RESULTS OF TESTS MADE WITH PLACEMENT FERTILIZATION ON THE KOTKANIEMI EXPERIMENTAL FARM

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Received February 5, 1970

Various tests have been made with the placement of fertilizers in spring cereals in the 1960's. On the one hand, the investigations aimed at finding out the kind of effect this method had on the crop yield, on the other hand, the technique of placement aroused interest. The results have shown that the increases in crop yields were considerable (ELONEN *et al.* 1967, ELONEN 1967, HEINONEN & NIEMINEN 1961, KÖYLIJÄRVI 1969, LARPES 1966, 1968, NIEMINEN 1963, NIEMINEN *et. al.* 1967, PESSI 1967), expecially on clay soils. The best depth of placement seems to be 8—12 cm (NIEMINEN *et al.* 1967). Placement also had its effect on the growth of cereals (AURA 1967, ELONEN 1967, ELONEN *et al.*1967), on the equality of ripening (KÖYLIJÄRVI, 1969), and on the quality of the crop (ELONEN 1967, ELONEN *et al.* 1967, LARPES 1966, NIEMINEN *et al.* 1967).

The tests were started on the Kotkaniemi Experimental Farm at Vihti in 1966. The technique of the tests can partly be seen from the headings of the Tables, but some details on the working technique are given below.

The fertilizers were placed at a depth of 8—10 cm. The machine used in the placement was a Juko fertilizer-cultivator. On the plots on which the fertilizers were being broadcast the mixing into the soil was made with a rigid-tine harrow. As different preparation of soils might have affected the final results, all the same phases of work were carried out on the test plots, e.g. the broadcast plots were driven with an empty fertilizer-cultivator. Rotation tests were carried out to enable exact fertilization in addition to which the fertilizer amounts to each plot were checked by weighing.

All the tests were accompanied by effective weed control. Chlormequat (CCC) was in most cases used in connection with weed control sprayings. The plots were harvested with a combine-harvester.

The monthly mean temperatures and monthly precipitations measured at a place 10 kilometres from the experimental farm are presented in the 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 month 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 (Tables 2—3, p. 195—196, and tables 4—6, p. 198—202)

Table 2 shows the average grain yields of two year tests in which the effect of the placement of different nutrients was studied. The placement of nitrogen has the greatest effect, even the placement of phosphorus and potassium seems to be of importance. Giving fertilizers together with seed also gave good results. In this case the moisture content of the crop was high at the moment of harvesting. Delay in ripening was noted throughout the growing time.

Results in Table 3 throw light on the importance of the placement of phosphorus. They show that although the basic fertilization with phosphorus was rather abundant, a smaller amount of phosphorus placed separately gave increases in crop yield 95 % statistical reliability was not achieved, however.

Table 4 shows how the placement of NPK-amounts of different sizes affected the crop. The placement of the smallest amount of fertilizer gave an average increase of about 600 kg/ha. The biggest amount gave an increase of 400 kg. The hectolitre-weight and the 1000-grain-weight rose simultaneously.

As seen in Table 2, the placement of nitrogen proved to be the most important. Tests were accordingly arranged during four years in order to compare nitrochalk (26 % N) and urea. In the tests, fertilizers and the seed were sown with separate machines in parallel rows.

Tables 5 and 6 show that the increase in crop yield caused by urea was not as good as that caused by nitrochalk. The average value of the tests in Table 5 shows a difference of 380 kg per hectare, in Table 6 this difference is 100 kg. Attention has to be paid to the annual fluctuation in the difference of crop yields.

Table 2. Results of two trials in placement of nutrients in 1966—67 at Kotkaniemi.

Test in 1966: Soil type sandy muddy clay. Fertilizers: nitrochalk, superphosphate, and potassium chloride. Nutrient amounts correspond to 450 kg/ha of compound fertilizer 15—20—15 (N-P_2O_5-K_2O) which amount was used when all the nutrients were given simultaneously. Svenno-wheat sown 21. 5. 66. Size of test plot 5 × 50 m, harvested plot 3.6 × 50 m. 4 replications.

