DP 2004/5

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June 2004

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Abstract

This study analyses whether the land tenure insecurity problem on leased land decreases long -term land improvements (liming and phosphorus fertilization) under the Common Agricultural Policy (CAP) and Nordic production conditions in the European Union (EU), such as Finland. The *pH* values of Finnish agricultural soils are commonly below the recommended level. Also, the Soil Test Phosphorus *(STP)* values are usually only at a moderate level and they should not be generally decreased below the current values. However, the amount of liming particularly has been far lower than recommended and gradually decreased during the last decade. The results suggest that the land tenure insecurity problem on leased land has a tendency to decrease land improvements that have a long pay-back period. In particular, *soil pH* was found to be significantly lower in the land cultivated under a lease contract compared to land owned by the farmers themselves.

***Index words**: land tenure, land improvements, land fertility, general linear mixed model*

Suggested citation: Myyrä, S., Ketoja, E., Yli-Halla, M. & Pietola, K. 2004. Land Improvements under Land Tenure Insecurity The case of pH and phosphate in Finland. MTT Economic Research, Agrifood Research Finland. Discussion Papers 2004/5.

1. Introduction

The soils of Finland have been formed of acidic rock and *pH* values in agricultural soils in the country are commonly below the recommended level. Therefore, liming is one of the basic ameliorative measures in order to maintain good yields. There used to be a slight but steady gradual increase of soil *pH* from the 1960's until the 1990's, but particularly during the last decade liming has been practiced far less than recommended. In order to maintain soil productivity, soil *pH* should be elevated by liming. Unlike many other industrial countries, phosphorous (*P*) fertilization commonly gives rise to yield increases in most parts of the agricultural land in Finland (Saarela *et al.*, 1995), and Soil Test P (*STP*) values are usually only at a moderate level. Partly owing to the relatively low density of domestic animals, excessive soil *P* values are quite rare (Mäkelä-Kurtto & Sippola 2002), and general lowering of the *STP* values should be avoided.

Policy reform caused by Finland's entry into the EU in 1995 significantly decreased agricultural output prices and, therefore, extensive policy measures were introduced to maintain farmer income and so stimulate structural development. In spite of the new policy measures, the Marginal Value Product (*MVP*) of long term land improvements, such as liming, drainage systems and P fertilization, significantly decreased with the reform. Decreased *MVP* has delayed land improvements, which has resulted only in moderate Total Factor Productivity (*TFP*) growth in the Finnish agriculture. The *TFP* growth has become even negative on arable crop farms (Myyrä 2003). There is a risk, therefore, that in European northernmost areas, the European Union CAP is failing to reach one its most important goals to stimulate favourable productivity growth of agriculture.

Hastened structural development has shifted cultivated land from land owners to tenants. Over the years 1995–2003, the share of land cultivated under lease contracts by tenants increased in Finland from 17.8% to 38.9%, *i.e.* by 21.1 percentage points. This trend is expected to continue further and even accelerate. An important policy issue then is the extent that gradually increasing land leasings decrease land improvements and stagnate agricultural productivity growth.

From the land owners' point of view, the lease contracts of a fixed duration and fixed lease payments per hectare of land can be auctioned with low information requirements. The land owner, who necessarily does not have agricultural education or experience in farming, can maximise short-term land rents simply by leasing his land to a farmer who pays the highest annual cash lease. Therefore, the standard is that land leasing contracts have a fixed duration (*e.g.* 5 years) and the annual lease payment is fixed per hectare of land when the contract is signed.

Particularly in fixed term cash lease contracts, the tenant's incentives to make long term land improvements may have been worsened by potential land tenure insecurity (Holden and Hailu 2002; Fraser 2004). Thus, in the long run these simple cash lease contracts result likely in a market failure since they may further decrease incentives on land improvements both for the tenant and for the land owner even if they could be beneficial for the society (*e.g.*, Lynne *et al.* 1988, Easter & Cotner 1981). Because the share of land cultivated under lease contracts is increasing, the potential land tenure insecurity is getting gradually more and more important. It may also hamper the efficiency of environmental policy measures, as many environmental investments have long payback periods.

The existing literature on land tenure insecurity focuses on developing countries where the problem has traditionally been the most prominent. Nevertheless, in these countries, farmer input use is often restricted by a large number of other constraints and only a weak link between the input use and the land tenure insecurity has been found (*e.g.* Gavian and Fafchamps, 1996; Holden and Hailu, 2002; Li *et al.* 1998). Literature on land tenure insecurity in the context of EU-countries and of the CAP is to our knowledge non-existent.

In the present study, parcels cultivated by land owners and tenants were compared with respect to *P* status and *pH* of the soil. The data for the comparison were obtained over the years of 1998-2000 from the farm accounting database by supplementing it with the data on land parcels and land quality. The main goal of the study was to estimate the mean differences in *P* status and *pH* between the land cultivated by tenants and the land cultivated by the owners themselves. The study parcels were divided into different subgroups and the consistency of the mean differences across the subgroups was examined. Furthermore, other essential farm and parcel characteristics thought to be related to the outcomes were explored in order so as to adjust the estimates for them, if necessary.

