Mapping of Spatial and Vertical Variation of Soil Mechanical Resistance Using a Linear Pressure Model

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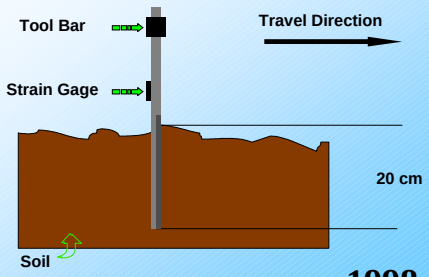
Reasoning

- There is a need to continuously measure soil mechanical resistance at various depths
- A vertical smooth blade is a simple mechanical system (cantilever beam) that can be pulled through the field
- An array of strain gauges can be used to detect blade's deflection resulting from variable soil resistance loads

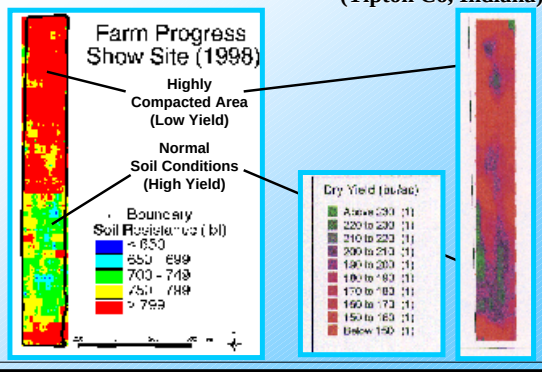
Soil Resistance Measurement



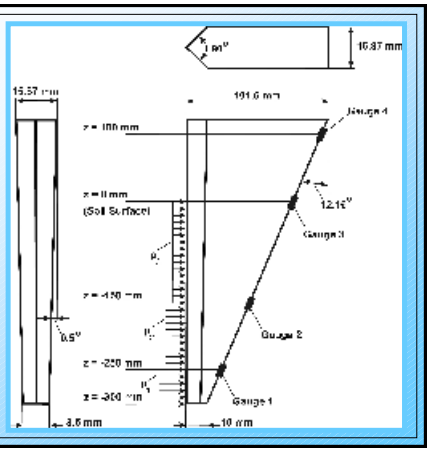
1998

Effect of Soil Compaction

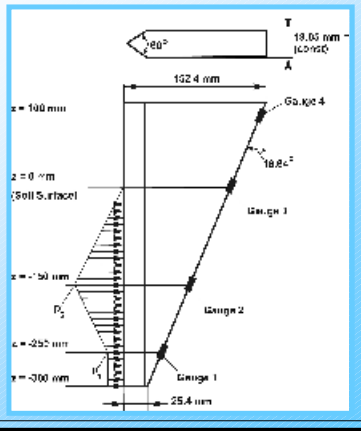
(Tipton Co, Indiana)



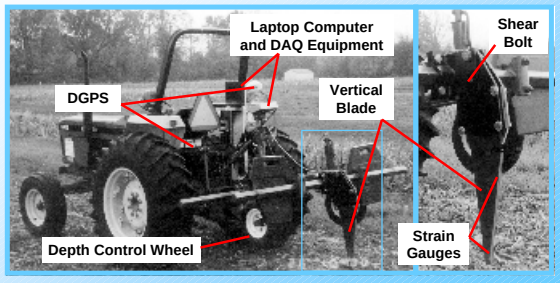
1999



2000



Soil Resistance Measuring Systems



Soil Resistance Parameters

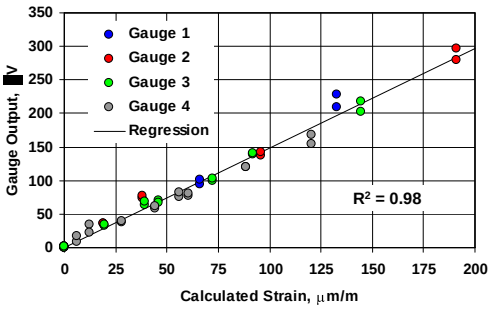
$$\begin{Bmatrix} p_1 \\ p_2 \end{Bmatrix} = \begin{bmatrix} 0.0157 & 0.0062 & 0.0128 & -0.0136 \\ -0.0441 & 0.0054 & -0.0070 & 0.0273 \end{bmatrix} \begin{Bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \end{Bmatrix}$$

