

CHEMICAL TILLAGE FOR CORN

by

D. E. Clark
Member C.S.A.E.
School of Agricultural Engineering

G. E. Jones
Crop Science Department

J. W. Ketcheson
Soil Science Department

University of Guelph, Guelph, Ontario

Twenty years ago McCuen (9) stated that "good soil structure—tilth—is not made and may easily be destroyed by gasoline". Since then, research directed at the maintenance of soil tilth and a reduction in the amount of gasoline used on farms has been conducted in many parts of the mechanized world. The first stage of this research, minimum tillage, was carried out in Ontario (3) and elsewhere. Minimum tillage systems invariably included the use of the moldboard plow along with a reduced number of secondary tillage operations. The second stage of this research, chemical or no tillage, strip tillage etc. was made possible by the development of selective herbicides such as atrazine, linuron, 2,4-D, etc. Chemical or no tillage and strip tillage systems are characterized by the substitution of selective herbicides for the moldboard plow to eradicate unwanted vegetation. Many reports (1, 4, 7, 10) indicate that the wind and water erosion hazard as well as the evaporation rate is reduced when the soil is not tilled with the moldboard plow. Lillard et al (8) noted that corn plants developed a more intensive root system and grew more rapidly in the chemically tilled plots in Virginia. The elimination of the moldboard plow from the pre planting tillage system, reduces the man hours per acre and the horsepower hours per acre required to place the seed in the soil. Lane (7) and McKibben (10) state that the pre harvest crop production costs are more than cut in half by using the no till or strip planting system instead of a conventional tillage system. Bower (2) warns that as the time required to place the corn seed in the soil is reduced, management decisions associated with farming become more critical. So far no attempt has been made to determine the cost of chemically tilling the soil because the cost of herbicides depends on the weeds that must be eradicated. However, the cost of herbicides must compare favourably with conventional tillage costs before

farmers can afford to adopt a chemical tillage system (12).

Chemical tillage and strip tillage systems, however, have not been developed without presenting new questions and problems to investigators. Several research workers (6, 8, 12, 13) indicate that unwanted vegetation must be completely eradicated if a chemical tillage system is to work. The application of the right herbicide must be correctly timed to be most effective. Most reports indicate by insinuation that corn yields with chemical tillage or strip tillage are equivalent to those obtained in conventionally tilled areas if plant stands are comparable. Lillard (8) however stated that plant stands were not reduced by the no tillage treatments in his experiment. Triplett (12) suggests that fertilizer placement is a problem in chemically tilled fields when existing planters are used. Parker (11) notes that not enough is known about the utilization of fertilizer by corn plants grown under a chemical tillage system. Hawkins (5), on the other hand, suggests that too little is known about the oxygen requirements of soils, plant roots and plants even under conventional tillage systems. As yet, the changes brought about by

EXPERIMENTAL PROCEDURE AND EQUIPMENT

An experiment was begun in 1963 to first select the soil working planter components that provided satisfactory penetration, trash handling capacity, seed placement and coverage without excessive soil disturbance and second to study the effect of eliminating all tillage on the yield of grain corn.

Weed Control

The timing of the application of the herbicide is important especially when killing a sod. The pre plant atrazine should be applied to the sod at least three weeks before planting. It has been found that this pre plant atrazine could advantageously be applied to the sod the previous fall. A commercial mixture of 2,4-D, Mecoprop and Dicamba called Kilmor at the rate of eight ounces of total acid per acre was used to control blindweed, alfalfa and dandelions which escaped the original herbicide treatment. Table 1 summarizes the rates at which the herbicides were applied.

Planting Equipment

During the experimental years, six different planters were used to plant the experimental plots and approximately 125 acres in chemically tilled

TABLE I. HERBICIDES USED FOR WEED CONTROL

Year	Previous Crop	Pre Planting		Post Planting	
		Herbicide	Rate*	Herbicide	Rate*
1963	Sod	Paraquat	1	Atrazine	2
1964	Corn Sod	Atrazine	2	Atrazine and oil	2
				Atrazine and oil	2
1965	Corn Sod	Atrazine	2	Atrazine and oil	1.5
				Atrazine and oil	2.0

*Rates are given in pounds of active material per acre.

chemical tillage systems are not sufficiently understood to make it possible to predict the disease and insect control problems that may be encountered in the future (12).

bluegrass sod, alfalfa sod, grain corn and ensilage corn fields. Table 2 lists some of the important features of these planters.

