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THE EFFECTS OF SPRING TILLAGE ON CROP EMERGENCE AND SOIL MOISTURE

by

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SUMMARY:

The effects of primary and secondary tillage on crop emergence and soil moisture was determined for a clay loam soil under Southern Alberta, Canada, growing conditions. Experimental factors included tillage depth and secondary tillage. While some trends were apparent from the soil moisture, particle size and trash results, no statistically significant relationship between experimental factors resulted. A literature review was also completed on the effect of spring tillage on soil moisture and crop yield. The literature review showed tillage experiments are site specific and yield results are often non-repeatable even under the same soil conditions.

KEYWORDS:

Soil Moisture,Tillage

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INTRODUCTION

Early spring tillage continues to be used in most farming practices to control weeds and prepare seedbeds. While weed control and seedbed preparation is required, moisture loss in the soil should be limited where possible.

A literature review was completed on the effect of spring tillage on soil moisture and crop yield. The literature review shows tillage experiments are site specific and yield results are often non-repeatable even under the same soil conditions. While tillage changes soil characteristics, the effects are usually not of the magnitude to significantly affect emergence and early plant growth in experimental plots. Most experiments on effects of different tillage systems yield non-significant results or inconsistent data from year to year. Tillage experiment inconsistencies are due to the complexity of changes in soil properties caused by tillage.

LITERATURE REVIEW

Tillage influences crop growth and yields by changing soil structure and moisture removal patterns over the growing season. Soil structure and moisture removal changes are dependent on soil properties, types of tillage and climatic conditions. Moisture removal patterns are of most importance to semi-arid regions of Canada since moisture is usually the limiting crop yield factor (Lindwall 1984). Tillage changes soil properties and the way the environment effects those properties. Soil properties and environment determine the rate of water movement in liquid and gaseous form into and out of soil. To understand how tillage changes soil moisture, soil properties affecting moisture need to be understood. Unfortunately, the relationship between soil moisture and tillage has not been completely defined.

The relationships between crop yield, soil moisture and tillage are not completely understood. The common approach to determining effect of tillage has been to evaluate tillage using crop yield or soil moisture content as per the following studies: Al-Darby and Lowery (1984), Bauer and Kucera (1978), Blevins et al. (1971), Bond et al. (1971), Chaplin et al. (1986), Douglas and McKyes (1983), Englehorn (1946), Fenster et al. (1964), Geiszler et al. (1971), Jones et al. (1969), Johnson et al. (1982), Kanwar (1989), Kramer and Alberts (1988), Larson (1964), Lindwall and Erbach (1983), McFarland et al. (1990), Power et al. (1958), Sarvis and Thysell (1936), Spomer and Hjelmfelt (1984), Tessier et al. (1990) and Wittmus and Yarzar (1980). While most researchers agree changes in soil moisture can influence crop growth depending on soil properties and environmental conditions, no general conclusions have been made (Belvins et al. (1971), Fenster et al. (1964), Kanwar (1989), Power et al. (1958) and Van Doren et al. (1976)). Experiments done by Lindwall (1983) and Tessier et al. (1990) indicated changes in soil moisture content due to tillage are not of the magnitude to influence crop production. General conclusions about tillage and crop yield are impractical because of the many combinations of soil properties, climate and crops. This was restated by Larson (1964) in an experiment on evaluation of tillage requirements for corn production. Larson (1964) concluded to define a set of parameters which could be used to evaluate tillage practices over wide areas is not practical because of limited knowledge and the many combinations of soil, crop and climate. Even when specific soil property changes on crop yield and soil moisture were understood, the tillage required to achieve those changes may not be possible or known (Ojeniyi and Dexter (1979a)).

Numerous experiments have shown tillage affects may be dependent on environmental and soil conditions (Allen et al. (1980), Fenster et al. (1964), Johnson et al. (1984), Kanwar (1989), Power et al. (1958), Sarvis and Thysell (1936)). Kanwar (1989) reported tillage systems affected soil-water tensions in the surface layer of soil in the second year of a two-year study. However, differences were not statistically significant at the 5% level in the first year of the study. An explanation of results was not given. However, Kanwar's results did conclude variable soil water tensions increased when soil became drier under all tillage systems. The amount of change in soil water tension began to decrease at 45 kPa of soil water tension. Water tension continued to decrease further at higher values of soil water tensions (reaching up to 80 kPa), indicating climatic conditions may have affected soil water tensions. An experiment by Fenster et al. (1964) concluded effects of tillage sequence on wheat yields were variable. Fenster et al. (1964) suggested weed control was of more importance for increasing yields during dry years but less important during years when moisture was adequate. Again, climate conditions affected tillage requirements and effects. Allen et al. (1980) found conservation tillage increased fallow season soil water storage and resulted in larger crop yields in dryland wheat and sorghum crops. Power et al. (1958) concluded yearly variations in climatic conditions appeared to have a much greater effect on factors of spring wheat production than the different methods of fallow (plow, one-way, stubble mulch, fall blade and fall chisel). Sarvis and Thysell (1936) concluded crops do not always respond to a given tillage method in the same manner and degree. This was concluded to be due to differences in climatic conditions. Johnson et al. (1984) compared three conservation tillage systems, chisel plowing, till plant and no till, to conventional moldboard plowing. Soil moisture advantages with conservation tillage varied because of profile water content, delayed plant growth and soil characteristics.

