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INFLUENCE OF WEATHER CONDITIONS AND LATE BLIGTH ON THE YIELDS OF POTATOES IN FINLAND, 1931—62

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To be presented, with the permission of the Faculty of Agriculture and Forestry of the University of Helsinki, for public critism in Auditorium 5 on May 12 th, 1971, at 12 o'clock.

HELSINKI 1971

PREFACE

I wish to express my gratitude, without mentioning names, to the many persons in various posts at the Agricultural Research Centre, Plant Breeding Institute of Hankkija, and Society of Peat Cultivation, who carried out the trials which served as the material of this study, placed their data at my disposal and so made this study possible.

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Tikkurila, January, 1971

Esko Seppänen

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INTRODUCTION

Potato yields in Finland are characterized by great variations from year to year. The average tuber yield of the country has exceeded 20 tons per hectare in good years, while not reaching even half this amount in the poorest years. During the period 1949—1968, for instance, the average yield ranged from 12.1 to 19.8 tons per hectare, and the mean was 14.6. When the averages of the different regions of the country are considered, the variations are still wider. Wide annual variation has also been a typical feature of the yield figures recorded in trial fields (Yllö 1965).

What are the causes of the great variability of our potato yields? It is obvious that weather conditions, directly or indirectly, must exert a decisive influence. In previous studies (e.g. Johansson 1922, Keränen 1931 a, 1931 b, Lunelund 1943, Tähtinen 1962, Yllö 1963 a, 1964) it has been demonstrated that climatic factors, in particular the earliness of the spring and the warmth in the beginning of the summer, substantially influence the yield figures. Similar conclusions have also been reached in the other Scandinavian countries (Vik 1914, Hallgren 1947, Frogner 1964 b). The starch content of the tubers has been found to depend primarily on the weather conditions of August: a negative correlation exists between rainfall and starch content (Frogner 1964 b, Yllö 1964, Varis 1970), and a positive correlation between mean temperature and starch content (Yllö 1964).

The extent to which the late blight disease, which is caused by *Phytophthora infestans* (Mont.) de Bary, contributes to the variation of the yields is a question in need of clarification. It should be kept in mind that blight thrives best in the same conditions in which the potato crop does well. It follows that infection with blight may offset the beneficial effects of favourable weather.

As long ago as 1910, Grotenfelt drew attention to the great fluctuations in the incidence of blight, and his observations have been borne out by subsequent investigations (Rainio 1937, Anttinen 1963, Simojoki 1963, Yllö 1963 a, 1963 b). Recently, Mäkelä (1966), when studying the overwintering of late blight and the dependence of susceptibility to this disease on the stage of growth of the potato plant confirmed the above observation. It is not surprising that incidence of late blight should fluctuate greatly, because it is very strongly correlated with the weather conditions, especially with the temperature and relative humitidy of the air.

Rainio (1937) attempted to determine the effects of blight on yields by analysing the yield statistics and the estimates of the extent of the disease made by growers. He found that in 1934, a severe blight year, the yield losses due to premature death of the tops and to tuber contamination totalled 37 %, whereas in 1935, a mild blight year, they were only 13 %. Rainio attributed the heavy losses to the widespread cultivation of varieties susceptible to blight, a conclusion also drawn by Jamalainen (1933) from an analysis of the same data.

Ever since the 1930s, measures for combatting blight have centred round the cultivation of resistant varieties. Chemical control has not gained any foothold in Finland, owing to the great fluctuations in the incidence of this disease and to doubt as to whether the benefits would justify the costs, at least in the central and northern parts of the country. Haulm destruction in order to protect the tubers is rarely practiced. To be sure, the haulm is often destroyed by autumn frost at the end of August or in early September.

At the agricultural research institutes and experimental stations of Finland, records have been kept for several decades in connexion with potato variety trials. In the present study these data have been analysed with a view to clarifying the influence of weather conditions and late blight on the yields of potatoes, as well as the incidence of blight, and the blight resistance of different varieties.

MATERIAL AND METHODS

Material

The present study is based on the results of variety trials arranged during the period 1931—62 at the Finnish research institutes and experimental stations (see Fig. 1) and on the observations made during the trials. This period was chosen for the reason that the German variety Rosafolia, which was introduced commercially in 1928, was included in nearly all the variety trials by the beginning of the 1930s and was later adopted as a check variety. Being a second early variety and one which is rather susceptible to leaf blight, Rosafolia constituted an excellent standard of comparison in surveys of the annual incidence of blight and also for comparisons between varieties. The data of the present study chiefly comprise the results of the main trials, supplemented on certain cases with results obtained in other comparable trials. The trial including the most important varieties was considered as the main trial. In such instances, the results were amended as indicated by the extent of their deviations from the results obtained with

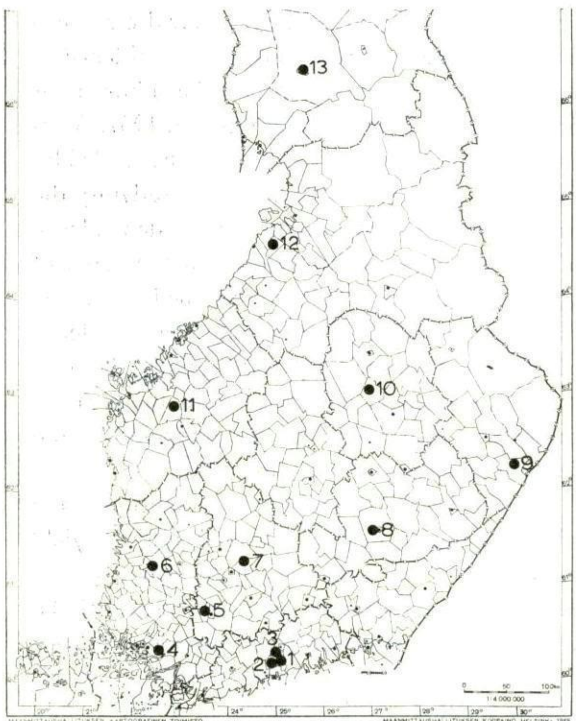


Fig. 1. Trial localities.
Kuva 1. Koepaikat.

1. Dept. of Plant Husbandry — *Kasvinviljelylaitos, Tikkurila*
2. The Plant Breeding Institute of Hankkija — *Hankkijan kasvinjalostuslaitos, Tammisto*
3. The Plant Breeding Institute of Hankkija, Experimental Farm Anttila — *Hankkijan kasvinjalostuslaitos, Anttilan koetila*
4. Dept. of Horticulture — *Puutarhantutkimuslaitos, Piikkiö*
5. Dept. of Plant Breeding — *Kasvinjalostuslaitos, Jokioinen*
6. Satakunta Agr. Exp. Sta. — *Satakunnan koeasema, Peipohja*
7. Häme Agr. Exp. Sta. — *Hämeen koeasema, Pälkäne*
8. South Savo Agr. Exp. Sta. — *Etelä-Savon koeasema, Mikkeli*
9. Society of Peat Cultivation, Exp. Sta. Tohmajärvi — *Suoviljelysyhdistyksen Karjalan koeasema, Tohmajärvi*
10. North Savo Agr. Exp. Sta. — *Pohjois-Savon koeasema, Maaninka*
11. South Ostrobothnia Agr. Exp. Sta. — *Etelä-Pohjanmaan koeasema, Ylistaro*
12. North Ostrobothnia Agr. Exp. Sta. — *Pohjois-Pohjanmaan koeasema, Ruukki*
13. Arctic Circle Agr. Exp. Sta. — *Perä-Pohjolan koeasema, Apukka*

All except nos. 2, 3 and 9 belong to the Agricultural Research Centre.

Table 1. Data of years, average planting dates in variety trials, average dates of onset of flowering and of blight epidemic in Rosafolia, average tuber and starch yields and starch content of Rosafolia and their variations at the different localities.
Taulukko 1. Tietoja koevuosista, lajikekokeiden keskimääräisistä istutusajoista, kukinnan ja ruttoepidemian keskimääräisistä alkamisajoista Ruusulehdessä, Ruusulehden keskimääräiset mukula- ja tärkkelyssadot sekä tärkkelyspitoisuus ja sen vaihtelu eri koepaikoissa.

Locality *Koepaikka*	Period [1] *Koejakso* [1]	Planting date *Istutus-aika*	Onset of flowering *Kukinnan alkamisaika*	Onset of blight epidemic *Ruttoepidemian alkamisaika*	Tuber yield *Mukula-sato* tn/ha	Starch yield, *Tärkke-lyssato* hkg/ha	Starch content % *Tärkkelyspitoisuus* Average *Keskiarvo*	Variation *Vaihtelu*
Tikkurila	1931—62	30.5	19.7	21.—25.8	32.7	52.4	16.0	13.2—21.9
Tammisto	1931—48	25.5	17.7	26.—31.8	33.6	53.0	15.9	11.7—20.1
Anttila	1949—62	—	16.7	16.—20.8	30.8	47.5	15.6	12.4—21.0
Jokioinen	1942—62	29.5	—	—	26.2	40.6	15.8	13.1—21.4
Peipohja	1931—62	26.5	—	—	34.1	56.0	16.5	13.5—20.3
Pälkäne	1931—62	29.5	19.7	21.—25.8	35.0	51.7	14.7	11.6—17.9
Mikkeli	1932—62	29.5	—	—	29.0	40.0	13.8	12.4—15.6
Tohmajärvi	1932—38 1950—58	25.5	—	26.—31.8	25.7	36.7	14.4	12.2—16.2
Maaninka	1931—62	1.6	21.7	26.—31.8	38.7	58.3	15.1	13.4—17.7
Ylistaro	1932—62	30.5	23.7	6.—10.9	31.9	47.7	14.9	10.1—22.3
Ruukki	1931—62	2.6	—	—	30.9	45.8	14.1	< 10.0—21.3
Apukka	1951—62	—	—	—	28.2	39.7	14.3	11.5—17.3

[1]) Results are not available for all the years of the period.
Kaikilta jakson vuosilta ei ole koetuloksia.

the check varieties in the different trials. The most important data on the trials are assembled in Table 1.

The soil type in each locality was the same in all years except at Tikkurila, where the main trials were conducted on clay soil containing 3—6 % organic matter in 1938—47, and on soil containing 20—40 % organic matter in the other years. The yields at Tammisto, Piikkiö, Jokioinen and Ylistaro consisted of clay soil and the others of sandy soil. At Tikkurila, Piikkiö and Peipohja, parallel trials were run in a few years on clay and on sandy soil.

The rate of application of fertilizers was heavy, enabling the plants to utilize any favourable weather conditions. It was not possible to specify the amounts of nutrients applied, because stable manure was often used, and the information on the previous nutrient status of the soil was also inadequate.

The weather conditions were very variable. The period covered by the study included the exceptionally warm years of the 1930s and for comparison, the growing seasons of 1952 and 1962, which were exceptionally cold. In consequence, the data provide an excellent opportunity for clarification of the direct as well as indirect influence of weather conditions on potato yields. In Appendix 1 the monthly means of temperature and rainfall at the different trial localities for the period 1931—60 are presented. More detailed data on the weather conditions during the period 1931—62 are to be found in the Meteorological Yearbook of Finland. Kolkki (1966, 1969) and Helimäki (1967) have analysed the weather conditions of the period 1931—60.

It should be noted that in the years 1938, 1941, 1951, 1955 and 1959, according to entries made in the field records, drought was a nuisance at virtually all the trial localities. Its harmful effect was greatest on the clay soils at Tikkurila, Tammisto, Jokioinen and Ylistaro. In 1955, total crop failure was caused by drought at Jokioinen.

Frost affected the trial crops comparatively frequently (Figs. 4—10). The greater importance of frost at the northerly localities of Maaninka, Ylistaro, Ruukki and Apukka was clearly evident. Sometimes, frost was even responsible for total crop failure, e.g. at Ruukki in 1941 and 1942.

The planting date in different years varied by 2—3 weeks (Figs. 4—10 and Table 1). On the other hand, the differences in the average planting date between different trial localities were smaller than expected. For instance, the difference between Tikkurila and Ruukki was only three days. In the southerly localities the potatoes may perhaps have been planted somewhat later in relation to the advent of summer.

The observations concerning the onset of flowering were incomplete, and data are presented here only with reference to the check variety, Rosafolia. The annual variation was even greater than in the case of planting time, from 2 ½ to 3 ½ weeks. The means fall on either side of July 20. The development of the crops was a few days slower at Maaninka and Ylistaro than at the southerly localities.