2. Data and methods

Subgroups and outcome variables

The data included originally 668 parcels of 65 farms located in all three main agricultural regions in Finland (Tables 1-3 and Figure 1). They were obtained over the years 1998-2000 from the farms in the Farm Accountancy Data Network (FADN) and were complemented by information on land parcels and land quality. The data on land parcels and their ownership status are from the Information Centre of the Ministry of Agriculture (TIKE). The data on land quality, phosphorus (P) status and soil acidity (pH) are from Viljavuuspalvelu Oy – Soil Testing Service Ltd, which is the market leader in soil testing in Finland. Soil testing is required in the agri-environmental programs and 94% of Finnish farmers participate in these programs. Therefore, the data do not include a self-selectivity bias and they have a reasonable coverage on the Finnish agricultural land.

The data were stratified according to the farm location (South = support regions A and B; North = support region C) and production line (arable crop production; animal production with grass). Arable crop production consists for the most part of cereals and it represents production lines which do not apply considerable amounts of manure on their parcels, whereas animal production farms apply manure on their parcels more frequently. Arable crop farms represent 35% of the sample farms and 45% of the parcels.

The endogenous outcome variables are 1) soil *pH*, which inversely reflects soil acidity, and 2) Soil Test Phosphorus (*STP*), indicating the P status of soil. Soil *pH* is determined in water, the soil-to-water ratio being 1:2.5. In the Finnish soil testing, STP is extracted with an acid (*pH* 4.65) ammonium acetate solution (0.5 M CH_3COOH, 0.5 M CH_3COONH_4) using the volumetric soil-to-solution ratio of 1:10 and the extraction time of 1 hour (Vuorinen & Mäkitie 1955). Soils are classified according to the concentration of Soil Organic Matter (SOM) and particle size distribution of mineral soils. Organic soils contain >20% of SOM and mineral soils contain <20% of SOM. The textural class and the categories of SOM (SOM1 <3%, SOM2: 3-6%, SOM3: 6-12%, SOM4: 12-20%) of mineral soil classes are determined by finger assessment by trained experts. These two soil characteristics are used in the interpretation of soil *pH* and *STP* results. This means that a given *pH* or *STP* value, measured in the laboratory, can result in different fertility classes, depending on the soil class and the content of SOM. The results of both *pH* and *STP* are divided into seven classes as follows: poor, rather poor, fair, satisfactory, good, high and excessive (Viljavuuspalvelu Oy 2000). The class limits are based on extensive number of field experiments. Satisfactory is the target class, considered sufficient for normal yields of field crops such as cereals and ley.

Within the South and North regions, there was a different distribution into the soil groups of the studied parcels (Table 1). More than half of the 332 parcels in the South region belonged to clay soils, while there were only three clay soils in the North region, which was dominated by coarse mineral soils and organic soils. Owing to their small number, the organic soils of the South region and the clay soils of the North region were omitted from the statistical analyses.

There was also an uneven distribution of the mineral soils into the different categories of SOM (Table 1), some of which had to be therefore combined for statistical analyses of the data. The class SOM1 (SOM <3%) was very rare among mineral soils. Consequently, in the South region, the following soil groups were used in the analyses of both *pH* and *STP*: 1) clay soils of SOM2, 2) clay soils of SOM3 and SOM4, and 3) coarse mineral soils of all SOM categories. In the North region, the following groups were used for *STP*, according to the interpretation of soil test results (Viljavuuspalvelu Oy 2000): 1) glacial till, coarse silt and very fine plus fine sand, all within the *SOM 3* and *SOM4* categories, 2) glacial till, coarse silt and very fine plus fine sand, all within the *SOM1* and *SOM2* categories, together with fine silt and loam of all *SOM* categories, and 3) organic soils. When modelling the data of soil *pH* in the North region, the soil groups were 1) coarse mineral soils (glacial till, sand, silt, loam) of *SOM1* and *SOM2*, 2) coarse mineral soils *SOM3* and *SOM4*, and 3) organic soils.

Table 1. Distribution of the number of own and leased parcels into different soil groups and categories of soil organic mater (SOM) stratified by region and production line.

			Clay soils			Coarse mineral soils					
Region	Production line	Tenure status	*SOM2*	*SOM3*	*SOM4*	*SOM1*	*SOM2*	*SOM3*	*SOM4*	Organic soils SOM >20%	Sum
South [a)]	Crop	Own	37	58	2	1	44	10	3	10	165
		Leased	20	27	0	0	14	3	1	3	68
	Animal	Own	16	10	1	0	15	11	2	5	60
		Leased	13	12	1	0	10	3	0	0	39
North [a)]	Crop	Own	2	0	0	0	18	5	1	5	31
		Leased	0	0	0	0	20	1	2	1	24
	Animal	Own	0	1	0	2	72	51	12	37	175
		Leased	0	0	0	1	58	25	4	18	106
											668

[a)] South covers the CAP-subsidy areas A and B; North covers the CAP-subsidy area C.

