallow land during winter months, until grain sorghum planting.

Results and Discussion

Moldboard plowing effects on soil temperature at 5, 10, 20, and 30 cm soil depths as related to days following the tillage operations for 1994-95 and 1995-96 are presented in Figures 1 and 4. Mean average soil temperatures at 5 cm in the moldboard plow treatments were initially slightly lower that those soil temperatures in the rotary mow plus stalk puller (Fig. 2 and 5) or flail shred plus stalk puller treatments (Fig 3 and 6). Soil temperatures in the moldboard plow treatments (Fig 1 and 4) at the other depths (10, 20, and 30 cm) varied somewhat but were generally not different from the stalk puller treatments (Fig. 2, 3, 5, and 6). This is important because the moldboard plow inverts the soil and places many cotton bolls and squares which contains boll weevil larvae and pupae at soil depths of 10, 20, and 30 cm, while the stalk puller treatments leave almost all bolls and squares at or near the soil surface (5 cm or less). The shallow soil depth of bolls and squares in the stalk puller treatments places many boll weevil larvae and pupae at lethal temperatures according to work done by Summy et. al. (6, 7), for a duration of at least two weeks (Fig 1, 4). Timing of infested fruit internment may be of more importance, i.e. bolls buried in August probably won't produce weevils capable of surviving until the next spring. Infested bolls buried after the compliance date have a much better chance of survival.

Soil moisture as affected by soil depth and time following the tillage operation are presented in figures 7-12. Regardless of tillage treatment, soil moisture increased with soil depth. Moldboard plowing places the cotton bolls and squares at various depths. Many bolls which contain boll weevil pupae and larvae are placed in a relatively cool, moist environment with the moldboard treatments which are more conducive to boll weevil survival (5, 7) than the stalk puller treatments which leave most crop residue on or near the soil surface.

Soil temperatures in August and September at 5 cm frequently were at or above 49° C in the stalk puller treatments. Soil temperatures in the moldboard plow treatments where bolls and squares had been turned under the soil surface to 20 or 30 cm generally were 31° C or lower which is conducive to survival or weevil pupae and larvae and cotton seeds. Soil moisture also was higher where the bolls and squares were in the moldboard plow treatment (20-30 cm). Very few live boll weevils were actually recovered in any of the 10 1-m^{-2} cages places in each plot. The effect of tillage on weevil overwintering or survival was not clearly determined but further studies are currently underway to answer questions about the impact of boll and square burial on boll weevil survival.

Seedling cotton and weed populations counted 21 days after tillage operations are presented in Table 2. Seedling cotton numbers were greater in the moldboard plow treatment when compared with either stalk puller treatment in 1994 and 1996. Populations of both Palmer amaranth and Panicum Texanum were quite variable over the 3 years but did not differ between the stalk puller and moldboard plow treatments (Table 2).

Soil surface temperatures can exceed 49° C in August, and depending on soil type and color, and environmental conditions may reach even greater temperatures. These high temperatures will desiccate and kill developing boll weevil larvae and pupae in the cotton squares and bolls. Thus by reducing tillage and the use of a cotton stalk puller, boll weevil populations may be reduced when compared to conventional moldboard plowing. Leaving cotton seed on the surface, exposed to hot conditions can destroy proteins within the seed and reduce fall germination of cotton seedlings. Mechanical or chemical destruction of fall seedling cotton can result in several additional tillage passes over a field prior to planting of the next crop.

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Table 1. Cost analysis per hectare for post-harvest cotton stalk destruction and soil preparation for the following crop using conventional moldboard plow system and a stalk puller system.

		Operation costs	Moldboard plow	Stalk - puller
machinery variable costs (fuel, labor, & repairs)				
shred cotton stalks	1 trip	$ 9.88	$ 9.88	$ 9.88
stalk puller	1 trip	$ 5.19	-----	$ 5.19
10' heavy offset disk	1 trip	$ 24.70	$ 24.70	-----
moldboard plow	1 trip	$ 29.64	$ 29.64	-----
10' heavy offset disk	2 trips	$ 24.70	$ 49.40	-----
6-row lister bedder	1 trip	$ 14.82	$ 14.82	$ 14.82
bed shaper	1 trip	$ 12.35	$ 12.35	$ 12.35
Moldboard system	8 trips		$ 140.79	------
Stalk puller system	4 trips		-----	$ 42.24

[a] dryland cotton may not need to be shredded prior to operation of stalk puller if cotton plant height is not excessive.

[b] bedding should not occur for 60-90 days after operation of the stalk puller.

