Table 6. Influence of N-rate, K-rate and nitrification inhibitors on grain yields and dry matter production on four corn hybrids at **physiological maturity**. Becker, MN 1990.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Total
#/A			#/A	Bu/A	----------T/A----------		
80	Pioneer 3615	---	---	147.7	3.49	3.80	7.29
80		NS	---	142.2	3.36	3.38	6.74
80		---	100	166.5	3.94	3.94	7.88
80		NS	100	159.0	3.76	3.60	7.36
80		---	200	143.1	3.39	3.65	7.03
80		NS	200	151.0	3.57	3.66	7.23
160		---	200	148.6	3.52	3.51	7.03
160		NS	200	169.4	4.01	3.73	7.74
240		---	---	155.7	3.68	3.43	7.12
240		NS	---	157.9	3.74	3.55	7.29
240		---	100	172.8	4.09	3.66	7.75
240		NS	100	185.3	4.38	4.24	8.63
240		---	200	159.7	3.78	3.63	7.41
240		NS	200	180.0	4.26	3.97	8.23
80	Pioneer 3737	---	---	154.1	3.65	3.36	7.01
80		NS	---	143.1	3.39	3.82	7.20
80		---	100	133.0	3.15	3.47	6.61
80		NS	100	141.4	3.35	3.45	6.80
80		---	200	121.2	2.87	3.33	6.20
80		NS	200	137.6	3.26	3.50	6.75
160		---	200	159.0	3.76	3.51	7.27
160		NS	200	152.3	3.60	3.65	7.25
240		---	---	158.1	3.74	3.71	7.45
240		NS	---	153.2	3.62	3.73	7.35
240		---	100	171.1	4.05	3.78	7.83
240		NS	100	162.0	3.83	3.65	7.48
240		---	200	157.1	3.72	3.47	7.19
240		NS	200	157.5	3.73	3.38	7.11
80	LH74 X LH85	---	---	159.8	3.78	4.11	7.89
80		NS	---	164.4	3.89	4.24	8.13
80		---	100	166.6	3.94	4.06	8.00
80		NS	100	152.4	3.61	3.66	7.27
80		---	200	149.4	3.53	3.73	7.27
80		NS	200	150.3	3.56	3.78	7.34
160		---	200	151.0	3.57	3.80	7.37
160		NS	200	172.7	4.09	4.07	8.16
240		---	---	162.3	3.84	3.82	7.66
240		NS	---	161.1	3.81	3.74	7.55
240		---	100	178.5	4.22	3.86	8.08
240		NS	100	166.8	3.95	4.31	8.26
240		---	200	157.3	3.72	3.73	7.45
240		NS	200	151.4	3.58	3.57	7.15
80	DeKalb 485	---	---	165.6	3.92	4.15	8.07
80		NS	---	175.9	4.16	3.91	8.07
80		---	100	151.9	3.59	3.86	7.46
80		NS	100	158.3	3.75	4.28	8.03
80		---	200	157.1	3.72	4.16	7.88
80		NS	200	160.3	3.79	4.05	7.85
160		---	200	173.3	4.10	4.19	8.29
160		NS	200	171.3	4.05	4.13	8.18
240		---	---	186.0	4.40	4.27	8.67
240		NS	---	155.2	3.67	3.97	7.65
240		---	100	174.4	4.13	3.95	8.08
240		NS	100	184.4	4.36	4.08	8.44
240		---	200	171.1	4.05	3.82	7.87
240		NS	200	167.0	3.95	4.16	8.11

Table 7. Influence of N-rate, K-rate and nitrification inhibitors on stover and grain N content and total N removal on four corn hybrids at **physiological maturity**. Becker, MN 1990.

N-Rate	Hybrid	Inh.	K-Rate	N-Concentration Stover	N-Concentration Grain	N-Removal Stover	N-Removal Grain	N-Removal Total
#/A			#/A	-------%--------		----------#/A---------		
80	Pioneer 3615	---	---	0.57	1.20	43.1	84.0	106.6
80		NS	---	0.58	1.37	39.0	92.3	131.3
80		---	100	0.56	1.12	44.6	88.7	133.2
80		NS	100	0.61	1.35	43.9	101.0	144.9
80		---	200	0.55	1.27	40.2	85.6	125.8
80		NS	200	0.49	1.24	36.0	88.3	124.3
160		---	200	0.74	1.54	51.9	108.4	160.3
160		NS	200	0.66	1.52	49.1	121.4	170.4
240		---	---	0.60	1.26	41.6	93.3	134.8
240		NS	---	0.74	1.48	52.5	110.4	162.9
240		---	100	0.66	1.53	48.3	124.7	173.0
240		NS	100	0.71	1.49	60.0	130.5	190.5
240		---	200	0.68	1.47	49.1	111.4	160.5
240		NS	200	0.73	1.40	57.9	118.8	176.7
80	Pioneer 3737	---	---	0.59	1.45	39.5	105.7	145.2
80		NS	---	0.50	1.40	38.7	94.9	133.6
80		---	100	0.57	1.24	39.3	77.6	116.9
80		NS	100	0.60	1.28	40.9	85.3	126.3
80		---	200	0.58	1.44	38.8	81.7	120.5
80		NS	200	0.56	1.35	38.8	87.8	126.7
160		---	200	0.72	1.48	51.0	110.7	161.7
160		NS	200	0.77	1.55	56.3	111.8	168.1
240		---	---	0.77	1.59	57.3	118.6	175.9
240		NS	---	0.84	1.53	63.0	111.0	174.0
240		---	100	0.72	1.52	54.0	122.9	176.9
240		NS	100	0.76	1.53	54.9	117.2	172.1
240		---	200	0.66	1.57	45.3	116.5	161.8
240		NS	200	0.85	1.49	57.5	111.4	168.9
80	LH74 X LH85	---	---	0.64	1.19	52.7	89.8	142.5
80		NS	---	0.58	1.17	49.6	91.5	141.1
80		---	100	0.81	1.13	65.8	89.0	154.8
80		NS	100	0.64	1.24	47.0	89.0	136.1
80		---	200	0.55	1.24	41.2	87.6	128.8
80		NS	200	0.62	1.15	47.0	81.9	128.9
160		---	200	0.79	1.49	59.7	106.5	166.2
160		NS	200	0.77	1.34	62.8	109.7	172.5
240		---	---	0.76	1.33	58.3	102.4	160.7
240		NS	---	0.67	1.45	50.4	110.2	160.6
240		---	100	0.94	1.42	72.2	119.7	191.9
240		NS	100	0.86	1.32	74.9	104.0	178.9
240		---	200	0.74	1.44	55.5	107.3	162.8
240		NS	200	0.76	1.44	54.5	103.7	158.2
80	DeKalb 485	---	---	0.65	1.27	54.4	99.5	154.0
80		NS	---	0.67	1.23	52.7	102.8	155.5
80		---	100	0.73	1.38	57.0	98.4	155.4
80		NS	100	0.57	1.29	48.6	96.4	145.0
80		---	200	0.58	1.08	48.5	79.9	128.4
80		NS	200	0.58	1.31	46.7	99.4	146.1
160		---	200	0.66	1.26	55.0	103.8	158.9
160		NS	200	0.76	1.24	62.7	100.9	163.5
240		---	---	0.73	1.67	62.4	146.6	209.0
240		NS	---	0.73	1.33	57.8	97.0	154.8
240		---	100	0.80	1.33	63.5	110.1	173.6
240		NS	100	0.83	1.38	67.5	120.0	187.5
240		---	200	0.71	1.50	54.1	121.2	175.3
240		NS	200	0.73	1.37	60.9	108.1	169.0

Table 8. Continued from table 1.

200 # K-Rate only (Hybrid X N-Rate X Inhibitor)	Whole Plant Silking Stover		
Hybrids	T/A	% N	#/A
Pioneer 3615	2.97	1.60	96.3
Pioneer 3737	3.13	1.72	107.7
LH74 X LH85	3.13	1.77	111.1
DeKalb 485	3.26	1.84	120.4
P-Value	99	99	99
BLSD (.05)	0.15	0.07	1.5
N-Rate			
80	3.15	1.40	89.3
160	3.20	1.88	120.4
240	3.02	1.93	117.0
P-Value	98	99	99
BLSD (.05)	0.13	0.07	6.1
Inhibitor			
None	3.06	1.71	105.4
N-Serve	3.18	1.76	112.4
P-Value	97	83	99
Hybrid X N-Rate	78	99	99
Hybrid X Inhibitor	16	71	72
N-Rate X Inhibitor	77	68	93
Hybrid X N-Rate X Inh.	32	99	99
Split Plot without the 160# N-Rate			
K-Rate			
0	3.12	1.84	114.9
100	3.17	1.74	110.7
200	3.08	1.66	103.1
P-Value	30	99	94
BLSD(.05)		0.12	
Hybrid X N-Rate X Inhibitor			
Hybrid			
Pioneer 3615	2.96	1.61	98.3
Pioneer 3737	3.13	1.79	112.4
LH74 X LH85	3.10	1.77	109.9
DeKalb 485	3.30	1.78	117.8
P-Value	99	99	99
BLSD(.05)	0.11	0.08	6.1
N-Rate			
80	3.13	1.54	97.0
240	3.12	1.95	122.1
P-Value	21	99	99
Inhibitor			
None	3.07	1.71	105.6
N-Serve	3.17	1.78	113.6
P-Value	99	99	99
Hybrid X N-Rate	63	91	64
Hybrid X Inhibitor	19	73	72
N-Rate X Inhibitor	1	90	72
Hybrid X N-Rate X Inhibitor	2	22	6
Hybrid X N-Rate X Inhibitor X K-Rate			
Hybrid X K-Rate	93	99	99
N-Rate X K-Rate	90	99	51
Hybrid X N-Rate X K-Rate	50	99	99
Inhibitor X K-Rate	73	99	80
Hybrid X Inhibitor X K-Rate	84	91	98
N-Rate X Inhibitor X K-Rate	43	98	99
Hybrid X N-Rate X Inhibitor X K-Rate	78	99	99

Table 9. Continued from table 2. **Milk Stage R3**

200 # K-Rate only RCB (Hybrid X N-Rate X Inh.)	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
Hybrids	Bu/A	----------T/A----------			
Pioneer 3615	41.1	0.97	3.66	0.67	5.31
Pioneer 3737	53.2	1.25	3.57	0.60	5.44
LH74 X LH85	53.9	1.27	3.70	0.73	5.71
DeKalb 485	43.4	1.02	4.09	0.68	5.77
P-Value	99	99	99	99	99
BLSD (.05)	2.8	0.06	0.21	0.04	0.29
N-Rate					
80	46.4	1.09	3.73	0.62	5.46
160	47.7	1.12	3.78	0.69	5.60
240	49.5	1.17	3.75	0.69	5.61
P-Value	92	93	12	99	63
BLSD (.05)				0.03	
Inhibitor					
None	47.3	1.12	3.72	0.66	5.51
N-Serve	48.4	1.14	3.78	0.68	5.61
P-Value	68	68	49	80	66
Hybrid X N-Rate	91	92	76	96	93
Hybrid X Inhibitor	67	67	27	62	27
N-Rate X Inhibitor	76	76	56	2	65
Hybrid X N-Rate X Inh.	84	84	23	93	32
Split Plot without the 160# N-Rate					
K-Rate					
0	48.7	1.15	3.70	0.71	5.57
100	46.0	1.08	3.83	0.67	5.59
200	48.0	1.13	3.74	0.66	5.54
P-Value	54	54	29	72	3
BLSD(.05)					
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3615	39.7	0.94	3.69	0.70	5.33
Pioneer 3737	51.2	1.21	3.66	0.63	5.50
LH74 X LH85	52.8	1.25	3.67	0.71	5.64
DeKalb 485	46.6	1.10	4.00	0.67	5.78
P-Value	99	99	99	99	99
BLSD(.05)	2.2	0.05	0.13	0.03	0.19
N-Rate					
80	46.2	1.09	3.75	0.65	5.49
240	48.9	1.15	3.76	0.71	5.64
P-Value	99	99	30	99	95
Inhibitor					
None	48.0	1.13	3.80	0.67	5.61
N-Serve	47.1	1.11	3.71	0.69	5.52
P-Value	48	48	89	84	76
Hybrid X N-Rate	59	59	72	63	81
Hybrid X Inhibitor	8	8	41	14	27
N-Rate X Inhibitor	17	17	77	52	69
Hybrid X N-Rate X Inhibitor	82	82	79	25	67
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	96	96	93	95	77
N-Rate X K-Rate	55	55	71	40	74
Hybrid X N-Rate X K-Rate	96	96	84	79	86
Inhibitor X K-Rate	32	32	34	19	32
Hybrid X Inhibitor X K-Rate	94	94	91	15	86
N-Rate X Inhibitor X K-Rate	82	82	86	6	86
Hybrid X N-Rate X Inhibitor X K-Rate	87	87	49	26	56

Table 10. Continued from table 3. **Milk Stage R3**

	N-Contration			N-Removal			
	Stover	Grain	Cob	Stover	Grain	Cob	Total
	---------%---------			----------#/A----------			
200 # K-Rate only RCB (Hybrid X N-Rate X Inh.)							
Hybrids							
Pioneer 3615	0.90	1.93	0.96	66.2	37.5	13.0	116.8
Pioneer 3737	0.92	1.86	0.80	66.7	47.0	9.7	123.5
LH74 X LH85	0.94	1.86	0.79	69.9	44.3	11.6	126.0
DeKalb 485	0.93	1.90	0.77	76.1	39.0	10.6	125.8
P-Value	32	99	99	98	99	99	82
BLSD (.05)		0.12	0.06	7.8	3.2	1.1	
N-Rate							
80	0.82	1.69	0.80	61.7	36.8	10.0	108.7
160	0.94	1.97	0.81	71.0	44.3	11.4	126.9
240	1.02	1.91	0.88	76.4	44.3	12.2	133.6
P-Value	99	99	99	99	99	99	99
BLSD (.05)	0.06	0.09	0.05	5.7	2.7	1.0	7.4
Inhibitor							
None	0.92	1.83	0.83	69.3	41.0	11.2	121.5
N-Serve	0.93	1.88	0.83	70.1	43.0	11.3	124.5
P-Value	7	83	20	26	90	28	64
Hybrid X N-Rate	96	73	72	93	93	50	95
Hybrid X Inhibitor	85	60	22	84	2	2	68
N-Rate X Inhibitor	99	87	64	95	2	40	85
Hybrid X N-Rate X Inh.	99	39	94	93	70	95	76
Split Plot without the 160# N-Rate							
K-Rate							
0	0.84	1.87	0.86	62.3	42.9	12.3	117.6
100	0.86	1.83	0.85	66.0	39.8	11.4	117.3
200	0.92	1.80	0.84	69.1	40.8	11.1	121.1
P-Value	99	75	52	79	82	81	28
BLSD(.05)	0.02						
Hybrid X N-Rate X Inhibitor							
Hybrid							
Pioneer 3615	0.89	1.95	0.99	66.0	36.4	13.9	116.5
Pioneer 3737	0.85	1.89	0.83	62.8	45.8	10.5	119.2
LH74 X LH85	0.87	1.70	0.80	63.5	42.6	11.4	117.7
DeKalb 485	0.88	1.81	0.78	70.5	39.9	10.6	121.4
P-Value	29	99	99	99	99	99	53
BLSD(.05)		0.07	0.02	5.5	2.3	0.6	
N-Rate							
80	0.78	1.74	0.83	58.5	37.7	11.0	107.3
240	0.97	1.93	0.86	73.1	44.6	12.3	130.1
P-Value	99	99	49	99	99	99	99
Inhibitor							
None	0.87	1.82	0.85	66.3	41.2	11.5	119.0
N-Serve	0.88	1.85	0.85	65.3	41.1	11.8	118.3
P-Value	25	83	35	41	5	82	25
Hybrid X N-Rate	63	85	1	53	64	32	47
Hybrid X Inhibitor	71	99	35	66	89	53	52
N-Rate X Inhibitor	80	3	91	91	33	87	91
Hybrid X N-Rate X Inhibitor	58	95	88	77	47	31	65
Hybrid X N-Rate X Inhibitor X K-Rate							
Hybrid X K-Rate	81	81	62	99	51	99	98
N-Rate X K-Rate	2	71	99	73	33	95	45
Hybrid X N-Rate X K-Rate	99	71	99	99	96	75	98
Inhibitor X K-Rate	92	89	5	94	82	10	95
Hybrid X Inhibitor X K-Rate	99	10	92	96	82	17	68
N-Rate X Inhibitor X K-Rate	99	27	99	99	95	83	97
Hybrid X N-Rate X Inhibitor X K-Rate	68	20	17	76	99	59	87

Table 11. Continued from table 4. **Dent Stage R5**

	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
	Bu/A	----------T/A----------			
200 # K-Rate only RCB (Hybrid X N-Rate X Inh.)					
Hybrids					
Pioneer 3615	113.8	2.69	3.06	0.80	6.57
Pioneer 3737	125.6	2.97	3.01	0.69	6.68
LH74 X LH85	126.5	2.99	3.10	0.82	6.91
DeKalb 485	119.7	2.83	3.41	0.79	7.03
P-Value	99	99	99	99	96
BLSD (.05)	6.5	0.15	0.18	0.04	0.4
N-Rate					
80	113.7	2.67	3.02	0.71	6.40
160	125.9	2.97	3.19	0.80	6.97
240	125.2	2.96	3.23	0.82	7.01
P-Value	99	99	97	99	99
BLSD (.05)	5.4	0.12	0.17	0.03	0.29
Iinhibitor					
None	121.3	2.87	3.10	0.77	6.74
N-Serve	121.6	2.87	3.19	0.78	6.85
P-Value	10	10	83	18	59
Hybrid X N-Rate	97	97	90	97	97
Hybrid X Inhibitor	95	95	82	39	90
N-Rate X Inhibitor	46	46	13	15	6
Hybrid X N-Rate X Inh.	90	90	47	85	74
Split Plot without the 160# N-Rate					
K-Rate					
0	122.3	2.89	3.16	0.81	6.87
100	121.5	2.87	3.21	0.80	6.88
200	119.2	2.82	3.12	0.76	6.71
P-Value	37	37	62	88	59
BLSD(.05)					
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3615	112.9	2.67	3.12	0.82	6.61
Pioneer 3737	122.0	2.88	3.00	0.70	6.60
LH74 X LH85	125.4	3.05	3.05	0.83	6.85
DeKalb 485	123.6	2.92	3.48	0.81	7.22
P-Value	99	99	99	99	99
BLSD(.05)	4.1	0.09	0.11	0.02	0.21
N-Rate					
80	115.8	2.73	3.10	0.75	6.59
240	126.2	2.98	3.23	0.83	7.05
P-Value	99	99	99	99	99
Inhibitor					
None	121.1	2.86	3.13	0.79	6.79
N-Serve	120.8	2.85	3.20	0.79	6.85
P-Value	17	17	86	33	56
Hybrid X N-Rate	96	96	93	93	98
Hybrid X Inhibitor	99	99	72	60	96
N-Rate X Inhibitor	55	55	42	79	59
Hybrid X N-Rate X Inhibitor	96	96	88	98	92
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	83	83	53	66	31
N-Rate X K-Rate	35	35	53	85	61
Hybrid X N-Rate X K-Rate	88	88	74	94	89
Inhibitor X K-Rate	33	33	16	96	21
Hybrid X Inhibitor X K-Rate	88	88	35	35	59
N-Rate X Inhibitor X K-Rate	90	90	8	13	46
Hybrid X N-Rate X Inhibitor X K-Rate	7	7	5	8	3

