AUTUMN AND WINTER APPLICATION OF NITROGEN FERTILIZERS ON CLAY SOILS

YRJÖ PESSI, MIKKO YLÄNEN, AUVO LESKELÄ and JORMA SYVÄLAHTI

Rikkihappo Oy, Helsinki

Received July 7, 1970

Abstract. In order to examine the application time of nitrogen given to cereals, several tests have been arranged on the Kotkaniemi Experimental Farm at Vihti ever since 1965. The tests have been carried out on solid clay soils, where the leaching of nitrogen has been expected to be slow.

In spring cereals the autumn application of nitrogen in November on frozen soil has given a good crop yield. The protein content of the crop in the plots where nitrogen was given in autumn was lower than in those where the spreading took place in spring.

As for winter wheat, application in December has given the best average crop yields but the decline of the protein content is to be considered a disadvantage. In rye, spring fertilization has given the best average crop yield. There has, however, clearly been less lodging in autumn applications than in plots where the nitrogen was spread in the spring.

Regarding nitrogen fertilization of autumn sown plants the usual custom in Finland is to give nitrogen in autumn for growth during the autumn and in the spring for the coming growing season. However, as low rainfall is typical of the Finnish spring, the effect of nitrogen given by broadcasting in early summer is slow, especially on solid soils like clay. As for spring cereals, the fertilizer placement at a depth of 8 to 10 cms has given distinctly better results than broadcasting and the usual mixing into the soil (Elonen 1967, Larpes 1966 and 1968, Nieminen 1967, Pessi 1970). The difference in the growth intensity has most clearly been evident in the early development of cereals. Simultaneously it has become clear that the placement of nitrogen has been of the greatest importance (Pessi 1970). As during winter in Finland the soil is usually frozen and covered with snow, no noteworthy leaching of nutrients takes place. On the basis of the results and observations mentioned above the question are as to what it would mean in practice in solid soils if the nitrogen was spread already before snowfall or on the snow, when the water from the melting snow would in spring cause the nitrogen to penetrate the soil. For this purpose tests were started on the Kotkaniemi Experimental Farm of Rikkihappo Oy in autumn 1965.

Arrangement of test

The tests were carried out on silty sandy clay through which water penetrates slowly. The physical character of the soil appears in the following analysis: clay, diameter less than 0,002 mm, 42 %; diameter 0.002—0,2 mm, 33 %; diameter over 0.02 mm, 25 %.

In the arrangement of the tests a test plot of such dimensions was planned, even several ares, that the work could be done by farming machines in all its phases while the test plots simultaneously gave a clear picture of the growth form of the crops. There were usually 4 replications. In large test plots the unhomogeneity of the soil causes more dis-

persion than in small ones; also the area needed by the test plot is large, positive points on the fact that it is possible to use ordinary farm-working techniques and to adapt the results directly into practice.

The meteorological conditions are shown in Table 1.

Table 1. Meteorological Observations at Vihti during the Growing Seasons 1965—69.

Monthly precipitations in millimetres

	V	VI	VII	VIII	IX	Total
1965	8.3	18.1	106.9	90.0	65.0	288.3
1966	15.1	40.7	74.9	28.3	77.7	236.7
1967	51.9	21.8	27.8	142.1	53.3	296.9
1968	70.5	30.6	67.1	111.4	74.4	354.0
1969	21.6	15.5	45.3	40.1	95.9	218.4
Average	33.5	25.3	64.4	82.4	73.3	278.8

Average temperatures per monthly in °C

	V	VI	VII	VIII	IX	Average (V—IX)
1965	7.7	16.0	14.6	13.4	11.6	12.66
1966	9.4	17.9	17.9	13.8	7.9	13.38
1967	10.1	14.7	17.6	15.2	10.5	13.62
1968	7.4	16.2	14.5	15.3	10.0	12.68
1969	8.7	15.3	16.2	15.2	9.6	13.00
Average	8.7	16.0	16.2	14.6	9.9	

Results

Spring cereals. The tests were started by using spring cereal as an experimental plant in fertilizations in autumn 1965. In 1966 they were expanded to include also winter cereals.