The observations on the incidence of late blight had only been made for purposes of comparing the resistance of varieties, and the number of observations recorded varied from year to year and from one locality to another. It was therefore very difficult to give a coherent account of aspects of the disease which were entirely different from those for which the original observations had been made. More frequent observations at more regular intervals at all localities would have been preferable. According to the number of trial localities and the number of trial years, the data provide an adequate basis for a picture of the importance of late blight. The observations on tuber blight were made prior to storage. The results are variable and perhaps deficient.

Yields were expressed as tuber yield, starch content and starch yield. The tuber yields were fairly high, but the annual variation was great. The highest average yield, 38.7 tons per hectare, was obtained at Maaninka, and the lowest, 26.2 tons per hectare, at Jokioinen. The latter figure is probably too low, owing to the absence of data from the favourable years of the 1930s. The yields of the best years were often 2—3 times those of the poorest years. The starch content of the tubers varied within wide limits. In some years with early night frost in autumn it was less than 10 %, and in the best years it was more than 20 %. The starch content was consistently lower at the northerly than at the southerly localities. The starch yield per hectare varied considerably, too. The figures exceeded 8 tons per hectare in the best years, but reached only a quarter of this figure in poor years. The variation in yield was less marked on sandy soils than on clay.

The possible disadvantages of changes in the trial blocks and of the small size of the trial plots could not be eliminated. The occurrence of virus diseases and even variation in the size of the seed tubers may have affected the development of the crops. Statictical analyses were not undertaken in instances in which the data did not satisfy the criteria imposed. But despite the deficiencies indicated, the data were fairly suitable for the present purpose.

Statistical treatment

The influence of weather conditions on tuber and starch yields and on the starch content was clarified by means of multiple regression calculations. The yield of Rosafolia was the dependent variable, and observations concerning its crops as well as weather statistics based on meteorological observations made at the trial localities were the independent variables. The date of cessation of growth was considered to be September 20, or else the date by which blight had destroyed 50 % of the leaves or frost had destroyed the tops. Large (1952) considers that increase of the tuber crop ceases when 75 % of the leaves have been destroyed by blight. In this study, the time corresponding to the 50 % figure is more appropriate, because subsequent growth at most compensates for the reduction of the crop which has already taken place prior to destruction of 50 % of the leaves. Since data with reference to onset of the blight epidemic and to the time of 50 % defoliation are deficient, the missing values have been determined by extrapolation and interpolation from actual observations. If only one set of observations was available, the values were estimated from the average rate of propagation of blight observed in Rosafolia in the trials at Pälkäne. Since weather conditions are one of the factors regulating the rate of spread of blight, this method does not give exact values, but provided the data are sufficiently ample, the errors will cancel out. Of the years with autumn frost, only those were taken into account in which no noteworthy damage was caused by frost, and, on the other hand, the years in which the vegetation was completely destroyed, and growth was thus arrested by frost, in a single night.

The most extensive calculations were made from the results of the trials at Pälkäne and Ylistaro, for which the longest usable series of data existed, covering 31 and 23 years, respectively. Some regressions were also calculated from the series of data collected at Tammisto and Maaninka, covering 14 years. Appendix 1 gives the mean values of temperature and rainfall during the growing seasons at the different trial localities.

The occurrence of blight was studied as a regional and as an annual phenomenon. Endeavours were made to elucidate its significance on the basis of its incidence and of the damage caused. An observation period of three decades may be considered adequate for collection of adequate data. The incidence was also recorded in relation to the severity of the epidemic, the blight years being classed as severe, moderate, etc.

The data concerning the incidence of tuber blight is so deficient that statistical treatment was not considered possible. The results of observations have merely been presented as such in the form of Appendix tables.

The comparisons between varieties with respect to resistance are presented, with reference to leaf blight, as average deviations of the observed values for each variety from that of Rosafolia (scale from 0 to 10, with 10 = healthy). Observations based on various scales were converted to a scale of 0—10. Observations in which the value 0 or 10 was obtained for one or other of the varieties were discarded. Differences in resistance were submitted to Student's t-test.

Observations concerning the incidence of tuber blight are not available for all years. Since, for most varieties, data have only been collected for a few years and since the annual

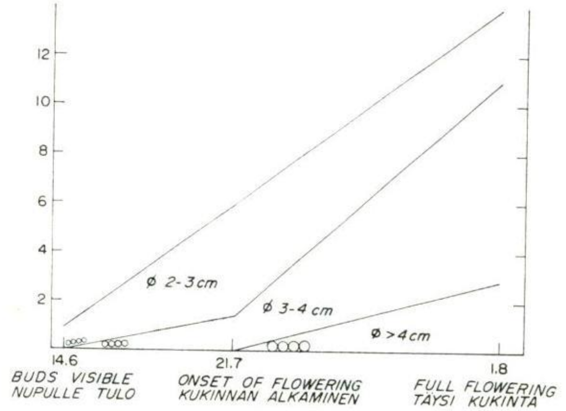


Fig. 2. Depedence of the development of tuber yield in Rosafolia on the onset of flowering in the trials at Tikkurila, Mikkeli, and Maaninka, 1967—68.

Kuva 2. Ruusulehden mukulasadon kehittymisen riippuvuus kukinnan alkamisesta Tikkurilassa, Mikkelissä ja Maaningalla v. 1967—68 järjestetyissä kokeissa.

variation between the different varieties is great, the raw data are presented in the form of tables. It is realized that mean values would suggest completely unwarranted comparisons between varieties and lead to erroneous conclusions.

The influence of blight on the yields of the different varieties has been clarified by means of correlation analysis. The relationship between incidence of blight and yield in Rosafolia was clarified by correlation analysis of the crop figures and times of outbreak of epidemics. In the intervarietal comparisons the relative yields of each variety (Rosafolia = 100) and the times of outbreak of epidemics were used. The use of these relative yields enabled the effect of blight on the yields of different varieties to be calculated directly. This procedure eliminated the influences of annual and varietal differences in yields. It is thus understood that the correlation indicates wheather the yields of the variety in question are reduced more or less strongly by blight than those of Rosafolia. The correlation coefficients were tested for statistical significance by Student's t-test. The respective regression equations were calculated for the graphical representations.

Calculations of yield losses. As a rule, the severity of a blight epidemic is measured by the proportion of leaves or tubers destroyed. With certain reservations, this method is appropriate for assessing the damage caused by tuber blight. The situation is different in the case of leaf blight: when it occurs late in the season, even a severe epidemic has no noteworthy effect on the yield, whereas an epidemic which develops early may cause marked reduction of the yield, even if comparatively mild. The decisive factors are thus how early the outbreak occurs and how rapidly the disease spreads through the crop. The situation is also affected by the stage of development of the crop, which may be earlier or later than normal.

The yield loss has been estimated in this study from a graph in which the date of onset of flowering is plotted against the date of cessation of growth, as specified above (p. 72). The size of the tuber crop in relation to the time of onset of flowering was clarified by means of field trials in 1967—1968. It can be seen from Fig. 2 that the average tuber yield at the onset of flowering was 5.9 tons per hectare. Towards the end of the growing season, the increase of the tuber crop has been assumed to slow down as a result of the changes in light and temperature conditions, so that during the period September 1—10 the daily increase of yield is half and during the period September 11—20 only one quarter of the increment in the corresponding period in August (cf. e.g. MURPHY 1939, KÖYLIJÄRVI 1962). If the tops were destroyed by blight during the course of the growing season, the potential yield was calculated, i.e. the yield which obviously would have been obtained in the absence of blight. The difference between the potential and actual yields is the yield loss. This is expressed as a percentage of the potential yield. Fig. 12 partly illustrates the method that has been employed.

RELATIONS OF YIELDS TO WEATHER CONDITIONS

Dependence of tuber and starch yields on weather conditions

The yield figures from Pälkäne and Ylistaro afforded the most extensive series of data for analysing the effect of weather conditions on the tuber and starch yields and on the starch content, because the longest usable series of results were available from these localities, covering 31 and 23 years, respectively. In some of the calculations the 14-year series of records from Tammisto and Maaninka were also used, the purpose, in these instances, being merely to corroborate the conclusions drawn from the Pälkäne and Ylistaro results. The mean temperature and rainfall data of the localities in question can be seen from Appendix 1.

As a first step, the meteorological factors during the growing season were taken as independent variables: the effective temperature sum from planting to the start of flowering and thence to cessation of growth, and the rainfall during the same periods. These factors accounted for only a small fraction of the total variation of the tuber and starch yields (Table 2). The partial regression was not statistically significant with regard to any factor. Of the total variation of starch content, however, nearly half was due to the weather factors, although only the weather conditions after the commencement of flowering had any notable effect. Table 5 shows the regression between the weather conditions of the latter part of the summer and the starch content; the weather conditions in the early part of the summer, being less important, have been disregarded. Increase of the effective temperature sum was associated with a significant rise in the starch content and increase of rainfall with a significant reduction in this yield parameter. At Pälkäne both exerted an equally strong effect, with beta coefficients of 0.421 and 0.427, respectively. At Ylistaro the influence of the effective temperature sum was greater (beta coefficient 0.707, against 0.503 for rainfall). This is thought to

Table 2. Total variation accounted for when various combinations of independent factors were used in analysing the relationship between weather factors and yield.

Taulukko 2. Säätekijöiden ja sadon välistä riippuvuutta selvitettäessä eri riippumattomien tekijöiden ryhmillä saadut kokonaisvaihtelun selvitysprosentit.

Combination of independent variables *Riippumattomien muuttujien tekijäryhmä*	Pälkäne			Ylistaro		
	Tuber yield *Mukulasato*	Starch yield *Tärkkelyssato*	Starch content *Tärkkelyspitoisuus*	Tuber yield *Mukulasato*	Starch yield *Tärkkelyssato*	Starch content *Tärkkelyspitoisuus*
Effective temperature sum and rainfall of growing season — *Kasvukauden tehoisa lämpötilasumma ja sademäärä*	17	27	44	11	15	48
Dates of onset of flowering and cessation of growth — *Kukinnan alkamisen ja kasvun päättymisen ajat*	26	27	—	23	29	—
All the factors named above — *Molemmat edellä mainitut ryhmät yhdessä*	40	42	46	50	46	55
Weather conditions of March—May and of the growing season, effective illumination only from latter part of growing season — *Maalis - toukokuun ja kasvukauden sääolot, tehoisa valosumma vain kasvukauden loppuosalta*	58	63	61	59	67	86

Table 3. Regression between onset of flowering and cessation of growth and the tuber and starch yields.

Taulukko 3. Kukinnan alkamisen ja kasvun päättymisen sekä mukula- ja tärkkelyssatojen välinen regressio.

Trial locality *Koepaikka*	Partial regression coefficient, and t-value *Osittaisregressiokerroin ja t-arvo*				R^2
	Onset of flowering *Kukinnan alkaminen*		Cessation of growth *Kasvun päättyminen*		
Tuber yield — *Mukulasato* (tn/ha):					
Pälkäne	—0.560	2.99**	0.187	1.93	0.261
Ylistaro	—0.610	2.42*	0.091	1.31	0.228
Tammisto	—0.618	1.62	0.279	1.02	0.453
Maaninka	—0.982	4.49***	0.192	1.31	0.660
Starch yield — *Tärkkelyssato* (tn/ha):					
Pälkäne	—0.095	2.94**	0.038	2.26*	0.273
Ylistaro	—0.123	2.63*	0.053	1.98	0.290
Tammisto	—0.164	2.60*	0.062	1.36	0.453
Maaninka	—0.128	2.71*	0.027	0.83	0.412

be due to the fact that the material includes data for years in which the haulm was destroyed rather early by frost.

As a second step, in addition to the weather factors, the dates of onset of flowering and cessation of growth were considered as independent variables; it is realized that these, too, are indirectly dependent on weather conditions. Now nearly half of the total variation of the tuber and starch yields could be accounted for (Table 2). The dependence of the yields in these factors reflecting the degree of development was distinctly stronger than their dependence on the weather conditions of the growing season. The yield figures are dependent, at a statistically significant level, both on the date of onset of flowering and on that of cessation of growth, the former appearing to rank considerably higher in importance than the latter (Table 4). Fairly similar results were obtained by analysing the data of Tammisto and Maaninka (Table 3). Provided that the regression coefficients in

Table 4. Dependence of tuber yield, starch yield and starch content of Rosafolia on the temperature and rainfall conditions of the growing season (effective temperature sum from planting to onset of flowering and thence to cessation of growth, and rainfall sums from corresponding periods) and on dates of onset of flowering and cessation of growth at Pälkäne and Ylistaro.