Table 12. Continued from table 5. **Dent Stage R5**

	N-Concentration			N-Removal			
	Stover	Grain	Cob	Stover	Grain	Cob	Total
	---------%---------			----------#/A----------			
200 # K-Rate only RCB (Hybrid X N-Rate X Inh.)							
Hybrid							
Pioneer3615	1.48	1.08	0.56	66.9	80.5	9.0	156.5
Pioneer 3737	1.55	1.08	0.46	66.1	92.8	6.5	165.5
LH74 X LH85	1.43	1.07	0.52	66.8	85.7	8.6	161.2
DeKalb 485	1.38	1.23	0.47	84.3	78.8	7.5	170.5
P-Value	99	99	99	99	99	99	97
BLSD (.05)	0.05	0.05	0.04	4.8	5.6	0.8	10.9
N-Rate							
80	1.33	0.91	0.52	55.7	71.3	7.5	134.5
160	1.50	1.16	0.49	74.5	89.5	7.9	172.0
240	1.55	1.27	0.50	82.9	92.6	8.3	183.9
P-Value	99	99	45	99	99	84	99
BLSD (.05)	0.04	0.04		4.1	4.6		7.6
Inhibitor							
None	1.08	1.48	0.50	67.6	85.6	7.8	161.1
N-Serve	1.16	1.44	0.51	74.4	83.3	8.0	165.9
P-Value	99	92	63	99	72	45	82
Hybrid X N-Rate	99	98	78	99	99	95	99
Hybrid X Inhibitor	85	85	76	23	84	59	54
N-Rate X Inhibitor	92	98	89	59	73	35	76
Hybrid X N-Rate X Inh.	99	2	98	98	70	84	86
Split Plot without the 160# N-Rate							
K-Rate							
0	1.18	1.46	0.51	75.2	84.7	8.4	168.4
100	1.16	1.45	0.51	75.2	83.9	8.2	167.4
200	1.09	1.44	0.51	69.3	81.9	7.9	159.2
P-Value	91	26	5	88	37	83	78
BLSD(.05)							
Hybrid X N-Rate X Inhibitor							
Hybrid							
Pioneer 3615	1.10	1.46	0.56	69.1	78.6	9.2	157.0
Pioneer 3737	1.13	1.55	0.45	68.6	90.1	6.5	165.3
LH74 X LH85	1.11	1.42	0.54	68.3	84.9	9.0	162.4
DeKalb 485	1.24	1.37	0.48	87.0	80.5	7.9	175.5
P-Value	99	99	99	99	99	99	99
BLSD(.05)	0.04	0.03	0.02	3.6	3.5	0.5	6.5
N-Rate							
80	0.99	1.33	0.52	62.0	73.1	6.5	143.1
240	1.30	1.57	0.50	84.6	93.9	7.0	186.9
P-Value	99	99	93	99	99	95	99
Inhibitor							
None	1.12	1.43	0.50	71.2	82.9	8.0	162.1
N-Serve	1.17	1.46	0.52	75.3	84.1	8.3	167.9
P-Value	99	98	95	99	64	91	99
Hybrid X N-Rate	99	99	99	99	99	99	99
Hybrid X Inhibitor	99	69	72	76	85	20	49
N-Rate X Inhibitor	98	99	75	72	44	7	66
Hybrid X N-Rate X Inhibitor	87	33	99	96	94	99	98
Hybrid X N-Rate X Inhibitor X K-Rate							
Hybrid X K-Rate	94	99	62	96	90	52	83
N-Rate X K-Rate	99	19	49	91	6	56	83
Hybrid X N-Rate X K-Rate	86	54	64	81	33	91	62
Inhibitor X K-Rate	98	88	97	91	48	99	40
Hybrid X Inhibitor X K-Rate	47	94	71	5	96	46	52
N-Rate X Inhibitor X K-Rate	73	52	93	39	72	75	23
Hybrid X N-Rate X Inh. X K-Rate	99	34	99	99	1	98	64

Table 13. Continued from table 6. **Physiological Maturity**

	Grain Yields	Dry Matter Production Grain	Stover	Total
	Bu/A	----------T/A----------		
200 # K-Rate only RCB (Hybrid X N-Rate X Inh)				
Hybrids				
Pioneer 3615	158.6	3.75	3.69	7.44
Pioneer 3737	147.4	3.48	3.47	6.96
LH74 X LH85	155.3	3.67	3.78	7.45
DeKalb 485	166.6	3.94	4.08	8.03
P-Value	99	99	99	99
BLSD (.05)	6.4	0.15	0.13	0.25
N-Rate				
80	146.2	3.46	3.73	7.19
160	162.1	3.83	3.82	7.66
240	162.6	3.84	3.71	7.56
P-Value	99	99	78	99
BLSD (.05)	5.4	0.12		0.22
Inhibitor				
None	153.9	3.64	3.71	7.35
N-Serve	160.0	3.78	3.80	7.59
P-Value	99	99	92	99
Hybrid X N-Rate	94	94	72	91
Hybrid X Inhibitor	91	91	21	76
N-Rate X Inhibitor	40	40	32	26
Hybrid X N-Rate X Inh.	88	88	76	83
Split Plot without the 160# N-Rate				
K-Rate				
0	158.8	3.75	3.81	7.57
100	164.0	3.86	3.86	7.74
200	154.4	3.72	3.72	7.37
P-Value	84	84	58	78
BLSD(.05)				
Hybrid X N-Rate X Inhibitor				
Hybrid				
Pioneer 3615	160.0	3.78	3.70	7.49
Pioneer 3737	149.1	3.52	3.55	7.08
LH74 X LH85	160.0	3.78	3.88	7.67
DeKalb 485	167.2	3.95	4.05	8.01
P-Value	99	99	99	99
BLSD(.05)	4.6	0.10	0.11	0.19
N-Rate				
80	152.1	3.60	3.79	7.38
240	166.0	3.93	3.81	7.74
P-Value	99	99	37	99
Inhibitor				
None	159.1	3.76	3.78	7.54
N-Serve	159.0	3.76	3.82	7.58
P-Value	6	6	61	36
Hybrid X N-Rate	99	99	69	96
Hybrid X Inhibitor	68	68	4	34
N-Rate X Inhibitor	67	67	83	21
Hybrid X N-Rate X Inhibitor	96	96	99	99
Hybrid X N-Rate X Inhibitor X K-Rate				
Hybrid X K-Rate	99	99	97	99
N-Rate X K-Rate	99	99	87	99
Hybrid X N-Rate X K-Rate	49	49	70	14
Inhibitor X K-Rate	90	90	53	79
Hybrid X Inhibitor X K-Rate	84	84	83	78
N-Rate X Inhibitor X K-Rate	50	50	88	75
Hybrid X N-Rate X Inhibitor X K-Rate	79	79	85	47

Table 14. Continued from table 7. **Physiological Maturity**

	N-Concentration		N-Removal		
	Stover	Grain	Stover	Grain	Total
	-------%-------		----------#/A----------		
200 # K-Rate only RCB (Hybrid X N-Rate X Inh.)					
Hybrids					
Pioneer 3615	0.63	1.40	47.3	105.6	153.0
Pioneer 3737	0.68	1.47	47.9	103.3	151.2
LH74 X LH85	0.70	1.34	53.4	99.4	152.8
DeKalb 485	0.67	1.29	54.6	102.2	156.8
P-Value	99	99	99	71	44
BLSD (.05)	0.04	0.05	3.3		
N-Rate					
80	0.56	1.25	42.1	86.5	128.6
160	0.73	1.42	56.0	109.1	165.1
240	0.73	1.45	54.3	112.3	166.6
P-Value	99	99	99	99	99
BLSD (.05)	0.03	0.04	2.7	4.9	6.1
Inhibitor					
None	0.66	1.39	49.1	101.7	150.9
N-Serve	0.68	1.36	52.5	103.6	156.1
P-Value	94	87	99	60	93
Hybrid X N-Rate	12	99	55	64	66
Hybrid X Inhibitor	93	67	51	52	31
N-Rate X Inhibitor	92	68	90	77	15
Hybrid X N-Rate X Inh.	94	99	79	78	45
Split Plot without the 160# N-Rate					
K-Rate					
0	0.66	1.37	50.8	103.1	153.9
100	0.70	1.34	55.1	104.6	159.8
200	0.64	1.35	48.2	99.4	147.6
P-Value	99	59	95	72	88
BLSD(.05)	0.01		4.9		
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3615	0.62	1.34	46.3	102.4	148.7
Pioneer 3737	0.66	1.44	47.3	102.5	149.8
LH74 X LH85	0.71	1.29	55.7	98.0	153.7
DeKalb 485	0.69	1.34	56.1	106.6	162.8
P-Value	99	99	99	99	99
BLSD(.05)	0.02	0.03	2.7	4.7	5.4
N-Rate					
80	0.59	1.26	45.5	90.7	136.3
240	0.74	1.45	57.2	114.0	171.2
P-Value	99	99	99	99	99
Inhibitor					
None	0.67	1.35	51.1	102.5	153.7
N-Serve	0.67	1.35	51.6	102.2	153.9
P-Value	13	19	41	20	8
Hybrid X N-Rate	96	34	85	76	90
Hybrid X Inhibitor	99	99	95	99	99
N-Rate X Inhibitor	99	99	99	99	15
Hybrid X N-Rate X Inhibitor	71	94	60	99	96
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	99	98	99	99	99
N-Rate X K-Rate	60	37	74	99	99
Hybrid X N-Rate X K-Rate	93	99	92	80	30
Inhibitor X K-Rate	93	75	79	73	77
Hybrid X Inhibitor X K-Rate	96	99	26	99	97
N-Rate X Inhibitor X K-Rate	5	30	67	11	45
Hybrid X N-Rate X Inhibitor X K-Rate	94	99	88	99	99

Table 15. Influence of N-rate, K-rate and nitrification on stover dry matter production, N content and total N removal on four corn hybrids at **silking**. Waseca 1990.

N-Rate	Hybrid	Inh.	K-Rate	Whole Plant Silking Stover		
#/A			#/A	T/A	% N	#/A
0	Pioneer 3615	---	---	2.46	0.94	46.4
0		---	100	2.69	1.03	55.1
80		---	---	2.81	1.39	78.0
80		NS	---	2.80	1.36	75.8
80		---	100	3.30	1.36	89.8
80		NS	100	2.96	1.31	77.6
160		---	---	3.01	1.44	86.6
160		NS	---	3.16	1.46	92.1
160		---	100	3.09	1.49	92.0
160		NS	100	3.08	1.41	86.4
0	Pioneer 3475	---	---	2.65	0.98	52.4
0		---	100	3.00	0.95	57.2
80		---	---	3.23	1.37	88.6
80		NS	---	3.11	1.31	81.7
80		---	100	3.73	1.38	103.3
80		NS	100	3.35	1.37	90.7
160		---	---	3.32	1.42	94.7
160		NS	---	3.52	1.51	106.1
160		---	100	3.48	1.39	97.1
160		NS	100	3.49	1.43	98.8
0	LH74 X LH51	---	---	2.69	0.90	48.4
0		---	100	2.39	0.91	43.7
80		---	---	3.33	1.54	102.5
80		NS	---	3.18	1.48	93.7
80		---	100	3.14	1.40	87.4
80		NS	100	3.15	1.41	88.0
160		---	---	3.05	1.86	112.7
160		NS	---	3.47	1.69	118.0
160		---	100	3.56	1.48	105.2
160		NS	100	3.32	1.52	100.8
0	LH74 X LH82	---	---	2.27	0.88	40.0
0		---	100	2.46	1.01	51.0
80		---	---	3.19	1.50	95.1
80		NS	---	2.83	1.48	83.2
80		---	100	3.11	1.48	91.9
80		NS	100	3.24	1.47	96.0
160		---	---	3.31	1.62	107.1
160		NS	---	2.75	1.63	89.9
160		---	100	3.40	1.62	110.3
160		NS	100	3.23	1.55	99.6

Table 16. Influence of N-rate, K-rate and nitrification on grain yields and dry matter production on four corn hybrids at the **milk stage R3**. Waseca 1990.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
#/A			#/A	Bu/A	----------T/A----------			
0	Pioneer 3615	---	---	74.8	1.77	3.46	0.58	5.81
0		---	100	69.8	1.65	3.44	0.56	5.64
80		---	---	93.5	2.21	3.59	0.71	6.51
80		NS	---	82.7	1.96	3.30	0.65	5.91
80		---	100	90.0	2.13	3.81	0.76	6.70
80		NS	100	81.7	1.93	3.69	0.73	6.36
160		---	---	99.7	2.36	3.73	0.83	6.93
160		NS	---	94.2	2.23	3.90	0.78	6.91
160		---	100	97.7	2.31	3.85	0.82	6.99
160		NS	100	94.1	2.23	3.96	0.78	6.96
0	Pioneer 3475	---	---	76.5	1.81	3.59	0.65	6.05
0		---	100	64.8	1.53	3.80	0.56	5.89
80		---	---	105.0	2.48	4.04	0.81	7.33
80		NS	---	96.6	2.29	4.26	0.80	7.34
80		---	100	95.7	2.26	4.83	0.80	7.89
80		NS	100	92.2	2.18	4.43	0.83	7.44
160		---	---	97.2	2.30	4.03	0.82	7.15
160		NS	---	108.9	2.58	4.51	0.88	7.97
160		---	100	97.1	2.30	4.81	0.79	7.90
160		NS	100	97.3	2.30	4.19	0.82	7.32
0	LH74 X LH51	---	---	56.8	1.34	3.93	0.50	5.77
0		---	100	52.6	1.24	3.98	0.47	5.70
80		---	---	81.5	1.93	4.54	0.64	7.11
80		NS	---	78.5	1.86	4.44	0.61	6.91
80		---	100	76.1	1.80	4.73	0.65	7.19
80		NS	100	67.8	1.60	4.71	0.62	6.93
160		---	---	83.3	1.97	4.70	0.68	7.35
160		NS	---	82.6	1.95	4.65	0.62	7.22
160		---	100	83.8	1.98	5.12	0.65	7.75
160		NS	100	80.4	1.90	5.21	0.68	7.80
0	LH74 X LH82	---	---	68.7	1.63	2.96	0.53	5.11
0		---	100	59.2	1.40	3.10	0.48	4.98
80		---	---	103.8	2.46	3.46	0.72	6.64
80		NS	---	103.6	2.45	3.55	0.75	6.75
80		---	100	105.2	2.49	3.96	0.77	7.23
80		NS	100	84.2	1.99	3.32	0.63	5.95
160		---	---	102.9	2.43	3.60	0.79	6.82
160		NS	---	107.3	2.54	3.33	0.80	6.67
160		---	100	106.5	2.52	4.02	0.76	7.31
160		NS	100	104.7	2.48	3.82	0.76	7.06

Table 17. Influence of N-rate, K-rate and nitrification on N content and total N removal on four corn hybrids at the **milk stage R3**. Waseca 1990.

				N-Concentration			N-Removal			
N-Rate	Hybrid	Inh.	K-Rate	Stover	Grain	Cob	Stover	Grain	Cob	Total
#/A			#/A	----------%----------			----------#/A----------			
0	Pioneer 3615	---	---	0.55	1.28	0.56	37.9	45.3	6.5	89.6
0		---	100	0.67	1.41	0.63	46.1	46.5	7.0	99.6
80		---	---	0.87	1.50	0.65	63.4	66.5	9.2	139.1
80		NS	---	0.94	1.61	0.54	62.0	62.9	6.9	131.7
80		---	100	0.90	1.60	0.73	68.5	68.7	11.1	148.3
80		NS	100	0.71	1.56	0.62	52.4	60.3	9.0	121.7
160		---	---	1.00	1.56	0.67	74.4	73.6	11.2	159.1
160		NS	---	0.96	1.58	0.64	75.0	70.4	10.0	155.5
160		---	100	1.09	1.78	0.60	84.5	82.5	9.9	176.9
160		NS	100	1.04	1.65	0.71	82.2	73.2	11.0	166.4
0	Pioneer 3475	---	---	0.58	1.29	0.59	41.3	46.9	7.7	95.8
0		---	100	0.55	1.30	0.59	42.3	40.0	6.5	88.8
80		---	---	0.81	1.55	0.58	65.4	77.0	9.4	151.8
80		NS	---	0.81	1.30	0.61	69.1	59.2	9.6	137.9
80		---	100	0.77	1.55	0.56	74.3	69.8	9.0	153.1
80		NS	100	0.84	1.50	0.68	75.0	65.4	11.2	151.6
160		---	---	0.88	1.52	0.67	70.6	69.6	11.0	151.2
160		NS	---	0.78	1.55	0.54	70.4	79.7	9.6	159.7
160		---	100	0.92	1.58	0.70	88.5	72.6	11.0	172.1
160		NS	100	0.92	1.59	0.77	78.2	73.1	12.7	164.0
0	LH74 X LH51	---	---	0.62	1.30	0.51	47.9	35.2	5.0	88.1
0		---	100	0.53	1.31	0.56	42.0	32.5	5.3	79.8
80		---	---	0.73	1.46	0.55	65.7	56.5	7.2	129.4
80		NS	---	0.80	1.46	0.54	71.1	54.4	6.6	132.1
80		---	100	0.73	1.50	0.53	68.8	53.2	7.0	129.0
80		NS	100	0.76	1.67	0.53	71.2	53.4	6.6	131.2
160		---	---	0.87	1.76	0.61	81.2	69.5	8.3	159.0
160		NS	---	0.98	1.76	0.54	91.1	68.8	6.6	166.6
160		---	100	1.14	1.70	0.58	117.1	67.5	7.5	192.2
160		NS	100	0.99	1.83	0.57	103.6	69.8	7.8	181.2
0	LH74 X LH82	---	---	0.57	1.15	0.58	33.3	37.1	6.1	76.5
0		---	100	0.54	1.43	0.65	33.4	40.2	6.0	79.6
80		---	---	0.92	1.45	0.53	63.6	71.2	7.6	142.3
80		NS	---	0.81	1.33	0.49	57.6	65.3	7.2	130.1
80		---	100	0.92	1.45	0.51	73.3	71.8	7.9	153.1
80		NS	100	0.92	1.43	0.50	61.2	57.0	6.3	124.5
160		---	---	1.09	1.71	0.54	78.8	83.0	8.4	170.2
160		NS	---	0.99	1.59	0.53	65.6	80.8	8.5	154.9
160		---	100	1.06	1.76	0.53	85.2	88.7	8.2	182.1
160		NS	100	1.00	1.63	0.55	76.2	80.3	8.4	164.9

Table 18. Influence of N-rate, K-rate and nitrification on grain yield and dry matter production on four corn hybrids at the **dent stage R5**. Waseca 1990.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Cob	Total
#/A			#/A	Bu/A	----------T/A----------			
0	Pioneer 3615	---	---	104.0	2.46	2.39	0.44	5.29
0		---	100	118.8	2.81	2.92	0.55	6.28
80		---	---	139.2	3.29	3.07	0.63	7.00
80		NS	---	139.3	3.29	2.82	0.61	6.72
80		---	100	163.5	3.87	3.29	0.75	7.91
80		NS	100	144.3	3.42	3.15	0.66	7.23
160		---	---	163.2	3.86	3.28	0.74	7.88
160		NS	---	148.1	3.50	3.04	0.68	7.22
160		---	100	169.9	4.02	3.55	0.82	8.40
160		NS	100	165.4	3.91	3.20	0.77	7.88
0	Pioneer 3475	---	---	122.3	2.89	3.09	0.63	6.62
0		---	100	111.8	2.65	3.34	0.53	6.51
80		---	---	155.4	3.68	3.53	0.71	7.92
80		NS	---	160.3	3.79	3.55	0.75	8.10
80		---	100	170.5	4.03	4.09	0.82	8.95
80		NS	100	150.3	3.56	3.68	0.76	8.00
160		---	---	160.9	3.81	3.85	0.77	8.42
160		NS	---	156.6	3.70	3.61	0.76	8.08
160		---	100	146.7	3.47	3.87	0.72	8.06
160		NS	100	152.8	3.62	3.85	0.72	8.19
0	LH74 X LH51	---	---	97.2	2.30	3.26	0.45	6.01
0		---	100	92.1	2.18	3.41	0.42	6.00
80		---	---	143.0	3.38	4.00	0.57	7.95
80		NS	---	130.2	3.08	3.96	0.57	7.61
80		---	100	132.5	3.13	3.94	0.56	7.63
80		NS	100	140.2	3.32	4.30	0.63	8.25
160		---	---	157.8	3.73	4.39	0.64	8.76
160		NS	---	155.2	3.67	4.39	0.64	8.70
160		---	100	148.0	3.50	4.45	0.57	8.51
160		NS	100	145.8	3.45	4.31	0.60	8.36
0	LH74 X LH82	---	---	105.2	2.49	2.61	0.48	5.58
0		---	100	84.8	2.01	2.53	0.44	4.98
80		---	---	151.0	3.57	3.13	0.65	7.36
80		NS	---	142.2	3.36	3.18	0.62	7.16
80		---	100	147.8	3.50	3.26	0.64	7.41
80		NS	100	140.3	3.32	3.12	0.62	7.06
160		---	---	155.1	3.67	3.32	0.71	7.70
160		NS	---	147.9	3.50	3.23	0.69	7.42
160		---	100	164.2	3.89	3.57	0.72	8.17
160		NS	100	153.5	3.63	3.39	0.67	7.69

Table 19. Influence of N-rate, K-rate and nitrification on N content, and total N removal on four corn hybrids at the **dent stage R5**. Waseca 1990.