The results of the experiments with compound fertilizer (8-13-9, N-P_2O_5-K_2O) are given in Table 2. Nitrogen given in autumn has in the tests given a clear increase in the crop yield, but spring fertilization has proved even better. However, it is to be noted that the superiority of spring fertilization in this case cannot with certainty be attributed to the better effect of nitrogen. It is well known that water-soluble phosphorus, which the used compound fertilizer contains, fixes fairly fast in a less soluble form. In autumn application this has happened more than in the spring application.

The three quality factors of the crop yield in Table 2 have not been affected by the time of fertilization. There has been no noteworthy lodging in any treatment.

Tables 3 and 4 present the 4-year results of the tests carried out with four different nitrogen fertilizers. They show that different fertilizers have given very similar results. Autumn application in November has usually given the best results, ammonium sulphate alone has proved an exception, in a way against all expectations. In the quality of the crop yield a clear consistency is to be seen in the protein contents of the cereals. In connection with autumn applications it is lower than in spring applications.

Table 3. Tests with spring cereals during application time of nitrogen in 1965—1969.

1965—66 Soil type sandy muddy clay. Nutrient in 1962 pH 5.6, Ca 2080, P 3.5, K 180. Tests made with Svenno wheat. Sown 17. 5. Harvested 12. 9. Size of test plot 10 × 10 m. Quantity of nitrogen used 150 kg N/ha. Fertilization in autumn 1 000 kg/ha of PK fertilizer (0-17-15).

1966—67 2nd test year. Soil type sandy silty clay. Nutrients in 1967 pH 5.9, Ca 2 900, P 4.2 and K 170 mg/l. Test made with Svenno whaet. Sown 17. 5. Harvested 5. 9. Size of test plot 10 × 10 m. Quantity of nitrogen used 150 kg N/ha. Fertilization in autumn 1 000 kg/ha of PK fertilizer (0-17-15).

1967—68 3rd test year. Soil type sandy clay. Nutrients in 1967 pH 5.2, Ca 2 200, P 3.3 and K 280 mg/l. Tests made with Balder barley. Sown 1. 6. Harvested 11. 9. Size of test plot 10 × 20 m. Quantity of nitrogen used 150 kg N/ha. Fertilization in autumn 1 000 kg/ha of PK fertilizer (6-17-15).

1968—69 4th test year. Soil type silty sandy clay. Nutrients in 1967 pH 5.8, Ca 2 525, P 5.3 and K 335 mg/l. Tests made with Pomo barley. Sown 8. 5. Harvested 13. 8. Size of test plot 10 × 30 m. Quantity of nitrogen used 150 kg N/ha. Fertilization in autumn 1 000 kg/ha of PK fertilizer (0-17-15).

Treatment	1966		1967		1968		1969		Averages		
	Grain yield		Grain yield		Grain yield		Grain yield		Grain yield		
	kg/ha	rel.	kg/ha	rel.	kg/ha	rel.	kg/ha	rel.	kg/ha	rel.	
I *By different fertilizers*											
1. Without nitrogen	2 390	100	2 740	100	2 190	100	1 100	100	2 110	100	
2. Calcium nitrate early October	3 370	141	3 570	130	3 760	172	2 740	249	3 360	159	
3. » » in November	3 380	141	4 060	148	4 000	183	3 900	354	3 840	182	
4. » » in December	2 990	125	4 250	155	3 640	166	2 310	210	3 300	156	100
5. » » in spring after melting of snow	3 350	140	4 070	149	3 060	140	2 380	216	3 220	153	
6. » » in spring at normal fert. time	3 150	132	4 300	157	3 180	145	2 620	238	3 310	157	
7. Calcium ammonium nitrate early October	3 710	155	3 870	141	2 600	119	1 070	97	2 810	133	
8. » » » in November	3 520	147	4 650	170	3 400	155	2 520	229	3 520	167	
9. » » » in December	3 240	135	4 170	152	3 720	170	1 880	170	3 260	155	93
10. » » » in spring after melt. snow	3 500	147	4 270	156	3 370	154	1 850	168	3 250	154	
11. » » » » at norm. fert. time	3 180	133	4 190	153	3 500	160	1 380	125	3 060	145	

