The connection between

Soil Crop Manure

The results from the K-trial
a 33-year study on the effect of fertilization on the properties of soil and crop

The study was executed 1958 – 1990 by
Bo D. Pettersson

The results are compiled by
Lars Kjellenberg and Artur Granstedt

Introduction

This report contains the results from of a long-term field trial during the years 1958 to 1990. The field trial was conducted at the Järna Institute of the Scandinavian Research Circle for Biodynamic Agriculture and it had the same layout during the whole period. The quality trial, or the K-trial, as it was more commonly called, ought to be unique, as it gives us the possibility to study how different fertilizer-types effects soil and crop on a long-term basis.

During the entire experiment period, the same person was responsible for maintenance and evaluation, namely agr. lic. Bo D. Pettersson. Until his death in March 1992, he worked with the final compilation of the results from the K-trial. Since 1990 some of his younger colleagues helped him out in this task. Bo did kindly place all his experience at the disposal to the ones who were destined, to give the final touch to his accomplished life mission. His unexpected death made a severe interruption in the work. What we have been able to do in this report is to add the computer-technology to the rich and vivid experience that Bo collected during all the trial-years. In the line of work Bo was always a source of inspiration and ideal. It is our hope, that the reader of this report will be able to experience some of the qualities that made Bo into one of the great research pioneers within the biodynamic agriculture.

It has been impossible for us to discuss all the different issues that the rich material awakens. Hopefully the results from the K-trial in this writing, contributes to the continuation and inspiration of researching the correlation between fertilization, soil and crop.

Acknowledgements

This long-term project started at a time when the term ecology hardly was known. The trial could not have been carried out without economical and moral support of several people, foundations and institutions, among others;

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Nordisk Forskningsring för Biodynamisk odling, Järna
Fond for Goetheanistisk Forskning, Slangerup

The support offered by different people, through advice and deeds, have over the years taken such proportions, that it herein is impossible to mention all those who contributed to the execution of the project.
To all those who helped to realize the intentions with this experiment, we hereby would like to express our cordial gratitude.

For the English version of our report we also would like to express our sincere thanks to the translator Miss Helen Mortensen.

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Starting points

How do various types of fertilizers affect the quality of our food? This issue is not easily answered. First, three areas must be illuminated to create a meaningful discussion;

- what does quality mean?
- how does quality arise?
- how can quality be determined?

When the Scandinavian Research Circle for Biodynamic Agriculture was founded in 1949 these three issues were essential. The K-trial was first constructed to be an observation-trial with the ambition to process two areas in particular:

- how can we find methods of analyses to indicate the quality of nutrients?
- how does fertilization influence the properties of plant products?

As the K-trial was carried out during 33 years, at the same location, and with more or less the same arrangement, other issues became equally important, such as:

- how does the fertilization affect the soil processing?
- what role does the weather play for the quality food?
- how does the fertilization affect the crops capacity to withstand extreme weather conditions?

Earlier publications on the K-trial

During the years the following part-reports, have been published presenting the on-going results from the K-trial:
Engqvist (1961), Engqvist (1963), Pettersson and Engqvist (1963), Pettersson and Engqvist (1964), Pettersson (1967), Pettersson (1972), Pettersson &. v.Wistinghausen (1977), Pettersson (1979), Pettersson, Brinton & v.Wistinghausen (1979) Pettersson, Reents &. v.Wistinghausen (1992).

Experimental layout

The field experiment had originally two purposes:

- to serve as a pilot test for future more detailed research
- to produce enough crops from the trial, to be able to test various quality methods

The experimental layout included 8 different fertilizer variants, each with a 4-fold crop rotation. This meant 32 different sub-plots as the K-trial ran without repetitions. The size of each plot was 387 ft^2 (36 m^2) gross, net harvestable area was 291 ft^2 (27 m^2). Grassland borders between variants were 5 ft (1.5 m)

Crop rotation

The crop rotation was four years and included: summer wheat with undersow –annual clover/grass ley - potatoes - beets (during the first years some other vegetables were also grown here). All the crops were cultivated every year in all varieties of fertilization.

Experimental variants and fertilization

The K-trial consisted of three variants fertilized only with organic manure, one variant was unfertilised, one variant received organic, as well as mineral fertilizer and three variants received different rates of mineral fertilizers. Each variant was labelled with the letter K and a digit from 1 to 8, see Table 1 next page.

Variant K1 Composted stable manure treated with the biodynamic compost-preparations 502-507. Between 1962 and 1981 an annual supply of 1% meat meal and 1% bone meal (from 1974). This was replaced during 1982-1989 with a urine additive. The field preparation 500 and 501 was used on all crops

Variant K2 As K1 except the use of the biodynamic field-sprays 500 and 501.

Variant K3 Raw stable manure. During 1974-1981 with additives of 1 % meat meal and 1% bone meal. This was replaced during 1982-1989 with a urine additive.

Variant K4 Raw stable manure combined with mineral fertilizer. The rates were calculated in a way that half of the nitrogen rate should come from the raw manure and the other half from the mineral fertilizer.

Variant K5 Unfertilised during the entire experimental period.

Variant K6 Mineral fertilizer, low rate. During 1958-1973 i.e. calcium nitrate and ammonium nitrate (for potatoes), super phosphate and potassium sulphate. From 1974 and onwards as NPK 11-5-18 with micro-substance additives.

Variant K7 Mineral fertilizer as in K6, medium rate, twice the level N, P and K compared to K6.

Variant K8 Mineral fertilizer as in K6, high rate, the amount of nitrogen four times higher than K6, otherwise as in K7. Half of the nitrogen was added as top-dressing with calcium nitrate and ammonium nitrate (for potatoes).

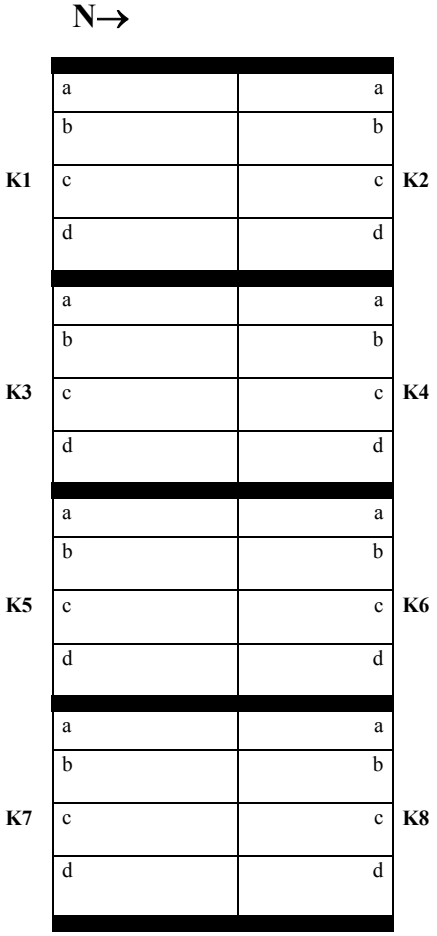

Fig. 1 Experimental layout. Numbers refer to variant and letters sub-plots.

The fertilization was distributed between the crops as seen in Table 1:

Variant	Fertilizer	Wheat	Ley	Potatoes	Beets
K1,K2	Compost	-	-	40%	60%
K3	Raw farm-yard manure	-	-	40%	60%
K4	Raw farm-yard manure mineral fertilizer, NPK	- 20%	- -	40% 40%	60% 40%
K5	Unfertilised	-	-	-	-
K6,K7,K8	Mineral fertilizer P, K mineral fertilizer N	- 20%	- -	40% 40%	60% 40%
Table 1	The fertilizer rates in % within one rotation of the crops in the K-trial.				

Experimental location

The experimental location can roughly be characterized as stated below:

Northern latitude	59,5°	
Eastern longitude	17,4°	
Height above sea-level	32 ft	(10 m)
Precipitation annual average	22 inches	(550 mm)
Temperature annual average	43° F	(6°C)
Snow-free months	(Mars) April – October	(November)

The climate in the experimental area, is presented in Fig. 2. The values are collected from SMHI's weather station in Södertälje 12 km from the experimental location.

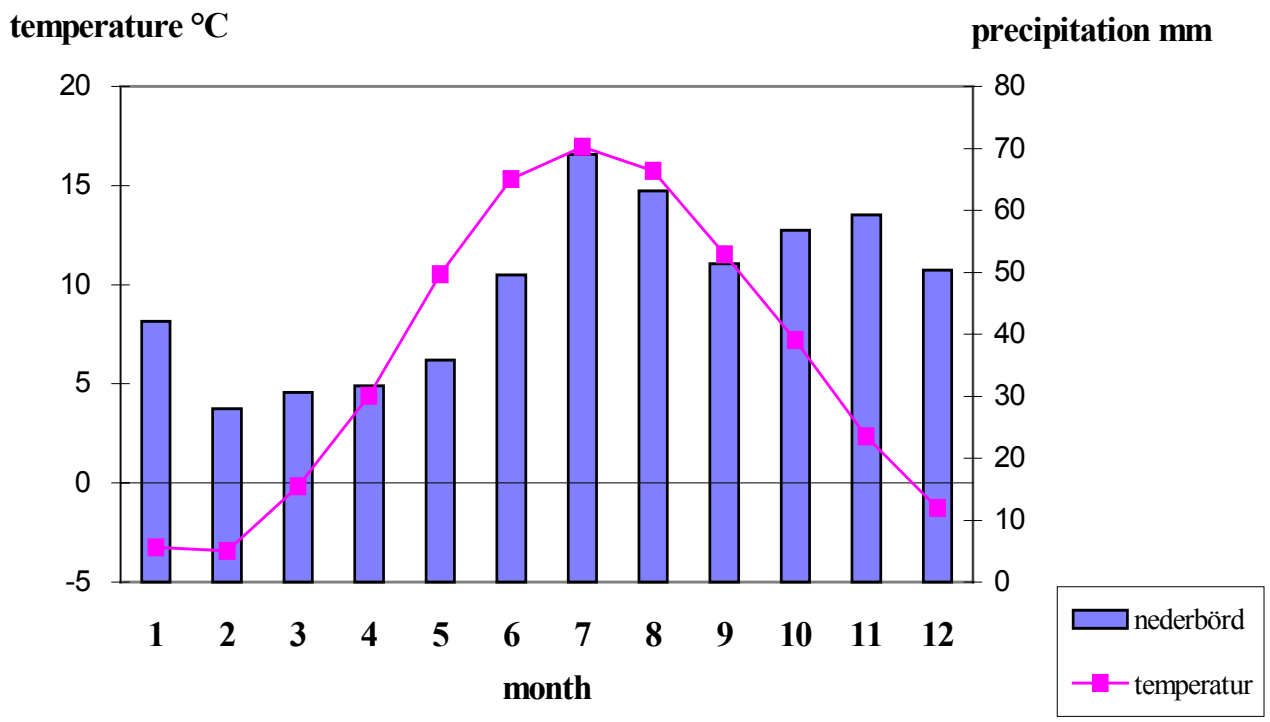

Fig. 2 Avarage monthly temperature during the trial period. The values are measured in Södertälje 12 km from the location. Source SMHI.

The climate is characterized as early summer draught. The soil has, in spite of that, a good water retention capacity. The soil at the location is an intermediate silty clay loam with 25 - 30% loam. The humus content is between 4 -5%.

Methods

Several new measuring methods was tested and further developed as the K-trial went on. Some of these methods were later to be used in the ongoing work. They will be presented shortly in connection to the presentation of the results. Further information about the methodical developments in relation to the K-trial is represented in:
Engqvist (1961), Engqvist(1963), Pettersson and Engqvist (1963), Pettersson and Engqvist(1964), Pettersson (1967), Pettersson(1970), Pettersson(1972), Pettersson (1979), Pettersson, Brinton & v.Wistinghausen (1979).

Chemical investigations of soil and fertilizers, as well as several of the plant products, have been performed at National Agro-Chemical Laboratory SLL, Uppsala. Taste investigations on the potatoes have been performed at National Seed Control Station, Sweden. The staff at Institut für biologisch- dynamische Forschung, Darmstadt, Germany, did soil investigations in 1976, 1985 and 1989.

Calculations, statistical processing and analyses used in this report have been performed with the assistance of the computer programme Microsoft Excel x.x and SPSS x.x. Graphs and diagrams have been produced with the computer programmes Graph in the Box 95, Microsoft Excel x.x and SPSS x.x
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Execution

Crop rotation during the trial period included the crops and cultivars as below:

Crop	**Trial-year**	**Cultivars**
Summer wheat (with undersow)	1958 - 1969 1970 -1973 1974 - 1989	Kaern II Pompe Drabant
Annual clover/ grass ley	1958-1989	Red clover, meadow fescue, timothy, alsike- clover, from 1978 lucerne.
Potatoes	1958 - 1973 1974 - 1981 1982 -1985 1986 - 1989	King Edward VII Grata Bellona Provita
Beets	1958 - 1969 1970 - 1989	Red beet = Forma, Nova and Rubia Red beet = Forma, Nova and Rubia Fodder sugar beet = Kyros
Table 2 Crops and cultivars used during 1958-1989.		

The beets were harvested with leaves and roots, the potatoes only the tubers. The clover/grass ley was harvested twice a year. From 1970 and on, the second harvest was returned to the plot as green manuring. In the summer wheat the straw and kernel was yielded.

To avoid the effects of draught in the K-trail, the plots were irrigated when dry weather. Irrigation was mainly performed during particular sensitive phases in the crop development e.g. germination of summer wheat and beets (May) and to support the growth process in the potatoes (July-August).

Fertilization

Fertilization was performed just before the sowing. Mineral fertilizing rates in K7 and K8 was divided and also given as topdressing. The amount of raw farmyard manure used in K3 was 45 ton/ ha for beets and 30 ton/ ha for potatoes. An equal amount was laid to be composted and used in K1 and K2. The remaining amount of manure after composting was then spread out on these plots. *Pettersson, Reents and Wistinghausen (1992)* states following average values of the annual supply of organic matter in K1, K2, K3 and K4:

Supply of	**K1 and K2**	**K3**	**K4**
Dried weight kg / ha	4066	3957	1979
out of that- organic matter %	72	83	83
Organic matter kg / ha	2928	3284	1643
Carbon kg / ha	1640	1642	822
Table 3 Average annual supply of organic substance K1, K2, K3 and K4. From *Pettersson, Reents and Wistinghausen (1992).*			

The amount of fertilizer-rates changed slightly as the K-trial went on. Yet, they were kept at a constant rate within one four-year crop rotation period. Worth noting is the intense increase in rates in the organic fertilized variants during the period 1970-1973. The increase presupposed an effort to equalize the differences between the variants concerning the amount of easy accessible nitrogen. From 1974 and on, the fertilization intensity was slightly lowered in these variants. In the mineral fertilized variants, the rate was slightly lowered during the first three cycles of the crop rotation, later to be raised again, at least in the case of nitrogen, to correspond to the original amount. The mineral fertilized variants, during the first four-year period, had high rates of phosphorus and potassium. During the later part of the K-trial, the rates were stabilized in phosphorus, as well as in potassium, so the final amount over the whole trial period was more or less the same for K1, K2, K3, K7 and K8. The rates of nitrogen, phosphorus and potassium during the eight crop rotation-periods are seen in Table 4.

	Year\Variant	K1	K2	K3	K4	K5	K6	K7	K8
Nitrogen	1958 - 61	80	80	61	47	0	34	69	137
	1962 - 65	60	58	57	42	0	23	46	94
	1966 - 69	67	67	77	49	0	19	39	78
	1970 - 73	111	111	162	97	0	31	63	125
	1974 - 77	90	90	108	70	0	31	63	125
	1978 - 81	74	74	103	67	0	31	63	125
	1982 - 85	76	76	96	64	0	31	63	125
	1986 - 89	84	84	98	64	0	31	63	125
	Average value	**80**	**80**	**95**	**62**	**0**	**29**	**58**	**117**
Phosphorus	1958 - 61	27	27	23	29	0	36	73	73
	1962 - 65	30	30	21	21	0	20	39	40
	1966 - 69	49	49	24	20	0	16	32	32
	1970 - 73	65	65	40	32	0	25	50	50
	1974 - 77	52	52	48	30	0	12	23	23
	1978 - 81	41	41	47	29	0	12	23	23
	1982 - 85	18	18	23	17	0	12	23	23
	1986 - 89	22	22	22	17	0	12	23	23
	Average value	**38**	**38**	**32**	**24**	**0**	**18**	**36**	**36**
Potassium	1958 - 61	61	61	55	59	0	59	116	116
	1962 - 65	54	52	73	53	0	32	65	65
	1966 - 69	66	66	77	52	0	27	54	54
	1970 - 73	103	103	126	88	0	44	87	87
	1974 - 77	86	86	93	67	0	41	82	82
	1978 - 81	59	59	92	67	0	41	82	82
	1982 - 85	98	98	117	79	0	41	82	82
	1986 - 89	84	84	94	65	0	41	82	82
	Average value	76	76	91	66	0	41	81	81

Table 4 Annual supply of nitrogen, phosphorus and potassium in four-year periods, kg/ha and year.

The supply of nutrients on the different crops was as seen in Table 5. The clover/grass ley was unfertilised in all variants. Summer wheat was fertilized only in the mineral fertilized variants and only with nitrogen fertilizer.

Nutrient	Crop	K1	K2	K3	K4		K5	K6	K7	K8
					Org	Min.				
N	ley	-	-	-	-	-	-	-	-	-
	wheat	-	-	-	-	25	-	23	46	94
	beets	192	192	228	74	50	-	46	93	187
	potatoes	128	128	152	50	50	-	46	93	187
P	ley	-	-	-	-	-	-	-	-	-
	wheat	-	-	-	-	-	-	-	-	-
	beets	91	91	77	28	29	-	43	58	58
	potatoes	61	61	51	19	19	-	29	86	86
K	ley	-	-	-	-	-	-	-	-	-
	wheat	-	-	-	-	-	-	-	-	-
	beets	182	182	218	79	79	-	98	195	195
	potatoes	122	122	146	53	53	-	66	129	129

Table 5 Average supply of N, P and K in kg/ha and year for different crops.

Liming

During the years 1982-85 the entire K-trial was limed. The aim was to achieve approx. the same pH-value as in the beginning of the trial, (i.e. 6,5). Since the pH-value had sunken in a much lesser degree in K1 and K2, the amount that was laid out in the different variants is seen in Table 6.

Variant	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
kg Ca/ha	587	587	1570	1570	1570	1570	1570	1570

Table 6 Amount total Ca in kg/ha supplied when liming during 1982-1985.

The biodynamic field preparations

The plots in K1 were treated with the biodynamic field preparations. Two different preparations were used; the humus-spray also called 500 and the silicium spray also called 501. The use of the sprays differed from crop to crop and from one year to the other. The humus-preparation was sprayed in the springtime, over all plots (including the clover/-grass ley) in connection to the sowing. Until 1964, all the plots in K1 were treated with the humus-spray also after harvest in October. Potatoes and beets were usually treated once more with the humus-spray in the end of May or in the beginning of June. The silicium preparation was sprayed on the clover/grass ley at the end of May or the beginning of June. The summer wheat was also treated with silicium spray 501 at this later date. All crops were also treated with silicium spray 501 in the midst of July. In certain years, all crops were treated in the end of July and on occasion in August, except summer wheat.

Measures and analyses

Soil

Soil investigations were performed, with a few exceptions, every fourth year. Extensive soil investigations were carried out in 1976, 1985 and 1989. In 1976 samples were taken from the plot grown with summer wheat with undersow (plot a) and from the plot grown with potatoes (plot c). In 1985 and 1989 samples were taken from all plots.

Year	1976		1985			1989		
soil depth, cm	0-10	25-35	0-10	25-35	50-60	0-10	25-35	50-60
soil density	x	x	x	x		x	x	
soil pore volume	x	x	x	x		x	x	
pH	x	x	x	x	x	x	x	x
carbon	x	x	x	x	x	x	x	x
nitrogen	x	x	x	x	x	x	x	x
phosphorus	x	x	x	x	x	x	x	x
potassium	x	x	x	x	x	x	x	x
magnesium	x	x	x	x	x	x	x	x
humification			x			x		
earthworms	x		x			x		
soil respiration	x		x			x		
dehydrogenase activity	x	x	x	x	x	x	x	x
urease activity	x	x	x	x	x	x	x	x
fulvo/humin acid ratio							x	

Table 7 Analyses in soil investigations performed in 1976, 1985 and 1989

Mineralization of nitrogen and preceding crop effect.

Studies on the N-mineralization were performed as a separate project in 1988, 1989 and 1990. Only the last two years will be presented in this report.

Beets

The beets were examined with reference to the root formation, sorting- and storage losses. Furthermore, studies were made on root-contents, such as dry matter content, crude protein, bio crystallization and extract decomposition, see Table 8.

Beets	Yr																																
	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	Nr
Yield traits																																	
yield beets	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	32
yield tops	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	32
root/neck width		x		x	x																												3
sorting		x	x	x		x																											4
Analyses																																	
crude protein									x																					x	x	x	4
extract dissolution										x	x																						2
d-m content	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	31
storage	x	x	x	x	x																												7
crystallization																x	x																2

Table 8 Summary of investigations and analyses made on beet crops 1958-1989.

Potatoes

During growth season the appearance of the stems were studied, as well as the presence of different parasites, e.g. late blight. After harvest the potatoes were sorted, and the total amount of losses was measured. Taste was examined directly after the harvest, as well as after the storage. Further, the potatoes were analysed in; crude protein, pure protein, starch, dry matter content, extract decomposition, crystallization value, free amino acids, quality indices, darkening of tissue and extract. Distribution of analyses during trial period is seen in Table 9.

Potatoes	Yr																																
	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	Nr
Botanical traits																																	
sprouts	x	x	x	x	x	x	x	x																									8
stems		x	x	x	x		x		x	x	x	x																					9
late blight			x	x	x	x	x	x		x		x										x	x					x	x	x	x		14
pathogen test									x	x	x	x																					4
Yield traits																																	
yield	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	32
sorting	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	31
Analyses																																	
crude protein	x	x	x	x	x	x	x	x	x	x	x	x	x															x		x		x	16
true protein				x	x	x	x																										4
darken.of tissue									x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
starch	x	x	x	x		x																											5
taste	x	x	x	x																													4
storage	x		x	x							x								x		x	x	x	x	x	x	x	x	x	x	x	x	17
d-m content	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	31
dissolution extract									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
crystallization									x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
daren. of extract										x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
free amino acids										x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
quality indice										x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22

Table 9 Summary of investigations and analyses in the potato crop during 1958-1989

Clover/grass ley

The clover/grass ley was examined with regard to hibernation and botanical composition. After harvest analyses were made on; crude protein and dry matter content. Distributions are shown in Table 10.

Ley	Yr																															
	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	Nr
Yield traits																																	
first yield		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	31
second yield			x	x	x	x	x	x							x	x	x	x	x	x	x	x	x	x	x	x	x		x	x	x	x	24
hibernation			x	x	x	x	x	x																									6
botanic analysis 1	x	x	x	x	x	x	x	x	x	x	x													x	x	x	x	x	x	x	x	x	17
botanic analysis 2					x																	x			x	x	x	x	x	x	x	x	10
d-m content																														x		x	2
crude protein																														x	x	x	3

Table 10 Summary of investigations and analyses in clover/grass ley crops during 1958-1989.

Summer wheat

Analyses were performed in summer wheat during the vegetation season concerning the length of straw and lodged stands. During a few years, analyses were made on leaf-width, earliness and health. In connection to harvest, the amount of yields in straw and kernel were established together with; hectolitre-weight, 1000-kernel-weight, kernel-size-distribution and dry matter content. The following analyses were made; wet gluten, dry gluten, crude protein, free amino acids, extract decomposition, crystallization values, falling number, and organic acids. Distributions are shown in Table 11.

	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	NR
Botanical traits																																	
sprouts	x	x	x	x		x	x	x	x															x	x	x	x	x	x	x	x	x	13
straw-length	x		x	x	x	x	x									x						x											6
lodged stands			x	x	x		x				x					x											x	x	x	x			10
elongation, ripeness					x	x																											2
Yield traits																																	
yield, kernel	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	32
yield, straw	x	x	x	x	x	x	x	x	x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	30
screening, sorting	x	x	x	x	x	x	x	x	x	x	x				x	x	x		x	x	x		x	x		x	x		x	x	x		24
Analyses																																	30
volumetric weight	x	x	x	x	x	x									x			x	x	x	x	x	x					x	x	x	x	x	18
1000-kernel weight	x	x			x	x															x	x	x	x			x	x	x	x	x	x	11
wet gluten									x	x	x													x	x	x	x	x	x	x	x	x	12
dry gluten																									x	x	x	x	x	x	x	x	8
d-m content	x								x						x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	19
crude protein									x																					x	x	x	4
free amino acids																x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	16
extract dissolution																x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
crystallization																												x	x	x	x	x	5
falling number																							x	x	x	x	x	x	x	x	x	x	10
dissolution 1																								x	x	x	x	x	x	x	x	x	8
organic acids																														x	x	x	3

Table 11 Summary of investigations and analyses in summer wheat crops 1958-1989

Climate

During the trial period several early summers drought did occur. The end of the trial-period was characterized, along with the mid 70´s, by mild winters with relatively poor precipitation (snowfall). In Fig.3 and 4 on the next pages, quarterly variations in precipitation and temperature are depicted. The values are reflected around the mean value in the corresponding quarter during the trial period.

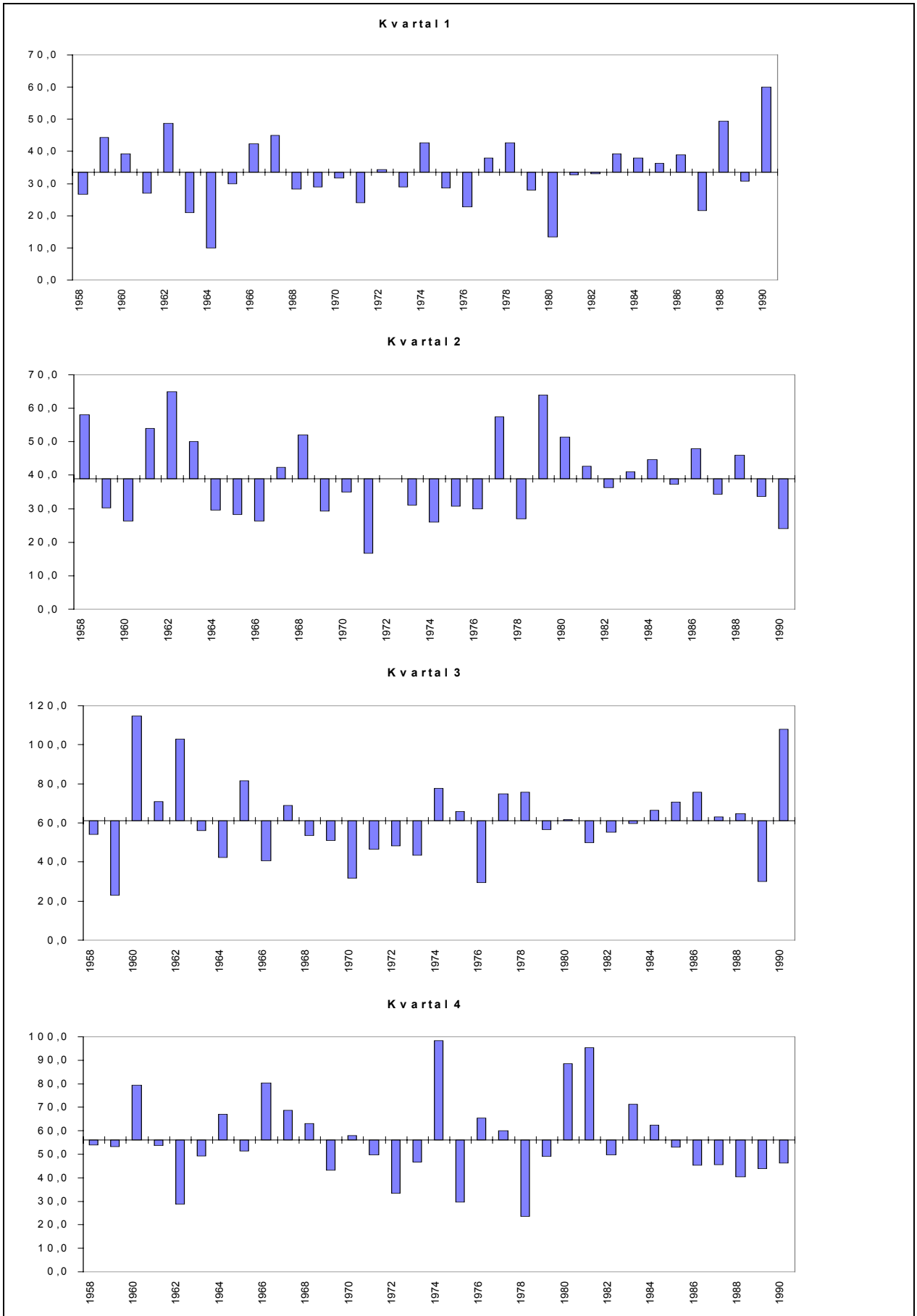


Fig. 3 Precipitation in mm, quarterly deviations from mean value

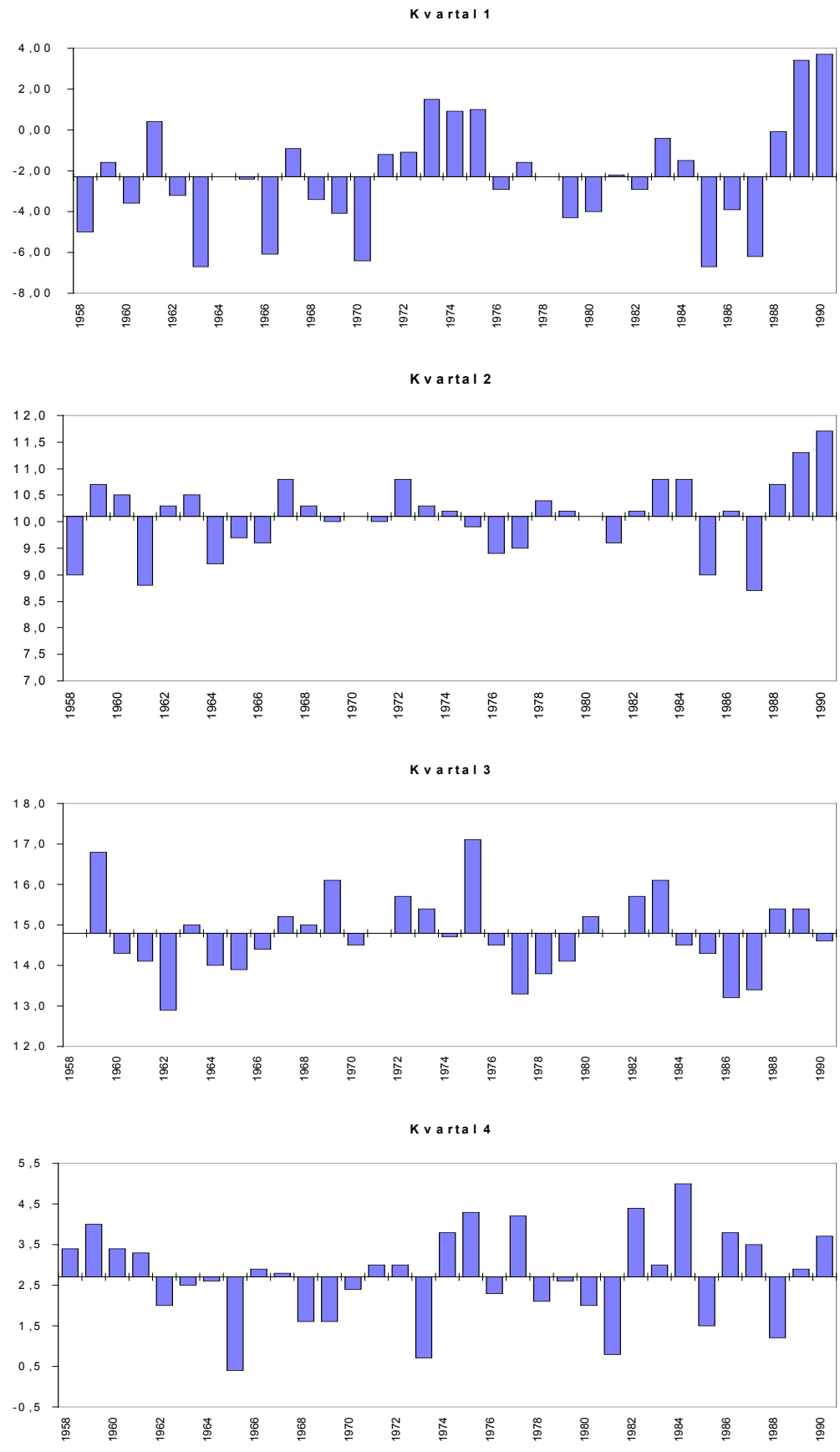


Fig. 4 Temperature °C, quarterly deviations from mean value

Results

The prerequisites at the start of the trial
The soil investigations that were made in 1958 show only small differences between the parts of the experimental field. The phosphorus numbers were slightly higher in the eastern part of the field, i.e. in variant K7 and K8. The potassium numbers was relatively equally distributed in the experimental-plant at the beginning of the trial. Layout of soil kernel size, see Table 12.

Variant	Clay	Silt	Moore	Sand
K1	28,2	62,2	8,0	1,8
K2	26,7	63,6	8,1	1,6
K3	27,2	61,9	9,4	1,5
K4	22,3	66,4	9,5	1,8
K5	30,4	61,5	6,7	1,4
K6	25,8	63,7	8,3	2,2
K7	32,7	59,5	6,0	1,8
K8	29,1	60,3	8,5	2,1

Table 12 Kernel-size-distribution in % at soil investigation 1958

A tendency to higher clay content in the southern variants (uneven variants) can be observed. The clay content also seems to slightly increase towards the east i.e. towards K7 and K8. K3 and K4 respectively, had the lowest clay content, amongst the uneven- and even numbered variants.

Initial differences should be obvious during the first years of trial. Above all, it should be distinctly pronounced in the clover/grass ley yield in 1959 as this crop, on the whole, was left unfertilised. The comparative yields during the first years of trial are seen in Table 13, which is arranged to clarify any possible gradients.

Variant.	Potatoes	Beets	Wheat	Ley	Rel	Variant	Potatoes	Beets	Wheat	Ley	Rel
K1	92,0	117,5	126,5	77,5	103,4	**K2**	109,6	107,9	107,0	96,5	105,2
K3	106,0	118,3	122,0	119,5	116,4	**K4**	112,9	102,8	95,0	136,1	111,7
K5	93,0	76,7	88,9	109,7	92,1	**K6**	108,6	92,1	84,4	111,4	99,1
K7	96,1	92,4	91,9	75,8	89,0	**K8**	81,8	92,4	84,4	73,5	83,0

Table 13 Relative amount of potatoes-, beets- and wheat-yield in 1958 and ley in 1959. Trial average in crops during crop year = 100.

The analysis in the first yield of the various crops, seems to indicate that the conditions were relatively comparable. Possibly they were slightly better in the middle and western parts of the trial field, i.e. in K1, K2, K3 and K4. Variant K8 K7 and K1 had remarkably low yield levels, especially in the ley crop. In 1959-1960 it seemed that K3 and K4 were poorly supported as well. K7 and K8 did not deviate in a negative sense this year from the rest of the variants, while K1 and K2 seemed to be poorly supported, at least in the wheat crop.

Variations between plots within one variant
If there is one continuous gradient in the field trial, then each plot in each variant, should arrange themselves in an ascending or descending scale according to a, b, c and d-plots as seen in Fig.1. Table 14 show the amount of yield at 1016 times of harvest. The numbers show the plots relative numbers compared to the trial average for each crop. As seen in Table 14, the b-plots deviated significant with lower yield from all the other plots.

Plot	Number yields	Relative yield mean = 100	Standard deviation	Standard error
a	256	105,9*	25,2	1,4
b	256	93,5	29,4	1,8
c	256	100,9*	35,4	2,2
d	248	102,7*	25,5	1,6

Table 14 The relative yields in different sub-plots,
*=significance compared to plot b.

The **c**-plots showed a slightly lower level in yields, as well. The highest level of yields was found in the plots at the borders i.e. **a** and **d**. An analysis with various measures in potatoes shows that the differences between the plots also applied to other parameters then just the yield alone. In summarizing all the variants, it is conclusively plot **a**, that had the highest indices value in potatoes. The difference compared to the other plots was significant. Free amino acids, darkening of extract and extract decomposition also displayed significant differences between the plots. Of all the variants, plot **a** showed better values than **b** and **c** plots in the middle. Plot **d** deviated in some cases significant compared to the middle-plots through having qualitative better values. The test results in dry matter content, crude protein content and crystallization, also showed that it was the border-plots that had better results in measures than the

middle-plots, even if differences not always were very significant. Furthermore, plot **d** showed significant greater number of large potatoes compared to plot **b**. The influence of the biodynamic sprays on the crop was most apparent in plot **c**, i.e. the plot with the second lowest yield. This applied to all crops, except clover/grass ley.

Variations between sow-rows within one plot.
During a couple of years, measures on potatoes were taken row-wise, which gives a simplified way of treating the question about the importance of the neighbouring crop-effect. These investigations also give complementary information on the issue of prospective of gradients in the trial field. The results showed a weak tendency to lower yields in the rows that was neighbouring the clover/grass ley crop. No length-wise gradient was evident within the plots.
In 1979 a more detailed investigation was made of the potato crop, at the time located with the clover/grass ley to the left and the grass border to the right. The potatoes from the rows nearest to the clover/grass ley had a tendency to have the highest stands and the highest amount of small potatoes. Furthermore, the infestation of late blight was highest nearest to the clover/grass ley, while surprisingly quality-indices were highest in these rows. The amount of first class potatoes after storage did not differ much between the rows. As the potato crop in 1979, was situated at the border of the plot, it cannot be ruled out that these measured values are the results of border-effects rather than negative effects of the clover/grass ley crop. The value of quality-indices seems for instance, to tend to be high in the rows cultivated at the border of the plot. However, it was generally observed during the trial period, that the potatoes growing nearest to the clover/grass ley more often than not, developed an inferior potato than in other parts of the same plot.

Variations between trial years.
Variations between separate years were usually greater than variations between different variants. This makes it very difficult to find statistically significant varieties between the different variants, even if all 32 years are used as a repetition. In Fig. 5 are seen variations between different variants and trial-years. The diagrams depict a 95% confidence- interval for separate years and in different crops.

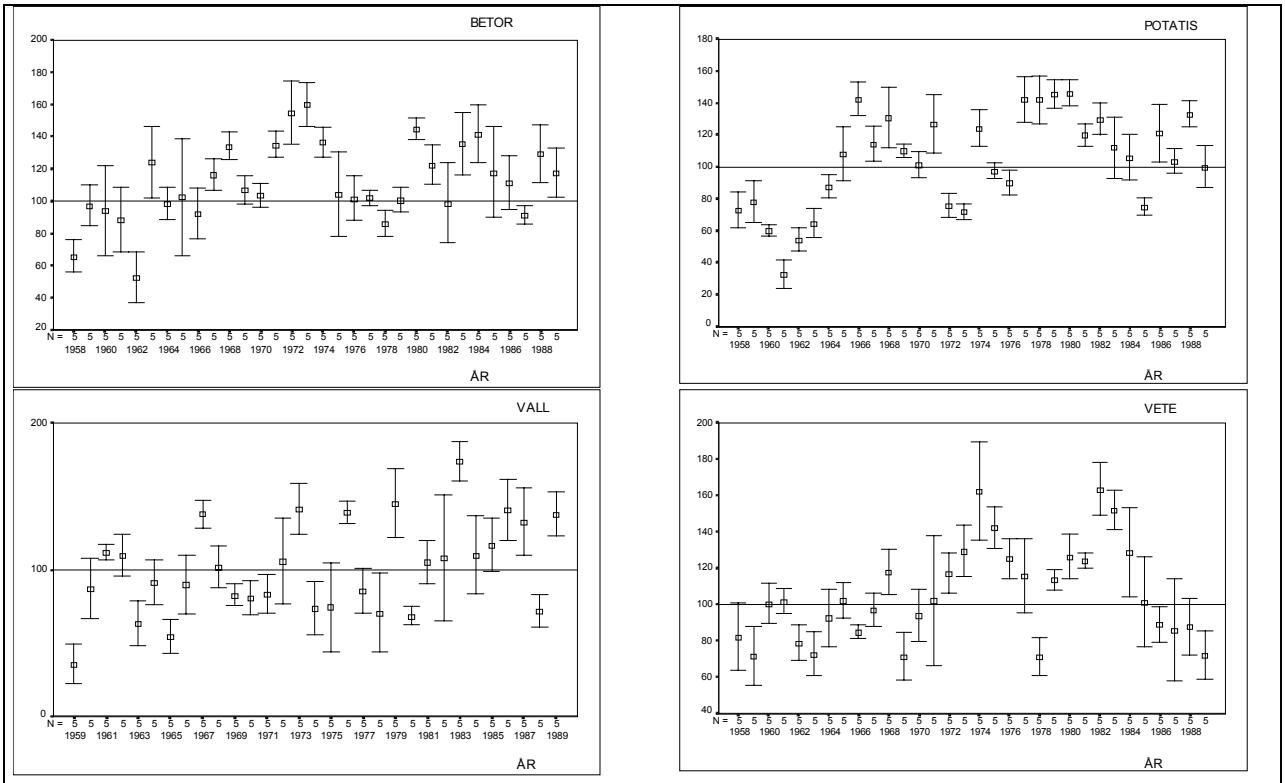


Fig. 5 Variations in yields between different trial years. Upper left beets, upper right potato, lower left lay and lower right summer wheat. Mean value of the entire experimental period = 100

It is because of the large variations between trial-years that the statistical processing has been based on the relative annual mean value. Fig. 6 shows the difference between the two ways of calculation.

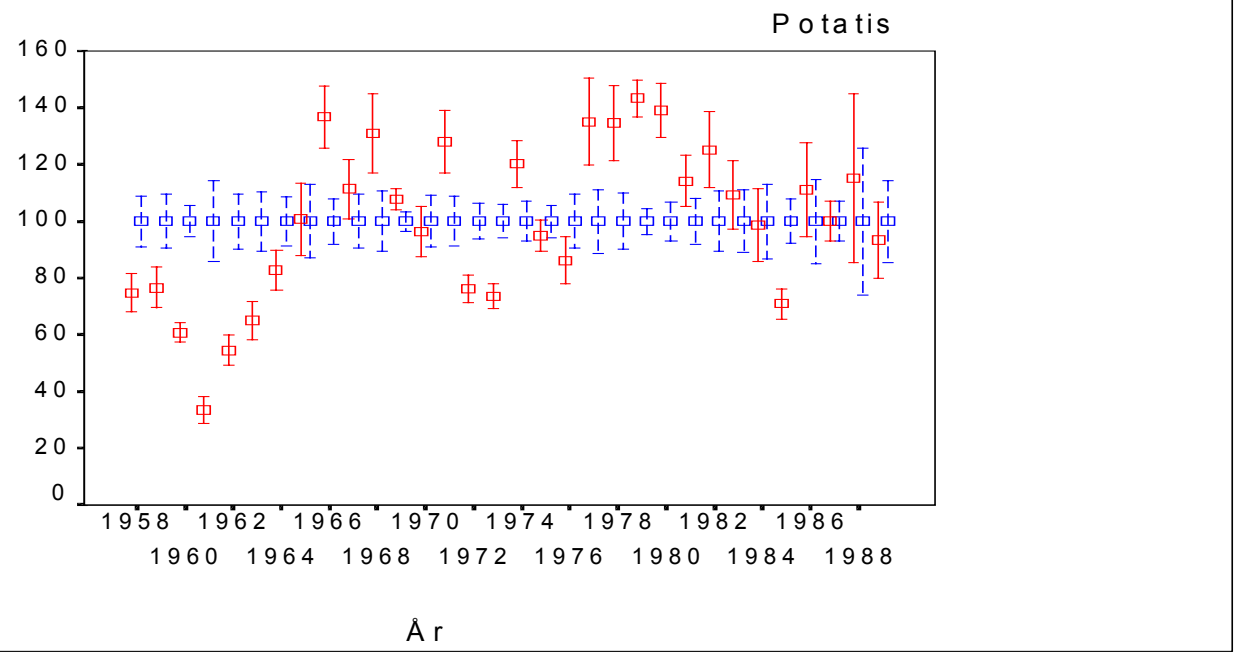


Fig. 6 Comparisons between different ways to display data. Whole, red, lines show the variation in relation to mean value for the entire trial period. Broken, blue, lines show the variation in relation to the annual mean value.

Soil

Three major soil investigations were performed in 1976, 1985 and 1989. In 1976 the samples were taken from the plot planted with summer wheat with undersow (plot **a**) and in the plot planted with potatoes (plot **c**). In 1985 and 1989 samples was taken from all the plots. The results from the soil surveys are published in:
Pettersson & v.Wistinghausen (1977), Pettersson, Brinton & v.Wistinghausen (1979) and Pettersson, Reents &. v.Wistinghausen (1992)

Soil surveying

Soil surveying was performed annually in the beginning and later, at least every fourth year. Plant nutrient contents in the soil were evenly spread in the experimental field. It is depicted in Fig. 7 that the pH–value, at start approx. 6,5, had sunken in the entire trial at the end of the 60´s up until the time of the liming in 1982-1985. The change was largest in the unfertilised and the mineral fertilized variants. The compost fertilized variants were the least affected in pH-change. Minimum change was in K1. After the liming some differences remained between the variants concerning the pH-value. This was despite the fact that K1 and K2 received only half the amount of calcium nitrate-rate compared to the rest of the variants.

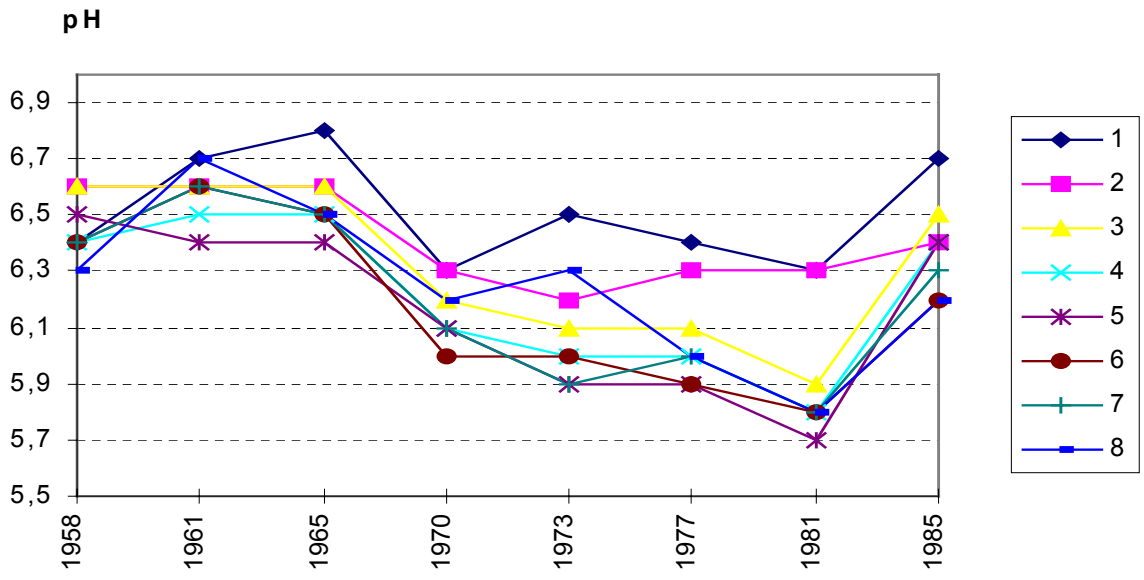


Fig. 7 Changes in pH-value 1958-1985.