Changes in soil properties due to tillage may not be of the magnitude to effect crop production. Tessier et al. (1990) reported, in general, conservation tillage significantly improved water available to crops. However, despite enhanced soil water reserve, zero tillage practices did not consistently yield more than conventionally grown wheat. Lindwall and Erback (1983) indicated tillage and planting systems often had significant effects on soil bulk density, soil moisture, soil particle size distribution and residue cover. Again, these effects were usually not of the magnitude to significantly effect emergence and early plant growth. A ten year study by Chang and Lindwall (1990) concluded saturated hydraulic conductivity and plant available water holding capacity was significantly lower and bulk density was higher at the 30 to 60 mm depth in no till treatments than in the conventional tillage regime. However, none of the soil properties approached values that would limit yield of Winter Wheat crops. In addition, Chang and Lindwall (1990) found soil physical properties at a depth of 0 to 30 mm and 90 to 120 mm (below the tillage zone) were not significantly different among tillage and crop rotation treatments. Englehorn (1946) indicated the storage of soil moisture, either under summer fallow or continuous cropping, was not greatly affected by type of tillage.

Most experiments on tillage relations to soil moisture or crop yield are neither consistent nor show significant differences among different tillage trials. Kanwar (1989) stated although a no till system of tillage tended to show more soil water storage in the soil profile, no significant statistical difference was found between the tillage systems on the basis of two years of field data. Kanwar's (1989) results showed tillage systems have little or no effect on soil water storage in the soil profile. Kramer and Alberts (1988) reported results of a six year study of three tillage systems (moldboard plow, chisel plow and no till). They concluded tillage systems had no significant effect on plant population or grain yield. Chaplin et al. (1986) found no significant effect of tillage system (moldboard plow, chisel plow, ridge plant and no till) on irrigated corn or soybean yields. Bauer and Kucera (1978) concluded storage of soil water under annual cropping in North Dakota was not significantly affected by tillage method, nor was soil water content consistently greater under any one tillage method. Al-Darby (1984) stated plant emergence was not significantly different among moldboard plow, chisel plow, till plant and no till tillage practices. In addition, yield was only significantly higher on the no till compared to the moldboard plow one of two years.

Experiments showing significant yield responses to tillage are usually site specific and not repeatable in other soil conditions. Blevins et al. (1971) indicated no till treatments had higher volumetric moisture content to a depth of 60 cm during most of the growing season. The largest differences occurred in the upper 0 to 8 cm depth. However, Blevins et al. (1971) also suggested soil moisture curves indicated two different water withdrawal patterns under the two contrasting methods of tillage, indicated crop type may have influenced results. Geiszler et al. (1971) stated the type of seedbed preparation on stubble land has a marked influence on wheat yields. However, seedbed preparation included fall and spring trials.

Most tillage experiment inconsistencies are due to the complexity of the changes in soil properties caused by tillage (Douglas and Mckyes (1983)). Chang and Lindwall (1990) indicated from a literature review, soil property changes due to tillage are related to several things. Those things include soil type, type of tillage equipment, tillage depth, soil conditions such as moisture content at the time of tillage and climatic conditions. Bauer and Kucera (1978) concluded inconsistencies in relative grain yield differences among tillage treatments over a period of years were, in part, associated with inconsistent differences in soil properties produced by given tillage treatments from one year to another. Inconsistencies were concluded to be likely associated with the presence of soil water at the time of tillage and climatic conditions - primary water supply, water distribution and temperature. Van Doren et al. (1976) stated researchers found conservation tillage practices resulted in lower yields on poorly drained soils and produced higher yields on well drained soils. Rydberg (1990) concluded ploughless tillage reduced the rate of evaporation, mainly by reducing slaking of the surface. Slaking was a result of higher content of undegraded crop residues and better stability of soil particles. Rydberg (1990) also concluded ploughless tillage could reduce evaporation more on a silty clay loam than on a heavy clay, indicating soil type influenced results. Burwell et al. (1966) stated the amount of moisture in the soil when it is tilled affects the resulting pore space. When soil moisture content level was different than the moisture content normally favourable for working a seedbed the pore space increased, indicating soil changes in pore space were greater than when tillage was performed at the favourable moisture content level. Ideal soil moisture content was not outlined.

Other soil and cropping factors may affect crop yields more than soil moisture content changes due to tillage. Ojeniyi and Dexter (1979a) stated cropping history showed continuous cereal crops produced larger soil particles and voids when periods of pasture or fallow are included in the rotation. Ojeniyi and Dexter (1979a) attributed the results to smaller organic matter content under continuous cropping. Greater frequency of tillage after fallow was also a contributing factor. Several studies have been conducted to assess effects of tillage systems on hydraulic properties of soils (Adeoye (1982), Belvins et al. (1983), Hamblin and Tennant (1981), Wittmus and Yazar (1980)). Allmaras et al. (1977) reported an increase in hydraulic conductivity with chisel plowing. Ehlers et al. (1980) concluded tillage may change soil bulk density, shoot and root growth and the water uptake pattern of a crop. McFarland et al. (1990) concluded long term effects of tillage practices on soil physical properties may depend on the associated cropping sequence and more research on interactive effects was required. Spomer and Hjelmfelt (1984) observed on the Treynor, Iowa research watersheds soil moisture was affected more by cropping (grass vs. corn) than tillage (conventional versus till plant). However, neither treatment caused significant differences.