Test in 1967: Soil type silty sandy clay. Soil analysis in 1967: pH 6.0, Ca 3000, P 2.6 and K 170 mg/l. The same fertilizers as in 1966, nutrient amounts correspond to 700 kg/ha of fertilizer 15—20—15. Svenno-wheat sown 16. 5. 67. Size of test plot 5 × 66 m, harvested plot 3.6 × 66 m. 3 replications.

Treatment	Average grain yield kg/ha	rel.	Lodging %	Hl-weight kg	1000 g.w. g	Falling number	Moisture % of grain**
1. Control yield	1 848	100	0	81.6	35.5	246	22.5
2. Compound fertilizer, broadcasting	2 939	159	0	82.2	36.7	216	24.3
3. Compound fertilizer, placement	3 802	205	1.4	82.6	37.1	310*)	22.3
4. N + P in rows, K on soil	3 615	196	9.2	82.3	37.3	225	24.0
5. N in rows, P + K on soil	3 688	200	2.5	82.6	37.2	198	22.5
6. Combine-drill	3 807	206	0	82.2	37.3	206	26.0

F-value (grain yields) in 1966 = 12.53***, $s_{\bar{x}}$ = 5.9
» » » in 1967 = 65.62** » = 3.3
*) only in 1966
**) only in 1967

Baking test analysis (1966)

Treatment	Flour yield %	Swelling number	Gluten % SM	Ash %	Falling number of flour	Raw protein %	Dough	Germinated grains %	Green grains %
1	67.9	16.0	33.0	0.62	199	13.6	Good	4.0	—
2	63.4	15.0	39.0	0.67	197	16.1	Good	4.8	—
3	65.5	14.0	38.0	0.62	196	14.5	Good	4.1	0.1
4	67.8	12.0	37.0	0.66	208	14.8	Good	2.8	0.2
5	66.6	14.0	39.0	0.59	213	15.8	Good	3.6	0.1
6	65.1	14.0	40.0	0.62	189	15.8	Good	2.8	0.1

In the tests described in Tables 5 and 6, the fertilizer was placed with a separate machine after the seed was sown. Owing to this, the urea came to be at different distances from the seed row and it is evident that in some cases it came so near the seed row that it may have had a detrimental effect on the development of the cereals.

Table 3. So-called start phosphorus in placement fertilization in 1966—1968 at Kotkaniemi.

In 1966: Soil type sandy muddy clay. Fertilization in autumn 1965: 800 kg/ha of PK-fertilizer (0—16.5—16.5). Test made with Svenno-wheat. Size of test plot 5 × 50 m. Harvested plot 1.8 × 50 m. 2 replications. Start phosphorus given in powdered superphosphate.

In 1967: Soil type clayey silt and fine sand. Soil analysis in 1967: pH 5.9, Ca 1600, P 18 and K 208 mg/l. Fertilization in autumn: 1000 kg/ha of PK-fertilizer (0—16.5—16.5). Test made with Pendek-oats. Size of test plot 5 × 30 m. Harvested plot 3 × 30 m. 3 replications. Start phosphorus given in granular superphosphate.

In 1968: Soil type clayey humus soil. Soil analysis in 1967: pH 5.2, Ca 2700, P 2.9 and K 295 mg/l. Fertization under spring preparation of seed-bed: 800 kg of PK-fertilizer (0—16.5—16.5) 31. 5. 68. Preceding crop fallow. Test made with Balder-barley. Sown 1.6. Size of test plot 5 × 50 m. Harvested plot 3 × 50 m. 4 replications. Start phosphorus given in granular superphosphate.