Taulukko 4. Ruusulehden mukula- ja tärkkelyssatojen sekä tärkkelyspitoisuuden riippuvuus kasvukauden lämpö- ja sadeoloista (tehoisat lämpötilasummat istutuksesta kukinnan alkamiseen ja siitä kasvun päättymiseen sekä sadesummat vastaavilta jaksoilta) sekä kukinnan alkamis- ja kasvun päättymisajankohdista Pälkäneellä ja Ylistarossa.

Independent variable *Riippumaton tekijä*	Partial regression coefficients, and t-value *Osittaisregressiokertoimet ja t-arvot*			
	Pälkäne		Ylistaro	
Tuber yield — *Mukulasato* (tn/ha):				
Effective temperature sum 1 (day-degrees above 5°C) — *Tehoisa lämpötilasumma 1 (°)*	—0.002	0.10	0.027	0.80
Rainfall sum 1 (mm) — *Sadesumma 1 (mm)*	—0.062	1.43	0.043	1.27
Date of onset of flowering (days) — *Kukinnan alkamisaika (pv)*	—0.893	2.89**	—1.619	3.52**
Effective temperature sum 2 — *Tehoisa lämpötilasumma 2*	—0.018	1.14	—0.058	2.60*
Rainfall sum 2 — *Sadesumma 2*	—0.024	0.77	0.009	0.25
Date of cessation of growth (days) — *Kasvun päättymisaika (pv)*	0.465	2.71*	0.573	2.50*
	F value — *F-arvo* = 2.63*	R^2 = 0.397	F value — *F-arvo* = 2.67	R^2 = 0.500
Starch yield — *Tärkkelyssato* (tn/ha):				
Effective temperature sum 1 (°C) — *Tehoisa lämpötilasumma 1 (°)*	—0.002	0.57	0.002	0.23
Rainfall sum 1 (mm) — *Sadesumma 1 (mm)*	0.006	0.83	0.009	1.27
Date of onset of flowering (days) — *Kukinnan alkamisaika (pv)*	—0.120	2.28*	—0.278	3.00*
Effective temperature sum 2 — *Tehoisa lämpötilasumma 2*	—0.001	0.50	—0.007	1.45
Rainfall sum 2 — *Sadesumma 2*	—0.009	1.61	—0.006	0.91
Date of cessation of growth (days) — *Kasvun päättymisaika (pv)*	0.066	2.26*	0.118	2.57*
	F value — *F-arvo* = 2.84*	R^2 = 0.415	F value — *F-arvo* = 2.26	R^2 = 0.459
Starch content — *Tärkkelyspitoisuus* (%):				
Effective temperature sum 1 (°C) — *Tehoisa lämpötilasumma 1 (°)*	—0.005	1.27	—0.011	1.13
Rainfall sum 1 (mm) — *Sadesumma 1 (mm)*	—0.008	0.95	0.008	0.80
Date of onset of flowering (days) — *Kukinnan alkamisaika (pv)*	0.055	0.87	—0.108	0.81
Effective temperature sum 2 — *Tehoisa lämpötilasumma 2*	0.005	1.45	0.007	1.07
Rainfall sum 2 — *Sadesumma 2*	—0.014	2.24*	—0.024	2.43*
Dade of cessation of growth (days) — *Kasvun päättymisaika (pv)*	—0.010	0.30	0.097	1.48
	F value — *F-arvo* = 3.38*	R^2 = 0.458	F value — *F-arvo* = 3.26*	R^2 = 0.550

Table 3 give a reliable idea of the dependence of yield on the times of onset of flowering and cessation of growth it appears that a shift in the commencement of flowering to one day earlier (with unchanged termination of growth) resulted in an increase of tuber yield, averaging about 0.6 tons and of starch yield averaging about 0.1 tons per hectare. Postponement of the cessation of growth by one day (with unchanged onset of flowering) increased the yields by only about one-third of the above figures.

Another observation that can be made from Table 4 is that an increase of rainfall seems to have a more favourable effect on yield when it occurs in the early part of the growing season. Even at best, however, the significance of the respective regression remains at the 80 % confidence level. The temperatures in the early part of the growing season seem to be of no significance, whereas an increase in the effective temperature sum in the latter part of summer has meant, as a rule, a lowering of the yield; at Ylis-

Table 5. Influence of thermal sum and rainfall after onset of flowering on the starch content of the tubers.
Taulukko 5. Kukinnan alkamisen jälkeisen kasvukauden tehoisan lämpötilasumman ja sademäärän vaikutus mukulain tärkkelysprosenttiin.

Variable *Muuttuja*	Partial regression coefficients, and t-value *Osittaisregressiokerroin ja t-arvo*			
	Pälkäne		Ylistaro	
Effective temperature sum (°C) — *Tehoisa lämpötilasumma (°)*	0.004	2.85**	0.013	3.61**
Rainfall sum (mm) — *Sademäärä (mm)*	—0.015	2.89**	—0.023	2.56*
	F value *F-arvo* = 9.12*** R^2 = 0.395		F value *F-arvo* = 6.95** R^2 = 0.410	

Table 6. Dependence of starch yield on tuber yield and starch content.
Taulukko 6. Tärkkelyssadon riippuvuus mukulasadosta ja tärkkelyspitoisuudesta (mittayksikköinä tonni ja prosentti).

Variable *Muuttuja*	Partial regression coefficients, t-value and β coefficient *Osittaisregressiokerroin, t-arvo ja β-kerroin*					
	Pälkäne			Ylistaro		
Tuber yield — *Mukulasato* (tn)	0.151	64.99***	0.867	0.144	31.37***	0.723
Starch content — *Tärkkelyspitoisuus* (%)	0.340	31.46***	0.420	0.301	19.80***	0.469
	F value *F-arvo* = 2816.85*** R^2 = 0.995			F value *F-arvo* = 958.14*** R^2 = 0.990		

taro, in fact, a significantly reduced tuber yield was noted.

The times of onset of flowering and cessation of growth showed no significant correlation with the starch content.

Analyses to settle the question of whether the starch yield is more closely correlated with the tuber yield or the starch content revealed that the tuber yield is distinctly more important (Table 6). With an increase of the tuber yield by 6.5 to 7.0 tons per hectare (with unchanged starch content) the starch yield increased by about one ton. Correspondingly, when the starch content increased by about 3 percent units (with unchanged tuber yield), the starch yield also increased by one ton. The beta coefficients in Table 6 indicate the relative importance of the two factors, as disclosed by the present data.

Of the factors influencing the time of onset of flowering, the planting time proved to be the most important (table 7). The earlier the potatoes were planted, the earlier was the onset of flowering. The regression was statistically significant in both localities. At Tammisto and Maaninka, too, the date of onset of flowering was significantly dependent on the planting date (correlation coefficients 0.55** and 0.61**, respectively). It is seen from Table 7 that a positive correlation existed between the accumulated effective temperature of the early part of summer and the date of onset of flowering, yet the correlation was not statistically significant. But this must not be interpreted to mean that an increase of the effective temperature sum would delay the commencement of flowering: pair correlation testing of the effective temperature sum and the time interval between planting and the onset of flowering established that the opposite was the case. The interval became shorter with increasing

Table 7. Effect of planting date and weather conditions from planting date to onset of flowering on the date of onset of flowering.

Taulukko 7. Istutusajan sekä istutus- ja kukinnan alkamisaikojen välisen ajan sääolojen vaikutus kukinnan alkamisaikaan.

Variable *Muuttuja*	Partial regression coefficients, and t-value *Osittaisregressiokerroin ja t-arvo*			
	Pälkäne		Ylistaro	
Planting date (days) — *Istutusaika (pv)*	0.580	5.54***	0.674	2.23*
Effective temperature sum (°C) — *Tehoisa lämpötilasumma (°)*	0.009	0.62	0.051	1.90
Rainfall sum (mm) — *Sademäärä (mm)*	0.023	1.00	0.050	1.86
	F value *F-arvo* = 14.09*** R^2 = 0.610		F value *F-arvo* = 3.64* R^2 = 0.441	

Table 8. Effect of planting time, effective temperature sum, rainfall and effective illumination after the onset of flowering on tuber and starch yields of Rosafolia at Pälkäne and Ylistaro.

Taulukko 8. Istutusajan, kukinnan alkamisen jälkeisen tehoisan lämpötilasumman, sademäärän ja tehoisan valosumman vaikutus Ruusulehden mukula- ja tärkkelyssatoihin Pälkäneellä ja Ylistarossa.

Independent variable *Riippumaton muuttuja*	Partial regression coefficients, and t-values *Osittaisregressiokertoimet ja t-arvot*			
	Pälkäne		Ylistaro	
Tuber yield — *Mukulasato* (tn/ha):				
Planting date (days) — *Istutusaika (pv)*	—0.206	1.27	—0.433	1.16
Effective temperature sum (°C) — *Tehoisa lämpötilasumma (°)*	—0.020	1.43	—0.052	2.28*
Rainfall sum (mm) — *Sadesumma (mm)*	—0.019	0.67	0.013	0.37
Effective illumination (EsH) — *Tehoisa valosumma (EsH)*	0.031	2.23*	0.056	2.61*
	F value *F-arvo* = 4.03* R^2 = 0.383		F value *F-arvo* = 2.93 R^2 = 0.395	
Starch yield — *Tärkkelyssato* (tn/ha):				
Planting date (days) — *Istutusaika (pv)*	—0.044	1.66	—0.068	0.94
Effective temperature sum (°C) — *Tehoisa lämpötilasumma (°)*	—0.001	0.67	—0.006	1.31
Rainfall sum (mm) — *Sadesumma (mm)*	—0.008	1.71	—0.007	1.08
Effective illumination (EsH) — *Tehoisa valosumma (EsH)*	0.004	1.91	0.011	2.66*
	F value *F-arvo* = 5.57** R^2 = 0.462		F value *F-arvo* = 3.11 R^2 = 0.409	

effective temperature sum, but when planting had been late, the commencement of flowering was postponed till the end of July, and the high temperatures in July caused a positive correlation between the effective temperature sum and the date of onset of flowering.

As a third step, the mean monthly temperatures of March, April, and May and the rainfalls of these months as well as the effective illumination in the latter part of the growing season were included among the independent variables, which thus number eleven altogether. With these inde-

Table 9. Effect of weather conditions from the onset of flowering to the end of growth on the starch yields (tn/ha) of Rosafolia at Pälkäne and Ylistaro.

Taulukko 9. Kukinnan alkamisen jälkeisen kasvukauden sääolojen vaikutus Ruusulehden tärkkelyssatoihin (tn/ha) Pälkäneellä ja Ylistarossa.

Weather component *Säätekijä*	Partial regression coefficient, and t-value *Osittaisregressiokerroin ja t-arvo*			
	Pälkäne		Ylistaro	
Effective temperature sum (°C) — *Tehoisa lämpötilasumma (°)*	—0.003	1.25	—0.006	1.37
Rainfall sum (mm) — *Sadesumma (mm)*	—0.010	2.32*	—0.007	1.01
Effective illumination (EsH) — *Tehoisa valosumma (EsH)*	0.006	3.30**	0.011	2.79
	F value *F-arvo* = 6.12** R^2 = 0.405		F value *F-arvo* = 3.87* R^2 = 0.380	

pendent variables, the percentage of the tuber yield variation accounted for increased to nearly 60 %, and for the starch content and starch yield the corresponding values were even higher (Table 2). However, mutually correlated factors detracted from each other's influence, and therefore only a few of the correlation coefficients were statistically significant. Therefore the less important factors were omitted from the further calculations.

The following were retained as independent variables: planting date and rainfall of the growing season after the onset of flowering, effective temperature sum, and effective illumination. The planting date serves as an indication of the effect exerted by the weather conditions of the spring, while the illumination replaces the dates of onset of flowering and cessation of growth. The total variation accounted for remained about 40 % for both the tuber and the starch yields. The results are presented in Table 8. It can be seen that the yield figures were most strongly affected by the effective illumination during the time after the onset of flowering. It is thought to be due to the correlation between this factor and the planting date (—0.49** at Pälkäne and —0.21 at Ylistaro) that these two factors masked each other, and the regression with regard to planting date remained weak, although paired analyses of planting date and yield figures revealed correlations (at Pälkäne, planting date tuber yield —0.50** and planting date starch yield —0.56**; at Ylistaro, respectively, —0.32 and —0.28). When the planting date was neglected, almost the same percentage of the variation in the starch yield was accounted for as above, but the regression between the illumination and starch yield became stronger (Table 9). Once more, it can be observed that increase of the effective temperature sum and rainfall after the onset of flowering were both factors that lowered the yield. This demonstrates the detrimental effect of high temperatures in July—August. It may be mentioned, moreover, that the yields were not significantly dependent on the combined effect of the effective temperature sum and illumination after the onset of flowering.