In addition to soil moisture changes, tillage may affect other soil physical and chemical properties. Changes in soil chemical properties can affect crop yield and crop responses to tillage. Bauer and Kucera (1978) suggested in addition to physical properties, certain chemical properties of soil can be affected by tillage, especially when tillage affects soil temperature. Nitrate levels were studied by Zingg and Whitfield (1957) and found to be lower in mulched soil compared to plowed. Work on tillage effects on potassium levels was completed by Moody et al. (1952). The number of tillage passes can also affect soil moisture contents. Ojeniyi and Dexter (1979b) stated during each implement pass there are two main effects on the soil macro-structure. The two factors are: mean soil particle size is reduced as a result of fragmentation and soil particles are sorted. Sorting occurs with the smaller ones tending to sink to the bottom of the tilled layer and the larger ones tending to rise to the surface. Sorting produces a zone of fine structure at depths where the seed will be sown and where roots will proliferate. Sorting also produces a zone of relatively coarse structure at the surface which reduces erosion by wind and water which will impede formation of the surface crusts or seals. Ojeniyi and Dexter's (1979b) work may also explain why tillage treatments cause non significant differences in soil moisture contents. Since sorting also creates an evaporation control layer to the depth of tillage, moisture contents below tillage depth may be higher than no-till treatment (Russell 1961). Experiments show no-till treatments may have higher soil moisture contents to depth of tillage, yield responses could be eliminated because of the higher moisture reserve in conventional tillage plots below depth of tillage. Hakansson and Von Polgar (1984) showed this work on seedbeds.

Site soil properties will affect how a tillage system changes the soil properties. Ojeniyi and Dexter (1979a) indicated there is an optimum water content were tillage produces a maximum number of small soil particles and a minimum number of large voids. This was equal to a gravimetric water content of around 0.19 of the soil's plastic limit. Ojeniyi and Dexter (1979a) also indicated greatest total macro porosity was produced in the range of water contents 12.6 to 18.3 per cent on an Urrbrae loam soil (17 per cent clay, 32 per cent silt and 51 per cent sand). Even if the effects of tillage and soil conservation were completely understood, other cropping factors such as wind and water erosion of soil must be considered. Russell (1961) states researchers generally accept that a soil particle size range of 1 to 5 mm is required for seedbeds. However, surface conditions effect wind erosion and stability of dry soil particles. Ojeniyi and Dexter (1979a) concluded to conserve moisture, one wants to till soil to minimize proportion of voids larger than about 8 mm. Dry soil particles 0.84 mm in equivalent diameter and smaller are generally considered erodible (Chepil 1955).

EXPERIMENTAL PROCEDURE

Based on comments from researchers and literature in the tillage area, a project examining tillage depth and secondary tillage interaction was developed.

STATISTICAL DESIGN

Chisel plow depth and secondary tillage operations were the two factors of the experiment. Chisel plow factor levels included 102 mm (4 in) tillage depth, 51 mm (2 inch) tillage depth and 0 mm or no chisel plow tillage. No tillage, harrows, packers and a harrow packer combination made up levels of the secondary tillage factor.

The three levels of tillage depth and the four levels of secondary tillage resulted in a 3 x 4 full factorial split block design experiment. The split block design was made of three blocks containing 12 plots each. Blocks were used to eliminate random effects due to differences in initial field moisture content.

PLOT LAYOUT

Plots were 8.53 m (28 ft) in width by 30.48 m (100 ft) in length. A 2.74 m (9 ft) tool bar was used to apply the tillage treatments to the plots. Twelve John Deere heavy duty cultivator shanks were mounted with 22.86 cm (9 in) spacing between shanks in four rows on the tool bar. The shanks were fitted with 30.48 cm (12 in) cultivator sweeps. John Deere specifications indicated a trip force of 658 kg (1450 lbs) on the shanks. Three row tine harrows and spiral packers were mounted on the back of the tool bar.

Three tillage passes at 8 km/hr (5 mph) on each plot resulted in 8.23 m (27 ft) width of worked plot. A 2.14 m (7 ft) Cereal Implements 2300 Hoe Drill was used to seed three strips in each plot. After seeding, plots were 6.4 m (21 ft) wide. Laura spring wheat was seeded at 84.08 kg/ha (75 lb/ac) and 29-25-0 fertilizer was applied at 84.08 kg/ha (75 lbs/ac).

SOIL TYPE

A Bouyoucos method soil particle analysis for the test plots was completed. The results showed a 39 percent sand, 30 percent clay, and 31 percent silt content.

RESULTS AND DISCUSSION

SOIL MOISTURE

Surface soil moisture content was measured using a 102 mm (4 in) core sampler with a 19 mm (0.75 in) diameter. The oven drying technique was used to determine soil moisture content. Three random samples were taken in each plot. Each day 108 soil moisture samples were taken over the plots. Soil moisture was determined prior to tillage and at 24 hour intervals up to seeding. Seeding took place 13 days after tillage of the plots. The same trends occurred in each plot over the 13 day sample period, with increased soil moisture content after precipitation.

GRAPH 1 outlines the average soil moisture data relating to tillage depth. After precipitation, any trends relating to soil moisture were less apparent. However, at a tillage depth of 102 mm (4 in), soil moisture content fell more rapidly than on plots tilled to a depth of zero or 51 mm (2 in) after the precipitation period.

Four levels of the secondary tillage factor were applied to the plots. GRAPH 2 illustrates the soil moisture with respect to the secondary tillage levels. Soil moisture decreased with warm, dry weather and increased with precipitation. No correlation between soil moisture content and secondary tillage was apparent.

GRAPH 3 shows the soil moisture data separated by blocks. No correlation between soil moisture content and block is apparent.

