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

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BACKGROUND AND OBJECTIVES

Soil organic matter and soil biology (microbial communities' population, diversity, and biomass) are key components of soil quality. High soil quality that properly functions 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.

Soil structure encompasses inherent and dynamic soil qualities (aggregate stability, organic matter). Parent material, climate, age, and landscape position are large factors in soil structure. The dynamic physical, chemical and biological factors that give soil its structure are ultimately responsible for cropping conditions and can be influenced by management. Larger soil aggregates are more stable and improve water infiltration, water holding properties, aeration, fertility, and reduce erosion potential. Tillage in crop production can decrease the soil's aggregate stability and organic matter content.

Little information is available 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, long-term (2011-2016) studies were conducted on silt loam soils at two locations. The studies were conducted in soybean/corn rotations using controlled traffic systems. The objectives were to evaluate corn crop residue management [burn corn residue vs no-burn] and tillage systems in irrigated (Stoneville) and non-irrigated (Verona) on: 1) soil quality (soil organic matter, aggregate stability, water holding capacity, respiration and microbial biomass, and soybean growth and yield; 2) crop residue yield and nutrient content (N, P, and K); and 3) returns above total specified expenses for each tillage system.

Soil P and K levels were maintained at high soil test levels. All tillage treatments [(no-tillage (old beds), bed-roller, TerraTill (one-pass operation, in-row subsoil-bed-roller) and disk 2(x) + TerraTill] were applied in the fall of each year, except Stoneville where 2013 and 2015 wet soil conditions delayed fall tillage applications until January 2014 and March 2016, respectively. In order to maintain bed heights greater than 3.0 inches, the no-tillage (old bed) system beds had to be reshaped every other year (March 2014 and 2016). Irrigation timing at Stoneville was based on visual observation and rainfall events. Each row middle was watered through roll-out plastic polypipe from a surface water source. With above normal rainfall during the 2016 growing season, only two irrigations were necessary to meet soybean crop water requirements.

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 laboratory analysis process or in the analysis preparation process for both locations. The delayed (fall 2016 drought followed by wet field conditions) fall corn crop residue burn and fall tillage applications were completed in March 2017 at both locations.

Objective 1

Verona (non-irrigated): Rainfall for June, July and August was 59, 21 and 105% of the 25-year (1987–2011) average (Table 1). Departure from the mean (DFM) monthly maximum air temperatures for June, July, and August were +4, +2 and +1 °F, respectively, from the 25-year (1987-2011) monthly means.

There was no crop residue management effect and no crop residue management by tillage interaction for all factors evaluated. Disk (2x) + TerraTill and no-tillage bed heights were lower than bed-roller and TerraTill (Table 2). Bed-roller beds were taller than no-tillage, TerraTill and disk (2x) + TerraTill. The disk (2x) + TerraTill and bed-roller had less ground cover than no-tillage and TerraTill which were not different (Table 2). Disk (2x) + TerraTill had lower organic matter than the other tillage systems which were not different (Table 2). There were no plant population differences among tillage systems 7 and 20 days after planting (DAP) (Table 3). Plant heights 21 and 35 DAP and at maturity indicated no differences among tillage systems (Table 3). Yields ranged from 65.3 to 70.6 bu/acre with no differences among tillage systems (Table 4). One hundred seed weights also indicated no differences between tillage systems (Table 4).