Table 2. Effect of moldboard plowing or stalk puller usage on seedling cotton and other weed populations during the post-harvest fall period.

treatment	volunteer cotton			Palmer amaranth			Panicum Texanum		
	1994	1995	1996	1994	1995	1996	1994	1995	1996
	---- plants/m^{-2} ---			---- plants/m^{-2} --			---- plants/m^{-2} ----		
tandem disk moldboard plow	12a	0.1 a	20 a	8 a	1 b	48 a	2 a	1 a	14 a
tandem disk rotary mow stalk puller	6b	0.0 a	5 b	15a	4 a	34 a	3 a	2 a	16 a
flail shred stalk puller	4b	0.8 a	9 b	8 a	3 a	47 a	1 a	1 a	8 a

Comparisons made using a Waller-Duncan K-ratio T-test within a column, values followed by the same letter within a column were not significantly different at P= 0.05 level of significance.

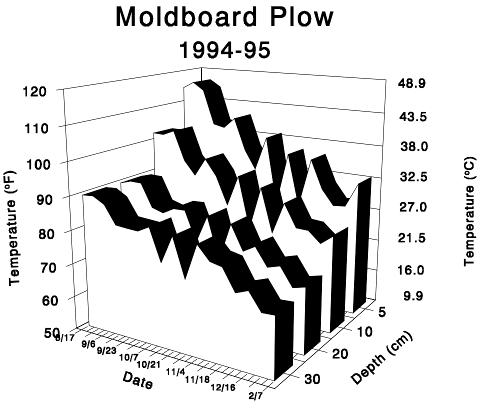

Fig. 1. 1994-95 moldboard plowing effects on soil temperature at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

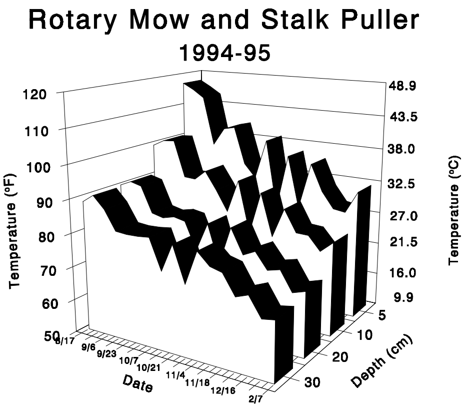

Fig. 2. 1994-95 rotary mow and stalk puller effects on soil temperature at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

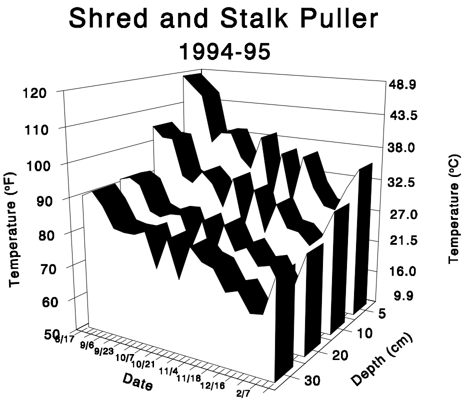

Fig. 3. 1994-95 shred and stalk puller effects on soil temperature at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

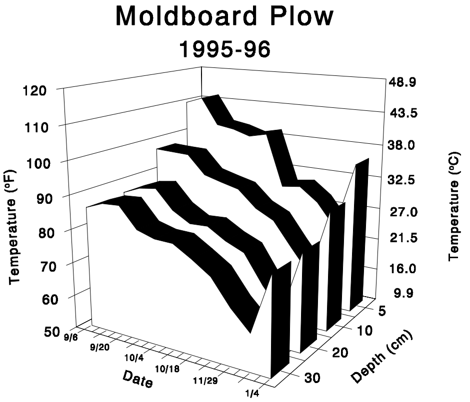

Fig. 4. 1995-96 moldboard plowing effects on soil temperature at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

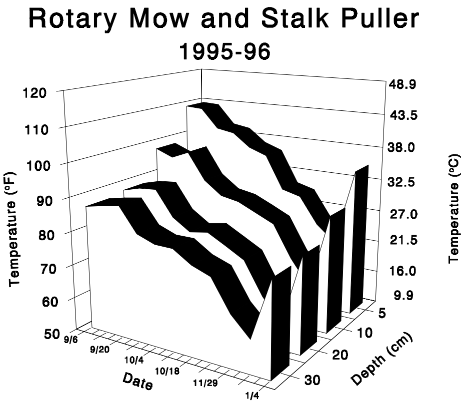

Fig. 5. 1995-96 rotary mow and stalk puller effects on soil temperature at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

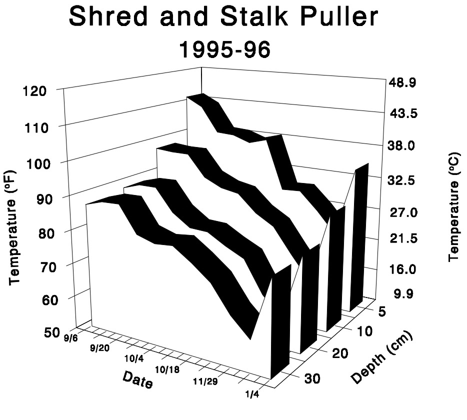

Fig. 6. 1995-96 shred and stalk puller effects on soil temperature at 5, 10, 20, and 30 cm soil depths as related to the proximity to the tillage operation.