				N-Concentration			N-Removal			
N-Rate	Hybrid	Inh.	K-Rate	Stover	Grain	Cob	Stover	Grain	Cob	Total
#/A			#/A	----------%----------			----------#/A----------			
0	Pioneer 3615	---	---	0.49	1.20	0.49	23.2	59.2	4.3	86.7
0		---	100	0.51	1.12	0.47	29.7	62.6	5.1	97.4
80		---	---	0.61	1.20	0.46	37.6	78.9	5.7	122.3
80		NS	---	0.62	1.12	0.46	35.0	73.5	5.6	114.2
80		---	100	0.66	1.15	0.46	43.7	88.9	6.9	139.5
80		NS	100	0.52	1.21	0.49	32.6	82.9	6.5	122.0
160		---	---	0.69	1.33	0.49	45.5	102.6	7.2	155.3
160		NS	---	0.64	1.38	0.45	39.4	96.3	6.2	141.9
160		---	100	0.66	1.34	0.47	47.1	106.8	7.7	161.6
160		NS	100	0.66	1.40	0.47	42.1	109.8	7.2	159.1
0	Pioneer 3475	---	---	0.47	1.00	0.48	28.9	57.5	6.1	92.5
0		---	100	0.48	1.06	0.45	32.4	56.2	4.8	93.4
80		---	---	0.56	1.18	0.46	39.6	86.6	6.5	132.8
80		NS	---	0.54	1.13	0.45	38.5	85.2	6.8	130.5
80		---	100	0.66	1.19	0.46	54.2	96.2	7.5	158.0
80		NS	100	0.61	1.07	0.47	44.8	76.0	7.2	128.0
160		---	---	0.68	1.30	0.47	52.2	99.4	7.2	158.8
160		NS	---	0.62	1.27	0.45	44.4	94.1	6.8	145.3
160		---	100	0.77	1.28	0.46	59.9	89.1	6.6	155.6
160		NS	100	0.68	1.26	0.47	52.4	91.0	6.8	150.2
0	LH74 X LH51	---	---	0.43	1.02	0.45	27.7	47.1	4.1	78.9
0		---	100	0.39	1.01	0.48	26.8	43.7	4.0	74.6
80		---	---	0.64	1.23	0.43	51.2	83.1	4.8	139.1
80		NS	---	0.63	1.20	0.42	49.8	74.1	4.8	128.8
80		---	100	0.65	1.18	0.43	50.9	73.6	4.8	129.3
80		NS	100	0.72	1.20	0.44	62.1	79.8	5.5	147.4
160		---	---	0.83	1.28	0.44	73.5	95.5	5.5	174.5
160		NS	---	0.77	1.26	0.43	68.3	93.3	5.5	167.1
160		---	100	0.74	1.33	0.43	66.3	93.1	4.9	164.3
160		NS	100	0.74	1.33	0.45	63.9	91.8	5.4	161.2
0	LH74 X LH82	---	---	0.46	0.99	0.42	24.1	49.1	4.0	77.2
0		---	100	0.44	1.16	0.45	22.2	46.2	3.9	72.3
80		---	---	0.69	1.25	0.45	43.5	89.1	5.9	138.5
80		NS	---	0.69	1.19	0.45	44.1	79.8	5.6	129.5
80		---	100	0.68	1.16	0.49	44.5	81.1	6.3	132.0
80		NS	100	0.55	1.11	0.43	33.9	73.3	5.3	112.5
160		---	---	0.75	1.32	0.45	50.4	96.8	6.3	153.5
160		NS	---	0.74	1.36	0.45	47.5	95.1	6.1	148.8
160		---	100	0.83	1.39	0.42	59.4	107.4	6.0	172.9
160		NS	100	0.80	1.38	0.44	54.2	99.8	6.0	160.0

Table 20. Influence of N-rate, K-rate and nitrification on grain yields and dry matter production on four corn hybrids at **physiological maturity**. Waseca 1990.

N-Rate	Hybrid	Inh.	K-Rate	Grain Yields	Dry Matter Production Grain	Stover	Total
#/A			#/A	Bu/A	----------T/A---------		
0	Pioneer 3615	---	---	118.2	2.80	3.15	5.94
0		---	100	126.3	2.99	3.35	6.33
80		---	---	146.6	3.47	3.11	6.58
80		NS	---	144.2	3.41	3.15	6.56
80		---	100	154.5	3.66	3.44	7.09
80		NS	100	143.3	3.39	3.22	6.61
160		---	---	158.6	3.75	3.07	6.82
160		NS	---	153.3	3.63	3.07	6.69
160		---	100	165.8	3.92	3.25	7.18
160		NS	100	156.1	3.69	3.28	6.97
0	Pioneer 3475	---	---	138.9	3.29	3.63	6.92
0		---	100	143.3	3.39	3.83	7.22
80		---	---	161.7	3.82	3.72	7.55
80		NS	---	149.6	3.54	3.71	7.24
80		---	100	164.1	3.88	3.82	7.70
80		NS	100	150.9	3.57	3.76	7.34
160		---	---	156.6	3.70	3.40	7.10
160		NS	---	156.6	3.70	3.67	7.38
160		---	100	164.6	3.89	3.96	7.85
160		NS	100	144.7	3.42	3.63	7.06
0	LH74 X LH51	---	---	114.9	2.72	3.36	6.08
0		---	100	114.3	2.71	3.44	6.15
80		---	---	150.7	3.57	3.69	7.26
80		NS	---	149.1	3.53	3.69	7.22
80		---	100	151.9	3.59	3.82	7.42
80		NS	100	138.3	3.27	3.62	6.89
160		---	---	153.9	3.64	3.68	7.32
160		NS	---	150.0	3.55	3.76	7.31
160		---	100	159.1	3.77	3.93	7.70
160		NS	100	166.8	3.95	4.04	7.99
0	LH74 X LH82	---	---	112.8	2.67	3.20	5.87
0		---	100	114.1	2.70	3.12	5.82
80		---	---	151.8	3.59	3.48	7.07
80		NS	---	145.1	3.43	3.49	6.92
80		---	100	143.4	3.39	3.21	6.60
80		NS	100	144.7	3.42	3.36	6.78
160		---	---	154.2	3.65	3.43	7.08
160		NS	---	148.1	3.50	3.63	7.13
160		---	100	161.8	3.83	3.83	7.66
160		NS	100	147.3	3.49	3.58	7.07

Table 21. Influence of N-rate, K-rate and nitrification on N content and total N removal on four corn hybrids at **physiological maturity**. Waseca 1990.

N-Rate	Hybrid	Inh.	K-Rate	N-Concentration Stover	N-Concentration Grain	N-Removal Stover	N-Removal Grain	N-Removal Total
#/A			#/A	------%-------		----------#/A----------		
0	Pioneer 3615	---	---	0.41	1.12	25.6	62.9	88.5
0		---	100	0.41	1.10	27.3	66.0	93.3
80		---	---	0.38	1.31	24.0	90.6	114.6
80		NS	---	0.38	1.22	23.7	83.1	106.8
80		---	100	0.40	1.35	27.3	98.9	126.1
80		NS	100	0.41	1.27	26.3	85.6	111.9
160		---	---	0.40	1.32	24.7	99.2	123.9
160		NS	---	0.43	1.44	26.2	104.8	131.0
160		---	100	0.44	1.37	28.7	107.6	136.3
160		NS	100	0.44	1.40	28.5	103.2	131.7
0	Pioneer 4757	---	---	0.41	1.07	30.0	70.6	100.5
0		---	100	0.40	1.12	30.4	76.4	106.7
80		---	---	0.41	1.15	30.6	88.3	119.0
80		NS	---	0.38	1.14	28.1	80.7	108.9
80		---	100	0.45	1.19	34.1	92.6	126.7
80		NS	100	0.40	1.32	30.0	93.9	123.9
160		---	---	0.45	1.28	30.4	94.9	125.3
160		NS	---	0.43	1.28	31.9	94.8	126.7
160		---	100	0.48	1.26	38.1	97.9	136.0
160		NS	100	0.48	1.28	34.7	87.6	122.3
0	LH74 X LH51	---	---	0.36	0.94	24.0	51.1	75.1
0		---	100	0.37	1.08	25.6	58.7	84.3
80		---	---	0.47	1.17	34.5	83.7	118.3
80		NS	---	0.41	1.11	30.5	78.5	109.1
80		---	100	0.39	1.28	29.8	92.4	122.2
80		NS	100	0.40	1.07	29.2	70.5	99.6
160		---	---	0.50	1.35	36.5	98.1	134.6
160		NS	---	0.45	1.35	34.0	95.6	129.6
160		---	100	0.46	1.32	36.5	99.3	135.8
160		NS	100	0.44	1.31	35.6	103.4	139.0
0	LH74 X LH82	---	---	0.42	1.06	26.8	56.2	83.0
0		---	100	0.45	1.20	28.0	64.5	92.4
80		---	---	0.48	1.21	33.4	86.6	120.0
80		NS	---	0.43	1.16	29.7	79.3	109.1
80		---	100	0.46	1.24	29.4	84.4	113.7
80		NS	100	0.47	1.09	31.5	74.9	106.4
160		---	---	0.49	1.33	33.5	97.2	130.7
160		NS	---	0.51	1.36	37.3	95.3	132.6
160		---	100	0.58	1.33	44.8	102.1	147.0
160		NS	100	0.51	1.46	36.2	102.1	138.3

Table 22. Waseca 1990

0 # K-Rate only RCB (Hybrid X N-Rate)	Whole Plant Tassling % N	Stover T/A	N-Removal #/A
Hybrids			
Pioneer 3615	1.26	2.75	70.3
Pioneer 3475	1.25	3.06	78.5
LH74 X LH51	1.43	3.02	87.6
LH74 X LH82	1.33	2.92	80.7
P-Value	99	94	99
BLSD (.05)	0.06		8.7
N-Rate			
0	0.96	2.51	46.8
80	1.45	3.14	91.0
160	1.58	3.17	100.2
P-Value	99	99	99
BLSD (.05)	0.06	0.18	6.7
Hybrid X N-Rate	99	88	93
100 # K-Rate only RCB			
Pioneer 3615	1.29	3.02	78.8
Pioneer 3475	1.23	3.40	85.8
LH74 X LH 51	1.26	3.02	78.7
LH74 X LH82	1.36	2.98	84.3
P-Value	94	99	75
BLSD (.05)		0.27	
N-Rate			
0	0.97	2.63	51.7
80	1.40	3.31	93.0
160	1.49	3.38	101.1
P-Value	99	99	99
BLSD (.05)	0.07	0.21	6.8
Hybrid X N-Rate	40	84	90
Split Plot without the 0 # N-Rate			
K-Rate			
0	1.50	3.12	94.1
100	1.44	3.28	94.6
P-Value	90	64	10
Hybrid X N-Rate X Inhibitor			
Hybrid			
Pioneer 3615	1.40	3.02	84.7
Pioneer 3475	1.39	3.40	95.1
LH74 X LH51	1.54	3.27	101.0
LH74 X LH82	1.54	3.13	96.6
P-Value	99	99	99
BLSD (.05)	0.05	0.15	5.3
N-Rate			
80	1.41	3.15	88.9
160	1.53	3.26	99.8
P-Value	99	99	99
Inhibitor			
None	1.48	3.25	96.3
N-Serve	1.46	3.16	92.3
P-Value	72	88	95
Hybrid X N-Rate	63	3	95
Hybrid X Inhibitor	27	54	44
N-Rate X Inhibitor	24	75	73
Hybrid X N-Rate X Inhibitor	33	73	84
Hybrid X N-Rate X Inhibtor X K-Rate			
Hybrid X K-Rate	99	38	99
N-Rate X K-Rate	88	38	81
Hybrid X N-Rate X K-Rate	70	86	45
Inhibitor X K-Rate	23	44	34
Hybrid X Inhibitor X K-Rate	64	91	76
N-Rate X Inhibitor X K-Rate	40	56	70
Hybrid X N-Rate X Inhibitor X K-Rate	29	59	13

Table 23 Waseca 1990

Milk Stage R3	Dry Matter Production				Grain
0 # K-Rate only RCB	Cob	Stover	Grain	Total	Yields
Hybrid (Hybrid X N-Rate)	----------T/A----------				Bu/A
Pioneer 3615	0.70	3.59	2.11	6.41	89.3
Pioneer 3475	0.75	3.88	2.19	6.84	92.8
LH74 X LH51	0.60	4.38	1.74	6.74	73.8
LH74 X LH82	0.68	3.33	2.17	6.19	91.8
P-Value	99	99	99	99	99
BLSD (.05)	0.04	0.28	0.14	0.47	6.3
N-Rate					
0	0.56	3.48	1.63	5.68	69.2
80	0.72	3.90	2.26	6.89	95.9
160	0.78	4.01	2.26	7.06	95.7
P-Value	99	96	99	99	99
BLSD (.05)	0.03	0.25	0.12	0.34	5.2
Hybrid X N-Rate	62	18	64	33	64
100 # K-Rate only RCB					
Hybrids					
Pioneer 3615	0.71	3.69	2.03	6.44	85.8
Pioneer 3475	0.71	4.48	2.03	7.22	85.8
LH74 X LH51	0.59	4.61	1.67	6.87	70.8
LH74 X LH82	0.67	3.69	2.13	6.50	90.3
P-Value	99	99	99	99	99
BLSD (.05)	0.05	0.29	0.17	0.50	7.4
N-Rate					
0	0.51	3.58	1.45	5.55	61.5
80	0.74	4.33	2.17	7.25	91.7
160	0.75	4.45	2.27	7.48	96.2
P-Value	99	99	99	99	99
BLSD (.05)	0.04	0.25	0.14	0.38	6.0
Hybrid X N-Rate	53	53	84	55	84
Split Plot without the 0 # N-Rate					
K-Rate					
0	0.74	3.97	2.24	6.96	95.0
100	0.74	4.27	2.15	7.17	90.5
P-Value	28	99	80	98	80
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3615	0.75	3.72	2.16	6.65	91.7
Pioneer 3475	0.81	4.38	2.33	7.54	98.7
LH74 X LH51	0.64	4.76	1.87	7.28	79.3
LH74 X LH82	0.74	3.63	2.42	6.80	102.2
P-Value	99	99	99	99	99
BLSD(.05)	0.02	0.16	0.10	0.25	4.3
N-Rate					
80	0.71	4.04	2.12	6.88	89.8
160	0.76	4.21	2.27	7.25	96.0
P-Value	99	99	99	99	99
Inhibitor					
None	0.75	4.17	2.24	7.17	94.9
N-Serve	0.73	4.08	2.15	6.96	91.0
P-Value	88	85	98	96	98
Hybrid X N-Rate	89	66	40	68	40
Hybrid X Inhibitor	86	43	47	35	47
N-Rate X Inhibitor	78	62	98	91	98
Hybrid X N-Rate X Inhibitor	16	18	25	3	25
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	77	21	19	2	19
N-Rate X K-Rate	84	47	84	12	84
Hybrid X N-Rate X K-Rate	45	72	24	70	24
Inhibitor X K-Rate	16	95	83	94	83
Hybrid X Inhibitor X K-Rate	81	96	55	86	55
N-Rate X Inhibitor X K-Rate	60	13	4	16	4
Hybrid X N-Rate X Inh. X K-Rate	73	62	55	75	55

Table 24. Waseca 1990	N-Concentration			N-Removal			
0 # K-Rate only RCB (Hybrid X N-Rate)	Cob	Stover	Grain	Cob	Stover	Grain	Total
Hybrids **Milk Stage R3**	----------%---------			----------#/A----------			
Pioneer 3615	0.62	0.80	1.44	8.9	58.5	61.7	129.2
Pioneer 3475	0.61	0.75	1.45	9.3	59.1	64.5	132.9
LH74 X LH51	0.55	0.73	1.51	6.8	64.9	53.7	125.4
LH74 X LH82	0.54	0.85	1.43	7.3	58.5	63.7	129.6
P-Value	99	99	69	99	71	99	37
BLSD (.05)	0.05	0.06		0.8		5.4	
N-Rate							
0	0.55	0.57	1.25	6.3	40.0	41.1	87.5
80	0.57	0.83	1.49	8.3	64.5	67.8	140.6
160	0.62	0.95	1.63	9.7	76.2	73.9	159.9
P-Value	98	99	99	99	99	99	99
BLSD (.05)	0.04	0.05	0.06	0.7	6.0	4.3	9.0
Hybrid X N-Rate	84	98	99	40	37	99	89
100 # K-Rate only RCB							
Hybrid							
Pioneer 3615	0.65	0.88	1.59	9.3	66.3	65.8	141.5
Pioneer 3475	0.61	0.74	1.47	8.8	68.3	60.8	138.0
LH74 X LH51	0.55	0.79	1.50	6.6	75.9	51.0	133.6
LH74 X LH82	0.56	0.84	1.54	7.3	63.9	66.9	138.2
P-Value	98	99	92	99	99	99	40
BLSD (.05)	0.07	0.05		0.9	7.4	5.7	
N-Rate							
0	0.60	0.57	1.36	6.2	40.9	39.8	86.9
80	0.58	0.82	1.52	8.7	71.2	65.8	145.8
160	0.60	1.05	1.70	9.1	93.8	77.8	180.8
P-Value	32	99	99	99	99	99	99
BLSD (.05)		0.04	0.07	0.7	5.5	4.7	9.1
Hybrid X N-Rate	99	99	74	92	99	88	97
Split Plot ,without the 0 # N-Rate							
K-Rate							
0	0.57	0.88	1.54	8.5	70.3	69.2	148.1
100	0.60	0.91	1.61	9.0	78.7	69.2	157.0
P-Value	83	88	77	85	99	3	96
Hybrid X N-Rate X Inhibitor							
Hybrid							
Pioneer 3615	0.64	0.93	1.60	9.7	70.2	69.7	149.8
Pioneer 3475	0.84	0.84	1.51	10.4	73.9	70.8	155.1
LH74 X LH51	0.87	0.87	1.64	7.2	83.7	61.6	152.5
LH74 X LH82	0.96	0.52	1.54	7.8	70.1	74.7	152.7
P-Value	99	99	99	99	99	99	36
BLSD(.05)	0.03	0.03	0.05	0.4	4.9	3.8	
N-Rate							
80	0.57	0.82	1.49	8.2	66.4	63.2	137.9
160	0.60	0.98	1.66	9.3	82.6	75.1	167.2
P-Value	99	99	99	99	99	99	99
Inhibitor							
None	0.59	0.91	1.59	8.9	76.4	71.3	156.8
N-Serve	0.58	0.88	1.56	8.6	72.6	67.1	148.3
P-Value	64	95	80	94	96	99	99
Hybrid X N-Rate	43	99	99	42	99	95	99
Hybrid X Inhibitor	57	88	97	99	80	74	89
N-Rate X Inhibitor	41	82	1	81	37	95	56
Hybrid X N-Rate X Inhibitor	99	37	85	98	51	81	16
Hybrid X N-Rate X Inhibitor X K-Rate							
Hybrid X K-Rate	93	60	8	95	67	28	9
N-Rate X K-Rate	37	99	21	43	99	72	98
Hybrid X N-Rate X K-Rate	94	91	77	97	76	25	34
Inhibitor X K-Rate	99	69	58	99	95	53	85
Hybrid X Inhibitor X K-Rate	69	99	93	95	28	49	8
N-Rate X Inhibitor X K-Rate	87	6	74	95	15	62	34
Hybrid X N-Rate X Inhibitor X K-Rate	24	95	23	2	61	62	55