Treatment	1966 Grain yield kg/ha	rel.	1967 Grain yield kg/ha	rel.	1968 Grain yield kg/ha	rel.	1969 Grain yield kg/ha	rel.	Average Grain yield kg/ha	rel.	
12. Ammonium sulphate nitrate early October	3 260	136	3 930	144	2 900	132	2 460	223	3 140	149	
13. » » » in November	3 270	137	4 530	166	2 070	94	2 770	252	3 160	150	
14. » » » in December	2 860	119	3 620	132	2 280	104	3 070	279	2 960	140	90
15. » » » in spring after melt. snow	3 210	134	4 010	147	1 610	73	3 290	299	3 030	144	
16. » » » » at norm. fert. time	3 300	137	4 010	147	1 870	86	3 100	282	3 070	145	
17. Ammonium sulphate early October	3 530	147	3 900	143	3 240	148	3 620	329	3 570	169	
18. » » in November	3 140	131	4 580	167	2 900	133	2 630	239	3 310	157	
19. » » in December	2 950	123	4 010	147	2 590	118	1 590	144	2 790	132	99
20. » » in spring after melt. snow	3 310	138	4 010	147	3 070	140	2 620	238	3 250	154	
21. » » » in spring at norm. fert. time	3 640	152	4 200	153	3 320	152	4 580	417	3 940	187	
II *By application periods (averages)*											
1. Without fertilizing with nitrogen	2 390	100	2 740	100	2 190	100	1 100	100	2 110	100	
2. Nitrogenous fertilization early October	3 470	145	3 820	140	3 130	143	2 470	225	3 220	153	(100)
3. » » in November	3 330	139	4 460	163	3 090	141	2 950	268	3 460	164	(107)
4. » » in December	3 010	126	4 010	147	3 060	140	2 210	201	3 070	145	(95)
5. » » in spring afr. melt. snow	3 340	140	4 090	149	2 780	127	2 540	230	3 190	151	(99)
6. » » » at norm. fert. time	3 310	138	4 170	153	2 970	136	2 920	265	3 340	158	(104)
	In 1966		In 1967		In 1968		In 1968		Averages of years		
Grain yields, application times	F = 4.63*		F = 5.35*		F = 0.40		F = 3.50*		F = 0.41		
saltp. grades	F = 2.29		F = 1.10		F = 9.51		F = 3.34*		F = 0.49		
	$s_{\bar{x}}$ = 2.4 %		$s_{\bar{x}}$ = 10.1 %		$s_{\bar{x}}$ = 7.4 %		$s_{\bar{x}}$ = 15.35 %		$s_{\bar{x}}$ = 14.81 %		

In spring 1968 there were waters of melting snow on the area spread with ammonium suplhate nitrate which may have contributed to the weak effect. In 1969, the area spread with calcium ammonium nitrate was as an area dryer than the others.

Different years F = 7.53**

Table 2. Average values of results from tests with spring cereals during application time of fertilizers (compound fertilizer 8-13-9) in 1965—69.

1965—66 Soil type sandy muddy clay. Nutrients in 1962 pH 5, 6, Ca 2080, P 3.5, K 180. Test made with Svenno spring wheat. Size of test plot 10 m × 50 m. 3 replications. Fertilization: 800 kg/ha of compound fertilizer 8-13-9.

1966—67 Soil type silty clay. Nutrients in 1967 pH 5,9, Ca 2 900, P 4.2 and K 170 mg/l. Test made with Svenno wheat. Size of test plot 10 m × 50 m. 3 replications. Fertilization: 800 kg/ha of compound fertilizer 8-13-9.

1967—68 Soil type clayey humus soil. Nutrients in 1967 pH 5.2, Ca 2 475, P 4.4 and K 300 mg/l. Test made with Balder barley. Size of test plot 10 m × 50 m. 4 replications Fertilization: 800 kg/ha of compound fertilizer 8-13-9.