The phosphorus values increased in all variants, except in K5 and K6. The phosphorus numbers was from the beginning slightly higher here, in the eastern part of the trial field, i.e. in variants K7 and K8. As of 1970 the increased fertilizer rate in the organic fertilized variants became evident. Above all did K1 and K2 show high phosphorus numbers. In the unfertilised variant K5 the phosphorus number was stabilized early on, around a value between 1,5 - 2 mg P / 100g soil. The results are shown in Fig. 8.

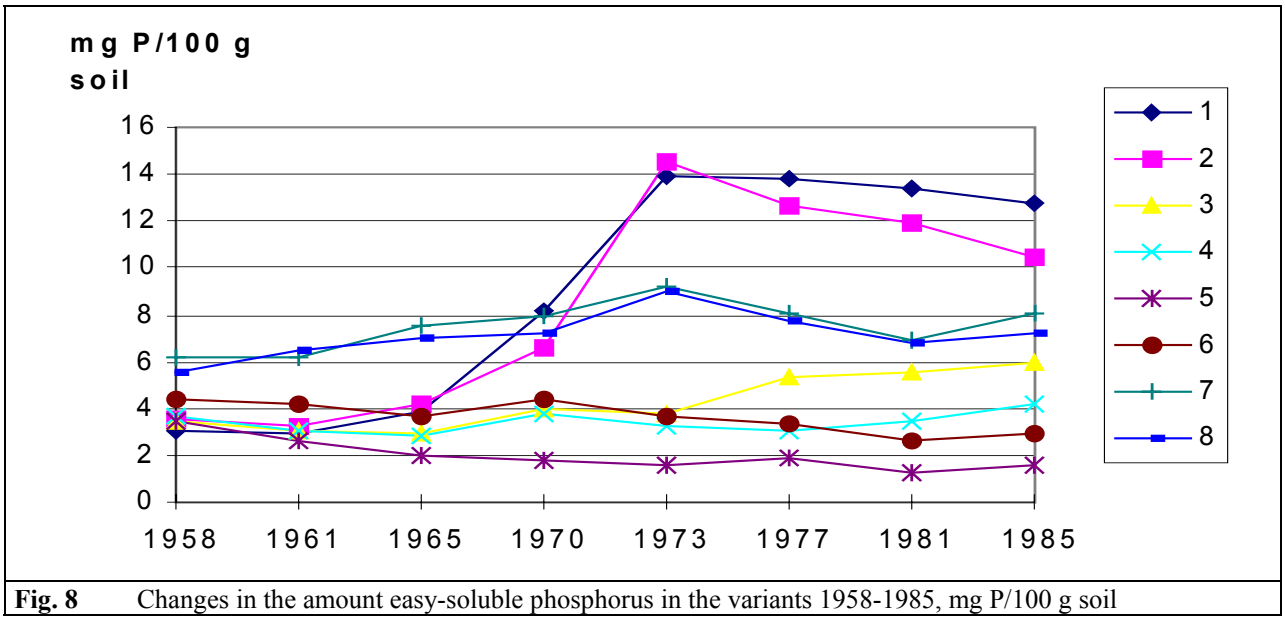


Fig. 8 Changes in the amount easy-soluble phosphorus in the variants 1958-1985, mg P/100 g soil

The potassium values did not significantly differ between the variants as seen in Fig. 9. Here it was mainly K3 and K7 that had slightly higher values than the rest. K8 showed in the later part of the trial a continuous decrease in potassium numbers, compared to K7 that received the same potassium fertilization. K5 did not deviate in any significant way in potassium numbers from the rest of the variants. The variation between years ware prominent especially in the beginning of the trial period.

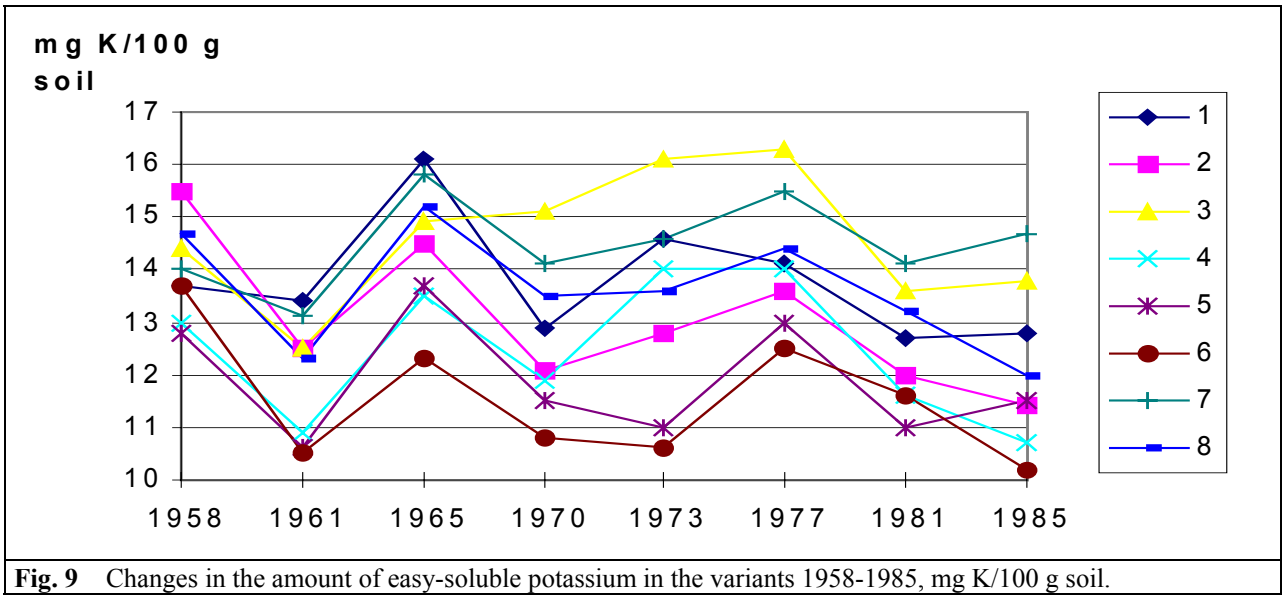


Fig. 9 Changes in the amount of easy-soluble potassium in the variants 1958-1985, mg K/100 g soil.

Soil physical investigations

Measures in the topsoil 1976, 1985 and 1989, concerning soil density, pore volume and water capacity showed only small or no distinct differences between the variants. The differences were slightly larger in the sub soil. Here the organic fertilized variants showed a larger pore volume. Especially the amount of air pores was higher in these variants.

Soil chemical investigations

Carbon content

Was performed through titration after wet oxidation (the Lichterfelder method modified according to Richter). The carbon content roughly points to the amount of organic matter in the soil. Carbon is essential to the soil structure.

The C-content increased slightly in most of the variants. In 1976, did K1, K3 and K8 show the highest amount of carbon in the topsoil. K2, K4 and K7 had the lowest amounts. In 1985 this difference had disappeared. Instead did the organic manure fertilized variants, i.e. K1, K2, K3 and K4 display a distinctly higher value than the rest of the variants. This formation remained in 1989 even if K2 showed slightly lower values at this time.

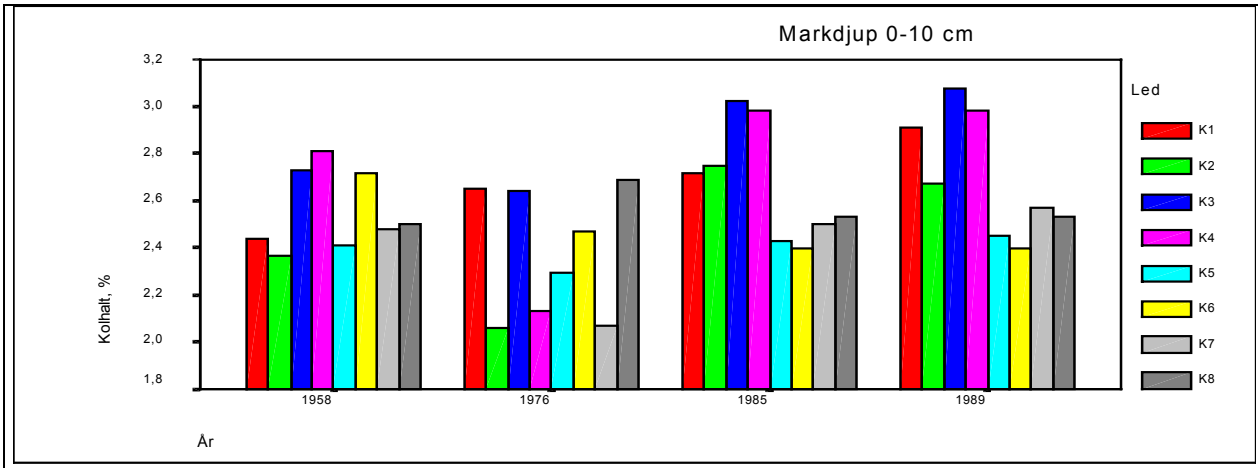


Fig. 10 Amount of carbon, in %, at 0-10 cm soil depth measured in 1958, 1976, 1985 and 1989

At 25-35 cm soil depth, i.e. just under plough depth, the differences were larger between the variants. The values do differ in such a way that this could be the result of error in measuring. In 1976 did K1 evidently have the highest C-content followed by K3 and K5. The variants that received mineral fertilizers, i.e. K4, K6, K7 and K8 displayed lower C-contents. K2 deviated to some extent, with slightly lower C-contents as well. In 1985 had K4 the highest C-contents followed by K3, K1, K8 and K2. This year K7 deviated with a lower C-content in the soil. It is this increase in C-contents in K4, that points to some error in measures at the time of the test in 1976. In 1989 it was K2 that deviated with a lower C-content in the soil. With the exception of K2 and K4, the C-contents just under plough depth, increased in a remarkable way during this 4-year period. K1 and K8 had the highest C-contents this particular year, while the rest except K2, was relatively low in C-contents.

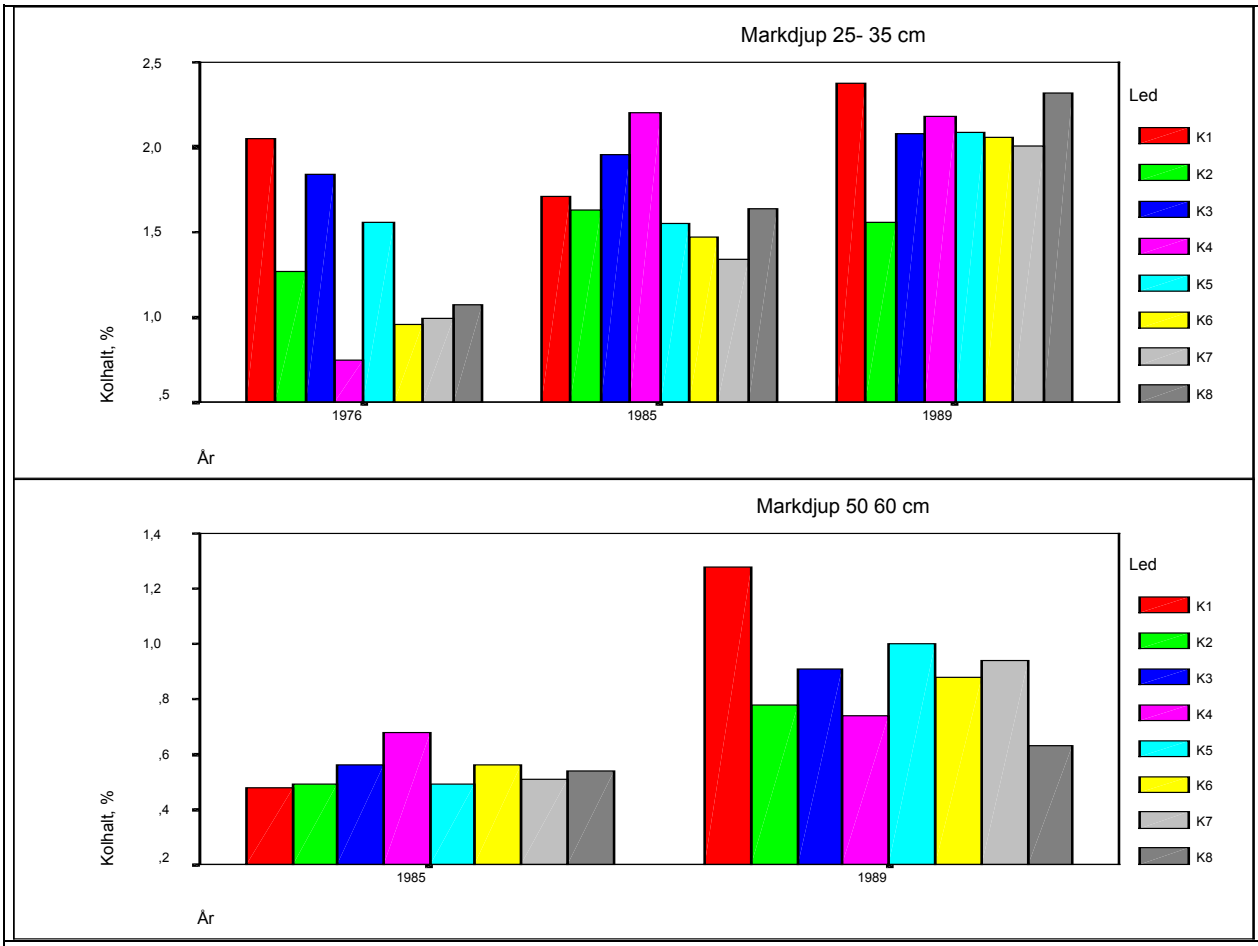


Fig. 11 Amount of carbon in %, upper at 25-35 cm depth measured in 1976, 1985 and 1989 and lower in soil depth at 50- 60 cm measured in 1985 and 1989

In the soil depth at 50-60 cm measures was taken only in 1985 and 1989. Here as well did the C-contents increase, mainly in K1. In 1985 all the variants was relatively equal in C-contents, with the exception of K4 that showed the highest values. In 1989 K1 deviated with obvious higher C-contents. K5, K7, K6 and K3 formed a middle group, while K2, K4 and K8 had the lowest C-contents.

Nitrogen content

The analyses were performed according to the Kjeldahl method, which measures the total amount of nitrogen. In the topsoil the N-content was relatively homogeneous between variants and between the different dates of measure. In 1976 the mineral fertilized variants K7 and K8 showed higher N-contents in the topsoil. Possibly this is due to the fact, that the measures this year was only taken in the plots planted with potatoes and summer wheat with undersow. In 1985 and 1989 when the tests were performed in all the plots it was mainly K3 and K4 that showed slightly higher N-contents in the topsoil.

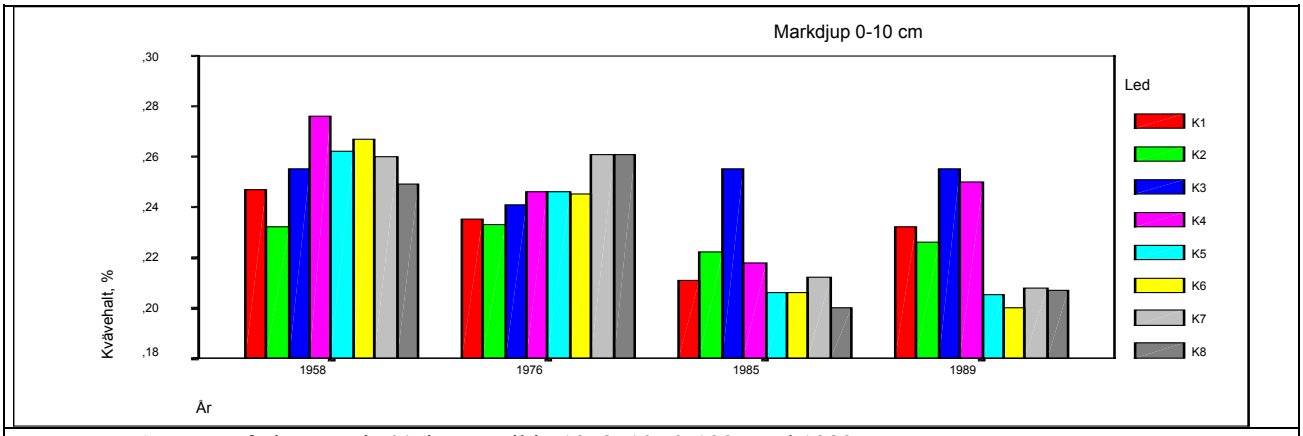


Fig. 12 Amount of nitrogen, in %, in topsoil in 1958, 1976, 1985 and 1989

In the layers just under the depth-depth, the measures differed slightly. If we presume that the low N-value in 1976 in K4, in conformity with the C-values, originated from error in measures, the picture becomes more homogeneous. In 1976 and 1985 the mineral fertilised variants showed a slightly lower N-content. This tendency was also present in 1989 but K8 deviated with high N-contents. In 1985 and 1989 did K2 show noticeable lower N-content. In the soil depth at 50-60 cm, the N-contents increased distinctly between 1985 and 1989, especially in K1 but also in K3, K5, K6 and K7.

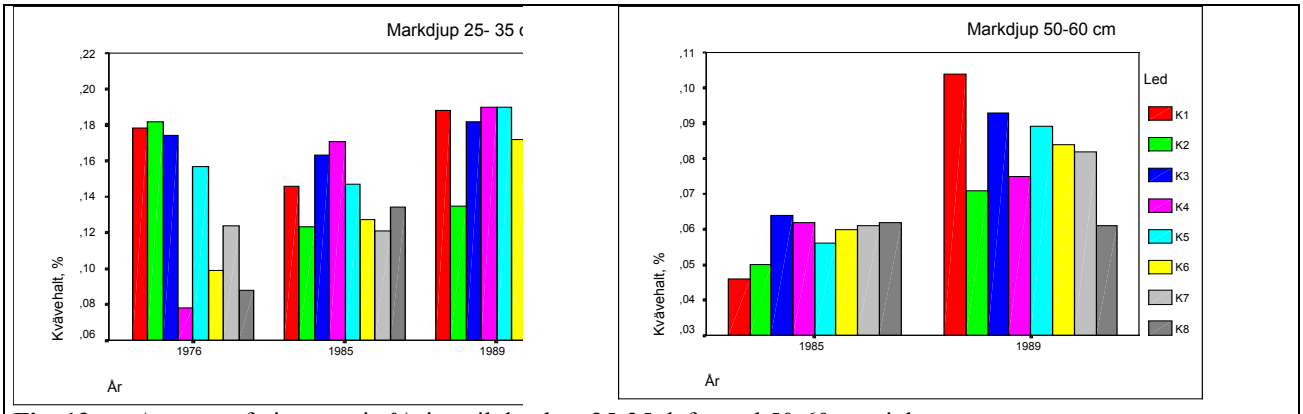


Fig. 13 Amount of nitrogen, in %, in soil depth at 25-35, left, and 50-60 cm right

Carbon-Nitrogen ratio

C-N ratio is determined through dividing the C-contents with the N-contents. The differences were equalized between the variants in the end of the trial. K1, K4 and to some extent K3 showed a tendency to be on the high side. As for K4 the reservation still applies for errors when measuring the C-contents in the soil, as mentioned earlier. Annual variations however, are more evident here, than the variations between variants. K2 was surprisingly low in N-contents in 1976. In the deeper layers of the soil, the C-N ratio had a tendency to be low in the mineral fertilized variants se also Table 15.

		Variant							
Soil depth	**Year**	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
0-10 cm	1958	9,9	10,,2	10,7	10,2	9,2	10,2	9,5	10,0
	1976	11,3	8,9	10,9	8,7	9,3	10,1	11,8	10,3
	1985	12,9	12,4	11,8	13,7	11,8	11,7	11,8	12,7
	1989	12,5	11,9	12,1	11,9	11,9	12,0	12,4	12,2
25-35 cm	1976	11,5	7,0	10,6	9,6	9,9	9,7	8,0	12,2
	1985	11,7	13,3	12,0	12,9	10,5	11,6	11,1	12,2
	1989	12,7	11,6	11,4	11,9	11,9	12,0	11,1	11,7
50-60 cm	1985	10,4	9,8	8,8	11,0	8,8	9,3	8,4	8,7
	1989	12,3	11,0	9,8	9,9	11,2	10,5	11,5	10,3
Table 15	C-N ratio at different soil depth								

Properties of humus
Analyses in 1985 and 1989 determined the humification degree and the fulvic/humic acid ratio, which only rendered minor differences between the variants.

pH
In 1976 and 1985 the pH was determined in 1 mol KCl , and in 1989 in 0,01 mol $CaCl_2$ Between 1976 and 1985 the soil was limed, which resulted in a more equal level of the pH-values. The tendency was that K1 had the highest pH-values in all layers of the soil depth. The mineral fertilized variants K7 and K8 showed low values in the topsoil and surprisingly high values in the deepest layer. Values are seen in Table 16.

		Variant							
Soil depth	**Year**	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
25-35 cm	1976	5,5	5,3	5,2	5,3	5,2	5,4	5,4	5,4
	1985	5,5	5,2	5,1	5,0	5,2	5,2	5,4	5,2
	1989	5,7	5,3	5,5	5,1	5,3	5,3	5,4	5,2
50-60 cm	1985	5,7	5,5	5,5	5,5	5,6	5,5	5,8	5,7
	1989	5,8	5,5	5,6	5,6	5,5	5,4	5,7	5,7
Table 16	Variations in pH-value in different layers in the sub-soil.								

Phosphorus content, P_2O_5
In 1976 and 1985 the P-content was determined in a double-lactate solution, in 1989 in a Calcium-acetate-saturated solution. The P-content in the topsoil was highest in the mineral fertilized variants. The unfertilised variant, had a very low value of easy soluble P. Inter-resting to point out, was the relative high values in K1 in the soil, just under the plough pan in 1976 as well as in 1989.

		Variant							
Soil depth	**Year**	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
25-35 cm	1976	9	6	7	4	5	4	5	3
	1985	3	3	3	3	1	1	2	5
	1989	6	4	4	3	2	4	6	9
Table 17	Amount of phosphorus, P_2O_5 just under plough depth,								

Potassium content, K_2O :
In 1976 and 1985 the amount of potassium was determined in a double-lactate solution, in 1989 in a Calcium-acetate-saturated solution. In 1976 and 1985 the topsoil in K3 measured the highest K-contents, in 1989 they were in K1. Variants K5 and K6 was throughout the lowest in value. The differences were not as obvious under plough depth. K3 had high values together with K7 and K8. In the 50-60 cm level did K2 display low values. K7 was highest in 1985. In 1989 did K1 have the highest values.

Magnesium content, Mg:
In 1976 and 1985 the Mg-content was determined in a double-lactate solution, in 1989 in a Calcium-acetate-saturated solution. The contents of available Mg in the topsoil were highest in K5 and lowest in K4 and K8. All other variants was equally unified somewhere in between. The organic fertilized variants had in 1985 a tendency to have lower Mg-values, especially in the deeper layers of the soil.

Investigations of the biological properties of the soil
Results from different analyses are seen in Table 18, next page.

Earthworm channels
On an area 4 * 900 cm^2 /plot, the amount of earthworm channels at 3 - 4 cm depth were counted. In 1976 the channels ware counted at a depth of approx. 10 cm. The amount of earthworm channels was throughout lowest in the two variants that received the highest rates of mineral fertilizer i.e. K7 and K8. The other two mineral fertilized variants were on average low, compared to the organic fertilized and the unfertilised variants. The order amongst these variants varied slightly between different years. K3 had the highest values in 1976 and 1989, while K1 was the highest in 1985.

Soil respiration
The amount CO_2 contained in soil samples was determined through titration of the un-consumed air with HCL, with consideration taken to placebo-tests. Soil respiration is a measure of the biological metabolism in the soil. The build-up of carbon dioxide is the result of decomposition in organic matter. The gaseous exchange of CO_2 tends to be high in organic fertilized variants. Especially K3 showed high values. Intensification in mineral fertilizer rate seemed to lower the exchange of CO_2. If calculating CO_2 exchange per percentage C in the soil, the differences are slightly equalized.

Dehydrogenase activity
The dehydrogenase activity was determined through titration according to the Thalmann method. High values indicate high biological metabolism in the soil. Measured numbers of dehydrogenase activity were increased between the three different occasions of analyses. Between the three organic fertilized variants the differences in the topsoil were small.
In K5, K6, K7 and K8 it was measured approx. 60% of the dehydrogenase activity in K1, K2 and K3. In the subsoil K1 distinctly deviated from the rest of the variants through a high dehydrogenase activity. Once again did K1 and K2 deviate from each other in the deeper layers of the soil.

Urease activity
The activity in the urease enzyme was determined according to the Hofmann method. The urease enzyme breaks down the urea. The enzyme is not strictly bound to living organisms but can also occur freely in the soil solution. At three different occasions of analyses, the average urease activity in the topsoil was apparently highest in K3 and lowest in the mineral fertilized variants. The rest of the variants formed a middle group. Concerning the deeper layers of the soil, such surveys were performed in 1989. Here K1 deviated with noticeable higher values than the rest of the variants.

Analyses	Depth\Variant	K1	K2	K3	K4	K5	K6	K7	K8
Earthworms	0-10 cm	319	296	327	246	263	209	105	110
Urease	0-10 cm	19,9	20,6	27,4	23,4	18,6	17,4	15,5	14,0
	25-35 cm	13,6	11,2	16,6	11,7	14,4	9,0	9,5	8,8
	50-60 cm	6,3	4,7	4,8	3,9	5,3	5,4	4,3	3,7
Soil respiration	0-10 cm	134,7	122,0	135,3	117,3	110,7	111,0	107,7	105,7
Dehydrogenase	0-10 cm	1025,5	797,0	894,0	770,5	626,5	502,0	537,5	480,0
	25-35 cm	466,5	219,5	346,0	293,5	268,5	246,0	286,0	245,5
	50-60 cm	214	20	72	55	76	22	68	0

Table 18 Mean value for some analyses made in the soil biological activity

If summoning the various measurements of the soil biological activity to a relative value, the picture shown in Fig. 14 emerges. K1 and K3 are the highest in all three soil layers, while K2 show surprisingly low values, especially in the deepest layer. The unfertilised variant has throughout relatively high values, especially in the deeper layers. In these layers there is no distinct difference compared to the mineral fertilized variants.

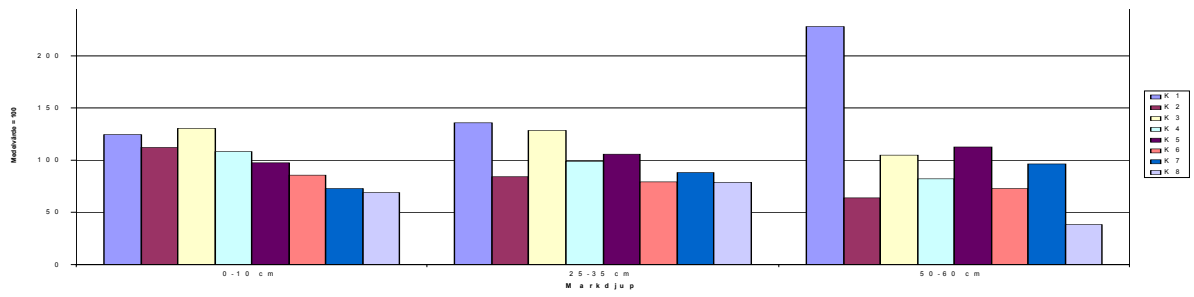


Fig. 14 Relative values when summoning different measures in soil biological activity.
Mean value at each soil layer = 100

Potatoes

Yield
The highest amount of potato tuber yields were in K7 followed by K4, K1, K8, K2, K3 and K6. These deviated significant from K5 with the lowest yield.

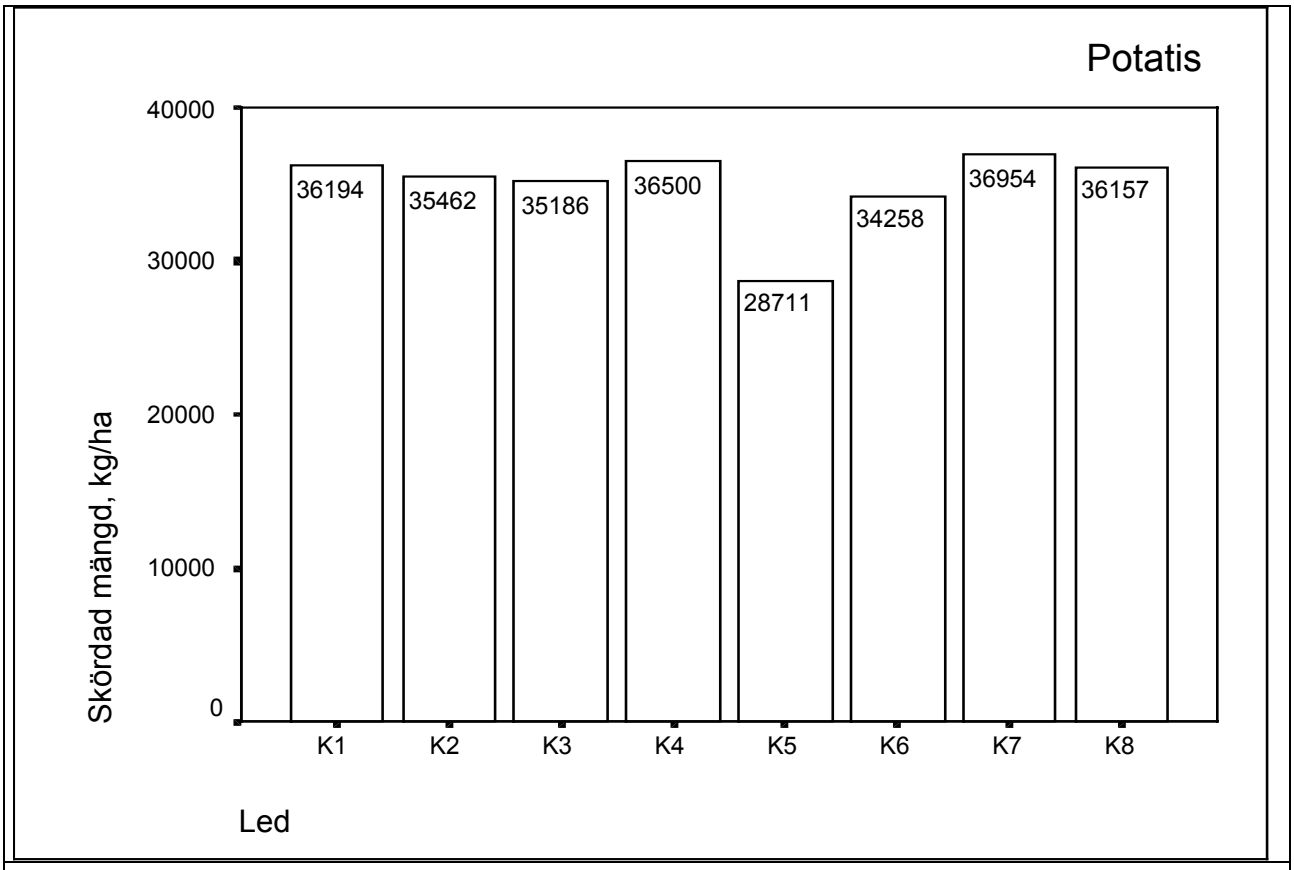


Fig. 15 Average yield of potatoes in the variants 1958 - 1989, kg/ha

The potato yields varied the most in the mineral fertilized variants, i.e. K7 and K8. The compost fertilized variants showed a greater variation than K3. K4 and K7 gave significant higher yields than K6

Properties of potatoes

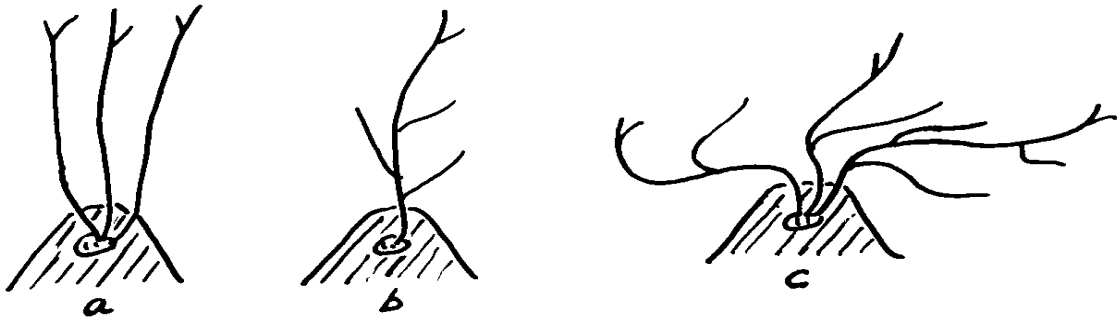
Late blight
The infestation of late blight in potatoes was graded as follows, The total infestation on a plant was given the value 10, the same as on total infestation on the whole row. The two measures on the force of attack were then multiplied with the total number of rows. Maximum value for the attacks were thereby 600 but already at 400 was the haulm chopped in the potato plants to prevent infestation to spread any further. Infestation of late blight occurred at several times in the potato crop. An average of 60 grading showed that the infestation was lowest in the unfertilised variant i.e. K5 as well as in K1. The compost fertilized variants deviated significant from all the other fertilized variants. Interesting here was, that the variants with raw manure, i.e. K3 and K4, showed just as much infestation of late blight as the mineral fertilized variants.

K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
94	111	167	173	96	150	152	182

Table 19 Mean values for the size of late blight infestation.
Relative values; 100 = mean value of infestation at the date of analysis

Amount of erect and horizontal stems
During nine years, morphological studies were done on the potato haulm. The way of growth in the different variants was judged according to the number of erect and horizontal stems per potato habitat. The method is described in *Pettersson (1970).*

The number of erect stems per habitat was distinctly higher in the organic fertilized variants K1, K2 and K3. The highest of all, were the compost-fertilized variants. The lowest number erect stems were found in K6 followed by K5, K8 and K4. It was interesting that K7 differed from K6 and K8 with a higher number of erect stems. The number of horizontal stems was distinctly higher in K8 followed by the rest of the mineral fertilized variants. K1 deviated from the rest, with a strikingly low number of horizontal stems. Also K5 had a low number of horizontal stems. These differences were also reflected in the way the potato-haulm was growing. In the plants with a low number of horizontal stems, the plant tops had a noticeable vertical habit of growth, whereas in the case of a high number, growth habit were more substantially horizontally orientated with the tops lying partially over.



Picture 1. Different types of potato stand; left vertical, right horizontal type

Sorting and Storage
The amount of losses when sorting in the autumn was high in K7 and K8. The rest of the variants did not differ very much from each other. K8 had the highest amount of large potatoes, while K4 had the highest amount of medium large potatoes. The smallest potatoes were found in K5. Between the other variants no noticeable difference were seen. The largest amount of losses after 6 to 7 months of storage was found in K8, K7 and K4, while the rest of the variants differed very little. K8 deviated significant from K1, K2, K3, K5 and K6 with higher losses.

Taste
Taste examinations have been performed by the Swedish Seed Control Station according to standardized regulations. Taste samples have been judged by following criteria:

- Potato flavour (5-point scale)
- Bitter flavour (5-point scale)
- Earthly flavour (5-point scale)

The studies included samples on newly yielded potatoes, autumn-values, as well as stored potatoes, spring-values. Testing the taste of the potatoes was performed 11 times, mainly during the 60´s. The results are shown in Fig. 16

Potato taste: The strongest potato flavour was in K1 and K8, directly after the autumn yield. The weakest flavour was in K4. In the springtime after storage, K8 had the most inferior potato flavour, while K1 kept the original flavour as it was in the autumn.

Bitter taste: K5 and K2 had the weakest flavour of bitter taste at the autumn test. The strongest taste of bitter was in K6 followed by K4, K3 and K8. In the spring K2 kept the low values while K5 was the variant that had the strongest bitter flavour, this time together with K6 and K8.

Earthly taste: In the autumn the mineral fertilized variants had the strongest earthly flavour. The lowest values were in K5. In the spring it was K4 and K8 that had the highest values of earthly flavour, while K1 and K5 had the lowest.

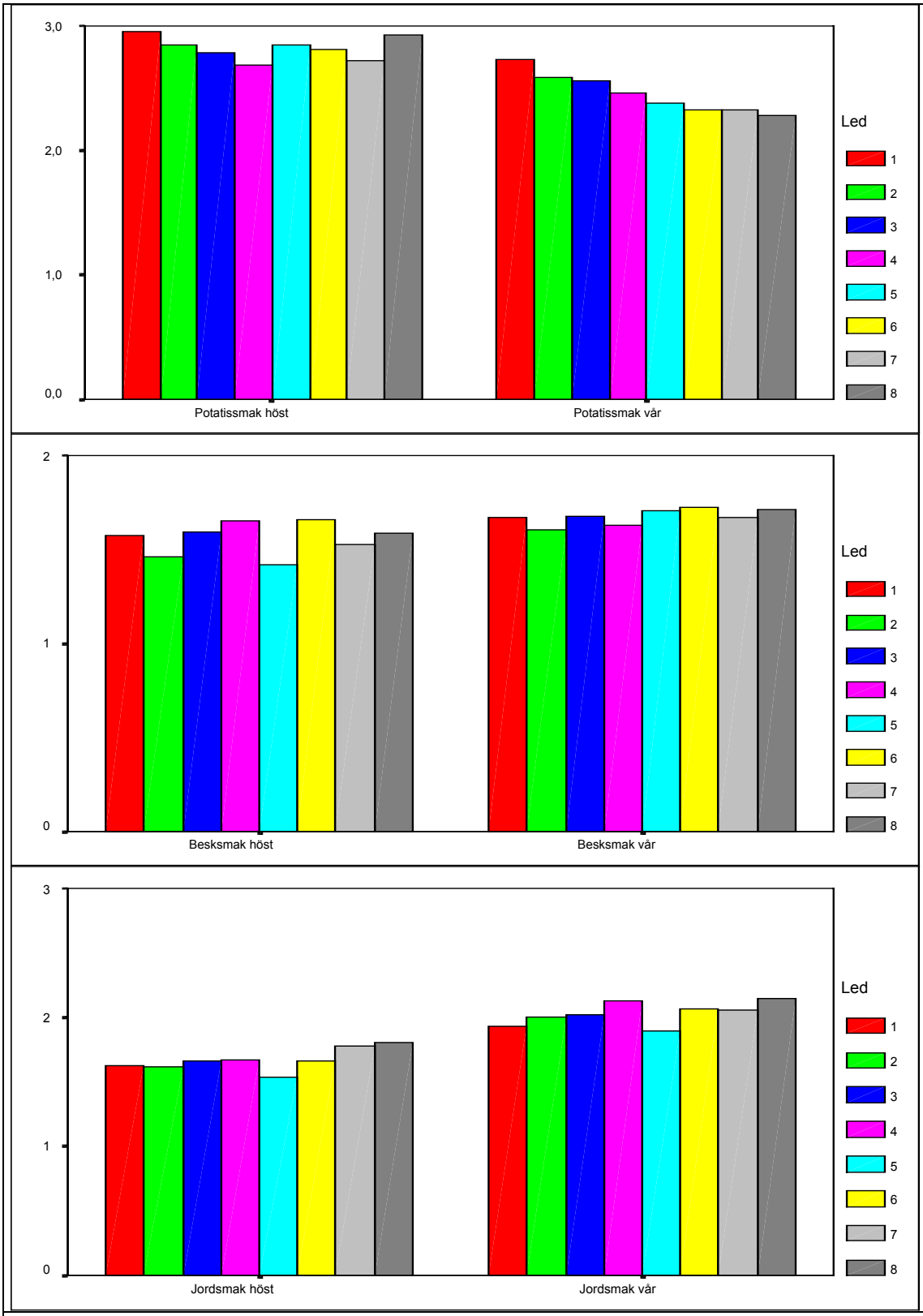


Fig. 16 Test results in potato flavours directly after yield, left, and in springtime after storage, right. Top= potato flavour-, middle= bitter flavour, bottom= earthly flavour.

Dry matter content
The results showed the following order between the variants beginning with the variants with the highest amount of dry matter; K5, K6, K1, K2, K3, K4, K7 and K8. K5 deviated by significantly higher values than the rest of the variants. K8 showed a significant lower dry matter content than the rest and in K7 the dry matter content was distinctly lower than K1, K2, K5 and K6. Variant K3 had significantly lower value compared to K6.

Crude protein
The total N-content was determined by the Kjeldahl-method. The crude protein content was calculated according to standard values. The amount of crude protein sank during the period 1958-1970 when analyses were performed. K8 deviated significant from all the other variants by higher values. The order among the rest was; K7, K6, K4, K5, K2, K3 and K1. K4, K6 and K7 displayed significantly higher values than K1, K2, K3, and K5. The mineral fertilized variants differed distinctly from the organic fertilized and above all from K1. The crude protein content in K1 was even lower than in the unfertilised variant K5.

Amount of pure protein
The amount of pure protein was determined in relation to the amount of crude protein. The values are given here in % of the total amount crude protein. High values are favourable. The highest values were found in the compost-fertilized variants, with K2 as the highest of all. K8 deviated with lower values. Between the others, no great difference was noticeable.

Variant	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
Crude protein	7,07	7,51	7,30	8,12	7,50	8,26	8,65	10,39
True protein	59,1	61,42	57,56	56,54	57,38	56,60	57,74	53,54

Table 20 Values of crude protein and amount of pure protein in % of the total amount crude protein.

Free amino acids
The amount of free amino acids has been determined with fine-grinded plant matter in a water-extract. The Sörensens formal-method with titration to pH 8,5 has been used. The method shows the amount of the amino acids that are not attached to the protein. Low values are favourable. The order between the variants were; K8, K4, K7, K3, K2, K1, K6 and K5. Variant K8 deviated distinctly from the others by significant higher values and K5 by significant lower values. Also K4 differed significant from K6.

Darkening of extract
Determination was done with fine-grinded plant matter in a water-extract. Measuring the darkening has been done photometrical at 530mm and with aq.dest. as a control reference. First measure was taken 2-4 hours after the start of the extract produce and repeated on a daily basis for 3 days. The method reflects the enzymatical decomposition of the potato extract. Low values are favourable. The decrease in falling order was; K8, K4, K6, K7, K3, K5, K1 and K2. The compost-fertilized variants differed together with K5 from the mineral fertilized by lower values. K8 deviated from the rest by significant higher values. Variant K4, K6 and K7 were significant higher than K1 and K2.

Extract decomposition
Determination was made in a water-extract of potato tissue 1:10. After the produce, the electrical conductance in the extract at 20°C was measured. The extract was then kept in this temperature and measured on a daily basis in the same way, until the conductance no longer changes. The method reflects first, the speed in the enzymatical and then the bacterial decomposition of the extract. Low values are favourable. K8 deviated significant from the rest by higher values. The order among the rest was; K4, K7, K6, K1, K2, K5 and K3. Variant K4 showed significant higher values than K3.

Darkening of tissue
The analysis is determined on plane-cut slices of tubers, 15 mm thick. The measures have been made by reflectance in a photo spectrometer with $MgCO_3$-block as a reference. A freshly sliced area from the same tuber serves as comparison. A low degree of darkening is favourable. K8 displayed the highest values followed by K7, K6, K4, K5, K3, K2 and K1. K8 deviated significantly from K1, K2, K3, K4, K5 and K6 by higher values and K1 deviated from all variants except K2 by lower values. Variants K7 and K6 showed significantly higher values than K2 and K3. K7 was significant higher than K5.

Pathogen test
This is a method to test the resistance against late blight, *Phytophthora infestans,* in potato-tissue. After piercing the potato-peel, the tubers are inoculated with a spore suspension of the fungi *Phytophthora infestans*. The tubers are then kept approx. 14 days at 18°C, and then they are sliced with two cuts, at a right angle to each other, through the middle of the inoculated site. Mean area from both cuts was used as a measure on the spread of infestation. Low values indicate high resistance toward fungi infestation. During the years 1966–1969, when this investigation was performed, did K1 show the strongest resistance to fungi infestation. K4 had the largest infestation degree, followed by the rest of mineral fertilized variants.

Crystallization analyses:
The method is performed by letting an organic extract influence the crystallization of copper chloride on a glass plate. For further information on method see *Pettersson (1970)* and *Engqvist (1970)*. Low values are interpreted as a good crystallized picture and are favourable. The order among the variants is as follows; starting with the highest values; K8, K7, K5, K6, K3, K4, K1 and K2. Variant K1 and K2 deviated significant from the rest, with less error units in the crystallized picture. K8 showed significant more disturbances in the picture than all other variants, except K7.

Quality-indices
Quality-indices, according to Pettersson, is an integrated value of the results from the following separate analyses with the ratio-value in parenthesis.

Free amino acids, N, mg/100 g dm (dry matter)	(275)
Darkening of extract, E48 *103	(500)
Extract decomposition, Rd/Ro	(25)

The obtained value from a separate method is expressed in % of the equivalent ratio-value. The three % -values are added and the sum is divided by 3. This mean value is ”inverted” arithmetically around the value 100. The obtained value is described as the quality indices. High values for the three mentioned properties will be equivalent to a low value on quality-indices and vice versa. High values-values are positive traits.
K5 showed the highest indices value followed by K1, K3, K2, K6, K7, K4 and K8. K8 deviated significant from the rest by low values and K5 by significant higher values.

A summary of the measured values from the variants are given in Table 21 and Fig. 17

	Variants							
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
Free amino acids mg/100 g dm	282,5	288,5	290,3	296,3	250,5	278,7	291,5	355,3
Darkening of extract, E 48	317,3	313,7	329,3	354,9	316,1	351,5	345,9	400,0
Extract decomposition Rd/Ro	31,9	32,0	30,6	32,8	31,4	32,1	32,4	40,1
Darkening of tissue, rD	24,9	26,2	26,8	27,6	26,7	28,3	28,9	29,9
Pathogen test, mm	377,8	406,0	419,3	504,8	445,3	454,0	459,5	460,0
Quality-indices	100,4	98,9	99,8	94,9	105,5	97,8	96,8	75,8
Crystallization value, error-units	7,3	7,2	7,6	7,6	7,7	7,6	8,0	8,3

Table 21 Values of measures from various analyses in potatoes

If one summarizes all the measures, the quality indices not included, from Table 21 to one value, then emerges the picture that is seen in Fig. 17. Here the mean value concerning a certain method is set to 100. Since all measuring are such, that a low value is considered desirable, this implies that this low gathered value is an expression for more desirable traits in the potatoes.