A further study was made of the factors influencing the planting date. The independent variables were the mean temperatures and rainfall figures for April and May of these, the most important was the temperature of April: the warmer this month, the earlier planting could be effected (Table 10). Increased rainfall in May delayed planting; a significant regression was established at Ylistaro but not at Pälkäne. At Pälkäne, potatoes had been planted as early as mid-May in a few years, which means that the planting date was not dependent on the weather conditions of the entire month. This may have affected the result of the calculation.

Tuber size. — The proportion of small potatoes (under 35 or 40 mm) in the yields of Rosa-

Table 10. Dependence of planting date on weather conditions of April and May at Pälkäne and Ylistaro.
Taulukko 10. Istutusajan (pv) riippuvuus huhti- ja toukokuun sääoloista Pälkäneellä ja Ylistarossa.

Weather component *Säätekijä*	Partial regression coefficients, and t-values *Osittaisregressiokertoimet ja t-arvot*			
	Pälkäne		Ylistaro	
Mean temperature of April (°C) — *Huhtikuun keskilämpötila (°C)*	—2.407	3.13**	—1.164	2.54*
Rainfall of April (mm) — *Huhtikuun sademäärä (mm)*	0.032	0.42	0.050	0.96
Mean temperature of May (°C) — *Toukokuun keskilämpötila (°C)*	0.170	0.24	—0.444	1.25
Rainfall of May (mm) — *Toukokuun sademäärä (mm)*	0.077	1.42	0.096	3.05**
	F value *F-arvo* = 3.72* R^2 = 0.364		F value *F-arvo* = 3.55* R^2 = 0.441	

Table 11. Correlations of small tubers (less than 35 or 40 mm) and mean tuber weight with tuber and starch yields.
Taulukko 11. Pienten mukuloiden (alle 35 tai 40 mm) ja mukuloiden keskipainon sekä sadon määrien väliset korrelaatiot.

Locality *Koepaikka*	Number of trial years *Koevuosia*	Small tubers vs. *Pienet mukulat/*		Mean weight vs. *Keskipaino/*	
		Tuber yield *Mukulasato*	Starch yield *Tärkk.sato*	Tuber yield *Mukulasato*	Starch yield *Tärkk.sato*
Pälkäne	25	—0.48*	—0.55*	0.54	0.52*
Maaninka	14	—0.55*	—0.60*	—	—
Ylistaro	27	—0.59**	—0.43*	—	—
Ruukki	23	—	—	0.78***	0.20

folia at Pälkäne, Maaninka and Ylistaro and the average tuber weights in the trials of Pälkäne and Ruukki are seen in Table 11. The average tuber weight and the proportion of small tubers in the yield were both significantly correlated with the tuber and starch yields. The higher the yield, the smaller was the proportion of small tubers in the crop; on the other hand, the higher the yield, the higher also was the average weight of the tubers.

Discussion

The tuber yield was most highly dependent on the dates of onset of flowering and cessation of growth. The first of these dates was most strongly influenced by the earliness of the summer. The earlier the advent of summer, the sooner planting could be undertaken (cf. KERÄNEN 1925), and the date of commencement of flowering, again, was significantly dependent on the planting date at all four localities. The planting date was affected by the mean temperature of March—May, and especially by that of April. An increase in the May rainfall delayed planting. At Ylistaro, where the trials had been established on clay soil, the effect was stronger (cf. TÄHTINEN 1962). However, the reliability of the regressions was only of the order of 90 %. The great importance of the thermal conditions of April has previously been noted in Finland by JOHANSSON (1922) and LUNELUND (1943). In Sweden the same conclusion was reached by HALLGREN (1947). The favourable effect of the thermal conditions of May has been stressed by JOHANSSON (1922), KERÄNEN (1925, 1931 a) and HALLGREN (1947). YLLÖ (1963 a) found a weak positive correlation between the temperature of May and the tuber yield. Previously, SALOHEIMO (1936), LÄHDE (1944), and SIMOJOKI (1961), working with potatoes, observed the advantage of early planting. This was also pointed out by CHRISTIE (1910), VIK (1915) and FROGNER (1964 a) in Norway, and by DYKE (1956) and others in England. It should be noted that in Finland a favourable effect of early sowing has also been reported with spring cereals (PESSI 1957, RYYNÄNEN 1958), turnip (ANTTINEN and KÖYLIJÄRVI 1961) and sugar beet (TÄHTINEN 1960, BRUMMER 1961).

Besides early planting, the weather conditions during the interval between planting and the onset of flowering are also of considerable importance. A negative correlation was established between the length of this interval and the weather conditions. In other words, high temperature accelerated development. High temperatures in June may thus partly offset the detrimental influence of late planting. This was more clearly evident at Ylistaro than at Pälkäne. In comparisons of the relative significance of the earliness of summer and the temperature of June with respect to their influence on the date of onset of flowering or on the yield, it has to be taken into account that the temperature of June depends on the earliness of the summer. The earlier the advent of summer, the warmer is the month of June. The correlations in the series of Pälkäne and Ylistaro amounted to $r = 0.47^{*}$ and 0.41, respectively. The statistic adopted as a measure of the earliness of summer was the mean temperature of the period March—May, which was correlated with the planting times (correlation coefficients —0.45* and —0.30). It is thus seen that warm spring months have an immediate influence on the earliness of planting and, indirectly, through the temperature of June, on the rate of growth of the crop, both these factors in turn leading to accelerated onset of flowering and, thereby, to increase of yield. A positive relationship between the mean temperature of June and the yield has also been indicated by JOHANSSON (1922), KERÄNEN (1931 a), LUNELUND (1943), TÄHTINEN (1962) and YLLÖ (1964). The mean temperature of June is, in fact, an excellent index by which to predict the yield, because it has an immediate effect on the rate of development of the crop and in it is also reflected the influence of the preceding months. It may be mentioned that in Sweden HALLGREN (1947) attributes less importance to June than to April and May.

The time of commencement of flowering can be regarded as an expression of the joint effect of the weather factors that have been acting up to that time. There is no information on the size or abundance of the haulm at the time when it reached the flowering stage, and therefore no possibility for a more detailed analysis of the effects of meteorological factors.

In addition to the time of commencement of flowering, the time of cessation of growth was found to have a significant influence on the tuber yield figure. It follows that the weather conditions at the time when the tubers are increasing in size have the most decisive influence on the yield. A weak negative correlation was found to exist between the effective temperature sum and the yield, which suggests an unfavourable effect of high temperatures in July (cf. YLLÖ 1963 a). A weak negative correlation was likewise observable between rainfall and yield. This is partly understandable, however, because in rainy years the significance of blight is greater, and because normally the rainfall was probably sufficient. The relation between added growth time of the tubers and yield proved to be weak (although at Pälkäne a significant correlation was found, $r = 0.38^{*}$), but the great importance of the date of onset of flowering suggested a closer study of whether decrease of the light dose due to decreasing day length was of any significance. The effective illumination sum was indeed found to be an excellent index of the variation in yield. The days rapidly decrease in length in July—August, and the assimilation time per day becomes less. WATSON (1947) has shown that the net assimilation rate decreases rapidly towards the autumn and is only 50—70 % of its maximum when the leaf area index of the potato reaches its maximum. This emphasizes the great importance of early development. THORNE (1960) has found that the net assimilation rate falls with age in plants. BORAH et al. (1960) reported that the incremental growth of the tubers is a positive function of incident radiation and day temperature and a negative function of night temperature, and that higher yields could be expected if the onset of tuber

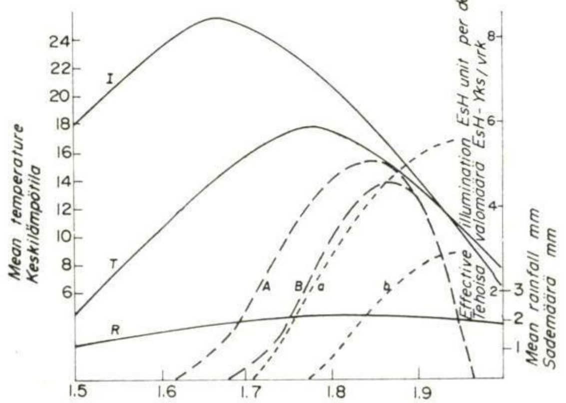


Fig. 3. Illumination (I), temperature (T) and rainfall (R) during the growing season at Pälkäne, and free-hand curves representing the amount of illumination received by the crop and the tuber yields. Curves *A* and *a* represent years with early development of the crop and *B* and *b* years with late development. Effective illumination according to LUNELUND (1941).

Kuva 3. Kasvukauden aikaiset valo-, lämpö- ja sadeolot (I, T ja R) Pälkäneellä sekä perunakasvuston vastaan ottamia käytettävissä olevia valomääriä ja vastaavia mukulasatoja kuvaavat käyrät. Käyrät A ja a esittävät aikaista, B ja b myöhäistä kehitystä. Tehoisa valomäärä LUNELUND*in (1941) mukaan.*

initiation could be accelerated. SCHOLTE UBING (1958) also pointed out the significance of the light dose. It should be noted that regarding the distribution of the light dose Finland differs essentially from Central Europe. In the present study it was not possible to use the leaf area index as a variable in regression calculations, but the results suggest that it is less significant than early development. In Finland, several investigators, including PESSI (1958) and BRUMMER (1961), have called attention to the significance of radiation, the former in his studies on spring cereals, and the latter with respect to the significance of early sowing of sugar beet.

In Fig. 3 the mean rainfall, temperature and light dose in May—September at Pälkäne are given, as well as curves indicating the effective illumination received by the potato plants, a figure which was arrived at by deduction. The areas enclosed by the curves A and B may be considered to represent the light dose conditions consistent with the light doses received by the crop. Curve A shows the light dose when the development of the crop is early and curve B when it is delayed. If, moreover, the fall in temperature towards the autumn and the effects of blight and frost are taken into account, it appears natural that the illumination available to the plant has a decisive effect on the yield. Curves a and b illustrate the course of development of the corresponding tuber yields. It can be assumed that the tuber yield increments in two-week periods from the beginning of July to the middle of September are on the average as $1:{}^4/_5:{}^3/_5:{}^2/_5:{}^1/_5$ (tn/ha/day). The same is also suggested by the results presented in Fig. 12.

Table 12. Relationship between the yield figures of certain varieties and of Rosafolia in the trials at Pälkäne and Ylistaro.
Taulukko 12. Eräiden lajikkeiden ja Ruusulehden (Rosafolia) satolukujen välinen riippuvuus Pälkäneen ja Ylistaron kokeissa.

Variables *Muuttujat*	Number of years *Vuosia*	Correlation coefficients *Korrelaatiokertoimet*		
		Tuber yield *Mukulasato*	Starch percentage *Tärkkelysprosentti*	Starch yield *Tärkkelyssato*
Pälkäne:				
Jaakko — Rosafolia	13	0.79**	0.94***	0.96***
Olympia — Rosafolia	12	0.94***	0.76**	0.91***
Ostbote — Rosafolia	19	0.76***	0.81***	0.82***
Ylistaro:				
Eigenheimer — Rosafolia	21	0.93***	0.96***	0.93***
Eldorado — Rosafolia	15	0.93***	0.92***	0.94***
Ostbote — Rosafolia	10	0.97***	0.68*	0.97***

Table 13. Correlations of tuber yields of Rosafolia and of mean yields in the districts surrounding the trial localities in the period 1931— 62.

Taulukko 13. Ruusulehden mukulasatojen ja koepaikkoja ympäröivien maanviljelysseurojen keskisatojen väliset korrelaatiot v. 1931—62.

Variables *Muuttujat*	Number of years *Vuosia*	Correlation coefficient *Korrelaatiokerroin*
Tuber yield of Rosafolia, *Ruusulehden mukulasato,* vs. average yield of Agricultural Society or Admin. District *Maanviljelysseuran keskisato*		
at Tammisto/Uusimaa	18	0.62**
at Pälkäne/Häme	32	0.46**
at Pälkäne/Häme—Satakunta	32	0.55**
at Maaninka/Kuopio	31	0.48**
at Ylistaro/Etelä-Pohjanmaa	30	0.59***

The starch content is most strongly influenced by the effective temperature sum of the late summer and by its rainfall; an increase of the former raises and that of the latter lowers the starch content. The correlation between the effective temperature sum and the rainfall amounted to —0.01 at Pälkäne and 0.48* at Ylistaro. A corresponding effect of the temperature and rainfall of the late summer on the starch content has previously been shown by a number of workers, including SIMOLA (1926), LAURILA and ANTILA (1956), FROGNER (1964 b), YLLÖ (1964) and VARIS (1970).