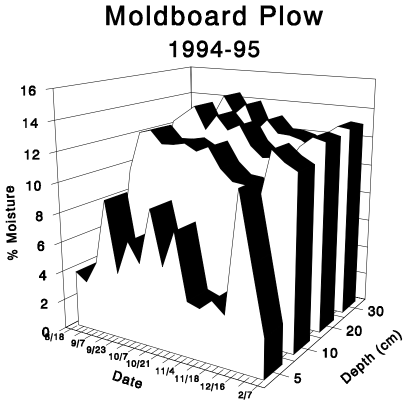

Fig. 7. 1994-95 moldboard plow effects on soil moisture at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

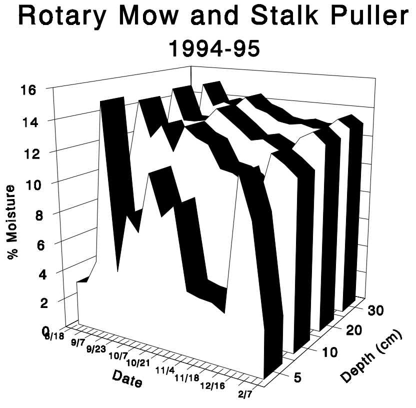

Fig. 8. 1994-95 rotary mow and stalk puller effects on soil moisture at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

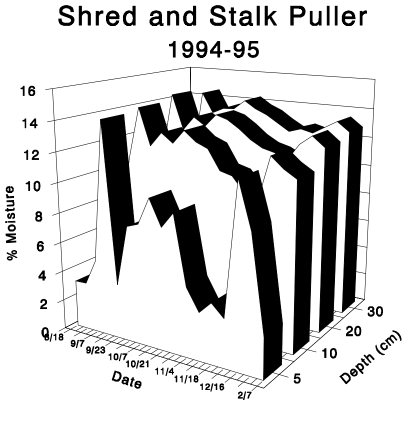

Fig. 9. 1994-95 shred and stalk puller effects on soil moisture at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

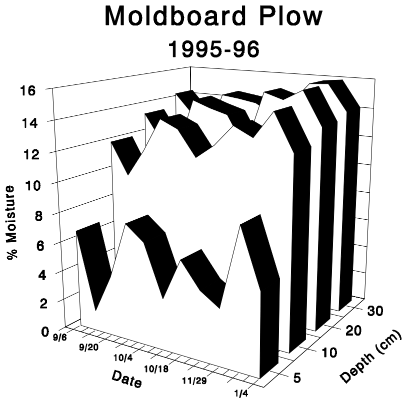

Fig. 10. 1995-96 moldboard plow effects on soil moisture at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

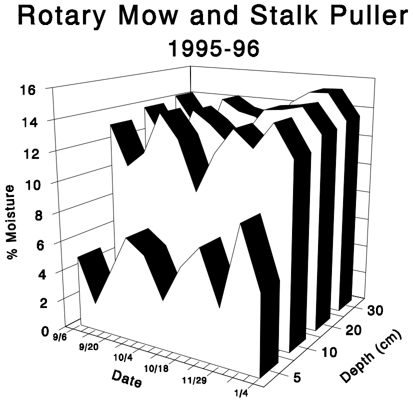

Fig. 11. 1995-96 rotary mow and stalk puller effects on soil moisture at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.

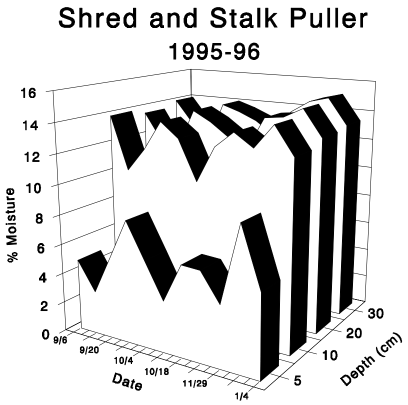

Fig. 12. 1995-96 shred and stalk puller effects on soil moisture at 5, 10, 20, and 30 cm soil depths as related to time proximity to the tillage operation.