MISSISSIPPI SOYBEAN PROMOTION BOARD
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2015 Annual Report

Project Title: Corn and Soybean Crop Residue Management Impact on Soil Quality, Yield and Returns

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BACKGROUND AND OBJECTIVES

Soil quality has been defined as how well the soil does what it is intended to do: "…soil quality is the capacity of a specific kind of soil to function, within natural or managed ecosystem boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and support human health and habitation" (NRCS, 2010a). Both soil organic matter and soil biology are key components of soil quality. A properly functioning soil is one that: is high in soil quality as determined by measurement; regulates water infiltration into and runoff from soil; sustains plant and associated animal life; filters potential pollutants; and recycles nutrients including the major crop nutrients of nitrogen (N), phosphorus (P), and potassium (K).

Soil structure encompasses both inherent and dynamic soil qualities. Factors such as parent material, climate, age, and landscape position are large factors in the inherent nature of a particular soil's structure, while dynamic physical, chemical and biological factors, which can be strongly influenced by management, are supplements that give to soil the structure ultimately responsible for cropping conditions.

Because soil aggregates are the basic units of soil structure, changes in aggregate stability or strength, and size, have been widely used as the measurement most indicative of improvement or reduction of soil structure, especially that of surface soil. Larger, more stable aggregates improve infiltration, water holding properties, aeration, and fertility, and reduce erosion potential. The use of tillage in crop production decreases the soil aggregate stability and organic matter content. Organic matter is the single most important cementing agent for surface soils and rooting zone. Organic residues applied to soil with different management systems have been shown to improve soil structure.

Information is unavailable in Mississippi regarding cropping systems and tillage effects on soil quality, ground residue cover, and yield. Since soil quality changes occur at a slow rate, a long-term 6-year (2011-2016) study is being conducted to learn how to manage different soil types (location) through cropping systems to improve soil function. These studies are being conducted to determine how corn and soybean crop residue management [burn corn crop residue (only) vs no-burn] and tillage in irrigated and non-irrigated environments affect 1) soil quality, crop growth, and yield; 2) crop residue yield and nutrient content in a corn-soybean rotation; and 3) the returns above total specified expenses for each tillage system and location.

REPORT OF PROGRESS/ACTIVITY

Soil analysis for soil aggregate stability, water holding capacity, soil respiration, soil microbial biomass, and crop residue fertilizer nutrient content are in the analysis process for both locations.

OBJECTIVE I

Verona (non-irrigated). Rainfall for June, July and August was 53, 142 and 192% of the 25-year (1987–2011) average (Table 1). Departure from the mean (DFM) monthly maximum air temperatures for June, July, and August were 0, +1 and -3 °F, respectively, from the 25-year (1987-2011) monthly means. Spring (March) bed heights and ground cover indicated a crop residue management (burn vs no-burn) by tillage interaction (Table 2). No-tillage, bed-roller and TerraTill bed heights indicated no difference between burn and no-burn. The disk (2x) + TerraTill bed height was greater with no-burn than the burn treatment. In both burn and no-burn, no-tillage and disk (2x) + TerraTill bed heights were lower than TerraTill and bed-roller. All tillage systems had less ground cover with burn than no-burn. The disk (2x) + TerraTill had less ground cover with both burn and no-burn treatments and was lower than all other tillage systems, except with the burn, TerraTill and disk (2x) + TerraTill ground cover were not different. No-tillage had the highest amount of ground cover (51% burn and 83% no-burn) and was higher than all other tillage systems. Soil bulk density indicated no differences among tillage systems (Table 2). Soil organic matter for no-tillage, bed-roller and TerraTill were not different but all were greater than the disk (2x) + TerraTill (Table 2). There were no plant population differences among tillage systems 14 and 28 days after planting (DAP) (Table 3). No-tillage plant heights 28 and 35 DAP were lower than disk + TerraTill, bed-roller and TerraTill (Table 3) with no differences at maturity.

Above normal rainfall and cooler temperatures during the August growing season resulted in high yields (70.4 to 75.1 bu/acre). TerraTill yield of 75.1 bu/acre was greater than no-tillage, disk (2x) + TerraTill and bed-roller with no differences between these tillage systems (Table 4). The disk (2x) + TerraTill compared to TerraTill alone did not enhance yield. Soil resistance measurements at the 3-inch and 6-inch depths were greater for no-tillage than the TerraTill and bed-roller (Table 4). But at the 3-inch depth, no-tillage was not different from the disk (2x) + TerraTill.