The date of onset of flowering had no effect on the starch content, but between the date of cessation of growth and the starch percentage there was a weak correlation ($r = 0.23$) at Pälkäne and a significant correlation ($r = 0.47^*$) at Ylistaro. These results support the generally held belief that the starch content as a rule increases towards the autumn (cf. e.g. CARLSSON 1964, BAERUG 1965, NEENAN 1965). The starch content was higher at the southerly localities than at the northerly ones (cf. UMAERUS 1970).

The starch yield seems to be most powerfully affected by the same factors as the tuber yield. This is understandable, because the starch yield was more strongly dependent on the tuber yield than on the starch content.

Since the calculations presented above concerning the relations of potato yields to weather conditions were all calculated from the yields of a single variety, Rosafolia, the question arises whether the results obtained here are of general applicability. Table 12 shows the correlations between the yields of Rosafolia and several varieties which were included in the trials for long periods. All these correlations are significant. In addition, there was a significant correlation between the tuber yields of Rosafolia obtained at Tammisto, Pälkäne, Maaninka and Ylistaro and yields in the vicinity of the trial localities (Table 13). Furthermore, a relationship was shown to exist between the time of onset of flowering of Rosafolia and the average yield of potatoes in the province surrounding the trial locality, the correlation being significant in two instances and weak in three (Table 14). Thus, it is obvious that the results obtained with Rosafolia may be considered, in Finnish conditions at least, to give a true indication of the general relationship between weather conditions and yields.

Table 14. Correlations of date of onset of flowering of Rosafolia and average yields in the districts surrounding the trial localities in 1931—62.

Taulukko 14. Ruusulehden kukinnan alkamisajankohdan ja koepaikkoja ympäröivien maanviljelysseurojen keskisatojen väliset korrelaatiot v. 1931—62.

Variables *Muuttujat*	Number of years *Vuosia*	Correlation coefficient *Korrelaatiokerroin*
Date of onset of flowering of Rosafolia *Ruusulehden kukinnan alkamisaika* vs. average yield of Agricultural Society or Admin. District *Maanviljelysseuran keskisato*		
at Tammisto/Uusimaa	16	—0.30*)
at Pälkäne/Häme	32	—0.40*
at Pälkäne/Häme—Satakunta	32	—0.40*
at Maaninka/Kuopio	21	—0.26*)
at Ylistaro/Etelä-Pohjanmaa	30	—0.27*)

*) Confidence level of correlation, $p = 0.75$.
*) *Korrelaation luotettavuus p = 0.75.*

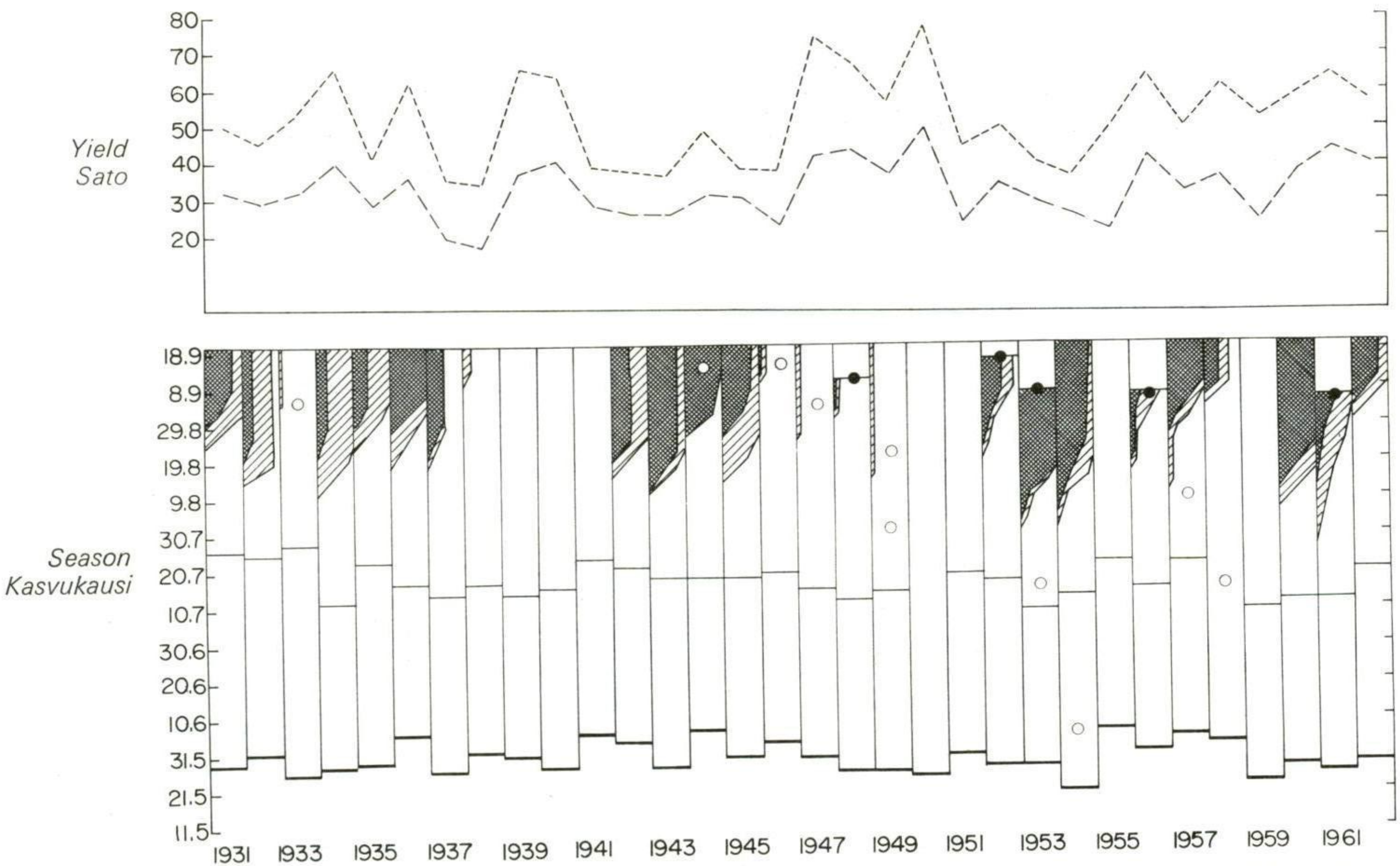


Fig. 4. Data on the dates of planting and dates of onset of flowering of Rosafolia, the occurrence of frost, the incidence of blight in the most susceptible variety and in Rosafolia, and the tuber and starch yields of Rosafolia, at Tikkurila, in the years 1931—1962.
Kuva 4. Tiedot istutusajoista, Ruusulehden kukinnan alkamisajoista, hallan esiintymisestä, ruton esiintymisestä arimmassa lajikkeessa ja Ruusulehdessä sekä Ruusulehden mukula- ja tärkkelyssadoista Tikkurilassa v. 1931—62.

- - - - starch yield — *tärkkelyssato*, hkg/ha, — — — — tuber yield — *mukulasato*, tn/ha, ▓ spread of blight in Rosafolia — *ruton leviäminen Ruusulehdessä*, ▨ spread of blight in the most susceptible variety — *ruton leviäminen arimmassa lajikkeessa*, ● severe frost — *ankara halla*, ⊙ mild frost — *lievä halla.*

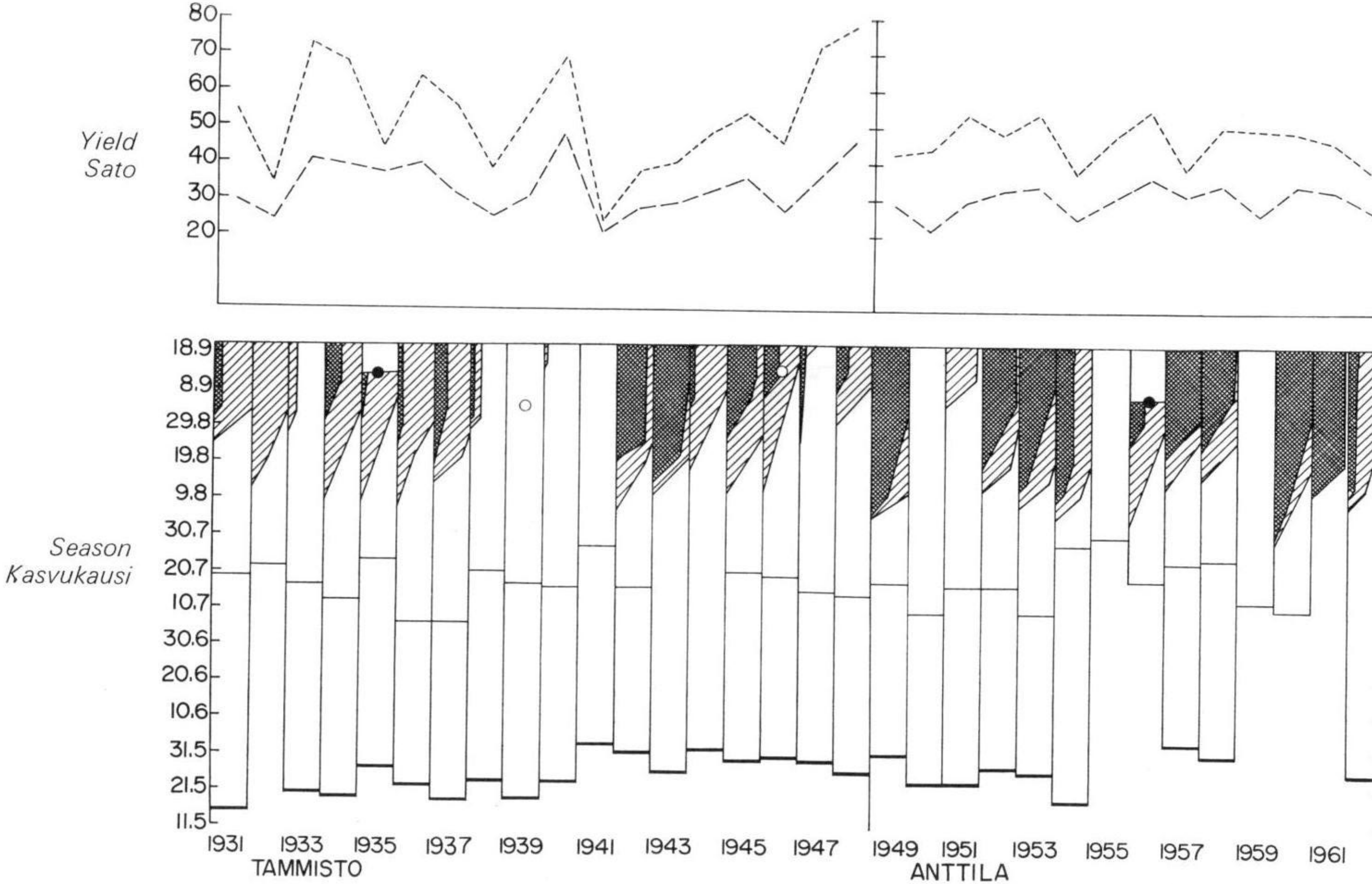


Fig. 5. Data on the dates of planting and dates of onset of flowering of Rosafolia, the occurrence of frost, the incidence of blight in the most susceptible variety and in Rosafolia, and the tuber and strach yields of Rosafolia, at Tammisto in the years 1931—1948 and Anttila in the years 1949—1962.

Kuva 5. Tiedot istutusajoista, Ruusulehden kukinnan alkamisajoista, hallan esiintymisestä, ruton esiintymisestä arimmassa lajikkeessa ja Ruusulehdessä sekä Ruusulehden mukula- ja tärkkelyssadot Tammistossa v. 1931—48 ja Anttilassa v. 1949—62.