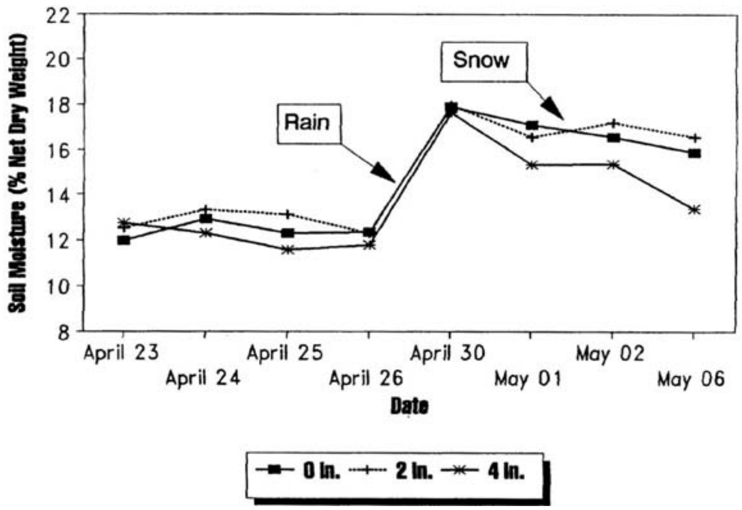
Since no correlation between soil moisture content and experimental factors occurred, soil moisture was graphed using differences between plot moisture just prior to the precipitation period and plot moisture before tillage. Precipitation occurred four days after tillage operations.

GRAPH 4 describes change in soil moisture related to tillage depth. A relationship between soil moisture and tillage depth appears to exist. The deeper the tillage, the greater the moisture loss. Plots which were not tilled gained soil moisture, while those tilled to depths of 51 mm (2 in) and 102 mm (4 in) lost 0.2 and 1.0 percent moisture content, respectively.

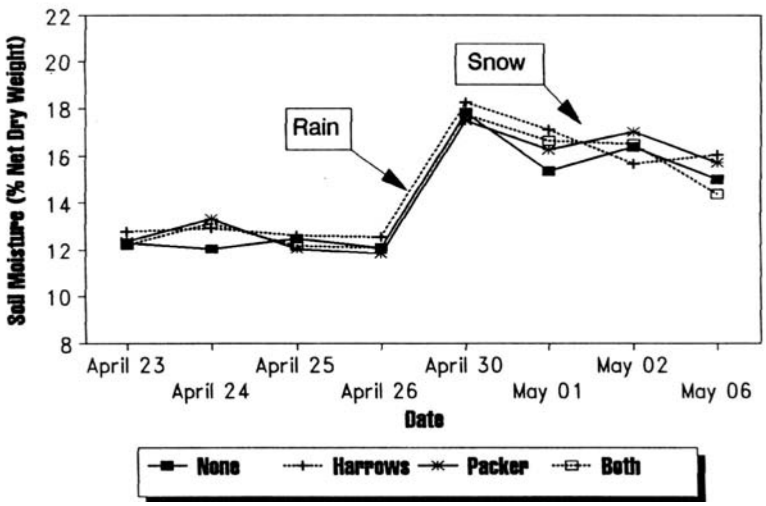
GRAPH 5 compares the change in plot soil moisture content to before tillage moisture. Plots tilled to a 102 mm (4 in) depth experienced greater moisture loss than others plots. The steep slope of the plotted line illustrates a more rapid moisture loss with the 102 mm (4 in) tillage. Any differences between the no-till group and the group tilled at 51 mm (2 in) are less obvious.

GRAPH 6 reflects the change in soil moisture content related to tillage depth. No correlation is apparent.

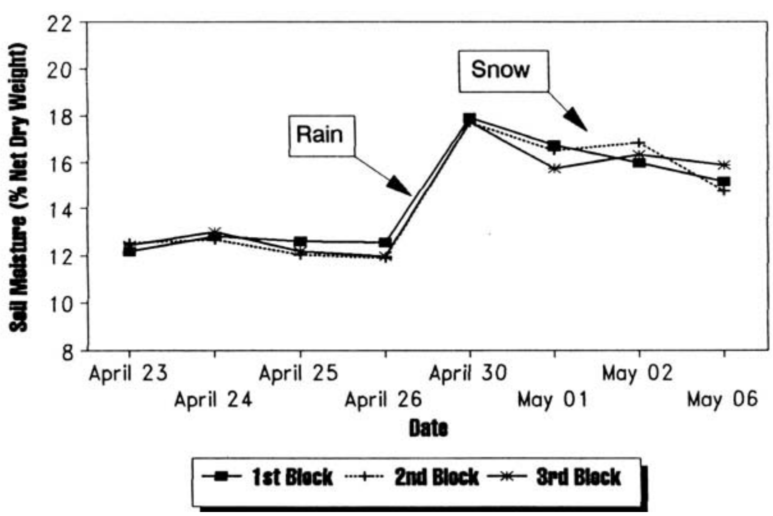
Moisture data was also analyzed with respect to tillage depth, excluding any plots which received secondary tillage treatments (GRAPH 7). Results indicated tilled plots lost more moisture than plots which were not tilled. There was no significant difference between those tilled to 51 mm (2 in) or 102 mm (4 in) in depth. However, no-till plots appeared to retain more moisture than tilled plots.