The frame of the John Deere 24B and

TABLE II. CHEMICAL TILLAGE EXPERIMENTAL PLANTERS

Year	Make of Planter	Soil Working Components Used			
		Furrow Openers		Seed Press	
		Seed	Fertilizer	Wheel	
1963	Blackhawk (15T)	DD*	none	no	disk coverers
1964	John Deere (24B)	DD	DD	yes	disk coverers
	Ford (310)	DD	DD	yes	notched or
	Pasture Renovator	hoe	hoe	no	rippled colters
1965	Experimental	experimental			disk coverers
	John Deere (24B)	DD	DD	no	
	Pasture Renovator	hoe	hoe	yes	same as 1964
	Experimental	experimental			
	Allis Chalmers	DD	DD	no	deeply rippled colter

*Double disk

Ford 310 planters used in 1964 had to be lengthened to permit the mounting of the seed press wheel and the two disk coverers. An additional spring was added in 1965 to the John Deere down pressure control linkage to increase the penetration of the seed and fertilizer furrow openers. Later fertilizer metering cones were substituted for the standard fertilizer hoppers to facilitate plot fertility studies.

Corn hoppers and liquid fertilizer equipment replaced the standard dry fertilizer, grain and grass seed equip-

to the machine.

Experimental Treatments and Criteria

The yield of grain corn and plant population data for each method of planting was obtained from randomly selected ten foot sections of row. Table 3 lists the treatments used in the experiment and the criteria used to evaluate these treatment effects.

OBSERVATIONS

Planter Performance

Seed placement and coverage in

used on the John Deere 24B and Ford 310 planters to mound the soil over the seed so that it would not be necessary to force the seed furrow openers into the soil. There were three things wrong with this idea even though adequate seed coverage was obtained. First, when the corn kernel was placed at or near the soil surface and covered over with soil, the roots of the corn plant developed at or near the soil surface. This resulted in inadequate support for the superstructure of the corn plant. Second, the disk coverers throw trash as well as soil on top of the corn seed. If corn stalks are thrown on top of the corn seed, seedling emergence is impeded. Third, the mound of soil over the corn seed is not stable enough to withstand the intense spring rains that often occur in Ontario.

The seed placement and coverage obtained with the pasture renovator, even with the seed press wheels attached, could be improved if each hoe type opener were independently suspended and could follow undulations in the soil surface. When the soil was wet, the furrow openers penetrated easily but satisfactory closing of the seed trench required a more positive covering device than a heavy press wheel. Table 4 summarizes the performance of the experimental planters.

Two additional observations are noteworthy. First, during a wet planting season, it was possible to plant a chemically tilled corn field before it could have been plowed. Conversely, chemically tilling a sod field delayed planting. Second, insects have damaged either the corn seed or the emerging corn plant in the chemically tilled plots but not in the conventionally tilled plots. It is hoped that an entomological investigation will help explain this occurrence.

TABLE III. EXPERIMENTAL TREATMENTS AND CRITERIA

Year	Previous Crops	Treatments	Experimental Criteria
1963	Alfalfa sod (field)	Chem. and conv. tillage	Grain Corn yield
1964	1. Alfalfa sod (plots)	as above plus three planters	as above
	2. Grain corn (plots)	Rotary, chem. and conv. tillage	as above
1965	1. Grain corn (plots)	Chem. and Conv. tillage plus fertility levels and two planters	Plant stands and grain corn yields
	2. Grain corn, Alfalfa sod (fields)	Four planters	as above

TABLE IV. RELATIVE PERFORMANCE OF PLANTERS

Planter	Previous Crop	Penetration	Trash Handling Capacity	Seed Placement and Coverage
Blackhawk (15T)		poor	poor	poor
Ford (310)		poor	fair	fair
John Deere 24B	sod	fair	fair	fair
	corn	fair	poor	fair
Pasture Renovator	sod	excellent	excellent	fair
Allis Chalmers	corn	excellent	good	fair
	sod	good	excellent	good
	corn	excellent	excellent	good

ment on the pasture renovator in 1965. In addition, three steel press wheels one inch wide by 16 inches in diameter, weighing 65 pounds each, were added

chemically tilled soils was of primary importance especially under the wide range of soil conditions and trash cover encountered. Disk coverers were

RESULTS AND DISCUSSION

Tables 6 and 7 summarize the results of the 1965 experimental work. The

TABLE V. 1964 YIELD OF GRAIN CORN AT 15.5 PER CENT MOISTURE

Chemically Tilled Sod Plots	
Planter	Mean Yield (bu./acre)
Ford (310)	81
Exp'l Planter	65
John Deere (24B)	77
Conventionally Tilled (check)	83