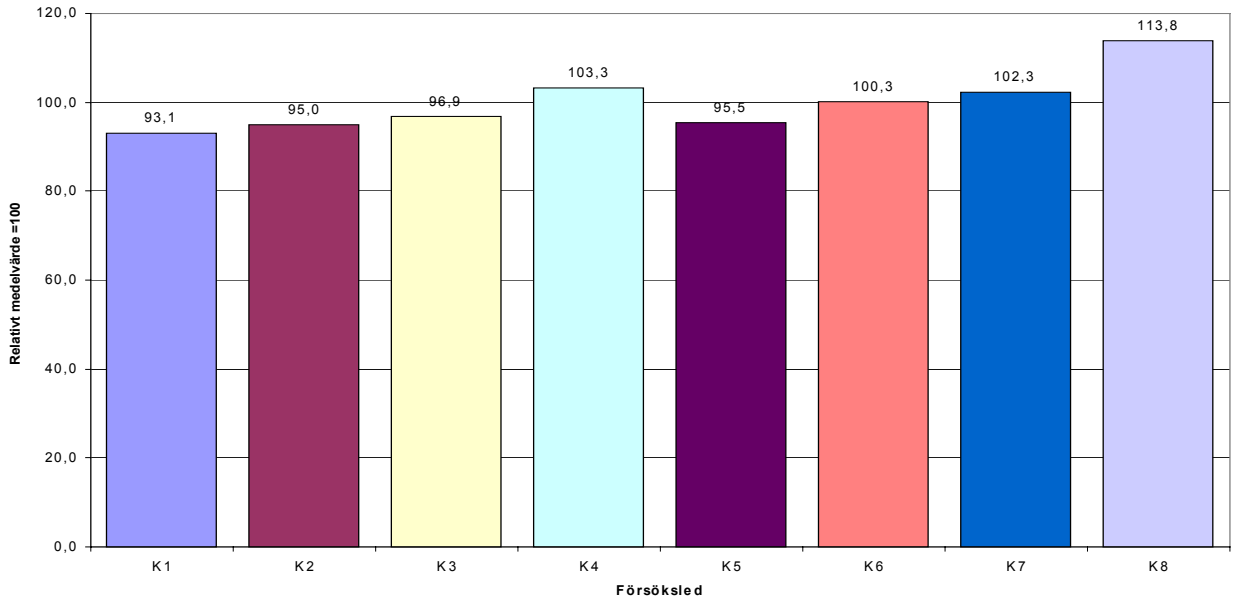


Fig. 17 Specification of measures in potatoes. Mean value = 100.

Beets

Yield

K5 and K6 deviated significant from the rest of the variants by a lower yield. K8 showed the highest yield level in beets, as well as the foliage.

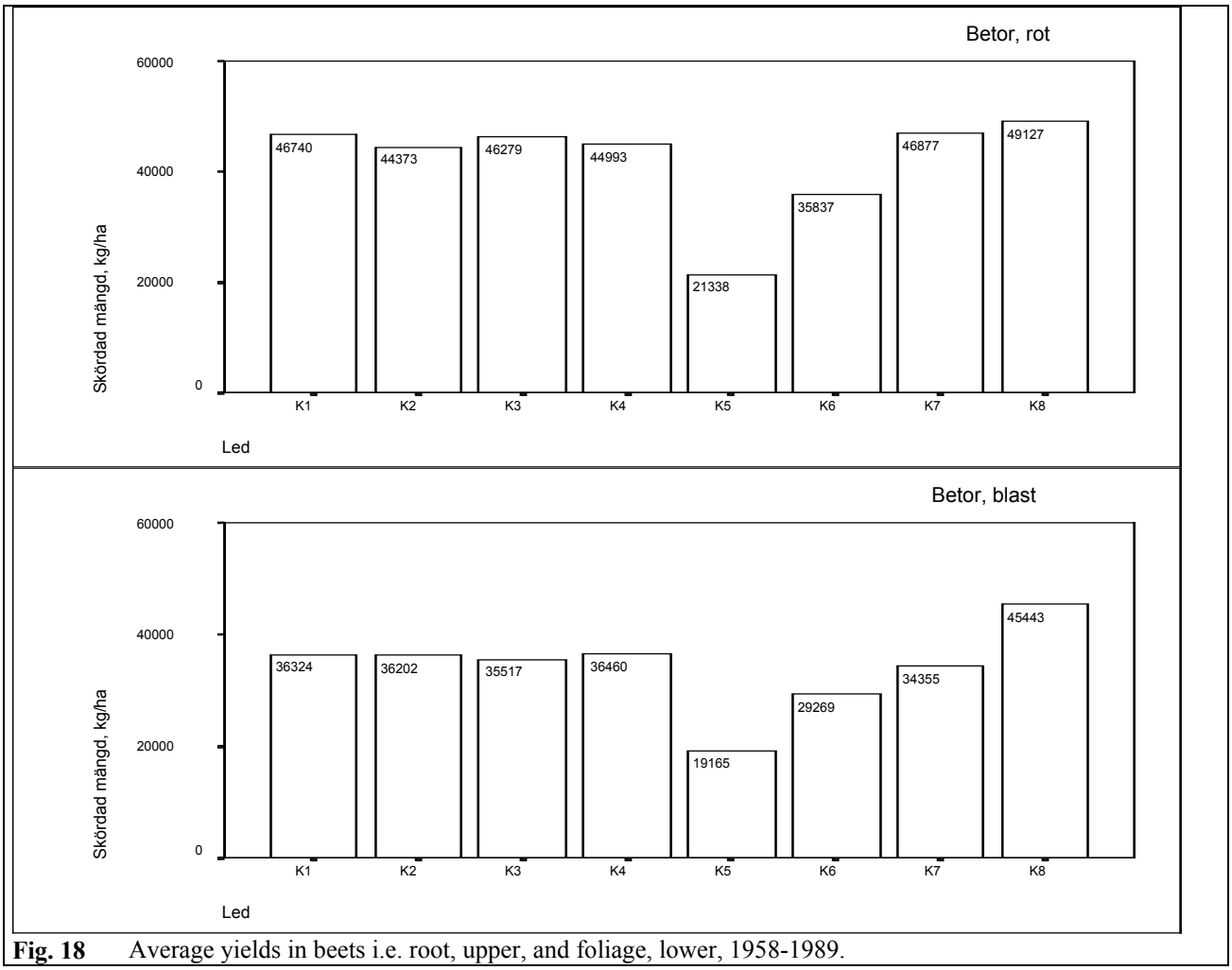


Fig. 18 Average yields in beets i.e. root, upper, and foliage, lower, 1958-1989.

K8 had the highest amount of yields in beetroots, the difference was significant compared to variants K2, K3, K4, K5 and K6. Variants K7, K1 and K3 formed a middle group followed by K4 and K2. Variant K6 and above all K5 deviated by significant lower yield levels. K8 had, compared to the rest, the lowest variation concerning the root yield and the highest variation with reference to the yield of the foliage. K3 had a high variation in root- as well as in foliage.
The yields of beet foliage were significantly higher in K8 than in the rest. It was especially during the first years of the trial, that K8 had relatively high foliage yields. Variants K4, and K1 had significantly higher yields than K7, K6 and K5. In variant K6 it was measured significantly higher yield than in K5.
Concerning the amount of root yields of the total yield, K7 showed the highest proportion followed by K3, K1, K4, K6, K2, K8 and lastly K5 with 51% roots of the total yield. Variant K7 deviated significant from the rest, except K3.
Variant K5 and K8 showed significant lower values than all the rest..

Properties of beets

Neck-root-width

The width of the beet neck was determined after yield by two right angle measures, D_1 and D_2. Thereafter the size of the root width was determined by one measure, d. The neck-root ratio was calculated with the formula $(D_1+ D_2)/2/d$. The measure gives a value on how much the beet has expanded in the neck area in comparison with the root area. The higher ratio the larger relative expansion. K5 had the highest ratio together with K1. The mineral fertilized variant had a lower ratio than the rest. Especially K8 had a low value.

Storage

The beets were sorted again after 6 to 7 months of storage. The beets not suitable to sell were sorted out. Comparisons of the beets storage efficiency gave only small differences between the variants. Especially K8 showed storage losses. Interesting to note was that K5 also resulted in relatively large storage losses, almost at the same levels as in K8. Variant K1 showed the best storage properties followed by K4. Between the other variants there were no appreciable differences.

Dry matter content

Shortly after the harvest the water content was determined by drying the beets. The amount of left over matter after drying, was determined as the dry matter content. The highest dry matter content was presented in K7 followed by K8, K5, K6, K2, K3, K1 and K4. Variant K7 deviated significant from all the other variants except K8.

Crude protein content

The crude protein content is a measure of the amount of N-total in the crop compared to the amount of dry matter. It is assumed as a standard that a certain amount of N is available as protein. Crude protein content was distinctly higher in K8. The compost-fertilized variants showed a slightly higher crude protein content than the variants fertilized with raw farm manure. The lowest crude protein content was found in K5. As the measuring of crude protein in beets was preformed only during the last three years of the trial, no significant differences could be determined between the variants.

Extract decomposition

The decomposition in the beet-extract was determined by following the changes of the electrical resistance in the fluid. High values indicate a more decomposed product, e.g. a more rapid pace in the extract decomposition. The method was performed in beets only twice during the trial period. No significant differences could be demonstrated between the variants. K7, K4 and K8 were however, above the other variants through a high value. The organic fertilized variants deviated through low values. The lowest value was in K3. K5 had higher values than the organic fertilized variants.

A summary of a few values from the investigations of the beets is seen in Table 22.

	Variant							
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
Neck: root ratio	2,73	2,54	2,62	2,43	2,65	2,55	2,50	2,28
Dry matter	16,3	16,7	16,6	16,2	16,8	16,7	17,3	16,8
Crude protein	11,3	11,4	11,0	11,0	10,4	10,4	11,3	12,6
Extract decomposition	6,4	5,1	4,6	9,1	7,9	7,0	9,9	8,5

Table 22 Values from various analyses in beets

Summer wheat

Yield

The variants K5, K2 and K6 deviated significant from the others, by lower yields. Between the other variants no distinctly differences could be noticed. The order among the variants were; K7, K8, K1, K4, K3, K6, K2 and K5. The low yields in K2 are remarkable. The yields of summer wheat kernel varied most in the mineral fertilized variants. K4 also had a relatively high variation. K5 and K3 had the lowest variation. The variations between different trial-years seemed to increase slightly at the end of the trial period.

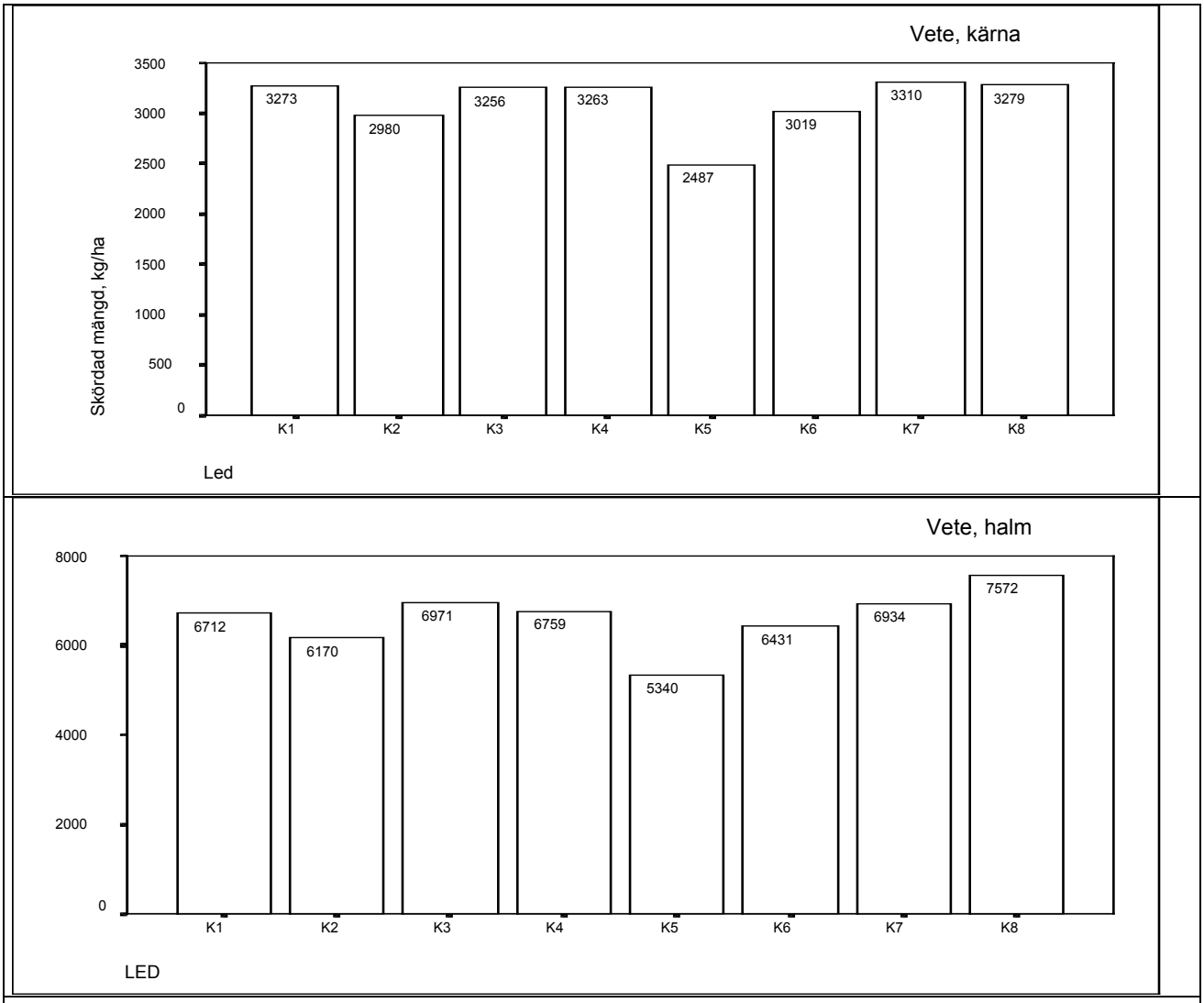


Fig. 18 Average yields of summer wheat, kernel, upper, and straw, lower, kg/ha, 1958-1989

The straw yield was highest in K8 followed by K7 and K3 that formed a group, and K4 and K1. The lowest straw yields were in K5. K2 and K6 had relatively low straw yields as well. Variations were highest in K3, followed by K6 and K1. K8 deviated significant from all the others, and so did also K5. K7, K4 and K3 had significant higher straw yields than K2, K5 and K6. Variant K1 deviated significant by higher straw yields compared to K2.

The amount of kernel in the total yield was distinctly lower in K8 compared to all the others. The differences between the variants were small. The order between the variants was; K4, K1, K6, K2, K3, K5, K7 and K8.

Properties of wheat

Length of straw and lodged stand
The length was measured on yielded straw. The amount of lodged stand was graded in the field. Concerning the length of straw, two variants deviated distinctly from the rest. That was K8 with the maximum length and K5 with the minimum length of straw. The differences between the others were insignificant. Variant K8 distinctly showed the highest amount of lodged stand. K1 and to a higher degree K3 did show very low values for lodged stand, despite the relatively large length of the straw.

Viability in kernel
The wheat kernel is germinated, usually on a bed of sand or a moistured paper. Number of germinated kernels was counted. The aim is, as high viability as possible. K1 showed the highest viability closely followed by K4. These two variants deviated significant compared to K5 with the lowest viability. The order between the variants were; K1, K4, K7, K8, K2, K6, K3 and K5.

Amount of large kernels
The kernels were sifted. Kernels over 2 mm were considered to be large. Generally, the aim is to have large kernels. K1 had the highest amount of large kernels. The variants was grouped together in the following order; K1, K4, K3, K7, K6, K8, K2 and K5. Significant differences were not appreciable.

1000 kernel weight:
Established by determine the total weight of 1000 kernels. Generally, the aim is to have a high 1000 kernel weight. K3 showed the highest weight followed by K2, K1, K4, K6, K7, K5 and K8. The variants K1, K2 and K3 differed significant from K5, K6, K7, and K8 while variant K4 distinctly deviated from K5, K7 and K8. Variant K8 had significant lower weight than all the rest, except from K5 and K7.

Volumetric weight
The weight of a certain volume of kernel is determined in a special container. High values are the aim. K1 showed the highest volumetric weight followed by K3, K2, K4, K5, K7, K6 and K8. Between K1 and K3 on one side and K6, K7 and K8 on the other, was a significant difference. K8 deviated by significant lower volumetric weight compared to all variants, except K6.

Dry matter content
The differences between the variants were small. Significant differences could be observed only between K1 and K3 and between K1 and K8. Variants K3 hade the highest amount of dry matter content followed by K8, K7, K6, K4, K5, K2 and K1.

Falling number
Falling number denotes the number of seconds, a special designed pole needs to fall a specific length in a flour water suspension that has been constantly stirred and warmed up to the boiling point. The falling number value also includes the 60 seconds that consists of warming up and the time to stir. Normally, high values are the aim for the falling number in wheat, at least within the range of size in the measures used here. Highest values were in K6 followed by K7, K1, K4, K3, K5 K2 and K8. Variant K8 deviated significant from K6, K7 and K1. Differences between K6 and K2 were also significant.

Gluten content
Gluten content is of great importance in the baking properties of the flour. High values are therefore favourable. The increasing number of gluten-allergic persons has however, resulted in a depreciation of the importance of gluten. K8 showed the highest dry gluten content followed by K1, K6, K4, K2, K7, K3 and K5. The differences between K8 and K2, K3, K4, K5 and K7 were significant. Furthermore, K5 deviated significant from K1. In wet gluten, the variants were grouped as follows: K8, K2, K1, K6, K4, K3, K7 and K5. Variant K8 had significant higher wet gluten content than the rest. K2 deviated significant from all variants except K1. Variant K5 had significant lower wet gluten content than the rest, while K1 was significant higher than K3 and K7.

Extract decomposition
Was performed in a flavour: water extract, 1:25. The method measures the resistance to decomposition in the extract. Low values are considered equivalent to a good resistance. None of the variants did show significant differences. K8 displayed the highest values followed by K4 and K3. All the rest was relatively equal.

Free amino acids
The method measures that part of the amino acids that is not incorporated in proteins. Low values are preferable in ripe products. K8 showed the highest value followed by K6, K1, K7, K3, K2, K5 and K4. K8 deviated significant from all variants except K6. Variant K4 had significant lower values compared to K1, K6 and K7. Variant K5 had lower values than K1 and K6.

Crude protein
Crude protein content is determined by standard values with the use of the total N content. The method gives a crude measure of the amount of N, but does not state in what form the N is available in the crop. K8 had distinctly the highest amount of crude protein, and following in decreasing order K2, K4, K1, K3, K6, K7 and K5. Variants K8 and K5 deviated like polarities, significant from all the others. K2 differed significantly from K7.

Crystallization
Crystallization samples are done by letting an organic extract influence the crystallization of copper chloride on a glass plate. Further information on the method see *Pettersson (1970)* and *Engqvist (1970)*. Low values are interpreted as a good crystallized picture and is favourable. The crystallization test was performed, far to few years to give reliable values. A tendency to a larger number of error-units was found in K8 and K5. Variant K1 and to a certain extent K4 had relatively few error units in the picture.

A summary of the measured values is seen in Table 23.

	K1	K2	K3	K4	K5	K6	K7	K8
Length of straw, cm	75,2	72,5	77,3	73,4	68,3	75,6	78,2	80,3
Lodged stand %	9,2	9,3	5,3	10,1	3,6	8,4	9,4	27,9
Falling number, seconds	223,5	206,7	215,9	220,9	213,5	225,3	224,1	192,6
Wet gluten, %	25,7	26,8	23,7	25,0	21,3	25,2	24,4	28,6
Dry gluten, %	10,4	9,9	9,5	10,0	9,1	10,2	9,8	11,3
Free amino acids, mg/100 g dry matter	36,4	34,6	34,8	32,9	32,9	36,6	36,5	38,3
Crude protein, %	13,4	13,7	13,3	13,5	12,1	13,1	12,9	14,4
Crystallogram, error-units	4,5	5,0	5,1	4,8	5,4	5,2	5,2	5,7

Table 23 Mean values in various measures in summer wheat

Ley

Yield

The clover/grass ley was left unfertilised in all variants with the exception of the first trial-year. Instead the crop was supporting itself on the nutrients already present in the soil, as well as with nitrogen fixation via the leguminous plants in the clover/grass ley crop. Tendencies were that the organic fertilized variants had a slightly higher level of yield than the rest. The highest yield was shown in K3 followed by K4, K2, K1, K6, K8, K5 and K7. Variant K3 had a significant higher yield than all others, except K4 and K2. These variants and K1 had significant higher yields than K5, K6, K7 and K8.

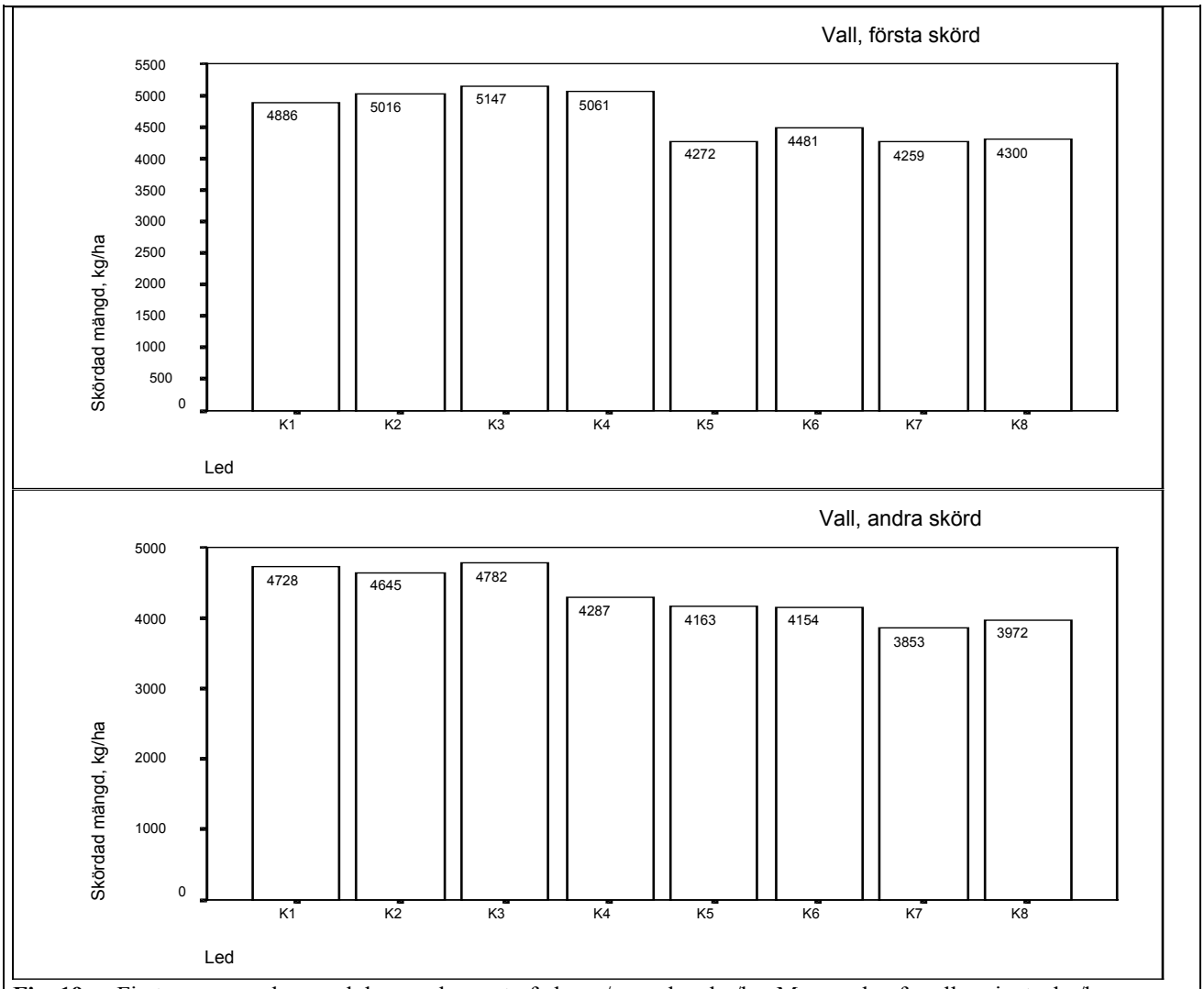


Fig. 19 First, upper, and second, lower, harvest of clover/grass ley, kg/ha. Mean value for all variants, kg/ha

The highest amount of yields in the second harvest was in K1, K2 and K3. These variants deviated significant compared to the rest, except K4. The mineral fertilized variants gave here, as well as in the first harvest, the lowest amount of yields. K7 deviated by lower yields compared to all variants, except K8. K8 had the highest variations in the clover/grass ley yields, in the case of both first and second harvest. In the first harvest it was K6, K3 and K1 that was high, while in the second harvest it was K7, K1, K2, and K3 together with K8, which had a high variation in yield levels.

Properties of ley

Hibernation

During six years the hibernation was graded, in spring after the sowing year. The hibernation was judged in the four various varieties of the clover/grass ley; alsike clover, red clover, meadow fescue and timothy. Grading was done row by row. Measures have here been recalculated to a percentage basis of full plant stand for each separate crop. High values in hibernation are favourable. K8 had throughout the lowest hibernation of all variants. Especially the clover varieties managed poorly in this variant. The highest hibernation was found in K3 and K6. K5 showed a good hibernation especially of the clover. The same applied to K2 and K3 in a lesser-pronounced degree. In K6, K3 and K4 the grasses had a strong hibernation.

	Variant							
Hibernation of	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
Alsike-clover	28	32	30	26	31	27	24	22
Red clover	19	23	23	20	27	20	20	25
Meadow fescue	39	38	38	41	26	36	29	31
Timothy	15	23	37	39	31	36	31	28

Table 24 Hibernation of different crops in the ley in % of full population.

Green forage

In the first harvest, the highest yields of green forage were found in the organic fertilized variants. Then the amount of yields decreased step by step to K8 that had the lowest yield of green forage in the first, as well as the second harvest. In the second harvest the differences was smaller. K6 was here on the same yield-level as the organic fertilized variants.

Amount of hay per kg green forage

The variants differed slightly concerning how much hay was received from 1 kg green forage. K8 had the highest amount in the first, as well as the second harvest. In the second harvest the differences was smaller.

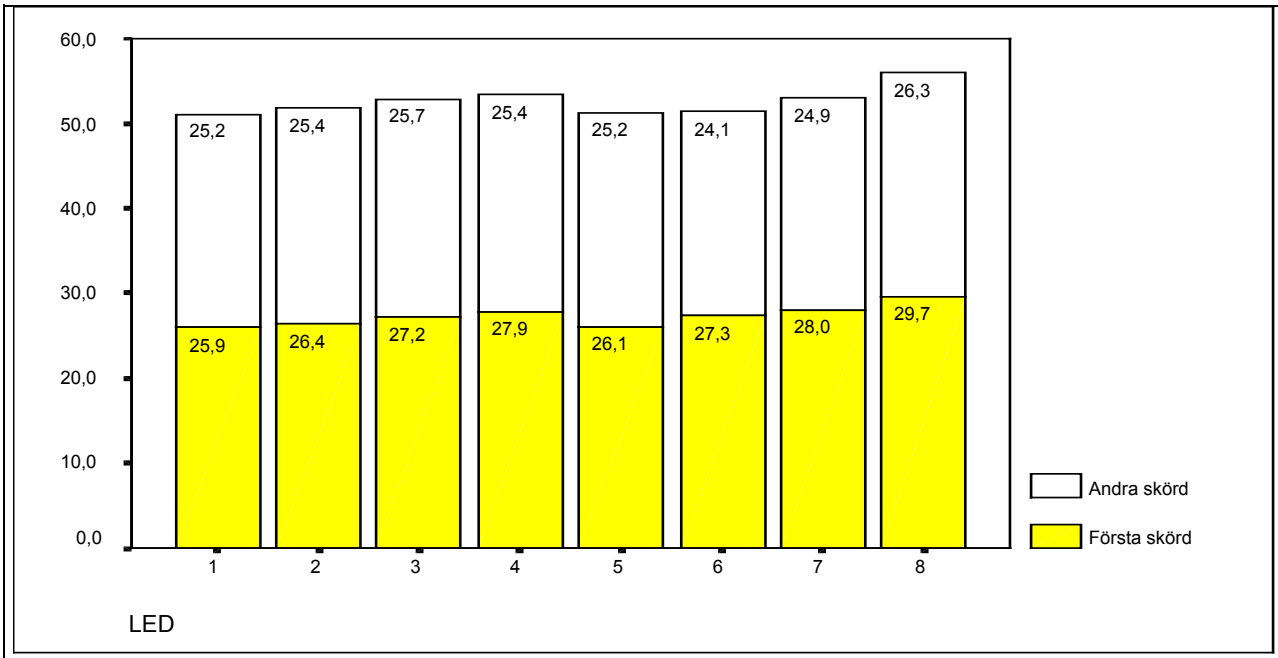


Fig. 20 Amount of hay in percentage of green forage yield, first harvest, yellow, second harvest, white

Botanical composition

The clover/grass ley crop was analysed at harvest, with reference to the amount of included clover/grass ley crops. The botanical analysis at the first and the second harvest, gave distinct differences between the variants. At the first harvest the greatest amount of grass was discovered in K4 and K8. These variants deviated significantly from the others, except K7. K1 had a significant lower amount of grass, compared to all mineral fertilized variants. The highest amount of leguminous plants was in K5 and K1. In K5 the amount of red clover was significantly higher than in the rest of the variants. Also K6 was very high here. Of the intensified fertilized variants, did K1 have the highest amount of clover. In K1 however, it was the lucerne that was most prominent. K1 had significantly higher amount of lucerne than K4, K6, K7 and K8. This relationship was even more obvious in the second harvest, when K1 had significantly higher amount of lucerne than the rest, except K2. K5 had a very high amount of red clover in the second harvest. In this case K5 deviated significant from all variants. K6 as well, had a high amount of red clover in the second harvest and differed significant from variants K3, K4 and K8. Interesting to note was, the relatively low amount of leguminous plants,

especially lucerne, in K3. High amount of grass was found in mineral fertilized variants K8, K4 and K7. Variant K8 had significant higher amount of grass than K1, K2, K5 and K6.

	First harvest								Second harvest							
Variant	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
Grass	32	36	39	48	35	41	45	48	23	28	28	32	20	27	31	41
Clover	28	28	24	23	36	32	28	22	22	20	34	25	60	45	46	32
Lucerne	18	16	13	11	12	9	11	9	49	46	24	22	13	22	18	22
Weed	18	16	16	18	14	16	14	18	7	7	11	12	8	8	5	6

Table 25 Amount of various crops at botanical analysis in clover/grass ley, % of total population

Dry matter content

The measures in the first harvest displayed only small differences between the variants. K8 had the highest dry matter content and K5 the lowest dry matter content. Between these variants the differences were significant. The rest of the variants were equal in the sequence; K8, K4, K3, K7, K2, K6, K1 and K5. It is possible, that differences between K8 and K5 is the result of differences in the botanical composition, rather than differences in individual physiology of the plants.

Crude protein content

Concerning the crude protein, K2 had the highest values, followed by K1, K5, K3, K4, K6, K7 and K8. Possibly, the high amount was a reflection of the high amount of leguminous plants in these variants. The mineral fertilized variants had distinctly the lowest amount of crude protein. K2 differed significant from K6, K7 and K8. Variant K1 deviated significant from K7 and K8 while K5 had significant higher values than K8.

N-mineralization and the value of the preceding crop

To be able to study the N-mineralization and its changes in the soil, samples were taken at 0-30 cm levels, every second week from sowing to harvest. Determination was made on the amount nitrate and ammonium-nitrogen. The amount of N was then converted to kg N per hectare. At the same time, the crop was cut in 2x50 cm length of strands, in the sow-row for determination of assimilated amount of N. Total N-amount in the part above ground of the crops, was multiplied with a factor of 1,32 to get a measure on the total amount of N content, at a presumed N-content in the roots equivalent to 25% of the total N-content in the crops. Methods for samples and analyses in soil and of crops has been made according to the standards applied in earlier studies on nitrogen support within ecological agriculture *(Granstedt, 1990).* The mineralization-supply in the total period of plant production in all treatments respectively, was calculated according to the formula: *Total N in the crop + mineral N in the soil at harvest – mineral N in the soil at sowing - supplied mineral N* = the mineralization-supply.
In the morphological investigation in 1990, 50 plants were yielded at random from the whole experimental-plot. Afterwards measures were done on; length of leaf, width of leaf, length of leaf sheath, straw-length, length of the upper internodes on the straw, distance of ear-base from flag-leaf, length of the ear and number of kernel-floors per ear.
The measures were conducted in 1989, within the frame of the ordinary experimental layout. In 1990 the summer wheat was sowed over the whole field, which gave an opportunity to study possible effects of the preceding crops. Only K7 and K8 were fertilized this year.

The trial-year 1989
The climate was slightly warmer than normal during May. June was slightly cooler and above average in precipitation (rainfall). July was very dry but not so hot, while August had a normal precipitation (rainfall) and temperature. September was dry.
The sowing of the summer wheat was done 26/4. Since growth was very uneven, a re-sowing was done in 11/5. The d-plots in K1, K2, K3, K5, K7 and K8 were studied. The preceding crop was beets in all variants. K1 and K2 had the previous years been fertilized with N; in 1987 111 kg N/ ha and in 1988 with 289 kg N/ha. K3 had in 1987 been fertilized with 158 kg N/ ha and in 1988 with 219 kg N/ha. K7 had in 1987 and in 1988 as well, been fertilized with 100 kg N/ha and K8 had in 1987 and in 1988 as well, been fertilized with 200 kg N/ha. The beet-yields had in all variants been above average in 1988, except in K5 that had a very low beet-yield.

Fig. 20, see next page, shows the increase of dry weight in the crops in the various variants. K3 had the most intensive growth process and K5 the weakest. K8 showed a relatively weak growth. Up and until the samples 79 days after the sowing, the growth process in the plants was relatively continuous and equal in all variants. Between day 95 and day 110, an increase in dry weight occurred in K5. K7 had here a depression and to a certain extent so did K8. In the organic fertilized variants it was measured a considerable higher amount of dry weight. K2 differed from the rest of the variants by having a slightly longer growth process. The increase in dry weight at the last occasion probably depends on the withering of the leaf-matter.

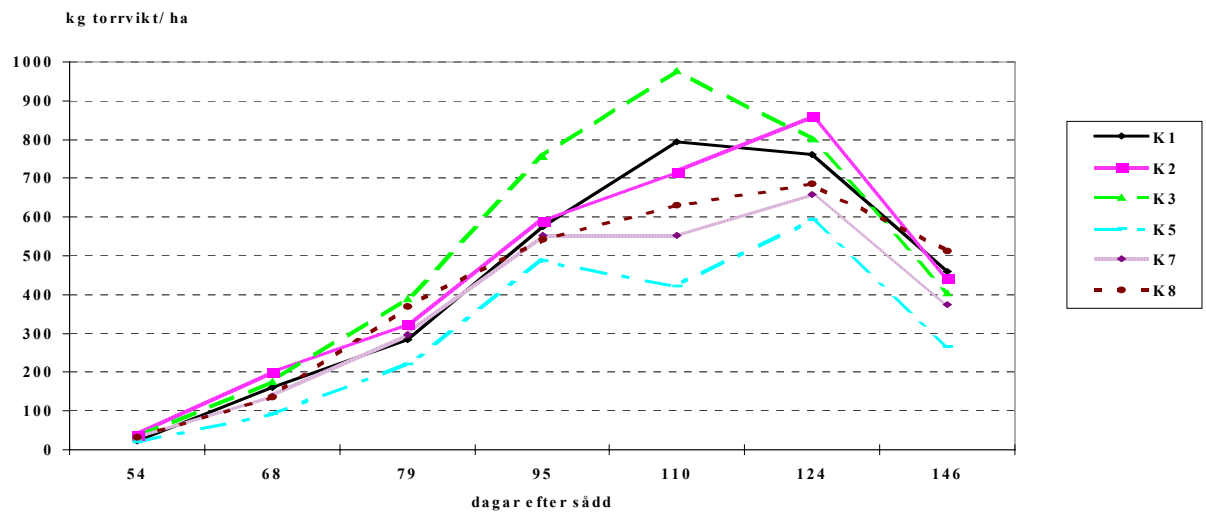


Fig. 20 Dry weight, kg/ha at different dates and in the different variants.

The amount of mineral-N in soil and crop are shown in Fig. 21 on the next page. In K2 and K3 was measured a slightly higher initial position concerning the N-content in the soil at sowing.

The amount of N increased in all variants up to 54 days after sowing. Then a dramatic decrease occurred in the amounts of mineral N in the topsoil in all the variants, except K8. In this variant the decrease did not enter until 68 days after sowing. The delay could possibly been caused by an infestation by the frit fly, that was especially intense in K8. Perhaps can this attack also be connected to the increase of soil-N contents in K8 that emerged between day 98 and day 112 after sowing. N-mineralization in the soil was, again greater in K8 than the N-uptake in the crop. Also in K7 and K5 was a lower translocation of N to be noticed, during the period between 95 days and 124 days after sowing. Maybe some explanation can be found in the dry weather in July.

During the later part of the farming-season, the amount of N-content increased again in K7 and K8. During this period the amount of mineral N increased in the soil, as well as the amount of N in the crop. In this case, the mineral fertilized variants reacted differently than the organic fertilized. There the amount of N increased in the crop, up to between the 110:th and the 124:th day, and was then decreasing until harvest. The amount N in soil was on the other hand, relatively constant up until the samples the 124:th day after sowing. K5 had the smallest increase of amount mineral -N in the soil just before harvest. This period should roughly coincide with the translocation of N in the kernel.

The amount of N in the soil increased in all the variants in connection to the last samplings. This depended no doubt, on the vestigial process and disintegration in the root system, as well as the very moderate N-uptake in the crop, at the same time as the mineralization in the soil continued, even though in a limited size. Up and until the harvest the amount of mineral-N in the soil in K8 could not be entirely used. In K5 the mineralization could not compensate for the absence of the N-fertilizing. This did occur in K1, K2 and K3.

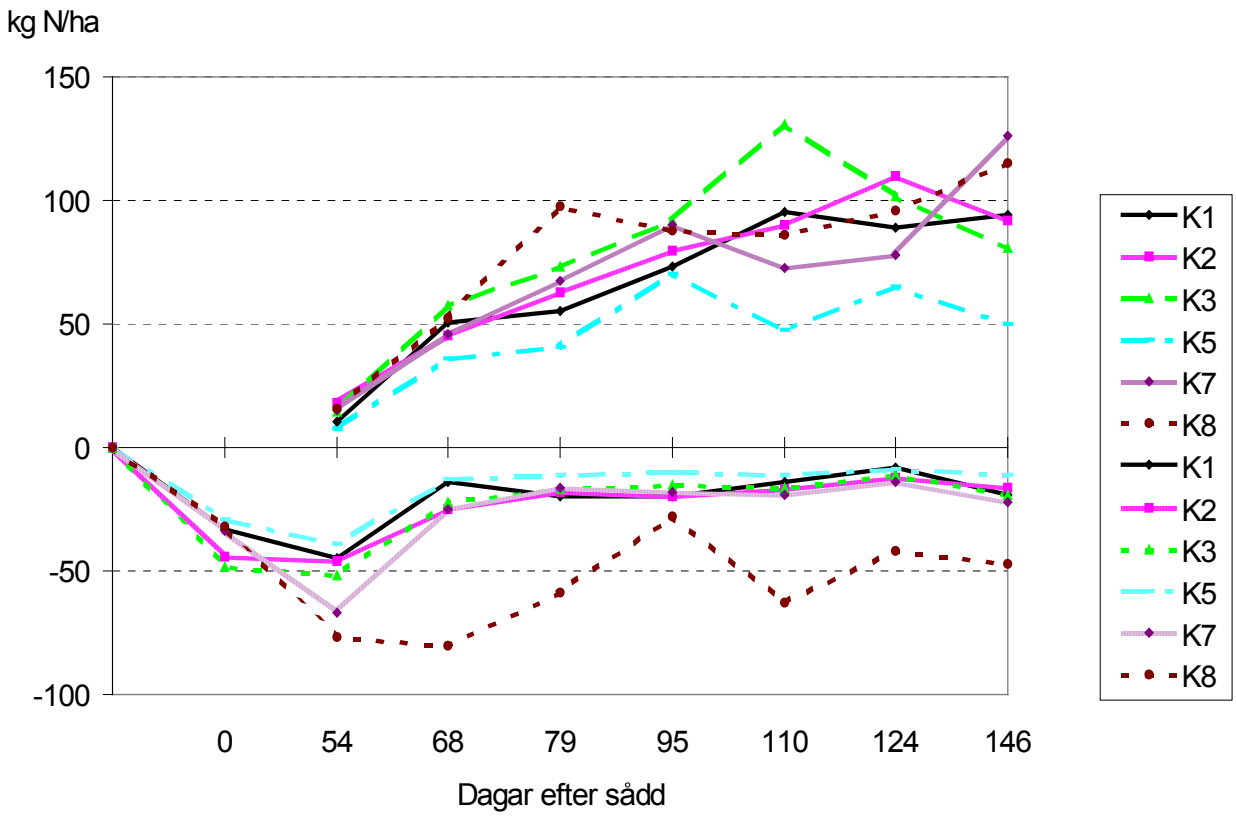


Fig. 21 N-uptake in crop as well as N in the topsoil at various dates. Amount of N in soil is stated as negative values.

Fig. 22 reproduces mineral-N values in the soil depth down to 90 cm, at the samples taken in the springtime and the autumn (including the mineral-N supply in K7 and K8) as well as total-N in the crops at harvest. Differences between spring- and autumn values were calculated as the mineralization supply during the vegetation period.

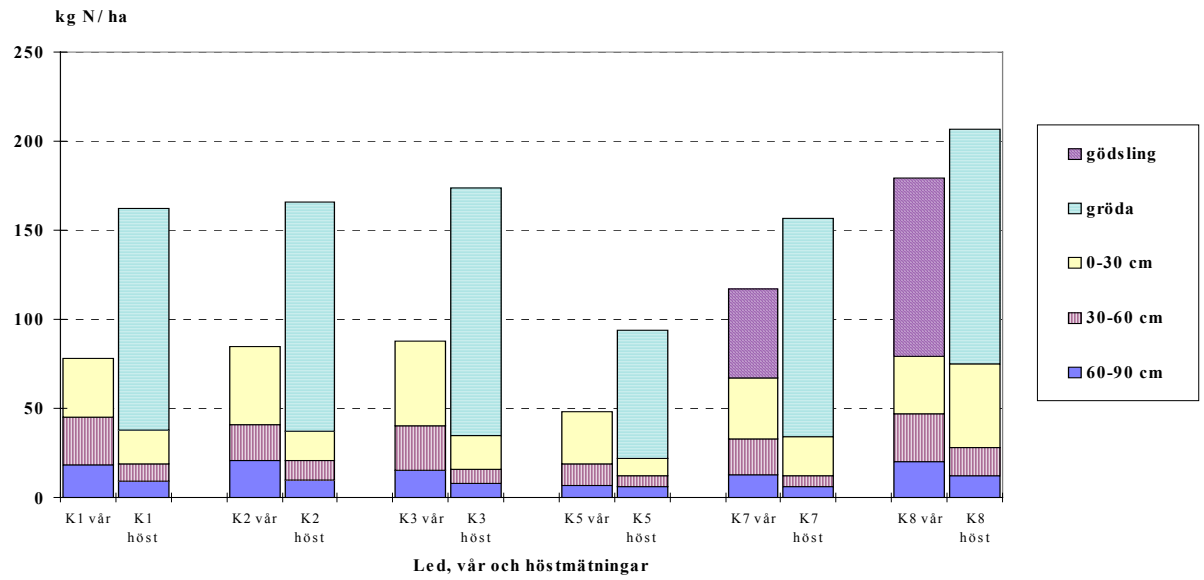


Fig. 22 The amounts of N in soil, "60-90 cm, 30-60 cm, 0-30 cm", crop, "gröda", and fertilizer , "gödsling", kg/ha,

The mineralization supply, as seen in Fig. 23, was approx. twice as high in the organic fertilized variants i.e. K1, K2 and K3 compared to the unfertilised K5. In K8 the mineralization supply was substantially lower. If supposedly K5, show the soils own mineralization potential, it seems that losses or immobilisation of mineral-N have occurred in K8 up to the equivalence to 18 kg N / ha.

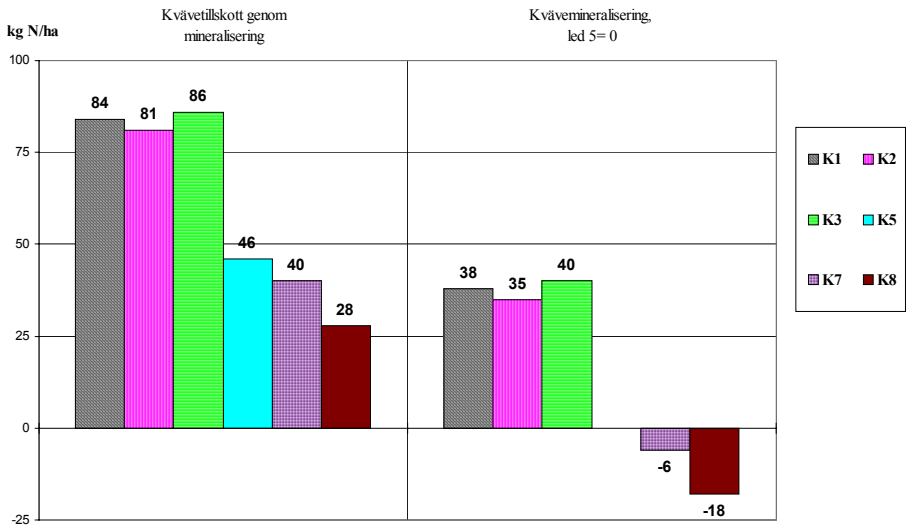


Fig. 23 Mineralization-supply in the variants in absolute numbers, left, and in relative numbers expressed as a comparison with the N-supply in K5, right

The obtained results indicates, that a mineralization potential has been built up in the organic fertilized variants, and in spite of the lack of mineral fertilization, gave the same N-yield as the conventional, mineral fertilized variants.

The trial-year 1990

In 1990 summer wheat was sowed across the whole experimental field. The a-plots had in 1989 clover/grass ley as crop, b-plots potatoes, c-plots beets and d-plots summer wheat with undersow. The climate was warm and relatively dry in May and June, while July was very rainy and cool. August and September was relatively dry and normal warm. The sowing was done 24/4, the crops developed normally, except that the clover/grass ley sowing failed. 29/5 the wheat was in the phase of growing side shoots, 5/6 in the beginning of straw elongation, 24/6 in the beginning of coming into ear and 9/7 in blooming. At the samples 25/7, 8/8 and 22/8 it was estimated that the wheat kernels were in milk ripeness, dough ripeness and yellow ripeness respectively. The crop was harvested in 5/9. The clover/grass ley 1988 in the b-plots was very poor in leguminous plants. In K8 no leguminous plants did occurred at all, in the first or the second harvest of clover/grass ley. In this variant the summer wheat yields had been very low in 1988 in the a-plot, as well as in 1989 in the d-plot.