1968—69 Soil type silty sandy clay. Nutrients in 1967 pH 5.8, Ca 2 390, P 5.7 and K 364 mg/l. Test made with Pomo barley. Sown 8.5. Harvested 12. 8. Size of test plot 10 m × 50 m. 4 replications. Fertilization: 800 kg/ha of compound fertilizer 8-13-9.

Treatment	Grain yield (4 test) kg/ha	Grain yield (4 test) rel.	Lodging %	Hl-weight	1000 g.w. g	Raw protein %
1. Without fertilization (test results only from 1966—67)	1 820	100	0	81.7	35.0	
2. PK fertilization on ploughed area early October	1 890	104	1	75.2	37.6	9.7
3. 8-13-9 fertilization before ploughing » »	2 500	137	1	76.1	37.9	10.0
4. » » after ploughing » »	2 560	141	0	75.4	39.5	9.5
5. » » on ploughed area after middle of November	2 650	146	5	76.1	39.6	9.2
6. 8-13-9 fertilization on ploughed in spring after melting of snow	3 080	169	9	74.9	40.1	10.2
7. 8-13-9 fertilization on ploughed in spring at normal fertilizing time	2 880	158	0	75.0	38.7	10.0

Grain yields	In 1966	In 1967	In 1968	In 1969
	$F = 16.35^{***}$	$F = 7.54^{**}$	$F = 4.54^{*}$	$F = 2.66$
	$s_{\bar{x}} = 3.11\ \%$	$s_{\bar{x}} = 9.06\ \%$	$s_{\bar{x}} = 6.70\ \%$	$s_{\bar{x}} = 12.54\ \%$

Winter cereals. The results of the tests carried out with winter cereals are presented in Tables 5 to 8. Tables 5 and 6 show the results of winter rye and Tables 7 and 8 those of winter wheat. No treatment without nitrogen fertilization was included in the tests but on the basis of other tests made in the same area it is possible to conclude that the crop yield without nitrogen fertilization is for rye 2140 kg/hectare and for winter wheat 2270 kg/hectare. The results show that for rye spring fertilization has given the best results on an average, and for winter wheat spreading in December. Yearly fluctuations have apparently existed, at least partly, because of the rain frequency of the spring. There have been clear differences in lodging. The smaller lodging of rye in connection with autumn applications compared with spring applications would seem to recommend autumn application of nitrogen on clay soils in connection with intensive cultivation aiming at high crop yield. On the other hand, the decline of the protein content of winter wheat in connection with autumn application of nitrogen is a disadvantage for the baking quality of the crop.

Table 4. Average values of results from tests with spring cereals during application time of nitrogen in 1966—1969. Tests made with Svenno wheat in 1966—67, Balder barley in 1968, Pomo barley in 1969.