Treatment	Gain yield kg/ha	Gain yield rel.	Lodging %	Hl-weight kg	1000 g.w. g	Protein %
In 1966 Svenno-wheat						
1. Basic fertilization in autumn 800 kg/ha of PK-fertilizer	1 632	100	0	76.7	36.9	—
2. In spring additional 300 kg/ha of Nitrochalk, placement	3 052	187	0	77.8	37.6	—
3. Basic fertilization, Nitrochalk and in addition 100 kg/ha of superphosphate	3 174	194	0	77.8	36.7	—
	F-value of grain yields = 178.3**, $s_{\bar{x}}$ = 2.4 %					
In 1967 Pendek-oats						
1. Basic fertilization in autumn 1000 kg/ha of PK-fertilizer	1 675	100	0	55.4	32.5	—
2. In addition 400 kg/ha of Nitrochalk, placement	4 103	245	0	52.3	31.1	—
3. Basic fertilization, Nitrochalk and in addition 100 kg/ha of superphosphate	4 489	268	0	52.6	31.4	—
	F-value of grain yields = 33.53**, $s_{\bar{x}}$ = 7.7 %					
In 1968 Balder-barley						
1. Basic fertilization in spring 800 kg/ha of PK-fertilizer, broadcasting	3 333	100	5.5	69.8	38.9	10.2
2. In addition 300 kg/ha of Nitrochalk, placement	4 267	128	77.5	65.6	28.4	11.4
3. Basic fertilization. Nitrochalk and in addition 100 kg/ha of superphosphate	4 568	137	79.5	66.2	21.8	12.0
	F-value of grain yields = 17.08**, $s_{\bar{x}}$ = 3.9 %					

Fertilization with start phosphorus has increased the grain yields every year but this cannot be considered statistically reliable.

Conclusions

On the basis of the results of the tests made on clay soils and on soils containing clay the following conclusions can be drawn:

Among different nutrients the placement of nitrogen proved to be the most important.

Placement of nutrients in rows at a depth of about 8—10 cm gave considerable increases in crop yield compared with ordinary broadcasting.

In the two tests where fertilizer and seed were sown in the same row, the crop yield was of the same size as in the case where they were sown separately. Ripening was delayed, however.

When fertilizer and seed were sown with separate machines and the fertilizer was placed closer than 10 cm to the seed, urea did not prove as good as nitrochalk.

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SELOSTUS

RIVILANNOITUSKOKEIDEN TULOKSIA KOTKANIEMEN KOETILALLA

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Kirjoituksessa selostetaan Vihdissä sijaitsevalla Kotkaniemen koetilalla vuosina 1966—1969 tehtyjen rivilannoituskokeiden tuloksia. Kokeet on tehty hiesupitoisilla savimailla. Tulosten perusteella voidaan tehdä mm. seuraavia päätelmiä:

Eri ravinteista on typen sijoitus osoittautunut tärkeimmäksi.

Ravinteiden sijoittaminen maahan riviin noin 8—10 cm:n syvyyteen on antanut huomattavia sadonlisäyksiä tavanomaiseen hajalannoitukseen verrattuna.

Kahdessa kokeessa mukana ollut menetelmä, missä lannoite ja siemen on kylvetty samaan riviin, on antanut samansuuruisen sadon kuin kylvö erikseen. Tuleentuminen on kuitenkin viivästynyt.

Menetelmässä, missä lannoite ja siemen on kylvetty eri koneella ja missä lannoite voi joutua myös lähelle siementä, urea ei ole osoittautunut oulunsalpietarin veroiseksi.

Table 4. Tests with placement fertilization 1967—1968 at Kotkaniemi
Soil type silty clay. Soil analysis in 1967: pH 5.8, Ca 2930, P 4.1 and K 170 mg/l. Size of test plot 10 × 30 m, harvested plot 9 × 30 m. 4 replications.