Morphological investigations

Sampling in 1990-05-29

The yield samples concerning the leaf-length, showed rather small differences between various types of fertilizing. K5 had throughout the shortest leaves. There is a tendency that leaf 1 was larger in K8. To a certain extent, leaf 2 but mainly leaf 3 was larger in K1. The total leaf length was larger in K1. This might indicate that the development was more rapid in K1and growth process more intensive in K8. The differences between various preceding crops were small. In K1 as well as K5, was the leaf-length largest with clover/grass ley as preceding crop. Tendencies to this were mostly evident in leaf 2 and 3, which can be interpreted as a sign of a more rapid growth development in these plots. The results are seen in Fig. 24

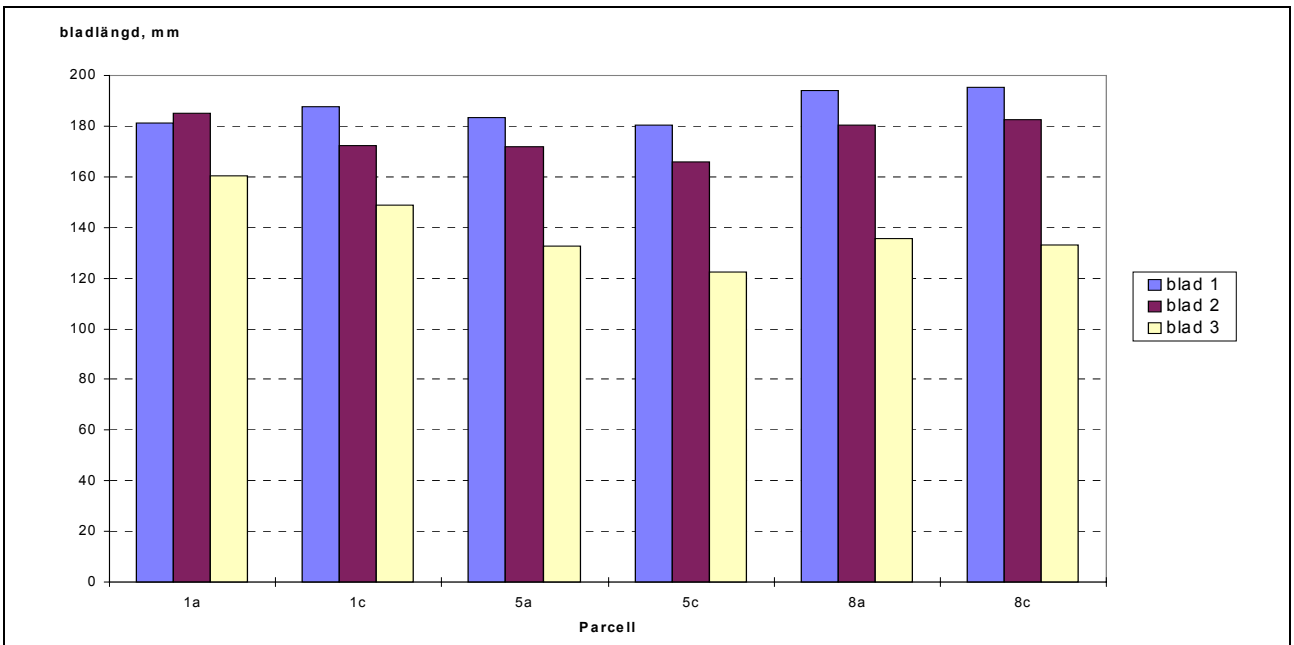


Fig. 24 Leaf-length in different variants. Leaf 1 = the first grown leaf. Blad 1 = leaf 1 etc. a-plots has clover/grass ley as preceding crop, c-plots has beets.

Samplings in 1990-06-15

The largest leaf length was in K1 and the lowest in K5. This applied to the individual, as well as to the total of the leaves. The tendencies from 29/5, with clover/grass ley as preceding crop, that they should give a larger amount of leaf-length was only maintained in K5. The differences between a- and c- plots in this variant were about 25%, calculated on the total of the leaf-length. In the other two fertilized variants, the plots preceded by beets, was throughout the source to larger leaf-length than the a-plots. The differences between a- and c-plots had a tendency to be larger in leaf 3 than in leaf 1 as well as larger in K8 than in K1. This can be interpreted, as if the development was slightly faster and the growth process more intense, in the plots with beets as preceding crop. In K5 it was the plot with clover/grass ley as preceding crop that showed the best conditions in both development, as well as growth process.

Samplings 1990-07-19

The length of the four top leaves deviated slightly from each other in the different variants. The greatest total in the leaf-length was in K8, the smallest in K5. The plants in K1 had the longest flag-leaves as well as the longest leaf 2. Especially leaf 2 was very long in the a-plots, and deviated strongly from all the other leaves.

K8 distinctly had the longest leaf 3 and leaf 4, especially in the c-plots. This could be a sign of more vegetative conditions in K1 in the a-plots with clover/grass ley as preceding crop and more vegetative conditions in K8 concerning the plots with beets as preceding crop. The plants in K1 and K5 reached the largest leaf-length total in the a- plots, while the plants in K8 had the largest leaf-length in the c- plots. In K1 the flag-leaf, leaf 2 and leaf 3 was longer in the a-plot than in the c-plot, while leaf 4 was longer in the c-plot.

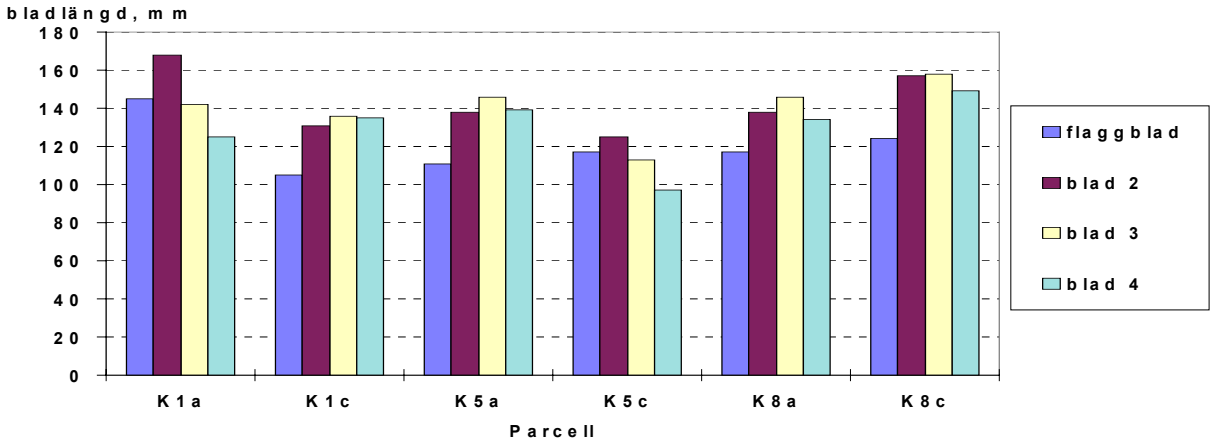


Fig. 25 Leaf-length in different variants. The leaves are counted in order, starting from the ear. Flaggblad = flag leaf, blad 2 = leaf under the flag leaf etc. a-plots has clover/grass ley as preceding crop, c-plots has beets.

Perhaps this indicates that earlier in the season, when leaf 4 was in growth, conditions was more vegetative in c-plot, while it later has occurred an intense growth process in the a-plot in K1. In K5 was leaf 2, 3 and 4 longer in the a-plot, while the flag leaf was slightly longer in the c-plot. In K8 the c-plot had the plants longer leaves throughout. If the total of the leaf length is set to a value of 100, then the difference in the relative length of the leaves is seen in Table 25.

Variant	Preceding	flag leaf	leaf 2	leaf 3	leaf 4
K1a	Ley	25	29	25	21
K1c	Beets	21	26	27	27
K5a	Ley	21	26	27	26
K5c	Beets	26	28	25	21
K8a	Ley	22	26	27	25
K8c	Beets	21	27	27	25

Table 26 The relative amount of the total leaf-length, different leaves at various types of fertilizers, values are in % of the total leaf-length in all four leaves.

K8 did not differ noticeably between plots with various preceding crops. As growth in total was larger in the c-plot within this variant, this can be interpreted as if the development was comparable with both preceding crops, while the growth potential was larger with beets as preceding crops. The relatively small amount of the total leaf length that the flag-leaves composed of in K8, can be interpreted as if the growth process had been emptied and the plant instead did build up its kernel yield through re-storage. K1 and K5 were like mirror images. In K1, the amount of flag leaf and leaf 2 was high in the a-plot and low in the c-plot. In K5 it was the opposite. It seems as if the growth conditions in K1 was such, that the plants in the plot with preceding clover/grass ley, in a stronger way could continue the growth process of leaves that developed at a later stage. The vegetative conditions seem in other words, to have lasted longer into the season in the plot with clover/grass ley as preceding crop. In K5 conditions seems to have been quite different. In the plot with beets as preceding crop growth was very small, but continued a longer period. This appeared in the relatively large amount of the total leaf length that was made up by the flag leaf. The small growth potential that existed in the c-plot accordingly, was being used mainly by the last formed leaves.
The leaf width varied proportionately within the test plots. This made reliable observations very difficult. The plants in the K1a-plot had a tendency to have the widest leaves followed by K5a- and K8c-plots. The narrowest leaves were in K5c-plot. The difference between a- and c-plots was relatively pronounced. The a-plots had the widest leaves in K1 and K5 while the leaves were widest in the c-plot in K8. Interesting was that the K5 a-plot distinctly had the widest flag leaves. The flag leaves in this plot were in other words, relatively short and wide.
The total length of the leaf sheaths was largest in K1 and K8. The difference between them was small, while on the other hand K5 throughout, had shorter leaf sheaths. In K1 and K5 the leaf sheaths distinctly were longer in the a-plots. In K8 it was the plants in the c-plot that had the longest leaf-sheaths. Concerning the flag leaf and leaf 2 the longest leaf sheaths were found in the K1a-plot while the longest leaf sheaths in leaf 3 and 4 were in K8c-plot.

The longest straw was found in the average plant in K1, while the straw length in K5 and K8, more or less, was equal. Again it was the a-plots in K1 and K5 as well as the c-plot in K8 that showed the largest growth. The longest straw was

found in the K8c-plot and the shortest in the K8a-plot. If the total length of the straw has a value=100 then the different length of the internodes can be seen in Table 27.

Plot	Preceding	The Internodes number					Straw-length
		1	2	3	4	5-	mm
K1a	Ley	47,3	23,5	11,9	6,2	11,1	782
K1c	Beets	45,2	23,8	13,1	8,7	9,6	742
K5a	Ley	45,2	24,2	12,5	6,0	12,1	742
K5c	Beets	50,7	21,3	11,3	7,7	7,4	708
K8a	Ley	49,0	22,6	13,3	7,7	7,4	665
K8c	Beets	43,5	24,0	13,4	8,5	10,6	797

Table 27 Total straw length in mm and the relative length of the internodes in the straw in %. Internode 1 is closest to the ear

Interesting to note was the correlation of the different internodes in the two plots in K8. The plants in K8c-plot, with beets as preceding crop, had a larger part of the straw in the earliest formed internodes, while the K8a-plot had a very large amount in the internode located directly below the ear. Again K8 was a mirror reflection of K1 and K5. In these variants it was the plants from the plot with preceding clover/grass ley that had a relatively large amount of the straw in the basal parts. However, there were a difference between K1 and K5 concerning the internode just below the ear. In K1 did the plants, with clover/grass ley as preceding crop, have relatively long internodes, while in K5 it was the plants with beets as preceding crop that had more protruding internodes directly below the ear.

The plants in K1 had on average the largest ear-length followed by K8 and lastly K5. The a-plots displayed the largest ear-length in K1 and K5, while in K8 it was the c-plot that had the longest ears. The ears in the K1a-plot were distinctly longer than in the other plots. Sequence in decreasing order was; K8c, K5a, K1c, K8a and lastly K5c. Concerning the amount of kernel-floors per ear, the K8c-plot distinctly showed the highest value followed by, in decreasing order; K1a, K1c, K5a, K8a, K5c. Expressing the form of the ears, in number of mm that each kernel floor has at its disposal, then the values arise as in Table 28.

Variant	K1a	K1c	K5a	K5c	K8a	K8c
mm/kernel floor	4,63	4,01	4,35	4,08	4,11	4,03

Table 28 Density of the ear measured as the length of each floor in the ear in different plots, mm/floor

As seen in Table 28 it is obvious that the loosened ears seems to be more common in the a- plots, i.e. the plots with clover/grass ley as preceding crop. Finally the height of the ear-base over the flag-leaf was also measured. The longest distance between flag-leaf and ear was shown in the K1a-plot followed in turn by the K5a, K8c, K8a, K1c and K5c-plots.

Yield

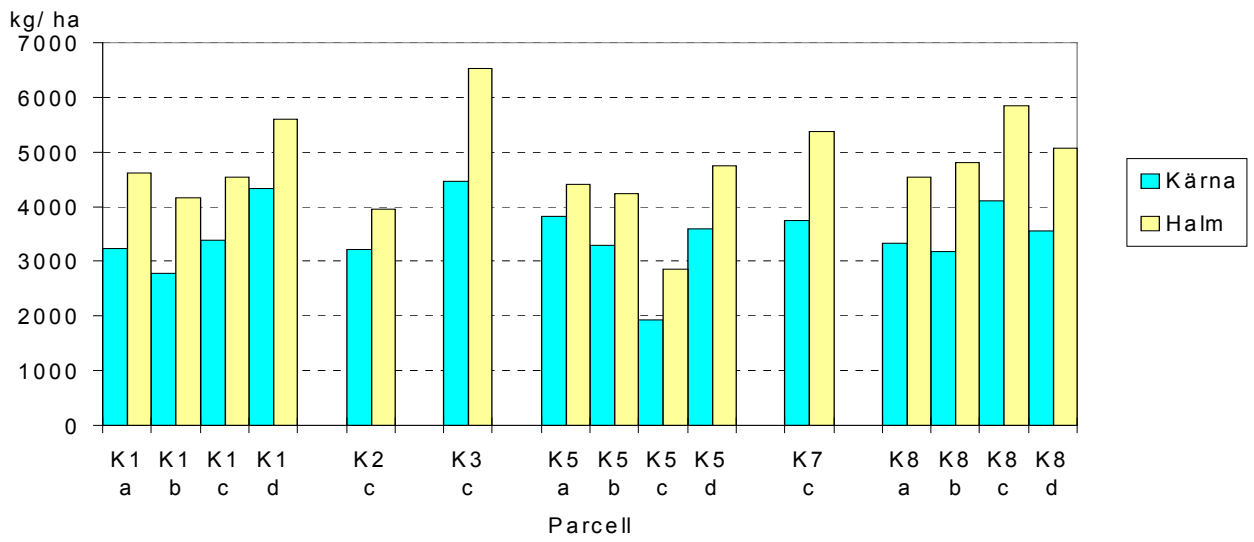


Fig. 26 Kernel and straw yield of summer wheat in the various plots. Kärna = kernel, Halm = straw
Preceding crop in a-plots= clover/grass ley, b-plots= potatoes, c-plots= beets and d-plots= wheat. Kg/ha

Kernel- and straw-yields of the summer wheat in the various plots are seen in Fig. 26 and Table 29. The highest yields were in the K3c-plot, in kernel as well as straw. This could be a result of the raw manure fertilizer for the beets the previous year. The relatively low amount of kernel compared to the straw-yield, indicates that it has been more vegetative conditions early in the season.
While K1 and K5 had the highest yields in the a- and d-border-plots, did K8 show the highest yields in middle-plots b and c. These plots in K8 received the most intense fertilization the two previous years. The a- and d-plots on the other hand, had both leguminous plants as preceding crop, in the a-plot as clover/grass ley and in the d-plot as undersow. It should be mentioned, that the undersow was not particularly strong in 1989. The b-plots with potatoes as preceding crop, had almost throughout a large straw yield compared to the kernel yield. Here it could be the intense fertilization the previous year, which intervened and supported the growth process in the first phases of development rather than the kernel translocation. In these plots it must have been stronger vegetative conditions in the springtime than later during the season. The values also points out that the K5c-plot distinctly deviated from the other plots by considerably lower levels of yields.

Variant	Amount of yield					N-yield				
	Kernel kg/ha	Standard error	**Straw kg/ha**	Standard error	Kernel yield/ total yield, %	**Kernel kg/ha**	Standard error	**Strawkg/ha**	Standard error	N in kernel %
K1a	**3232**	155	**4623**	309	41,1	**69,8**	3,3	**35,7**	2,5	66,2
K1b	**2782**	123	**4155**	214	40,1	**59,0**	2,5	**28,4**	1,5	67,5
K1c	**3294**	138	**4535**	160	42,8	**72,2**	2,9	**28,5**	1,0	71,7
K1d	**4327**	223	**5597**	301	43,6	**86,0**	4,4	**34,6**	1,9	71,3
K2c	**3219**	408	**3948**	468	44,9	**69,3**	8,7	**25,2**	3,0	73,3
K3c	**4464**	299	**6526**	445	40,6	**84,6**	5,8	**43,1**	2,9	66,2
K5a	**3823**	481	**4406**	270	46,5	**79,2**	9,9	**32,9**	2,3	70,0
K5b	**3294**	78	**4235**	73	43,8	**60,5**	1,5	**25,2**	0,4	70,6
K5c	**1937**	209	**2853**	264	40,4	**36,5**	3,9	**13,6**	1,2	72,9
K5d	**3603**	376	**4752**	539	43,1	**73,0**	7,4	**31,8**	3,4	69,7
K7c	**3740**	391	**5381**	588	41,0	**77,7**	8,0	**40,6**	4,4	65,7
K8a	**3232**	320	**4544**	350	42,3	**76,5**	7,6	**40,2**	3,2	65,6
K8b	**3186**	156	**4802**	240	39,9	**72,3**	3,6	**34,9**	1,9	67,4
K8c	**4098**	219	**5848**	267	41,2	**94,1**	5,0	**51,6**	2,3	64,6
K8d	**3561**	269	**5072**	244	41,2	**82,4**	6,2	**41,2**	2,1	66,7

Table 29 Yields of kernel and straw and N-yield of summer wheat.

Nitrogen metabolism
The highest N-yield per hectare was found in the K8c-plot followed by; K1d, K3c, K8d, K7c and K8a. In K1 accordingly, was the highest N-yield in the plot with summer wheat as preceding crop, there after followed the plots in sequence; clover/grass ley, beets and potatoes. In K5 the plot with preceding clover/grass ley, gave the highest N-yield followed by the preceding summer-wheat and potatoes, while preceding beets gave very low N-yields. In K8 it was the preceding beets that gave the highest N-yields followed by wheat, potatoes and clover/grass ley. The N-yields in kernel, straw and calculated in roots are also seen in Table 29 and Fig. 27

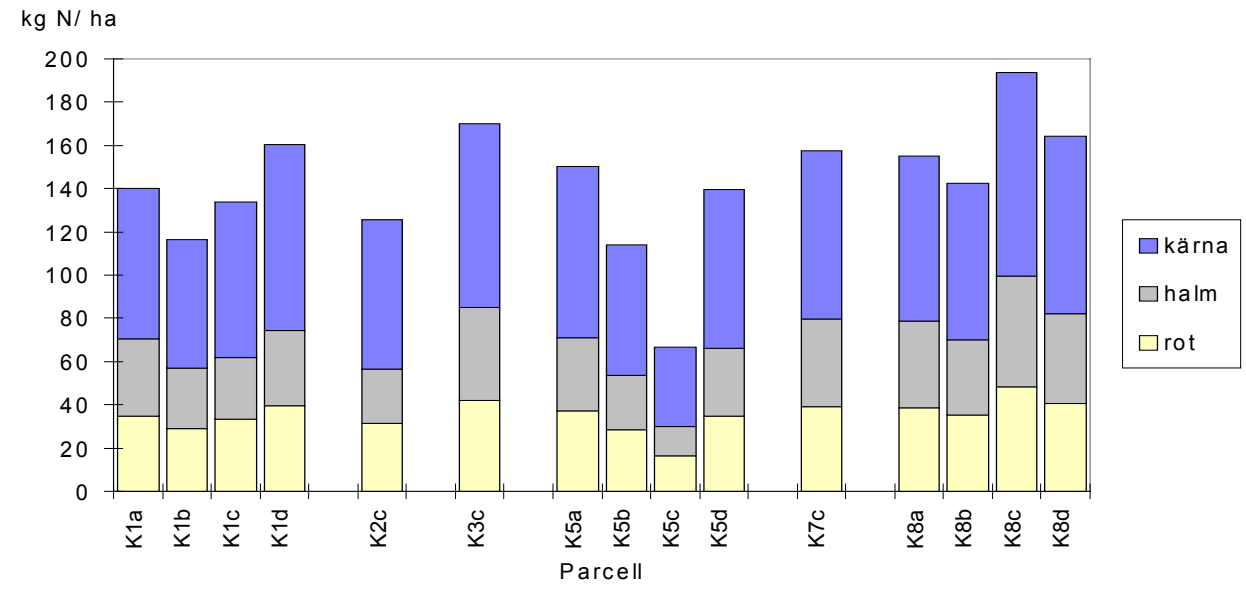


Fig. 27 N-yields in different parts of the plant, kg/ha, Kärna= kernel, halm= straw, rot= root

The mineralization-supply in the various plots is evident in Fig.28 In K1 summer wheat undersown with clover/grass ley, yielded the highest preceding crop effect (129 kg N/ha). Clover/grass ley yielded a somewhat lower preceding crop effect (122 kg N/ha) while potatoes yielded the lowest preceding crop effect. In the totally unfertilised system K5, clover/grass ley yielded the highest preceding crop effect (135 kg N/ha), while summer wheat yielded a slightly lower (107 kg N/ha). The preceding crop effect then decreased gradually in potatoes (84 kg N/ha) and lastly in beets (43 kg N/ha).

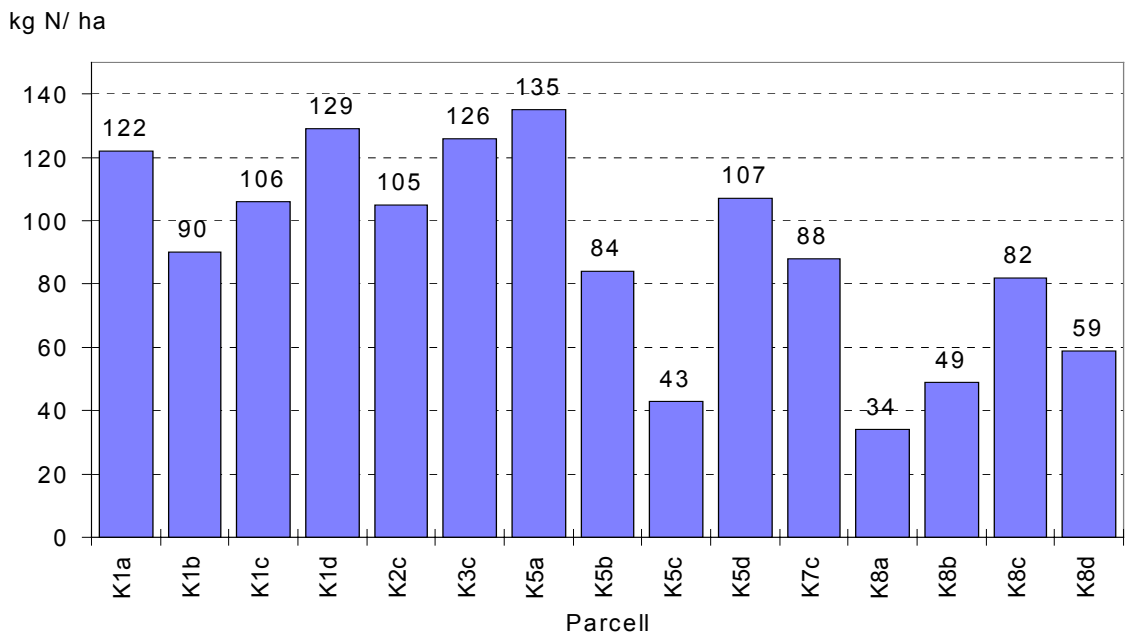


Fig. 28 The calculated mineralization supply of N in various plots, kg/ha.

In the mineral fertilized K8, with a addition of 100 kg N per hectare as NPK or calcium nitrate, the preceding crop effect was lowest after clover/grass ley (34 kg N/ha) slightly higher after potatoes (49 kg N/ha) and summer wheat with undersow (59 kg N/ha) and highest after beets (82 kg N/ha). Concerning the mineralization supply, it was the border plots in K1 and K5 and the middle plots in K8 that displayed the highest values. The total of N-yields as well as the mean value for the mineralization supply in K1, K5 and K8 is evident in Fig. 29 on the next page. The mineralization supply was on average twice as high in K1 as in K8 and 22% higher in K1 than in K5.

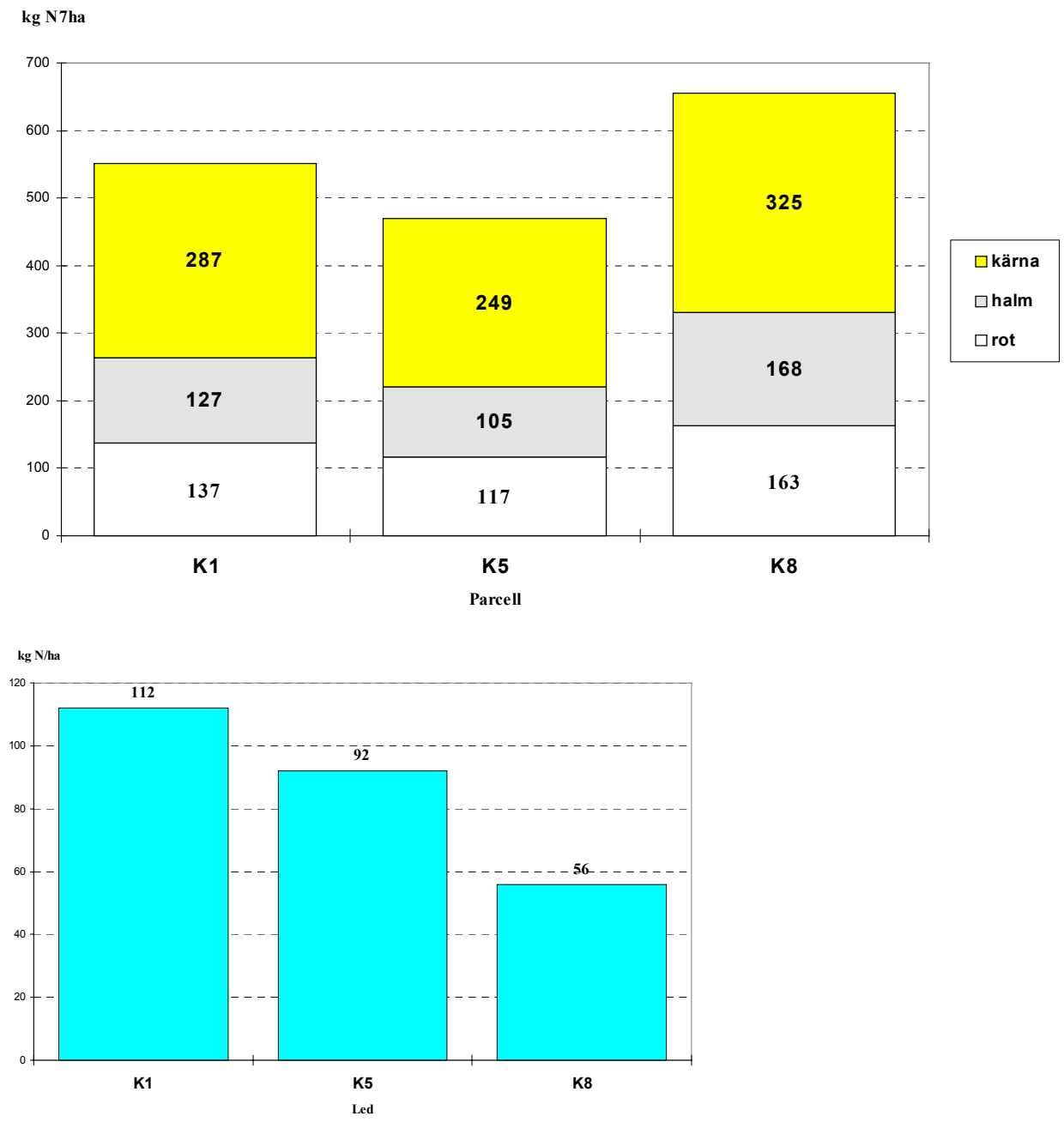


Fig. 29 Total N-yields, upper, and the calculated N-mineralization-supply, lower, in K1, K5 and K8. Kärna= kernel, Halm= straw, rot= root.

Through the repeated samples of mineral-N in the soil and the N-uptake in the crops it was possible to study the interplay between soil and crop. The results of these samples and analyses have been stated in Fig. 30 on the next page. The amounts of mineral-N in the soil are specified below the 0-line and total-N in the crop above the 0-line. After both preceding clover/grass ley and summer wheat undersown with clover/grass ley, between the two first samples, the mineral-N increased in the soil after sow, in K1 and K5. The mineralization was in other words, higher than the N-uptake in the crop. In K8 the plots with preceding clover/grass ley, potatoes and summer wheat at the first sample after sowing, the values for mineral-N in the soil was higher than the supply of commercial fertilizer. At the last samples, losses in biomass could have occurred by leaf abscission from straw and possibly by ear damage.

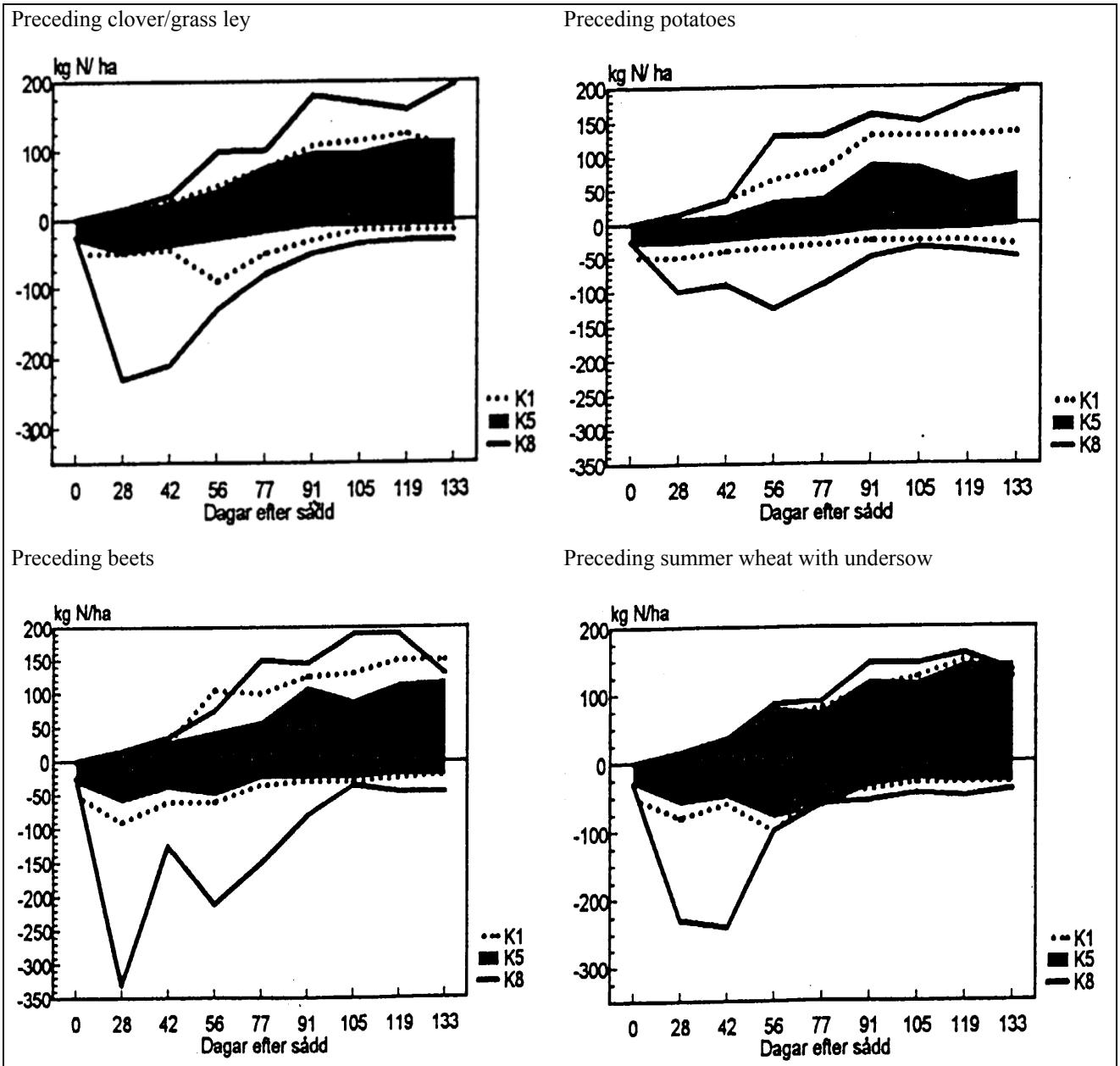


Fig. 30 Amount of N in soil, below 0-level, and in crop, above 0-level, in K1, K5 and K8 with four preceding crops.

In the diagram at the bottom to the left in Fig. 30, is stated that the mineralization in K5 and K8 was equal or larger, than what has been used by the crop up to ca 60 days after the sowing. Thereafter a decrease in the amount of mineral-N in the soil in all fertilization-systems. In the autumn, 80 days after sowing, additional mineralised N had been used by the crop in K1 and K5, in the plots with the preceding clover/grass ley, potatoes and summer wheat with undersow. Mineralization after beets (three years after clover/grass ley in the crop rotation) seems to be insignificant in the autumn. In K8, in the plot with preceding beets, the amount of mineral-N sank in the soil 40 days after sow, without a comparable N-uptake in the crop. The extremely high amount of N in the soil 28 days after sow in this plot, could also point to errors in measuring at this occasion.

Correlation

The huge experimental material at hand, allows comparisons to possible relations with various measurements between; weather conditioned environment in a specific year, of crop development and simple calculations of plant nutrient balance during the experimental period. A presentation of all the possible aspects is restricted by the space available here .

Between measurements

A pronounced relationship was found in potatoes, between various methods of analyses. The correlation of free amino acids, darkening of extract and tissue, extract decomposition, was unequivocal and positive.
Quality indices was positively correlated to yield-level, dry matter content and storage capability and negatively correlated to crude protein content and darkening of tissue.
The free amino acid content was positively correlated with the darkening of extract and with the extract decomposition and negatively correlated with yield-level, quality indices and dry matter content.
The darkening of extract was in all the variants negatively correlated to quality indices and to crystallization values. The extract decomposition was negatively correlated to quality indices and yield-level. The dry matter content was negatively correlated to crude protein content, darkening of tissue and extract and free amino acids and positively correlated to yield-level. The crude-protein content was negatively correlated to quality indices and yield-level.

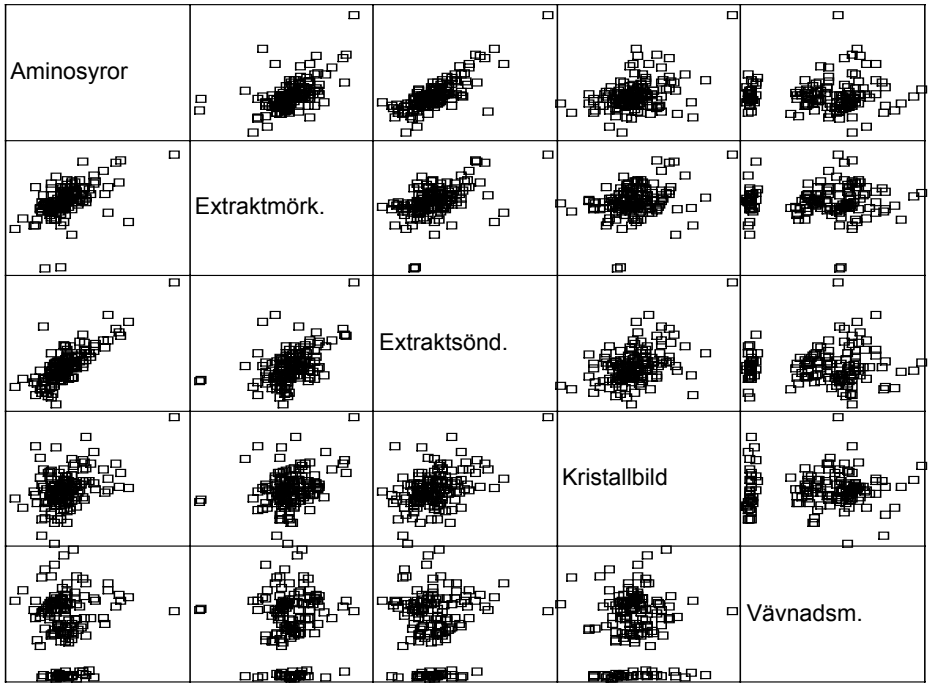


Fig. 31 Graph showing the relation between various measurements in potatoes.
Aminosyror= amino acids, Extraktmörk. = Darkening of extract, Extraktsönd. = decomposition of extract, Kristallbild= crystallization, Vävnadsm. = darkening of tissue.

In Fig. 31 and Table 30 are representations of the correlation of a few different analyses of potatoes. This show among other things, that there was a connection between free amino acid content, darkening of extract and extract decomposition. In these three analyses it was the darkening of extract that deviated most from the other two.
There were also differences between the various variants. As an example, only the quality indices in K1 and K5 was distinctly positive correlated to the yield-level, even if this indices tended to alter when yield-level increased in all variants. The weakest in this tendency was K8. Darkening of tissue in K8 was on the other hand, distinctly positive correlated to the yield-level. In other words, higher yields resulted in a more intense darkening of tissue.

Pearson-correlation	Indices	Yield	Dark.of tissue	Dark.of extract	Extract-decomp..	Crude protein	Free amino a.
Indices	1	0,427**	-0,001	-0,395**	-0,811**	-0,31	-0,778**
Yield	0,427**	1	0,192**	-0,12	-0,369**	-0,431**	-0,473**
Darkening of tissue	-0,001	0,192**	1	-0,131	-0,173*	0,253	0,035
Darkening of extract	-0,395**	-0,12	-0,131	1	0,138	-0,109	0,178*
Extract decomposition	-0,811**	-0,369**	-0,173*	0,138	1	0,502**	0,634**
Crude protein	-0,31	-0,431**	0,253	-0,109	0,502**	1	-1,000
Free amino acids	-0,778**	-0,473**	0,035	0,178*	0,634**	-1,000	1
* = the correlation is significant at 0,05- level				** = the correlation is significant at 0,01- level			
Table 30 Correlations-coefficients for the relation between various measurements in potatoes							

The beets were not analysed extensively. Only the different values in the yields, i.e. root- tops- and fruit-yield, seemed to show distinct relationships. The root-yield was positively correlated to the tops-yield in all variants. A weak tendency was that the root-neck ratio should increase at rising of yield-levels.

In summer wheat the kernel-yield was positively correlated to the straw-yield. Even more distinctly related was the kernel-yield to the fruit-yield. This can be interpreted concerning the kernel-yield, which they increased, more than tops-yield, in good years. There was a positive relation between kernel-yield and germination capacity, dry matter content and 1000-kernel-weight. When the kernel-yield increased, the extract decomposition, free amino acid content, and dry-gluten content, tended to decrease.

The straw-yield showed a positive relation to wet-gluten, otherwise they followed the pattern of the kernel-yield. In years when the fruit-yield was high, i.e. when kernel-yield was high compared to the straw-yield, the kernels tended to have lower gluten contents. In years when the crude protein content was high, a tendency to higher values concerning free amino acid content, higher germination capacity, higher amount of large kernels and higher dry gluten.

On the contrary, tended the extract decomposition to sink in such years. A higher content of free amino acids was connected with lower yields of straw and kernel, lower germination capability, a larger amount of small kernels, higher crude protein content, higher extract decomposition and higher gluten content. In the years when high values in the extract decomposition tended more often to have a lower germination capability. Falling numbers showed a negative relation with the straw-yield, while the relation was positive to germination capacity and the kernel-size.

Dry gluten content was durable positively correlated to the crude protein content, which was not the case with the wet gluten content.

The number of errors in the crystallized pictures was negatively correlated to the falling number, germination capacity, the amount of small kernels, dry matter content, 1000-kernel-weight and volumetric weight .

By comparing the relation between yield-levels in summer wheat the previous year and the levels on the first harvest in the clover/grass ley, the following correlations-coefficients appeared:

variant	K1	K2	K3	K4	K5	K6	K7	K8
Coefficient	0,4079*	0,4482*	0,2958	0,4167*	0,2771	0,1587	0,1542	0,0745
Table 31 Coefficients calculated on correlation between summer wheat-yields in year X and first harvest of ley yr X+1. *show 95% significance.								

The organic variants had a stronger correlation of a good preceding- and a good clover/grass ley-crop than in the case of the mineral fertilizer variants. As the summer wheat served as nurse crop for the clover/grass ley, this could also be of importance. At the same time it is necessary to mention that the fertilization with mineral fertilizers in K6, K7 and K8 seems to have made it difficult for the leguminous plants to establish. Perhaps the mixed ley-grasses and the wheat crop were all to similar in botanical character, to tolerate each other. A good wheat crop could therefore also bring difficulties for the clover/grass ley-grasses to establish. The hibernation of the various clover/grass ley-crops did differ between the variants. In Table 32 is an overview where + means good hibernation and – means bad hibernation of the crop in question.

	Variant							
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
Timothy	-	-	+	+	-	+	+	+
Meadow fescue	+	+	+	+	-	+	-	-
Alsike-clover	+	+	+	-	+	+	+	-
Red clover	+	-	+	-	+	+	+	-
Table 32 Hibernation of the various clover/grass ley crops in different variants.								

In a year with a high first harvest, the yield was usually low in second harvest and vice versa. This did not apply to compost fertilized variants and above all not to K1. It was also differences here between the compost- and raw-manure fertilized variants. In Fig. 32 is seen how the yield-level in the first and second harvest respectively, related to each other in K1 and K3.

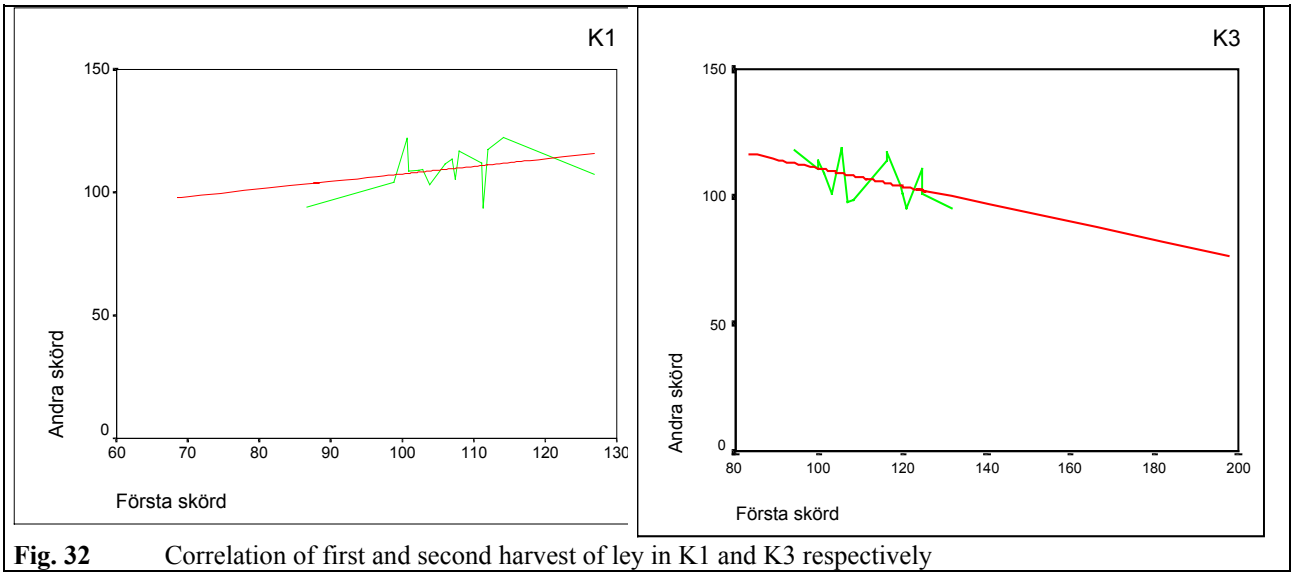


Fig. 32 Correlation of first and second harvest of ley in K1 and K3 respectively

In years with high yield-level in the first harvest, there K2 and K3 positively correlated to the amount leguminous plants, especially lucerne. This also applied to K1 although not in a significant extension. In K6 on the other hand, was a high yield-level negatively correlated with the amount of lucerne and in K7 and K8 it was positively correlated to the amount of grass mix. In the organic fertilized variants tended in other words, the hay-yield to be high during the year when leguminous plants were high. In the mineral fertilized treatments it was instead the ley-grass mix that was important for the origin of the high amounts of yield. In K6 it even seemed that high amount of lucerne in the clover/grass ley more often occurred in years when the amount of yield was low. A high amount of lucerne in the first harvest in K1, K3, K4 and K5 was positively correlated with the amount of lucerne in the second harvest. In K5 and K8 a high amount of lucerne in the first harvest was positively correlated to the amount of red clover. K2 was negatively correlated to the amount of grass mix. In K5 a high amount of red clover in the first harvest, was negatively correlated to the amount of grass mix in the second harvest. In K6 the amount of grass mix in the second harvest was negatively correlated to the amount of red clover in the first harvest, while the amount of grass mix in the first harvest in K7 was negatively correlated to the amount of lucerne.

With weather in a specific year

The interaction between the crop and the world around us has been investigated after-wards, in terms of precipitation, temperature and the length of the farming season, beginning and end. With the help of weather-data for the experimental location, the total of precipitation and temperature has been calculated, partly in the period 1/5 to 30/6 partly in the period 1/5 to the last of October. Hopefully, the first total can facilitate to find the effect of early summer draught on the crop. During dry years the trial was irrigated, why the importance of the draught cannot fully be appreciated. The below description is based on measurements that, according to a calculated correlation, with more than 95 % accuracy, are related to one another.

Temperature

Years with a lot of warmth in early summer, i.e. high total temperature up and until 30/6 tended to correspond with the following properties in crops; potatoes had larger amount of big tubers with a higher content of dry matter and crude protein and higher values in the extract decomposition. At the same time, it was generally lower yield and measures for darkening of extract and tissue. The rising in temperature-total did not influence the beets. Summer wheat on the other hand, tended to get higher straw-yield, volyme-weigth, dry matter content and better germination capacity during years with early summer-warmth. Furthermore, it was generally; lower extract decomposition, lower contents of organic acids and lower amount of kernel in total yield. The latter indicates that the straw-yield increased more vigorously than the kernel-yield. The clover/-grass ley was harvested first time, usually around midsummer every year. Warm early summers gave more often higher clover/grass ley-yield, which applies, to the first, as well as the second harvest. The amount of grass was higher in the first, as well as the second harvest when early summer was warmer. The same applied to the amount of red clover in the first harvest. Furthermore, lower amount of lucerne in the first, as well as the second harvest. Also the crude protein content was lower after a warm early summer. If the warmth kept on during the whole farming season it was generally a higher amount of small potatoes in the yield. At the same time, was the extract decomposition in potatoes higher in contents of dry matter and crude protein. Furthermore, during such years, more error-units in the crystallized pictures occurred. The yield tended to become lower, as well as storage losses and the darkening of extract. In summer wheat was a tendency to higher straw-yield and a greater amount of small kernels at

the same time as the measurements for dry matter content, organic acids, wet gluten and the content of free amino acids got higher. In warm years it was furthermore, generally lower 1000-kernel-weigth, higher crude protein content, lower germination capability and lower extract decomposition. The clover/grass ley reacted in warm years with higher contents of crude protein and higher amount of red clover in the first harvest. The second harvest tended to be higher, while the amount of lucerne on the other hand was lower in the second harvest.

Precipitation

In years when it was much rain up until midsummer, it was generally higher yields in potatoes, a larger amount of small and medium-sized potatoes, higher dry matter content and a better storage-efficiency. In the few measures made on the beets, there were no signs of any relationship to the precipitation up to 1 of July. In wheat, after rainy early summers, it was generally higher falling number and higher 1000-kernel-weight. Furthermore, the germination capability and the content in dry gluten tended to increase. On the contrary, did a decrease occur in the amount of large kernels in the total-yield, as well as the content in organic acids.