Treatment	Grain yield (4 tests) kg/ha	rel.	rel. by	Lodging %	Hl-weight	1 000 g.w. g	Raw protein % (only in 1969)
			fert. grades				
I *By different fertilizers*							
1. Without nitrogen	2 110	100		0	78.2	38.4	8.6
2. Calcium nitrate, early Oct. (ground not frozen)	3 360	159		11	78.0	38.6	10.7
3. » » November (ground frozen)	3 840	182		14	75.6	39.3	8.7
4. » » December (ab. 20 cm snow)	3 300	156	100	14	79.2	39.4	10.1
5. » » April (in spring after melt. snow)	3 220	153		3	77.9	39.5	12.9
6. » » May (in spring at norm. fert. time)	3 310	157		5	77.6	39.6	13.2
7. Calcium ammonium nitrate, early October	2 810	133		1	78.2	38.4	10.1
8. » » » November	3 520	167		79	39.4	39.4	11.8
9. » » » December	3 260	155	93	3	78.3	38.1	11.4
10. » » » April	3 250	154		2	77.3	38.7	10.7
11. » » » May	3 060	145		6	77.8	38.9	12.5
12. Ammonium sulphate nitrate, early Oktober	3 140	149		2	80.0	39.1	10.6
13. » » » November	3 160	150		2	78.8	40.0	11.7
14. » » » December	2 960	140	90	0	78.5	40.1	12.7
15. » » » April	3 030	144		1	78.0	40.0	12.4
16. » » » May	3 070	145		1	78.4	40.5	13.0
17. Ammonium sulphate, early October	3 570	169		4	79.1	39.9	10.0
18. » » » November	3 310	157		2	78.9	40.3	10.3
19. » » » December	2 790	132	99	1	78.3	38.9	11.3
20. » » » April	3 250	154		1	77.8	40.3	12.6
21. » » » May	3 940	187		2	78.4	40.6	12.4
Grain yields, treatments 2—21: fertilizer grades		F = 0.49					
application periods		F = 0.41					
years		F = 7.53** (= various plants also)					
		$s_{\bar{x}}$ = 14.81 %					
II *By application periods*							
1. Without nitrogen	2 110	100		0.25	76.0	38.4	9.8
2. Early October (ground not frozen)	3 220	153	(100)	4.75	76.0	39.9	11.1
3. November (ground frozen)	3 460	164	(107)	5.5*ii*	76.1	39.6	11.7
4. December (ab. 20 cm snow)	3 070	145	(95)	4.75	75.8	39.2	12.4
5. April (in spring after melt. of snow)	3 190	151	(99)	2.25	75.1	39.5	12.9
6. May (in spring at normal fert. time)	3 340	158	(104)	3.75	75.0	39.4	13.4
Grain yields, treatments 1—6: fertilizer periods		F = 18.87***					
years		F = 47.56*** (in 1968—69 barley)					
without/N fert.		F = 87.52***					
		$s_{\bar{x}}$ = 3.66 %					
Grain yields, treatments 2—6: fertilizer periods		F = 2.29					
years		F = 52.23*** (in 1968—69 barley)					
		$s_{\bar{x}}$ = 3.00 %					

Table 5. Test with winter rye during nitrogen application time.

1966—67 Soil type silty sandy clay. Nutrients in 1967 pH 5.8, Ca 2 500, P 5.3 and K 335 mg/l. Fertilization in connection with seed-bed preparation 500 kg compound fertilizer (8-13-9) and 600 kg/ha PK fertilizer (0-17-15) by broadcasting. Tests made with Pekka rye. Size of test plot 5 m × 50 m. 4 replications. For shoots 150 kg N/ha as calcium ammonium nitrate.

1967—68 Soil type silty clay. Nutrients in 1967 pH 5.8, Ca 2 600, P 6.4 and K 220 mg/l. Fertilization in connection with seed-bed preparation 600 kg compound fertilizer (8-13-9) and 500 kg/ha PK fertilizer by drilling. Tests made with Pekka rye. Size of test plot 10 m × 20 m. 4 replications. For shoots 150 kg N/ha as calcium ammonium nitrate.

1968—69 Soil type clayey sand and silt. Nutrients in 1967 pH 5.8, Ca 2 100, P 10 and K 315 mg/l. Fertilization in connection with seed-bed preparation 700 kg/ha compound fertilizer (15-25-10) by drilling. Tests made with Pekka rye. Size of test plot 7 m × 27 m. 3 replications. For shoots 150 kg N/ha as calcium ammonium nitrate.

Nitrogen application time	1967 Grain yield		1968 Grain yield		1969 Grain yield		Averages	
	kg/ha	rel.	kg/ha	rel.	kg/ha	rel.	kg/ha	rel.
1. Early October	3 540	100	1 920	100	3 740	100	3 070	100
2. » November	4 040	114	1 870	98	3 410	91	3 110	101
3. » December	4 070	115	1 800	93	3 370	90	3 080	100
4. 20—40 cm snow	4 070	115	1 860	97	3 180	102	3 250	106
5. In spring after melting of snow	3 960	112	2 340	122	3 740	100	3 350	109
6. At normal spreading time	3 980	112	2 430	127	3 980	106	3 460	113
	1967		1968		1969			
Grain yields	F = 1.15		F = 3.95*		F = 1.06			
$s_{\bar{x}}$	=4.74 %		6.70 %		=6.27 %			

Table 6. Test with winter rye during nitrogen application time.