SOM categories: SOM1 = low in SOM (<3%); SOM2 = average in SOM (3-6%); SOM3 = high in SOM (6-12%); and SOM4 = very high in SOM (12-20%).

Parcel size and distance from the farm compound

Based on earlier studies (Suomela 1950, Myyrä 2001), it was expected that the parcel size and the parcel's distance from the farm compound are related to intensity of cultivation and also land improvements on the parcels under the Nordic production environment and farming structure. The preliminary hypothesis was that the parcel size and intensity of cultivation are positively related and the parcel's distance from compound and intensity of cultivation are negatively related. The distributions illustrated in Figure 1 show that leased land parcels of the study were, in general, somewhat smaller and farther away from the farm compound than the land owned by the farmer.

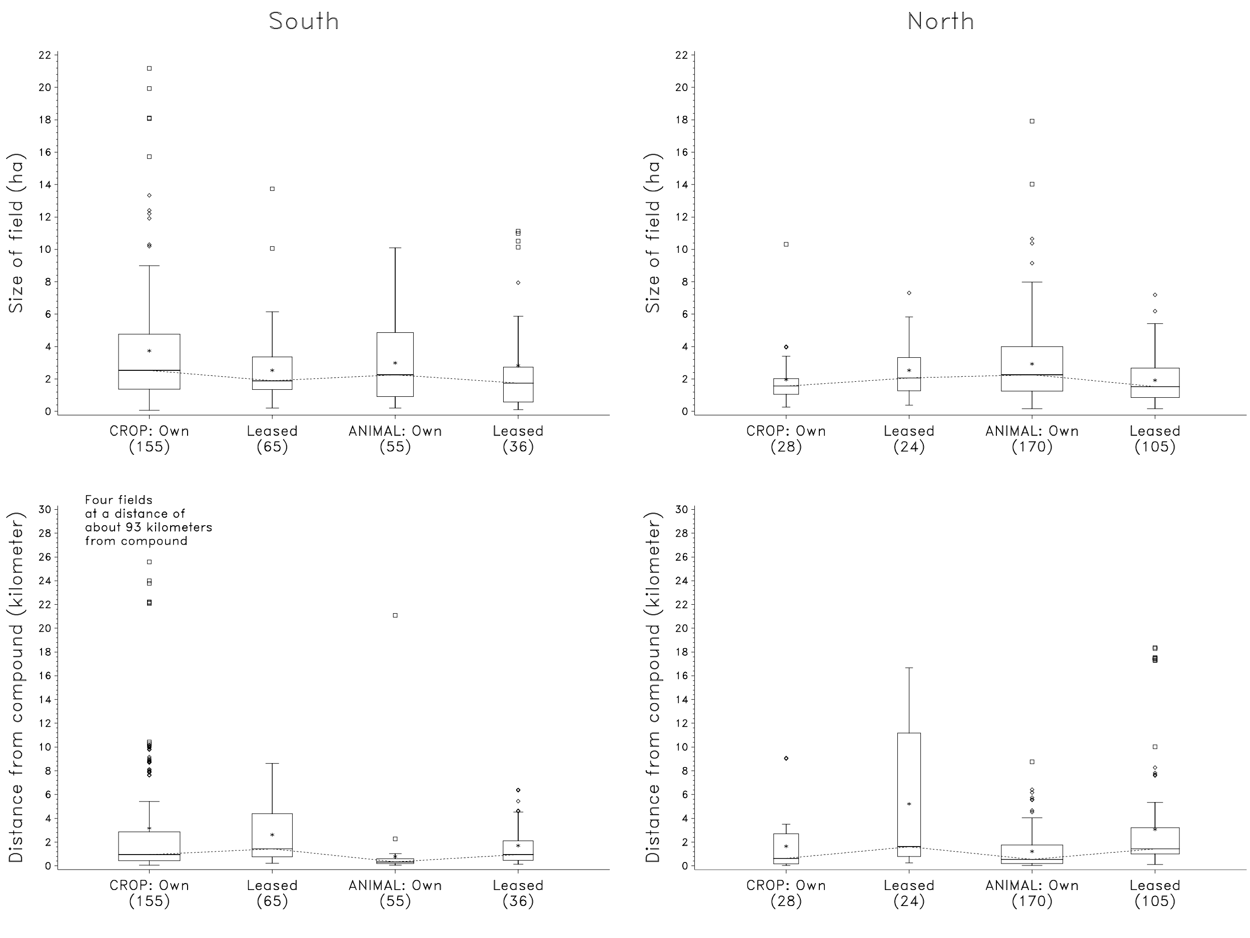

Figure 1. Distributions of field size and distance from the farm compound for the owned and leased fields in the four location-by-production line combination. The upper and lower boundaries of the box indicate the upper and lower quartiles, respectively. The horizontal line denotes the median and the asterisk the mean. Vertical bars represent the tails of the

distribution. Mild and extreme outliers are marked with open circles and squares, respectively. Numbers of fields are in parentheses. In the case of nine parcels size and distance from compound were unknown.