TABLE VI. 1965 PLANT POPULATION, SURVIVAL PER CENT AND YIELD OF GRAIN CORN AT 15.5 PER CENT MOISTURE

Chemical Tillage Planter Field Trials

	Previous Crop	Planter			
		P.R.	A.C.	J.D.	Exp'l
Planting Rate (seeds/acre)		25,900	25,000	23,800	22,650
Mean Plant Stand (Plants/acre)	Corn	12,600	16,230	11,940	8,430
	Sod	11,150	12,680	8,940	7,270
	Average	11,875	14,455	10,440	7,850
Survival Per Cent	Corn	48.6	64.9	50.2	37.2
	Sod	43.1	50.7	37.6	32.1
	Average	45.8	57.8	43.9	34.6
Yield (Bu/acre)	Corn	59.8	58.7	55.7	41.6
	Sod	57.1	61.9	41.3	35.3
	Average	58.5	60.3	48.5	38.5

TABLE VII. 1965 PLANT POPULATION, SURVIVAL PER CENT AND YIELD OF GRAIN CORN AT 15.5 PER CENT MOISTURE

Plot Trials

	Treatment	Planter	
		A.C.	Exp'l
Planting Rate (Seeds/acre)		25,000	22,650
Mean Plant Stand (Plants/acre)	Chemical	19,770	14,420
	Convent.	19,240	16,190
Survival Per Cent	Chemical	79.0	63.6
	Convent.	77.0	71.5
Mean Yield (Bu/acre)	Chemical	27.3	19.5
	Convent.	50.5	42.0

fact that the survival per cent in the chemically tilled soils was much higher in the plot area (Table 7) than it was in the fields (Table 6) could perhaps be attributed to the following causes—(1) the use of different hybrids (Seneca 155 in the field and Pride 5 in the plots), (2) the reduction in forward speed while planting the plots and (3) the earlier field planting date. The survival per cent in the plots (Table 7) indicates that the planters placed the seeds in a satisfactory environment for germination and emergence regardless of the tillage treatment. However, the severe yield reduction in the chemically tilled plots indicates that conventional tillage improved the environment for plant growth and/or the utilization of fertilizer. The mean yield for the entire plot area (approximately 35 bushels per acre) was low because the plot area was subjected to a severe frost in mid June and at the end of August.

CONCLUSIONS

At this stage in the chemical tillage experiment, there are still many unanswered questions regarding production costs, soil conservation, soil compaction, soil tilth, fertilizer placement, etc. that must be answered before chemical tillage for corn can be universally recommended. The best existing equipment must be improved so that the long term effects of chemical tillage can be studied more carefully.

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The classes for which the irrigation requirements are calculated (Output from Program 1111-05-02B as discussed in this report) may be selected according to the gross depth of water that is practical for a single application. The probabilities for which these requirements are computed (Output from Program 1111-03-60, as reported) could be chosen to represent average and extreme demands depending on the risk for which the irrigation equipment has to be designed.

Obviously, several other interpretations of the output data are possible. To use this information correctly, it is important to remember that several other factors such as soil type and depth of water applied per irrigation affect the irrigation efficiency (10). Therefore, the supplemental irrigation water requirement estimated from this technique is less than the actual gross depth of water that has to be applied per irrigation. The influence of local conditions on the irrigation efficiency can be accounted for to some extent either by selecting appropriate input controls to the program or by adjusting the output data. Nevertheless the program package provides useful information on supplemental irrigation water requirements as a basis for the design of irrigation schemes and equipment. The necessary calculations by computer can easily be carried out for a number of weather stations since only standard climatological observations are required as input data.

ACKNOWLEDGMENTS

The computer programs were written by the computer systems programmer staff of the Agrometeorology Section under supervision by D. A. Russelo. A summer student employee, J. F. Curley, provided by the Meteorological Branch, D.O.T. also assisted in preparing the data. The calculations were performed by the Data Processing Service, Canada Department of Agriculture.

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APPENDIX*

Computer Program Package

1. Application No. 1044: Quality Control Procedure for No. 4 format cards using I.B.M. Unit Record Machine Types 083, 108, 188 and 514.
 2. Program 1111 - 05 - 04: Calculation of LE using No. 4 or some other format and supplemental cards containing long-term average climatic data.
 3. Program 1111 - 05 - 02B: Irrigation Budget using output cards from 1111-05-04 as input.
 4. Program 1111 - 03 - 60: Conversion from frequencies to amounts of supplemental irrigation water requirements in inches.
- (*) Programmes in Fortran II language for I.B.M. 1620 electronic computer. These programmes are filed in the program library of the Data Processing Service, Canada Department of Agriculture, Ottawa.

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ACKNOWLEDGMENTS

The authors wish to thank the Allis Chalmers Manufacturing Co., Milwaukee, Wisconsin and the International Harvester Co. of Canada, Toronto, for supplying equipment and assistance that have made phases of this study possible.