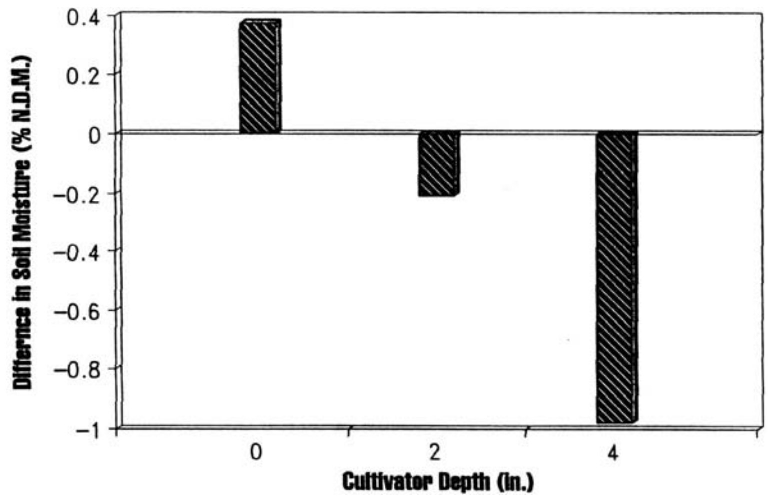
GRAPH 1. Soil Moisture Data vs. Tillage Depth



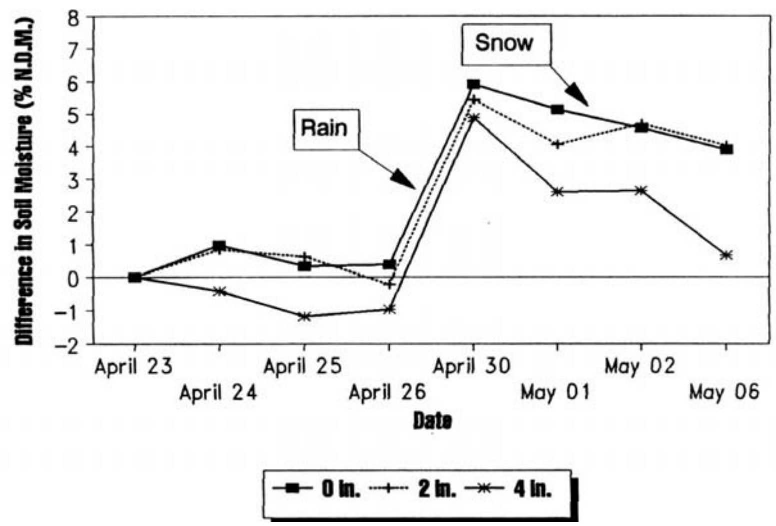
GRAPH 2. Soil Moisture Data vs. Secondary Tillage Treatment



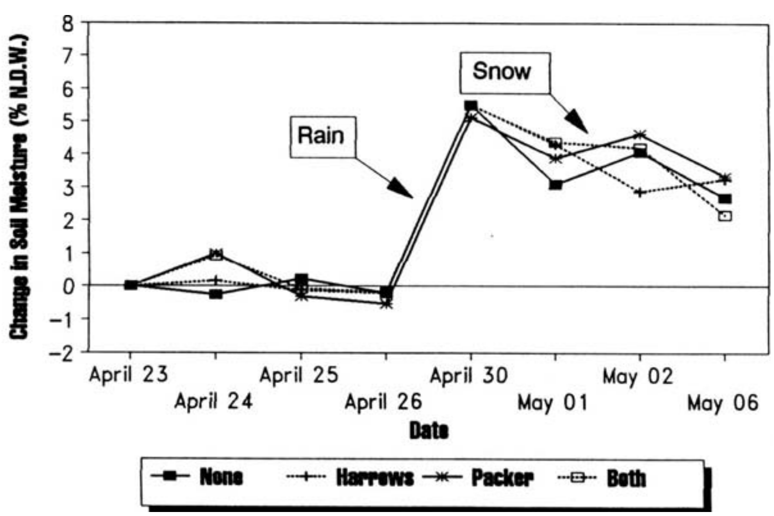
GRAPH 3. Soil Moisture Data vs. Block



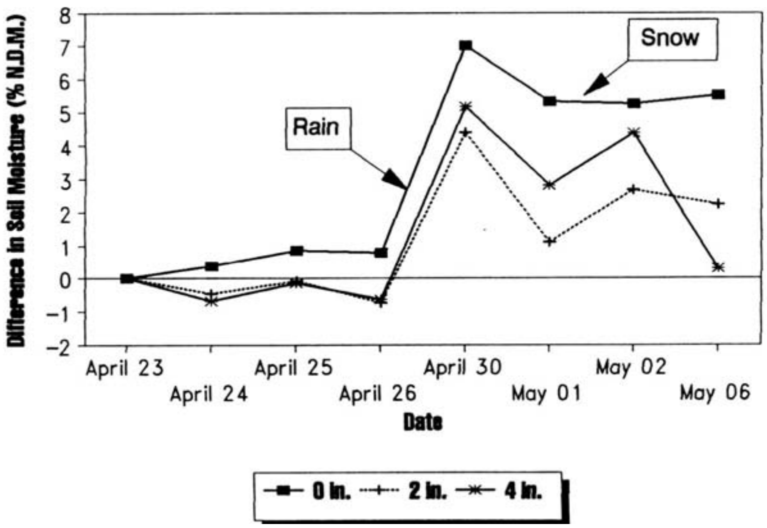
GRAPH 4. Soil Moisture Depletion vs. Tillage Depth



GRAPH 5. Change in Soil Moisture vs. Tillage Depth



GRAPH 6. Change in Soil Moisture vs. Secondary Tillage Treatment



GRAPH 7. Change in Soil Moisture vs. Tillage Depth (Excluding 2nd Treat)

An analysis of variance was performed on the soil moisture data (TABLE 1). Since variations in the results because of the block design were considered random effects, the analysis was performed with the interactions of the blocks and the factors in the error term. All interactions, including the blocks, were non-significant at a P-value above 10%. P-values above 10% indicated little or no relation between the experiment factors and soil moisture content.