Farm data

The farm size and farmer age distribution are summarised in Table 2. Farm size and farmer age were chosen for potential explanatory variables, because they have been shown to be correlated with farmers' production, investment and exit decisions (Pietola *et al.* 2003; Pyykkönen 1996). Entrepreneurial profit / loss and the equity ratio can be seen as measures of the farmer's skills and they are examined for potential cause of different farming practices on own and leased parcels. The percentage of farms that did not invest in liming during the sample period ranged from 26% (North & Animal) to 50% (South & Crop, see Table 3).

Table 2. Farm size and farmer age in the sample stratified by farm location and the production line.

Farm location	Production line	Number of farms	Farm size (land, ha)			Farmer age		
			Q1	Md	Q3	Q1	Md	Q3
South [a)]	Crop	18	44.6	59.3	90.4	40	46	52
	Animal	15	32.0	42.5	65.0	35	38	52
North [a)]	Crop	5	34.6	34.7	45.1	36	39	45
	Animal	27	25.6	37.7	56.0	34	40	48

[a)] South covers the CAP-subsidy areas A and B; North covers the CAP-subsidy area C.

Q1 = lower quartile (approximately 25% of the values lie below Q1)

Md = median (approximately 50% of the values lie below Md)

Q3 = upper quartile (approximately 75% of the values lie below Q3)

Table 3. Annual expenditure on liming (€/farm) and the amount of liming (kg/ha).

Farm location	Production line	Number of farms	No liming [b)]	Liming expenditure			Amount of liming		
				Q1	Md	Q3	Q1	Md	Q3
South [a)]	Crop	18	9	0	0	920	0	0	419
	Animal	15	5	0	741	1,382	0	487	1,034
North [a)]	Crop	5	2	0	469	549	0	343	363
	Animal	27	7	0	427	949	0	394	597

[a)] South covers the CAP-subsidy areas A and B; North covers the CAP-subsidy area C.

[b)] Number of farms with no liming on years 1998-2000.

Q1, Md, Q3 are quartiles, see Table 2.

Representativeness of the data

The sample median and mean *pH* of the parcels was 6.1 (standard deviation s=0.5). The average *pH* was slightly higher than that in a recent study based on 705 samples from all over the parcels of Finland (median and mean 5.8, s=0.5, Mäkelä-Kurtto & Sippola 2002). With Viljavuuspalvelu Oy-Soil Testing Service Ltd. about 850,000 soil samples were analysed for *pH* in 1996-2000, and they had a mean *pH* of 5.7. In a survey where about 1,600 parcels were tested in 1998 and 2002 (Mäntylahti 2002) the mean *pH* was between 5.8 and 6.1, depending on soil class. On the basis of these references, our data represent parcels that are cultivated by farmers interested in the fertility of their soils and the economy of their farm.

The sample mean of STP was 12.5 mg/l (s=9.4 mg/l), and the median was 9.8 mg/l. In the Mäkelä-Kurtto and Sippola (2002) and Mäntylahti (2002) studies, the mean values were 13.1 mg/l and 13.0 mg/l, respectively. The mean of STP was close enough to those values in order to consider the present material representative for all parcels of Finland.

The size distribution of the parcels is representative for all the parcels of Finland (TIKE). There is no previous information about the size distribution of leased parcels, so the representativeness of that part of our material cannot be assessed.

3. Statistical analyses

The North and South regions were analysed separately because the soil quality differed between those two areas (Table 1). The statistical analyses of the *STP* and *pH* measurements were based on the linear mixed model in which an outcome variable is assumed to be normally distributed. Distributions of the *STP* for the compared groups were positively skewed, but could be normalised by a logarithmic (base-10) transformation. The soil *pH* values needed no transformation ($pH = -log_{10}(H^{+})$, where H^{+} is the hydrogen ion concentration of an aqueous solution. When examined by scatter diagrams, the *STP* and soil *pH* measurements appeared to depend on the size of the parcels and their distance from the compound in accordance with the preliminary hypothesis. Moreover, the parcels cultivated by land owners and tenants differed somewhat in size and distance (Figure 1). Hence, to take account of the fact that the two parcel characteristics were related to the outcomes and were unbalanced between the land tenure status groups, they were incorporated as covariates in the models. However, the scatter diagrams indicated greater variability in the *STP* and soil *pH* values for the smaller than for the larger values of the covariates. To stabilise the variability, a logarithmic (base-10) transformation was made also on both covariates. After the transformations, the relations between the outcome variables and the covariates were linear. Other potential explanatory variables (farm size, age of farmer, entrepreneurial profit / loss, equity ratio, total liming expenditure on farm) were not associated with *STP* and soil *pH* on grounds of the scatter diagrams, and were therefore not needed in the models. Instead, the interaction between soil group and tenure status was included in the models irrespective of statistical significance because interpretation of *STP* and soil *pH* values depends on soil group (Viljavuuspalvelu 2000). Further, to take account of the hierarchical structure of the data, production line and location were included as explanatory variables in the models. Consequently, the simplest model fitted to the data of both regions was of the following form:

$$\log(y_{ijkl}) = \mu + P_i + f_{j(i)} + S_k + T_l + ST_{kl} + \alpha \log(x_{ijkl}) + \beta \log(z_{ijkl}) + e_{ijkl} \qquad (1)$$

where log (y_{ijkl}) is the logarithmic *STP* or soil *pH* value for a parcel of farm *j* with production line *i* representing soil group *k* and tenure status group *l*; x_{ijkl} and z_{ijkl} are the distance and the size of a parcel, respectively, and α and β are regression coefficients. Parameter μ is a constant, *P*, *S* and *T* denote the fixed main effects of production line, soil group and land tenure status, and *ST* is the fixed soil group-by-tenure status interaction; $f_{j(i)}$ is the random effect of farm *j* with production line *i*, and e_{ijkl} is the random error. The assumptions for the random effects are: $f_{j(i)} \sim iid\ N(0,\ \sigma^2_f)$ and $e_{ijkl} \sim iid\ N(0,\ \sigma^2)$, $f_{j(i)}$ and e_{ijkl} independent of one another. In determining the *"best"* model for each data, a hierarchical backward elimination procedure was applied. The starting model was the largest possible model. Besides the terms in the above model, it contained the terms *PS*, *PT*, and *PST*, which represent the fixed interactions between production line (*P*) and the effects of soil group (*S*), tenure status (*T*) and their interaction (*ST*), respectively, as well as all possible interactions between the fixed effects and the two covariates.

The starting model was simplified by eliminating terms one at a time on the basis of their p-values, beginning first with the term with the largest p-value. In addition, the hierarchy principle was applied which states that if a product term (ST_{kl} for example) is retained in the model, then all lower-order components of that term (S_k, T_l) must be retained. The models were fitted by using the residual maximum likelihood (REML) estimation method. The significances of the model terms were determined by an F-test. The method described by Kenward and Roger (1997) was used to calculate degrees of freedom. After finding a satisfactory model, covariate-adjusted group means were computed and compared through two-sided t-type tests.

The adequacy of the models was checked graphically. The residuals were plotted against the fitted values. The normality assumption of the residuals was checked by using the box plot (Tukey 1977). Furthermore, for each farm predicted values $\hat{f}_{j(i)}$ were computed in order to detect farms discrepant from most others (Littell *et al.* 1996). Plotting these predicted values with their signs against the spatial locations of the farms made it possible to examine a positive spatial correlation between measurements of the farms in proximity to each other, which would have violated the assumption of independent farm effects. According to the plots, the final models for both support regions adequately fitted the logarithmic *STP* and soil *pH* values with the exception of a few discrepant farms and parcels whose influence on the results was examined by deleting them one at a time from the data. Since their influence was minor, results based on all data are presented. The analyses were performed by the MIXED procedure in SAS/STAT software (Littell *et al.* 1996).

4. Results

The model (1) presented above was found to be satisfactory with the exception of the *STP* data in the North region. For these data the model was augmented by the interactions 1) between land tenure status (T) and production line, and 2) between T and log-transformed distances from compound. The analyses of the data indicated no relations between the outcome variables and farm size, age of farmer or farm equity.

STP estimates in the region South

In the South region, there was slight evidence of the difference in mean STP between owned and leased parcels in favour of owned parcels (Table 4). In each soil group, the mean STP of the owned parcels was higher than that of the leased parcels. However, the estimated means of both land tenure status were within the satisfactory fertility class, *i.e.* in the target range.

The *STP*-values decreased slightly as the parcel's distance from the compound increased, but had an opposite trend with parcel size (Table 5). There was, however, no statistically justified evidence that the mean *STP*-difference between the owned and leased land would depend on the parcel distance and parcel size.

The data of the South region included 10 parcels with excessive high *STP*-values. Seven of these values were measured from land owned by farmer and three were observed on leased land (Figure 2). Nevertheless, dropping out these observations, which were clearly above the target level, from data did not essentially alter the results from those reported.