1966—67 Soil type silty sandy clay. Nutrients in 1967 pH 5.8, Ca 2 500, P 5.3 and K 335 mg/l. Fertilization in autumn 1966 with 500 kg compound fertilizer (8-13-9) and with 600 kg/ha PK fertilizer (0-17-15) by broadcasting. Tests made with Pekka rye. Size of test plot 5 m × 50 m. 4 replications. Fertilizing with 150 kg N/ha as calcium ammonium nitrate.

1967—68 Soil type silty clay. Nutrients in 1967 pH 5.8, Ca 2 600, P 6.4 and K 220 mg/l. Fertilization in connection with seed-bed preparation: 600 kg compound fertilizer (8-13-9) and 500 kg PK fertilizer/ha by drilling. 150 N/ha as calcium ammonium nitrate given for shoots. Tests made with Pekka rye. Size of test plot 10 m × 20 m. 4 replications.

1968—69 Soil type clayey sand and silt. Nutrients in 1967 pH 5.8, Ca 2 100, P 10 and K 315 mg/l. Fertilization in connection with seed-bed preparation with 700 kg/ha compound fertilizer (15-25-10) by drilling. For shoots 150 N/ha as calcium ammonium nitrate. Tests made with Pekka rye. Size of test plot 7 m × 27 m. 3 replications.

Treatment	Grain yield kg/ha	rel.	Lodging %	Over-wintering observ. 13. 4. 67. covering %	Hl-weight	1 000 g.w. g	Falling number	Raw protein %[1]) x
1. Early October	3 070	100	36.8	92.8	75.9	26.6	190	9.6
2. » November	3 110	101	38.3	89.0	76.1	28.5	207	9.8
3. » December	3 080	100	41.0	88.4	76.4	26.0	196	11.2
4. 40 cm snow	3 250	106	41.2	90.3	76.6	25.8	192	10.1
5. In spring after melting of snow	3 350	109	77.7	89.5	75.9	26.5	191	12.4
6. At normal fertilizing time	3 460	113	82.8	89.4	75.7	26.3	189	10.6

Grain yields, F-value = 0.15 (different years F = 12.27**)
[1]) Only in 1969.

Table 7. Test with winter wheat during nitrogen application time.

1966—67 Soil type silty sandy clay. Nutrients in 1967 pH 5.9, Ca 3 100, P 8.8 and K 170 mg/l. Fertilization in connection with seed-bed preparation with 1 000 kg/ha PK fertilizer (0-17-15) by broadcasting. Tests made with Linna wheat. Sown 3. 9. 66. Harvested 23. 8. Size of test plot 5 m × 50 m. 4 replications. For shoots 150 kg N/ha as calcium ammonium nitrate.

1967—68 Soil type silty clay. Nutrients in 1967 pH 5.5, Ca 3 375, P 4.0 and K 290 mg/l. Fertilization in connection with seed-bed preparation: 600 kg compound fertilizer (8-13-9) and 500 kg PK fertilizer/ha by drilling. Test made with Linna wheat. Sown 7. 9. 67. Harvested 22. 8. 68. Size of test plot 8 m × 30 m. 4 replications. For shoots 150 kg N/ha as calcium ammonium nitrate.

1968—69 Soil type clayey sand and silt. Nutrients in 1967 pH 5.8, Ca 2 025, P 4.8 and K 284 mg/l. Fartilization in connection with seed-bed preparation with 700 kg/ha compound fertilizer (15-25-10) by drilling. Tests made with Linna wheat. Sown 5. 9. 68. Harvested 12. 8. 69. Size of test plot 10 m × 50 m. 4 replications. For shoots 150 kg N/ha as calcium ammonium nitrate. (When coming into ear another 200 kg/ha calcium ammonium nitrate was given).