Treatment	Grain yield kg/ha	Grain yield rel.	Shooting %	Lodging %	Hl-weight kg	1000 g.w. g	Protein %	Height of straw cm	Length of head cm
Paavo-barley 1968									
1. Control yield	764	100	64.5	0	62.0	33.9	9.7	40.8	4.1
2. 450 kg/ha of fertilizer 15—20—15 (N-P_2O_5-K_2O) broadcasting	1 752	229	79.0	0	61.6	34.3	9.4	50.6	4.0
3. » » » placement	2 630	344	88.0	0	63.6	36.0	9.5	57.7	4.4
4. 900 kg/ha » broadcasting	2 361	309	81.5	0	60.5	32.7	10.8	55.5	4.5
5. » » » placement	2 931	384	80.0	0	61.6	34.7	10.4	63.2	4.7
	F-value of grain yields = 21.51***, $s_{\bar{x}}$ = 8.4 %								
	Placement/broadcasting F-value = 33.74***								
Otra-barley 1968									
1.	1 128	100	77.8	0	64.1	37.3	10.6	52.5	4.1
2. See above	2 142	190	85.8	0	64.0	38.4	10.3	66.6	4.4
3. » »	3 112	276	91.3	0	65.4	39.6	10.1	72.0	4.4
4.	2 671	237	84.0	4	61.2	36.9	12.2	68.1	4.2
5.	4 008	355	95.0	10	64.1	39.2	11.6	73.6	4.5
	F-value of grain yields = 10.71***, $s_{\bar{x}}$ = 11.8 %								
	Placement/broadcasting F-value = 27.97***								
Otra-barley 1969									
1.	2 148	100		0	72.0	37.0	9.1	51.1	3.5
2. See above	2 965	138		2	72.7	41.1	12.3	50.9	3.7
3. » »	4 743	221		7	72.6	41.3	10.2	66.2	4.3
4.	4 559	213		6	73.7	42.5	12.5	59.9	3.9
5.	5 782	269		25	72.0	42.4	12.4	73.7	4.4
	F-value of grain yields = 57.35***, $s_{\bar{x}}$ = 4.77 %								
	Placement/broadcasting F-value = 60.46***								
Pendek-oats 1968									
1.	2 364	100	82.8	0	52.1	35.0	11.2	68.8	
2. See above Paavo-barley	3 449	146	86.0	0	51.8	33.0	10.8	79.1	
3. » » »	3 680	156	93.0	0	53.7	34.6	11.3	78.1	
4. » » »	3 526	149	86.5	0	48.2	32.7	12.1	81.9	
5.	3 782	160	92.8	0	50.0	32.7	12.5	84.2	
	F-value of grain yields = 8.67***, $s_{\bar{x}}$ = 5.4 %								
	Placement/broadcasting F-value = 7.30*								
Svenno-wheat 1967								Falling number	
1.	2 604	100		14	82.3	34.0		231	
2. See-above Paavo-barley	3 455	133		3	83.7	36.6		238	
3. » » »	4 205	161		14	82.8	36.1		249	
4.	4 042	155		10	82.8	36.8		224	
5.	4 111	158		47	81.6	34.0		214	
	F-value of grain yields = 18.48***, $s_{\bar{x}}$ = 5.8 %								
	Placement/broadcasting F-value = 8.34*								

Treatment	Grain yield kg/ha	Grain yield rel.	Shooting %	Lodging %	Hl-weight kg	1000 g.w. g	Protein %	Height of straw cm	Lenght of head cm
Apu-wheat 1968									
1.	1 354	100	57.8	2	73.2	31.0	13.8	319	
2. See above Paavo-barley	1 858	137	72.5	10	73.8	31.8	13.8	311	
3. » » »	2 135	158	84.0	12	74.3	29.6	14.6	332	
4.	2 247	166	80.0	12	73.3	28.8	15.4	272	
5.	2 074	153	70.0	16	72.1	27.7	15.4	287	
	F-value of grain yields = 3.17*, $s_{\bar{x}}$ = 10.1 %								
	Placement/broadcasting F-value = 0.15								