Table 25 Waseca 1990

Dent Stage R5	Dry Matter Production				Grain
0 # K-Rate only RCB	Cob	Stover	Grain	Total	Yields
Hybrid	----------T/A----------				Bu/A
Pioneer 3615	0.60	2.91	3.20	6.72	135.4
Pioneer 3475	0.70	3.48	3.46	7.65	146.2
LH74 X LH51	0.55	3.88	3.13	7.57	132.6
LH74 X LH82	0.61	3.02	3.24	6.87	137.0
P-Value	99	99	96	99	96
BLSD (.05)	0.03	0.22	0.25	0.38	10.9
N-Rate					
0	0.50	2.83	2.53	5.87	107.1
80	0.64	3.43	3.48	7.55	147.1
160	0.71	3.71	3.76	8.19	159.2
P-Value	99	99	99	99	99
BLSD (.05)	0.03	0.19	0.17	0.31	7.5
Hybrid X N-Rate	95	19	64	51	64
100 # K-Rate only RCB					
Hybrid					
Pioneer 3615	0.70	3.25	3.56	7.52	150.7
Pioneer 3475	0.69	3.76	3.38	7.83	143.0
LH74 X LH51	0.51	3.93	2.93	7.38	124.1
LH74 X LH82	0.60	3.12	3.12	6.85	132.2
P-Value	99	99	99	98	99
BLSD (.05)	0.04	0.34	0.29	0.68	12.5
N-Rate					
0	0.48	3.04	2.41	5.94	101.8
80	0.69	3.64	3.63	7.97	153.5
160	0.70	3.85	3.72	8.28	157.2
P-Value	99	99	99	99	99
BLSD (.05)	0.03	0.29	0.23	0.49	10.0
Hybrid X N-Rate	98	35	94	80	94
Split Plot without the 0 # N-Rate					
K-Rate					
0	0.67	3.52	3.55	7.75	150.3
100	0.68	3.68	3.60	7.98	152.2
P-Value	96	98	35	82	35
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3615	0.70	3.17	3.64	7.53	154.1
Pioneer 3475	0.75	3.75	3.70	8.21	156.7
LH74 X LH51	0.59	4.21	3.41	8.22	144.0
LH74 X LH82	0.66	3.27	3.55	7.49	150.2
P-Value	99	99	99	99	99
BLSD(.05)	0.02	0.16	0.17	0.32	7.5
N-Rate					
80	0.66	3.50	3.50	7.64	146.8
160	0.69	3.70	3.70	8.09	155.7
P-Value	99	99	99	99	99
Inhibitor					
None	0.68	3.66	3.65	8.00	154.3
N-Serve	0.67	3.54	3.50	7.72	148.2
P-Value	86	91	98	98	98
Hybrid X N-Rate	99	38	98	88	98
Hybrid X Inhibitor	94	54	30	53	30
N-Rate X Inhibitor	18	48	28	15	28
Hybrid X N-Rate X Inhibitor	2	11	9	12	9
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	99	29	94	78	94
N-Rate X K-Rate	97	39	48	57	48
Hybrid X N-Rate X K-Rate	82	25	54	51	54
Inhibitor X K-Rate	33	18	9	17	9
Hybrid X Inhibitor X K-Rate	65	11	36	28	36
N-Rate X Inhibitor X K-Rate	53	1	66	41	66
Hybrid X N-Rate X Inh. X K-Rate	57	57	82	72	57

Table 26. Waseca 1990	N-Concentration			N-Removal			
0 # K-Rate only RCB (Hybrid X N-Rate)	Cob	Stover	Grain	Cob	Stover	Grain	Total
Hybrids Dent Stage R5	----------%---------			----------#/A----------			
Pioneer 3615	0.47	0.59	1.24	5.7	35.4	80.2	121.4
Pioneer 3475	0.46	0.57	1.15	6.5	40.2	81.1	128.0
LH74 X LH51	0.43	0.63	1.17	4.8	50.7	75.2	130.8
LH74 X LH82	0.44	0.63	1.18	5.4	39.3	78.3	123.0
P-Value	99	88	96	99	99	61	66
BLSD (.05)	0.02		0.06	0.4	5.6		
N-Rate							
0	0.46	0.46	1.05	4.6	25.9	53.2	83.8
80	0.44	0.62	1.21	5.7	42.9	84.4	133.1
160	0.45	0.73	1.30	6.5	55.4	98.5	160.5
P-Value	54	99	99	99	99	99	99
BLSD (.05)		0.04	0.04	0.4	4.6	5.7	8.9
Hybrid X N-Rate	35	91	99	94	97	63	80
100 # K-Rate only RCB							
Hybrid							
Pioneer 3615	0.46	0.61	1.20	6.5	40.1	86.0	132.8
Pioneer 3475	0.45	0.63	1.17	6.2	48.8	80.5	135.6
LH74 X LH51	0.45	0.59	1.17	4.5	48.0	70.1	122.7
LH74 X LH82	0.45	0.65	1.23	5.4	42.0	78.2	125.7
P-Value	29	95	92	99	96	99	91
BLSD (.05)		0.04		0.4	6.1	6.8	
N-Rate							
0	0.46	0.45	1.08	4.4	27.7	52.1	84.4
80	0.46	0.66	1.16	6.3	48.3	84.9	139.6
160	0.44	0.75	1.33	6.3	58.1	99.0	163.5
P-Value	29	95	92	99	99	99	91
BLSD (.05)		0.03		0.4	4.5	5.4	
Hybrid X N-Rate	89	99	89	97	93	99	98
Split Plot without the 0 # N-Rate							
K-Rate							
0	0.44	0.67	1.24	6.0	47.5	88.6	142.5
100	0.45	0.68	1.24	6.2	50.7	90.0	147.0
P-Value	35	74	3	75	99	48	92
Hybrid X N-Rate X Inhibitor							
Hybrid							
Pioneer 3615	0.46	0.63	1.26	6.6	40.3	92.4	139.4
Pioneer 3475	0.46	0.64	1.21	6.9	48.2	89.6	144.8
LH74 X LH51	0.43	0.71	1.25	5.1	60.7	85.5	151.4
LH74 X LH82	0.44	0.71	1.26	5.9	47.1	90.3	143.4
P-Value	99	99	99	99	99	97	98
BLSD(.05)	0.01	0.03	0.03	0.2	3.4	5.1	8.2
N-Rate							
80	0.45	0.62	1.17	5.9	44.1	81.3	131.5
160	0.45	0.72	1.32	6.3	54.1	97.6	158.1
P-Value	7	99	99	99	99	99	99
Inhibitor							
None	0.45	0.69	1.25	6.2	51.2	91.7	149.2
N-Serve	0.45	0.65	1.24	6.0	47.0	87.2	140.0
P-Value	28	99	70	86	99	99	99
Hybrid X N-Rate	47	73	97	98	85	99	88
Hybrid X Inhibitor	17	63	83	93	77	32	62
N-Rate X Inhibitor	15	16	92	6	58	79	29
Hybrid X N-Rate X Inhibitor	89	70	31	55	46	21	30
Hybrid X N-Rate X Inhibitor X K-Rate							
Hybrid X K-Rate	15	98	53	98	91	96	70
N-Rate X K-Rate	66	44	96	98	12	40	12
Hybrid X N-Rate X K-Rate	15	99	78	37	98	88	96
Inhibitor X K-Rate	66	59	54	38	47	27	7
Hybrid X Inhibitor X K-Rate	66	83	61	48	75	55	71
N-Rate X Inhibitor X K-Rate	80	84	57	84	58	41	57
Hybrid X N-Rate X Inhibitor X K-Rate	43	66	40	23	48	86	76

Table 27 Waseca 1990

Physiological Maturity	Dry Matter Production				Grain
0 # K-Rate only RCB	Cob	Stover	Grain	Total	Yields
Hybrid	----------T/a----------				Bu/A
Pioneer 3615	---	3.10	3.33	6.54	141.1
Pioneer 3475	---	3.58	3.60	7.18	152.3
LH74 X LH51	---	3.57	3.31	6.88	139.8
LH74 X LH82	---	3.36	3.30	6.67	139.6
P-Value		99	99	99	99
BLSD (.05)		0.14	0.15	0.23	6.5
N-Rate					
0	---	3.33	2.86	6.20	121.2
80	---	3.50	3.61	7.11	152.6
160	---	3.39	3.68	7.08	155.8
P-Value		96	99	99	99
BLSD (.05)		0.14	0.12	0.19	5.2
Hybrid X N-Rate		94	95	99	95
100 # K-Rate only RCB					
Hybrid					
Pioneer 3615	---	3.34	3.52	6.86	148.8
Pioneer 3475	---	3.86	3.72	7.59	157.3
LH74 X LH51	---	3.73	3.35	7.08	141.8
LH74 X LH82	---	3.38	3.30	6.69	139.7
P-Value		99	99	99	99
BLSD (.05)		0.13	0.18	0.28	7.9
N-Rate					
0	---	3.43	2.94	6.37	124.4
80	---	3.57	3.63	7.20	153.4
160	---	3.74	3.85	7.59	162.8
P-Value		99	99	99	99
BLSD (.05)		0.12	0.15	0.23	6.3
Hybrid X N-Rate		99	84	99	84
Split Plot without the 0 # N-Rate					
K-Rate					
0	---	3.48	3.59	7.07	151.8
100	---	3.61	3.63	7.24	153.5
P-Value		98	37	85	37
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3615	---	3.19	3.61	6.81	152.7
Pioneer 3475	---	3.70	3.69	7.40	156.0
LH74 X LH51	---	3.78	3.60	7.38	152.4
LH74 X LH82	---	3.50	3.53	7.03	149.5
P-Value		99	96	99	96
BLSD(.05)		0.08	0.11	0.15	4.9
N-Rate					
80	---	3.51	3.53	7.05	149.3
160	---	3.57	3.69	7.26	156.0
P-Value		91	99	99	99
Inhibitor					
None	---	3.55	3.69	7.24	156.1
N-Serve	---	3.54	3.53	7.07	149.2
P-Value		28	99	99	99
Hybrid X N-Rate		99	97	99	97
Hybrid X Inhibitor		12	67	45	67
N-Rate X Inhibitor		55	24	46	24
Hybrid X N-Rate X Inhibitor		58	71	78	71
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate		88	36	74	36
N-Rate X K-Rate		99	90	99	90
Hybrid X N-Rate X K-Rate		76	85	81	85
Inhibitor X K-Rate		99	84	98	84
Hybrid X Inhibitor X K-Rate		37	41	49	41
N-Rate X Inhibitor X K-Rate		77	23	62	23
Hybrid X N-Rate X Inhibitor X K-Rate		98	93	99	93

Table 28. Waseca 1990	N-Concentration		N-Removal		
0 # K-Rate only RCB (Hybrid X N-Rate)	Stover	Grain	Stover	Grain	Total
Hybrids **Physiological Maturity**	------%---------		---------#/A--------		
Pioneer 3615	0.39	1.25	24.7	84.2	108.9
Pioneer 3475	0.42	1.16	30.3	84.6	114.9
LH74 X LH51	0.44	1.15	31.6	77.6	109.3
LH74 X LH82	0.46	1.20	331.2	79.9	111.2
P-Value	99	99	99	99	83
BLSD (.05)	0.02	0.05	2.3	5.1	
N-Rate					
0	0.39	1.04	26.5	60.1	86.7
80	0.43	1.21	30.6	87.3	117.9
160	0.45	1.32	31.2	97.3	128.6
P-Value	99	99	99	99	99
BLSD (.05)	0.02	0.04	2.0	3.7	4.5
Hybrid X N-Rate	99	98	99	98	99
100 # K-Rate only RCB					
Hybrid					
Pioneer 3615	0.41	1.27	27.7	90.8	118.5
Pioneer 3475	0.43	1.19	34.1	88.9	123.1
LH74 X LH51	0.40	1.22	30.6	83.4	114.0
LH74 X LH82	0.49	1.25	34.0	83.6	117.7
P-Value	99	96	99	95	82
BLSD (.05)	0.03	0.06	3.1	7.2	
N-Rate					
0	0.40	1.12	27.7	66.3	94.1
80	0.42	1.26	30.1	92.0	122.1
160	0.49	1.32	37.0	101.7	138.7
P-Value	99	99	99	99	99
BLSD (.05)	0.02	0.04	2.5	4.9	6.3
Hybrid X N-Rate	90	91	99	94	94
Split Plot without the 0 # N-Rate					
K-Rate					
0	0.43	1.26	30.5	90.6	121.2
100	0.44	1.28	32.5	93.5	126.0
P-Value	55	76	81	79	91
Hybrid X N-Rate X Inhibitor					
Hybrid					
Pioneer 3615	0.40	1.33	26.1	96.6	122.7
Pioneer 3475	0.43	1.23	32.2	91.3	123.5
LH74 X LH51	0.43	1.24	33.3	90.1	123.4
LH74 X LH82	0.49	1.27	34.4	90.2	124.7
P-Value	99	99	99	99	17
BLSD(.05)	0.01	0.03	1.4	3.4	
N-Rate					
80	0.41	1.20	29.4	85.2	114.7
160	0.46	1.34	33.5	98.9	132.5
P-Value	99	99	99	99	99
Inhibitor					
None	0.45	1.27	32.2	94.6	126.8
N-Serve	0.43	1.26	30.8	89.5	120.4
P-Value	99	30	99	99	99
Hybrid X N-Rate	67	99	99	99	99
Hybrid X Inhibitor	76	98	48	7	14
N-Rate X Inhibitor	27	99	44	99	99
Hybrid X N-Rate X Inhibitor	34	99	34	88	70
Hybrid X N-Rate X Inhibitor X K-Rate					
Hybrid X K-Rate	99	42	99	16	63
N-Rate X K-Rate	83	93	99	6	75
Hybrid X N-Rate X K-Rate	24	94	69	97	97
Inhibitor X K-Rate	23	68	74	83	89
Hybrid X Inhibitor X K-Rate	63	90	75	35	14
N-Rate X Inhibitor X K-Rate	99	47	99	17	61
Hybrid X N-Rate X Inhibitor X K-Rate	96	97	97	97	95

1990 WEATHER DATA
NORTHWEST EXPERIMENT STATION, CROOKSTON, MN

T.E. Cymbaluk[1]

The drought continues. Mother nature still has not cooperated with the amount of precipitation that is needed. Seven months in 1990 were below average in precipitation. 1990 received a total of 16.49 inches, four inches less than the 100 year average. The small grain season, (May 1 - July 31), received 6.98 inches of precipitation, 2.15 inches below normal. The sugarbeet season (May 1 - September 31), received 10.9 inches of precipitation, 3.29 inches less than the 100 year average. The months of May and July recieved less than 25 percent of their normal rain fall. In the last seven years, since 1984, there has been a deficit of 18.47 inches of precipitation when compared to the 100 year average. The last three years, since 1988, there has been a deficit of 11.91 inches of precipitation. The greatest amount of precipitation that occurred in a single day in 1990 was 2.33 inches on June 1.

Seven months in 1990 were below normal in regard to temperature. The average temperature for 1990 was 41.14°F, 1.66° higher than the 100 year average. January, Febuary, and March were well above the average temperature and December was well below the average temperature. The highest temperature in 1990 occurred on August 16 at 94°F. The coldest temperature was -38°F which occurred on December 25 and 26.

The last frost of the spring was on May 17, 1990 (30°F) which initiated a 127 day frost-free period ending on September 22 (25°F). The ground frost depth reached 37.5 inches on March 15. The ground frost started to thaw on March 30 and by April 25 the ground frost was gone.

Table 1. Weather summary for 1990 with 100-year averages precipitation and mean temperature.

Month	Precipitation 1990	Precipitation 1890-1989	Mean Temperature 1990	Mean Temperature 1890-1989
	------ inches ------		------- °F --------	
January	0.25	0.56	17.1	3.9
Febuary	0.31	0.56	14.5	8.5
March	1.96	0.84	28.5	23.0
April	1.75	1.51	41.4	41.7
May	0.71	2.60	54.5	54.8
June	5.79	2.71	64.8	64.4
July	0.48	3.03	68.1	69.7
August	3.01	2.93	69.0	67.4
September	0.91	2.13	58.7	57.3
October	0.53	1.47	42.3	45.1
November	0.07	0.78	28.1	26.7
December	0.72	0.58	6.7	11.2
Total	16.49	20.49	Mean 41.1	39.5

[1] Junior Scientist, Northwest Experiment Station, University of Minnesota, Crookston, MN.

Table 2. Records broken or matched at the Northwest Experiment Station, Crookston, MN in 1990.

Highest Maximum Temperature

Date	Old Record	New (1990)
	-------- °F	---------
January 6	40 (1984)	40
January 10	44 (1958)	49
March 1	47 (1918)	47
March 9	50 (1902)	52
March 10	50 (1977)	55
March 11	53 (1902)	58
April 23	83 (1942)	89
September 24	83 (1930)	85
October 26	76 (1989)	76
October 31	69 (1950)	71
November 1	66 (1978)	68
December 8	45 (1939)	50
December 9	51 (1939)	56

Lowest Maximum Temperature

Date	Old Record	New (1990)
	--------- °F	--------
April 11	63 (1951)	60
April 28	34 (1950)	33
December 21	-15 (1989)	-16
December 22	-10 (1945)	-11
December 29	-8 (1934)	-16

Lowest Minimum Temperature

Date	Old Record	New (1990)
	--------- °F	-------
May 9	22 (1945)	22
October 11	19 (1893)	16
December 25	-35 (1933)	-38
December 26	-33 (1933)	-38

Highest Minimum Temperature

Date	Old Record	New (1990)
	------ °F	-----
January 22	21 (1983)	22
March 11	33 (1977)	39
April 23	52 (1957)	53
April 24	54 (1900)	59
October 31	45 (1948)	45
November 20	35 (1962)	44

Greatest amount of precipitation in a single day.