TABLE 1. ANOVA of Soil Moisture Content

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P-VALUE
Treatment	11	35.067	3.188	0.774	>0.10
Blocks	2	7.845	3.922	0.953	>0.10
Depth (3)	2	11.012	5.506	1.337	>0.10
Tillage (4)	3	0.877	0.292	0.071	>0.10
Error	22	90.584	4.117		
TOTAL	35	133.496			

RESIDUE COVER

Nine random residue cover samples were taken prior to tillage. Residue cover was determined by weighing 0.25 m^2 (2.291 ft^2) samples of laying and standing stubble. Samples were cut, bagged and weighed. Before tillage, average stubble density was 2687.511 kg/ha (2390 lb/ac) with a standard deviation of 875.09 kg/ha (780.84 lb/ac). The coefficient of variation between the samples was 32%. Three random 0.25 m^2 (2.291 ft^2) samples were taken from each plot after tillage. (TABLE 2 and GRAPH 8). Samples included both trash laying on the surface and standing stubble.

No correlation between tillage depth or secondary tillage to stubble amount is apparent. No correlation was attributed to the small sample size and the large variation in the initial trash density of the field. In addition, both standing and laying stubble were collected. Tests done where standing stubble was only collected may have caused more variations in the stubble density. Due to the number of samples taken and variation in initial field stubble measurements, an analysis of variance was not performed on the data.

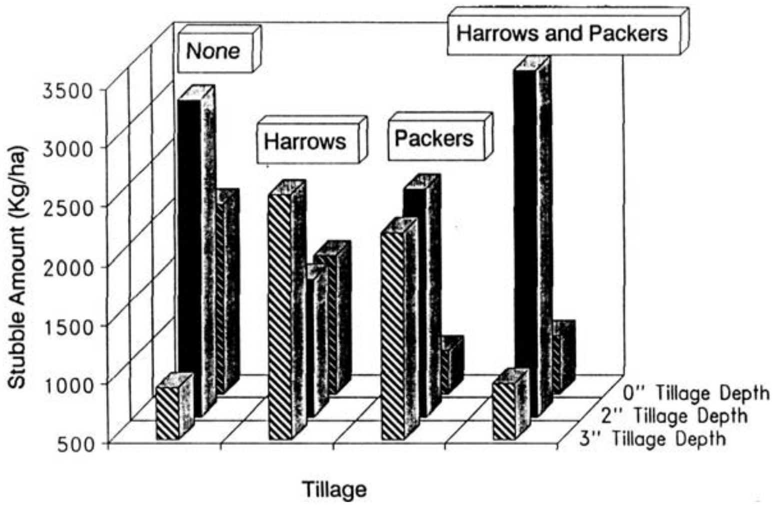
TABLE 2. Residue Cover

BEFORE TILLAGE:

Average Concentration = 2687.51 kg/ha
Standard Deviation = 879.05 kg/ha
Coefficient of Variation = 32.56%

AFTER TILLAGE:

TILLAGE DEPTH mm (in)	SECONDARY TILLAGE	STUBBLE DENSITY (Kg/ha)
0 (0)	None	2106
0 (0)	Harrows	1671
0 (0)	Packers	874
0 (0)	Harrows and Packers	998
51 (2)	None	3189
51 (2)	Harrows	1675
51 (2)	Packers	3448
51 (2)	Harrows and Packers	943
102 (4)	None	2427
102 (4)	Harrows	2571
102 (4)	Packers	2258
102 (4)	Harrows and Packers	977



GRAPH 8. Residue Cover

SOIL PARTICLE SIZE

Soil particle size samples were taken 24 hours after the tillage operations. A 30 kg (66 lb) sample of soil was taken from the top 102 mm (4 in) of each plot of the first block. Samples were placed in Canadian standard sieve numbers 3.5, 6, 8, 12, 16 and 20. Soil remaining on each sieve and passing through all sieves was weighed. Sieves were shook for 30 seconds in a mechanical shaker. Samples were weighed and percentages of soil in each sieve determined (TABLE 3).