Svenno-wheat 1969

Method A

Treatment	Grain yield kg/ha	Grain yield rel.	Lodging %	Hl-weight kg	1000 g.w. g	Ptotein %	Falling number	Height of straw cm	Length of head cm
1.	2 521	100	0	81.1	35.5	10.2	277	67.0	5.5
2. See above Paavo-barley	2 833	112	0	82.5	36.4	12.9	299	69.2	5.6
3. » » »	3 600	143	0	81.8	37.9	12.0	290	80.2	6.4
4.	3 354	133	0	82.4	36.9	13.6	275	76.4	6.0
5.	4 583	182	0	81.4	41.2	13.3	273	83.3	6.7
	F-value of grain yields = 17.64***, $s_{\bar{x}}$ = 5.59 %								
	Placement/broadcasting F-value = 27.67***								

Method B

1.	2 107	100	0	82.8	35.6	9.6	257	64.4	5.5
2. See above Paavo-barley	2 847	135	0	83.3	37.4	12.2	297	68.3	5.7
3. » » »	3 945	187	0	81.8	38.5	11.0	311	78.7	6.4
4.	3 877	184	0	83.3	37.9	12.8	297	70.6	5.9
5.	4 997	237	0	81.8	41.2	12.0	273	83.9	6.7
	F-value of grain yields = 64.96***, $s_{\bar{x}}$ = 3.9 %								
	Placement/broadcasting F-value = 64.87***								

A = Seed sown in line with the fertilizer rows
B = Seed sown across the fertilizer rows

Average value of grain yields of all the crops

1.	1 874	100
2. See above Paavo-barley	2 663	142
3. » » »	3 506	187
4.	3 330	178
5.	4 035	216

Table 5. Comparison tests with nitrochalk and urea in 1966—1969.

Wheat in 1966—69. Soil type sandy clay. Soil analysis in 1967: pH 5.9, Ca 2400, P 4.0 and K 190 mg/l. Fertilization in spring: 800 kg/ha of PK-fertilizer (0—16.5—16.5), N in different forms in 1966 75 kg/ha, in 1967 137 kg/ha, in 1968 90 kg/ha and in 1969 87 kg/ha. Test made with Svenno-wheat. Size of test plot 10 × 120 m. Harvested plot 6 × 120 m, 2 replications.

Barley in 1966—68. Soil type silty clay. Soil analysis in 1967: pH 5.8, Ca 2300, P 3.0 and K 215 mg/l. Fertilization in spring: 800 kg/ha of PK-fertilizer (0—16.5—16.5), N in different forms 100 kg/ha/year. Test made with barley. Size of test plot 7.5 × 65 m. Harvested plot 6 × 65 m, 2 replications.

Treatment	Grain yield kg/ha	rel.	Lodging %	Hl-weight kg	1000 g.w. g	Protein %
Test with wheat						
Wheat 1966						
1. PK-fertilizing	1 960	100	0	74.5	39.3	
2. In addition Nitrochalk, placement	2 410	123	0	70.8	40.8	
3. » urea »	1 790	91	0	71.3	37.4	
Wheat 1967						
1.	2 160	100	0	82.9	36.1	
2.	3 590	166	45	80.8	35.6	
3.	3 490	160	35	82.6	36.7	
Wheat 1968						
1.	1 300	100	0	78.2	29.4	12.4
2.	3 250	250	18	79.6	32.8	14.8
3.	3 110	239	18	80.0	32.8	14.3
Wheat 1969						
1.	1 470	100				
2.	2 610	178				
3.	2 190	149				
Wheat 1969 *2. test on sandy soil*						
1.	1 980	100				
2.	3 490	176				
3.	2 880	145				

Fertilization 80 kg N/ha. Test plot 2.5 × 30 m. 3 replications.