Date	Old Record	New (1990)
	------ inches	------
June 1	2.01 (1969)	2.33

DIRECT COMPARISON OF DEEP NITRATE-N LEVELS AND OPTIMUM N FERTILIZER RATE

John A. Lamb[1/]

Considerable information has been obtained on the optimum N rate to use on soil where soil nitrate-N tests are greater than 40 pounds per acre in the 2 to 4 foot depth. Most recommendations concur that 80-90 pounds N per acre are needed to ensure adequate early season growth. A direct, side-by-side comparison between a high subsoil nitrate-N and low subsoil nitrate-N soil has not been done. With the use of a deep fertilizer injector built at the Northwest Experiment Station, it was possible to duplicate a high nitrate condition within the same experimental site where the low nitrate condition occurs. This approach allows a direct and statistically sound method of measuring the differences in the N response of sugarbeet.

Materials and Methods:

A field trial was conducted on a Wheatville loam at the Northwest Experiment Station, Crookston, MN in 1990 with two deep fertilizer treatments of either 0 or 100 pounds N per acre injected to a depth of 30 inches in 12 inch increments in each row in October 1989. Surface broadcast treatments of 0, 40, 80, and 120 pounds N per acre were applied and incorporated at the same time. The initial 0-2 feet nitrate-N soil test was 60 lb. N per acre and 18 lb. N per acre at the 2 to 4 foot depth. Four replications with a randomized complete block design was used. KW 1745 was planted April 23, 1990 froze, and replanted May 11. The plots were overplanted and thinned back to 125 plants per 100 feet of row. Petiole samples for nitrate-N determination were taken July 24, August 21, and September 20. Sugarbeet tops were sampled at harvest with yield and total N content determined later. Root quality was determined at American Crystal Sugar Company's Quality lab in East Grand Forks, MN where the brei was sampled. Total N content of the brei was determined later.

Results and Discussion:

Root yield and recoverable sucrose per acre was not significantly effected by the either deep N or surface N applications, Table 1. The placement of N at 30 inches did reduce the sucrose concentration and recoverable sucrose per ton by 0.7 % and 15 pounds per ton, Table 1. The dry season influenced the lack of response to N fertilizer. Other than as a result of May and June precipitation there was very little growth and actually the yield level achieved was surprising.

[1/] Associate Professor, Soil Science Dept., University of Minnesota, St. Paul, MN

Table 1. Root yield, sucrose concentration, recoverable sucrose per acre, and recoverable sucrose per ton for deep N application study, 1990 NWES.

Deep N lb/A	N Rate lb/A	Root Yield T/A%	Sucrose Conc. %	Recoverable Sucrose lb/A	lb/T
0	0	11.1	17.8	3550	322
0	40	12.5	16.7	3708	296
0	80	12.1	17.2	3674	303
0	120	13.1	17.1	3895	298
100	0	12.8	16.4	3681	289
100	40	13.4	17.1	4006	299
100	80	12.6	16.1	3523	281
100	120	13.2	16.5	3792	288
0		12.2	17.2	3707	305
100		13.0	16.5	3751	290
	0	11.9	17.1	3616	306
	40	13.0	16.9	3857	297
	80	12.3	16.6	3599	292
	120	13.1	16.8	3843	293
Statistic Analyses					
Deep N		NS	++	NS	++
N Rate		NS	NS	NS	NS
Linear		NS	NS	NS	NS
Quadratic		NS	NS	NS	NS
Deep N X N Rate		NS	NS	NS	NS
C.V. %		12.9	6.2	12.8	7.8

++ is significant at the 0.10 level.

The reduction in recoverable sucrose per ton can be attributed to the increase in amino-N concentration by the deep N treatment, Table 2. The use of surface N also significantly increased amino-N and tended to increase K concentrations, Table 2. Sodium (Na) was not effected by any treatment. Surface N application increased the loss to molasses 0.31 % which under the current quality payment system would directly effect the economic return. Deep N also increased the loss to molasses but only 0.10 %. In 1990 at NWES the optimum N application for both 0 and 100 pounds N per acre deep N treatments was 0 pounds N per acre. Hopefully in the future this study will be conduct under more optimum conditions in which more useful information can be obtained.

Table 2. Root Na, K, amino-N, and loss to molasses for deep N application study, 1990 NWES.

Deep N lb/A	N Rate lb/A	Na	K	amino N	loss to molasses
		----------ppm----------			%
0	0	413	2015	510	1.55
0	40	639	1925	598	1.74
0	80	503	2084	676	1.83
0	120	566	2160	770	2.00
100	0	574	1996	635	1.78
100	40	596	1997	743	1.93
100	80	561	2091	686	1.87
100	120	550	2042	755	1.94
0		531	2046	638	1.78
100		570	2031	705	1.88
	0	494	2005	572	1.66
	40	617	1961	670	1.83
	80	532	2087	681	1.85
	120	558	2101	763	1.97
Statistic Analyses					
Deep N		NS	NS	*	++
N Rate		NS	NS	**	**
Linear		NS	++	**	**
Quadratic		NS	NS	NS	NS
Deep N X N Rate		NS	NS	+	NS
C.V. %		31.3	7.3	12.1	8.9

+, ++, *, and ** are 0.20, 0.10, 0.05, and 0.01 significance levels, respectively

PRIMARY TILLAGE EFFECTS ON SOIL SUSCEPTIBILITY TO EROSION AFTER SUGARBEET HARVEST

John A. Lamb[1/]

After sugarbeet harvest the soil is exposed to possible wind erosion. There are two strategies that can reduce susceptibility to erosion: residue and soil roughness management. Tillage affects both of these management strategies. Use of the correct tillage tool can increase the amount of residue left on the soil surface, (sugarbeet tops) by "unburying" the tops and at the same time leaving the surface in a rougher conditions. In fall 1989 a study was started with the objective to determine if there is an optimal primary tillage operation after sugarbeet production that will minimize soil erosion and not reduce crop production the following year.

Materials and Methods:

A study was conducted after sugarbeet harvest in 1989 on a Fargo silty clay soil at the Northwest Experiment Station. Five primary tillage treatments were implemented October 11, 1989 after sugarbeet harvest: 1) moldboard plow, 2) chisel plow (twisted shanks), 3) field cultivator, 4) disk, and 5) no tillage. Percent ground cover was measured October 17, 1989, April 18, 1990 (before fertilization), and April 25, 1990 (after planting). Dry aggregate distributions were only measured October 17, 1989, and April 19, 1990. Nitrogen fertilizer was applied according to soil test recomendations and incorporated with a multiweeder April 20, 1990. Marshall spring wheat was planted April 23, 1990 with a conventional double disk press wheel drill. Grain yields were taken August 1, 1990.

Results and Discussion:

There was a significant difference in ground cover as effected by primary tillage on all three measured dates, table 1. On the October date, after sugarbeet harvest, the soils which were treated with a field cultivator and light tandem disk had the most cover, 29 %, followed by chisel and no tillage, 20 and 21 %, and plowed soils having the least cover, 4 %. The amounts measured early spring before tillage had similar differences with small coverage reductions over the winter. After planting, April 25, 1990, the soils treated with a field cultivator, disk, and no tillage maintained 19 % coverage; chisel, 14 %, and plow, 3 %. This suggests that a shallow tillage operation such as with a field cultivator or disk will provide more wind protection than no tillage at all.

The geometric mean diameter (GMD) is a measurement of soil cloddiness. Aggregate (clods) with a size of 0.84 mm and greater are considered to be nonerodible. The greater the GMD is the less erodible a soil is. The data suggests that plowed soil has considerably greater GMD than the other treated soils on both dates measured. There is no significant difference occured between the soils treated with the other four primary tillages.

Grain yield is reported on a 13.5 % basis in table 1. There were no significances in yields from the different tillage treatments.

In the future it is planned to do similar studies on different soil textures.

Table 1. Ground cover, geometric mean diameter, grain yield, and grain protein as effected by primary tillage on a Fargo silty clay at NWES.

Primary Tillage	Ground Cover 10/17/89	Ground Cover 4/18/90	Ground Cover 4/25/90	Geometric Mean Diameter 10/17/89	Geometric Mean Diameter 4/19/90	Grain Yield bu/A	Grain Protein %
	%	%	%	mm	mm		
Plow	4	3	3	5.28	1.24	50.8	11.9
Chisel	20	16	14	2.88	1.00	54.3	11.0
Field Cult.	29	28	19	2.41	1.02	52.2	12.2
Disk	29	26	19	2.22	1.06	58.2	10.8
No Tillage	21	21	18	2.30	1.04	55.2	11.6
LSD 0.05	6.2	5.2	4.4	1.25	0.12	NS	1.1

[1/] Associate Professor, Soil Science Dept., University of Minnesota, St. Paul, MN

NITROGEN EFFECTS ON QUALITY OF SELECTED SUGARBEET VARIETIES

J.A. Lamb and L.J. Smith[1/]

During the recent drought years the amount of residual soil nitrate-N has risen and caused problems with maintaining sugarbeet quality. One possible management practice is to select a low impurity variety. Most varietal development occurs under more optimum soil N conditions. The objective of this study is to determine a low impurity variety will continue to be a low impurity variety at elevated soil nitrate-N levels and if that would be more cost effective management decision compared to average varieties under these conditions.

Three locations were used in 1990, Northwest Experiment Station (NWES), near Casselton, ND (CASS), and near Bird Island, MN (SOMN). The treatments were five varieties with the following characteristics, 1.) low Amino-N (LAN), 2.) low K, Na, and Amino-N (LKNAN), 3.) high K, Na, and Amino-N (NKNAN), 4.) small top growth (ST), and 5.) large top growth (LT), with two N levels (soil nitrate-N 0 - 2 ft + fertilizer), of 100 and 300 pounds per acre at NWES and CASS and 84 and 211 pounds per acre at SOMN. The study was a split plot design with four replications. Nitrogen levels were the main plots with varieties as the subplot. The subplot size was 14.7 ft (8 rows) wide and 35 ft long. The plots were planted May 3, May 4, and May 9, 1990 at NWES, Cass, and SOMN, respectively. Sugarbeet seed was overplanted and thinned to 125 plants per 100 feet of row. Petiole samples were taken three times during the period of July through harvest. Harvest occurred on September 20, September 27, and September 25, 1990 at NWES, CASS, and SOMN, respectively. At harvest the tops and roots were sampled for total N analyses along with root yield and quality. Quality was determined at the American Crystal Sugar Tare Lab in East Grand Forks, MN.

Results and Discussion:

Root yield and sucrose concentration are listed in table 1. Root yield over the three locations was increased 2.4 tons per acre when the N level was increased. The varieties root yields were different and the ranking from least to greatest was different at each location. Sucrose concentration was not affected at SOMN and NWES by the treatments. At CASS, there was an interaction between N level and variety. The varieties' sucrose concentration were effected differently by the addition of N. At the lower N level the LAN, HKNAN, and ST varities had the greatest sucrose. At the greater N level the LT variety had the greatest sucrose concentration.

Table 2 lists the means and statistics for recoverable sucrose per acre, recoverable sucrose per ton, and loss to molasses. Recoverable sucrose per acre and per ton and loss to molasses were inconsistant as to the response to change of N level by each variety over locations. On the average N increased recoverable sucrose per acre and loss to molasses with added N decreasing recoverable sucrose per ton.

Table 1. Root yield and sucrose concentration at NWES, CASS, and SOMN locations, 1990.

		Root Yield			Sucrose Conc.		
Variety	N Rate	NWES	CASS	SOMN	NWES	CASS	SOMN
	lb/A	------ T/A -----			------ % -------		
LKNAN	100	11.3	19.8	8.5	16.5	16.9	13.9
LAN	100	11.9	18.8	12.2	17.8	17.9	14.0
HKNAN	100	12.2	20.4	12.5	17.1	17.9	13.8
LT	100	10.9	18.9	13.4	17.4	17.3	14.0
ST	100	14.4	20.5	12.3	17.0	17.9	13.9
LKNAN	300	16.3	22.4	12.1	16.9	17.3	13.5
LAN	300	13.9	20.8	14.7	16.0	17.6	13.8
HKNAN	300	13.3	21.7	16.8	16.6	17.3	13.3
LT	300	13.6	21.1	14.2	16.6	18.2	13.4
ST	300	15.3	22.0	15.7	16.8	17.3	14.0
Statistical Analyses							
NLEVEL		*	NS	**	NS	NS	NS
VARIETY		**	**	*	NS	++	NS
NLEVEL X VARIETY		NS	NS	NS	++	*	NS

**, *, and ++ are the 0.01, 0.05, and 0.10 significance levels, respectively.

[1/] Associate Professor, Soil Science Dept., University of Minnesota, St. Paul, MN and Superintendent, Northwest Experiment Station, University of Minnesota, Crookston, MN.

The root impurities: Na, K, and Amino-N, are listed in table 3. Sodium was affected by variety at all locations. At the CASS site the varietal differences were affected by N level. Potassium was not affected by treatments at the SOMN site. At NWES there was a significant difference in K caused by variety but no difference caused by N application. At the CASS location the K in the beet root changed differently depending on the variety. With the LT and LKNAN varieties K was reduced with the addition of N. Root K was increased with the addition of N for the LAN, HKNAN, and ST varieties.

Root Amino-N at NWES and SOMN increased with increasing N fertilization. At NWES the varieties had significantly different amino-N concentrations. At SOMN there were no differences in amino-N because of varieties. There was a significant interaction between N level and varieties at CASS for amino-N. The LT variety actually had a lower amino-N concentration when N was applied while the other varieties had greater amino-N.

Table 2. Recoverable sucrose per acre, recoverable sucrose per ton, and loss to molasses at NWES, CASS, and SOMN, 1990.

		Recoverable Sucrose						Loss to Molasses		
Variety	N Rate	NWES	CASS	SOMN	NWES	CASS	SOMN	NWES	CASS	SOMN
	lb/A	-----	lb/A	-----	-----	lb/T	-----	------	%	-------
LKNAN	100	3368	6029	2079	298	305	243	1.51	1.53	1.64
LAN	100	3808	6121	2958	321	326	242	1.59	1.48	1.74
HKNAN	100	3669	6625	2919	302	325	236	1.84	1.51	1.79
LT	100	3361	5786	3240	307	306	243	1.82	1.84	1.65
ST	100	4317	6628	2986	300	324	242	1.81	1.57	1.62
LKNAN	300	3877	6940	2776	292	310	231	1.81	1.59	1.77
LAN	300	3831	6584	3455	274	316	238	2.04	1.67	1.69
HKNAN	300	4735	6691	3712	291	309	233	2.17	1.74	1.92
LT	300	3889	6924	3240	287	328	225	2.08	1.59	1.92
ST	300	4490	6785	3784	293	309	241	1.93	1.67	1.78
Statistical Analyses										
NLEVEL		**	NS	**	NS	NS	NS	*	NS	NS
VARIETY		**	NS	*	NS	NS	NS	**	++	NS
NLEVEL X VARIETY		NS	*	NS	++	**	NS	NS	**	NS

**, *, and ++ are the 0.01, 0.05, and 0.10 significance levels, respectively.

Table 3. Root impurities at NWES, CASS, and SOMN, 1990.

		Na			K			Amino-N		
Variety	N Rate	NWES	CASS	SOMN	NWES	CASS	SOMN	NWES	CASS	SOMN
	lb/A	-----	ppm	------	-----	ppm	------	-----	ppm	------
LKNAN	100	385	225	499	1817	2179	2269	547	523	486
LAN	100	450	202	575	1906	2169	2331	561	496	516
HKNAN	100	550	174	653	1997	2323	2339	686	490	524
LT	100	600	358	607	1984	2370	2199	665	665	470
ST	100	429	195	490	2009	2140	2137	707	574	505
LKNAN	300	399	266	621	1913	2057	2184	742	586	564
LAN	300	574	240	679	2044	2228	2075	828	613	509
HKNAN	300	505	233	766	2245	2366	2288	894	630	596
LT	300	610	228	671	2048	2212	2374	840	561	612
ST	300	344	206	561	2038	2236	2142	822	626	605
Statistical Analyses										
NLEVEL		NS	NS	NS	NS	NS	NS	**	NS	++
VARIETY		**	**	*	++	**	NS	**	NS	NS
NLEVEL X VARIETY		NS	**	NS	NS	*	NS	NS	*	NS

**, *, and ++ are the 0.01, 0.05, and 0.10 significance levels, respectively.

In summary, one years results does not show any clear trend as to whether a variety that has lower impurities under normal soil nitrate-N conditions will preform similarly under high soil nitrate-N conditions.

I would like to thank Allan Cattanach and NDSU crew, and Stan Prokosch for their cooperation and help with the CASS and SOMN locations.

BRIGHT SUN ON SPRING WHEAT AND SUGARBEET

J. A. Lamb and T. E. Cymbaluk[1/]

Two studies were conducted in 1990 at the Northwest Experiment Station, Crookston, MN to evaluate the use of Bright Sun, a foliar topdress product on spring wheat and sugarbeet. Both studies were conducted on a Wheatville loam.

Spring Wheat

The treatments were a factorial combination of three soil N levels; 50, 100, and 150 pounds of soil nitrate-N 0 to 2 feet plus fertilizer N, and with and without Bright Sun. The fertilizer for the soil N treatments was applied as Urea (46 - 0 - 0) April 18, 1990 and incorporated with and multiweeder. The spring wheat variety, Marshall, was planted at a rate of 100 pounds of seed per acre on April 18, 1990. The experiment had four replications and was in a randomized complete block design. Population measurements were taken before tillering. The Bright Sun was applied at a rate of three gallons per acre with a total carrier, water, of 15 gallons per acre on June 14, 22, and July 10, 1990. The following measurements were taken at soft dough; forage yield, height, head number, heads per plant, and seeds per plant. The wheat was machine harvested August 1, 1990. At harvest grain yield (corrected to 13.5 % moisture), bushel weight, and grain protein (corrected to 13.5 % moisture) were determined.

Results and Discussion:

The growing season in 1990 was a continuation of the droughts of 1988 and 1989. The subsoil moisture was depleted at the start of the growing season and only seven inches of precipitation fell during the growing season which is 3.3 inches less than the 100 year average. The use of Bright Sun did not effect any of the parameters measured (Tables 1 and 2). The use of N fertilizer did increase plant height, heads per plant, seeds per plant, grain yield, grain protein, and forage yield. Soil N decreased bushel weight. Plant population was greatest at the 100 lb N/A rate with wheat treated with 50 the 150 lb N/A having less population.

Table 1. The effect of soil N level and Bright Sun on population, height, heads per acre, heads per plant, and seeds per plant at NWES in 1990.

Soil N lb/A	Bright Sun	Plant height in	Plant population plant/A	Heads per acre #/A	Heads per plant #/plant	Seeds per plant #/plant
50	No	24.0	927828	1989240	2.10	21.7
50	Yes	24.0	876427	2562780	2.35	22.3
100	No	25.3	956578	2904000	2.60	24.3
100	Yes	25.3	958320	2642640	2.85	23.1
150	No	26.0	899078	2417580	3.05	25.1
150	Yes	26.0	865973	2315940	3.10	24.2
	No	25.3	927828	2436940	2.58	23.7
	Yes	25.1	900240	2507120	2.77	23.2
50		24.0	902128	2276010	2.23	22.0
100		25.3	957449	2773320	2.73	23.7
150		26.3	882526	2366760	3.08	24.7
Statistical Analyses						
Soil N		**	++	NS	**	++
Bright Sun		NS	NS	NS	NS	NS
SN X BS		NS	NS	NS	NS	NS
C.V. %		5.0	6.8	20.6	16.9	9.8

**, and ++ are 0.01 and 0.10 significance levels, respectively.

[1/] Associate Professor of Soil Science Dept., University of Minnesota, St. Paul, MN and Junior Scientist, Northwest Experiment Station, University of Minnesota, Crookston, MN.