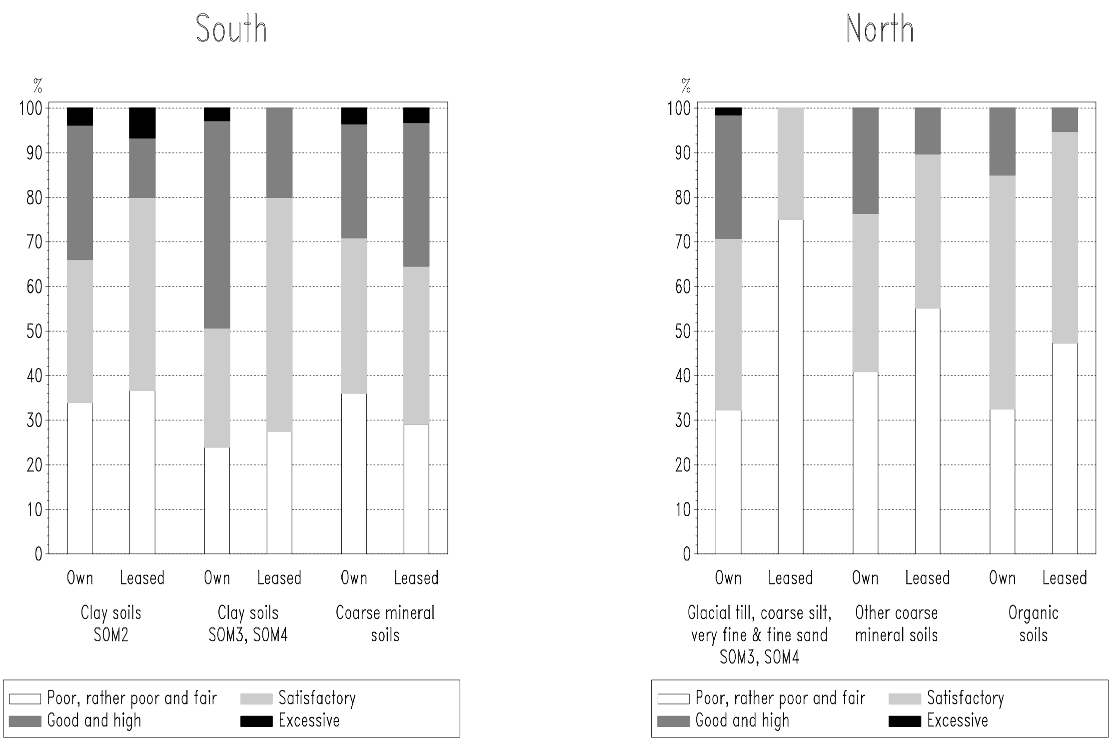

Figure 2. Distribution of the Soil Test P (*STP*) values of the own and leased parcels into the different *STP* classes in the regions South and North. "Satisfactory" is the target and considered sufficient. SOM2 = average (3-6%), SOM3 = high (6-12%) and SOM4 = very high (12-20%).

Table 4. Comparison of parcels cultivated by land owners and tenants in respect of covariate-adjusted mean of Soil Test P (STP) in the South and North. The adjusted means are predicted values obtained from the estimated model evaluated at the two hectare parcel, located at one kilometre distance from the compound.

Region / Tenure		Number of parcels	Adjusted mean [b)]	95% confidence interval for the mean [b)]	Difference between the means (log scale)	Standard error of the difference	P-value
South [a)]							
All soils	Own	210	10.6	(8.9 – 12.5)	0.0614	0.0341	0.07
	Leased	101	9.2	(7.6 – 11.0)			
North [a)]							
All soils	Own	198	10.5	(8.9 – 12.5)	0.13	0.04	< 0.005
	Leased	129	7.8	(6.4 – 9.5)			

[a)] South covers the CAP-subsidy areas A and B; North covers the CAP-subsidy area C.

[b)] Logarithmic values back-transformed to the original scale.

Table 5. Statistical significances of the terms in the model for the data of region South. Outcome variable is $\log_{10}$(STP).

Model term	Degrees of freedom: Numerator	Degrees of freedom: Denominator	F-value	P-value	Estimate of slope	Standard error of slope
Production line	1	31.5	0.31	0.58		
Soil	2	294	4.31	0.01		
Tenure	1	301	3.25	0.07		
Soil * Tenure	2	296	0.73	0.48		
Log (distance from compound)	1	302	56.0	< 0.0001 [1)]	-0.2029	0.0271
Log (size of parcels)	1	297	3.91	0.05 [1)]	0.0658	0.0332

Soil = Soil class and the category of soil organic matter.
[1)] The null hypothesis is H_0: slope = 0

STP estimates in the North region

In the North region, the mean *STP* was also higher in the parcels owned by the farmer than in the parcels cultivated under a lease contract (Tables 4 and 6). In each soil group, the estimated means of owned parcels were within the satisfactory class, whereas the means of leased parcels were within the fair class. However, the 95% confidence intervals for the means of leased parcels implied that the true means can be within the satisfactory class, too. Furthermore, the interaction between land tenure status and production line was statistically significant, indicating that the difference between owned and leased parcels is smaller in the animal production than in the crop production. The result suggests that P supplied in manure is quite evenly distributed on owned and leased parcels. More land may have been leased on animal farms, particularly to obtain a sufficient land area for manure management.

The difference in mean *STP* between owned and leased parcels depended also on the distance of the parcel from the compound (Table 6). For owned parcels, the relation between *STP* –values and parcel's distances was similar to that in the region South: the longer the parcel's distance from compound, the smaller the STP tended to be. For leased parcels, the STP-values were not related to the parcels' distances. As a consequence, the mean difference between owned and leased parcels diminished gradually and, at the distance of two kilometres, the difference was no longer statistically significant. In the North region, the data included only one excessive high *STP*-value, the removal of which did not have any essential effect on the results reported above (Figure 2).