- - - - starch yield — *tärkkelyssato*, hkg/ha, — — — — tuber yield — *mukulasato*, tn/ha, [cross-hatched] spread of blight in Rosafolia — *ruton leviäminen Ruusulehdessä*, [hatched] spread of blight in the most susceptible variety — *ruton leviäminen arimmassa lajikkeessa*, ● severe frost — *ankara halla*, ⊙ mild frost — *lievä halla.*

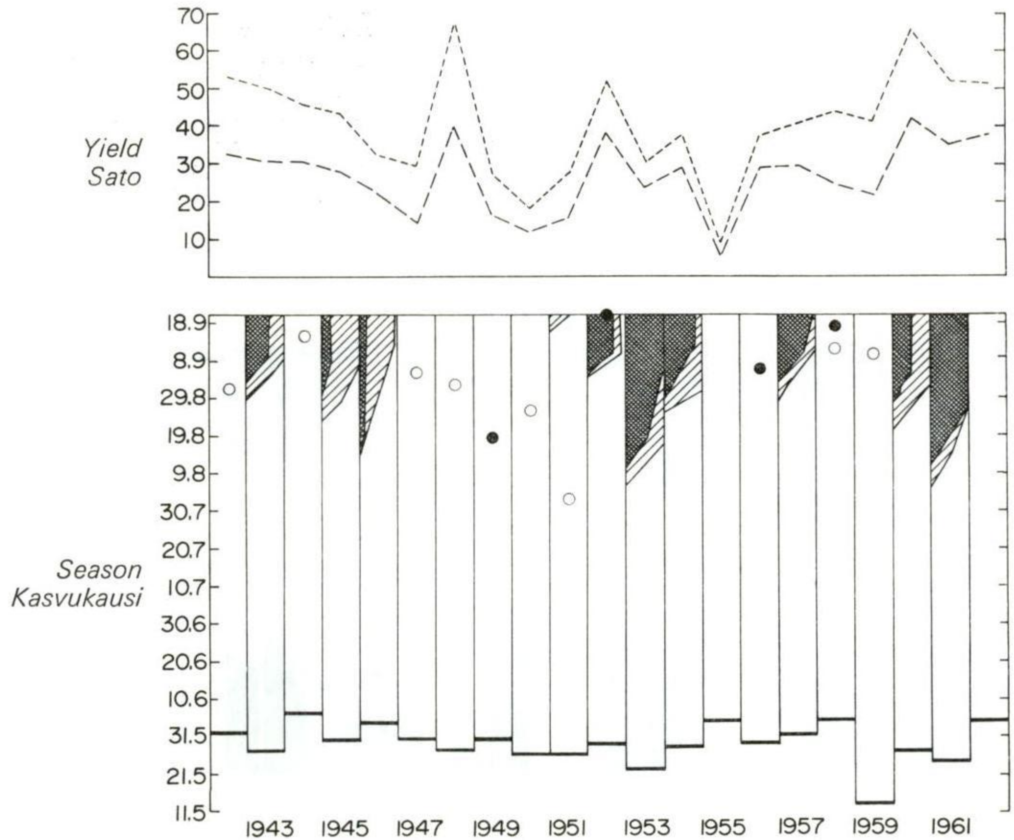


Fig. 6. Data on the dates of planting, the occurrence of frost, the incidence of blight in the most susceptible variety and Rosafolia, and the tuber and starch yields of Rosafolia, at Jokioinen 1942—1962.

Kuva 6. Tiedot istutusajoista, hallan esiintymisestä, ruton esiintymisestä arimmassa lajikkeessa ja Ruusulehdessä sekä Ruusulehden mukula- ja tärkkelyssadoista Jokioisissa v. 1942—62.

- - - - starch yield — *tärkkelyssato*, hkg/ha, — — — — tuber yield — *mukulasato*, tn/ha, [dark shading] spread of blight in Rosafolia — *ruton leviäminen Ruusulehdessä*, [hatching] spread of blight in the most susceptible variety — *ruton leviäminen arimmassa lajikkeessa*, ● severe frost — *ankara halla*, ⊙ mild frost — *lievä halla.*

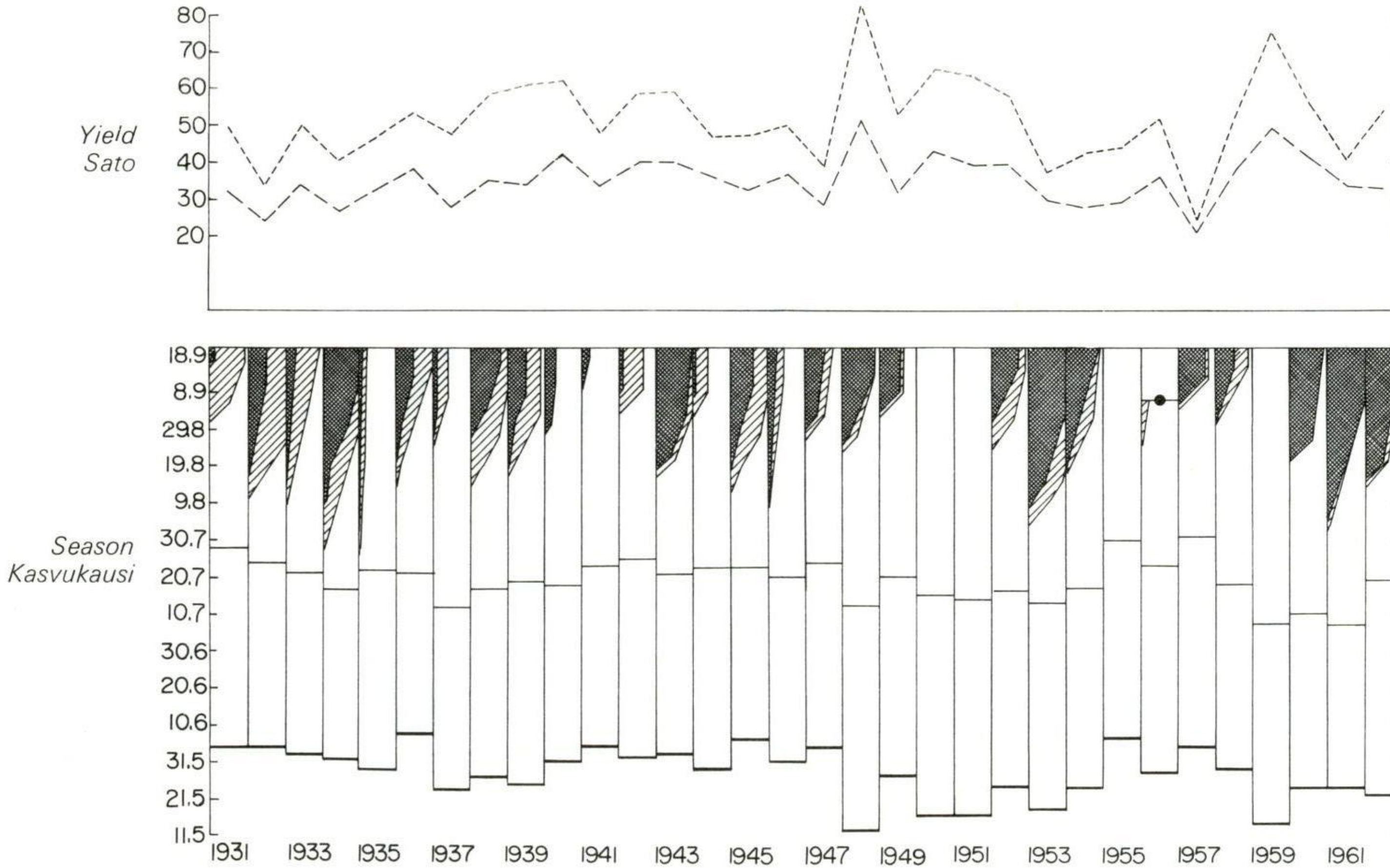


Fig. 7. Data on the dates of planting and dates of onset of flowering of Rosafolia, the occurrence of frost, the incidence of blight in the most susceptible variety and in Rosafolia, and the tuber and starch yields of Rosafolia, at Pälkäne 1931—1962.

Kuva 7. Tiedot istutusajoista, Ruusulehden kukinnan alkamisajoista, hallan esiintymisestä, ruton esiintymisestä arimmassa lajikkeessa ja Ruusulehdessä sekä Ruusulehden mukula- ja tärkkelyssadoista Pälkäneellä v. 1931—62.

- - - - starch yield — *tärkkelyssato*, hkg/ha, — — — — tuber yield — *mukulasato*, tn/ha, [cross-hatched] spread of blight in Rosafolia — *ruton leviäminen Ruusulehdessä*, [hatched] spread of blight in the most susceptible variety — *ruton leviäminen arimmassa lajikkeessa*, ● severe frost — *ankara halla.*

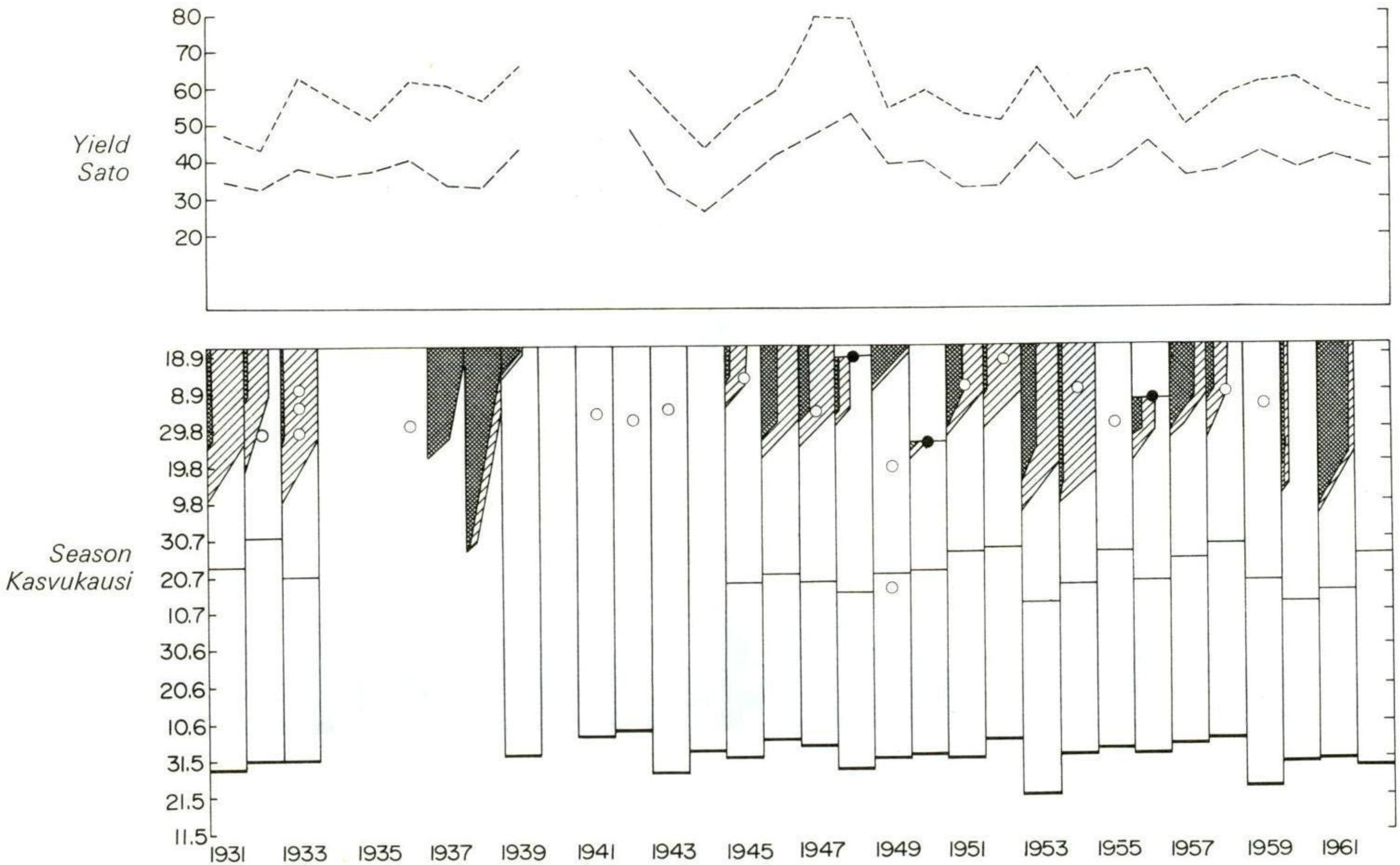


Fig. 8. Data on the dates of planting and dates of onset of flowering of Rosafolia, the occurrence of frost, the incidence of blight in the most susceptible variety and in Rosafolia, and the tuber and starch yields of Rosafolia, at Maaninka 1931—1962.

Kuva 8. Tiedot istutusajoista, Ruusulehden kukinnan alkamisesta, hallan esiintymisestä, ruton esiintymisestä arimmassa lajikkeessa ja Ruusulehdessä sekä Ruusulehden mukula- ja tärkkelyssadoista Maaningalla 1931—62.