Stoneville (irrigated): DFM maximum air temperatures from the 25-year (1987-2011) monthly mean for June, July, and August ranged from 0 to +1 °F (Table 5). June, July and August rainfall was 157, 170, and 204% of the 25-year (1987-2011) monthly average, respectively (Table 5). There was no crop residue management effect and no crop residue by tillage interaction for all factors evaluated. The March bed heights ranged from 1.4 to 2.6 inches (Table 6). No-tillage, bed-roller and TerraTill bed heights were not different. The disk (2x) + TerraTill bed height of 1.4 inch was not different from no-tillage but was lower than TerraTill and bed-roller. Ground cover for no-tillage and bed-roller indicated no differences but both were greater than TerraTill and disk (2x) + TerraTill (Table 6). Plant populations 10 and 16 DAP and early season (16 to 30 DAP) plant height indicated no differences among tillage systems (Table 7). Yields ranged from 67.5 to 69.4 bu/acre with no tillage treatment differences (Table 8). Bed-roller had lower 100 seed weights than disk (2x) + TerraTill but was not different from TerraTill and no-tillage (Table 8).

Soil Quality: Soil quality factors (aggregate stability, water holding capacity, microbial biomass and respiration) first began to show differences in 2015 at both locations (Table 9). Except for water holding capacity at Verona and Stoneville, no-tillage (old beds) most often had higher soil quality values than the other tillage systems. No-tillage, bed-roller and disk (2x) + TerraTill water holding capacities were not different at both locations, but no-tillage had greater water holding capacity than TerraTill. At Stoneville and Verona, TerraTill and no-tillage aggregate stability were not different; and at Stoneville, TerraTill and no-tillage soil respiration values were not different. No tillage had greater microbial biomass than the other tillage systems at both locations.

Objective 2

There was no crop residue management effect or crop residue management by tillage systems interaction for crop residue yields at both locations. Verona soybean crop residue yields ranged from 1.05 to 1.36 tons/acre (Table 4). TerraTill was not different from no-tillage but was higher than bed-roller and disk (2x) + TerraTill. The Stoneville soybean crop residue yields ranged from 2.48 to 3.10 tons/acre (Table 8). The TerraTill crop residue yield of 2.48 tons/acre was equal to the disk (2x) + TerraTill and no-tillage but lower than bed-roller. Crop residue's nutrient (N, P and K) content is in the analysis phase.

Objective 3

The 2016 economic analysis for both locations indicated there was no crop residue management or crop residue management by tillage systems interactions for returns above total specified costs. Returns for Verona ranged from $361 to $431/acre with differences in tillage systems (Table 4). TerraTill had the greatest return of $431/acre and was greater than the disk (2x) + TerraTill but was not different from no-tillage and bed-roller. Stoneville returns ranged from $334 to $352/acre with no differences between tillage systems (Table 8).

IMPACTS AND BENEFITS TO MISSISSIPPI SOYBEAN PRODUCERS

The five-year results indicate the disk operations [disk (2x) + TerraTill vs TerraTill] did not enhance yield or net returns at both locations. In the non-irrigated environment (Verona), TerraTill (in-row subsoil-bed-roller, one pass operation) returns above total specified cost were greater than no-tillage (re-shaped beds every two years), bed-roller and disk (2x) + TerraTill.

In contrast, in the irrigated environment at Stoneville, no-tillage (old beds) yield and net return was equivalent or higher than the TerraTill, (in-row subsoil-bed-roller, one-pass operation), disk (2x) + TerraTill, and bed-roller. Neither subsoiling nor disking (2x) are necessary in the Mississippi Delta, and compared to TerraTill or disk (2x) + TerraTill, the annual bed-roller system reduces production costs by $4000 or $22,000/1000 acre farm, respectively. Preliminary results indicate reducing tillage operations improved soil quality.

END PRODUCTS

Journal Publications:

Shanmugam, S.G., N.W. Buehring, M.W. Ebelhar, M.S. Cox, J.L. Oldham, D.G. Peterson and W.L. Kingery. 2016. Short-term effects of tillage treatments on soil microbial biodiversity under soybean-corn rotation. International Journal of Agriculture and Environmental Research 2: 1277-1303.