When precipitation (rainfall) had been high during the whole summer, in potatoes it was generally higher levels of yield, especially in medium-sized potatoes and higher values in the darkening of extract. On the other hand, the amount of large potatoes was lower, as well as the storage-capability. After a summer rich in precipitation, it was in the beets generally higher yield of root and leaves. In wheat during these years, the amount of large kernels was usually higher, combined with higher crude protein content, better germination capability and higher falling number. The number of error units in crystallized picture tended to be fewer, the contents in free amino acids, wet gluten and organic acids was lower, as well as the measures for extract decomposition. When heavy rainfall occurred during the summer it was generally higher content of red clover and lower content of lucerne in the first harvest and higher amount of grass in the second harvest.

Date of sowing

In years when the potatoes was planted later than usual, generally the new tubers got higher measured values in extract decomposition and higher content of free amino acids. Furthermore, the potatoes storage-efficiency got worse and the error units in the crystallized picture increased. When planted at a later date, the potatoes tended to get lower contents of dry matter and lower measures in the darkening of extract. In the beets a relation to the date of sowing could not be indicated. If the wheat was sowed at a later date, then by the time for harvest, it was generally higher contents of wet gluten, free amino acids, dry matter and organic acids. Furthermore, a late sowing was related to an increase in small kernels and higher values in extract decomposition. On the other hand, tended the crude protein content to sink as well as the falling number, while germination capability and the kernel-size surprisingly seemed to increase. The sowing of the clover/grass ley was determined to the date when it was undersowed in the summer wheat crop. A late sowing of clover/grass ley had a tendency to increase the amount of lucerne in the first harvest and the amount of clover in the second harvest.

Date of harvest

In years when potatoes were harvested at a later date than usual, it was generally higher yield, higher amount of large potatoes and an increase of error units in the crystallized pictures. In such years tended the values for darkening of extract to be lower.

A late harvest of summer wheat frequently gave higher straw-yields, higher amount of small kernels and higher contents of dry- and wet gluten. In these years the kernel-yield tended to be lower as well as the amount of kernel in the total yield. In addition to that also a decrease in germination capability. A later first harvest of clover/grass ley, was related to higher amount of grass in the first, as well as in the second harvest. The second harvest also tended to be higher during such years. Contrary, at late harvest, it was generally lower yield-levels and lower amount of red clover in the first harvest. The amount of lucerne in the second harvest tended to decrease when the clover/grass ley at a later date, was harvested for the first time.

Length of farming season

A long farming season in the potatoes was related to higher amount of large potatoes, higher yield, higher dry matter content, higher values in extract decomposition and an increase of error units in the crystallized pictures. In such years it was generally low values in the darkening of tissue, as well as extract. In beets a long vegetation-time was related to, better storage-efficiency and a higher amount of roots in the total-yield. This probably depended on the fact that the tops-yield in such years, tended to sink even thou this could not be determined with statistical significance. When summer wheat could grow during a long season it was generally higher contents of organic acids, wet gluten, dry matter and free amino acids. Such years, was also related to a higher amount of kernels and higher values in extract decomposition. Furthermore, the amount of kernel was higher in the total-yield these years. Besides, this was not related to any decrease in the straw-yield. On the contrary, there was a decrease in the contents of crude protein as well as in the falling number and germination capability. During the years when farming seasons was long, it seems in other words, as if the summer wheat characteristics was more pronounced by late harvest rather than an early sowing. When the clover/grass ley could develop a longer time until the first harvest, this was related to higher crude protein content and higher amount of leguminous plants in the first harvest.

The development during the experimental period

The beets showed increasing yield-levels up until 1963 and then decreasing until 1970. In the mid-70´s the highest yield-levels during the whole experimental period was noted. The yields then decreased slightly, later to regain a lesser maximum in the mid-80´s. With the exception of the harvest-depression in the mid-60´s did the tops-yields reasonably follow the development of the root yield-levels. The lower leaf yield in the beginning of the trial was probably because red beets that was grown. The increase in yield was most intensive in K7, K3 and K1 while K5 had a distinctly deviated yield-fashion. Also the contents of dry matter increased during the trial period, strongest in K5 but also in K6, K1 and K4. In K6 the storage efficiency degenerated during the trial.

The yield-levels in potatoes were generally very low in the first years, but increased and reached a first maximum in the end of the 60´s. In the beginning of the 70´s did the yield-levels sink slightly, and then again reach a maximum in the first years of the 80´s. In potatoes all the variants have a positive yield-fashion even if not statistically significant in K5 and K6. The yields increased distinctly in K8 followed by K1, K3, K7, K4 and K2. This crop also tended to increase in the content of dry matter during the trial, most distinct in K8 followed by K1 and K5. The number of error units in the crystallized pictures in-creased during the trial period. The difference was significant in all variants, except K6 and K2, and clearest in K7. Values in darkening of tissue tended to get low during the trial period. This tendency was significant in K1, K4, K2, K5, K6, and K3. Values in K7 and K8 decreased only marginally. Fig. 32 presents the calculated fashion for the various crops with, from top to bottom; beets, potatoes, first-yield of clover/grass ley and summer wheat.

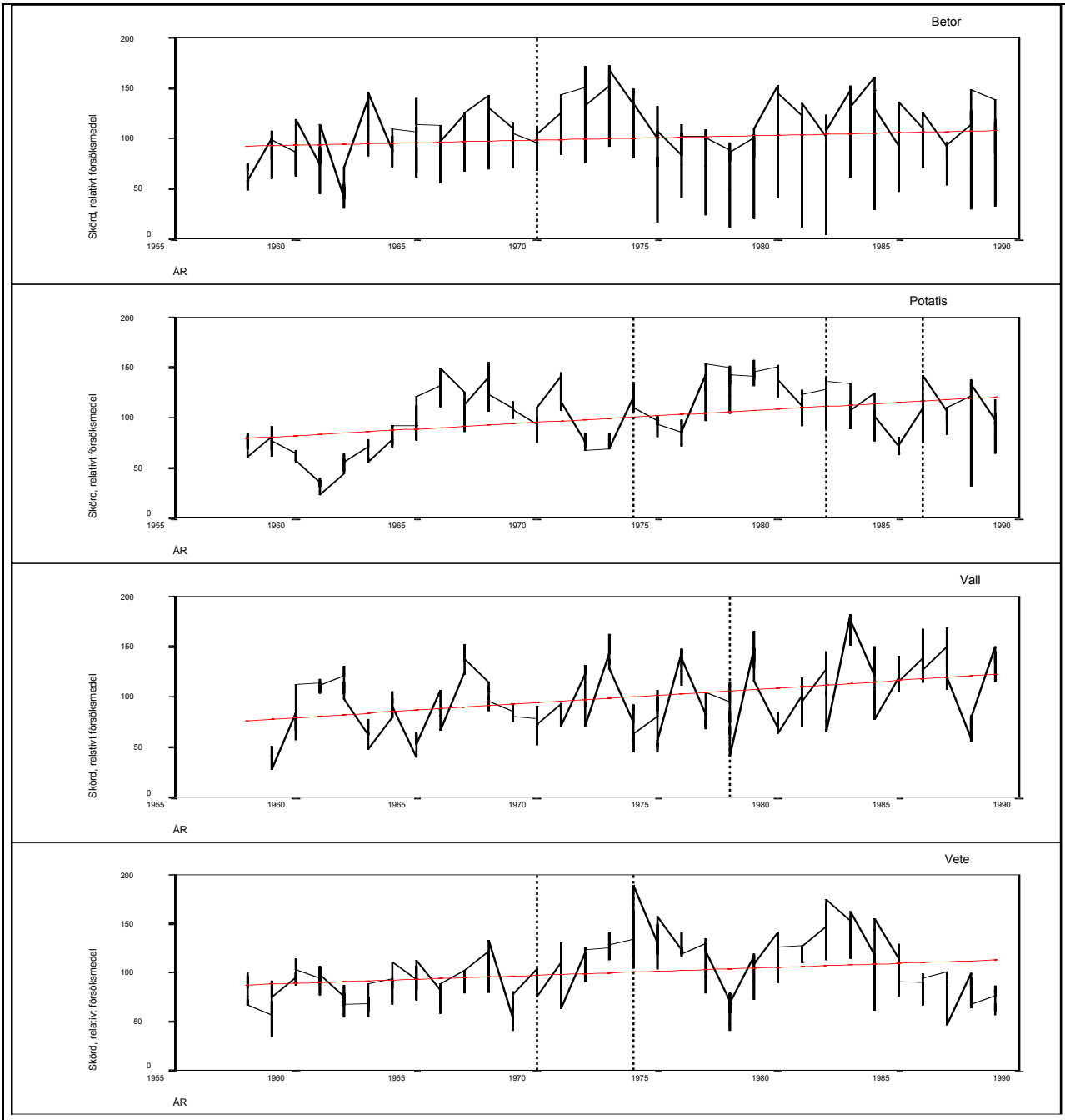


Fig. 32 Regression-analysis of yield development. Vertical lines soils change of variety. The values represent relative trial-mean. Crops in diagram's from upper; beets, potato, lay, wheat.

The variation in the clover/grass ley-yields was high in between years. The clover/grass ley had a slower, but steadier alteration of yield-levels during the experimental trial. The alteration was slightly lesser in the mineral fertilized variants than the other variants. The highest yields, on the whole, were obtained around 1983. The values from the second harvest followed more or less the first harvests, distinctly in K2 followed by K4, K3 and K1.

The yield levels in the wheat crop were steadily altered during the trial-period. The mineral fertilized treatments tended to reach a maximum already in the mid 70´s, while yield levels in K1, K2 and K3 also were distinctly altered in the beginning of the 80´s. Most of the variants reached a maximum in the kernel-yields during the first years in the 80´s. Thereafter a dramatic decrease in levels occurred in K8. The straw-yield increased more distinctly than the kernel-yields. Concerning the kernel-yield the increase was apparent in K2 followed by K1, while the straw-yield distinctly tended to rise in K1 followed by K3, K2 and K6. On average, in all variants, the free amino acid content tended to sink during the trial period, as well as the germination capability. On the other hand, the measured values seemed to rise in dry matter content, wet- and dry gluten content, volumetric- and 1000-kernel-weight. The gluten content was distinctly altered in K7 while the 1000-kernel- and the volumetric-weight increased significant in K8.

If instead, one compares the development in the various variants, then the picture emerges, that in a very small format is represented in Fig. 34. The calculation is done with annual mean value as comparison. The figures show in other words, if the yield-level has risen or sunken compared to one another. The most positive development is displayed by K1 while the yields in K5 developed negatively compared to the other variants. Also here is shown a tendency, that K8 had difficulties to maintain its position, towards the rest of the variants during the end of the trial period.

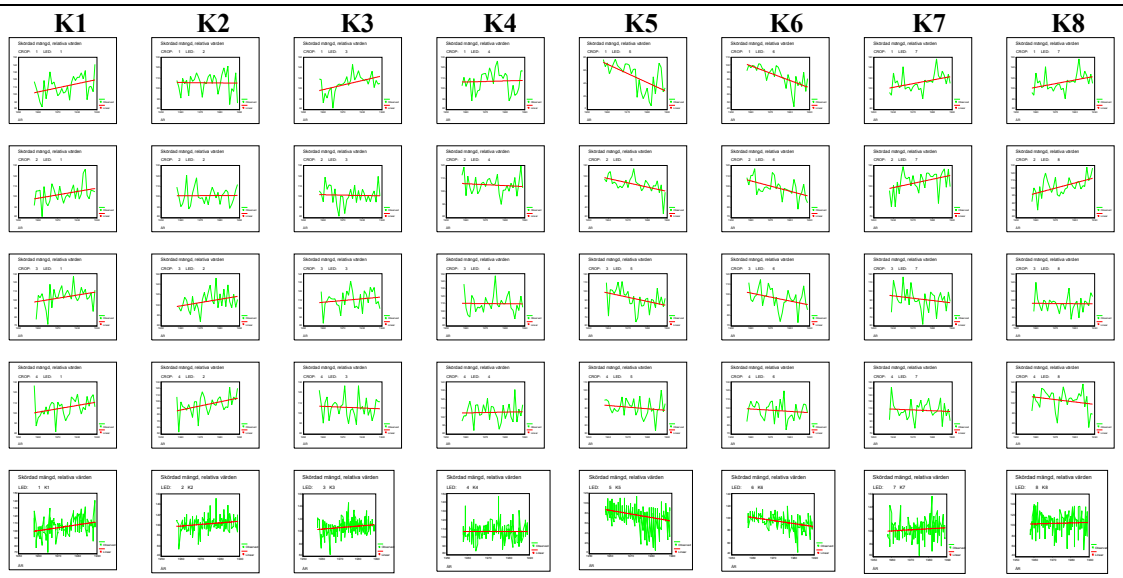


Fig. 34 The yield development in various variants during the trial-period. The development relates to the annual mean value.

Concerning the soil, calculations has been based only on the values from the soil surveys, which were performed during the entire experimental period. The tendencies were, that contents of potassium in the topsoil decreased, except in K3 and K7. The amount of easy soluble phosphorus increased significant during the trial-period. Apparent was the increase in K1, K2 and K3 while the contents tended to decrease in K5 and K6. Up and until 1980 the pH-value decreased significant, most evident in K5

Plant nutrient balance

In an attempt to theoretically calculate the prolongation of different nutrients, a simple plant nutrient-balance has been established. This balance consists of two items;

- with the fertilizer - the supplied amount of nutrient
- with the crop - the abducted amount of nutrient

nutrient	supplied amount calculated as;	abducted amount calculated as;
Carbon	% of measured amount dm in fertilizer	-
Nitrogen	amount of N in fertilizer according to analysis	crude protein content for the crops and variants has served as basis
Phosphorus	amount of P in fertilizer according to analysis	template values for the different crops with consideration to dm-content (dry matter)
Potassium	amount of K in fertilizer according to analysis	template values for the different crops with consideration to dm-content (dry matter)

Table 32 Calculation-basis when establishing the plant nutrient-balance.

The plant nutrient-balance for the different variants is presented in Fig. 35. As seen in the Fig. all variants are calculated as to have had a deficit of potassium. The deficit was at a min. in K3 and at max. in K5 and K6.
Only K8, and close enough K3, received more N than the abducted N. K5 and K6 was also here obviously low, as well as K4 and K7.
K1, K2, K7 and K8 were well supported in phosphorus, mainly during the later part of the experiment. The other variants had, more or less a balance in the P-economizing.
K1 and K2 had furthermore, received through the fertilization 52480 kg C/ ha, as the trial went on. K3 received 52544 kg C/ ha and K4 26304 kg C/ ha (according to the calculations in *Pettersson, Reents and Wistinghausen (1992).*

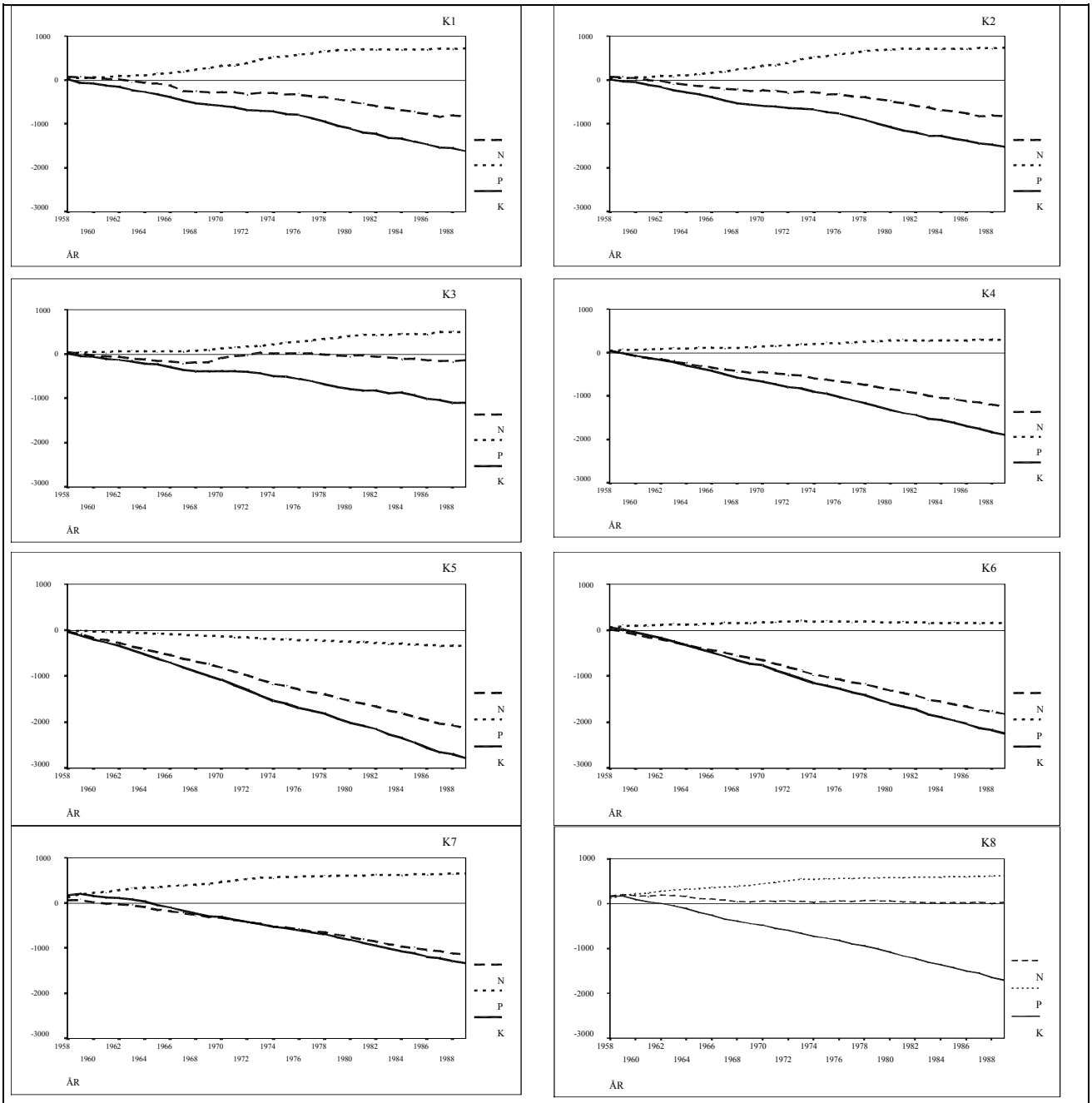


Fig. 34 Simplified nutrient-balance in kg/ha for nitrogen, phosphorus and potassium.

Comparisons

Characteristics of the variants

K1

The experimental variant is characterized by a good humus-build-up that rapidly became deep going, all the way down to the subsoil. The high C-N ratio throughout, in all soil-depths, suggests that the treatments strongly stimulated to structural build-up rather than mediate prolongation. Perhaps this contributed to the fact that K1 showed the best buffering capability contra lowering of pH-value in the soil. If the chemical- physiological measures suggest a structural-build-up, then the biological parameters show a high life-activity in the soil. K1 together with K3, were highest in most of the measures.

Yield-wise, K1 did not differ from the majority of the variants. The weakest crop, yield-wise, was the first harvest of clover/grass ley. Calculated in relative values, the development in yields was most positive in this variant.

The potatoes that was yielded from the variant was characterized by low attacks of late blight, less amount of horizontal stems per erect stem and thereby a more vertical growth habit, good storage properties and good potatoe flavour, but with certain extraneous flavour of earth and bitters. The crude protein content tended to be low with a high content of true protein. Also the contents were low in free amino acids and the values for darkening of extract and tissue. The tubers showed great resistance against inoculation of injurious fungus and high values on quality indices and few error-units in the crystallized pictures. Measured values for darkening of tissue, decreased significant in K1, than on average in the trial during the entire period. The beets grown in the variant, had a tendency to more spherical form, than in the other variants and good storage properties. Summer wheat displayed insignificant inclination to lodged stands of cereal, straw-length above average for the trial, high amount of large kernels, relatively high falling number and high contents of gluten and few error-units in the crystallized picture. During the trial period, the germination capability in the kernels increased significant in K1, compared to the mean value within the trial. The clover/grass ley displayed a high amount of leguminous plants, especially lucerne.

K2

K2 was characterized by a relatively good humus build-up, especially in the topsoil. The soil displayed a surprisingly good buffering capability and during the latter part of the trial-period high values of easy soluble phosphorus. Also the soil biological measures showed relatively high values, especially in the topsoil.

Yield-wise, K2 was placed around the mean value for the trial. It was the clover/grass ley crop that gave the best yield, compared to all other variants. Yield-levels for summer wheat was in K2 distinctly below average for the trial in kernel, as well as straw. This is difficult to explain especially as K1 had, on average 10 % higher yield of wheat during the trial period and this will be brought up to discussion in connection to the biodynamic preparations. It was observed during the whole trial-period, that the summer wheat yields developed significant more positive than the average for the trial. In relative values, conclusive for all crops, the development within K2 was the second best of all variants during the 32 years of ongoing trial. This can be interpreted as such, that the initial conditions within the experimental-plot was slightly worse in K2 than the rest of the plots, which could be observed especially in the unfertilised summer wheat crop.

The potatoe crop had relatively few attacks of late blight, good potatoe-flavour with few extraneous flavours, high amount of true protein derived from the crude protein, the lowest value of darkening of extract of all the variants and few error-units in the crystallised picture. The beets had a relatively high tops-yield and good storage properties. In relationship to all other variants, did the fruit-yield increase in K2 significant. The summer wheat denoted through; low contents of free amino acids, high falling number, low decomposition inclination, low dry gluten content, but relatively high wet gluten content and relatively large kernels.

K3

K3 was characterized by a very strong biological activity in the soil and a relatively good humus build-up. The buffering capability was lower than in the compost-fertilized variants. The content of easy-soluble phosphorus did not deviate noticeably from the other variants, while potassium values were high.

Yield-wise, K3 was placed above the average. The first harvest of clover/grass ley was the best-yielded crop, in relationship to the other variants. Yield development in beets was significant more positive in K3 than on average within the trial. This also applied to straw-yield of summer wheat. K3 had the third best yield development of all variants, if the relative annual mean value was used at the comparison.

The potatoes in K3 was intensively attacked by late blight, the tubers had a tendency to earth-flavour and to very low values in extract decomposition. The number of error-units in the crystallized picture was relatively high. The beets had a high amount of roots of the total-yield, while the wheat had high yields of kernel, as well as straw and relatively large kernels. The clover/grass ley in K3 was distinguished by a high amount of grass in the first harvest.

K4

The variant was characterized by a relatively low buffering capability and low contents easy-soluble phosphorus and also to some extent potassium. The humus build-up was relatively good and soil-relations tend to strongly emphasise structure, rather than prolongation.

Yield-wise, K4 was placed substantially above average among the variants. It was only the second harvest of the clover/grass ley that deviated slightly by lower yield-levels. Measured with relative numbers in K4, the yield-level hardly developed at all. This means that the treatment by large, followed the average yield-development within the experiment.
The potatoes had very large attacks of late blight, relatively large storage losses, weak potato-flavour, especially directly after harvest. The variant also presented a high amount of large potatoes and a low amount of small potatoes. At analyses appeared; high contents of free amino acids, low quality indices, high values for darkening of extract and extract decomposition. Furthermore, the tubers from this variant was highly sensitive to inoculated fungus invasion. The variant also presented low values of quality indices. Measurements in darkening of tissue on the other hand, decreased significant in K4, than on average for the whole experiment during the trial period. The beets had relatively good storage-properties and a low dry matter content. Summer wheat showed a high amount in kernel of the total yield, high values for extract decomposition, low contents of free amino acids and low falling number. Furthermore, the kernels were relatively large and showed a high germination capability. The clover/grass ley was distinguished by a high amount of grass and low crude protein content.

K5
K5 presented a very low buffering capability, low values in easy-soluble potassium and very low values of easy-soluble phosphorus. The humus build-up and the soil biological activity were comparable with the average for the trial.
Yield-wise, it was only the second harvest of clover/grass ley, which reached to similar levels as the other variants. Especially the yield of beetroots was very low, and of all the crops did K5 have a distinctly negative yield-development, which was most evident in beets and potatoes. This also applied if one calculated the development in relative numbers.
The crops from K5 presented good storage properties and relative high contents of dry matter. Measurements for free amino acids and extract decomposition in potatoes were low, while quality indices were very high. On the other hand, there were relatively many error-units in the crystallized pictures. The amount of small potatoes was very high. The potatoe crop showed a very small inclination to be infested by late blight, while invasions at the inoculation directly into the tuber, showed the average values for the trial. The taste on the potatoes was distinctly without extraneous flavour. In relationship to the other variants during the trial period, there was in K5, a significant increase in crude protein and free amino acids. The summer wheat showed low contents in gluten, free amino acids and crude protein. The amount of small kernels was high and the number of error-units in the crystallized pictures was high. The clover/grass ley consisted to a very high degree, of red clover especially in the second harvest.

K6
K6 presented a low buffering capability and low contents of easy-soluble phosphorus and potassium. The humus build-up was low, as well as the soil biological values.
Yield-wise, the variant was below the average values for the trial, especially what applies to the yield of beetroot and beet-tops. Yield development in potatoes and beets during the trial period, was significant more negative than trial-average. As an average for all crops, K6 had a negative yield development. Only the development in K5 was worse in this sense.
The potatoes in K6 was relatively receptive to late blight, it had a large amount of small potatoes when harvested, high measures for darkening of extract and tissue decomposition, a high amount of crude protein but a low amount of free amino acids. Taste-wise the bitter extraneous flavour was present directly after harvest. The clover/grass ley had a relatively high amount of red clover, while the amount of lucerne was low. The summer wheat crop showed a relatively high amount of kernel in the total-yield, high contents of free amino acids and high values in falling number and extract decomposition and also in the gluten contents, to some extent. On the other hand, measures for crude protein was relatively low and decreased significant in K6 than on average for the experiment during the trial period.

K7
K7 had a relatively low buffering capability and high value of easy-soluble phosphorus and potassium. The humus build-up was slow. The soil within the variant showed low values in the soil biological parameters.
Yield-wise, K7 was high in all crops, except in the clover/grass ley, where the first harvest was low and the second harvest showed a high variety in amount. The yields of beets and potatoes developed in K7 significant more positively than on trial-average. Calculated as an average for all the crops, then the development within K7 was the fourth best in the trial. This applies if relative annual mean values are used when calculating.
The beets had a high amount of roots in the total-yield, high dry matter contents and a low storage capability. The low storage capability also applies for potatoe, but in this crop the content of dry matter was relatively low. K7 was relatively sensitive towards invasion of late blight and also showed relatively little resistance to fungi-invasion at the inoculation. Concerning the taste-values was the potatoe-flavour relatively weak and the extraneous flavours was evident when tested directly after harvest. Measures for darkening of tissue and extract was high, as well as the number of error-units in the crystallized pictures. Measures for darkening of tissue increased, while the crude protein content decreased during the trial period, in such a way, that it deviated significant from the average for the trial. The clover/grass ley crop presented high amounts of grass in the first, as well as the second harvest, while the amount of lucerne was low. The amount of lucerne in the first harvest developed significant negative in comparison to trial-

average. It was relatively much red clover in the second harvest. Summer wheat had a high straw-yield and high contents of free amino acids. On the other hand, the measures were low for extract decomposition, gluten contents and the amount of large kernels. The content of dry gluten in-creased during the trial period.

K8

K8 presented a relatively good buffering capability, this could probably result from the usage of calcium and ammonium nitrate in this variant. The contents of phosphorus and potassium were high, while the humus build-up was slow. The N-contents in the soil was high, while the soil biological measures were very low.

Yield-wise, K8 was high in most of the crops, except clover/grass ley. The development of the potatoe-yield and the fruit-yield in the beets, deviated significant positive from the average in the trial during the period. Calculated as relative annual mean value, did K8 have a weak development. This could be due to the relative intense mineral fertilization in K8, and from start reached a high level, that could not be altered as much as the rest of the variants. As an average for all crops, K1 as well as K2, K3 and K7 had a more positive development.

The beets had a very low amount of roots compared to the total-yield and bad storage properties. The potatoes were very sensitive to late blight infestation and had bad storage properties. Taste-wise, the potatoes had a good flavour directly after harvest, but less evident potatoe flavour after storage. Measures of free amino acids, darkening of extract and tissue, extract decomposition, crude protein content was very high. The value for quality indices was distinctly lowest among the variants and the number of error-units in crystallized pictures was high. The variant also denoted in a very high amount of large potatoes. In the clover/grass ley was measured low values of crude protein. The amount of grass was very high in the first, as well as the second harvest, while the amount of leguminous plants were low, especially lucerne. K8 had during the trial period a significant more negative development in the amount of red clover in the first harvest than on average for the trial. Summer wheat showed a relatively low kernel-yield in relation to the total-yield, very high contents of crude protein and high values in extract decomposition. The falling number was very low, while the gluten contents were high. The 1000-kernel-weight in-creased significant more in K8, than average for trial during the experimental period.

Comparisons between various types of fertilizer-variants

Organic or mineral fertilizer
Here four different groups will be compared; unfertilised variant, organic fertilized variant, mineral fertilized variant and the mixed fertilized, where both organic and mineral fertilizer was used. These four will forthwith be described as:

Unfertilised = K5
Organic fertilizer = mean values for K1, K2 and K3
Mix of organic and mineral fertilizers = K4
Mineral fertilizer = mean values for K7 and K8

K6 has been omitted in this comparison, to get fertilizer-groups with approx. equal yield-levels, except the unfertilised variant.

Soil
Of the investigated properties in the soil, it was above all in the biological parameters that differences emerged between variants. The differences were foremost located in the topsoil-layer.

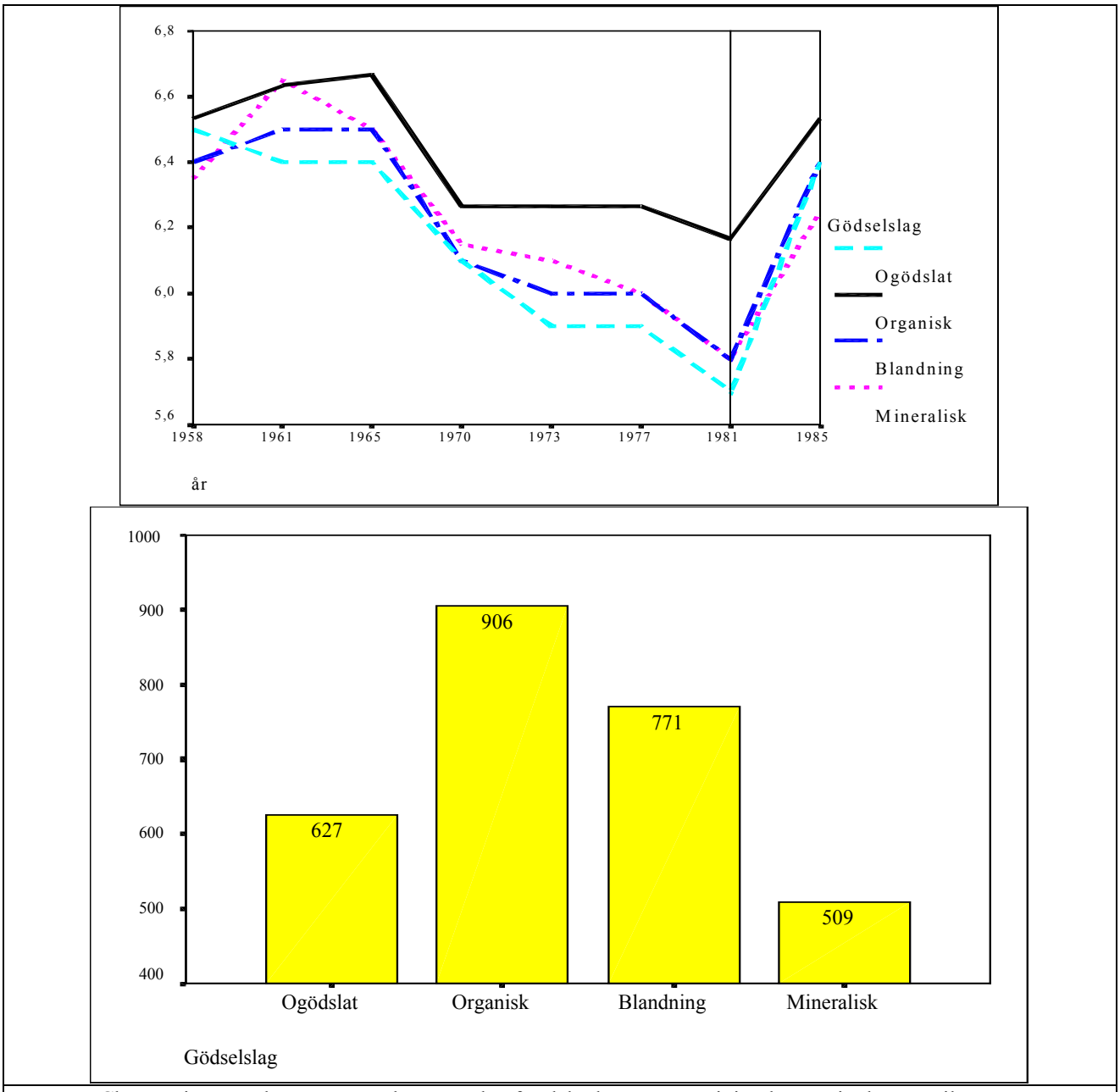


Fig. 36 Changes in pH-value, upper, and mean value for dehydrogenase-activity, lower, in the topsoil. Ogödslat= unfertilised, Organisk= organic manure, Blandning= mixture of organic and mineral fertilisers, Mineralisk= mineral fertiliser

The amount of earthworms was highest in the organic fertilized group, at two of three measurings. The lowest amount of earthworms, was found in the mineral fertilized group on all three occasions.
The biological turnover in the soil measured as the dehydrogenase and urease activity and soil respiration was highest in the organic fertilized group and lowest in the mineral fertilised. The mixed fertilized variant was slightly higher than the unfertilised variant. Concerning urease activity, the mixed fertilized variant was on the whole, at the same level as the organic fertilized group. The content of plant nutrients showed no great differences between the fertilized variant. The mineral fertilized group tended to have the highest value. Above all did this apply to the phosphorus content. In the soil chemical traits the pH–value also deserves to be mentioned. The organic fertilized group displayed distinctly higher pH-values than all the other variants, especially during the period 1970-1980.

Potatoes
The yield of potatoes was relatively equal among the three fertilized groups. Infestation of late blight fungus in the potatoes was significant higher in the mineral fertilized group compared to the organic fertilized group and the unfertilised variant. At the fungi occulation of the potatoe-tissue, the organic fertilized group, showed definitely the greatest resistance. The largest spread of fungi-infestation was in the mineral fertilized group. The amount of erect stems/habitat was distinctly highest in the organic fertilized variant. The difference was however, significant only in comparison with the unfertilised variant that had the lowest amount of erect stems. The largest amount horizontal stems were shown in the mineral fertilized group. The differences here were significant in relation to all other groups. The amount of prima potatoes was significant lower in the mineral fertilized group in comparison with both the organic fertilized and the mixed fertilized group. This applied to the sorting after harvest, as well as to the sorting after storage. Concerning the taste-tests it was the organic fertilized group that had the highest values in potatoe-flavour. At the taste-samples directly after autumn harvest, the difference was not as great in relation to the other variants, while the taste-samples after the storage becomes significant com-pared to all the other groups.

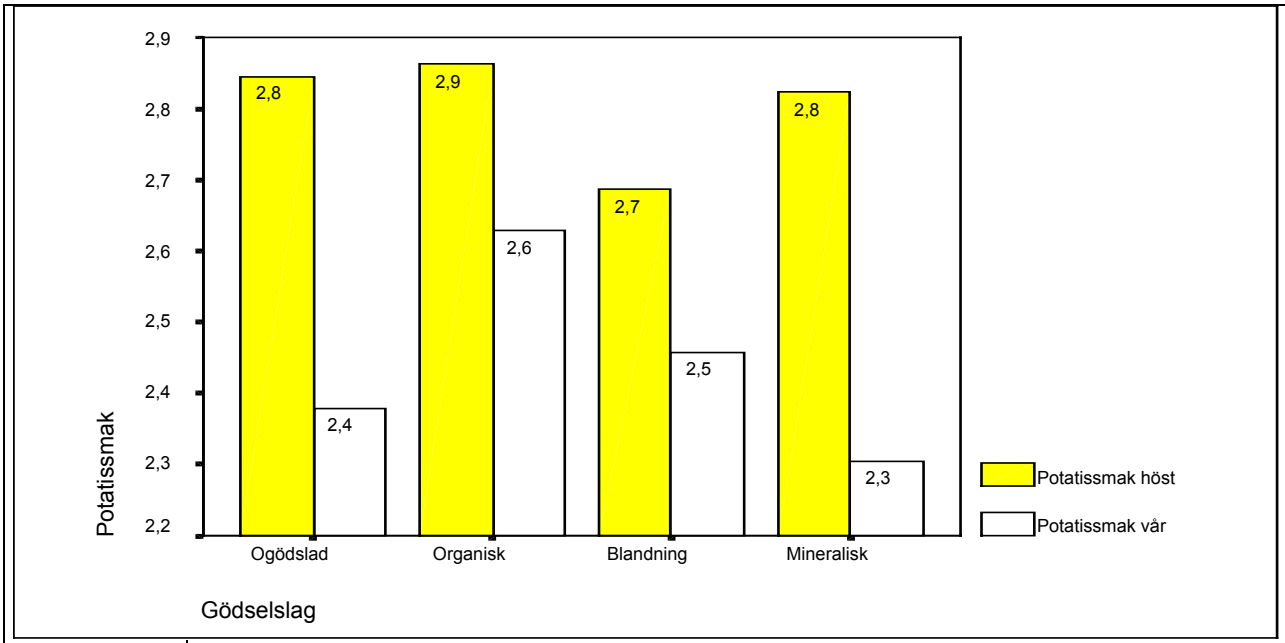


Fig. 36 Potatoe flavour, autumn(potatissmak host) and spring-values (potatissmak vår). Highest positive taste-value = 5
Ogödslat= unfertilised, Organisk= organic manure, Blandning= mixture of organic and mineral fertilisers, Mineralisk= mineral fertiliser

The mixed fertilized and the mineral fertilized group showed at the autumn relatively good flavour-values which however, distinctly detoriated after storage. In the autumn, the un-fertilized group had the lowest values in bitters- and earth-flavour, and in both cases followed by the organic fertilized group. In the autumn, the mineral fertilized group was the source to potatoes with the most pronounced earth-flavour. In the spring, potatoes with earth-flavour were found foremost in the mixed fertilized variant. The unfertilised variant had significant higher amount small potatoes and lower amount of large potatoes in comparison with the mineral fertilized group. The dry matter content was significant lower in the mineral fertilized group in comparison to the unfertilised variant, as well as the organic fertilized group. Concerning the crude protein, the mineral fertilized group had significant higher contents than the other three fertilizer-variants. The same applied also for the values in extract decomposition, the content of free amino acids and in the values of darkening of tissue. The unfertilised variant was lowest concerning the measures of darkening of extract followed by the organic fertilized group. The calculated value of quality indices according to Pettersson, was in the unfertilised variant and the organic fertilized group significant higher than in the mineral fertilized.

The point of error in the valuation of the crystallised pictures did not differ significant between the various fertilizer-groups. The organic fertilized group had the least amount of error-units in the crystal-picture, while the mineral fertilized group had the largest amount of error-units. The values are seen in Fig. 37

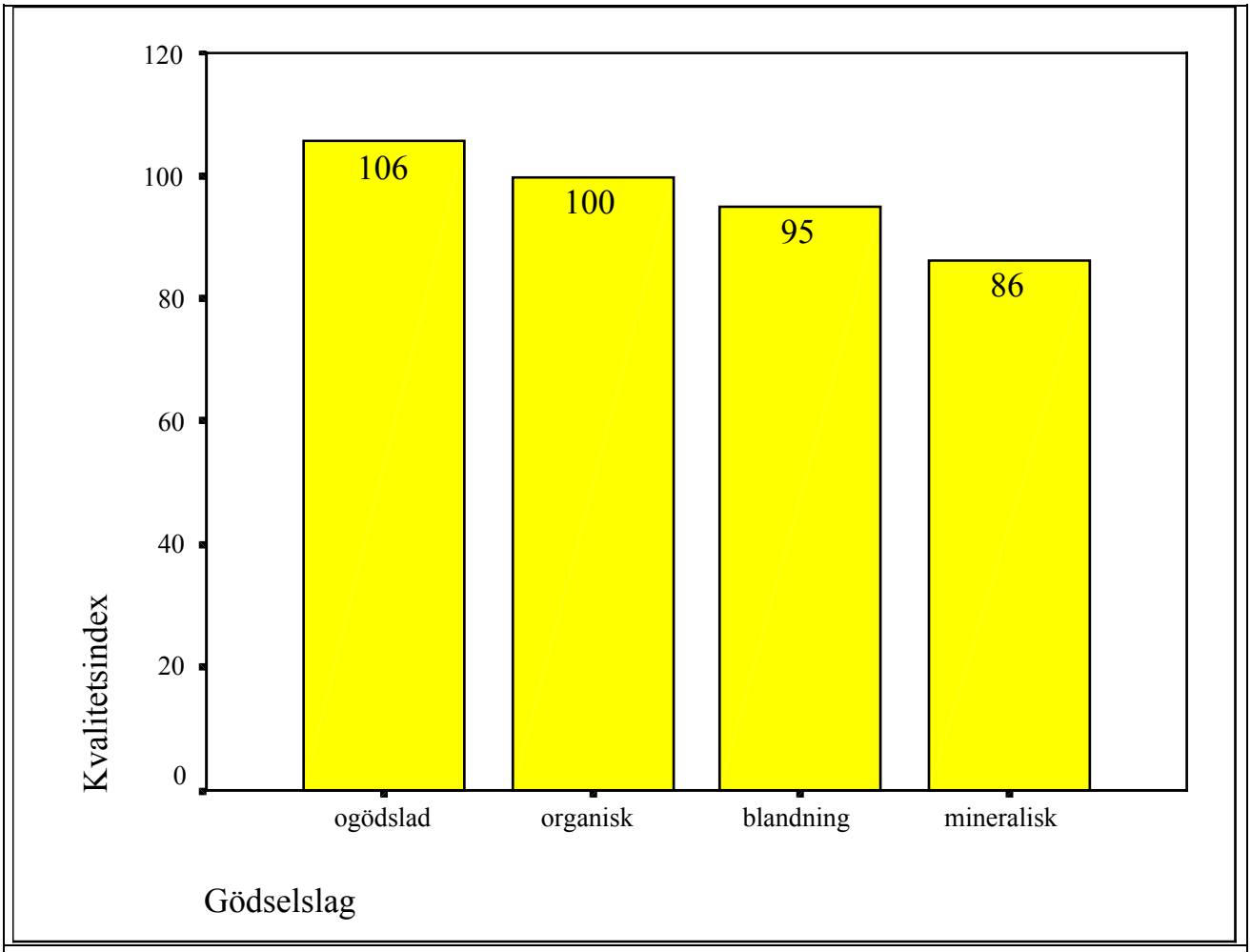


Fig. 37 Quality indices in potatoes.
Ogödslat= unfertilised, Organisk= organic manure, Blandning= mixture of organic and mineral fertilisers, Mineralisk= mineral fertiliser

Beets

In the beets, all the fertilized groups gave significant higher yield than the unfertilised variant. Among the rest, no significant differences were found concerning the root-yield. The yields in the different groups are seen in Table 32.

	Unfertilised	Organic	Mixed	Mineral
Root-yield, kg/ha	21327	45797	44993	48002
Tops-yield kg/ha	19165	36014	36450	38899
Fruit-yield %	51,1	56,3	55,6	55,7

Table 32 Levels in yield in beets with different types of fertilizers.
Mean value 1958-1989.

In 31 of 33 years gave the unfertilised variant the lowest yield, while some mineral fertilised variant gave the highest yield during 15 years and some organic fertilized variant gave the highest yield during 13 years. Also concerning the tops-yield deviated the unfertilised variant from the rest of the group. Here the differences were significant between mineral and organic fertilizing. The organic fertilized group differ from the rest by having higher fruit-yield. The difference in amounts of prima beets was very small after when sorting after the harvest. The unfertilised variant had a slightly lower amount of prima roots. At the sorting after six - seven months of storage were the differences somewhat larger although not in a significant way. The highest amount of prima roots was found in the organic fertilized group followed by the mixed fertilized group, the unfertilised and lastly the mineral fertilized. At the investigations of extract decomposition, the mineral fertilized group gave significant higher values than the organic fertilized group. The content of dry matter was significant lower in the mixed fertilized variant compared to the purely mineral fertilized group. Among the rest no significant differences was appreciable.

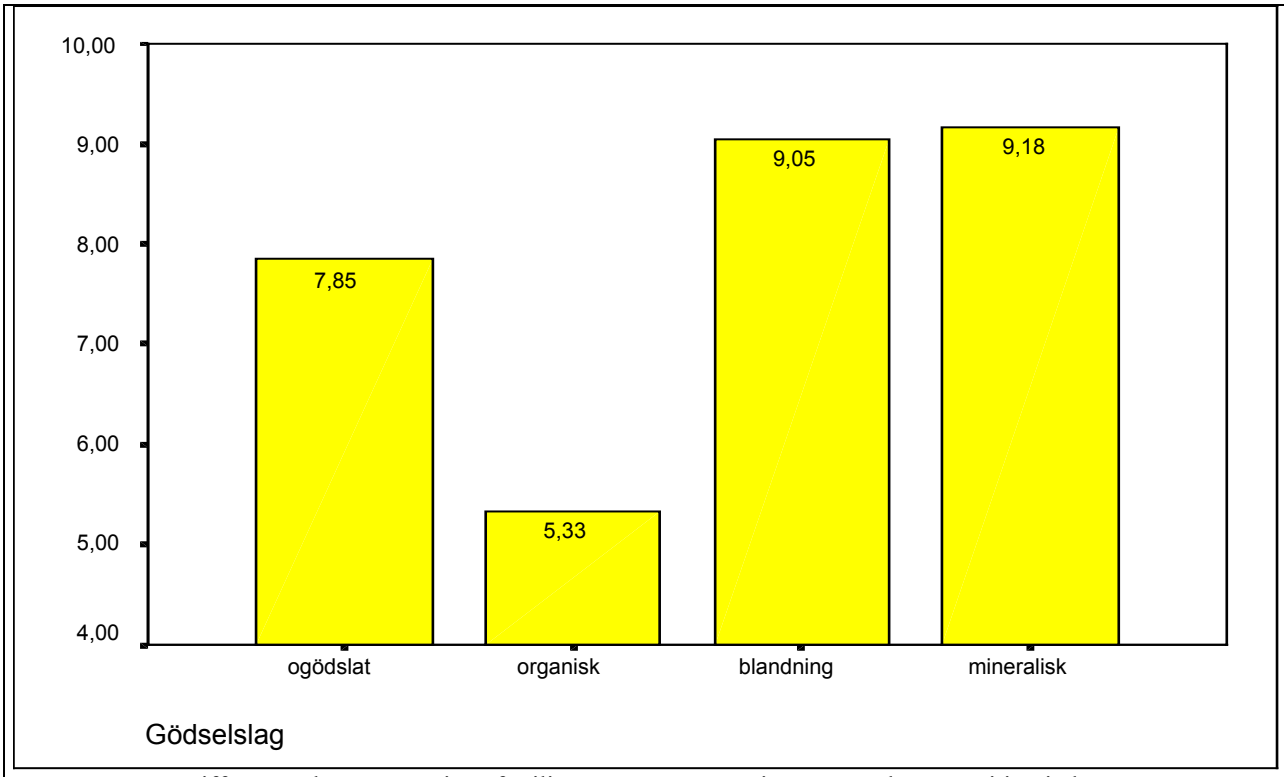


Fig. 38 Differences between various fertilizer-groups concerning extract decomposition in beets. Ogödslat= unfertilised, Organisk= organic manure, Blandning= mixture of organic and mineral fertilisers, Mineralisk= mineral fertiliser

Summer wheat

The yield-level in summer wheat was rather equal for the three fertilized groups. The unfertilised however, deviated from the rest with a significant lower yield of kernel and a distinctly lower yield of straw.