Gauge Outputs

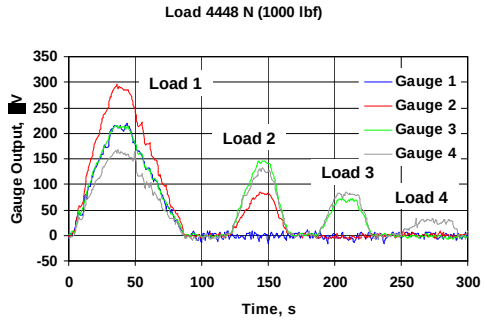
p_1 = soil resistance 25 cm below surface, MPa
p_2 = soil resistance 15 cm below surface, MPa
p = average soil resistance, MPa
P_θ = soil resistance change with depth, MPa/m

$$p = \frac{1}{3} p_1 + \frac{5}{12} p_2 \qquad p_\theta = \frac{p_1 - p_2}{z_2 - z_1}$$

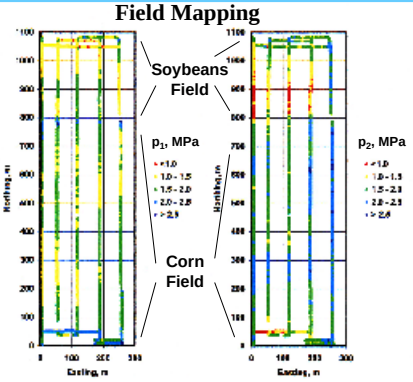
Laboratory Test



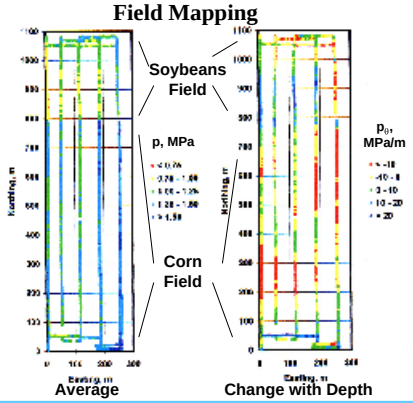
Laboratory Test



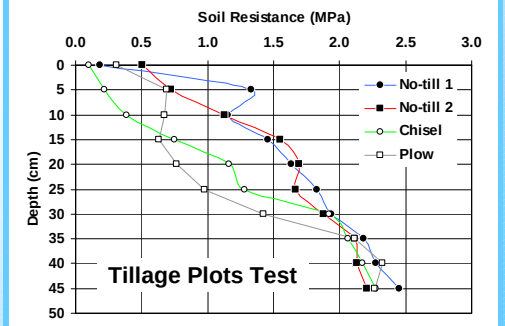
Field Mapping



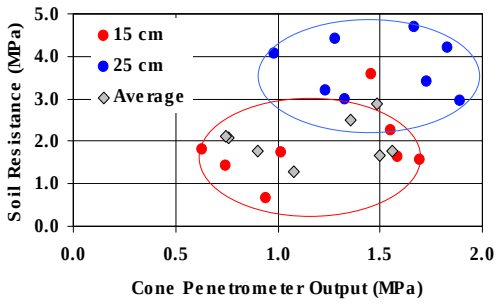
Field Mapping



Cone Penetrometer Resistance



Tillage Plots Test



Tillage Plots Test

Tillage	Moisture	Cone Penetrometer			Soil Resistance Measuring System			
Plot	%	25 cm	15 cm	Avg.	p_1 (25 cm)	p_2 (15 cm)	p	p_0
		MPa	MPa	MPa	MPa	MPa	MPa	MPa/m
Test 1 (04/16/01)								
Chisel	24	1.3	0.7	0.8	4.4	1.4	2.1	30
No-till 1	28	1.8	1.5	1.5	4.2	3.6	2.9	6
No-till 2	28	1.7	1.6	1.4	4.7	2.3	2.5	24
Plow	27	1.0	0.6	0.7	4.1	1.8	2.1	23
Test 2 (04/20/01)								
Chisel	25	1.3	0.9	1.1	3.0	0.7	1.3	23
No-till 1	26	1.7	1.7	1.6	3.4	1.6	1.8	18
No-till 2	26	1.9	1.6	1.5	3.0	1.6	1.7	13
Plow	27	1.2	1.0	0.9	3.2	1.7	1.8	15

Conclusions

- A vertical smooth blade can be used to map spatial and vertical variation of soil resistance
- Mathematical equations were proven through a laboratory test
- A commercial field was mapped to identify specific compaction related field areas
- Tillage plots test was conducted to compare vertical blade and cone penetrometer methods

Future Work

- Depth control
- Eliminating plant residues
- Data collection improvement
- Moisture and travel velocity compensation
- Usage of soil resistance maps
- Agroeconomic evaluation

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