Professional Meetings:

- Falconer, L.L., N.W. Buehring and M.W. Ebelhar. 2016. Economic analysis of corn and soybean crop residue management and tillage strategies in Mississippi. Southern Agricultural Economic Association 2016 Annual Meeting, San Antonio, TX, February 6-9, 2016.
- Ebelhar, M., and N.W. Buehring. 2016. Effect of residue management and tillage on corn and soybean yields in rotations. In annual meeting abstracts [CD] ASA-CSSA and SSSA. Phoenix, AZ, November 7, 2016.

- Shanmugam, S.G., N.W. Buehring, M.W. Ebelhar, M.S. Cox, J.L. Oldham and W.L. Kingery. 2016. Long term impact of tillage and crop rotation management on soil microbial biodiversity and soil health. In annual meeting abstracts [CD] ASA, CSSA and SSSA, Phoenix, AZ, November 7, 2016.

Grower Meetings:

- Harrison, M.P., N.W. Buehring, A.R. Taylor, M.W. Ebelhar, L.L. Falconer, W.L. Kingery and S.G. Shanmugam. 2016. Soybean yield and net returns response to corn crop residue management and tillage systems in a corn/soybean rotation. Presented at the North Mississippi Research and Extension Center Producer Advisory Council Meeting, February 18, 2016, Verona. MS.
- Taylor, A.R., M.P. Harrison, N.W. Buehring, M.W. Ebelhar, L.L. Falconer, W.L. Kingery, and S.G. Shanmugam. Crop residue management and tillage systems effect on bed height, ground cover, corn grain yield and net returns. 2016. Presented at the North Mississippi Research and Extension Center Producer Advisory Council Meeting, February 18, 2016, Verona, MS.

Table 1. Monthly rainfall and mean monthly maximum air temperature in 2016, Verona, MS.

	----------Maximum air temp (°F)----------			----------Rainfall (in)----------		
		25-yr avg			25-yr avg	
Month	DFM[1] 2016	(1987-2011)	DFM[1]	2016	(1987-2011)	%
April	75	74	+1	4.38	4.96	88
May	81	82	-1	0.90	5.53	16
June	92	88	+4	2.81	4.73	59
July	94	92	+2	0.96	4.56	21
Aug	93	92	+1	4.02	3.84	105

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

Table 2. Influence of tillage system on soil organic matter, bed height and ground cover, averaged over crop residue management systems in 2016, Verona, MS.

	----------March----------		
Tillage	**Bed height (in)**	**% Ground cover**	**% Soil organic matter**
No-tillage	3.3 c[1]	90 a	1.41 a
Bed-roller	7.0 a	81 c	1.36 a
TerraTill	5.6 b	88 a	1.28 a
Disk (2x) + TerraTill	3.4 c	83 b	1.08 b

[1]Numbers in a column with the same lower case letter are not significantly different according to Fisher's Protected LSD (P=0.05).

Table 3. Influence of tillage system on soybean plant population and early season plant height, averaged over crop residue management systems in 2016, Verona, MS.

		----------	----------Plant height (in)----------			
		----------Days after planting----------				
Tillage system		**7**	**20**	**21**	**35**	**Maturity**
No-tillage		120,866 a[1]	130,322 a	3.5 a	10.4 a	48.9 a
Bed-roller		117,256 a	123,445 a	3.5 a	10.4 a	49.3 a
TerraTill		113,098 a	122,929 a	3.8 a	10.6 a	48.6 a
Disk	(2X)+	99,203 a	129,634 a	3.6 a	10.4 a	48.6 a

[1]Numbers in a column with the same lower case letter are not significantly different according to Fisher's Protected LSD (P=0.05).

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Table 4. Influence of tillage system on seed weight, soybean grain yield, crop residue yield and returns above total specified costs, averaged over crop residue management systems in 2016, Verona, MS.