Nitrogen application time	1967 Grain yield kg/ha	rel.	1968 Grain yield kg/ha	rel.	1969 Grain yield kg/ha	rel.	Averages of all years kg/ha	rel.
1. Early October	4 700	100	1 900	100	1 230	100	2 610	100
2. » November	4 890	104	2 340	123	1 070	87	2 770	106
3. » December	4 510	96	3 230	170	1 190	97	2 980	114
4. 20—40 cm snow	4 550	97	2 860	150	1 300	105	2 900	111
5. In spring after melting of snow	3 920	83	3 380	178	1 190	97	2 830	108
6. At normal application time	4 110	87	3 090	163	1 080	88	2 760	106

	1967	1968	1969
Grain yields	F = 5.32**	F = 3.16*	F = 0.43
$s_{\bar{x}}$	3.54 %	11.50 %	11.53 %

Table 8. Test with winter wheat during nitrogen application time.

1966—67 Soil type silty sandy clay. Nutrients in 1967 pH 5.9, Ca 3 100, P 8.8 and K 170 mg/l. Store fertilization with 1 000 kg/ha PK fertilizer (0-17-15) on the surface. Tests made with Linna wheat. Sown 3. 9. 66. Harvested 23. 8. Size of test plot 5 m × 50 m. 4 replications. As fertilizer 150 kg N/ha calcium ammonium nitrate.

1967—68 Soil type silty clay. Nutrients in 1967 pH 5.5, Ca 3 375, P 4.0 and K 290 mg/l. Fertilization in connection with seed-bed preparation: 600 kg compound fertilizer (8-13-9) and 500 kg PK fertilizer/ha by drilling. Tests made with Linna wheat. Sown 7. 9. 67. Harvested 22. 8. 68. Size of test plot 8 m × 30 m. 4 replications. In the fertilization 150 g/ha N as calcium ammonium nitrate has been used.

1968—69 Soil type clayeye sand and silt. Nutrinets in 1967 pH 5.8, Ca 2 025, P 4.8 and K 284 mg/l. Fertilization in connection with seed:bed preparation with 700 kg/ha compound fertilizer (15-25-10), by drilling. For shoots 150 kg/ha N as calcium ammonium nitrate. Tests made with Linna wheat. Sown 5. 9. 68. Harvested 12. 8. 69. Size of test plot 10 m × 50 m. 4 replications. (When coming into ear another 200 kg/ha calcium ammonium nitrate was given).

Treatment	Grain yield kg/ha	rel.	Lodging %	Over-winter observ. 13. 4. 67. covering %	Hl-weight	1 000 g.w. g	Falling number	Raw protein %
1. Early October	2 610	100	17.1	95.5	76.9	33.3	262	11.7
2. » November	2 770	106	17.3	95.5	78.9	33.2	253	12.2
3. » December	2 980	114	21.9	96.0	78.9	35.6	256	12.6
4. 40 cm snow	2 900	111	15.0	96.2	79.3	34.2	249	12.2
5. In spring after melting of snow	2 830	109	27.5	95.5	79.0	35.1	266	12.6
6. At normal fertilizing time	2 760	106	25.3	96.5	78.1	35.2	258	13.2

F = 0.23 (different years F = 76.67***)

The protein contents of the grain yield are smaller because of the nitrogen application in autumn than they would be after application in spring. A factor which may be of importance e.g. in the cultivation of malting barley.

Concerning tests carried out elsewhere in Finland, the results over one year have been published in two experimental farms (Köylijärvi 1969, Varis 1969). In the tests Köylijärvi carried out in Mietoinen in 1969, the spring application of calcium ammonium nitrate gave better results for winter wheat than application in autumn or early winter, but when broadcasting was used the December application of compound fertilizer (15-20-15) gave a better result than spring application. In the tests carried out by Varis in Anttila, autumn application has given better results for winter wheat than spring application, but the protein contents have been lower respectively (11.4 and 12.5 %). A similar decline in protein contents has been noted in tests carried out in the U.S.A. (Stevenson *et al.* 1969). Paavilainen (1970) noted in the fertilization of marshland forest that part of the nitrogen fertilizer spread on snow late in winter was lost.

In the U.S.A. ALDRICH (1969) has examined the spreading time of nitrogen on corn and found autumn application about as good as spring application in northern regions where the temperature of the soil is low in winter. Also tests in Hungary have given similar results for winter wheat in autumn and spring applications, when the autumn application has been given into frozen soil (DUDAS *et al.* 1968). NÖMMIK (1966) in Sweden has also paid attention to nitrogen keeping over the winter.