Table 2. The effect of soil N level and Bright Sun on grain yield, bushel weight, grain protein, and forage yield at NWES in 1990.

Soil N lb/A	Bright Sun	Grain Yield bu/A	Bushel Weight lb/bu	Grain Protein %	Forage Yield lb/A
50	No	23.8	62.1	10.3	3633
50	Yes	23.2	61.2	10.6	4035
100	No	28.3	58.3	12.5	4958
100	Yes	26.3	58.5	13.2	4173
150	No	25.1	56.5	13.5	5694
150	Yes	25.5	57.0	13.5	4681
	No	25.7	58.9	12.1	4762
	Yes	25.0	58.9	12.4	4296
50		23.5	61.6	10.5	3834
100		25.3	58.4	12.8	4565
150		27.3	56.7	13.5	5187
Statistical Analyses					
Soil N		*	**	**	**
Bright Sun		NS	NS	NS	NS
SN X BS		NS	NS	NS	NS
C.V. %		9.4	1.4	6.0	15.6

** and * are 0.01 and 0.05 significance levels, respectively.

Sugarbeets:

Similar treatments were used in the sugarbeet trial as the spring wheat trial. The soil N levels were 60, 110, 160 lb N/A as soil nitrate-N, 0 to 2 feet plus fertilizer N applied as urea (46-0-0) on May 2, 1990. The sugarbeet variety KW 1745 was overplanted May 2, 1990 and thinned to a stand of 125 beets per 100 foot of 22 inch wide rows. As with the spring wheat, Bright Sun was applied at a rate of three gallons per acre with a total carrier, water, of 15 gallons per acre on June 22, July 13, and August 3, 1990. The roots were machine harvested September 20, 1990 and quality samples taken at that time. The quality parameters were determined in the American Crystal Sugar Company's Tare Lab in East Grand Forks, MN.

Results and Discussion:

Similar to the spring wheat, the application of Bright Sun did not effect any parameters measured in this trial. The soil N treatment increased root yield, recoverable sucrose per acre, sucrose loss per acre, root K concentration, and loss of molasses, (Tables 3 and 4).

Summary:

In 1990 at the Northwest Experiment Station, the application of Bright Sun did not effect the growth, yield, or quality of spring wheat or sugarbeet.

Table 3. The effect of soil N level and Bright Sun on root yield, sucrose, recoverable sucrose per acre, recoverable sucrose per ton processed, and sucrose loss per acre at NWES in 1990.

Soil N lb/A	Bright Sun	Root Yield T/A	Sucrose %	Recoverable Sucrose lb/A	Recoverable Sucrose lb/T	Sucrose Loss lb/A
60	No	13.4	17.1	4183	311	422
60	Yes	13.9	18.1	4579	330	433
110	No	14.3	18.0	4636	326	428
110	Yes	14.3	18.3	4779	333	479
160	No	16.2	17.8	5204	322	561
160	Yes	16.0	17.8	5137	322	553
	No	14.6	17.7	4674	320	488
	Yes	14.7	18.1	4831	328	488
60		13.7	17.6	4381	320	427
110		14.3	18.2	4707	330	480
160		16.1	17.8	5170	322	557
Statistical Analyses						
Soil N		*	NS	++	NS	**
Bright Sun		NS	NS	NS	NS	NS
SN X BS		NS	NS	NS	NS	NS
C.V. %		10.6	5.7	13.2	6.9	11.5

**, *, and ++ are 0.01, 0.05, and 0.10 significance levels, respectively.

Table 4. The effect of soil N level and Bright Sun on impurity index, root Na, root K, root amino-N, and loss to molasses at NWES in 1990.

Soil N lb/A	Bright Sun	Impurity Index	Na ppm	K ppm	Amino-N ppm	Loss to Molasses %
60	No	619	343	1849	495	1.44
60	Yes	579	322	1850	493	1.42
110	No	633	361	1924	552	1.52
110	Yes	616	346	1847	572	1.54
160	No	648	346	1971	571	1.58
160	Yes	650	357	1965	568	1.57
	No	634	350	1915	539	1.52
	Yes	615	342	1887	544	1.51
60		599	333	1850	494	1.43
110		625	354	1886	562	1.54
160		649	352	1968	570	1.58
Statistical Analyses						
Soil N		NS	NS	*	NS	++
Bright Sun		NS	NS	NS	NS	NS
SN X BS		NS	NS	NS	NS	NS
C.V. %		13.0	27.6	4.2	14.3	8.7

* and ++ are 0.05 and 0.10 significance levels, respectively.

RESIDUAL NITROGEN STUDY AT LAMBERTON[1]

D.J. Fuchs and W.W. Nelson[2]

Abstract: Corn and soybean yields are usually greater in a rotation than in a monoculture system. This study was conducted to determine the nitrogen-rate response of corn and the ensuing year effect of residual nitrogen on soybean yields. The effect of 6 N-rates (0 - 400 lbs/ac) were examined in a corn-soybean rotation on a Normania loam. In 1990, as in all previous years, excluding 1988, N-rate response was noted for corn but not for soybeans. In 1990, as in all previous years, excluding 1989, soybean yields showed no significant positive N-rate response from increasing nitrogen rates applied on the previous corn crop. Corn yields demonstrated a non-linear response to increasing N-rates, characteristic of a diminishing return relationship.

(Annual report of this experiment has been included in past University of Minnesota, Soil Science Department's "Blue Book", and much of the previous data will not be repeated here. 1990 was the final year of this study.)

Introduction: The soybean plant has the ability to produce its own nitrogen for plant growth and development via rhizobium bacteria activity. However, the symbiotic bacteria may not be able to provide adequate nitrogen for the soybean plant during the entire growing season. The residual nitrogen in the soil may act like starter fertilizer for the underdeveloped soybean plant. Also, the soil nitrogen may be used during soybean seed fill when the nodules become inactive. If nitrogen is below the zone of symbiotic activity (approximately 9-12 inches) it will not inhibit N fixation and may be used by the soybean plant later in the growing season while uptaking water at deeper depths. This study was initiated to examine the possible benefit of increased soybean yields from nitrogen leftover from the previous corn crop in a corn-soybean rotation.

Methods & Materials: The experiment was initiated in 1984 on a Normania loam. Each plot is 30 by 48 feet with 8 replications each arranged in a randomized block design. In 1984, all 8 blocks were planted in corn. Starting in 1985, half the blocks have been in corn, the other half in soybeans, alternating each year. The treatments consist of six N-rates ranging from 0 to 400 #/Ac applied side dress as urea during the corn year. Addition management data is given in Table 1.

Results: 1990 and six year average corn and soybean yields are given in Table 2. Soil Nitrogen information is provided in Tables 3 and 4.

Regression analysis was used to determine if there was a significant effect of nitrogen rate on corn and soybean yields. There was a significant non-linear relationship between nitrogen rates and corn yields (see Table 2). Corn yields increased with increasing nitrogen rates until the 150 lbs/ac rate, then the yields began to decline (see Table 2). In the past, corn had a significant response to nitrogen each year. The six year average corn yields indicate only slightly increased yields after the 100 lbs/ac N rate (see Table 2). In 1990, there was not a significant effect on soybean yields from the residual nitrogen remaining from the corn plots. 1989 was the only year a significant non-linear relationship existed between the residual nitrogen rates applied to corn in 1988 (see the 1990 Bluebook for more information). Table 3 contains the soil nitrogen data from the fall of 1988 for the 0, 100, and 400 lbs/ac nitrogen rates at 1 foot increments down to 5 feet, and Table 4 contains soil nitrate data for the 0, 100, and 400 lbs/ac nitrogen rates at 1 foot increments down to 5 feet for 1984, 1985, and 1987 (not previously published in "Blue Books"). The total nitrogen in the soil is much greater under 400 lbs/ac N rate than the 0 and 100 lbs/ac N rate at all depths (Table 3 and 4). The soil nitrogen from the 100 lbs/ac N rate follows the 0 lbs/ac N rate very closely, except for the 0 to 1 foot increment following the 1988 drought (Table 3 and 4).

Summary: The results from this study indicate that excessive rates of nitrogen applied to corn in a corn-soybean rotation does not have a significant effect on ensuing soybean yields. The 400 lbs/ac of nitrogen rate resulted in much greater soil nitrogen values, whereas the 100 lbs/ac N rate had only slightly increased levels from the 0 lbs/ac N rate. The greatest amount of soil nitrogen occurred in the upper 2 feet of the profile.

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[1] Funding provided by the Agricultural Experiment Station.

[2] Assistant Scientist and Superintendent - University of Minnesota, Southwest Experiment Station, Lamberton, MN 56152, respectively.

Table 1. 1990 Corn and Soybean Management Information.

Item		Corn	Soybean
Soil Test (ppm)			
P_2O_5		40	30
K_2O		155	174
pH		6.1	5.9
1989 Fall Primary Tillage:		Soil Saver	Soil Saver
Secondary Tillage	Type:	Digger (Twice)	Disk (Twice)
	Date:	23 April	3 May
Seed	Hybrid/Variety:	Pioneer 3615	Hardin
	Rate:	27,700 ppa	150,000 seeds/ac
	Date:	25 April	4 May
Herbicide	Brand:	Eradicane-Bladex	Treflan-Sencor
	Rate:	2.5 & 1.5 #/ac	0.75 & 0.25 #/ac
	Date:	23 April	3 May
Cultivation	Date:	12 & 22 June	11 June & 6 July

Table 2. 1990 and Six Year (1985-90) Averages of Corn and Soybean Yields (Bu/Ac).

Nitrogen (lbs./ac.)	1990 Corn	1990 Soybeans	6 year Avg. Corn	6 year Avg. Soybeans
0	97.0	40.2	87.8	41.7
50	116.2	40.9	109.9	41.8
100	121.8	43.5	121.1	42.6
150	129.0	43.3	122.7	43.3
200	128.8	45.3	124.3	43.9
400	127.6	46.2	124.9	43.3

Table 3. Fall 1988 residual soil nitrogen (ppm) information.

Depth	0 lbs/ac			100 lbs/ac			400 lbs/ac		
(feet)	NH_4	NO_3	Total N	NH_4	NO_3	Total N	NH_4	NO_3	Total N
1	8.1	6.4	14.5	10.6	12.3	22.9	19.7	34.4	54.1
2	3.9	3.4	7.3	3.1	5.2	8.3	4.2	10.9	15.1
3	3.3	1.2	4.5	3.0	1.2	4.2	2.5	2.2	4.7
4	2.6	0.9	3.5	3.1	1.6	4.7	3.6	5.8	9.4
5	3.3	1.0	4.3	3.6	1.9	5.5	2.9	3.4	6.3

Table 4. 1984, 1985, and 1987 soil NO_3 (ppm) information for the 0, 100, and 400 lbs/ac N rates.

Depth	1984			1985			1987		
(feet)	0	100	400	0	100	400	0	100	400
1	1.7	3.2	10.1	2.6	2.6	27.2	2.3	5.1	43.8
2	0.8	1.4	17.6	2.1	2.8	23.3	0.5	0.9	2.7
3	1.4	2.3	8.1	1.5	2.8	13.7	0.5	2.4	3.2
4	3.5	3.8	4.2	1.7	2.2	12.1	0.9	1.4	3.2
5	4.8	4.2	4.6	2	2.3	7.7	1.4	1.5	3.8

THIRTY ONE YEARS OF FIELD EXPERIMENTATION WITH NITROGEN SOURCE, PLACEMENT, AND TIME OF APPLICATION TO A WEBSTER CLAY LOAM AT THE SOUTHWEST EXPERIMENT STATION LAMBERTON, MN[1]

D.J. Fuchs and W.W. Nelson[2]

Abstract: Corn yields may be affected by different nitrogen management systems. This study was conducted to determine if differences exist between nitrogen forms (urea or ammonium nitrate), amounts ranging from 0 to 160 pounds N/Ac, and their time of application (fall, spring or sidedressed) and placement (surface, moldboard plow incorporation or sidedress) on corn yields. The effects were examined on continuous corn with 30-inch rows in a Webster clay loam. In 1990, there was little difference between the 80 and 160 pounds N/Ac treatments. The 40 pounds N/Ac treatments had lower yields with the check having the lowest yields. The time of application and N forms affected yields as they have in the past 30 years. The 30 year average of the treatments indicate that corn yields respond the greatest to N rate with a slight advantage to spring application with little difference between N forms.

(Annual reports of this experiment have been included in most of the University of Minnesota Soil Science Department "Blue Books" and much of this information will not be included here).

Introduction: The Continuous Corn Study is a nitrogen fertilization experiment involving various rates and application times of ammonium nitrate and urea. The experiment has been conducted since 1960 on a tiled Webster clay loam.

Methods: The fertilizer treatments have now been applied annually to the same plot area for 30 years. Each plot is 20 by 77.5 feet with the four replications arranged in a randomized block. After ear corn removal and stalk cutting, the fall treatments are broadcast on their respective plots and the entire area is then moldboard plowed to approximately 12 inches deep. The fall surface treatments are then broadcast with no further working of the plow area. Spring treatments are broadcast before seedbed preparations in late April or early May. The corn is planted in 30-inch rows at a plant population of 26,000 plants/A, using a band starter fertilizer of 8-24-12 at a rate of 180#/A over the entire experimental area, thus supplying an additional 14 #N/A to all plots. Sidedress treatments are broadcast in June and incorporated during cultivation.

Results: The 1990 yields from this experiment are given in Table 1. The 30-year yield averages are provided in Table 2 (In 1976, no yields were obtained due to drought, thus only 30 years of data exist). The one-way analysis of variance (Table 3) indicates a significant treatment effect. The LSD for 1990 yield comparisons ($\alpha = 0.05$) is 15.1.

The results of 1990, like the results of 1989, did not completely follow the trend of the past where greatest yield response is to increasing N-rates with application time in the spring. This may have been caused by residual nitrogen that was not used during the dry 1988 growing season and was available for use in 1989 and 1990. The highest yielding treatments was 80 pounds of urea N/Ac fall incorporated (see Table 1). However, there was no significant difference in yields between either forms of N at the 80 and 160 lbs/ac rates, except for the significantly lower yielding fall incorporated 80 lbs/ac of ammonium nitrate treatment (see Table 1). This year and in the past, there has been a moderate response to delayed application time with the greatest response at the 40 lbs/ac N rate. The long term averages indicate that urea nitrogen treatments had approximately a 2 bu/ac yield advantage over ammonium nitrate, not including the side dressed ammonium nitrate rate of 160 lbs/ac. This year as in the past, there is little difference in yield between ammonium nitrate and urea treatments.

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[1] Funding provided by Agricultural Experiment Station

[2] Assistant Scientist and Superintendent - University of Minnesota, Southwest Experiment Station, respectively.

Table 1. 1990 Yields (Bu/Ac).

Application Time	Ammonium Nitrate 40#	80#	160#	Urea 40#	80#	160#
	Bu/Ac					
Fall (Incorporated)	119	128	142	124	145	138
Fall Plowed Surface	123	---	---	120	---	---
Spring	133	135	---	124	137	---
Side Dress	123	140	139	130	135	---
Check	81			Grand Mean	124	

LSD (α = 0.05) = 15 Bu/Ac

Table 2. 30 Year Average Yields (Bu/Ac).

Application Time	Ammonium Nitrate 40#	80#	160#	Urea 40#	80#	160#
	Bu/Ac					
Fall (Incorporated)	85	105	112	88	104	113
Fall Plowed Surface	83	---	---	88	---	---
Spring	96	108	---	94	109	---
Side Dress	98	105	117	98	113	---
Check	67			Grand Mean	101	

Table 3. One-way analysis of variance.

Source	DF	Sum of Squares	Mean Square	P value
Block	3	1199.8	399.9	0.0204
Treatment	19	30808.0	1621.5	0.0000
Error	55	6212.2	113.0	

THE EROSION-PRODUCTIVITY STUDY AT THE SOUTHWEST EXPERIMENT STATION, LAMBERTON, MN[1]

D.J. Fuchs, M. Lindstrom, and W.W. Nelson[2]

Abstract: Field data is needed to evaluate crop growth simulation models. The objective of this study is to determine the interactive effect of tillage and soil erosion level on corn yields. Continuous corn is grown under conventional (fall moldboard plow) or ridge tillage on sites which have been slightly, moderately, or severely eroded. In 1990, tillage and erosion levels had a significant effect on corn yields (alpha = 0.01). The effect of tillage on corn yields has not been consistent. The ridge tillage treatment had the highest yields in 1990. The effect of erosion level on corn yields has been constant with the higher yields occurring on the less eroded treatments. Corn yields usually decrease with increasing erosion levels for both tillages.

Introduction: This experiment is part of RRF project NC-174, Soil Productivity and Erosion. The objectives of this study are "To asses the effect of erosion-modified soil physical properties on potential productivity of selected soils under rainfed conditions, with emphasis on evaluation of physically-based simulation models." The experiment was started in 1984. Detailed results from 1985 and 1986 were presented in the 1987 "Bluebook", and results from 1987 and 1988 were presented in the 1989 "Bluebook", and 1989 results were presented in the 1990 "Bluebook".

Methods and Materials: Plots for this study were located in areas of a field which had been slightly, moderately, and severely eroded. The soil type for the slight and moderately eroded areas is a Ves (fine-silty, mixed mesic Typic Hapludalf). The soil type on the severely eroded area is a Storden (fine-loamy, mixed (calcareous), mesic Typic Udorthent). Two tillage systems were used on the field: fall moldboard PLOW and RIDGE-tillage.

The field has been in continuous corn since the experiment started. Additional management information is given in Table 1. The entire study was moldboard plowed in the fall of 1989 because of the visual and measured potassium deficiency symptoms that occurred in the ridge tillage treatment. Ridges were re-established during the 1990 growing season.

Summary of results: Grain yields are given in Table 2. Analysis of variance, using a spilt plot design (tillage = whole plots, erosion class = split plots) is furnished in Table 3.

In 1990, there was a significant difference between moldboard plow and ridge tillage (see Table 2). The ridge tillage treatment averaged 135.2 bu/ac and the moldboard plow treatment averaged 123.5 bu/ac over all erosion levels. The severe erosion class had significantly lower yields than the moderate and slight erosion class (see Table 2). Least significant differences (LSD's) are provided.

In 1990, as in the past, erosion levels affected corn yields with greatest yields occurring on the least eroded areas. Primary tillage effects on yields have not been consistent. In 1990, ridge tillage had the highest yield. The ridge tillage plots were plowed in the fall of 1990, so actually the comparison between tillages is actually a cultivation technique comparison. Therefore two possible explanations for increased yields in the ridge area are: 1) the ridge cultivation on 6/21 provided better moisture conservation and soil environment which resulted in increased plant growth and yield and/or; 2) the moldboard plow and secondary tillage operations thoroughly mixed the soil liberating soil nutrients that were formerly unavailable to the plant for growth and development (recall that the ridge plots had lower K levels in the earleaves and showed visual symptoms of K deficiency).

Acknowledgements: The Southwest Experiment Station would like to thank the John Deere Company for providing the JD 7000 Conservation ridge tillage.

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[1] Funding provided by the USDA - CSRS and the Agricultural Experiment Station.

[2] Assistant Scientist - U of MN, Southwest Experiment Station; Soil Scientist - USDA-ARS, Morris, MN 56267; Superintendent - U of MN, Southwest Experiment Station, respectively.

Table 1. 1990 Management Information.