Stoneville (irrigated). DFM maximum air temperatures from the 30-year (1971-2000) monthly mean for the months June, July, and August ranged from +1 to +2 °F (Table 5). June, July and August rainfall was 59, 83, and 33% of the 30-year (1971-2000) monthly average, respectively. The March bed height of 3.7 inches for the bed-roller system was higher than all the other treatments (Table 6). The disk (2x) + TerraTill bed height of 0.8 inch was lower than all other tillage systems. March ground cover data indicated a crop residue management by tillage interaction (Table 6). Ground cover for no-tillage and bed-roller indicated no differences between burn and no-burn. While the TerraTill and disk (2x) + TerraTill had more ground cover in the no-burn than burn. In both burn and no-burn, no-tillage had more ground cover than all other tillage systems and TerraTill had more ground cover than bed-roller and disk (2x) + TerraTill. In the burn, bed-roller and disk (2x) + TerraTill ground cover were not different, but lower than no-tillage and TerraTill. While in the no-burn, the disk (2x) + TerraTill ground cover was greater than the bed-roller. Soil root resistance at the 3-inch depth indicated no-tillage had greater resistance than the other tillage system. At the 6-inch depth, no-tillage and bed-roller had greater resistance than TerraTill. The TerraTill and disk (2x) + TerraTill were not different. The disk (2x) + TerraTill and TerraTill resistance were not different. Soil bulk density and soil organic matter (Table 6), plant populations 6, 11 and 17 DAP, and early season (17 to 33 DAP) plant height indicated no differences among tillage systems (Table 7). Yields ranged from 32.3 to 36.8 bu/acre with no tillage treatment differences. The low yields are attributed to June 6 planting date and extreme dry period during the pod-fill period with only two irrigations. The limited number of irrigations were related to irrigation issues. TerraTill had lower 100 seed weights than no-tillage, and disk (2x) + TerraTill but was not different from the bed-roller (Table 8).

Objective II

Crop residue yields were not influenced by crop residue management or tillage systems for both locations. Verona soybean crop residue yields ranged from 2.13 to 2.45 tons/acre with no differences among tillage systems (Table 4). The Stoneville soybean crop residue yields ranged from 1.46 to 1.70 tons/acre (Table 8). The TerraTill crop residue yield of 1.70 tons/acre was greater than the disk (2x) + TerraTill but not different from no-tillage and bed-roller. The no-tillage, bed-roller and disk (2x) + TerraTill crop residue yields were not different. Crop residue fertilizer (S, N, P and K) nutrient content are in the analysis process for both locations.

Objective III

The 2015 economic analysis for both locations indicated crop residue management had no influence on net returns above total specified costs; and there was no crop residue management by tillage systems interaction. The net returns for Verona ranged from $310/acre to $360/acre with differences in tillage systems (Table 4). TerraTill had the highest return of $360/acre and was greater than no-tillage and the disk (2x) + TerraTill. TerraTill and bed-roller indicated no return differences. Stoneville had negative returns above total specified cost and ranged from -$22 to - $51/acre with no differences between tillage systems (Table 8). The negative returns were related to the low yields associated with irrigation failures.

Impacts and Benefits

With the exception of 2014 (above normal rainfall and cooler temperatures) at Verona (non-irrigated environment), TerraTill (in-row subsoil bed-roller, a one pass operation) had higher yields and net returns ($60, 2012; $126, 2013; $25, 2014; and $15/acre in 2015) than no-tillage (old beds). The results indicated the disk operations [disk (2x) + TerraTill vs TerraTill] did not enhance yield or net returns at both locations. Therefore, the one-pass TerraTill (a one-pass conservation tillage system) in a non-irrigated environment would reduce the cost of production by $18/acre in comparison to the disk (2x) + TerraTill which would result in $9000 savings on 500 acres of soybeans.

In contrast, four-year (2012-2015) results for the Stoneville, in an irrigated environment, indicated no-tillage (old beds), yields and net returns were equivalent or higher than the TerraTill, disk (2x) + TerraTill and bed-roller all of four years. In a controlled traffic system and irrigated environment, disking and/or in-row-subsoiling (TerraTill) may not be necessary for maximizing returns. Using a bed-roller system as the primary tillage every year would cost $8.00/acre and $4.00/acre using it every other year. The annual bed-roller would result in $9/acre savings compared to the TerraTill and $27/acre savings compared to disk (2x) + TerraTill. Using the bed-roller every other year (no-tillage on old beds) would result in a two-year average cost of $4/acre. This would result in a $14/acre savings in comparison to annual TerraTill and $32/acre savings compared to the disk (2x) + TerraTill.

End Products

I. 2015

- Journal publications: none.
- Conference/professional meeting presentations:
  Ebelhar, M.W., N.W. Buehring and W.L. Kingery. 2015. Crop residue management and tillage interactions for soybean/corn rotation. Southern Branch ASA meeting, Southern Association of Agricultural Scientist Meeting, Feb. 1-4, 2015, Atlanta, GA.
- Shanmugam, S.G, M.W. Ebelhar, M.S. Cox, J.L. Oldham and W.L. Kingery. 2015. Impact of tillage and residue management on soil microbial biodiversity under soybean-corn rotation. Annual Meeting of the American Society of Agronomy. Minneapolis, MN. Nov. 15-18, 2015.