Yield	**Unfertilised**	**Organic**	**Mixed**	**Mineral**
Kernel kg/ha	2486,7	3169,8	3263,0	3295,0
Straw kg/ha	1998,6	2926,9	2725,3	2836,4
Fruit- yield	65,2	69,0	63,0	66,7

Table 34 Yield -level in summer wheat at different types of fertilizers. Mean value for the years 1958-1989.

The length of straw in summer wheat was distinctly largest in the groups that were given mineral fertilizer. Both the mixed fertilized and the mineral fertilized group deviated here significant from the other two groups. The organic fertilized group had in turn significant longer straw than the unfertilised. Concerning the amount of lodged stands the mineral fertilized groups deviated by a more obvious higher amount lodged stands. The differences were here significant compared to all other groups. The mixed fertilized variant also had a distinctly higher amount of lodged stands than the other two. Interesting to note was that the organic fertilized group had a slightly lower amount of lodged stands in comparison with the unfertilised. The dry-gluten content was highest in the mineral fertilized group that deviated significant from the unfertilised, which had the lowest value. Also the wet-gluten content was lowest in the unfertilised and highest in the mineral fertilized group.

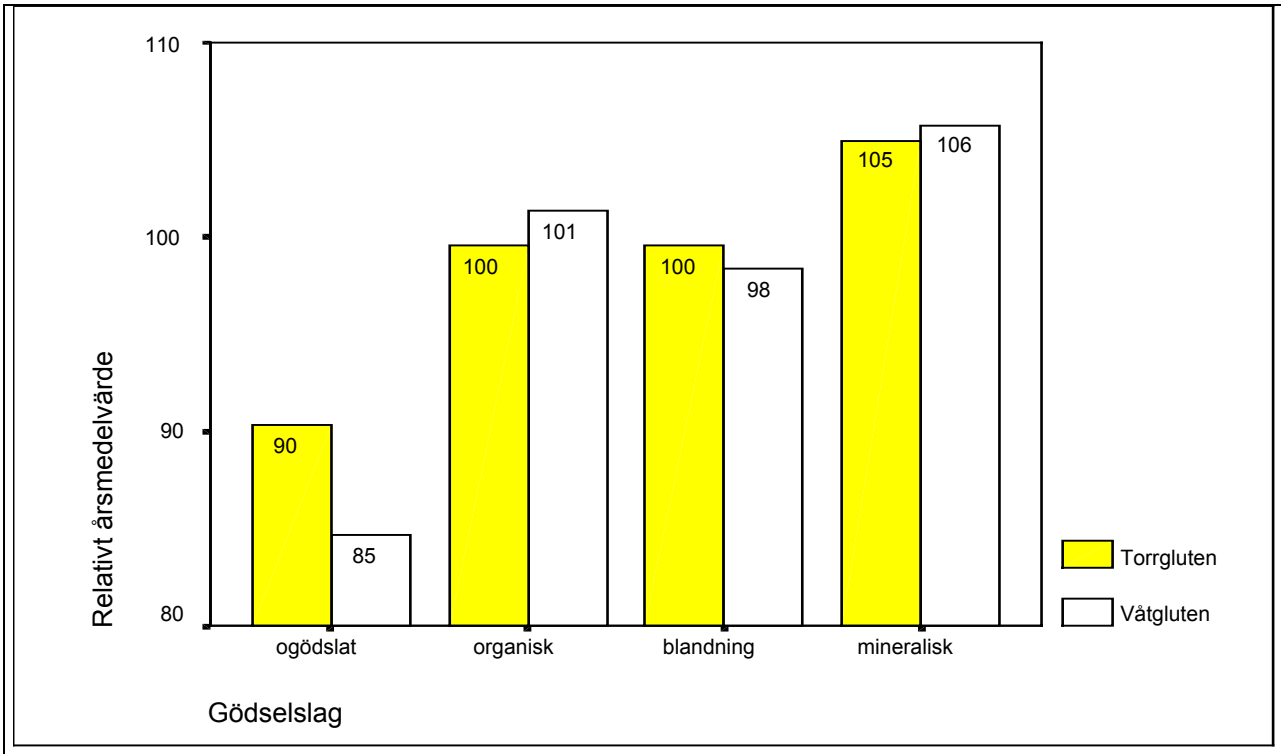


Fig. 39 Relative contents of dry- (torrgluten) and wet gluten (våtgluten) respectively. Annual mean value for the trial = 100.
Ogödslat= unfertilised, Organisk= organic manure, Blandning= mixture of organic and mineral fertilisers, Mineralisk= mineral fertiliser

The contents of crude protein in summer wheat, was grouped together in such a fashion, that the unfertilised group had the lowest values, compared to the mineral fertilized and the organic fertilized that deviated by significant higher values. Concerning the free amino acid content and extract decomposition, no appreciable great differences were found among the groups, this also applies for the dry matter content. 1000-kernel-weight was significant higher in the organic fertilized group compared to the mineral fertilized that had surprisingly low values. Volumetric-weight did not differ so much between the different groups. The falling number was on average highest in the mixed fertilized group and lowest in the mineral fertilized. However, the differences were not significant. The viability did not show any significant differences either. The viability was lowest in the unfertilised group, while quite equal among the other three. The amount of small kernels was highest in the unfertilised variant. The rest did not appreciable deviate from each other. The most inferior crystallized pictures were found in the mineral fertilized group together with the unfertilised. These two deviated, although not significant, distinctly from the other two groups.

Clover/grass ley
The first harvest of clover/grass ley showed a distinctly grouping among the different fertilizer groups. The mixed fertilized and the organic fertilized group formed a duo with higher yield-level, while the unfertilised and the mineral fertilized formed a group with lower yield-level. The difference between these two groups was significant. At the second harvest the organic fertilized group differed by a significant higher yield-level in comparison to the mineral-fertilized group. The organic fertilized group deviated also here distinctly, although not significant from the other two fertilizer groups.

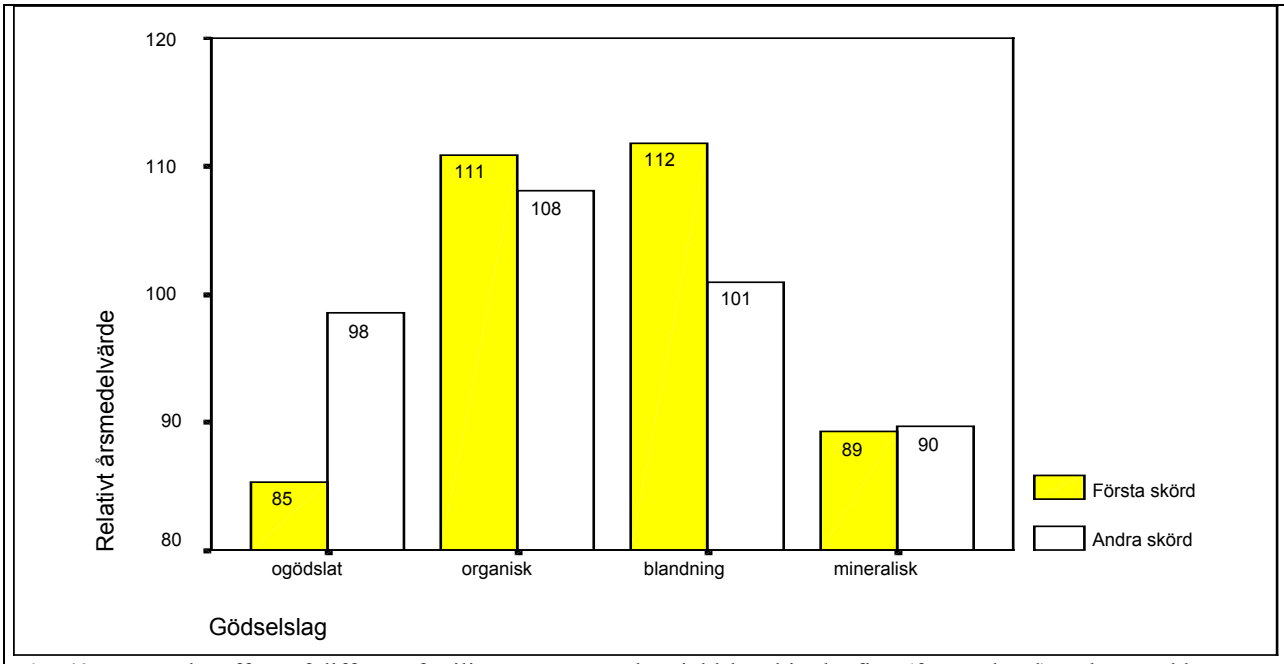


Fig. 40 The effect of different fertilizer groups on the yield-level in the first (första skörd) and second harvest (andra skörd) of clover/grass ley. Annual mean value = 100.
Ogödslat= unfertilised, Organisk= organic manure, Blandning= mixture of organic and mineral fertilisers, Mineralisk= mineral fertiliser

Concerning the botanical compound in the second harvest, the organic fertilized deviated by a significant higher amount of lucerne. The unfertilised variant deviated by a significant higher amount of red clover. This relation was already suggested in the first harvest but was further fortified up to the second harvest in the clover/grass ley. The mineral fertilized and mixed fertilized groups soiled themselves by a higher amount of grass in the clover/grass ley. This difference was not significant towards the rest of the groups. The very few determinations performed on the dry matter content in the clover/grass ley, showed the highest dry matter content in the organic fertilized group. This group differed significant from the mineral fertilized that had the lowest contents of dry matter. The hibernation of the clover/grass ley was found in the unfertilised group. The worst hibernation was found in the mineral fertilized group for all four types of plants that was covered by the investigations. The hibernation of alsike clover was significant higher in the unfertilised variant and in the organic fertilized group in comparison with the mineral fertilized. The same relationship existed in red clover and meadow fescue. The hibernation of timothy deviated here slightly from the others in that the mixed fertilized group had the highest hibernation. Differences between variants were not significant.

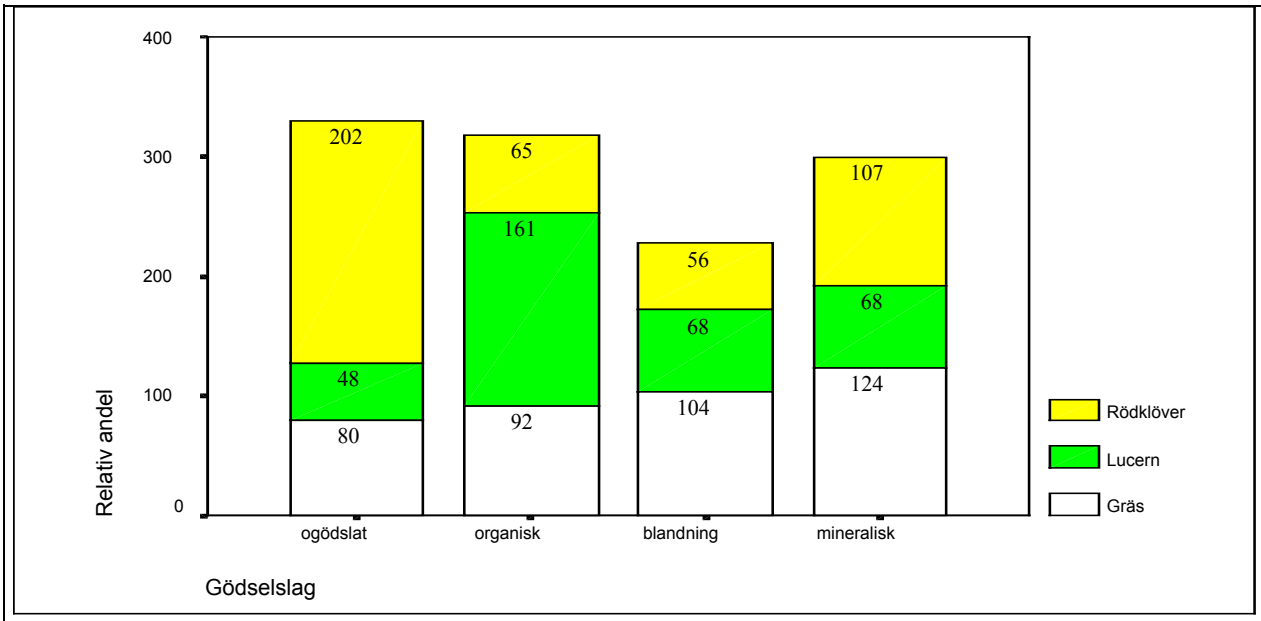


Fig. 41 The effect of different fertilizer groups on the botanical compound in clover/grass ley. Annual mean value = 100. Rödklöver=red clover, Lucern= Alfa Alfa, Gräs= grass
Ogödslat= unfertilised, Organisk= organic manure, Blandning= mixture of organic and mineral fertilisers, Mineralisk= mineral fertiliser

Alteration of the mineral fertilizer rate
Comparison is established on variants K6, K7 and K8 why diagrams and some other measured values are accounted for in the part that show the results.

Soil
Among the purely mineral fertilized variants K6, K7 and K8 no obvious differences were stated concerning the soil physical properties. The soil chemical contended K8 slightly more N in the layer at 25 - 35 cm depth and slightly less N in the layer at 50 - 60 cm depth at least this was the case, when the measures were taken in 1989. K8 deviated from K6 and K7 by a higher amount of fulvo acids in the humus. K7 and K8 had distinctly higher phosphorus content in the topsoil. In the layer at 25-35 cm depth was the phosphorus contents highest in K8. K7 tend on the contrary, to have the highest amount of potassium in the topsoil, while Mg-content decreased with the increase in fertilization intensity. This tendency applies to all soil biological parameters.

Potatoes
The potato-yield was highest in K7 and lowest in K6. No differences were significant. The infestation of late blight fungus showed no significant difference between the variants. They were highest in K8 and lowest in K7. The number of erect stems/habitat was highest in K7 and lowest in K6. However, K8 deviated significant from both the other two variants by a strikingly higher number of horizontal stems/habitat. The amount prima potatoes when sorting in the autumn, was significant higher in K6, than in the two other variants. Concerning the amount of prima potatoes at the sorting after storage, also here did K6 show the highest values. However, this time was the differences not significant. The resistance towards fungi-infestations was highest in K7, while K6 and K8 at large had the same value. The differences were not significant.

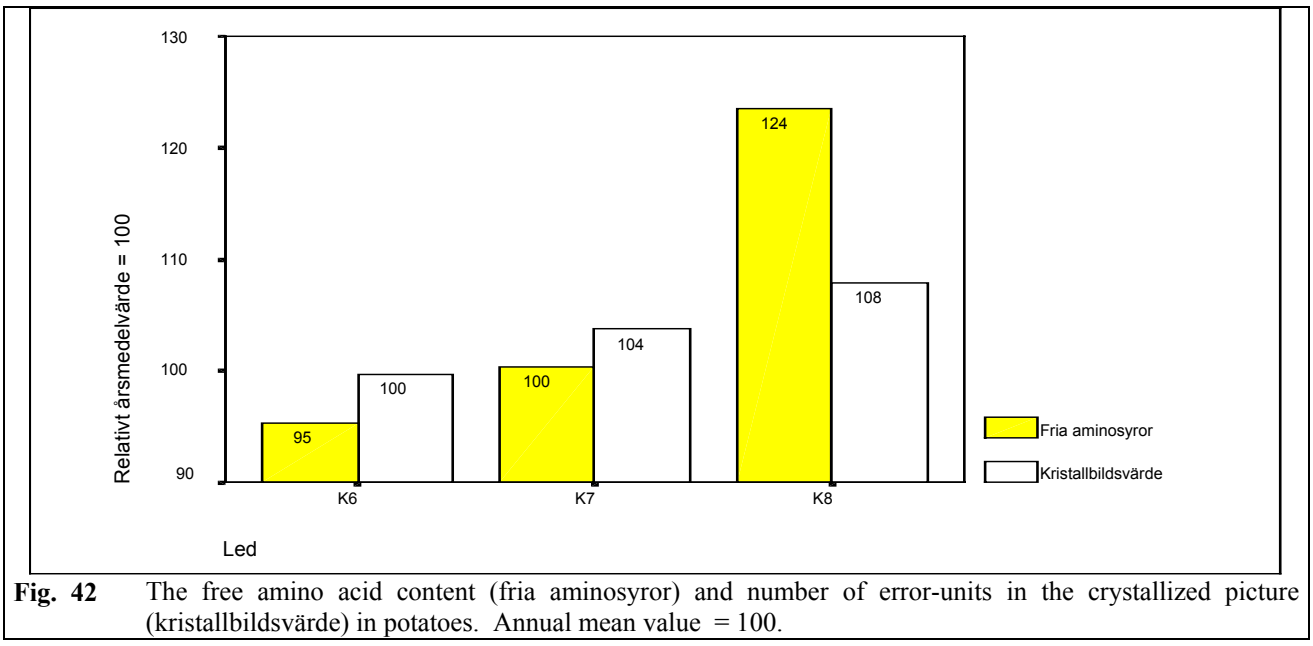


Fig. 42 The free amino acid content (fria aminosyror) and number of error-units in the crystallized picture (kristallbildsvärde) in potatoes. Annual mean value = 100.

K8 tended to have the highest amount of the smallest, as well as the largest potatoes-size. K6 had the highest dry matter content and K8 the lowest. The difference between these two variants was significant. K8 deviated significant from K7 as well as from K6 by higher content free amino acids, higher content crude protein, extract decomposition and a lower quality index. Furthermore, K8 showed the highest values of darkening of extract and tissue and the most inferior crystallized pictures.
From the flavour-tests there are no significant differences amiable between the variants. Concerning flavour-flavour had K8 the highest values in the autumn and the lowest in the spring. K7 had the worst values in the autumn and the best in the spring. K6 showed the worst values in bitters in the autumn and differed distinctly here from K7 that had the best values. The differences were however, more or less erased in the springtime. K8 had worst values in earth-flavour in the autumn as well as in the springtime. On both occasions did K6 have the best values.

Beets
The root-yield was highest in K8 followed by K7. These variants deviated significant from K6. The tops-yield was also significant highest in K8 followed by K7. The fruit-yield was highest in K7 and lowest in K8. The extra-altered mineral fertilizer rate, tended in other words, to stronger stimulate the leaf-growth than the root-growth. See Fig. 42

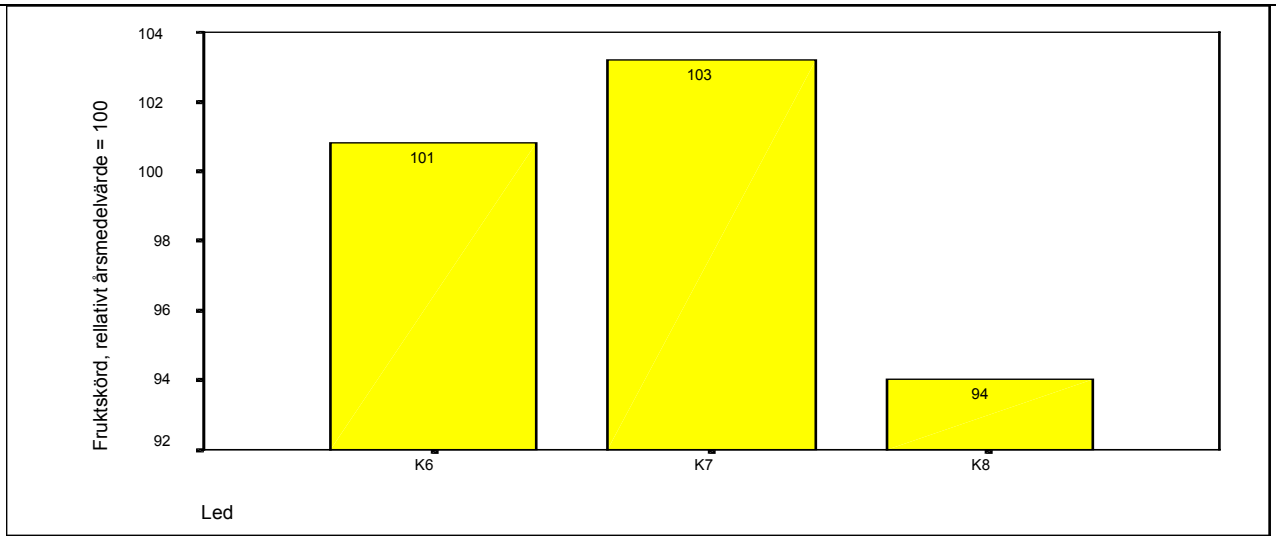


Fig. 43 Fruit-yield, e.g. percentage of roots and kernel respectively in the total-yield of beets and summer wheat.
Annual mean value= 100

Den highest content of dry matter was in K7 and also the highest value for extract dissolution/decomposition. The crude protein content was highest in K8. In all these measuring the lowest values were in K6. However, no differences were significant. The difference between the variants, concerning the amount prima roots at the sorting did not give any significant results. Concerning the root-neck-ratio, did K6 as well as K7 show a significant higher ratio than K8. K6 had the highest ratio concerning this type of measure on the root-formation.

Summer wheat
In wheat no appreciable significant differences was seen. An alteration of the mineral fertilizer rate can here be summoned as follows: higher tops-yield, lower fruit-yield, higher content crude protein, a faster extract decomposition, lower falling number, a larger amount small kernels, worse crystallized picture value, higher content free amino acids, higher content of dry- and wet gluten and lower 1000-kernel-weight and volumetric weight. Length of straw and amount of lodged stands was significant higher in K8 than in K6 with a distinctly lower amount of lodged stands than in K7.

Clover/grass ley
The clover/grass ley was unfertilised. In spite of that, some differences were found between the groups. K6 had the highest yield-level in the first, as well as the second harvest. The differences were insignificant. In only one incident in the clover/grass ley was the measures significant among the groups. That concerned the dry matter content in K8 that deviated from the other two by a higher dm-content. An alteration of the mineral fertilization in the unfertilised clover/grass ley tended to; higher contents of crude protein, larger amount of grass, smaller amount of red clover, slightly larger amount of lucerne above all in the second harvest and slightly more weeds in connection with the first harvest. The hibernation of the clover/grass ley crop was distinctly better in the variant that received the lowest N-yield. K6 deviated concerning the grass, significant compared to the other two variants by having a better hibernation capability. Also in the clover species, the hibernation was distinctly best in K6, even if the differences here were insignificant. In all four crops of clover/grass ley the variants grouped themselves according to the altered N-yield, with K8 as the variant with the worst hibernation.

Different forms of organic fertilizer
A comparison between K1 and K3 gives us a description of possible differences between one soil and one crop, that has been fertilized with raw farm-yard manure and one fertilized with compost and treated with the biodynamic preparations.

Soil
The differences between the effects the fertilizer types have on the soil is mainly observed in the soil biological and in some of the soil chemical investigations. The development of pH-value suggests that K1 managed the acidification better than the raw manure.

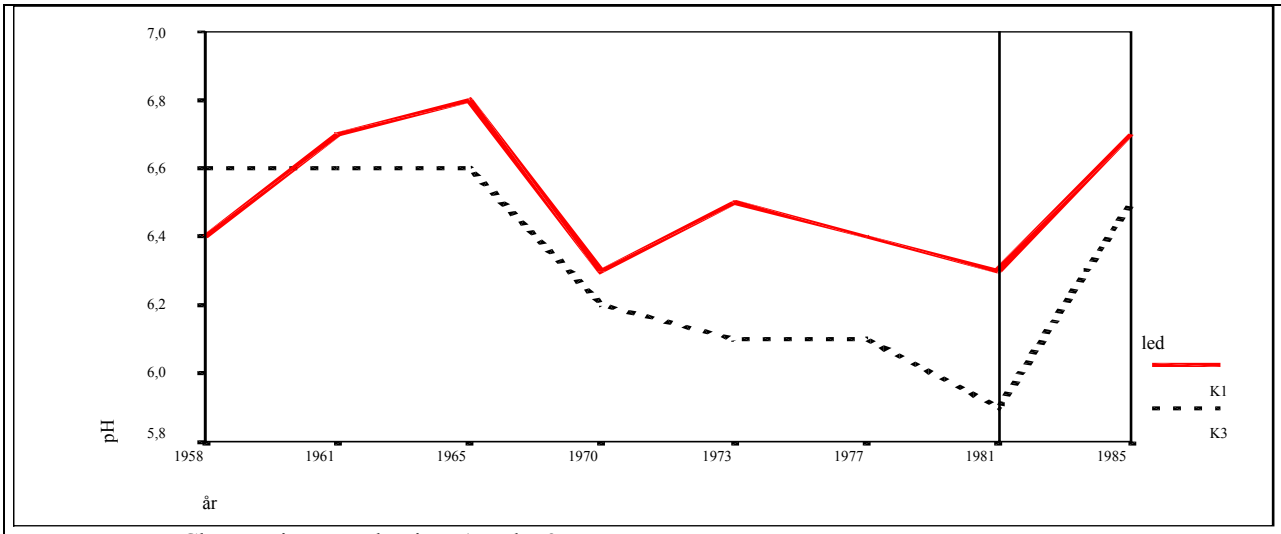


Fig. 44 Changes in pH-value in K1 and K3.
Vertical line marks the date of liming.

The variant fertilized with raw farmyard manure had slightly higher contents of N in the soil. This is possibly the reason why the urease activity was higher at a depth of 35 cm in the soil. Further deeper down was however the urease-activity higher in K1. The dehydrogenase activity was throughout highest in K1, while the number of earthworms was more or less equal.

The average yield-level in the four crops, was almost exactly the same in the two variants. Compared to trial-mean value was K3 at 6,4% above and K1 at 6,2% above the mean value for all variants. Usually it was higher yield-levels in K3 concerning the clover/grass ley, while in potatoes, beets and summer wheat it was usually higher yields in K1. See Fig. 45

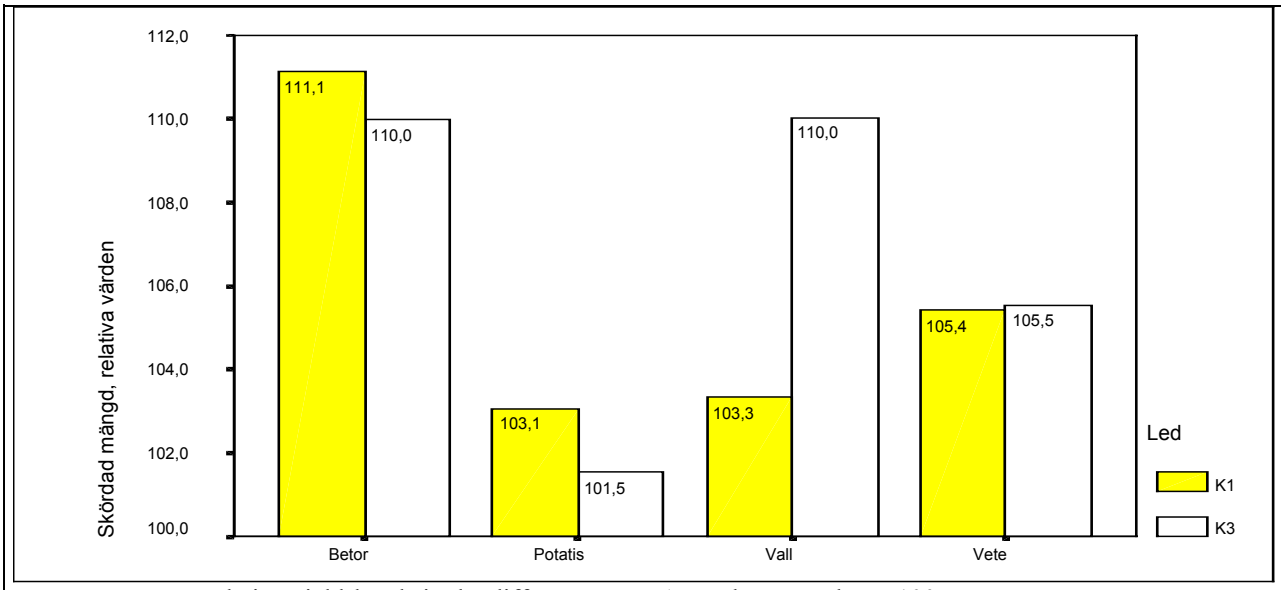


Fig. 45 Relative yield-levels in the different crops. Annual mean value = 100
Betor=beets, Potatis=potato, Vall= ley, first harvest, Vete= summer wheat

Potatoes
The difference was large between K1 and K3 concerning the receptivity to late blight fungus. In ca 80% of the grading did K1 have a lower infestation-grade than K3. The free amino acid contents were slightly lower in K1, as well as the values for darkening of tissue. The values for extract decomposition was slightly higher in K1 that also showed slightly higher quality indices and better crystallized picture values and distinctly lower darkening of extract. The potato-size did not differ so much between the variants. A weak tendency was that K3 had the largest amount of small and medium-sized potatoes, while K1 showed a larger amount of very big potatoes. Sorting-losses were lower in K1 as well as total-waste after storage. The speed in fungi-infestation development in the area of the spread, was larger in K3. Taste-wise did K1 show the most distinctly flavour-flavour in the autumn- as well as in the spring-samples. At the same time, did this variant have the lowest values for extraneous flavours. The number of erect stems was slightly larger in K1, as well as the number of horizontal stems.

Beets
Root-yield was slightly larger in K1 as well as tops-yield. The neck/root ratio was slightly larger in K1. Sorting-losses were slightly larger and storage losses slightly smaller in K3.

Wheat
Kernel-yield was slightly higher in K1 as well as straw-yield. Dry matter content and free amino acids was lower, while the contents of crude protein and organic acids was higher in K1. Furthermore, the values for extract decomposition were higher in K1. The falling number was higher in K3, while K1 had a higher viability and amount of large kernels. K1 showed also the best crystallized pictures, while the values for dissolution-test was slightly larger in K3. The gluten content, dry and wet gluten, was higher in K1 while the 1000-kernel-weight was lower. The volumetric-weight was the same, more or less in both variants.

Clover/grass ley
Clover/grass ley-yield was highest in K3. This applied above all, in the first harvest. K1 had significant higher amount lucerne in the first and second harvest. The amount of clover was significant higher in K3 at the second harvest. Interestingly did K1 have a slightly higher amount of red clover at the first harvest. In addition to this, was the amount of grass higher in K3, in the first as well as the second harvest. The hibernation of red clover, timothy and meadow fescue was highest in K3 that had the best hibernation all together. The hiber-nation of alsike clover was slightly better in K1. The amount crude protein was distinctly higher in K1.

The biodynamic field preparations
This analysis is determined through a comparison between K1 and K2. In both variants the different biodynamic compost preparations were used in connection with the making of the compost. In K1 the two field-preparations/sprays was also used.

Soil
There was a tendency to a higher pH-value in K1 than in K2. K1 reacted more intensively on the liming, which come into expression in the more marked alteration of pH-value in this variant during 1981-1985.

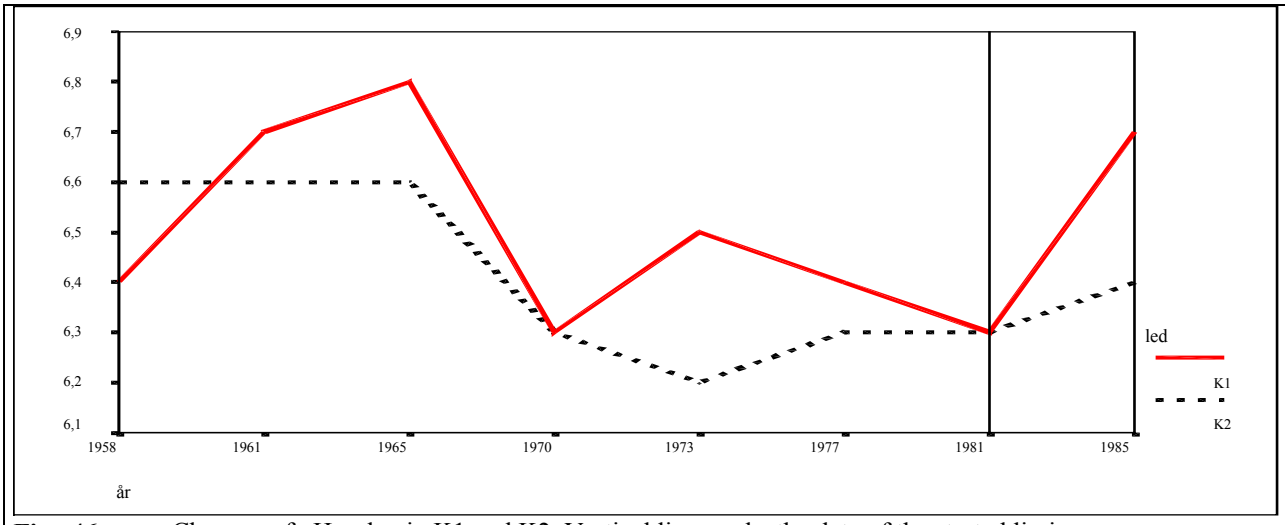


Fig. 46 Changes of pH-value in K1 and K2. Vertical line marks the date of the started liming.

In 1976 there was a big difference between K1 and K2 concerning the C-content in the soil. When this difference had almost disappeared in later measures, the interpretation can be done in two ways. Either it is a question of errors in measuring, or the increase in humus-content was initially faster in K1 than in K2 and was equalized later on. The C-contents tended to in deeper layers to be higher in K1 than in K2. This difference did not disappear when later analyses were made. Also the C-N ratio tended to be higher in K1. Concerning the enzymatical activity, K1 showed throughout more or less, higher values than K2, especially in the deeper soil-layers.

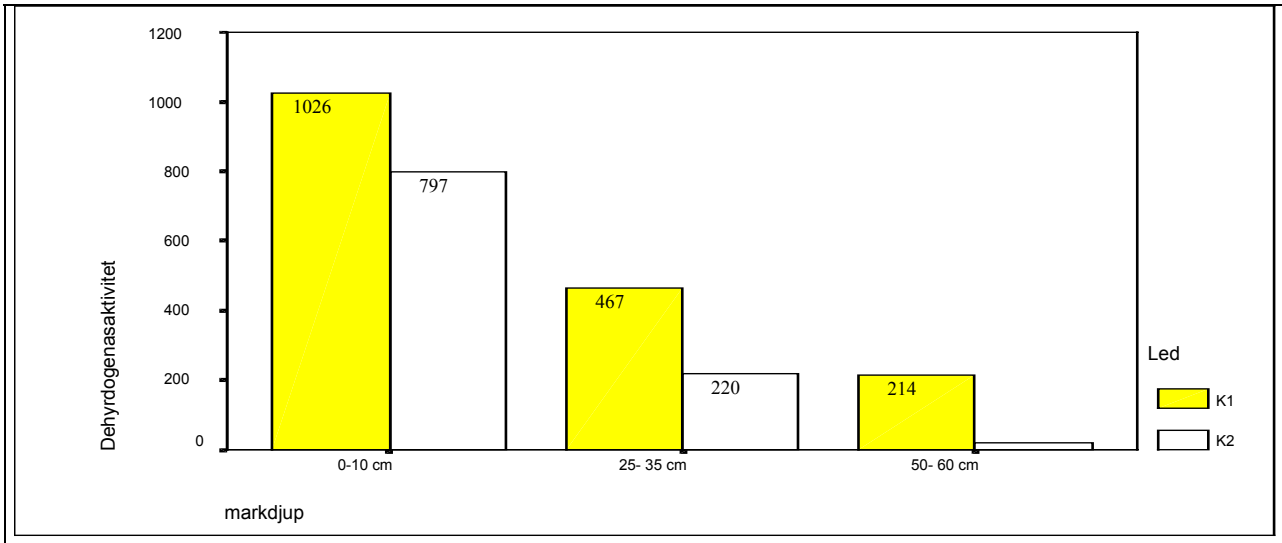


Fig. 47 Dehydrogenase activity in different soil depths.
Comparison between K1 and K2.

About the yields it can generally be said, that among the 127 yield occasions, K1 had higher yields at 80 of these occasions, distributed on 22 occasions in beets, 18 in potatoes, 13 in clover/grass ley and 27 in summer wheat.

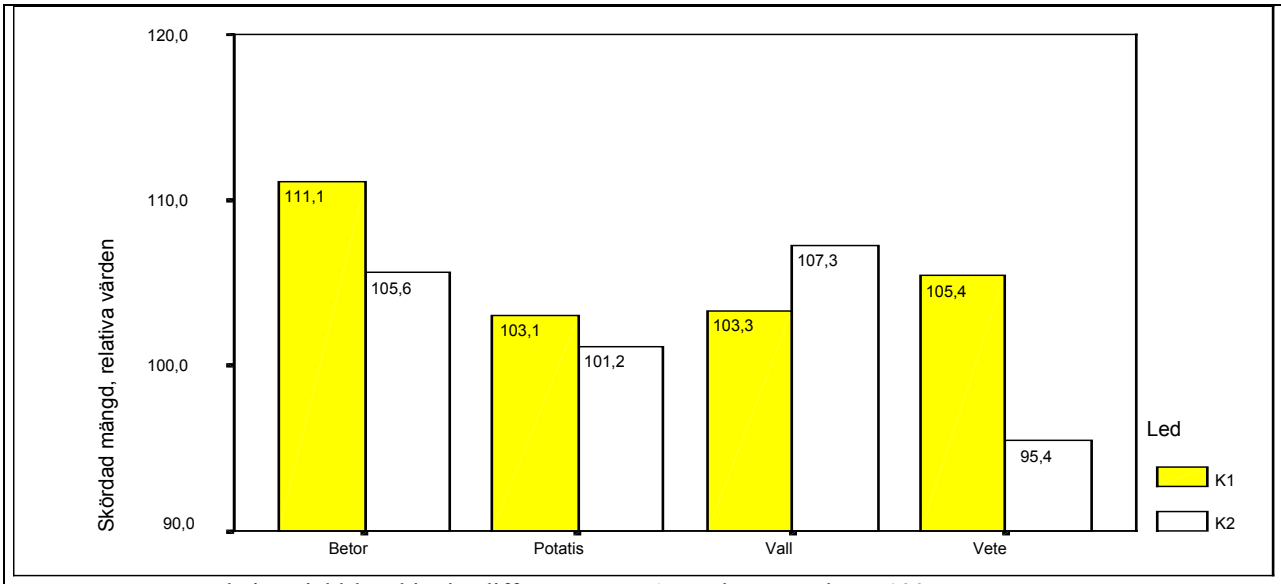


Fig. 48 Relative yield-level in the different crops. Annual mean value = 100.
Betor=beets, Potatis=potato, Vall= ley, first harvest, Vete= summer wheat

Potatoes
In the potatoes had K1 a slightly higher yield-level, distinctly smaller attacks of late blight fungus, slightly distinct potato taste, but at the same time distinct extraneous flavours. Number of erect stems per habitat was about the same in both variants, while the number of horizontal stems was lower in the preparation-treated variant. K2 had a larger amount of prima potatoes at the sorting after yield. This sorting also showed that K1 had a distinctly larger amount of small potatoes, smaller amount of medium-size and a larger amount of big and distinctly larger amount of very big potatoes. The amount of screening after storage was about the same in the two variants, while K1 showed a larger resistance to fungi-infestations. K1 had slightly lower darkening of tissue, while the value for darkening of extract was, more or less equal between the variants. The extract decomposition was slightly faster in K1. Dry matter content was similar between the variants, while crude protein content and free amino acids were lower in K1. And finally, did also K1 differ with slightly worse crystallized picture value but at the same time, slightly better quality indices.

Beets
K1 showed a higher yield of roots, approx. the same yield of beet-tops and thereby a higher fruit-yield. Furthermore, K1 had a lower content of dry matter and crude protein and faster extract decomposition. Concerning sorting and storage did K1 show in both cases smaller losses as well. The beets in K1 also had a higher neck/root ratio.

Summer wheat
The yield of summer wheat was distinctly higher in K1. This applies to the kernel-yield and to a higher degree in the straw-yield. Differences between variants were here approx. at 10 percentages. K1 showed furthermore; higher viability, shorter straw, smaller amount of lodged stands , higher amount of large kernels, higher volumetric-weight, and lower 1000-kernel-weight. Further, the variant treated with the field-preparations, differed with a lower content of dry matter and crude protein and a higher content free amino acids. K1 had a lower falling number, lower content organic acids, higher content dry gluten and lower content wet gluten. At last, K1 had fewer error-units in the crystallized picture, and a higher degree of extract decomposition.

Clover/grass ley
In the clover/grass ley crop K1 differed from K2, through a lower first harvest, but with a higher second harvest. The hibernation was better in the BD-preparation-treated variant. This applies to all the crops in the clover/grass ley, grass as well as leguminous plants. The botanical analysis gave K1 a lower amount grass and a higher amount of leguminous plants. This applies to the first, as well as the second harvest. It was above all, the amount of lucerne, but also the amount of red clover that were higher in K1. The clover/grass ley crop in K1 had a slightly lower content in dry matter as well as in crude protein.

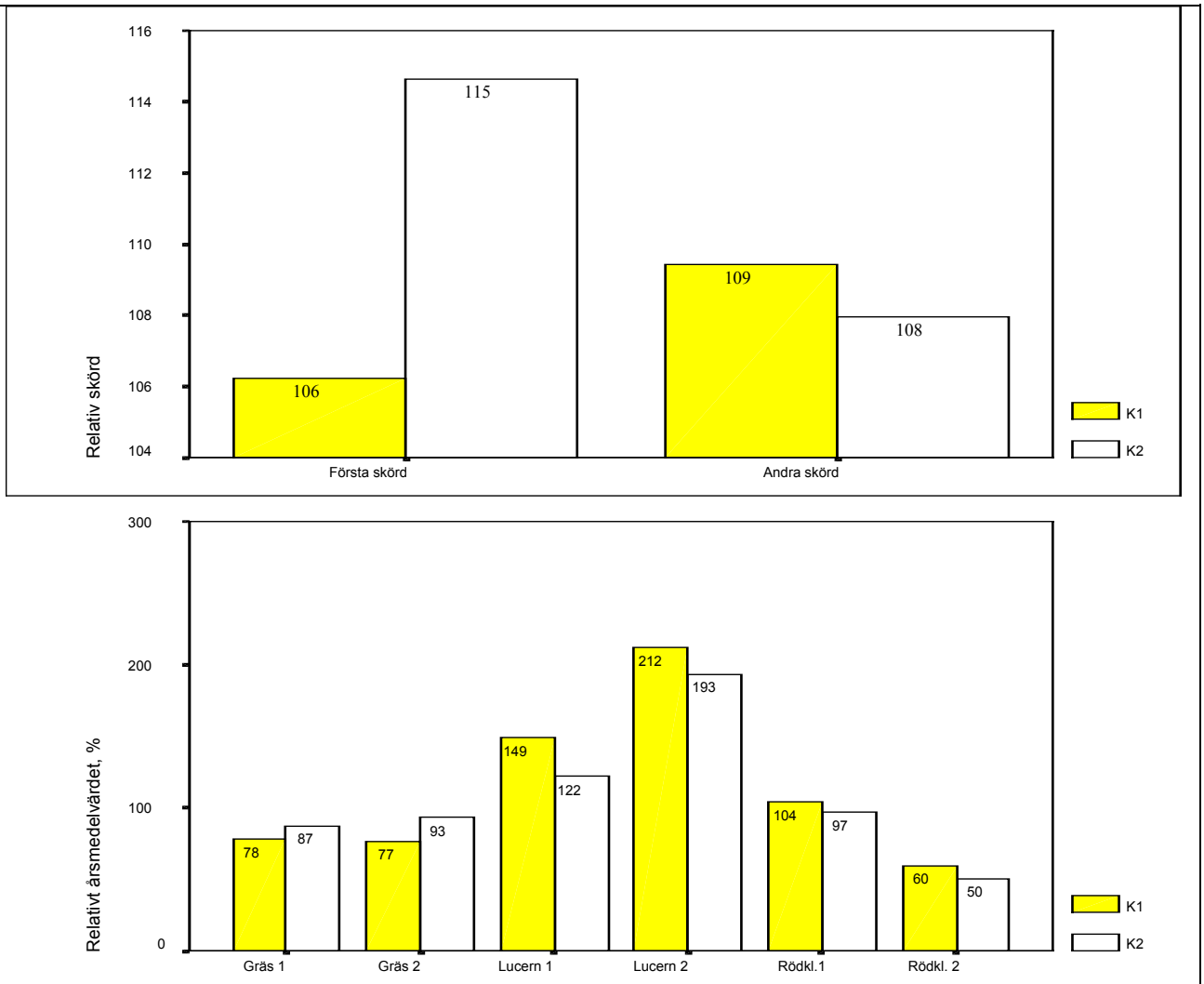


Fig. 49 Relative amount of yield of the first and second harvest of clover/grass ley, top diagram, and the amount of different crops in the clover/grass ley, lower diagram. Comparison between K1 and K2. Annual mean value for the trial = 100. Gräs1= Grass, first harvest, Gräs2= Grass, second harvest, Lucern= Alfa Alfa, Rödkl.= Red clover.

The BD preparation seemed to influence the amount of yield, more intensive at low yield-levels, while the effect on the amount of yield did almost totally disappear, or turned
out to be negative, at high yield-levels. This tendency was found in all four crops, but was distinct in summer wheat and clover/grass ley. Through linear regression emerge the diagrams in Fig. 50, next page. Depicted are the relative

yield-levels for K2 on the x-axis. and the relative yield-change, through the biodynamic field-preparations on the y-axis.

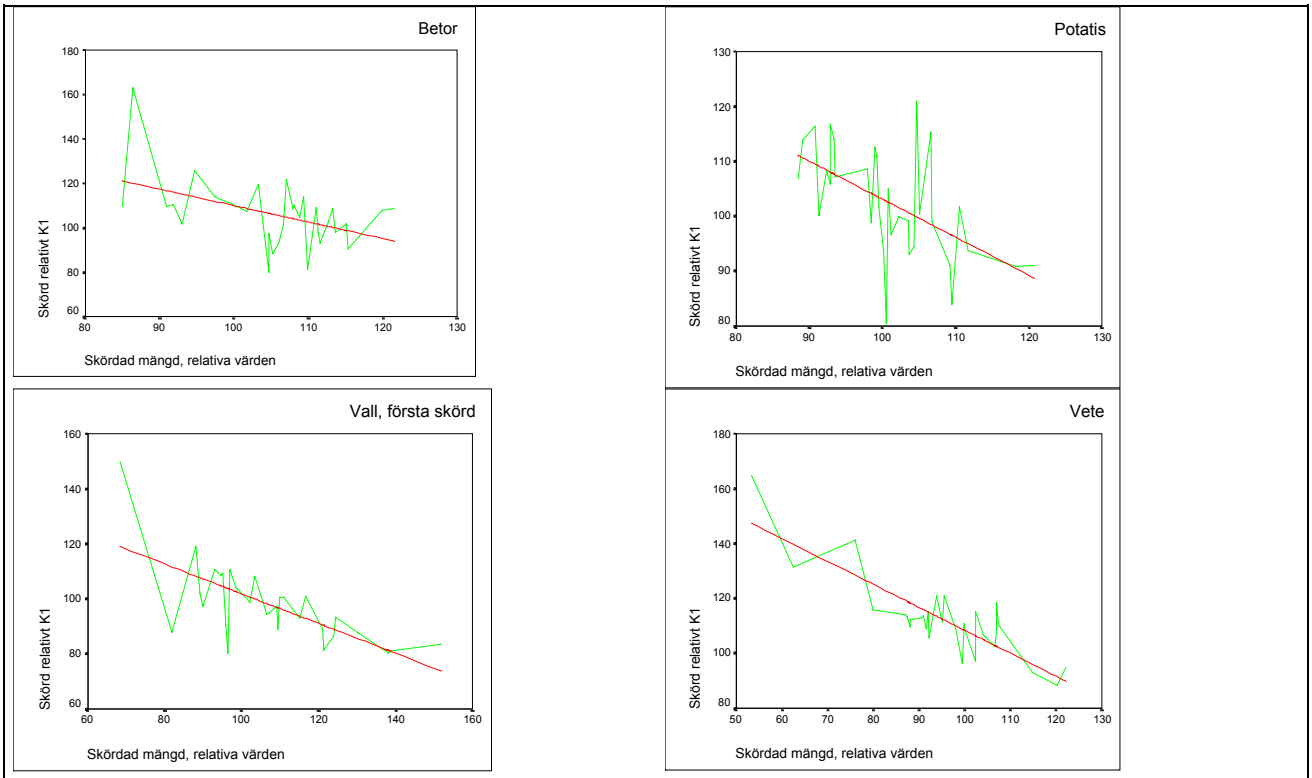


Fig. 50 Analysis of the relation between yield-level and the effect of the biodynamic field-preparations. Upper left= Beets, Upper right= Potato, Lower left= Ley, first harvest. Lower right= summer wheat.

