METHODS OF APPLICATION OF NITROGEN FERTILIZER FOR CONSERVATION TILLAGE

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With a growing interest in conservation tillage there is a need to evaluate various methods of nitrogen fertilizer application. Fertilizer management in many instances, can "make or break" an attempt at an alternative tillage system (Moncrief 1984). Although conservation tillage is a general term which can include various degrees of reduced tillage, the context of this paper refers to it as no-tillage cropping.

In early studies regarding no-tillage cropping it was assumed that surface broadcasting was the most practical method of applying nitrogen fertilizers (Triplett and VanDoren Jr. 1969). This assumption was the result of the lack of research into fertilizer placement for no-tillage cropping systems and the lack of appropriate equipment that could band or inject fertilizers while clearing the plant residues at the soil surface (Bandel et al 1980).

In 1980 and 1981 a series of experiments were conducted in Southern Alberta to begin to initiate the evaluation of nitrogen fertilizer forms and methods of application under no-tillage cropping (Jensen 1982). In the 1980 experiment N-15

enriched urea and ammonium nitrate were broadcast on the residue covered soil surface prior to seeding. The results from this study demonstrated that the ammonium nitrate resulted in significantly greater levels of plant uptake of fertilizer nitrogen compared to urea. The average uptake of fertilizer nitrogen into the grain of spring seeded cereals was 15 and 29% respectively for urea and ammonium nitrate. In the 1981 experiment, broadcast and banded ammonium nitrate and urea treatments were compared along with injected anhydrous ammonia. Fertilizers were applied one day before seeding or in conjunction with seeding. The top yielding treatments occured where the fertilizer was band placed or injected into the soil.

These initial studies had shown that greater crop yields were possible when nitrogen fertilizers were placed in bands rather than broadcast on the surface. In addition, if surface broadcasting was the only fertilizer placement available it was more efficient to use ammonium nitrate instead of urea.

The results of these initial experiments led to the conducting of the study that is reported in this paper. An experiment was designed to compare broadcasting to banding. In addition the experiment was to compare fall and spring applications.

MATERIALS AND METHODS

This study was conducted from fall 1981 until fall 1982 on a Dark Brown soil with a silty clay loam textured Ap horizon. The site was near Carmangay, Alberta. The fertilizer plots were placed on a gently undulating, well drained field that had been continuously cropped using no-tillage for four years. N-15 enriched ammonium nitrate fertilizer was applied to 1 m by 1 m plots at 40 kg/ha of nitrogen. There was a 1.1 m border separation between the plots to avoid contamination from one plot to another. There were fall and spring applications of no-till broadcast and banded fertilizer treatments. In addition there were spring and fall broadcast-incorporated treatments where the fertilizer was mixed into the top 100 mm of soil using a hoe and garden rake. There was no additional tillage done on these last two treatments. There were two control plots that receivced no nitrogen fertilizer. There were four replicates of the various treatments. One control plot was not tilled, while the other was tilled in the same manner as the broadcast-incorporated fertilizer treatments.

The banded fertilizer was applied in two bands 0.3 and 0.6 m from the edge of a plot with the fertilizer placed at a 100 mm depth. The bands were positioned in the same direction as seeding.

Phosphate fertilizer was seed row placed at a rate of 10 kg/ha of phosphorous. Seeding was done with a hoedrill equipped with narrow openers (20 mm) at a 200 mm spacing the first week in May. The plants were grown to maturity and harvested the first week in September. The total above ground plant parts were included in the yield sample. The weights of grain and straw plus chaff were recorded after threshing. The grain and the straw plus chaff were ground and analyzed separately for total nitrogen content and for determination of the percentage of N-15 in the total nitrogen.

The soil within the various treatment plots was sampled three days after harvesting and analyzed for total nitrogen content and the percentage of N-15 in the soil nitrogen. The soil sample depths were 0-0.15, 0.15-0.30, 0.30-0.60, 0.60-0.90 and 0.90-1.2 m.

Plant yield weights and laboratory analysis results were used to determine the amount of fertilizer nitrogen present in the above ground plant parts, residual in the soil and the amount lost from the soil-plant system. This loss was estimated indirectly as the difference between the total fertilizer nitrogen applied minus the sum of fertilizer nitrogen present in the plants and residual in the soil.

Experimental results were analyzed using analysis of variance and the mean differences were tested using the least

significant difference.