- Taylor, A.R., N.W. Buehring, M.P. Harrison, L.L. Falconer, M.W. Ebelhar, W.L. Kingery and S.G. Shanmugam. 2015. Crop residue management and tillage system effect on bed height, ground cover, corn grain yield and net returns in a soybean/corn rotation. American Society Agronomy Meeting. Minneapolis, MN. Nov. 15-18, 2015.
- Harrison, M.P., N.W. Buehring, A.R. Taylor, M.W. Ebelhar, L.L. Falconer, W.L. Kingery and S.G. Shanmugam. 2015. Soybean yield and net returns response to corn crop residue management and tillage systems in a corn/soybean rotation. American Society Agronomy Meeting, Minneapolis, MN. Nov. 15-18, 2015.
- Falconer, L.L., N.W. Buehring and M.W. Ebelhar. 2016. Economic analysis of corn and soybean crop residue management strategies in Mississippi. Southern Agricultural Economic Association Meeting, February 5-9, 2015, San Antonio, TX.
- Poster Presentations:
- Harrison, M.P., N.W. Buehring, A.R. Taylor, M.W. Ebelhar, L.L. Falconer, W. Kingery and S.G. Shanmugam. Soybean yield and net return response to corn crop residue management. North Mississippi Producer Advisory Council meeting, February 18, 2015.
- Shanmugam, S.G., N.W. Buehring, M.W. Ebelhar, M.S. Cox, J.L. Oldham and W.L. Kingery. 2015. Impact of tillage and residue management on soil microbial biodiversity under soybean-corn rotation. Annual Meeting of the American Society of Agronomy. Minneapolis, MN. Nov. 15-18, 2015.
- Taylor, A.R., N.W. Buehring, M.P. Harrison, L.L. Falconer, M.W. Ebelhar, W.L. Kingery and S.G. Shanmugam. 2015. Crop residue management and tillage system effect on bed height, ground cover, corn grain yield and net returns in a soybean/corn rotation. American Society Agronomy Meeting. Minneapolis, MN. Nov. 15-18, 2015.
- Harrison, M.P., N.W. Buehring, A.R. Taylor, M.W. Ebelhar, L.L. Falconer, W.L. Kingery and S.G. Shanmugam. 2015. Soybean yield and net returns response to corn crop residue management and tillage systems in a corn/soybean rotation. American Society Agronomy Meeting, Minneapolis, MN. Nov. 15-18, 2015.

II. Publications/conferences presentations planned for 2016.

- Agron. Journal. (in preparation)
  1. Impact of tillage and crop residue practices on soil chemical and microbiological properties in a corn-soybean rotation.
  2. Impact of tillage and crop residue management practice on corn and soybean yield response and net returns in a corn-soybean production system.
- 2016 Conference Presentations:

  Falconer, L. and N.Buehring. 2016. Economic analysis of corn and soybean corn residue management and tillage strategies in Mississippi. Southern Association of Agricultural Economic Association Meeting, Feb. 6-9, 2016, San Antonio, TX.

Table 1. Monthly rainfall and mean monthly maximum air temperature in 2015, Verona, MS.

	----------Maximum air temp (°F)-----------			-------------Rainfall (in)------------		
Month	**2015**	**1987-2011**	**DFM[1]**	**2015**	**1987-2011**	**%**
April	75	74	-1	7.63	4.96	154
May	83	82	+1	6.66	5.53	120
June	88	88	0	2.52	4.73	53
July	93	92	+1	6.46	4.56	142
Aug	89	92	-3	7.36	3.84	192

[1]DFM means departure (+/-) from the 25-year (1987-2011) average.

Table 2. Influence of tillage system on soil bulk density, soil organic matter, bed height and ground cover in 2015, Verona, MS.

	------------------------March----------------------				Soil bulk	Soil organic
	Bed height (in)		% Ground cover		density	matter
Tillage	**Burn**	**No-burn**	**Burn**	**No-burn**	**g/cm^3**	**%**
No-tillage	3.9 A[2]b[1]	4.2 Ac	51 Ba	83 Aa	1.86 a	1.14 a
Bed-roller	5.7 Aa	6.4 Aa	35 Bb	59 Ab	1.85 a	1.12 a
TerraTill	5.1 Aa	5.3 Ab	32 Bbc	54 Ab	1.89 a	1.09 a
Disk (2x) + TerraTill	3.0 Bc	4.0 Ac	23 Bc	29 Ac	1.91 a	0.99 b

[1]Numbers in a column with the same lower case letter are not significantly different at the 5% probability level.
[2]Numbers across columns within the subject with same upper case letters are not different at the 5% probability level.