Table 6. Statistical significances of the terms in the model for the data of region North. Outcome variable is $\log_{10}$(STP).

Model term	Degrees of freedom: Numerator	Degrees of freedom: Denominator	F-value	P-value		Estimate of slope	Standard error of slope	P-value [1)]
Production line	1	26.6	0.01	0.94				
Soil	2	314	1.01	0.37				
Tenure	1	309	26.76	< 0.0001				
Soil * Tenure	2	303	2.19	0.11				
Production line * Tenure	1	302	4.25	0.04				
Log(distance from compound)	1	312	8.58	< 0.005				
Log(distance from compound) * Tenure	1	315	19.66	< 0.0001	Owned	-0.1730	0.0292	<0.0001
					Leased	0.0370	0.0367	0.31
Log(size of parcels)	1	308	0.21	0.65 [1)]		-0.0146	0.0320	

Soil = Soil class and the category of soil organic matter.
1) The null hypothesis is H_0: slope = 0

Soil pH -estimates

The results suggest that the soil pH is higher in the South region than in the North region, but the difference in mean soil pH between owned and leased land is similar in both regions (Table 7). The mean soil pH was estimated to be 0.2 pH points higher in the land owned by the farmer than in the land cultivated under a lease contract. In each soil group in the two regions, the mean soil pH for the owned parcels was higher than that of the leased parcels. However, the endpoints of the 95% confidence intervals for the mean implied that the true means of both land tenure status can be within the satisfactory class.

There was no evidence that the observed difference in pH would depend on parcel size, parcel distance or on any farm characteristics available in this study. Nevertheless, the *soil pH* is predicted to increase as parcel size increases and to decrease with parcel distance independently of the land tenure status (Table 8).

Table 7. Comparison of parcels cultivated by land owners and tenants in respect of covariate-adjusted mean soil pH in the South and North. The adjusted means are predicted values obtained from the estimated model evaluated at the two hectare parcel, located at the distance of one kilometre from the compound.

Region / Tenure		Number of parcels	Adjusted mean	95% confidence interval for the mean	Difference between the means	Standard error of the difference	P-value
South [a)]							
All soils	Own	210	6.2	(6.1 – 6.4)	0.22	0.05	< 0.0001
	Leased	101	6.0	(5.9 – 6.2)			
North [a)]							
All soils	Own	198	6.0	(5.9 – 6.2)	0.20	0.06	< 0.005
	Leased	129	5.8	(5.7 – 6.0)			

a) South covers the CAP-subsidy areas A and B; North covers the CAP-subsidy area C.

Table 8. Statistical significances of the terms in the models for the data of region South and region North. Outcome variable is soil pH.

Region	Degrees of freedom				Estimate	Standard error
Model term	Numerator	Denominator	F-value	P-value	of slope	of slope
South [a)]						
Production line	1	32.4	2.62	0.12		
Soil	2	300	1.06	0.35		
Tenure	1	300	17.6	< 0.0001		
Soil * Tenure	2	291	1.27	0.28		
Log (distance from compound)	1	296	7.90	0.01 [1)]	-0.1164	0.0414
Log (size of parcels)	1	291	10.4	< 0.005 [1)]	0.1627	0.0505
North [a)]						
Production line	1	26,9	2.07	0.16		
Soil	2	314	39.4	< 0.0001		
Tenure	1	318	9.83	< 0.005		
Soil * Tenure	2	302	0.93	0.40		
Log (distance from compound)	1	313	0.08	0.78 [1)]	-0.0134	0.0477
Log (size of parcels)	1	308	1.20	0.27 [1)]	0.0729	0.0666

a) South covers the CAP-subsidy areas A and B; North covers the CAP-subsidy area C.
Soil = Soil class and the category of soil organic matter.
1) The null hypothesis is H_0: slope = 0

The distribution of soil *pH* values is depicted in Figure 3. The data included 20 observations with excessively high *pH* values. Nevertheless, dropping these extreme observations did not alter the results reported above.