Treatment	Grain yield kg/ha	rel.	Lodging %	Hl-weight kg	1000 g.w. g	Protein %
Tests with wheat, on an average: (in 1966—1969) (5 tests)						
1.	1 770	100				
2.	3 070	173				
3.	2 690	152				
		Treatment 2/3	t = 4.22**			
Tests with barley						
1. Control yield	300	100	0	63.8	41.8	
2. Nitrochalk, in rows	2 000	667	0	62.9	43.3	
3. Urea in rows	1 060	333	0	63.1	41.8	
4. Nitrochalk, broadcasting	1 510	503	0	61.3	39.5	
Barley 1967						
1.	1 520	100	0	69.5	38.6	
2.	2 670	176	13	67.8	42.5	
3.	2 320	153	5	68.1	41.8	
4.	2 400	158	5	68.1	41.9	
Barley 1968						
1.	1 110	100	0	55.6	33.5	11.5
2.	2 830	255	13	57.0	33.2	10.4
3.	3 010	274	10	57.3	32.1	11.2
4.	2 980	268	9	55.6	33.0	11.1
Tests with barley, average: (3 tests)						
1.	980	100				
2.	2 500	255				
3.	2 130	217				
4.	2 300	235				
		Treatment 2/3	t = 1.75 (t 5 % = 2.57)			
Tests with barley and wheat, average:						
1.	1 380	100				
2.	2 790	202				
3.	2 410	175				

Table 6. Comparison of nitrochalk and urea in potassium metaphosphate tests in 1966—1969.

Soil type silty sandy clay. Soil analysis in 1967 pH 5.6, Ca 2300, P 4.0 and K 235 mg/l. Test made with Svenno-wheat in 1966—67, with Otra-barley in 1968. Size of test plot 8 × 30 m, harvested plot 6 × 30 m. 3—4 replications. Nutrient amounts correspond to 500 kg/ha of fertilizer 15—20—15 (N-P_2O_5-K_2O). Straight fertilizers: superphosphate (Psf), potassium chloride, potassium metaphosphate, nitrochalk and urea. Potassium metaphosphate: P_2O_5 57 % and K_5O 36 %. The fertilizers were broadcast.

Treatment	Grain yield kg/ha	Grain yield rel.	Lodging %	Hl-weight kg	1000 g.w. g	Shooting %	Protein %
Svenno-wheat (1966—67)							
1. Control yield	1 992	100	0	82.1	35.2		
2. Superphosph. + potassium chloride + nitrochalk	3 195	160	0	82.6	37.0		
3. Potassium metaphosphate + nitrochalk	3 219	162	0	82.3	37.3		
4. » » + urea	3 162	159	0	82.1	37.5		
	F-value of grain yields in 1966 = 10.35, $s_{\bar{x}}$ = 4.2 %						
	F-value of grain yields in 1967 = 14.25 $s_{\bar{x}}$						
Otra-barley (1968)							
1. Control yield	793	100	0	62.1	42.4	73.8	9.80
2. Superphosph. + potassium chloride + nitrochalk	2 235	281	0	60.2	33.5	77.5	10.15
3. Potassium metaphosphate + nitrochalk	2 220	280	0	60.4	34.4	75.8	10.13
4. » » + urea	2 142	270	0	61.0	38.0	76.3	10.40
	F-value of grain yields = 42.51, $s_{\bar{x}}$ = 5.8 %						
Winter wheat, Linna (1969)							
1. Control yield	4 372	100					
2. Superphosph. + potassium chloride + nitrochalk	6 012	138					
3. Potassium metaphosphate + nitrochalk	5 514	126					
4. » » + urea	5 305	121					
	F-value of grain yields = 9.73, $s_{\bar{x}}$ = 4.16 %						
Average (test years 1966—69)							
1. Control yield	2 287	100					
2. Superphosph. + potassium chloride + nitrochalk	3 659	160					
3. Potassium metaphosphate + nitrochalk	3 543	155					
4. » » + urea	3 443	150					

Statistically reliable differences between grain yields were not observed in connection with the tested crops in treatments 2—4.