Item	Type	Rate	Date
Secondary Tillage	disk	twice	4/20 & 4/21
Insecticide	Furadan	1.0 #/Ac	4/21
Seed	Pioneer 3615	27,700 p/Ac	" "
Herbicides	Eradicane	2.5 #/Ac	4/24
	Bladex	1.5 #/Ac	" "
Fertilizer	Starter	N = 14 #/Ac	4/21
		P_2O_5 = 41 #/Ac	" "
		K_2O = 15 #/Ac	" "
	Broadcast (Urea)	N = 125 #/Ac	4/19
Mechanical Weed Control	Cultivation	twice	6/1 & 6/21
Ridged[1]		once	6/21

1/ Both tillages received the 6/1 cultivation, and on 6/21 ridge plots were ridged and moldboard plow plots were cultivated.

Table 2. Mean yields (bu/ac) of tillage, erosion class and interactions.

Tillage[1]	Erosion Class[2]			Overall
	Slight	Moderate	Severe	Mean
Plow	131.8	132.4	106.3	123.5
Ridge	141.5	139.5	124.6	135.2
Overall Mean	136.6	136.0	115.4	129.3

1/ $LSD_{0.05}$ = 3.1 for comparing tillage treatments (averaged over all erosion classes).

2/ $LSD_{0.05}$ = 8.0 for comparing erosion classes (averaged over both tillage treatments).

Table 3. Analysis of Variance.

Randomized block with split plot restriction

Number of: Cases = 24 Blocks = 4
Tillage Levels = 2 Erosion Levels = 3

Source	DF	SS	MS	P-value
Block	3	7.7	2.6	0.7373
Tillage	1	819.0	819.0	0.0013 **
Whole Plot Error	3	17.3	5.8	
Erosion	2	2324.4	1162.2	0.0001 **
Interaction	2	135.8	67.9	0.3210
Sub-Plot Error	12	651.3	54.3	

** significant at alpha = 0.01

MANAGEMENT OF SLOPES USING VARIOUS TILLAGES, TILLAGE AND ROW DIRECTION AT THE SOUTHWEST EXPERIMENT STATION[1]

D.J. Fuchs, M. Lindstrom, and W.W. Nelson[2]

Abstract: Field research is needed to evaluate soil movement under different crop production practices and its consequent effect on crop growth. This study was conducted to examine soil movement and crop yields on three different slope percentages (1%, 4%, and 8%), three tillages (ridge tillage, moldboard plow, and chisel), and tillage/planting directions (up and down the slope, or contour to the slope) in a corn - soybean rotation. In 1990, tillage had a significant effect on the 4 percent slopes only with the chisel plow treatment having the highest corn yields. No other treatments were significant excluding the row direction by slope position (top, middle or lower) treatment. In the past, slope position and/or planting direction also had significant effect on crop yields.

(The 1989 University of Minnesota "Blue Book" contains information for the years 1986, 1987 and 1988. The 1990 "Blue Book" contains information for 1989.)

Materials: This study began in the spring of 1985 to examine soil movement on three different slope percentages (1%, 4%, and 8%), using various tillages (ridge tillage, moldboard plow, and chisel), and tillage/planting directions (up and down the slope, or contour to the slope) in a corn and soybean rotation. The slope positions are not taken into account for the 4 and 1 percent slopes, and the tillage/planting directions are not taken into account for the 1 percent slopes. Yields are measured every year. Soil movement is being monitored by grass catch strips and infrared transit survey.

Additional management information is provided in Table 1.

Results: Main effects are presented in tables followed by the interaction effects. Analysis of variance for each slope treatment is provided (Table 2-7). The 4% slope had a significant tillage effect with greatest yields occurring on the chisel plow treatments (see Table 4B & 5). The effect of tillage treatments on yields have not been consistent (see previous "Blue Books"). Analysis of variance was not performed on the different slope percentages (8, 4 & 1%) however, the overall average yield decreased with increasing slope (see Table 2A, 4A & 6A).

Table 1. 1990 Management Information.

Item	Type	Rate	Date
Secondary Tillage[1]	Digger	2 passes	4/23
Seed	Pioneer 3615	27,700 seeds/ac	4/24
Herbicides	Lasso	3.0 lbs/ac	4/27
	Bladex	1.5 lbs/ac	4/27
Fertilizer	Urea-N	N = 130 lbs/ac	6/14
	Starter	N = 7 lbs/ac	4/24
		P_2O_5 = 20 lbs/ac	
		K_2O = 7 lbs/ac	
Cultivation			6/22

1/ No secondary tillage on ridge tillage plots.

[1] Funding provided by the USDA - CSRS and the Agricultural Experiment Station.

[2] Assistant Scientist - U of MN, Southwest Experiment Station; Soil Scientist - USDA-ARS, Morris, MN 56267; Superintendent - U of MN, Southwest Experiment Station, respectively.

Table 2 (A-H). Corn Yields (bu/ac) on the 8 Percent Slope.

2A. Overall Average.

	Avg	s[3]
Overall	125.6	8.0

n (sample no.) = 54

2B. Tillage.

Tillage	Avg	s
Chisel	124.6	6.2
Moldboard	126.8	7.5
Ridge	125.5	10.0

n = 18

2C. Row Direction.

Row Direction	Avg	s
Up & Down	124.4	9.1
Contour	126.9	6.6

n = 27

2D. Slope Position.

Slope Position	Avg	s
Top	124.1	8.7
Mid	126.9	5.4
Bottom	125.8	9.5

n = 18

2E. Tillage - Row Direction Interaction.

Tillage	Row Dir.	Avg	s
Chisel	Up & Down	122.2	7.0
Chisel	Contour	127.0	4.5
Moldboard	Up & Down	125.9	10.1
Moldboard	Contour	127.6	4.5
Ridge	Up & Down	125.0	10.5
Ridge	Contour	126.0	10.1

n = 9

2F. Tillage - Slope Position Interaction.

Tillage	Slope Pos.	Avg	s
Chisel	Top	123.8	6.8
Chisel	Mid	126.2	5.7
Chisel	Bottom	123.8	6.9
Moldboard	Top	122.4	9.0
Moldboard	Mid	130.0	5.4
Moldboard	Bottom	127.9	6.8
Ridge	Top	126.2	11.1
Ridge	Mid	124.6	4.2
Ridge	Bottom	125.8	14.1

n = 6

[3] s = sample standard deviation

2G. Row Direction - Slope Position Interaction.

Row Dir.	Slope Pos.	Avg	s
Up & Down	Top	119.3	9.8
Up & Down	Mid	126.6	6.1
Up & Down	Bottom	127.2	9.6
Contour	Top	129.0	3.5
Contour	Mid	127.3	4.9
Contour	Bottom	124.4	9.7

n = 9

2H. Tillage - Row Direction - Slope Position Interaction.

Till[4]	Row Dir.	Slope Pos.	Avg	s
CH	Up & Down	Top	120.0	8.3
CH	Up & Down	Mid	125.3	6.5
CH	Up & Down	Bottom	121.3	7.9
CH	Contour	Top	127.5	1.8
CH	Contour	Mid	127.1	6.0
CH	Contour	Bottom	126.2	6.3
MP	Up & Down	Top	117.3	11.1
MP	Up & Down	Mid	131.7	4.0
MP	Up & Down	Bottom	128.7	9.7
MP	Contour	Top	127.5	1.9
MP	Contour	Mid	128.4	7.0
MP	Contour	Bottom	127.0	4.3
RT	Up & Down	Top	120.5	13.7
RT	Up & Down	Mid	122.9	5.2
RT	Up & Down	Bottom	131.8	11.1
RT	Contour	Top	131.9	4.7
RT	Contour	Mid	126.3	3.1
RT	Contour	Bottom	119.9	16.4

n = 3

Table 3. Analysis of Variance for the 8 Percent Slope.
Randomized block with split - split plot restriction

Number of: Cases = 54 Blocks = 3
Row Directions = 2 Tillage Levels = 3 Slope Positions = 3

Source	DF	SS	MS	P-value
Block	2	697.4	348.7	0.0614
Row Dir.	1	83.88	83.88	0.1951
Whole Plot Error	2	45.59	22.79	
Tillage	2	43.09	21.54	0.6848
Row*Tillage	2	35.74	17.87	0.7287
Sub-Plot Error	8	434.1	54.26	
Position	2	72.87	36.44	0.4960
Row*Position	2	379.3	189.6	0.0380 *
Tillage*Position	4	145.2	36.30	0.5870
Row*Till*Pos	4	227.8	56.94	0.3666
Sub-Sub Plot Err	24	1211.0	50.46	

* significant at alpha = 0.05

[4] Tillage codes: CH - chisel, RT = ridge tillage, MP = moldboard plow

Table 4 (A-D). Corn Yields (bu/ac) on the 4 Percent Slope.

4A. Overall Average.

	Avg	s
Overall	134.6	8.4

n = 12

4B. Tillage. (ranked by descending averages).

Tillage	Avg	s
Chisel	140.8	6.8
Moldboard	132.9	8.2
Ridge	129.9	7.9

n = 4 $LSD_{0.05}$ = 6.8

4C. Row Direction.

Row Dir.	Avg	s
Up & Down	130.8	9.7
Contour	138.3	5.4

n = 6

4D. Tillage - Row Direction Interaction.

Till	Row Dir.	Avg	s
CH	Up & Down	138.8	11.0
CH	Contour	142.8	0.7
MP	Up & Down	127.8	9.9
MP	Contour	138.1	0.2
RT	Up & Down	125.9	7.6
RT	Contour	133.9	8.1

n = 2

Table 5. Analysis of Variance for the 4 Percent Slope.

Randomized block with split plot restriction

Number of: Cases = 12 Blocks = 2
Tillage Levels = 3 Row Directions = 2

Source	DF	SS	MS	P-value
Block	1	66.27	66.27	0.6867
Row Dir.	1	165.8	165.8	0.5523
Whole Plot Error	1	230.6	230.6	
Tillage	2	252.4	126.2	0.0254 *
Row*Tillage	2	20.10	10.05	0.4958
Sub-Plot Error	4	47.84	11.96	

* significant at alpha = 0.05

Table 6 (A-B). Corn Yields (bu/ac) on the 1 Percent Slope.

6A. Overall Average

	Avg	s
Overall	139.2	6.0

n = 6

6B. Tillage.

Tillage	Avg	s
Chisel	136.3	0.4
Moldboard	139.7	7.1
Ridge	141.6	9.9

n = 2

Table 7. Analysis of Variance for the 1 Percent Slope.

Randomized block

Number of: Cases = 6 Blocks = 2
Tillage Levels = 3

Source	DF	SS	MS	P-value
Block	1	92.04	92.04	0.2117
Tillage	2	29.42	14.71	0.6559
Whole Plot Error	2	56.08	28.04	

WEST CENTRAL EXPERIMENT STATION
WEATHER SUMMARY - 1990

		Precipitation			Temperature			Soil Temperature (10 cm depth)	
Month	Period	1990	100-yr. av.	Dev. from av.	1990	100-yr. av.	Dev. from av.	1990	10 yr. av.
January	1-31	0.08	0.68	-0.60	22.4	8.0	+14.4	25.7	20.7
February	1-28	0.33	0.67	-0.34	18.3	12.8	+ 5.5	23.4	23.9
March	1-31	1.49	1.13	+ 0.36	31.3	26.7	+4.6	33.5	29.2
April	1-10	0.06	0.57	+0.51	36.2	38.0	- 1.8	37.4	
	11-20	0.16	0.64	-0.48	39.2	44.4	- 5.2	41.3	
	21-30	1.72	1.05	+0.67	56.3	48.3	+ 8.0	55.0	
Total or av.		1.94	2.26	-0.32	43.9	43.6	+ 0.3	44.6	41.4
May	1-10	0.07	0.77	-0.70	50.8	52.0	- 1.2	52.6	
	11-20	1.07	0.95	+0.12	51.0	55.8	- 4.8	55.2	
	21-31	0.50	1.25	-0.75	60.3	60.0	+ 0.3	62.8	
Total or av.		1.64	2.97	-1.33	54.2	56.1	- 1.9	57.1	57.1
June	1-10	0.90	1.29	-0.39	60.6	63.0	- 2.4	63.8	
	11-20	2.99	1.30	+1.69	68.4	66.3	+ 2.1	71.0	
	21-30	1.27	1.37	-0.10	70.4	68.1	+ 2.3	75.4	
Total or av.		5.16	3.96	+1.20	66.5	65.8	+ 0.7	70.1	69.3
July	1-10	0.05	1.44	-1.39	72.0	70.1	+ 1.9	81.8	
	11-20	1.00	1.06	-0.06	67.3	71.4	- 4.1	78.1	
	21-31	0.16	1.01	-0.85	67.5	71.4	- 3.9	75.1	
Total or av.		1.21	3.51	-2.30	68.9	70.9	- 2.0	78.2	76.[illegible]
August	1-10	0.02	1.04	-1.02	68.5	70.4	- 1.9	79.0	
	11-20	0.70	0.93	-0.23	66.6	69.0	- 2.4	75.5	
	21-31	0.92	1.04	-0.12	70.5	66.9	+ 3.6	73.4	
Total or av.		1.64	3.01	-1.37	68.6	68.7	- 0.1	75.9	73.9
September	1-30	2.15	2.20	-0.05	61.9	59.0	+ 2.9	64.9	61.5
October	1-31	1.60	1.74	-0.14	44.2	47.2	- 3.0	48.5	47.8
November	1-30	0.07	0.97	-0.90	33.3	29.7	+ 3.6	39.3	33.6
December	1-31	0.35	0.68	-0.33	12.6	15.2	- 2.6	26.3	23.4
April-Aug. Growing Season		11.59	15.71	-4.12	60.5	61.0	- 0.5	65.2	63.8
January-December Annual		17.66	23.78	-6.12	44.0	42.0	+ 2.0	46.7	46.7

CONTINUOUS CORN SILAGE[1]
MORRIS, 1990

S. D. Evans[2]

ABSTRACT: This long-term study addresses the effects of removal of continuous corn silage and corn grain on soil properties and yield. Results after 25 years show no yield differences due to the removal of silage versus grain. A significant difference in yield exists between the long-term high and low fertilizer rates.

Objective: This is the 25th year of a continuing study initiated in 1965 on a McIntosh silt loam soil. The study was initiated to determine the effects of removal of continuous corn silage and fertilizer rate on soil properties and yield. Half the plots receive a fertilizer rate of 74+48+48 ($N+P_2O5+K_2O$) lbs./acre and the other half a rate of 148+96+96. Silage and shelled corn yield samples were collected.

Experimental Procedure: The experiment is set up as a latin square with 4 treatments: (1) silage, low fertility (2) silage, high fertility (3) grain, low fertility (4) grain, high fertility. The previous years corn stalks were chopped on October 23, 1989. The fertilizer was then applied and disked in on October 23, 1989. The experimental area was moldboard plowed on October 24, 1989. The study was field cultivated two times on April 25, 1990 for seedbed preparation. The study was then seeded to Pioneer 3751 corn at 26,000 seeds/acre on May 4, 1990. Furadan 15G was applied in the row at seeding at 10 lbs./acre (1.5 lbs./acre a.i.). Lasso @ 3 lbs./acre a.i. + Bladex @ 2.2 lbs./acre a.i. were applied pre-emergence broadcast om May 4. Date of tasseling and silking was recorded. Silage yields were chopped from 3 10-foot rows on September 17 and grain yields were calculated from 2 45-foot rows harvested with a plot combine on October 2, 1990. Yields were also taken, as in past years, on an adjacent unfertilized (check) area where only the grain is removed.

Results and Discussion: Silage yields are given in Table 1. There were no significant differences in silage yields in 1990. The 25-year average shows no effect of silage versus grain but does show significant differences between high and low fertility treatments. Grain yields, including the grain yield from the unfertilized check area adjacent to the plots, are given in Table 2. The 1990 yields show no significant difference in grain yield between the high and low fertility treatments. The long-term 25 year average does show a significant grain yield advantage for high fertility over low fertility. This study will be continued in 1991.

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[1] Funding provided by the West Cent. Expt. Sta., Univ. of Minnesota.

[2] Professor, West Cent. Expt. Sta., Univ. of Minnesota.

Table 1. Effect of removal of continuous silage or grain on silage yields.

Treatment	1990 Yield	1966-1990 Yield
	dry matter, tons/acre	
Silage, low fertility	5.72	5.51
Silage, high fertility	5.12	5.98
Grain, low fertility	4.90	5.54
Grain, high fertility	5.01	5.84
Signif. Levels (%)		
Treatment	73	>99
Year	--	>99
Treatment x Year	--	99
LSD, treatment (.05)	NS	0.16

Table 2. Effect of fertilizer level on grain and silage yields.

Treatment	1990 Yield	1966-1990 Yield
	bu/ac @ 15.5% M.	
Grain, low fertility	83.8	86.4
Grain, high fertility	77.4	90.6
Signif. Levels (%)		
Treatment	49	99
Year	--	>99
Treatment x Year	--	>99
LSD, treatment (.05)	NS	3.0
Grain, check (Bu/Ac)	44.0	46.7
Silage, check (D.M. Tons/Ac)	2.38	3.51

WINTER UREA APPLICATION ON HIGH pH SOILS[1]
MORRIS, 1990

S.D. Evans and G.A. Nelson[2]

ABSTRACT: A 3-year study designed to record the effects of winter application of urea nitrogen on high pH soils for corn production was completed in 1990. Applying nitrogen during the winter months may help reduce fall and spring workloads allowing for timely spring planting, but losses may occur due to application of nitrogen on frozen soil and/or on snow. Applying urea nitrogen on frozen soil appears to be as effective as spring applications, but applying urea nitrogen on snow appears to result in some yield loss, although there were no significant differences in yield due to time of application.

Objective: The nitrogen retention study was designed to record the effects of off-season applications of urea nitrogen for corn production. Applying nitrogen fertilizer during non-cropping times may allow for more timely spring planting operations. The retention study had four treatments 1) a check with no nitrogen application 2) nitrogen applied on frozen soil 3) nitrogen applied in mid-winter with at least a 3-inch snow cover, and 4) nitrogen applied in the spring prior to corn planting. This study will determine if nitrogen loss primarily from volatilization is a problem with late fall and mid-winter applications of urea on high pH soils.

Experimental Procedure: The experimental procedures for all years of the study were the same. Soil tests in the fall of 1989 were as follows: pH=7.8, $NaHCO_3$ P=21 lbs./acre, exch. K=200 lbs./acre, NO_3-N (0-24 inches) = 56 lbs./acre, and NO_3-N (24-48 inches) =93 lbs./acre. The experimental area for 1990 was moldboard plowed October 28, 1989 and the plots were staked out October 31, 1989. The frozen soil treatment (Trt. 2) was applied on November 16, 1989. The mid-winter treatment (Trt. 3) was applied March 16, 1990 with a snow cover depth of 6 inches. The spring treatment (Trt. 4) was applied April 25, 1990. All treatments had 120 lbs./acre nitrogen applied and urea (46-0-0) was the nitrogen source. The experimental area was field cultivated twice on April 25, immediately after Trt. 4 was applied. The plot area was seeded to Pioneer 3906 corn at 26,000 seeds/acre on May 4, 1990. Lasso 3.0 lbs./acre a.i. + Bladex 2.2 lbs./acre a.i. were broadcast pre-emergence after corn planting on May 7. The experiment was cultivated on June 14 and June 27, 1990. Tasseling and silking dates were recorded and a stand count was taken on August 16. Six plants and ears were harvested at the black layer stage of maturity for total nitrogen uptake analysis on September 17. Grain yield, moisture, and test weight were recorded at grain harvest on October 2, 1990. The plots were harvested with a plot combine, harvest area was four 65-foot rows.

Results and Discussion, 1990: Plant measurements are given in Table 1. No differences were found between treatments for tassel date, silking date, plant population, grain yield, or grain moisture. The lack of a significant yield response may have been due to the high NO_3-N in the 24-48 inch zone.