- - - - starch yield — *tärkkelyssato*, hkg/ha, — — — — tuber yield — *mukulasato*, tn/ha, spread of blight in Rosafolia — *ruton leviäminen Ruusulehdessä*, spread of blight in the most susceptible variety — *ruton leviäminen arimmassa lajikkeessa*, ● severe frost — *ankara halla*, ⊙ mild frost — *lievä halla.*

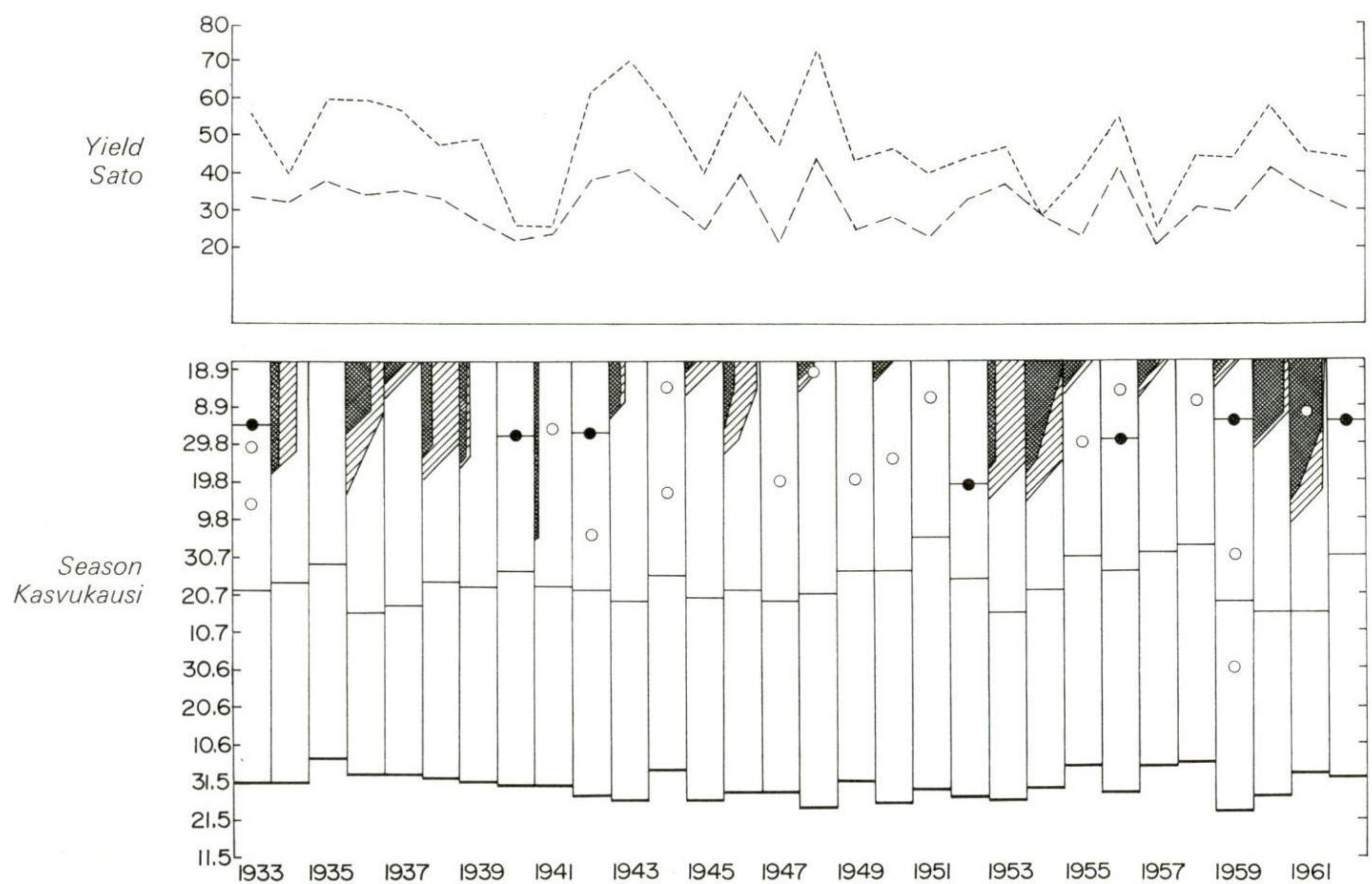


Fig. 9. Data on the dates of planting and dates of onset of flowering of Rosafolia, the occurrence of frost, the incidence of blight in the most susceptible variety and in Rosafolia, and the tuber and starch yields of Rosafolia, at Ylistaro 1933—1962.

Kuva 9. Tiedot istutusajoista, Ruusulehden kukinnan alkamisajoista, hallan esiintymisestä, ruton esiintymisestä arimmassa lajikkeessa ja Ruusulehdessä sekä Ruusulehden mukula- ja tärkkelyssadoista Ylistarossa v. 1933—62.

- - - - starch yield — *tärkkelyssato*, hkg/ha, — — — — tuber yield — *mukulasato*, tn/ha, [dark shading] spread of blight in Rosafolia — *ruton leviäminen Ruusulehdessä*, [hatching] spread of blight in the most susceptible variety — *ruton leviäminen arimmassa lajikkeessa*, ● severe frost — *ankara halla*, ○ mild frost — *lievä halla.*

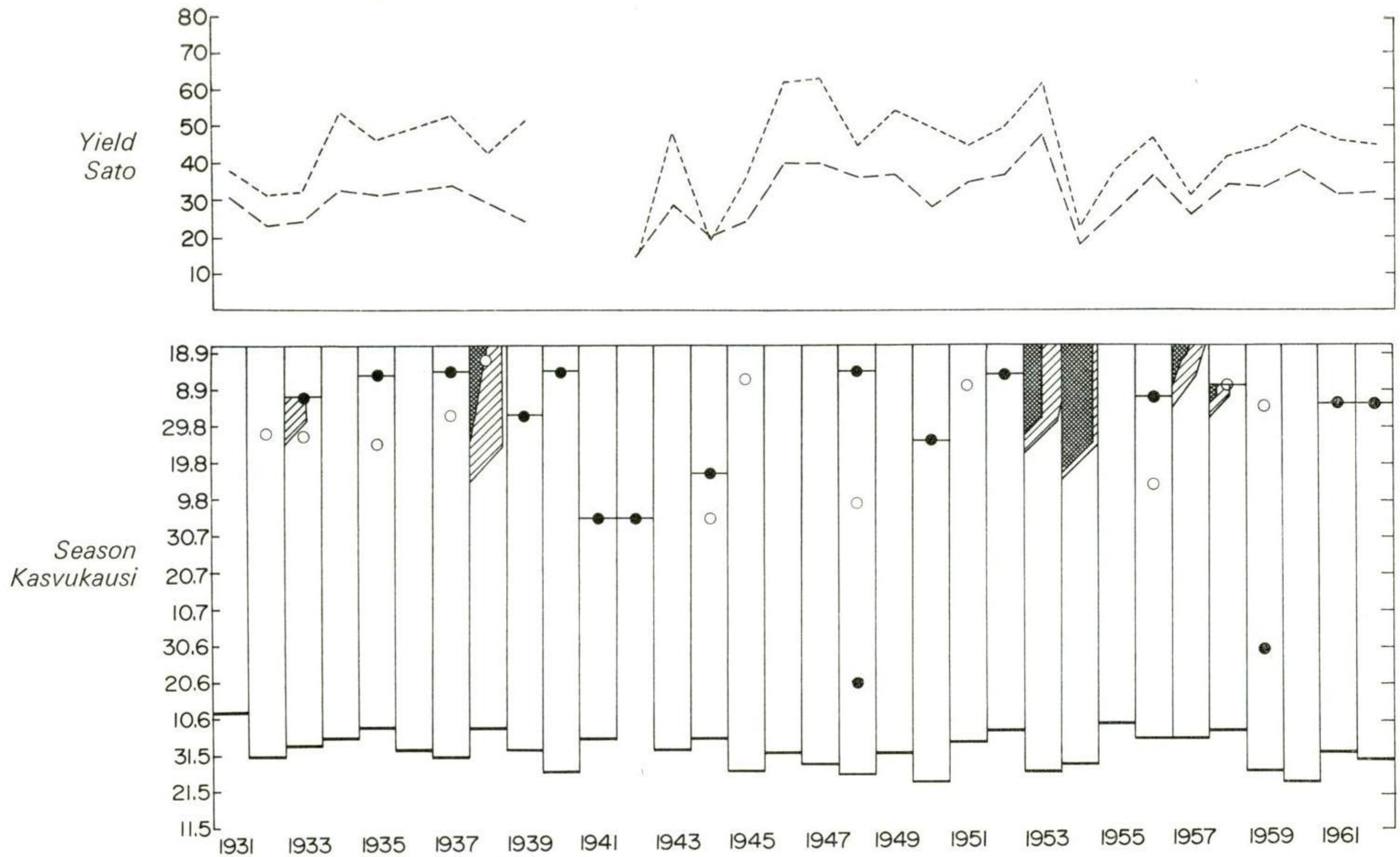


Fig. 10. Data on the dates of planting, the occurrence of frost, the incidence of blight in the most susceptible variety and in Rosafolia, and the tuber and starch yields of Rosafolia, at Ruukki 1931—1962. Blight was also observed in 1936, 1943, 1952 and 1961, but detailed data are lacking.

Kuva 10. Tiedot istutusajoista, hallan esiintymisestä, ruton esiintymisestä arimmassa lajikkeessa ja Ruusulehdessä sekä Ruusulehden mukula- ja tärkkelyssadoista Ruukissa v. 1931—62. Ruttoa on todettu myös v. 1936, —43, —52 ja —61, mutta tarkemmat tiedot puuttuvat.

- - - - starch yield — *tärkkelyssato*, hkg/ha, — — — — tuber yield — *mukulasato*, tn/ha, [dark hatched] spread of blight in Rosafolia — *ruton leviäminen Ruusulehdessä*, [hatched] spread of blight in the most susceptible variety — *ruton leviäminen arimmassa lajikkeessa*, ● severe frost — *ankara halla*, ⊙ mild frost — *lievä halla.*

Leaf blight

Wide annual variation of incidence was a typical feature of leaf blight. The earliest recorded epidemics began at the end of July, but in most years the disease did not break out until the latter half of August, and in some years no blight occurred at all.

Figs. 4 to 10 give a general idea of the incidence of blight in the different years and at the different trial localities. Unfortunately, regular and frequent observations were not made, and the descriptions of the spread of blight through the crop leave much to be desired.

The particular varieties proving most susceptible to blight varied with the locality as well as with the year, for which reason the times of outbreaks in different years were not mutually comparable. However, the observations made on Rosafolia may be considered to reflect the differences between the years as well as between the localities. The frequency of frost at the northerly localities merits attention.

There was distinct uniformity in the incidence of blight between the southerly localities of Tikkurila, Tammisto-Anttila, Jokioinen and Pälkäne. Piikkiö and Peipohja also belonged to this group. Tohmajärvi seemed to be intermediate between these and Maaninka and Ylistaro, which formed the other group. At Ruukki and Apukka only occasional outbreaks of blight were of importance.

If the results of observations on the southern group are slightly smoothed, it is evident that the blight epidemic had broken out by August 10 in four years, i.e. during one year in eight on the average. In at least eleven years, i.e. during one year in three, on the average, it had started by August 20, and in twenty years, i.e. in two out of three years, before the end of August. In seven years, i.e. during one year in five, an outbreak of the epidemic occurred in September, and in five years, i.e. during one year in six, there had been no blight at all. The average frequency of occurrence of severe epidemics (growth of the most susceptible varieties arrested by blight by about mid-August) was once in five years. A moderate blight year (growth of the most susceptible varieties arrested before the end of August) was encountered once in two years, while once in three years, on the average, blight was negligible or there was no outbreak.

At the latitude of Maaninka and Ylistaro the epidemic only broke out prior to August 20 during one year in five and by August 30, once in two or three years on the average. Approximately once in two years on the average the attacks of blight were very mild, or the disease was not observed at all.

At Maaninka, there was a very bad blight year once in five or six years, while there was only one such year at Ylistaro. Severe or moderate blight occurred at Maaninka once in two years, at Ylistaro only once in four years on the average. The importance of blight was less at Ylistaro than at Maaninka, which is due, at least in part, to the more frequent occurrence of frost at the former locality.