An increasing number of cultivation-days seemed to increase the difference in yield between K1 and K2, at least in the potatoes. Years with low precipitation until midsummer tended to give distinct yield-increasing effects from the field-preparations in the first harvest of clover/grass ley. For potatoes it was the opposite. Here it was rainy seasons that resulted in higher yield-altered effects from the preparation treatment. It was above all, rain during the later part of the season that was of importance. For potatoes it was further more that a high total-sum in temperature, up until 1 July was weakly negative correlated to higher yield-levels in K1. Also here was the relationship opposite for the clover/grass ley, where high total-sum in temperature up until 1 July was positively correlated to higher yield-levels in K1. One alteration of potato-yield in K1 was positively correlated with a precipitation-rich season, while negatively correlated to the amount of small potatoes. Compared to K2 did the yields increase in K1 during rainy summers, mainly by the increase in the potato-size. Warm years tended to be negatively correlated to increasing yields when treated with the preparations.

In years with higher yields in K1, the potatoes in this variant tended to have; lower content free amino acids, lower content crude protein, lower darkening of extract, higher quality indices, lower storage-waste and good crystallized pictures. Altered yield-levels in K1 tended to also be positively correlated to early sowing and late yield, i.e. a long farming season, and to increasing yields in potassium.

The number of treatments with the 500 spray was positively correlated to the value for darkening of extract, i.e. the repeated treatments with 500 increased the value for darkening of extract. Among the rest no significant differences show, concerning the number of treatments with the field-preparations. The tendencies was however, that an increase in the number of treatments with 500, decreased the amino acid content, crude protein and dry matter content and slightly decreased the value for darkening of tissue. Furthermore, storage efficiency, quality indices and crystallized picture value was improved. Concerning preparation 501 tended to in years with an increased number of treatments to give K1 slightly higher values of free amino acids, crude protein, darkening of extract, extract decomposition and darkening of tissue and lower values in dry matter content and quality indices. The values for crystallized pictures had a weak improvement.

In the beets were the increased yield-differences of roots between K1 and K2 positively correlated to yield-differences of beet-tops. The increase of the root-yield was proportionally smaller than the increase in tops-yield. A possible interpretation is, that the preparations intensively stimulated the growth progress in the tops, rather than in the beetroots. In root, as well as in tops were the sprays yield-altering effects slightly larger at the end of the experiment

period. Also this effect was larger in tops than it was in root. Fruit-yield was positively correlated to the number of treatments with the humus-spray. The root-yield tended to increase, while the tops-yield slightly decreased at an increasing number of treatments.

The silicium-spray tended to, with an increased number of treatments, to lower the yield of root and tops. The number of treatments per season with the field-preparations diminished as the trial went on, especially concerning 501. It is therefore impossible to say, if this effect depended on changing conditions at the end of the trial period, or on the number of treatments. In years with longer farming seasons, did the spray-treated variants give a higher dm-content. Alterations of the dry matter content were positively correlated with early sow and with late yield. High fertilizing levels tended to lower the preparations yield-altering effect on root and tops. This applies also to N, as well as P-contents.

The first harvest of clover/grass ley showed larger yield-alterations in K1 during the years that were dry and warm. The second harvest on the other hand, showed increasing yield-levels during years were above all, early summer was slightly rainy and the season as such was cold.

The number of treatments with the field-preparations did not indicate any distinct tendencies. Possibly it can be said, that an increase of 500 spray, resulted in lower levels in the first harvest and to higher levels in the second harvest. Besides, the increasing number of treatments with 501 did lower the amount of grass in the first and also the second harvest. Several sprayings with 500 also tended to increase the crude protein content, while 501 here had an effect in the opposite direction. Higher yield-levels in K1 were also positively correlated to higher amount of lucerne in the first harvest and to a certain extent, to the second harvest. A higher amount of lucerne in the first harvest was however, negatively correlated to increasing yield-levels concerning the second harvest.

The preparations yield-increasing effect in the yield of summer wheat was not distinctly correlated neither to precipitation, temperature nor to the number of treatments. Higher kernel-yield in K1 was positively correlated with higher content free amino acids, higher straw-yield, distinctly higher fruit-yield, lowered content crude protein, higher falling number, inferior viability, inferior crystallized picture value, lower 1000-kernel-weight and volumetric-weight and lower content of organic acids as well as dry and wet gluten. When treated with the field-sprays, kernel-yield tended to increase more than straw-yield. The years with positive effects of the field-sprays in the straw-yield, also increased the amount of small kernels. In connection to this, there was a great deal of significant relationships between different variables. Table 35 shows a few of these correlations.

Variable 1 was	**positively correlated to Variable 2**
Free amino acids	1000-kernel-weight, late yield
Falling number	Large amount of large kernels, inferior crystallized picture, higher organic acids, early sowing, warm seasons
Number of treatments with 501	Lowered amount of small kernels, improved crystallized picture value
Dry matter content	Content of wet gluten
1000-kernel-weight	Increased yield

Table 35 A few variables related to treatment with the field-sprays in summer wheat.

If we through a linear regression, produces the effects of the biodynamic preparations, on the amount of yield as a function of the 32 years of trial, the graphs emerges as in Fig. 51 The effects of the preparations tended to be smaller in yield-increase during the trial period in clover/grass ley and wheat, while the tendency was the opposite in potatoes and beets. The effects on the yield-amounts in wheat-straw and beet-tops seemed both to have increased as the trial period went on.

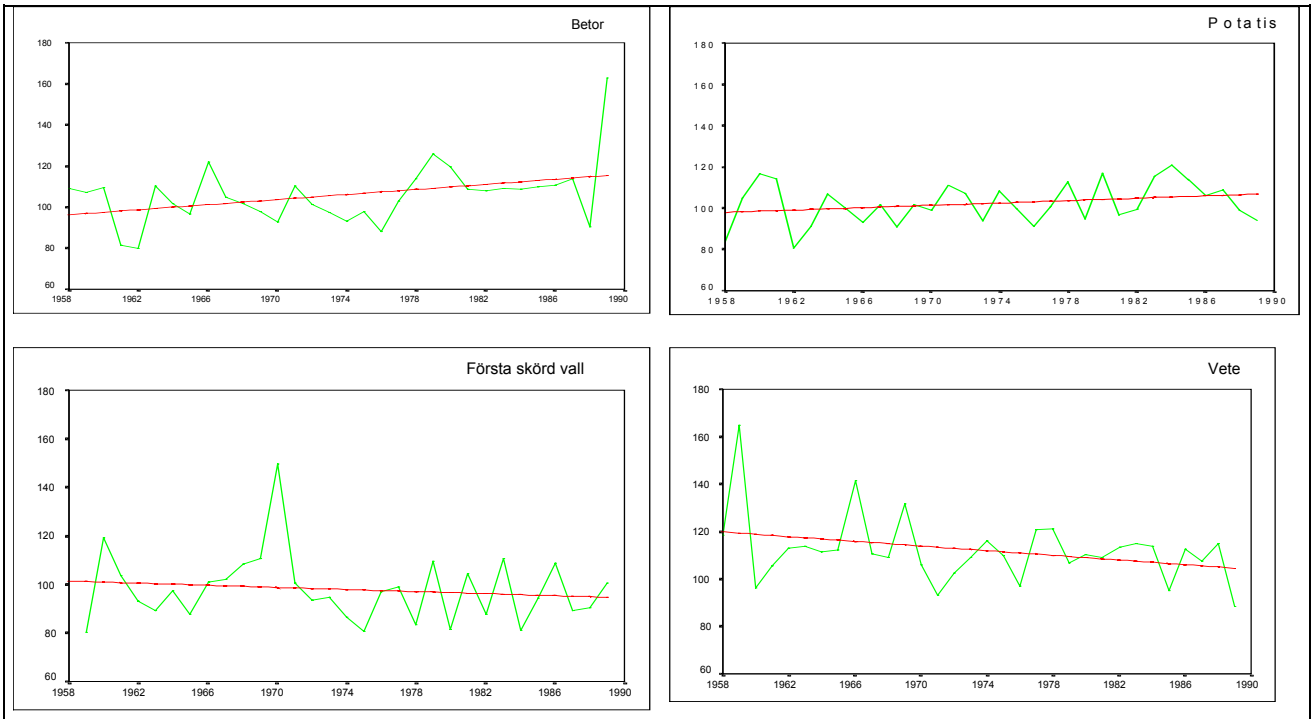


Fig. 51 Regression-analysis of the effects of the field-preparations, during the trial period. The crops are from top left; beets, potatoes and from bottom left; the first harvest of clover/grass ley and summer wheat

Discussion

The K-trial was planned to be more of a cultivation to receive crops from, rather than a standardized field experiment. The lay-out in the K-trial lacked a great deal of the requirements that today can be set as conditions for a comparable experiment. The lack of repetitions makes a discussion on the results from this trial, only meaningful if the results from other more standardized planned trials, also are taken under consideration.

As the crops in the K-trial were fertilized in different ways, it required a broad spectrum of foodstuff from which different methods of quality-investigations could be worked out. It was this development in methods that was the primary aim with the K-trial. That is the reason why all the different methods of analyses have been tried, while only a few of them were used during all the 32- years of trial.

When the K-trial had been operating in 15-20 years it was given an additional meaning. Due to the long trial-period did the K-trial become unique, concerning the ability to de-scribe different types of fertilization and the effects of these in soil and crop. At this time the analyses were also stabilized, so that a base of different analyses were conducted every year.

But the K-trial had another aim as well. The trial was intended to be pilot project. Through the K-trial one should not only find adequate measuring, one should furthermore, inspire to other research-issues, that in turn would inspire to further standardized planned field experiments. A row of such experiments was indeed carried out.

The aim of the trial

The experimental work very often denotes that the questions needs to be limited to just a few areas of measuring, while other conditions are kept as constant as possible. Initially it will be discussed here, how the ambitions with the K-trial were realized and by which limitations this was possible.

Equalized yield level?

In the K-trial the yield-level was a factor that should be as equal as possible between most of the variants. This basic condition for the trial also denotes possibilities, as well as limitations. The possibilities consisted of, that at similar yield-levels the differences between the variants concerning all other traits, should be related to the fertilization. The variants that above all, should be comparable in this way were K1, K3, K4 and one of the mineral fertilized variants K6, K7 or K8. A specification of the results from the trial, shows that the yield-levels were about the same in K1, K3, K4, K7 and K8. Only the clover/grass ley crop deviated from this, by that the mineral fertilized variant came to be circa 15 to 20 percentage lower than the rest of the variants. See Table 36.

Crop	K1	K3	K4	K7	K8
Beets, root	111,4	110,3	107,2	111,7	117,1
Potatoes	103,6	100,7	104,5	105,8	103,5
Ley	104,5	110,0	108,2	91,0	91,9
Wheat	105,3	104,7	105,0	106,9	105,5
Mean	106,2	106,4	106,2	103,9	104,6
Table 36	Relative yield-values for a few variants 1958-1989. Trial-mean =100				

The results from the K-trial should in other words, be able to offer a basis for a discussion about the effects of fertilization on crops and soils properties. Qualitative differences between the variants can in other words not be related to quantitative differences concerning the yield.

Comparison of fertilizer-type or cultivation-system?

In the farmer's case, the fertilization is only one part of all the actions that he sets in. Together with other procedures the farmers activities is formed into a system of cultivation. Here one of the obscurities in relation to the K-trial is observed. The experiment has been understood by many, as a comparison between cultivation-systems. This misunderstanding is partly concealed in the trial layout as such.

It can be said about K1, that in the fertilization-aspect, the conditions were comparable to that in biodynamic farming. But the trial layout does in several aspects deviate from the praxis within this form of agriculture. The preceding crop rotation is shorter in the trial and contains a large amount of chopped fruits. Furthermore, resting-time for the clover/-grass ley is shorter. The amounts of fertilizer are also higher than customary. It would be very hard to perform this in practical farming life, especially when the fertilizer-rates reached a peak in the mid-part of the trial period and at the same time keep up the basic principle in biodynamic farming, i.e. that each farm shall be self sufficient in fodder and fertilizer. This also applies to K2 and K3.

Concerning the mineral fertilized variants, it also must be pointed out, that in the ambition to be able to compare different types of fertilizers with one another, the trial has alienated itself from the practical reality. The trial lay-out with preceding crop rotation, selected species and other different farming procedures implies a compromise and do not justify the farming that uses mineral fertilizer. The unfertilised clover/grass ley, the potato-haulm that was chopped as soon as late blight fungus infestation was threatening the potato-tubers, instead of using chemical treatments, are examples of deviations from the type of farming where chemical means of input are used.

The K-trial with the strong directions towards comparison of different types of fertilizers and towards creating conditions for the development of quality-indicating methods, thus takes away the possibility to compare the entire

farming-system. At the same time, there were in the entire trial layout, an intention to be able to do exactly that. When we com-pare e.g. K1 with K2 or K3 it is precisely the farming-system and not the type of fertilizer we are studying. The differences between K2 and K3 are not easy traceable to the difference between compost and raw farmyard manure. To the compost in K2 was also the addition of biodynamic compost-preparations. The difference between K1 and K2 also lies in how the biodynamic preparations and not the fertilization were used.
Here we find accordingly, that despite all, the trial contains elements to be a comparison between farming-systems along with the ambition to compare the types of fertilizer-effect on crops and soil properties. When continuing this discussing, the differences between fertilizer-types and between farming-systems, must these limitations be distinctly kept in mind.

Is the K-trial confirmed by other field experiments?

Two "daughter trials" were developed through the K-trial and performed 1971-1976 in Uppsala and 1971-1979 in Järna. These experiments will here be called UJ-trials. The results are reported in; *Dlouhy, 1981* and *Pettersson, 1982*.
In the UJ-trials, two different farming-systems were compared, biodynamic agriculture and conventional agriculture. They include comparisons with consideration taken to crop rotation, fertilization and pesticides used in the conventional system.

Correlation of measuring

In the UJ-experiment it was observed significant correlation between crude protein and a few other practised measuring (*Pettersson 1982*). In Table 37 is given an overview of these relationships. The results from the K-trial confirms at large in these correlation of crude protein and the below stated methods of analyses that came into use in this trial.

Crop	Compared parameter	Type of relation	Significance, P<
Potatoes	dry matter content	negative	0,001
	relative true protein content	negative	0,01
	EAA-indice	negative	0,001
	Ascorbic acid	negative	0,001
	boiling-quality	negative	0,01
	taste-quality	negative	0,001
	free amino acids content	positive	0,001
	extract dissolution	positive	0,001
	darkening of extract	positive	0,001
Wheat	EAA-indice	negative	0,01
	extract dissolution	positive	0,001
	falling number	positive	0,05
	gluten content	positive	0,01
	baking-efficiency	positive	0,01
Table 37	The crude protein connection to a few other properties. Compiled from *Pettersson, 1982*		

Potatoes

In both of the UJ-trials, with shorter trial-periods the yield of potatoes was significantly lower in the biodynamic variants. This was partly a result of higher yield-losses caused by *Phytophtora infest.* in the biodynamic variants and the use of chemical pesticides in the conventional fertilized variants.
The tendency to a higher value of dry matter content in the biodynamic variants in the K-trial was also found in both of the UJ-trials and was there significant. The amount of crude protein was also significant higher in the mineral treated variants, while amount true protein was significant higher in the biodynamic treated variants. The value free amino acids were lower in the biodynamic variants. The higher quality on protein in the biodynamic cultivated crops was determined by comparing the relative content of essential amino acids and the biologic value of protein, calculated as EAA-indice. The value was significant higher for the biodynamic systems.
In both the K-trial and the UJ-trials it was appearing that the darkening of tissue as well as of extract, were more prominent and developed more rapidly in the mineral fertilized than in the organic fertilized variants. The difference was significant in the UJ-trials.
Measures of extract decomposition in the K-trial displayed that the organic fertilized variants on average, had a lower value of dissolution than the other variants. Similar results were found with significant differences in a comparison of the conventional and the biodynamic treatments in the UJ-experiment.
In the K-trial tended the storage losses and losses caused by fungi-attacks and dehydration to be lower in the organic variants. In the UJ-trial in Järna this difference was significant.
The degree of infestation of late blight fungus was significantly lower in the variants K1, K2 and K5 in comparison with variant K8, K3 and K4 during the 14 years of studies. In the UJ-trials the conventional variants were treated with pesticides against fungi. The yield-differences between the various fertilizer-systems, with high infection values, were largest during the first years.

The number of horizontal shoots differed in the various treatments, the values tended to be lower in the organic and higher in the conventional variants. This negative correlation indicates that a low number of horizontal shoots are related to high product-quality. In the UJ-trial Järna, the number of horizontal lateral shoots was significant lower in the biodynamic variants.
Concerning the analyses of crystallized picture, these showed less error-units in the organic than they did in the conventional variants.
In Fig. 52 are presented the results from the three experiments. In the K-trial it was K8 that represented the conventional farming-system. As seen in the bar graph all three trials show a good conformity. It is only concerning the yield-level that more marked differences are at hand. Here the results deviates from the more long termed K-trial, showing by far, the same yield-level between the two farming-systems.

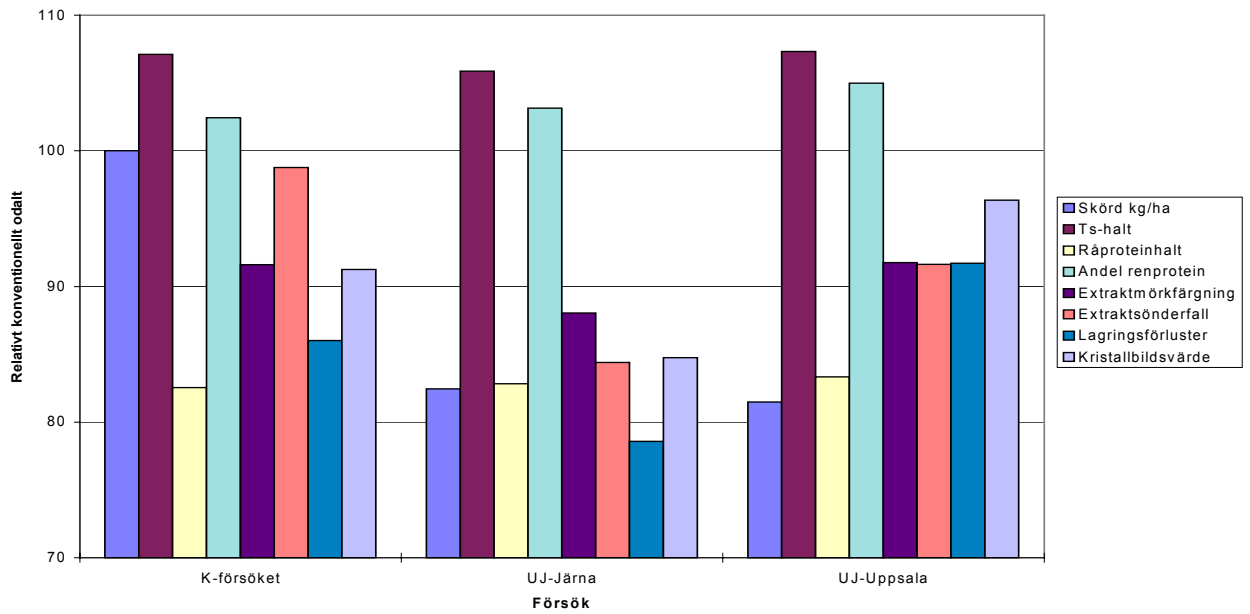


Fig. 52 Comparison between the K-trial and the Ultuna- Järna-trials concerning different parameters in potatoes. Relative values, conventionally cultivated =100.
Skörd= yield, Ts-halt= dry matter content, Råproteinhalt= crude protein content, andel renprotein= proportion of pure protein, Extraktmörkfärgning= darkening of extract, extraktsönderfall= decomposition of extract, Lagringsförluster= loosen during storage, Kristallbildsvärde= error units in crystallisation picture

Summer wheat

In the UJ-trials were the yield-levels of summer wheat significant lower in the biodynamic treated variants. The contents of crude protein were higher in the mineral cultivated variants, in both the K-trial and in both of the UJ-trials. The value of relative true protein was higher in the organic variants in the K-trial as well as in the UJ-trial in Järna. The fact that the protein quality was higher in the biodynamic variants, was confirmed by the determination of the EAA-indice for the essential amino acids. The resistance against extract decomposition was higher in the biodynamic variants. Also the starch-quality, determined as falling number and amylogram was higher in the biodynamic variants. Concerning the summer wheat, there are fewer investigations brought to use in the UJ- and the K-trial. When that is the case, it seems to be a good conformity between the trials.

What is quality and how can it be indicated?

In the writings by Bo Pettersson there are only a few attempts to adapt to the issue of quality. In *"Ugeskrift for Jordbrug" nr 8 1987* there is an article that here will be reproduced in whole, as it can serve as a basis to illuminate the quality-aspects that developed as a result of the K-trial. Bo writes in this article:

The quality in biodynamic products

In the plant we do not only find an ability to build a form, but also that mineral substances form a living organic matter. These two processes works in a parallel fashion and one can presume that they do influence one another. In that case, it can be assured that one can give information about the other.

The building-up of the organic matter follows after a shorter or longer period of decomposition. The processes that build the plant can be followed especially distinct during the first conditions of life in the plant. In Fig. 53 below, is an attempt to graphically express the build-up. The build-up occurs successively and in the beginning there is a large amount of low-molecular chemical matter. Of N-compounds exist e.g. nitrate, amides, free amino acids and such. Slowly high-molecule matter replaces these as fully constructed proteins. When the plant product is mature, this process reaches an optimum. After the decomposition-processes occurs, that to a certain degree is a mirror image of the build-up process. This can occur through the plants own internal metabolism with the help of enzymes or through, from the outside incoming organisms as bacteria, fungus etc.

Through following the build-up- and decomposition-processes one gets an impression of how the plant or parts of the plant are coping with this procedure. One can draw this symbolically in a curve, with one ascending and one descending part as in Fig. 53. The base-line marks the time, and since the time is included in the investigation, then one arrives at the living, where the processes always takes place within a time sequence.

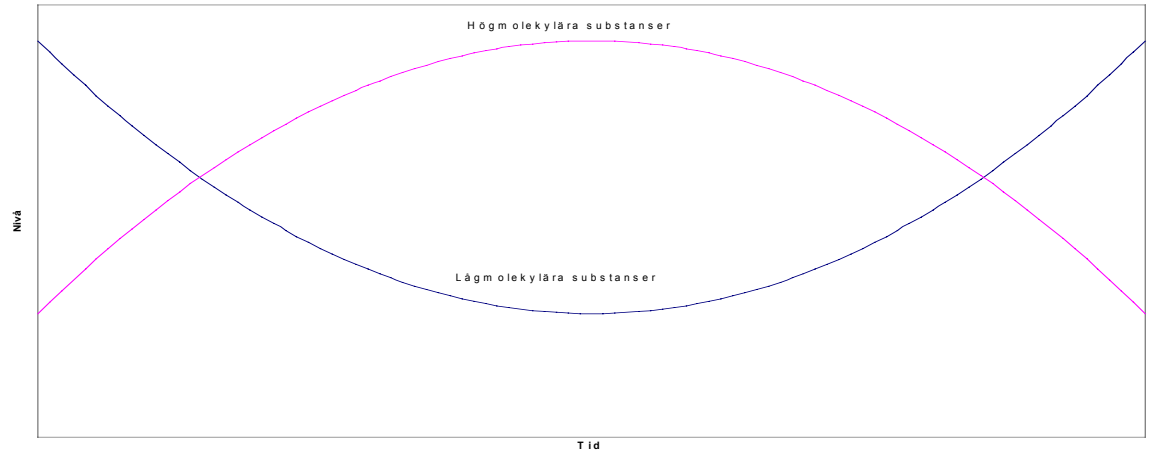


Fig. 53 The change of the content high-molecular (högmolekylära) and low-molecular (lågmolekyleära) matter during the farming season.

In Table 38 is an example given from the decomposition of potatoes. Whether this occurs enzymatic or during more mixed conditions, it does show that the biodynamic potatoes have a better durability.

Enzymatic decomposition	**Biodynamic**	**Conventional**
Catalase activity, µmol H_2O_2 per min. and gram dm	165	215
Peroxidase activity, µmol GJ per min. and gram dm	3215	5320
Mixed decomposition		
Extract decomposition, 4 days	28,5	30,0
Weight-loss in storage	13,4	15,5
Shrinking, 259 days	19,0	34,5

Table 38 Decomposition of matter. Potatoes.
Analyses by B. Pettersson and I. Samaras. *(* after *Pettersson, 1982)*

Samaras, 1977, has interpreted the higher enzyme-activity in the conventional cultivated potatoes as a sign of unripeness, in comparison with the biodynamic, as these decomposed enzymes are inactivated to a considerable degree when maturing.

The plant in light and shadow

The light is an essential factor for the plant with exhaustive effects on form and matter. Through limiting the light for the plant, e.g. by screening of the light and create shade, one can register these effects on the plant. With that as a starting point, one has within the biodynamic research-work, constructed a relative light-shadow grading that can be used to find out, which of two plants has received the most light.

Growth properties	**Light**	**Shadow**
Growth-habit	vertical	horizontal
Progress	quickened	delayed
Tissue structure	firm	porous
Dry matter content	increases	decreases
Crude protein content	decreases	increases
Free amino acid content	decreases	increases
Amount true-protein of the crude protein	increases	decreases
Decomposition of matter	slow	rapid
Form-ability at crystallization	improves	deteriorates

Table 39 Examples how different properties in the plant are influenced by growth-location in light and shadow respectively.

The light-effect can be reinforced or weakened by other elements, e.g. it is reinforced on sand soil and weakened on humus soil. Nitrogen weakens, phosphorus content and silicium strengthen it, untreated raw farmyard manure has a weakening effect, while composted farmyard manure is almost neutral in effect.

In Table 40 a comparison is done between two potato-series that has been cultivated differently during nine years. It is exciting to see that the biodynamic potato series has properties as if it had grown in more light than the conventional.

From trial with potatoes 1971 -1979	**Biodynamic**	**Conventional**
Yield, kg/ha	32300	38500
Dry matter content	21,7	20,2
Storage waste, October- April	21,8	30,0
Crude protein, % of dry matter content	7,7	9,9
Free amino acids, % of crude protein	18,6	19,6
True protein, % of crude protein	63,8	61,1
C- vitamin, mg/100g fresh weight	17,6	15,5
Darkening of extract, E48	345	423
Extract decomposition, %	20,0	25,8
Crystallized picture, error-units	4,8	5,7

Table 40 Comparison of potatoes cultivated under biodynamic and conventional conditions respectively.

Levels of investigations

When investigating living organisms or procedures the individual analysis dominates as method. Here we investigate a specific property i.e. the amount of one substance. But if the analysis is to be valuable, then it is a dire necessity to be able to evaluate the importance of this substance in the life-processes. But this task becomes almost impossible because of the fact that the individual substance never acts alone and more over, is involved within, yes even is under the command of the life-processes, which we first must know something about, before we can judge the effect of that individual substance. This indicates that we first must make an analysis on a higher level than where the individual analyses are located.

One such ”higher” analysis is performed e.g. when we follow the build-up and decomposition of living matter. Such processes can be followed with the help of several different types of specific analyses, but this time adjusted to a time-sequence. In this way we have a possibility to penetrate deeper into the area of the living. Despite this, can such meanings of life-processes in our nutrients, be difficult to understand as this area as yet is little explored. Even more difficult becomes the interpretation of the light shadow effects, as it is concerned with several combined life-processes. The plants reaction on effects of light is as such distinct enough, and it must as such, exist a similar effect in their ability to support other organisms with nutrients, but how shall we be able to follow this road of abilities into another organism? It is here, the future tasks within quality-research lays awaiting ”.

So far Bo Petterssons own words.

Different groups of methods of analyses

One of the aims with the K-trial was to develop methods to indicate the quality in foodstuff. To be able to compare the objectives in most of the methods, is to set a measure on a certain trait. Thereby will a quantitative feature enter into the determination of quality. The measuring is summoned into a dignity and a unit, where the dignity is the quantitative side and the unit the qualitative side. A judgement about the quantitative side implies a knowledge about the qualitative properties that has been decided. That the yield of summer wheat was 3000 kg/ha show that the qualitative unit ”summer wheat” at harvest been present to an extent that was measured to 3000 kg/ha. Only in the picture creating methods, at least to start with, this quantitative side was amiss when describing a crop. In the K-trial these methods have also been supplemented with a quantitative analysis through different ways of trying to set a dignity onto the pictures. This resulted in e.g. beginning to determine the number of error-units in the crystallized pictures or the number erect stems in the potato-haulm or set a value on potatoe-taste. What is accounted for here all throughout, are in other words, the results that are based on quantitative as well as qualitative properties. Often attached to the determination of the quality is a valuation on what is considered to be superior or inferior quality. This is done against the background of the knowledge about the measured traits in question.

Some different quality-aspects come into view in the methods that was tried out during the trial period. Roughly can these different methods be brought together in four groups as below:

- **Yield** - this group includes all measuring on yielded amount of crop or ”fruit”. This indicates a measure of the weight and the quantity of a plant or a part of a plant.
- **Chemistry** - chemical analysis of the quantity of different substances in a plant or the soil.
- **Time-related** - a description of changes in time, i.e. a decomposition process or a growth-process
- **Sense-based** - a description of the impression of the senses, e.g. taste or form. Here are also the results resumed from the picture-created methods and botanical properties of the crops.

These groups do not claim in any way to completely describe what we call quality. The first three groups indicate a quantification of a certain quality without describing what this quality is. At harvest of, e.g. potatoes, the amount of tubers are measured without the question if the potatoes in one variant really are as many tubers as in another variant. The fourth group, sense-related methods, is based on the fact that we as humans always experience a phenomenon with many senses at the same time. Observation with the senses has the character of a total-experience. The difficulty in these methods is to make an abstraction out of an objective value. To do this we must first divide our experience into parts, i.e. potato-taste, earth-taste and bitters-taste. This division also implies some form of quality-experience to relate to and a material to compare with.

Yield

The amount of the yielded crop must also be considered to be a part of the crops quality. What can be discussed is whether this trait too often has been dominating in the research- and experimental-activity.

Method	**Used in**	**Higher values are judged as**
yielded amount of ”fruit”	all crops	positive
yielded amount of straw or tops	beets, sum. wheat	positive
yielded amount of green forage	clover/grass ley	positive

Table 41 Analyses with yield extension and basis for judgement

Fig. 54 shows a ranking order of different measures of yield-parameters. The most positive value for the property in question that year of measure has been given the value 8, the least positive value 1. K5 appears here as very weak. Values for beets lay i.e. close to 1. This means that K5 almost all years presented the lowest yield-levels among the variants. The mineral fertilized variants K7 and K8 have good values in all crops, except for the clover/grass ley. K3 is higher than the compost fertilized variants in all crops, except for potatoes where K1 had a better ranking order. Potatoes are the only crop where the straw, tops or absolute leaf-like organs have not been included in the yield-comparison. Perhaps the results express the thought, that raw farmyard manure more intensely stimulates the vegetative growth-process. K1 is higher than K2 in all crops. Potatoes responded positively concerning yields on mixed fertilizer. On the whole K4 is high concerning the yield-types of comparison.

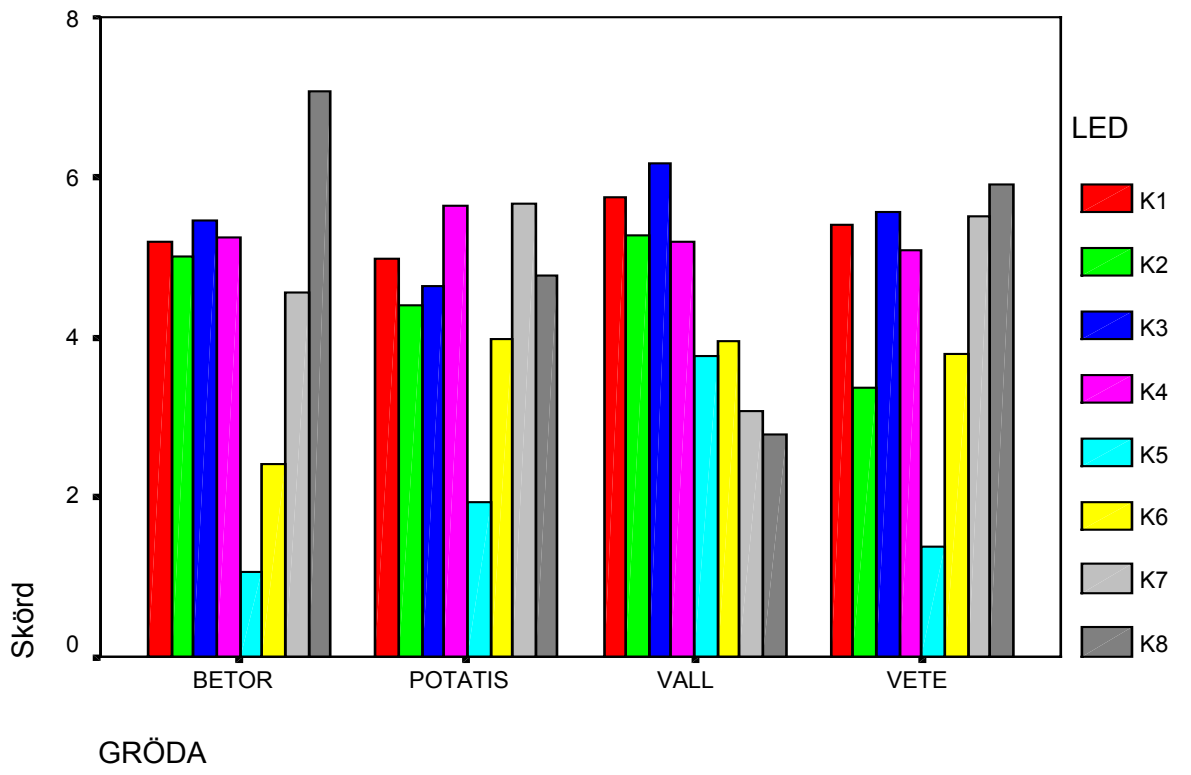


Fig. 54 Specification over the ranking order of the various variants concerning different yield-values. High value indicates high yield compared to the rest of the variants during a specific year of trial.
Betor= beets, Potatis= potato, Vall= lay first harvest, Vete= summer wheat

Chemistry

Through chemical analysis it is possible to determine weights and contents of different substances and put these values in correlation to one another. The development within the K-trial aimed towards finding correlation of the chemical analyses and above all, the picture creating methods (crystallization).

Method	**Used in**	**Higher values are judge as**
content of dry matter	All crops	positive
content of crude protein	All crops	negative
amount of true protein	potatoes	positive
content of free amino acids	potatoes, summer wheat	negative
content of dry gluten	summer wheat	negative
content of wet gluten	summer wheat	negative
pH-value	soil	positive
content of coal	soil	positive
content of nitrogen	soil	positive
content of phosphorus	soil	positive
content of potassium	soil	positive
content of magnesium	soil	positive

Table 42 Analyses with chemical relation and their basis for judgement

The methods of investigation that are based on chemical analyses, were performed mainly in the soil. These will be presented later on. In Fig. 55 are the results from various crops.

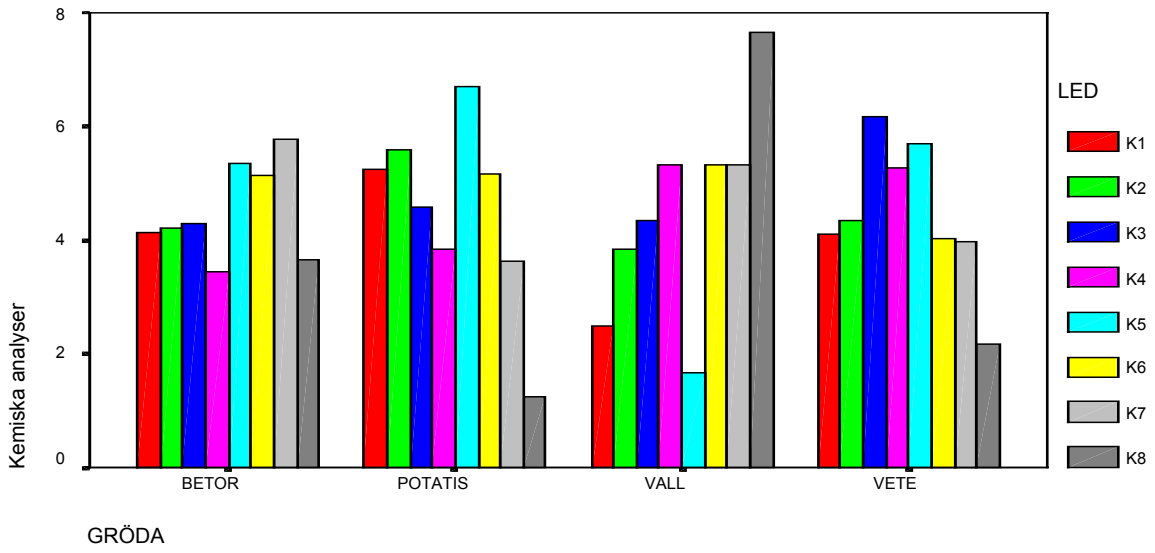


Fig. 55 Specification in ranking order of the different variants concerning various chemical analyses. High ranking order-values are equivalent to desirable quality-traits.

K5 tended to high values in most of the crops. It was probably the low yield-level that in this variant, increased the contents of different substances. When the clover/grass ley yield-level was not low in K5, this variant did show very weak values in the chemical analyses. Also K1 showed weak values in most of the crops as well as K8. K2 had better values than K1 in all crops. The large swinging back and forth between the variants in certain crops depends on, that the number of measuring used, were relatively low. That e.g. the variant K8 did reach such high values in short fallow after clover/grass ley, depends on the result, that the low amount leguminous plants showed a high dry matter content and low crude protein content. In this particular group of analyses, it might only be the potatoes and summer wheat that have a number of analyses large enough, to make this type of comparison interesting.

Time-related

In the K-trial a long row of various methods have been used, that measures changes within a time-interval. These methods and the basis for determination, are seen in Table 43.

Method	**Used in**	**Higher values are judge as**
late blight fungi infestation	potatoes	negative
darkening of extract	potatoes	negative
extract dissolution	potatoes, wheat, beets	negative
falling number	summer wheat	positive
viability	summer wheat	positive
storage efficiency, sorting	potatoes, beets	positive
hibernation	clover/grass ley	positive
pathogen-test	potatoes	negative
darkening of tissue	potatoes	negative
soil respiration	soil	positive
dehydrogenase- activity	soil	positive
urease-activity	soil	positive
number of earthworms	soil	positive

Table 43 Analysis-methods with relation to time and their basis for determination.

If this basis for determination is applied to the different crops in the K-trial appears the picture as seen in Fig. 56

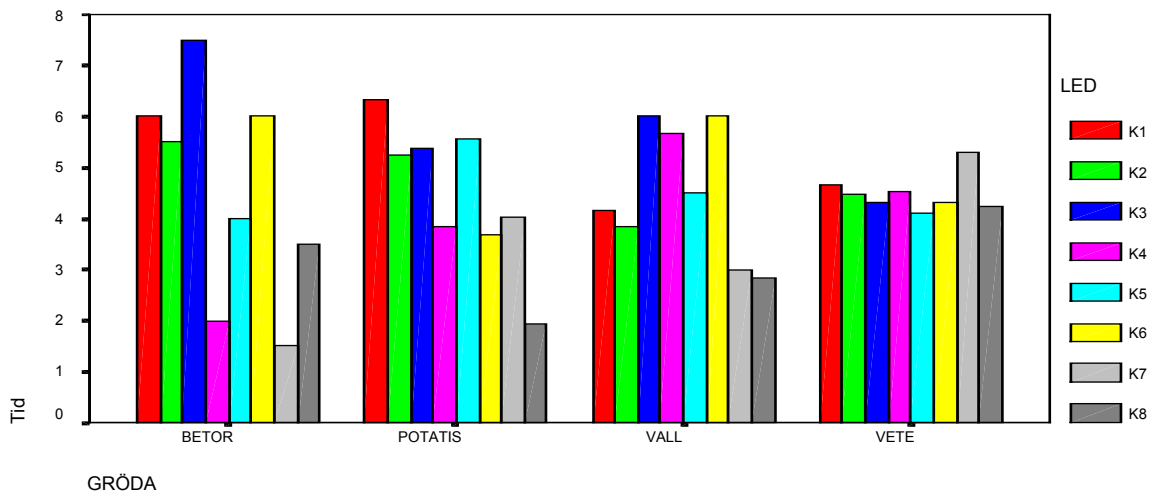


Fig. 56 Ranking order of the different variants concerning time-related methods. High-ranking order-values are equivalent to more desirable quality-trait.
Betor= beets, Potatis= potato, Vall= lay first harvest, Vete= summer wheat

The organic fertilized variants tended to get better values in most of the crops. The large differences in beets and clover/grass ley depend on that only a few analyses are included. In potatoes does K1 show the best values followed by K5. The mineral fertilized variants show the worst values. In summer wheat K7 is distinguished with good values and K5 with worse, otherwise the difference is not significant between the variants.

Sense-related
In the K-trial, and above all during the first part, several analyses were tried out with relation to properties that could be experienced with different senses. These are seen in Table 44. To this group is also added, certain botanical properties in the crop.

Method	**Used in**	**Higher values are judge as**
number error-units in cryst.pic.	potatoes, wheat, beets	negative
potato-flavour	potatoes	positive
earth-flavour	potatoes	negative
bitters-flavour	potatoes	negative
number erect stems	potatoes	positive
number horizontal stems	potatoes	negative
root/neck ratio	beets	positive
amount ”fruit” of total-yield	beets, summer wheat	positive
length of straw	summer wheat	positive
lodged stands	summer wheat	negative
kernel-size	summer wheat	positive
amount hay of green forage	clover/grass ley	positive
amount legum. pl. in hay-yield	clover/grass ley	positive
amount weeds in hay-yield	clover/grass ley	negative
volumetric-weight	summer wheat	positive
1000-kernel-weight	summer wheat	positive

Table 44 Analyses with relation to sense and the basis of determination.

In the beets only a few sense-related investigations were carried out. K7 was here very high because of the high amount of roots in the total-yield. Thereafter follows K3 and K1. The values in K5 and K8 were worse. In potatoes the compost-fertilised variant had the best values together with K5. The mineral fertilized variants K7 and K8 showed the worst values. In the clover/grass ley, K8, K2 and K1 were high, while K3 and K4 deviated by worse values. In summer wheat had K1 high values, while K7 and K8 showed the worst values. The results from this ranking order, see Fig. 57

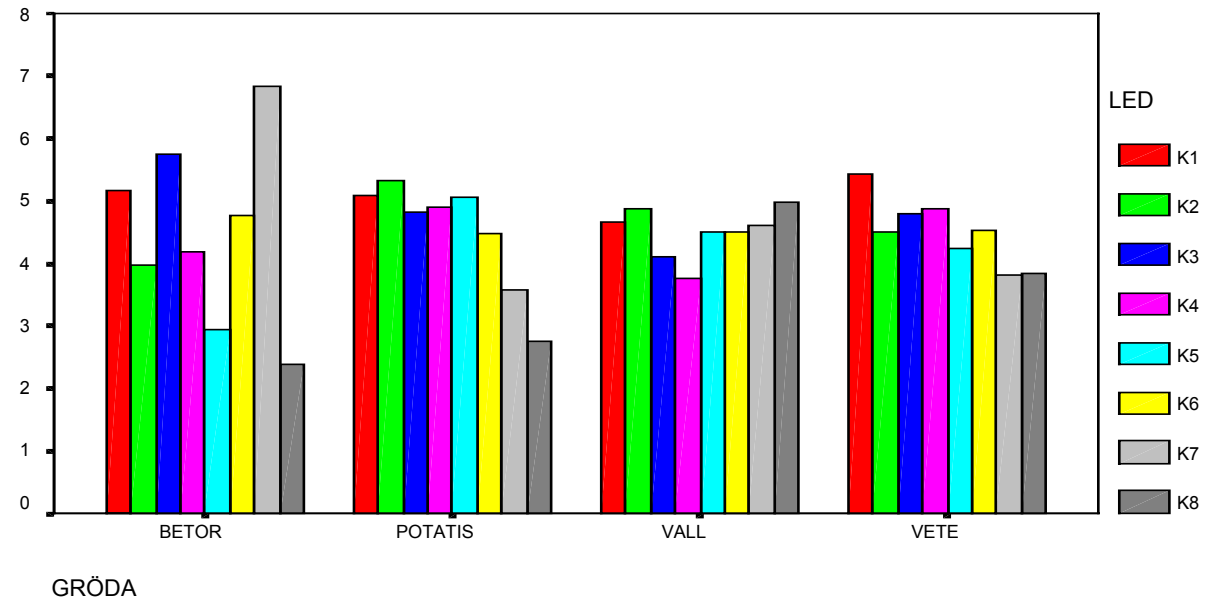


Fig. 57 Ranking order of the different variants concerning various sense-related measures. High ranking-value equivalent to a more desirable quality-trait.
Betor= beets, Potatis= potato, Vall= lay first harvest, Vete= summer wheat

A specification of the ranking order of all these analyses-measures, see Fig.58 The line marked at the value 4,5 show the mean value for the ranking order. K1 is placed high in all groups, except the chemical, there the variant has approx. mean values. K2 is placed approx. around the mean value in all analyses-groups. K3 is above mean value in all analyses-groups. K4 is below mean value in all groups, except the yield. K5 show high values concerning chemistry and time and very low values for yield. K6 has low values for yield and time and values above mean concerning chemistry and sense. K7 was above mean value in yield and just above mean value in chemistry and sense, while time was below mean value. K8 had good yield-value, but otherwise low values in the rest of the groups, especially in chemistry and sense.