Results and Discussion, 1987, 1988 and-1990: Results from 1989 have been omitted from this report because high residual soil NO_3-N levels from the previous year resulted in a lack of nitrogen response when the check treatment was compared to the other treatments.

In 1987, 1988, and 1990 there were no significant differences in grain yield due to time of urea nitrogen application (Table 2). The spring treatment was the highest yielding in 1987 and 1990, and the frozen soil treatment was the highest yielding in 1988 and the 3-year average. The snow cover treatment yielded above the check treatment but lower than the other treatments in 1987, 1990, and the 3-year average. The snow cover treatment yielded above the spring treatment but below the frozen soil treatment in 1988. It appears that applying urea nitrogen on frozen soil is as good as a spring application and that an application of urea nitrogen on snow cover results in yield loss, possibly due to volatilization and/or runoff. The above mentioned differences in yield were small and not significant. High residual soil NO_3-N levels undoubtedly influenced this study in 1988, 1989, and 1990.

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[1] Funding provided by the West Cent. Expt. Sta., Univ. of Minnesota.

[2] Professor and Junior Scientist, West Cent. Expt. Sta., Univ. of Minnesota.

Table 1. Summary of plant measurements - 1990.

Treatment	Tassel Date from 7/1	Silk Date from 7/1	Plant Pop.	Grain Yield	Grain Moisture	Grain Test wt.
			1,000's/ac	bu/ac	%	lbs/bu
Check	28.0	30.8	26.5	106.6	19.7	53.3
Frozen Ground	28.0	31.0	26.9	111.6	20.2	52.5
Snow Cover	28.0	31.0	27.3	110.9	20.1	53.3
Spring	28.0	31.0	27.1	116.3	20.3	53.1
Signif. Levels:						
Treatment (%)	--	56	36	39	71	95
LSD (.05)	--	NS	NS	NS	NS	0.7
C.V. (%)	--	0.8	3.5	8.9	2.3	0.8

Table 2. Winter urea application study, Morris 1987-1988-1990, grain yield results.

Treatment	Grain Yield 1987	1988	1990	1987-90
	bu/ac			
Check	81.9	67.4	106.6	85.3
Frozen Ground	96.1	72.7	111.6	93.5
Snow Cover	89.2	64.4	110.9	88.2
Spring	100.0	61.8	116.3	92.7
Signif. Level:				
Treatment (%)	60	39	39	65
LSD (.05)	NS	NS	NS	NS
C.V. (%)	16.7	17.4	8.9	13.9

EFFECT OF TILLAGE AND SUBSOILING ON SOIL WATER RECHARGE AND CORN YIELDS[1]

Morris, 1990

S.D. Evans, M.J. Lindstrom, J.F. Moncrief, W.B. Voorhees, and G.A. Nelson[2]

Abstract: Many producers are using subsoilers to alleviate expected compaction due to traffic from tillage, planting, and harvesting equipment. In the fall of 1988 a study was initiated at the West Central Experiment Station to study the effects of a one-time subsoiling and its interaction with various primary tillage systems on subsequent soil compaction, soil water recharge, corn growth, and yield. In the spring of 1989 it was found that the subsoiled areas had a lower bulk density and a lower volumetric moisture content than non-subsoiled areas. There was a highly significant subsoiling by wheeltrack interaction on both variables. By the fall of 1989 the moisture differences disappeared, but the bulk density differences remained. It appeared that wheel traffic from secondary tillage, planting, cultivating, spraying, and harvesting equipment repacked the soil to its original density. There were no effects of tillage or subsoiling on corn grain yields in 1989. Soil moisture samples taken in both the spring and fall of 1990 showed that subsoiling had no effect on volumetric moisture content. In the spring of 1990 there were no effects from subsoiling on soil bulk density, but in the fall of 1990 there was a slight subsoiling by depth interaction effect on bulk density. However, most soil measurements were no longer affected by subsoiling. Penetrometer measurements show large effects of wheel traffic, but very small effects of subsoiling, regardless of tillage system. There were no effects of tillage or subsoiling on corn grain yields in 1990. Based on the results of 2 years of measurements, subsoiling did not increase yields and had no lasting effect on soil bulk density or water content.

OBJECTIVES: A 3-year study was initiated at the West Central Experiment Station to study the effects of (one time) subsoiling on subsequent crop growth, soil compaction, and soil moisture in 4 primary tillage systems (fall moldboard plow, fall chisel plow, spring disk, and no-till). The experiment was established on a Hamerly clay loam (Aeric Calciaquoll) and Aastad clay loam (Pachic Udic Haploboroll) complex and is cropped to continuous corn. This report will discuss the 2nd year, 1990, results of the 3-year study.

TILLAGE, PLANTING, and HARVEST PROCEDURES: The experimental plot area was established the fall of 1988. The entire plot area was fertilized with a 150 lbs. P_2O_5/acre and 10 lbs./acre Zn broadcast on October 13,1988. Four main plot treatments were then established in the experimental plot area with each treatment split into subsoiled and non-subsoiled subtreatments. A split plot design with 4 replications was used with plots 30 feet wide by 100 feet long. The 1988 crop was corn harvested as silage, and the 1989 crop (1st year of the study) was corn harvested with a combine. The plot area was seeded with a 6-row planter. The treatments are moldboard, subsoiled (MSS), moldboard, no subsoiling (MNS), chisel, subsoiled (CSS), chisel, no subsoiling (CNS), no-till, subsoiled (NSS), no-till, no subsoiling (NNS), spring disk, subsoiled (DSS), and spring disk, no subsoiling (DNS). One-half of each main plot was subsoiled on October 14, 1988. A 5-tooth subsoiler with a 30-inch tooth spacing, operating 16 inches deep, was used on the MSS, CSS, and NSS treatments. A paraplow, operating 13 inches deep, was used on the DSS treatment. The MSS, CSS, NSS, and DSS plots were not tilled with any other implement in the fall of 1988. The non-subsoiled treatments were treated as follows: (1) The MNS treatment was plowed using an onland hitch with 6 18-inch bottoms and the CNS treatment was chiseled with a mounted 10-foot chisel plow, (2) The MSS and CSS treatments were not moldboard plowed or chisel plowed before or after the subsoiling operation in the fall of 1988, and (3) The DNS and NNS treatments were not tilled in the fall of 1988.

In the fall of 1989 the plots were treated as follows: (1) The MSS and MNS treatments were plowed using an onland hitch with 6 18-inch bottoms, (2) The CSS and CNS treatments were chiseled with a 15-foot pull type chisel plow, and (3) The NSS, NNS, DSS, and DNS treatments were not tilled.

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[1] Funds provided by West Cent. Expt. Sta., Univ. of Minnesota. Measurements taken by USDA-ARS, Morris, MN.

[2] S.D. Evans, and G.A. Nelson are Professor and Junior Scientist respectively with the West Cent. Expt. Sta., Univ. of Minnesota. M.J. Lindstrom and W.B. Voorhees are Soil Scientists with the Agricultural Research Service, USDA, Morris, MN, and J.F. Moncrief is Associate Professor, Soil Science Dept., Univ. of Minnesota.

Crop residue measurements were taken on April 10, 1990. On May 9, 1990 corn stalks were chopped on the NSS, NNS, DSS, and DNS treatments. On May 11 the MSS, MNS, CSS, CNS, DSS, and DNS treatments were all disked twice for seedbed preparation. All wheel traffic from tractors during the tillage operations was confined to the position to be used by the tractor pulling the corn planter. All subsequent wheel traffic was also be confined to corn planter tractor wheel tracks. The NSS and NNS treatments were no tilled. The plots were seeded to Pioneer 3788 corn at @ 18,000 seeds/acre on May 14, 1990 with a 6-row planter. Lorsban 15G @ 10 lbs./acre (1.5 lbs./acre a.i.) was applied at seeding. No starter fertilizer was used. Lasso + Bladex (4 + 2.2 lbs./acre /a.i.) was broadcast pre-emergence on May 15 and 16. Crop residue measurements after planting were taken on May 16. Anhydrous ammonia was applied at 120 lbs. N/acre on May 31. Two 10-foot rows in each plot were staked out on June 4, 1990 and heights of corn plants were measured on June 20, July 7, July 19, and August 3 to record any plant growth differences. Plots were cultivated on June 25. Atrazine + Crop Oil (1.5 lbs./acre a.i. + 1 gal./acre) was broadcast post-emergence on July 24. Tasseling and silking notes were recorded from July 29 through Aug 3. Plots were harvested for grain with a JD 3300 combine on October 5, 1990. A grain sample was retained. Bulk corn was harvested from the plots on October 8 and corn stalks were chopped on all treatments. The MSS and MNS treatments were plowed using an onland hitch with 6 18-inch bottoms on October 24 and the CSS and CNS treatments were chiseled with a 15-foot pull type chisel plow on October 23. Post-tillage crop residue measurements were taken on November 6, 1990.

SOIL SAMPLING PROCEDURES: Two 2-foot soil cores were taken from each plot in wheel track and non-wheel track areas after corn planting on May 18 and 21. No attempt was made to keep track of the subsoiler slots, so some sampling may have coincided with the slots and some sampling would have occurred in areas between subsoiler slots. Plots were sampled to a depth of 2 feet in 0-6, 6-12, 12-18, 18-24 inch increments. The soil samples were weighed, dried at 105°C, and weighed back for bulk density and soil moisture determination. Penetrometer readings were taken on May 21. After grain harvest in the fall of 1990, but before any fall tillage, two 2-foot soil cores in 0-6, 6-12, 12-18, and 18-24 inch increments were again taken in wheel track and non-wheel track areas of each plot for bulk density and soil moisture determination. At the same time one 2- to 5-foot soil core in 24-36, 36-48, and 48-60 inch increments was taken in the wheel track and non-wheel track areas of each plot for soil moisture determination. Sampling took place on October 9 and 10, and penetrometer readings were taken on October 10, 1990.

MEASUREMENTS AND DISCUSSION: Growing conditions were somewhat poor in 1990 with adequate moisture available through June but then very dry conditions in July, August, and September. Summaries of residue and plant measurements are given in Table 1. Subsoiling did not affect residue cover in pre-plant or post-plant measurements. There was a significant subsoiling by tillage interaction on residue measurements made prior to corn planting, but there was no interaction on post-plant residue measurements (Tables 1 and 2). Tillage systems did significantly affect residue cover. Date of tasseling, date of silking, grain moisture at harvest, and bushel weight were significantly influenced by tillage. The moldboard treatment tasseled earlier, silked earlier (except for the chisel treatment), had lower grain moisture, and a heavier test weight than the other treatments. Grain yield was not influenced by tillage, subsoiling, or their interaction.

The height of corn plants measured at 2-week intervals beginning 37 days after planting is given in Table 3. Corn plant height was significantly influenced by tillage at all measuring dates and also significantly influenced by subsoiling on August 3. There were no subsoiling by tillage interactions. The moldboard plow treatment had significantly taller plants than the spring disk and no-till treatments at all dates and taller plants than the chisel treatment at all dates, significantly so on July 6 and July 19.

An overall statistical analysis of the volumetric soil moisture taken in the study is given in Table 4. In the spring of 1990 a significant tillage by depth interaction shows that soil moisture content was greater in the spring disk and no-till treatments than in the moldboard plow and chisel plow treatments at the 0-6 inch depth and possibly at the 6-12 inch depth (Table 5). The wheel traffic by depth interaction was significant in both the spring and fall of 1990 showing a difference in the upper 12 inches but no or very little difference occurring below the 12-inch depth (Table 6). In both the spring and fall, the wheel track areas had greater soil moisture content in the upper 12 inches than the non-wheel track areas. There was no increase in soil moisture content below 12 inches in the wheel track areas in the spring and only a slight increase in the 12-18 and 18-24 inch depths in the fall. Subsoiling did not significantly affect any soil moisture measurement.

An overall statistical analysis of bulk densities taken in the study is given in Table 7. There was a significant tillage by depth interaction on bulk densities in the fall of 1990 (Table 8). The moldboard plow treatment had a lower bulk density than spring disk and no-till treatments at all soil depths. The chisel plow treatment had the same bulk density as moldboard plow and a lower bulk density than spring disk and no-till at 6-12, 12-18, and 18-24 inch soil depths. At the 0-6 inch depth, chisel plow had the same bulk density as spring disk and no-till and a higher bulk density than moldboard plow. The tillage

by depth interaction was not significant in 1989. In the spring of 1990 the significance level was 90% whereas in the fall of 1990 the significance level was 96%, perhaps indicating a difference in bulk densities associated with maturing tillage systems. There was a subsoiling by depth interaction effect on bulk densities, shown in Table 9, that occurred in the fall of 1990, but most of the effects came from depth. The subsoiled areas had slightly lower bulk densities than the non-subsoiled areas (varying from 0.01 g/cm³ to 0.04 g/cm³). There was no subsoiling by depth interaction in the spring of 1990. There were significant wheeltrack by depth interactions on bulk density in the spring and fall of 1990 (Table 10). In the spring and fall, wheel traffic increased the bulk density in the 0-6 and 6-12 inch depths while having little or no effect in the 12-18 and 18-24 inch depths.

Penetrometer resistance measurements taken in the spring after planting and in the fall after harvest are shown in figure 1. Primary differences observed are related mostly to wheel track (WT) and non-wheel (NWT) interrows. Subsoiling (SS),no subsoiling (NS) or paraplow in the case of the disc tillage have essentially disappeared for this second crop year. Differences in penetrometer resistance measurements observed between the spring and fall sampling may be attributed to soil moisture content at time of sampling. Statistical analysis of penetrometer resistance data has not been completed at this point.

In conclusion, results from the 2nd year of a 3-year study show a one-time subsoiling had no effect on grain yield and most other agronomic characteristics in 4 primary tillage systems. The subsoiling effects on soil bulk density remaining 2 years after treatment are very small. In 1989 the effects were highly significant, but in 1990 the effects were significant at the 86% level in the spring sampling and at the 63% level in the fall sampling. It appears that a combination of factors such as subsidence after the subsoiling operation and wheel traffic have reduced the subsoiling effects on bulk density. The volumetric water content was again highly affected by subsoiling in 1989, whereas in 1990 these effects were not significant. Based on the results of 2 years of measurements, subsoiling did not increase yields and had no lasting effect on soil bulk density or water content.

Table 1. Summary of plant measurements due to tillage and subsoiling, 1990.

Treatment	4/10	5/16	Tassel Date from 7/1	Silk Date from 7/1	Grain Harvest Moisture	Grain Yield 15.5% M.	Grain Test Weight
	- - % cover - -				(%)	(bu/ac)	(lbs/bu)
Moldboard	7.5	12.3	29.1	31.4	18.1	99.4	54.8
Chisel	53.5	41.3	30.0	32.3	19.6	92.7	53.8
Spr. Disk	88.3	65.5	30.9	33.1	20.4	108.5	52.3
No-Till	92.8	81.3	30.8	33.5	21.0	111.5	52.6
Main plots:							
Signif. Level (%)	>99	>99	>99	>99	>99	88	>99
LSD (.05)	4.3	5.0	0.5	0.9	1.3	NS	0.6
C.V. (%)	2.3	13.7	0.8	1.0	7.0	6.7	3.0
Subsoiled	60.9	49.6	30.2	32.5	19.8	102.3	53.2
Not subsoiled	60.1	50.5	30.2	32.6	19.8	103.8	53.5
Sub-plots:							
Signif. Level (%)	85	28	--	71	15	44	34
Interaction:							
Signif. Level (%)	95	14	69	83	63	38	60

Table 2. Effect of tillage treatments on residue cover in 1990.

Trt.	Before Planting 4/10	After Planting 5/16
MNS	8.0	11.5
MSS	7.0	13.0
CNS	52.0	41.0
CSS	55.0	41.5
DNS	87.5	67.5
DSS	89.0	63.5
NNS	93.0	82.0
NSS	92.5	80.5

Table 3. Corn plant heights measured at 2-week intervals, 1990.

Treatment	Date June 20	July 6	July 19	August 3
	inches			
Moldboard	41.1	113.6	183.5	242.6
Chisel	36.8	101.1	168.1	231.5
Spring Disk	34.1	92.9	156.1	217.0
No-Till	32.5	87.9	147.5	207.0
Main Plots:				
Signif. Level (%)	97	>99	>99	>99
LSD (.05)	6.0	9.7	9.5	11.5
C.V. (%)	5.5	6.0	4.2	3.1
Subsoiled	36.7	100.3	166.2	228.1
Not subsoiled	35.6	97.4	161.4	221.0
Sub-Plots:				
Signif. Level (%)	87	80	92	99
Interaction:				
Signif. Level (%)	51	51	67	80

Table 4. Statistical analysis of soil volumetric moisture content.

Variable	Spring 1990	Fall 1990
	Pr > F	
Tillage (T)	.4267	.2688
using Rep * T as an error term		
Subsoiling (SS)	.6624	.8001
T * SS	.6722	.5034
using Rep * T as an error term		
Wheel Traffic (Wt)	.0025	.0001
T * Wt	.6050	.2841
SS * Wt	.1271	.3672
T * SS * Wt	.8515	.6818
Using Rep * T * SS * Wt as an error term		
Depth	.0001	.0001
T * D	.0001	.5156
SS * D	.4076	.2889
Wt * D	.0001	.0001
T * SS * D	.8174	.8875
T * Wt * D	.3371	.8138
SS * Wt * D	.2317	.6367
T * SS * Wt * D	.3517	.4969
C.V. (%)	10.6	9.1

Table 5. Effects of tillage and depth on volumetric water content, Spring, 1990.

	Depth (inches)				
	0-6	6-12	12-18	18-24	Mean
	- - - - - - - - - - - - % v/v - - - - - - - - - - - -				
Moldboard	27.2	41.3	37.5	38.8	36.2
Chisel	26.7	42.2	38.3	36.6	36.0
Spring Disk	35.0	43.1	38.4	37.0	38.4
No-Till	32.7	44.0	37.5	37.2	37.9
Mean	30.4	42.7	37.9	37.4	

Table 6. Effects of wheel traffic and depth on volumetric water content, 1990

	Spring 1990 Wheel Traffic			Fall 1990 Wheel Traffic		
Depth	No	Yes	Mean	No	Yes	Mean
inches	- - - - % v/v - - - - - -			- - - - - % v/v - - - -		
0-6	26.0	34.8	30.4	27.7	36.4	32.1
6-12	42.0	43.4	42.7	36.3	38.6	37.5
12-18	38.3	37.6	38.0	30.8	31.8	31.3
18-24	38.5	36.4	37.5	29.9	31.2	30.6
24-36	----	----	----	31.3	31.5	31.4
36-48	----	----	----	35.2	35.2	35.2
48-60	----	----	----	37.2	34.8	36.0
Mean	36.2	38.1		32.6	34.2	

ble 7. Statistical analysis of bulk densities in subsoiler study.

Variable	Spring 1990	Fall 1990
	- - - - - - - Pr > F - - - - - - -	
Tillage (T)	.1977	.8796
- - - - - - - using Rep * T as an error term - - - - - - - -		
Subsoiling (SS)	.1447	.3715
T * SS	.1175	.1377
- - - - - - - using Rep * T * SS as an error term - - - - - -		
Wheel Traffic (Wt)	.0001	.0001
T * WT	.8142	.5412
SS * WT	.0937	.3091
T * SS * WT	.9510	.6863
- - - - - - - using Rep * T * SS * WT as an error term - - - -		
Depth (D)	.0001	.0001
T * D	.0985	.0411
SS * D	.5954	.0148
WT * D	.0001	.0001
T * SS * D	.6769	.6441
T * WT * D	.2164	.9490
SS * WT * D	.1879	.8416
T * SS * WT * D	.8905	.1240
C.V. (%)	7.5	7.5