RESULTS AND DISCUSSION

The soil cultivation on the one control plot resulted in a yield increase over the undisturbed no-tillage control plot. The average yields were 1050 and 680 kg/ha respectively (Table 1). This yield increase could be due to more nitrogen being made available to the crop as the soil disturbance caused increased mineralization from plant residues and soil organic matter. The increase in available nitrogen from the soil cultivation did not significantly affect the amount of fertilizer nitrogen uptake nor the yields for the fertilized treatments (Tables 2 and 1, respectively).

The lowest levels of plant uptake of fertilizer nitrogen were the no-tillage fall broadcast and fall broadcast-incorporated treatments that were 14 and 10 % respectively. Both the spring broadcast-incorporated and no-tillage spring broadcast treatments had equal fertilizer uptake levels of 23 %. The banded treatments had uptakes of 34 % for the fall application and 43 % for the spring application (Table 2).

These results show that the least efficient manner to

supply nitrogen fertilizer to the crop plants was to broadcast the fertilizer in the fall whether it was mixed into the soil or not. Spring broadcast applications resulted in higher levels of plant uptake compared to fall broadcasting. All broadcast treatments however resulted in lower uptake than banded treatments, whether banded in the fall or spring. The spring banded treatment resulted in a significantly higher level of plant uptake than any other application method.

In regards to fertilizer nitrogen that was residual in the soil, the two treatments with the lowest levels of soil residual fertilizer were spring banded and fall banded (Table 3). These treatments had the highest levels of plant uptake of fertilizer. The third lowest and not significantly higher level of residual fertilizer nitrogen was the no-tillage fall broadcast application. It is noteworthy that this treatment resulted in the highest calculated loss of fertilizer (Table 4).

The lowest determined loss was 9% for the spring banded treatment. The spring applications tended to have lower losses than equivalent fall applications and there were lower losses for banding compared to broadcasting. Although incorporating a broadcast application appeared to have little effect on plant uptake, it did somewhat reduce losses for the fall broadcast-incorporated treatment compared to the no-tillage

fall broadcast treatment.

Table 1 Yield results of the fertilizer treatments and control plots, Carmangay, 1982

TREATMENT				GRAIN YEILD
Tillage	Time	Placement	N kg/ha	kg/ha
No-till	----	control	0	680
No-till	fall	broadcast	40	1539
No-till	spring	broadcast	40	1660
No-till	fall	band	40	2040
No-till	spring	band	40	2180
Incorporated	fall	control	0	1050
Incorporated	fall	broadcast	40	1390
Incorporated	spring	broadcast	40	1520

L.S.D. (P = 0.05) = 510 kg/ha

Table 2 The effect of tillage, time of application, and methods of application on the uptake of N-15 enriched ammonium nitrate fertilizer, Carmangay 1982

TREATMENT				Fertilizer uptake
Tillage	Time	Placement	N kg/ha	%
No-till	fall	broadcast	40	14
No-till	spring	broadcast	40	23
No-till	fall	band	40	34
No-till	spring	band	40	43
Incorporated	fall	broadcast	40	10
Incorporated	spring	broadcast	40	23

L.S.D. (P = 0.05) = 9

Table 3 The effect of tillage, time of application and methods of application on recovery of N-15 enriched ammonium nitrate fertilizer in the soil, Carmangay, 1982

TREATMENT			N	Recovery of fertilizer
Tillage	Time	Placement	kg/ha	%
No-till	fall	broadcast	40	50
No-till	spring	broadcast	40	65
No-till	fall	band	40	49
No-till	spring	band	40	48
Incorporated	fall	broadcast	40	66
Incorporated	spring	broadcast	40	62

L.S.D. (P = 0.05) = 16

Table 4 Calculated loss of fertilizer nitrogen as affected by method of placement and timing of application, Carmangay, 1982

TREATMENT			N	Calculated loss
Tillage	Time	Placement	kg/ha	%
No-till	fall	broadcast	40	36
No-till	spring	broadcast	40	12
No-till	fall	band	40	17
No-till	spring	band	40	9
Incorporated	fall	broadcast	40	23
Incorporated	spring	broadcast	40	16

L.S.D. (P = 0.05) = 20

CONCLUSIONS

An important conclusion of this study, with regards to nitrogen fertilizer management under conservation tillage, is that band placement is a more efficient manner to supply nitrogen to the crop than broadcasting regardless of whether it is a fall or spring application. In addition, a spring application results in greater yields and increased plant uptake than an equivalent fall application.

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