In Oregon, U.S.A., COOPER (1956) has found nitrogen given in spring and in autumn equally effective for hay.

REFERENCES

ALDRICH, S. R. 1969. Fall application. Agr. Chem. 24, 6: 12—14.

COOPER, C. S. 1956. The effect of source, rate and time of nitrogen application on the yields, vegetative composition and crude protein content of native floodmeadow hay in eastern Oregon. Agr.J. 48: 543—545.

DUDÀS, F., JELINEK, K. & PELIKÀN, M. 1968. Method of fertilization with nitrogen in relation to yield and quality to winter wheat. Rostl. Vyroba 14, 5: 489—498.

ELONEN, P., NIEMINEN, L. & KARA, O. 1967. Tuloksia kevätviljojen sadetuksesta savimailla. Maat. ja Koetoim. 21: 7—17.

KÖYLIJÄRVI, J. 1969. Näinkin voi käydä . . . Koetoim. ja Käyt. 26: 37.

LARPES, G. 1966. Rivilannoituksen vaikutus kevätviljoissa. Maat. ja Koetoim. 20: 14—20.

—»— 1968. Rivilannoituskokeet vv. 1965—67. Maaseudun Tulevaisuus 52. 12. 58—59.

NIEMINEN, L., KARA, O. & ELONEN, P. 1967. Kokemuksia sijoituslannoituksesta. Maat. ja Koetoim. 21: 42—49.

NÖMMIK, H. 1961. Kalium- und ammoniumfixierung in schwedischen Ackerböden. K. skogs- och lantbr. akad. tidskrf. Suppl. 5: 28—39.

—»— The residual effects of nitrogen fertilizers in relation to the quantities of mineral nitrogen recovered in the soil profile. Acta Agric. Scand. 16: 163—178.

PAAVILAINEN, E. 1970. Tutkimuksia levitysajankohdan vaikutuksesta nopealiukoisten lannoitteiden aiheuttamiin kasvureaktioihin suometsissä. Folia Forest. 75: 1969.

PESSI, Y. 1969. Typpilannoitteiden syyslevityksestä. Leipä leveämmäksi 4: 29—31.

—»— YLÄNEN, M., LESKELÄ, A. & SYVÄLAHTI, J. 1970. Results of tests made with placement fertilization on the Kotkaniemi experimental farm. J. Sci. Agric. Soc. Finl. 42: 193—202.

STEVENSSON, C. K. & BALDWIN, D. S. 1969. Effect of time and Method of Nitrogen Application and Source of Nitrogen on the yield and Nitrogen Content of Corn. Agr. J. 61: 381—384.

VARIS, E. Syysvehnän laadusta vehnän tuotannon pulma? Pellervo 70: 1186—1187.

SELOSTUS

TYPPEÄ SISÄLTÄVIEN LANNOITTEIDEN SYYS- JA TALVILEVITYKSESTÄ SUOMESSA

YRJÖ PESSI, MIKKO YLÄNEN, AUVO LESKELÄ ja JORMA SYVÄLAHTI

Rikkihappo Oy, Helsinki

Viljoille annettavan typen levitysajan tutkimiseksi on Kotkaniemen koetilalla Vihdissä järjestetty useita kokeita vuodesta 1965 lähtien. Kokeet on tehty tiiviillä savimailla, joilla typen kulkeutuminen on oletettu hitaaksi.

Kevätviljoilla typen syyslevitys marraskuussa routaantuneelle maalle on antanut hyvän satotuloksen. Sadon valkuaispitoisuus syksyllä typen saaneilla alueilla on alempi kuin keväällä levitetyillä alueilla.

Syysvehnällä on joulukuun levitys antanut keskimäärin parhaan sadon, mutta valkuaispitoisuuden aleneminen on luettava haitaksi. Rukiilla on kevätlannoitus antanut keskimäärin parhaan sadon. Lakoutuminen on kuitenkin syyslevityksessä ollut selvästi vähäisempää kuin keväällä typen saaneilla alueilla.