Table 3. Influence of tillage system on early season soybean plant population and plant height, averaged over crop residue management systems in 2015, Verona, MS.

	---Plants/acre---		----------------Plant height (in)---------------		
	-------------------Days after planting---------------------				
Tillage system	**14**	**28**	**28**	**35**	**Maturity**
No-tillage	121,726 a[1]	127,399 a	6.0 b	9.4 b	40.0 a
Bed-roller	124,648 a	126,540 a	6.6 a	10.8 a	42.2 a
TerraTill	119,147 a	121,382 a	6.7 a	10.8 a	42.0 a
Disk (2X)+ TerraTill	125,336 a	126,540 a	7.1 a	10.9 a	41.9 a

[1]Numbers in a column with the same lower case letters are not significantly different at the 5% probability level.

Table 4. Influence of tillage system on seed weight, soybean grain yield, crop residue yield, soil resistance and returns above total specified costs in 2015, Verona, MS.

Tillage system	Seed wt g/100	Grain yield bu/acre	Crop residue yield ton/acre	Net returns[2] $/acre[2]	Soil resistance depth -----------(lb/in^2)----------- 3-in	6-in
No-tillage	15.5 a[1]	70.4 b	2.18 a	335 b	125 a	215 a
Bed-roller	15.6 a	72.0 b	2.23 a	341 ab	104 b	118 b
TerraTill	16.2 a	75.1 a	2.13 a	360 a	103 b	128 b
Disk (2x) + TerraTill	14.9 a	71.7 b	2.45 a	310 b	116 ab	128 b

[1]Numbers in a column with the same lower case letters are not significantly different at the 5% probability level.
[2] Net Returns above total specified costs.

Table 5. Monthly rainfall and monthly mean maximum air temperature in 2015, Stoneville, MS.

Month	-------Maximum air temp (°F)----- 2015	1971-2000	DFM[1]	---------------Rainfall (in)--------------- 2015	1971-2000	% 30-yr avg
April	76	74	+2	6.33	5.32	119
May	83	83	0	6.96	5.10	136
June	91	89	+2	2.57	4.33	59
July	93	91	+2	3.17	3.80	83
Aug	92	91	+1	0.73	2.21	33

[1]DFM means departure (+/-) from the 30-year (1971-2000) average.

Table 6. Influence of tillage system on bed height, soil resistance, soil organic matter, ground cover and soil bulk density in 2015, Stoneville, MS.

Tillage	March bed height (in)	March % ground cover burn	no-burn	Soil resistance (lb/in^2) 3-in	6-in	Soil bulk density g/cm^3	Soil organic Matter %
No-tillage	1.9 b[1]	81 A[2]a	86 Aa	150 a	227 a	1.54 a	1.00 a
Bed-roller	3.7 a	23 Ac	34 Ad	120 b	212 ab	1.57 a	1.10 a
TerraTill	2.9 b	61 Bb	73 Ab	113 b	177 c	1.58 a	1.10 a
Disk (2X) + TerraTill	0.8 c	33 Bc	63 Ac	111 b	190 bc	1.55 a	1.10 a

[1]Numbers in a column with the same lower case letter are not significantly different at the 5% probability level.
[2]Numbers across columns within the same subject matter with the same upper case letters are not significantly different at the 5% probability level.

Table 7. Influence of tillage system on plant population and plant height, averaged over crop residue management systems in 2015, Stoneville, MS.

	---------------Plants/acre---------------			---------Plant height (in)----------		
	---Days after planting----------------------					
Tillage System	**6**	**11**	**17**	**17**	**24**	**33**
No-tillage	48,352 a[1]	73,290 a	99,535 a	4.8 a	8.0 a	13.3 a
Bed-roller	58,915 a	60,440 a	93,436 a	4.7 a	7.8 a	13.0 a
TerraTill	50,747 a	67,845 a	104,217 a	5.0 a	7.7 a	12.5 a
Disk (2X) + TerraTill	42,263 a	54,777 a	100,297 a	5.1 a	7.7 a	13.3 a

[1]Numbers in a column with the same letter are not significantly different at the 5% probability level.

Table 8. Influence of tillage system on soybean grain yield, crop residue yield, net returns and seed weight, averaged over crop residue management systems in 2015, Stoneville, MS.

Tillage system	**Grain yield bu/acre**	**Net returns \$/acre[2]**	**Seed wt. g/100**	**Crop residue ton/acre**
No-tillage	34.8 a	-22 a	12.48 a	1.62 ab
Bed-roller	32.3 a	-51 a	12.22 ab	1.52 ab
TerraTill	34.6 a	-40 a	12.07 b	1.70 a
Disk (2X) + TerraTill	36.8 a	-39 a	12.40 a	1.46 b

[1]Numbers in a column with the same lower case letters are not significantly different at the 5% probability level.
[2]Net returns per acre above total specified costs.