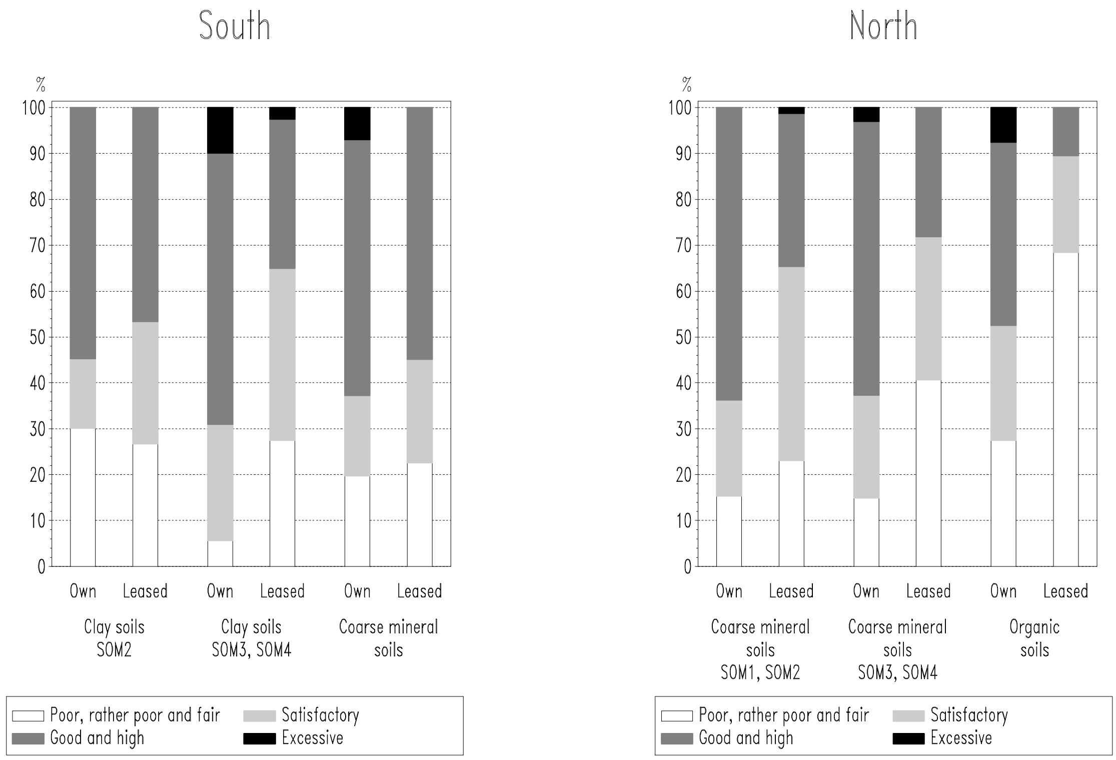

Figure 3. Distribution of sample parcel into soil pH categories in the regions South and North. "Satisfactory" is the target and considered sufficient. SOM1 = low (<3%), SOM2 = average (3-6%), SOM3 = high (6-12%) and SOM4 = very high (12-20%).

5. Concluding remarks

The results give signals about implications of land tenure insecurity which is confronted by farmers cultivating leased land. Both the soil *pH* and *STP* were lower on leased land than on the land owned by the farmer. Even if the levels of soil *pH* and *STP* were found to depend on other farm characteristics, such as parcel size and parcel distance from the compound, the difference in mean soil *pH* and *STP* between the leased and owned land was not essentially altered by these variables. An exception was the mean difference in *STP* in the North region where no difference was found between owned and leased land if the parcels were located approximately at 2 km distance from the compound or farther away. According to our results, also the excess *P* supply on intensive animal production farms seems to equalise the *STP*–values between the leased and owned land.

The data available for this study included only the stock measures on the soil *pH* and *STP*. The corresponding control variables, *i.e.*, liming applications and P-fertilization, could not be observed at parcel level. Using the stock variables, instead of the corresponding control variables, has likely decreased the power of our testing for two reasons. First, differences in the control variables are transmitted into the stock variables only gradually over time since both soil phosphorus and soil acidity exhibit significant from year-to-year carry over effects. This may have significantly smoothed out the true differences in the control variables. Secondly, the point of the time when the tenure insecurity problem has emerged for a particular parcel is unobserved and censored in the data.

Nevertheless, since both of these factors clearly harm our setup, we can conclude that differences found in the stock variables must have resulted from consequential differences in the corresponding control variables. The differences in the control variables are likely to have been even clearer and also economically more alarming. Land insecurity problem, therefore, exists on land cultivated under fixed duration cash lease contracts in well developed countries, such has Finland. The problem is getting more and more prominent since land leasing is steadily increasing as a result of fast structural development in the Nordic agricultural sectors. Land leasing is even promoted in some structural adjustment programs, such as the farmer early retirement programs in Finland.

One may also claim that the revealed differences in the soil *pH* and *STP* values on leased and owned land are a result of the adverse selection problem raised by Akerlof (1970) in land markets. This would imply that the land supplied in the lease market has lower overall quality than the land owned by farmers. The difference between owned and leased parcels may have developed as a combined cultivation practices (less liming, less P fertilization) by the owner (before the lease) and by the tenant. Even if this problem drives up the potential bias in our results, it is not likely. There is no evidence that about one third of Finnish arable land which is supplied in the lease market exhibits lower than average land quality, other than controlled through endogenous land improvements, such as drainage, liming, and fertilization.

We conclude that the problem of land tenure insecurity is for its own part contributing to decreasing productivity growth in the Finnish arable crop cultivation. It is expected that this trend is further proceeding and driving the sector into a low productivity trap if the problem is not solved by better contract design.

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