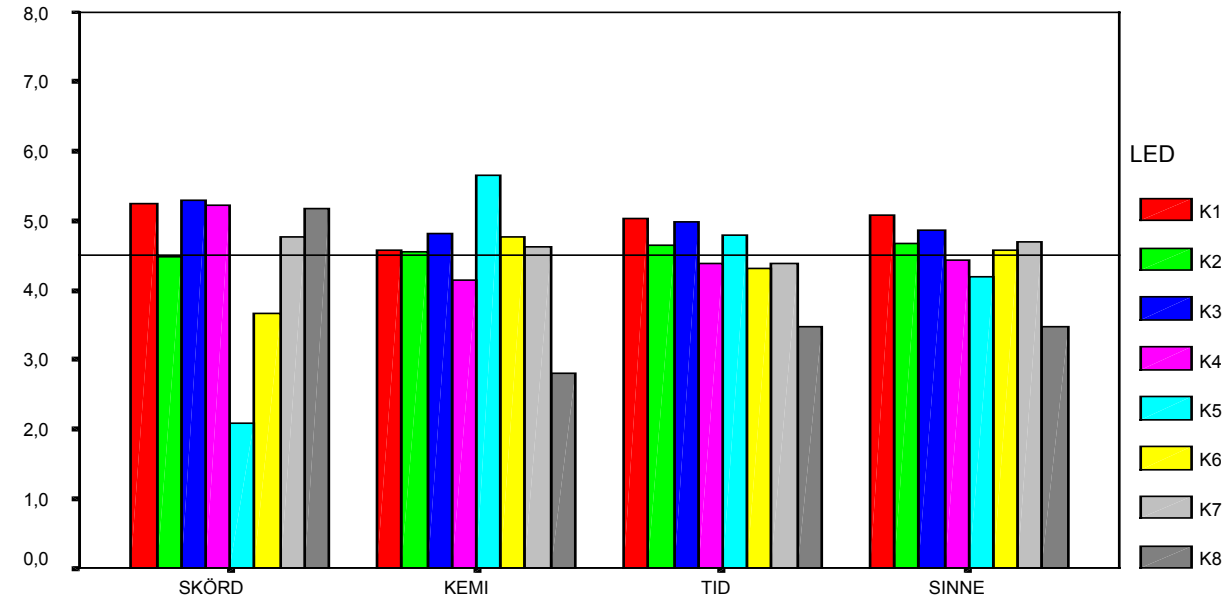


Fig. 58 Ranking order of different variants concerning various analyses.
High ranking-value equivalent to a more desirable quality-trait.
Skörd= Yields, Kemi= Chemistry, Tid= Time, Sinne= Sensory

Somewhat simplified it can be said, that variants K5 and K6 show a relatively good quality, but they cannot compete yield-wise with the rest of the variants. K7, K4 and above all K8 show the opposite picture; relatively good yield-values but worse quality. In the organic fertilized variants we find signs to bring together quantity and quality, high yield with good properties in the yielded crop. A combined value, without any judgement whatsoever of the mutually meaning of one measuring or the other, of all analyses that has been carried out in the different crops over the 32 years of trial are

displayed in Fig. 59 This show that the variants have grouped themselves into three groups. K3 and K1 show the best values and K8 the distinctly worst. The other variants are somewhere in between.

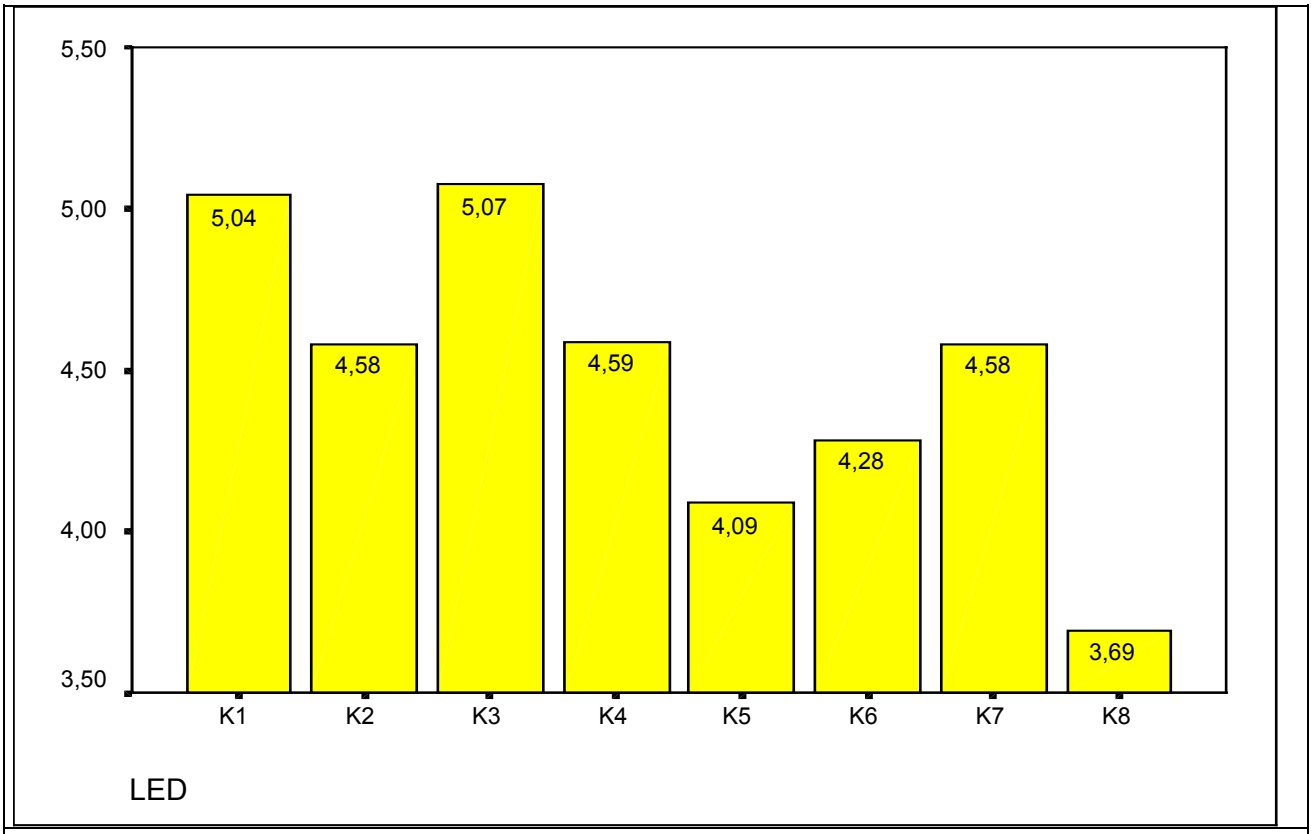


Fig. 59 Ranking order of all measuring in the K-trial.
High ranking-value is equivalent to a more desirable quality-trait.

The correlation of yield and quality is worth high lightning somewhat further. In Fig. 60 the values are depicted from the ranking order that includes yield-measure and the rest of the three groups, put together to what here is called quality. The values are divided year by year. In Fig. 60 is seen that K5 and K8 did not succeed to combine quantity with quality. K6 show a deviation in yield-development as well as to a certain extent so did K4. K3 and K7 seem to be the variants where yield and quality follow one another strongly. In the compost fertilized variants K1 and K2 is a tendency to high yield-values being connected to lower quality-values and vice versa. Above all, in K1 there is a tendency to increasing ranking-values during the trial period. However, these calculations must be seen only as a suggestion to more detailed experiments and not considered as a certification.

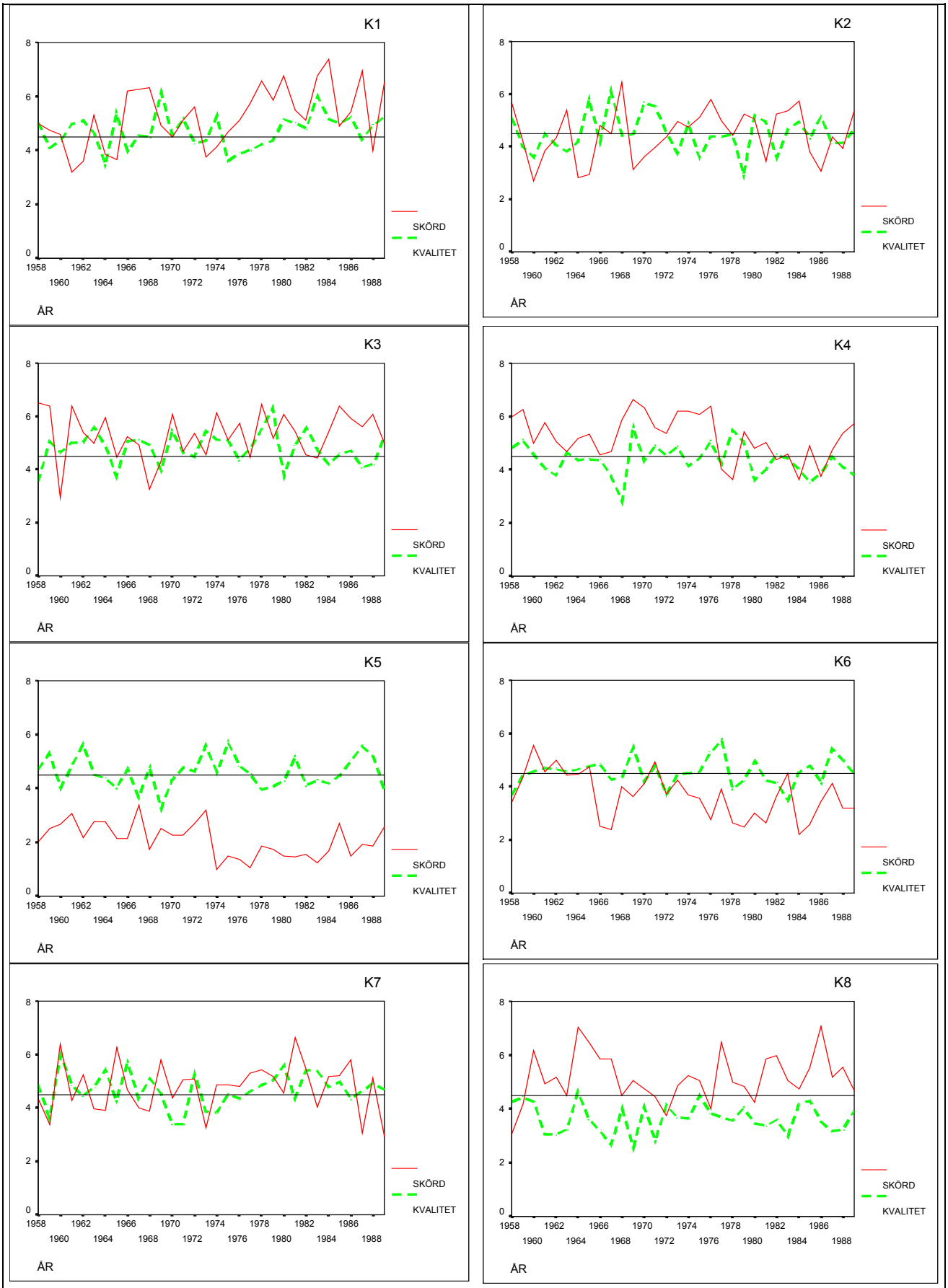


Fig. 60 Correlation of yield and all other analyses during the trial period. High ranking-value is equivalent to a more desirable quality-trait.
Skörd= Yields, Kvalitet = Quality

If the same type of calculations is carried out with the values from the soil investigations then a relative uniformed picture is seen. Concerning the soil investigations, only the chemistry and time-related groups were carried out. K1 show the best values in all soil-depths in time-related as well as chemistry-related analyses. K3 is also placed high in both groups. K7 and K8 show high ranking-values concerning the chemistry-related methods while these variants have very low values for the time-related methods. K4 show surprisingly low values, especially concerning chemistry. Also utterly surprising is the very weak value in deepest soil-layers concerning variant K2. The entire unfertilised variant, K5, show ranking-values that turns better, the deeper down in the soil the measures were taken.

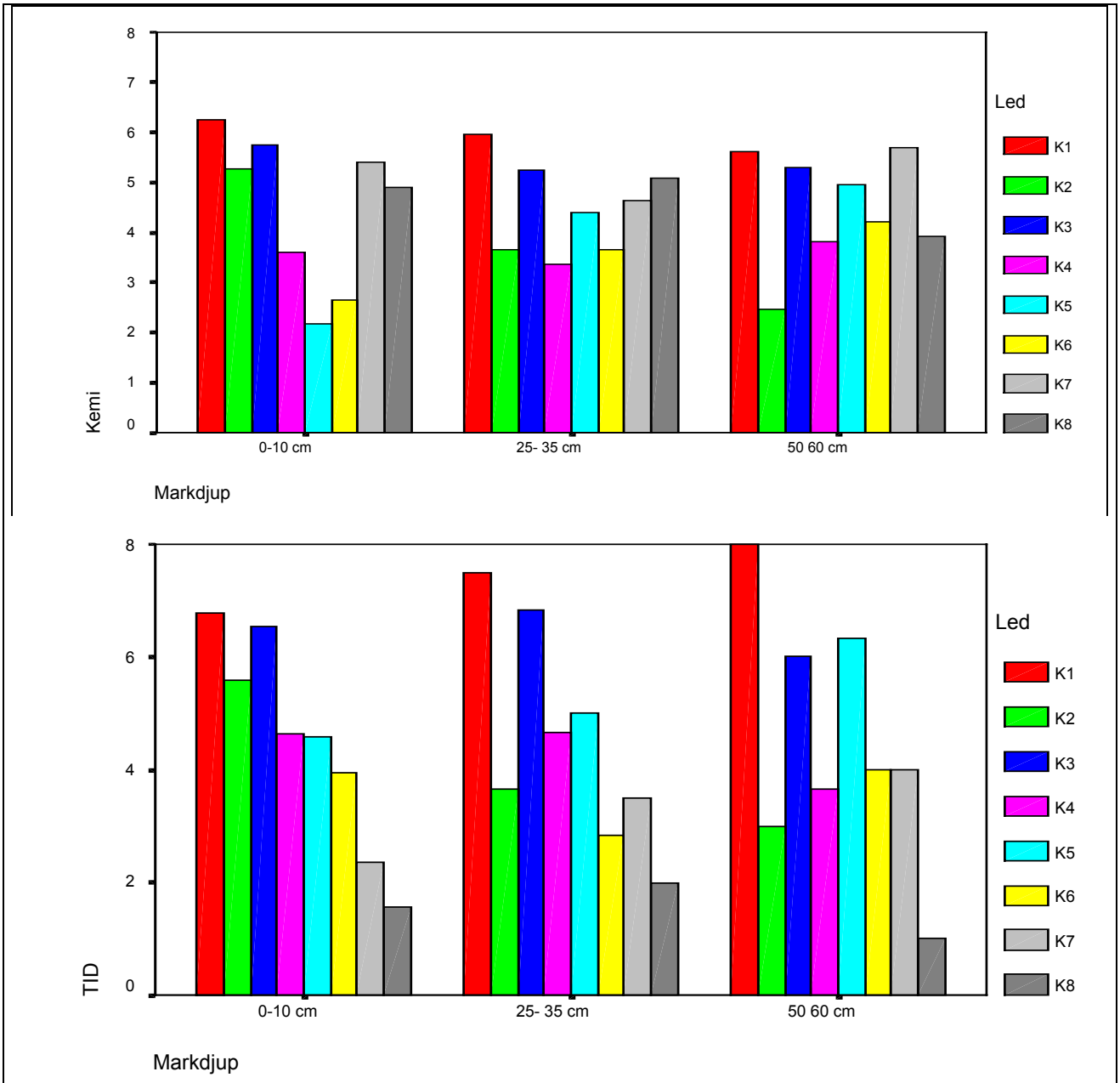


Fig. 61 Ranking order of values in soil investigations. High ranking-value is equivalent to a more desirable quality-trait. Top diagram chemistry-, below time- related values

Correlation of fertilizing, soil and crop

With the starting point from the completely unfertilised variant, some aspects of correlation of fertilizing, soil and crop can be highlighted.

Completely without fertilizing

33 years without fertilizing did not give rise to large differences in the soil properties compared to the rest of the variants. This probably depended on the influence of the clover/grass ley. In the topsoil, K5 was generally lower than the rest of the variants. At the end of the trial K5 showed a C-content in the soil, that did not appreciably deviate from the mineral fertilized variants. In the soil-depth between 50 and 60 centimetres K5 showed the second highest value. Perhaps this is a result of the poor nutrient situation in the topsoil that forced the plant roots to grow deeper down into the soil-profile. Concerning the biological activity, K5 did not deviate so strongly from the rest of the variants, in the deeper soil-layers. The same applies for the contents of N in the soil. We will return to this in the next chapter. Instead, it was the low contents of the P-content that distinctly showed that K5 was not given any plant nutrient during the 33 years. Besides, the soil in K5 did show the worst buffering ability according to the pH-value. These soil conditions were not able to bring forth any larger amounts of yield, especially not concerning the chopped-fruits. On the other hand, the products from this variant showed a good resistance towards fungi-infestation and low contents of none-convertible compounds at harvest. In the clover/grass ley the conditions gave an intense growth-process in red clover, especially during the later part of the seasons. The total impression is, that this variant brought forth crops on the verge to being precocious. To connect to the light shadow scheme that was out-lined by Bo Pettersson above, then one gets the impression of this variant, that the crops have been growing in a too strong light and thereby becomes precocious.

Mixed fertilizer

A mix of mineral and organic fertilizers might seem to be a good compromise between two fertilization-principles. This impression is re-enforced, if one studies the yield-values concerning potatoes, summer wheat, the first harvest in the clover/grass ley or the yield of beet-tops and wheat-straw. Compared to this, did K4 show surprisingly low values at many investigations in the soil. In the topsoil the values of P and Mg-content was low, while the C and N contents was above the mean value. Urease-activity was very high in the topsoil to decrease at a faster pace in the deeper soil-layer than average in the trial. The dehydrogenase-activity was relatively low in all soil-layers. The mixed fertilized variant had a certain implication to make zones between topsoil and sub-soil. Above all in the deepest soil-layer, but also just right under the plough-depth, the values was distinctly lower than average. The crop given the mixed fertilizer gave relatively low quality. This was showed above all, in the time-related investigations and maybe most distinct concerning receptivity towards fungi-infestation. Above all, it was the chopped-fruits that gave worse quality. Summer wheat that was only fertilized with mineral fertilizer, did not deviated in quality from the other variants. In the clover/grass ley, the mixed fertilized variant had together with K8 the lowest amount leguminous plants at the first, as well as the second harvest. The leguminous plants had in this variant hard to hibernate, while the grass and above all, the timothy showed a very good hibernation. Total-image of this type of fertilization is in other words very complex. It appears to a great deal, to be the opposite of the unfertilised variant. It has difficulties to force its way down to depths, but also to maintain itself in the time-based analyses and during the later part of the trial period. According to the light-shadow-scheme K4 can be referred to as being more on the shaded side. The crops showed a lot of immature characters.

Mineral fertilizer

A mineral fertilizer alteration in the K-trial did give rise to the yield-amount, lower soil-activity and worse quality. The optimised N-rate seemed to be the one that occurred in K7, i.e. ca 60 kg N per hectare and year. Therefore, shall we concentrate on the results from this variant. In the soil, this variant was distinguished through a relative weak-buffering capability, low C- and high P- and K-content. The Contents of N was surprisingly low, above all in the tops-soil, if the measures in 1976 are considered to be an exception. The soil biological values were generally very low, especially in the two first soil-layers. The higher activity in the deeper soil-layers, was perhaps a consequence of slightly higher nutrient contents. This can be taken as a sign that, the downward-transportation of nutrients during the years has build-up a certain biological activity in the sub-soil. Yield-wise K7 was, as well as K8 very high, if the unfertilised clover/grass ley crop is considered to be an exception. This show that the fertilization was capable off giving rise to a large growth-process in the crop, but could not create such conditions, that the soil itself could deliver the nutrient needed to the plants. The intense growth-process in the mineral fertilized crops was not capable of creating any appreciable nutrient quality. Even if K7 showed distinctly better values than K8, the total-impression was that the mineral-fertilized variants, together with K4, gave crops with worse quality-traits than the rest. Especially did this apply to the chopped fruits, potatoes and beets, while K7 did not deviate significant from the organic fertilized variants concerning the quality-traits in summer wheat. Just as the mixed fertilized variants, so does the mineral-fertilized variants, give the impression that they represent a shadier place of growth.

Organic fertilizer

The organic fertilized group gave rise to a high activity in the soil, high yield-levels and relatively good quality traits in the crops. It is the type of fertilizer that was best able to combine the more quantitative yield-measures with the more qualitative properties in the crop. It was however, differences between compost and raw farmyard manure. The trial

layout was such, that it was not possible to compare the raw farmyard manure with the compost. The compost was always treated with the biodynamic preparations. Hence this suggests a comparison between a cultivation that uses raw farmyard manure with a cultivation that uses compost and biodynamic preparations, i.e. to compare K3 with K1. These two variants were by and large equal, concerning soil, yield-level and the crop-properties. A detailed study however, shows some differences. K1 showed distinctly better buffering capability and higher P-contents in the soil. K3 had higher contents K, N and C in the topsoil. Also concerning the soil biological measures in the topsoil K3 showed higher values than K1. In the deeper layers did K1 tend to have higher values in the soil chemical as well as in the soil biological measures. It does seem as if, the cultivation measures taken in K1 more intensely stimulated the soil processes in the deeper soil layers, while the fertilization with raw farm-yard manure gave a more concentrated effect in the topsoil. The difference can perhaps partly be explained by the clover/grass leys properties. K1 showed a considerable higher amount of leguminous plants, especially in the second harvest. Possibly this resulted in a stronger penetration of the plant-roots in the deeper soil profiles that in turn gave a fertile soil-life that could develop deeper down. Yield-wise, K1 and K3 were more or less on the same level. K1 gave slightly higher yields of potatoes, beetroots, beet-tops and summer wheat, while K3 gave distinctly higher first harvest and slightly higher second harvest of clover/grass ley and wheat-straw. The potatoes fertilized with raw farm-yard manure was considerably more receptive to fungi-infestations and also gave the impression at other measures, to be more immature than the potatoes treated with compost and biodynamic preparations. In the summer wheat the differences was smaller. K3 showed here better values than K1, concerning many of the chemical analyses, while K1 gave better values at the crystallization. In the light-shadow scheme it appears that the raw farmyard manure seems to be more on the shaded-side and the compost with biodynamic preparations more on the light side.

This briefing activates the issue, what is the aim of the fertilization. The opinions differ here between a more conventional emphasized and a biodynamic inspired farmer. The conventional view on fertilizers is, that it should be able to satisfy the plant-nutrient requirement. The biodynamic inspired insists that the fertilization is there, to enrich and build up the soil processes. In turn, it is these soil processes that are capable to satisfy the plants nutrient needs. This view on the fertilization reflects in turn, the differences in the view on what life is and thereby, the differences in opinion of how food quality arises.

Correlation of fertilization and nitrogen economizing

To give an example in the handling of plant-nutrient substances in the different cultivation-systems, the nitrogen will here be studied in some further detail. The nitrogen plays a central role in the discussion about plant-nutrients. Nitrogen is also an important foundation in many nutrient substances, but forms at the same time a much-discussed factor, in case it leaks out from the field and ends up in other eco-systems. The K-trial permit's a discussion about these issues, concerning handling the fertilizer, preceding crop values, N-mineralising and N-fixation.

Fertilization and fertilizer-handling

Mineral N-fertilizer is produced through a synthetically fixation of the N in the air. To accomplish this, a large amount of energy is required. From a resource-economizing point of view the use of mineral N-fertilizer, is therefore less suitable. As is evident in the results from the K-trial, mineral fertilizer is not to be recommended to achieve a good food-nutrient quality. Instead it is the yield-increasing effects that have brought about the conventional fertilized agriculture we have today. The results from the K-trial show that it is possible to build up a farming-system with yield-levels that are comparable to that in a mineral fertilized system. The criteria for this, was in the K-trial an integration of cattle-management and plant production. In the K-trial there was no entire green-fertilized variant carried out. Closest to that, was the unfertilised variant K5 with leguminous plants, two years of four in the crop rotation. For the one, who is investing in an integration of animal and plant production, the question soon arises, how the fertilizer needs to be treated. K-trial offers a comparison between the use of raw farmyard manure and compost with the additive of biodynamic preparations/sprays. These two fertilizer-variants gave rise to the differences described in the previous chapter. If we now look at the N-economy within these two systems, we can establish that the composting indicates considerable N-losses. With raw farmyard manure is meant i.e. fertilizer that is taken directly from the manure pad. However, it can at times be stored at the manure pad before it is used. Despite that, the raw farmyard manure did contain more N than the same amount of fertilizer that was placed out and composted in the previous autumn. Divided on all 32 trial-years the difference was close to two tons pure N per hectare. To K3 was supplied a total of 12193 kg N during the trial period. Corresponding number for K1 was 10281. This signifies an average N-loss through the composting-process equivalent to 15,7%. This is not particularly acceptable from an economizing point of view, either. The composted and preparation-treated fertilizer on the other hand, show that it is capable of contributing to the build up of a solid soil-structure and also to create conditions for the resistance in plants and a good nutrient-quality.

Nitrogen-mineralising capability

At the measures in 1989 and 1990 variants K1, K2 and K3 showed twice as high N-liberalization compared to K8. This indicates that the organic fertilized variants have been building up a higher mineralising potential. This potential cannot easily be explained only by higher humus content. The humus content-levels were approx. on the same level in all these variants. Instead, it is the quality of the humus, in the humus metabolic ability and in the soil biological activity one should probably look for an explanation to this 2-3 times higher N-delivering capability in the soil. It also seems here to be a rather insignificant difference between the organic fertilized variants, concerning their N-mineralising ability. This

capability must be said to depend on the entire soil-system capability to hold a larger amount of N in the organic fertilized variants than in the mineral fertilized variants. This signifies a better N-economy in more ways than one, not to say the least of the risks that the leaching decreases. This applies of course, only to the fertilizer-levels that were used here. At too high fertilizer-yields, the organic fertilized soil also run the risk to start N-leakage. But at comparable amounts, the risk for N-leakage is smaller in the organic fertilized variants. The measures from the K-trial show that the N-contents in the topsoil kept at a constant level on the whole. In some variants a decrease can be noticed, above all in K5, K6, K7 and K8. In the deeper soil-layers, the tendency is a rather weak increase of the N- contents. If calculating a balance only on N, concerning import in the form of fertilizer and export in the form of yielded products, then one gets the values as seen in Table 45.

Variant	**K1**	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**
N-balance, kg N/ha and year	-22,7	-28,8	-4,3	-38,8	-66,7	-56,9	-35,9	0,9

Table 45 Difference between supplied and abducted amount N in kg/ha and year.

Preceding crop values

At the studies of the preceding crop effects, the attention was concentrated to K1, K5 and K8. Both clover/grass ley and summer wheat with undersow did have high preceding crop effects in K1 and K5. It seems that in the results from K1, it could be that the clover/grass ley with undersow, one particular year can give the same or a somewhat higher preceding crop effect than the clover/grass ley crop. This was not the case in K5. In K8 could a higher preceding crop-value of the clover/grass ley in comparison with the rest of the crops not be determined. The second year after clover/grass ley one can still speak of a preceding crop-effect of the clover/grass ley. The third year, on the other hand, was the N-transportation from the incorporated material and the created top-humus after the clover-/grass ley crop probably totally consumed. But the higher N-mineralising the third year after the clover/grass ley in K1, in comparison with K5, must above all be ascribed to the higher metabolising capability in the humus-storage that has been building up in the soil in K1. In K8 the preceding crop-effect of clover/grass ley was low, likewise was the N-transportation that occurred from the soil-humus-storage. Here dominated the direct fertilization effect of mineral-N. This was noticeable in the high yield-levels after the intensely fertilized beets. Of a special interest was the so-called priming-effect in form of an increased liberalization that could be determined right after N-fertilization but that followed a corresponding N-immobilization. This corresponded with what could be determined from earlier studies by *Granstedt (1990)*.

During the regular experiment the summer wheat always followed after the beets. In Fig. 62 comparisons in yield of summer wheat in 1990 with the average for the entire trial period. As seen in the diagram the yield in 1990 followed by and large the same pattern as the rest of the trial-years. The difference in soil-fertility between the different variants that was built up over the years has probably played a role also this year. Variant 1d deviated however, from this pattern. The summer wheat with undersow here was apparently a better preceding crop for summer wheat than the beets. The same can be said about K5 where also clover/grass ley and potatoes seemed to be better preceding crops than beets. In K8 appeared the well-fertilized beet-crop as the best preceding crop for the summer wheat, while above all, the ley did not offer any more positive preceding crop value.

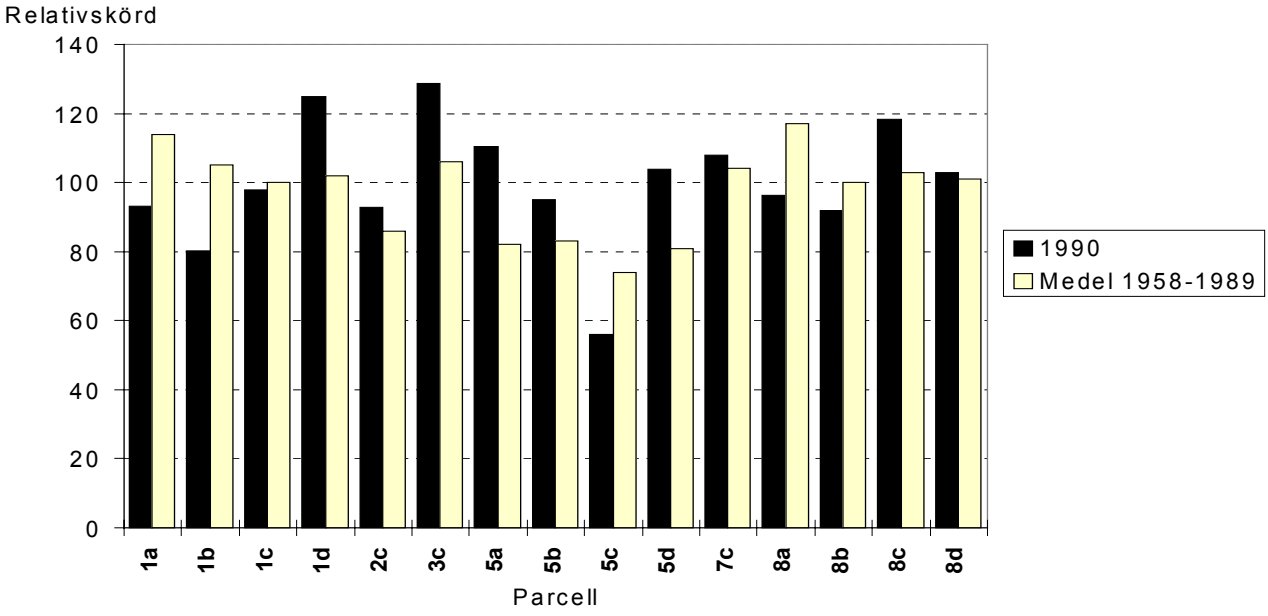


Fig. 62 Yield of summer wheat in different variants 1990 with different preceding crops and mean-yields of summer wheat in the variants 1958-1989 with beets as preceding crop. Relative-yield, trial-mean = 100. Plot a=clover/grass ley, b=potatoes, c=beets, d=wheat as preceding crop.

Nitrogen fixation

Related to the question of the N-economizing is also the ability to fixate the air–N in the leguminous plants. By starting at the amount of yielded dry matter content in the clover/-grass ley and also considering the amount leguminous plants, the N-fixation have been estimated according to the formula modified after *Granstedt, 1990*. The values that has been calculated in this way for the K-trial, corresponds well with other calculations of the N-fixation-size.

The values are seen in Fig. 63 and Fig. 64. It is in other words, rather large amounts of N that probably has been fixed in the clover/grass ley crop. At these calculations no consideration has been taken to the undersow, although a certain N-fixation surely has occurred there as well. The large differences between the variants were above all in the second harvest, which is why one can presume that the differences in N-fixation in the undersow aught to be smaller.

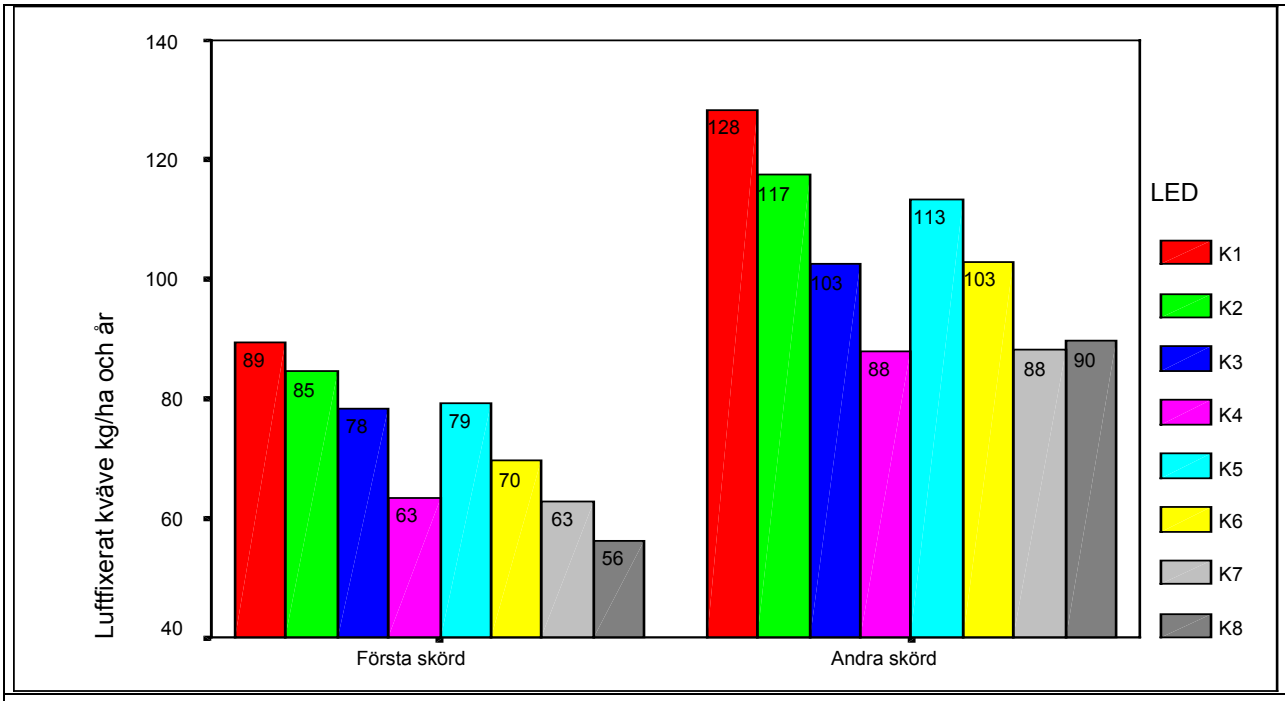


Fig. 63 Calculated values of N-supply via air-fixation in the first, första skörd, and second, andra skörd, harvest respectively, of clover/grass ley in kg N /ha

The order between the variants was, by and large, the same in the first as in the second harvest. K1 was highest. This is the result of a combination of high yield-levels and high amounts of leguminous plants in the clover/grass ley. Thereafter followed K2, K5, K3 and K6. K4 and K7 showed among themselves equal large N-fixation in both clover/grass ley yields, while the values for K8 was lowest in the first harvest but slightly higher in the second. If this N-fixation is divided on all the 33 trial-years emerges the numbers as seen in Fig. 64.

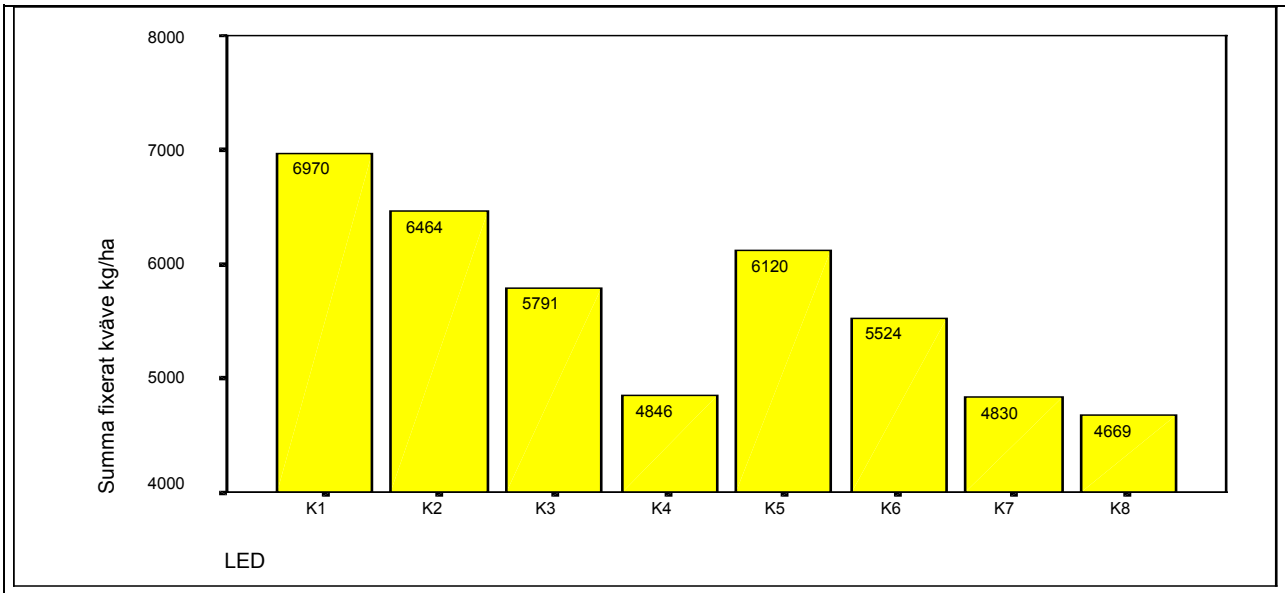


Fig. 64 Calculated values of N-supply via air-fixation during the period 1958-1989 in kg N /ha

If these values are included in the calculation as well, then some phenomenon arises that are worth noting. A decrease occurs in the differences between variant K1 and K3 concerning the N-utilization. The composting-process added to a N-loss equivalent to 1912 kg during the period 1958 to 1989. When later fertilizing with this compost, such conditions aroused that led to an increase in N-fixation, equivalent to 1179 kg N per hectare, during the same period. The total N-loss that was a consequence of using the compost in this crop rotation amounted to 732 kg or ca 9,6 %. If the calculations of the N-fixation is added to the total N-balance the values emerges as seen in Table 46.

Variant	K1	K2	K3	K4	K5	K6	K7	K8
N-balance, kg N/ha and yr	31,7	24,7	40,9	-0,9	-18,9	-13,8	1,7	37,4

Table 46 Difference between supplied and abducted amount N in kg/ha and year. Adjusted values with consideration taken to the calculated N-fixation-size.

In Table 46 appears that K1, K3 and K8 ends up in approx. the same group, concerning N-balance. These variants show excess in N equivalent to between 30 to 40 kg N per hectare and year. Even at these calculations does K4 and to a certain extent K7 end up surprisingly low. Compared to K1 did K3 receive 15 kg and K8 did receive 37 kg more N per hectare and year through the fertilization. At the end, this resulted in K3 with 9,2 kg more and in K8 with 5,7 kg more N-excess at the calculated N-balances. When the yield-levels on the whole, were similar between these three variants, then must at least the use of the last 20 kg N in K8, appear as a bad business in an economical, as well as from a resource-economizing point of view. If one also adds to this, that the mineral fertilizer was not capable of building up any larger soil fertility and did not contribute to an improved nutrient quality, then the use of this fertilizer appears even more doubtful.

If one hypothetically should consider, that no clover/grass ley-yield should have been transported away, but instead been used as a green-fertilizer, then even the variant K5 show that it almost reached a positive N-balance. The deficit in this variant became at these conditions equivalent to 1,6 kg N per hectare and year. A green-fertilizer-crop every forth year should in other words, be able to support the yield-levels that variant K5 showed during the trial period. The question is however, if these yield-levels should satisfy any practically working farmer.

Of these numbers on the N-economizing, new issues arises like, how the farm-yard manure should be treated so that we can combine the raw manure with its high content of plant nutrients and its strong life-stimulation in the soil processes, with the composted fertilizer and its structure giving and mature-stimulating effect.

The biodynamic field-sprays

The biodynamic preparations are a much-discussed issue in the biodynamic agriculture. Nowadays the preparations are rather well documented in different research reports. The K-trial lay out only allowed a comparison, concerning the treatment of the biodynamic field-sprays. The differences that appeared between the variants, can be summarized in such a way that preparation-treated variants showed;

- better buffering capability in the soil concerning pH-changes
- larger biological activity in the soil
- more building up of the soil processes at depth
- higher yield in all crops except the first harvest of clover/grass ley
- higher yield of straw and beet tops and second harvest of clover/grass ley
- higher amount wheat-kernels and beet roots respectively of total-yield
- higher amount leguminous plants in clover/grass ley crop

The qualitative differences were on the contrary, more difficult to determine. The large differences in storage-capability, accounted for earlier in other trials with the field-sprays, i.e. *Wistinghausen, 1979* did not become apparent here at all. On the other hand, earlier observations confirmed, that the positive effect of biodynamic field-preparations on yield, was distinct in years when general yield-levels were low. This has by several scientists, been taken as a sign, that the biodynamic preparations has a regulating and balancing effect rather than one univocal. Also here, difficulties aroused to transfer this statement onto anything else but the yield. None of the quality-parameters seems to follow this pattern.

Differences in the nitrogen fixation between the two variants K1 and K2 has already been described in this discussion. The calculated total N-fixation was during the trial period approx. 500 kg larger in K1 than in K2. This is equivalent to approx. 15,6 kg N/ha and year. The differences concerning clover/grass ley crop has surely been important, in the origin of the differences that could be established between the variants. Yield-differences between K1 and K2 in summer wheat, could be established early on in the experiment, why preparations-effects must be sought via other factors as well. What is most surprising in the summer wheat crop, is that yield-level is so low in K2. Here one gets the impression that the compost fertilization together with the biodynamic preparations has lowered the yield, e.g. in

comparison with raw farmyard manure. When the field-sprays came into use, they rather restored the yield-level in comparison with non-compost fertilized variants.

Finally

A possible interpretation of the results in the K-trial is, that a soil with a well developed biological-chemical activity manage to give rise to crops with better quality than a soil that certainly is fertilized with nitrogen, phosphorus and potassium but where the soil-processes has not been stimulated. This phenomenon awakes the issue, what determines a food nutrient quality? The nutrient discussion has for a long-time been focused on the asset to certain groups of nutrients. This reflects a thinking comparable to that which lead to the mineral fertilizer utilization. If one instead takes the results from the K-trial as a starting point then perhaps one can study the issue of quality from a somewhat different aspect. All living organisms need nourishment to be able to survive. If we observe humans, animals and to a certain extent plants, then these life forms get their nourishment by breaking down what other life-forces have build up. Is it perhaps this particular disintegration-process that determines the nutrient value? This process-process occurs in most of the cases through the cooperation of microorganisms. The higher life formes are capable, at least to a certain extent, to regulate the environment in which the disintegration occurs to fit their own demands of nutrients. The more this disintegration occurs according to these demands, the larger surplus we receive of the nourishment. This is probably obvious to us all. The next step now is to ask oneself – is it possibly so, that the more the carrot, substantially, really is a carrot, that is disintegrated by my metabolism, the larger nutrient-quality I will receive. This is close at hand. The more vital the soil was in the K-trial, the better quality came from the crops grown there. The plant takes up its nutrients through the disintegration that is performed by microorganisms in the soil. The word quality can, so to speak, mean a description of how something is, of its condition. When we speak of a carrot we can line up various different traits, that all contribute to make the picture of the carrot richer, but without any specific trait that can be said to determine, that it really is a carrot. The question what characterizes a carrot goes beyond the quality-issue. By describing qualitatively what a carrot is, we can arrive at an intuitive picture of the carrots existential being, as referred to in Aristotle's category-teachings. To be able to understand the nutrient we eat, we must also consider how it develops in the time frame. It is precisely this time-related metamorphosis that is typical to all living beings. Each life form has its conformity to law concerning the time. The quality-issue rarely is about these fields, even though they are the starting point for all cultivation. We take the crops existence or being for granted, and it is the same with the time-related conformities of law that characterize them. Instead the quality-issue often concerns the correlation of me and the food that I eat. Even this correlation is possible to describe in a qualitative concept. To be able to do this, we as human beings must develop our senses. No measuring apparatus in the world, can replace the sense-experience I have towards a foodstuff when I eat it. This does not only apply to form, colour, scent or consistency, but also to the degree of vitalization I experience from the food. Do I feel full or gorged afterwards, or perhaps still hungry? Bearing this in mind, two important fields can be laid out for the future quality-research. One of the fields consists of describing the time-related conformity of law that all food nutrients are integrated in. The other field consists of developing the sensory methods to a point that makes it possible to describe the correlation of the foodstuff and the individual who gets his nourishment from them. Method-development within the K-trial only give hints to a few methods for these time-related and sense-related research-fields. Much is still left to research. The results from the field trial gives many suggestions to how we can better learn to understand the correlation of fertilization, soil and crop.

Conclusion

In 1958 started a comparative fertilization-trial, called the K-trial, within the frames of Scandinavian Research Circle for Biodynamic Agriculture. The trial ended in 1990. This report accounts for the results that have been collected over this 33-year long trial-period.
The ambition with the trial was to develop methods of analyses that could indicate foodstuff quality. The long-term trial-period also brought along, a possibility to study the correlation of fertilization, soil and crop.
The difference between a cultivation that uses organic fertilizer compared to one that uses mineral fertilizer and where both achieves comparable yield-levels can according to the results from the K-trial be summarized as:

Soil	- higher enzyme-activity, soil respiration and occurrence of earthworms
	- more deep going soil processes
	- considerably higher nitrogen-mineralising capability
	- better soil-fertility
Crop	- better storage efficiency and resistance against decomposition
	- higher grade of maturity
	- higher amount of leguminous plants in the clover/grass ley

The results from the K-trial in this report, has been compared to the results from two ”daughter-trials”. In these trials two different systems was compared, biodynamic agriculture and conventional agriculture. The effects of these different fertilizing-systems on the quality in products in the K-trial corresponded with the results from the daughter-trials. In comparison with the conventional methods, the crude protein content was lower in the organic variants, but the quality in the protein was higher in potatoes and wheat. Resistance against decomposition and storage-quality for potatoes, was higher in the organic variants and the same applied to the starch-quality in wheat. The organic fertilisation resulted in a higher fertility in soil and crops, with higher quality in protein and starch.

The differences were more difficult to determine between de variant that was fertilized with compost and the ones that received raw farmyard manure, partly because the compost was also treated with the biodynamic compost-preparations. Somewhat simplified, the differences consisted in the fresh farm-yard manure more strongly did stimulate the vegetative processes and the metabolism in soil and crop, while the compost more strongly contributed to building up the soil structure and the form of the crop.

The biodynamic field-preparations effects could be determined as a positive effect on the yield in all crops, except the first harvest of clover/grass ley. The effect of the preparations on yield was largest during the years when yield-level was low. Field-preparation effects were also apparent in the more deep-going soil processes, and in higher amount-amount in the clover/grass ley. This calculated supply of nitrogen by this higher amount of amount plants amounted to approx. 16 kg N per hectare and year.

The results from the K-trial indicate the demand of a discussion on issues concerning food- stuff-quality. In this report a few aspects on the concept of quality has been treated.
Furthermore, formulated is also a frame of a few possible future research-fields connected to the issue of quality.

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