Tillage system	Seed wt g/100	Grain bu/acre	Crop residue yield ton/acre	Returns $/acre[2]
No-tillage	13.0 a[1]	66.6 a	1.23 ab	401 ab
Bed-roller	14.0 a	67.0 a	1.15 b	406 ab
TerraTill	13.1 b	70.6 a	1.36 a	431 a
Disk (2x) +	12.7 b	65.3 a	1.05 b	361 b

[1]Numbers in a column with the same lower case letter are not significantly different according to Fisher's Protected LSD (P=0.05).
[2]Returns above total specified costs.

Table 5. Monthly rainfall and monthly mean maximum air temperature in 2016, Stoneville, MS.

	-------Maximum air temp (°F)-----			----------Rainfall (in)----------		
Month	2016	25-yr avg (1987-2011)	DFM[1]	2016	25-yr avg (1987-2011)	% 25-yr avg
April	77	72	+5	4.31	5.13	84
May	83	84	-1	3.26	4.94	67
June	91	90	+1	5.06	3.23	157
July	93	92	+1	6.53	3.83	170
Aug	92	92	0	5.48	2.69	204

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

Table 6. Influence of tillage system on bed height and ground cover, averaged over crop residue management systems in 2016, Stoneville, MS.

Tillage system	March bed height (in)	March % ground cover
No-tillage	2.2 ab[1]	59 a
Bed-roller	2.6 a	55 a
TerraTill	2.5 a	42 b
Disk (2X) + TerraTill	1.4 b	41 b

[1]Numbers in a column with the same letter are not significantly different according to Fisher's Protected LSD (P=0.05).

Table 7. Influence of tillage system on plant population and plant height, averaged over crop residue management systems in 2016, Stoneville, MS.

	---------Plants/acre---------		---------Plant height (in)----------		
	----------Days after planting----------				
Tillage System	**10**	**16**	**16**	**24**	**30**
No-tillage	92,130 a[1]	159,430 a	2.3 a	2.8 a	4.7 a
Bed-roller	83,635 a	155,836 a	2.2 a	2.8 a	4.6 a
TerraTill	80,368 a	146,188 a	2.1 a	2.8 a	4.7 a
Disk (2X) + TerraTill	77,428 a	146,362 a	2.2 a	2.8 a	4.6 a

[1]Numbers in a column with the same letter are not significantly different according to Fisher's Protected LSD (P=0.05).

Table 8. Influence of tillage system on soybean grain yield, crop residue yield, returns and seed weight, averaged over crop residue management systems in 2016, Stoneville, MS.

Tillage system	**Grain yield bu/acre**	**Returns $/acre[2]**	**Seed weight g/100**	**Crop residue ton/acre**
No-tillage	68.6 a[1]	352 a	13.4 ab	2.98 ab
Bed-roller	67.5 a	342 a	13.2 b	3.10 a
TerraTill	69.0 a	347 a	13.4 ab	2.48 b
Disk (2X) + TerraTill	69.4 a	334 a	13.5 a	2.89 ab

[1]Numbers in a column with the same lower case letters are not significantly different according to Fisher's Protected LSD (P=0.05).
[2]Returns per acre above total specified costs.

Table 9. Soybean soil quality factor analysis, averaged over crop residue management in 2015, Verona and Stoneville, MS.

Tillage	**% Aggregate stability**	**% Water holding capacity**	**Microbial biomass ug co_2/gm soil**	**Soil respiration ug co_2/gm soil**
	----------Verona----------			
No-tillage	57 a[1]	26 a	43 a	61 a
Bed-roller	44 b	24 a	30 d	50 bc
TerraTill	47 ab	20 b	37 b	54 b
Disk (2x) + TerraTill	44 b	23 ab	32 c	47 c
	----------Stoneville----------			
No-tillage	56 a	38 a	41 a	73 a
Bed-roller	40 b	36 a	25 b	46 b
TerraTill	50 a	25 b	31 b	65 a
Disk (2x) + TerraTill	39b	32 a	30 b	53 b

[1]Within a column, numbers with the same lower case letters are not significant according to Fisher's Protected LSD (P=0.05).