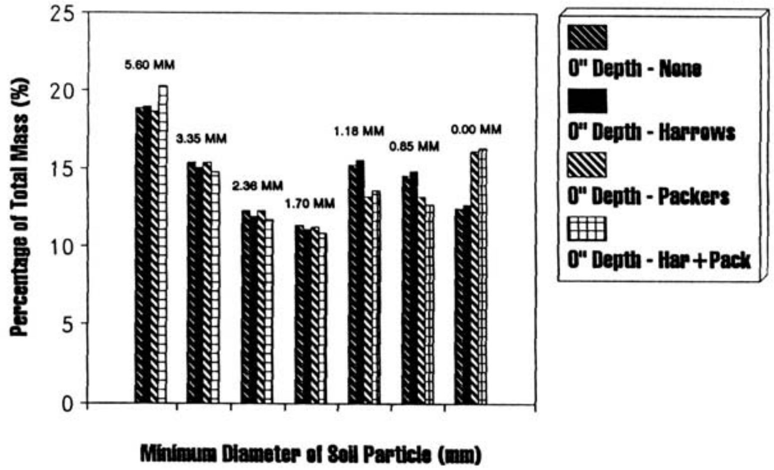
TABLE 3. Soil Particle Analysis

TILLAGE DEPTH mm (in)	SECONDARY TILLAGE	PERCENTAGE OF TOTAL IN SIEVE (%) SIEVE SIZE (mm)						
		5.60 to +	3.35 to 5.60	2.36 to 3.35	1.70 to 2.36	1.18 to 1.70	0.85 to 1.18	0.00 to 0.85
0 (0)	None	18.83	15.39	12.30	11.35	15.19	14.53	12.43
0 (0)	Harrow	18.94	15.03	11.93	11.09	15.51	14.83	12.66
0 (0)	Packer	18.62	15.35	12.30	11.28	13.19	13.18	16.08
0 (0)	Har. + Pac.	20.23	14.76	11.72	10.80	13.54	12.69	16.27
51 (2)	None	17.18	15.32	12.58	11.66	13.22	16.02	14.03
51 (2)	Harrow	19.95	15.29	11.97	10.99	14.78	13.84	13.19
51 (2)	Packer	20.38	14.76	11.53	10.57	16.85	12.43	13.50
51 (2)	Har. + Pac.	17.17	15.72	12.59	11.58	13.23	16.39	13.32
102 (4)	None	18.61	14.63	11.56	11.34	18.05	12.99	12.82
102 (4)	Harrow	16.10	14.73	11.84	12.32	20.12	12.26	12.64
102 (4)	Packer	18.33	15.61	12.53	11.44	11.96	13.96	16.18
102 (4)	Har. + Pac.	20.50	16.27	13.09	12.02	12.06	12.87	13.19

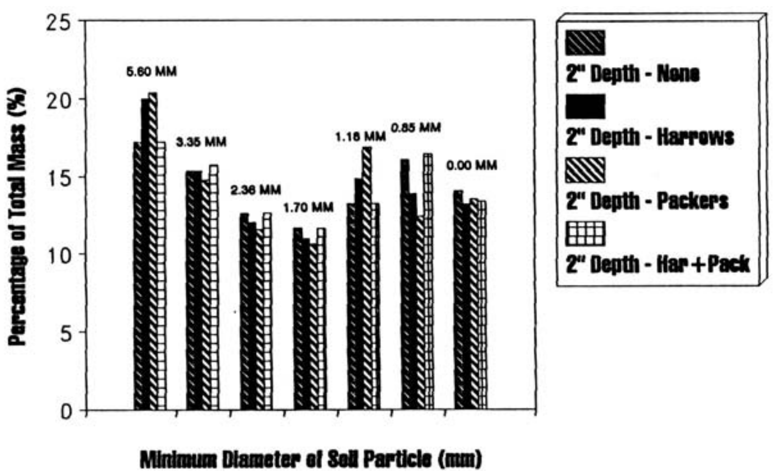
Only one sample was taken from the first twelve plots. Based on the small sample size, the analysis of variance was only applied to the different sieve sizes with the depth of tillage and secondary tillage being considered in the error term. ANOVA results indicated a significant difference in the mass percentage of contents of the sieves. TABLE 4 illustrates the ANOVA results. The significant difference in sieve sizes is evident in the results. GRAPHS 9, 10, AND 11 illustrate the trends among the samples. An increase in percentages of soil particles in sieves occurred with the 5.6 and 1.18 mm sieves. No relationship between the experiment factors and particle distribution was apparent.

TABLE 4. ANOVA of Soil Particle Size

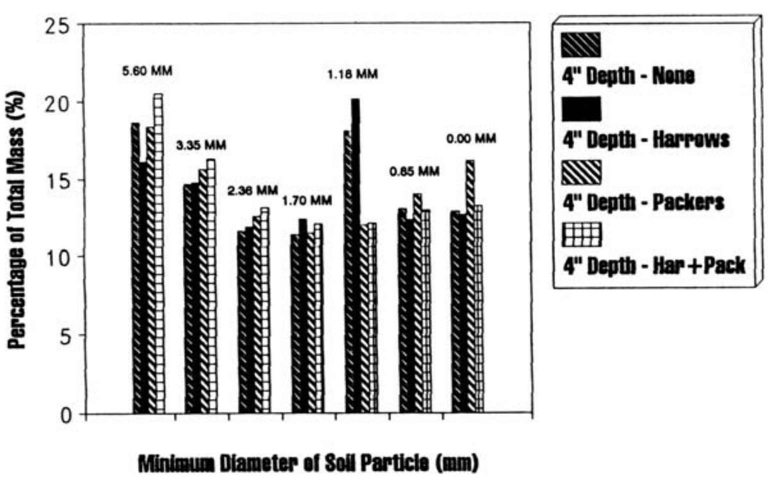
SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P-VALUE
Treatment	11	0.000	0.000		
Blocks (7)	6	412.649	68.775	31.970	<0.005
Error	66	141.982	2.151		
TOTAL	83	554.631			



GRAPH 9. Soil Particle Distribution 0 Depth



GRAPH 10. Soil Particle Distribution 51 mm (2 in) Depth



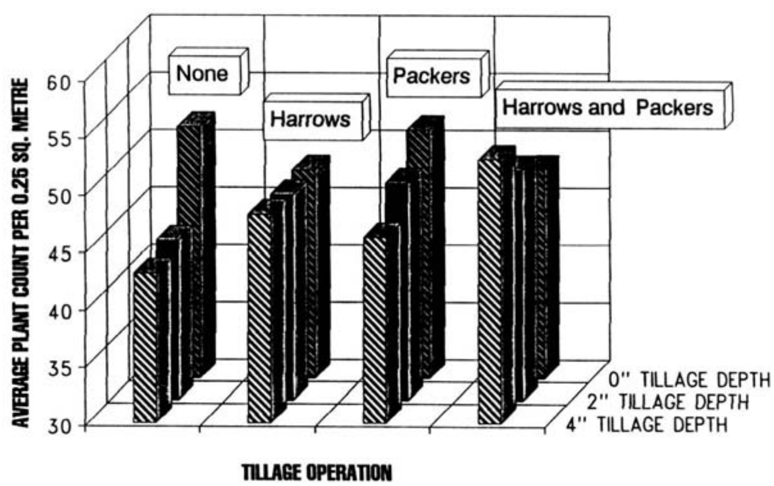
GRAPH 11. Soil Particle Distribution 102 mm (4 in) Depth

CROP EMERGENCE

Four random 0.25 m^2 (2.691 ft^2) crop emergence samples were taken on each plot. Samples were taken by counting the number of plants in the 0.25 m^2 (2.691 ft^2) area (TABLE 5). Emergence samples were taken 15 days after seeding. GRAPH 12 illustrates the average crop emergence for the plots.

TABLE 5. Crop Emergence Results

DEPTH mm (in)	SECONDARY TILLAGE	BLOCK NUMBER 1	2	3
0 (0)	None	65 46 48 45	62 43 46 46	51 61 61 49
0 (0)	Harrow	47 50 40 51	49 44 55 43	37 66 45 51
0 (0)	Packer	61 50 57 47	45 39 61 49	52 52 56 51
0 (0)	Har. + Pac.	36 57 47 51	45 39 59 57	44 43 60 41
51 (2)	None	49 34 36 71	34 36 39 42	55 47 50 34
51 (2)	Harrow	25 45 56 54	40 76 35 37	62 55 48 42
51 (2)	Packer	50 46 38 53	51 44 54 55	43 41 58 54
51 (2)	Har. + Pac.	44 46 37 54	45 44 61 52	37 72 51 58
102 (4)	None	32 44 36 62	48 35 41 36	33 55 39 58
102 (4)	Harrow	40 65 55 48	43 48 40 38	54 55 40 42
102 (4)	Packer	65 47 32 49	52 31 44 45	51 43 50 45
102 (4)	Har. + Pac.	43 63 62 60	62 51 61 54	60 27 44 48



GRAPH 12. Average Crop Emergence

The overall average plant count was 48.42 plants per 0.25 m^2 (2.691 ft^2) sample. ANOVA results (TABLE 6) indicated no statistical significance among blocks or experimental factors related to crop emergence. No significance was probably due to the large amount of precipitation which brought all soil moisture contents and soil temperatures to approximately the same values.

TABLE 6. ANOVA of Crop Emergence

SOURCE OF VARIATION	DF	SUM OF SQUARES	MEAN SQUARE	F	P-VALUE
Treatments	11	303.440	27.585	1.934	>0.10
Blocks (3)	2	32.056	16.028	1.123	>0.10
Depth, D (3)	2	44.858	22.428	1.572	>0.10
Second, S (4)	3	80.422	26.807	1.879	>0.10
D, S	6	178.156	29.693	2.081	>0.10
Error	22	14.266			
TOTAL	35	649.350			

CONCLUSIONS AND RECOMMENDATIONS

A literature review was completed and showed tillage experiments to be site specific with yield results often non-repeatable even under the same soil conditions. The results of this study were much the same as many of the experiments outlined in the literature review.

No relationship between initial and final soil residue cover was apparent. Small sample numbers and large variations in initial residue levels contributed to no significant trends. In addition, both standing and laying stubble was used in the samples. In the future, laying and standing stubble should be separated and taken as two different samples.

When comparing crop emergence to experimental factors, no relationship was apparent. Precipitation on the plots was concluded as the main factor influencing no significant crop emergence results. If no rain fell, plots may have shown a significant difference in emergence.

Soil particle samples showed no significant difference among experimental factors. Difficulty in sampling and length of sampling time resulted in only 12 samples taken. A larger sample size may have resulted in more apparent trends among experimental factors. Statistical differences were found between sieve size, but the same trends occurred regardless of tillage depth or secondary tillage used. An increase in the percentage of total soil in the sieve occurred with the 5.6 mm and 1.18 mm sieves. Sampling techniques currently available for soil particle analysis are inconclusive and extremely time consuming. If future work into soil particle sizing is to be conducted, a new method of sample analysis should be addressed.

No statistically significant relationship was found between soil moisture and experimental factors. Since no relationship between soil moisture and experimental factors occurred, results were compared to pre-tillage moisture contents. When soil moisture was compared to pre-tillage moisture, relationships between moisture content and experimental factors existed. Deeper tillage caused greater moisture loss in the sampled top 102 mm (4 in) of the soil. Plots which were not tilled gained soil moisture. Those tilled to depths of 51 mm (2 in) and 102 mm (4 in) lost 0.2 and 1.0 percent moisture content, respectively. Moisture was also analyzed with tillage depth, excluding any plots which received secondary tillage treatments. Tilled plots lost more moisture than plots which were not tilled. There was no significant difference between those tilled to 51 mm (2 in) or 102 mm (4 in). However, no-till plots appeared to retain more moisture than tilled plots in the top 102 mm (4 in) of the soil.

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