Tuber blight

The information concerning the occurrence of tuber blight was incomplete. In the years for which such data are lacking it is probable that the disease reached only negligible proportions, or was not encountered at all.

Numerous factors impede the study of the importance of tuber blight. Firstly, Rosafolia cannot be accepted as a standard for the incidence of tuber blight, owing to its exceptional resistance. Most other varieties, again, had only been included in the trials for comparatively short periods, and the proportion of the crop consisting of their blight-infested tubers had varied greatly. For these reasons, statistical analysis of the data was not considered warrantable, and only the most important observations are presented in Appendices 2 to 11.

The wide variation in the incidence of tuber

Table 15. The resistance to leaf blight of the most common varieties cultivated in Finland compared with Rosafolia. Results obtained at different trial localities. On the right the resistance of varieties after SALONEN (1962). Scale 0—10.

Taulukko 15. Yleisimpien perunalajikkeidemme lehtiruton kestävyys eri koepaikoissa Ruusulehteen verrattuna. Vertailun vuoksi on esitetty myös SALOSEN (1962) perunanviljelyoppaassa esittämät arvosanat. Asteikko 0—10.

Variety *Lajike*	Tikkurila: Number of years *Koevuosia*	Tikkurila: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Tikkurila: t-value *t-arvo*	Tammisto: Number of years *Koevuosia*	Tammisto: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Tammisto: t-value *t-arvo*	Anttila: Number of years *Koevuosia*	Anttila: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Anttila: t-value *t-arvo*	Jokioinen: Number of years *Koevuosia*	Jokioinen: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Jokioinen: t-value *t-arvo*
Early Rose — *Aikainen ruusu*	—	—	—	—	—	—	—	—	—	—	—	—
Tammiston aikainen	—	—	—	9	—5.2	7.12***	—	—	—	—	—	—
Harbinger — *Vesijärvi*	—	—	—	7	—4.4	4.76**	—	—	—	—	—	—
Sieglinde — *Siikli*	—	—	—	—	—	—	6	—3.6	6.55**	6	—3.0	5.88**
King George V — *Kuningas Yrjö V*	10	—1.4	3.19**	6	—1.7	3.47*	—	—	—	10	—1.9	3.17*
Eigenheimer	—	—	—	9	—1.4	3.59**	—	—	—	10	—2.2	3.93**
Jaakko	8	—0.2	0.51	—	—	—	7	+0.2	0.34	10	—0.6	1.54
Up-to-Date — *Upto*	—	—	—	9	—0.7	1.91	—	—	—	—	—	—
Paul Wagner — *Pauli*	—	—	—	13	—0.3	1.00	—	—	—	8	+0.5	0.64
Olympia	7	+0.6	1.54	—	—	—	8	+1.3	2.28	8	+0.1	0.23
Ostbote	11	+3.3	9.43***	6	+1.5	2.63*	7	+5.2	8.67***	8	+2.5	4.55**
Alpha — *Alfa*	6	+2.4	2.86*	6	+1.8	2.50	—	—	—	8	+2.2	3.61**
Record — *Rekord*	—	—	—	—	—	—	6	+3.1	2.91*	—	—	—
Aquila — *Akvila*	7	+6.4	5.73**	—	—	—	6	+5.2	5.15**	8	+2.2	3.73**
Frühnudel — *Nuutti*	—	—	—	—	—	—	—	—	—	6	+3.0	4.69**

Variety *Lajike*	Pälkäne: Number of years *Koevuosia*	Pälkäne: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Pälkäne: t-value *t-arvo*	Ylistaro: Number of years *Koevuosia*	Ylistaro: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Ylistaro: t-value *t-arvo*	Maaninka: Number of years *Koevuosia*	Maaninka: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Maaninka: t-value *t-arvo*	Tohmajärvi: Number of years *Koevuosia*	Tohmajärvi: Mean deviation compared with Rosafolia *Keskim. ero Ruusulehteen*	Tohmajärvi: t-value *t-arvo*	Blight resistance of varieties (Rosafolia 7 and 10) *Perunan viljelyoppaan arvosanat Lehdistö* (*Ruusulehti 7 ja 10*): Haulm	Blight resistance of varieties: Tubers *Mukulat*
Early Rose — *Aikainen ruusu*	—	—	—	—	—	—	12	—4.4	4.51	17	—2.4	6.49***	—	—
Tammiston aikainen	—	—	—	—	—	—	12	—4.4	4.51***	15	—2.9	5.47***	4	5
Harbinger — *Vesijärvi*	9	—3.6	3.41*	6	—3.3	3.41*	—	—	—	13	—1.3	2.45*	4	5
Sieglinde — *Siikli*	13	—1.9	4.87**	—	—	—	8	—4.1	3.53**	—	—	—	5	6
King George V — *Kuningas Yrjö V*	—	—	—	7	—2.1	1.76	11	—4.0	4.44**	—	—	—	6	9
Eigenheimer	8	—0.8	2.00	17	—1.1	2.89**	15	—0.9	1.84	11	—0.1	0.23	6	5
Jaakko	14	—1.1	2.17*	6	—1.2	2.31	8	—1.8	3.75**	—	—	—	6	6
Up-to-Date — *Upto*	—	—	—	—	—	—	18	—1.7	2.62*	18	+0.5	1.04	7	6
Paul Wagner — *Pauli*	7	—0.8	1.89	9	—0.9	0.88	—	—	—	11	+0.1	0.37	8	8
Olympia	13	—0.2	0.75	8	+1.0	2.08	—	—	—	—	—	—	8	9
Ostbote	23	+1.5	3.50**	6	+2.3	2.74*	10	+1.2	1.70	—	—	—	9	9
Alpha — *Alfa*	16	+2.6	6.77***	—	—	—	—	—	—	—	—	—	9	8
Record — *Rekord*	11	+2.6	4.38**	—	—	—	—	—	—	—	—	—	8	9
Aquila — *Akvila*	—	—	—	—	—	—	—	—	—	—	—	—	10	9—10
Frühnudel — *Nuutti*	—	—	—	10	+2.0	3.57**	—	—	—	—	—	—	10	10

blight is apparent from the tables. In some instances, the majority of the crops were infected, while in other years the whole crop, even of the most susceptible variety, escaped entirely. On the average, tuber blight broke out at nearly every locality approximately every other year, or in two years out of three. At Jokioinen and Pälkäne it was only encountered in one year in three. The differences between the localities may also have been affected by the differences in the accuracy of the observations. For example, the percentage of affected tubers had sometimes been rounded off to whole numbers, sometimes stated with greater accuracy.

Moderately frequent tuber blight had been noted in 1934, 1936, 1938, 1943, 1953, 1954, 1957 and 1961, i.e. in one year in four on the average. These years can be considered bad tuber blight years. In addition, some tuber blight was encountered, in the years 1932, 1935, 1937, 1945, 1946, 1952 and 1960. Tuber blight had thus been of some importance in at least one year in two. In one year in three it had been negligible or not encountered at all. It is obvious that frost had to some extent restricted the occurrence of tuber blight, by destroying the infected haulms.

Blight resistance

The resistance of a given variety to blight is usually understood to mean its resistance to a combination of leaf and tuber blight. In the present study the resistance to leaf blight and to tuber blight have been considered separately, as well as the relative resistance of the different varieties to leaf blight.

The values indicating resistance to leaf blight presented in Table 15 have been compiled from observations made at eight localities. Only those varieties were included for which observations covering at least six years and in at least two localities were available for comparison with Rosafolia. The results revealed little that is new, compared to the scores presented by SALONEN (1962).

Of the second early varieties, King George V and Frühnudel, of the main crop varieties, Paul Wagner and Olympia, and of the late varieties, Ostbote, Alpha and Aquila had one too many points, while the scores of the other varieties were fairly appropriate.

No statistical analysis of the resistance of the varieties to tuber blight was possible. However, attempts were made to gain some idea of the resistance of the varieties by comparisons of pairs. The assessments thus obtained were compared with those assigned by SALONEN and partly presented in Table 15. The scores of Barima (5) and of Ostbote and Record (9 both) are one point, and those of Bintje (6), Magnum Bonum and Paul Wagner (8 both), King George V and Olympia (9 both) and Aquila and Frühnudel (10 both) are no less than two points too high.

The relative resistance of a variety to leaf blight indicates whether the yield was reduced by attacks of blight more or less strongly than that of Rosafolia. Since the lower limit of the useable pairs of results was set at seven and in regard to each variety results from at least two localities were required, correlation coefficients could only be presented for 40 cases. These related to six localities and thirteen varieties (Table 16). A positive correlation meant that the variety in question was relatively more susceptible, and a negative correlation that it was relatively more resistant, than Rosafolia. Owing to the limitations of the data, only a few of the correlations were statistically significant, even though the correlation appeared obvious in a greater number of cases.

Of the varieties commonly cultivated in Finland, Harbinger, King George V, Eigenheimer, Up-to-Date and Olympia were more susceptible to blight than Rosafolia, the losses being the greater the earlier the epidemic started. The opposite was true of the damage to crops of Frühnudel and Jaakko in relation to Rosafolia.

Table 16. Correlations between the date of outbreak of a blight epidemic and the relative yields (Rosafolia = 100) of the most important varieties in the trials at Tikkurila, Tammisto, Jokioinen, Pälkäne, Maaninka and Ylistaro.
Taulukko 16. Ruton alkamisajankohdan ja tärkeimpien lajikkeiden subteellisten satojen (Ruusulehti = 100) väliset korrelaatiot Tikkurilan, Tammiston, Jokioisten, Pälkäneen, Maaningan ja Ylistaron kokeissa.

Variety *Lajike*		Tikkurila		Tammisto		Jokioinen		Pälkäne		Maaninka		Ylistaro	
		Number of years *Koevuosia*	Correlation coefficient *Korrelaatiokerroin*	Number of years *Koevuosia*	Correlation coefficient *Korrelaatiokerroin*	Number of years *Koevuosia*	Correlation coefficient *Korrelaatiokerroin*	Number of years *Koevuosia*	Correlation coefficient *Korrelaatiokerroin*	Number of years *Koevuosia*	Correlation coefficient *Korrelaatiokerroin*	Number of years *Koevuosia*	Correlation coefficient *Korrelaatiokerroin*
Harbinger *Vesijärvi*	tuber yield *mukulasato*	—	—	—	—	—	—	9	0.51	12	0.64*	11	0.82**
»	starch yield *tärkkelyssato*	—	—	—	—	—	—	9	0.41	12	0.72**	11	0.78**
King Georg V *Kuningas Yrjö V*	tuber yield *mukulasato*	15	0.44	—	—	7	0.27	—	—	12	0.58*	10	0.06
»	starch yield *tärkkelyssato*	15	0.47	—	—	7	0.08	—	—	12	0.59*	10	0.76*
Eigenheimer	tuber yield *mukulasato*	—	—	10	0.23	8	0.83*	8	0.39	—	—	19	0.13
»	starch yield *tärkkelyssato*	—	—	10	0.61	8	0.75*	8	0.59	—	—	19	—0.09
Up-to-Date *Upto*	tuber yield *mukulasato*	—	—	11	0.33	—	—	—	—	17	0.44	—	—
»	starch yield *tärkkelyssato*	—	—	11	0.39	—	—	—	—	17	0.46	—	—
Olympia	tuber yield *mukulasato*	8	0.53	—	—	11	—0.33	13	0.26	—	—	10	0.68*
»	starch yield *tärkkelyssato*	8	0.47	—	—	11	—0.15	13	0.52	—	—	10	0.75**
Paul Wagner *Pauli*	tuber yield *mukulasato*	—	—	16	—0.17	—	—	7	0.80*	—	—	—	—
»	starch yield *tärkkelyssato*	—	—	16	—0.08	—	—	7	0.57	—	—	—	—
Sieglinde *Siikli*	tuber yield *mukulasato*	—	—	—	—	—	—	10	0.16	9	0.55	—	—
»	starch yield *tärkkelyssato*	—	—	—	—	—	—	10	0.18	9	0.53	—	—
Ostbote	tuber yield *mukulasato*	19	0.17	—	—	10	—0.12	21	0.32	9	—0.07	9	—0.07
»	starch yield *tärkkelyssato*	19	—0.17	—	—	10	0.01	21	0.63**	9	0.14	9	—0.07
Record *Rekord*	tuber yield *mukulasato*	—	—	—	—	8	0.69	11	—0.08	9	—0.18	—	—
»	starch yield *tärkkelyssato*	—	—	—	—	8	0.16	11	0.08	9	—0.40	—	—
Alpha *Alfa*	tuber yield *mukulasato*	13	0.38	—	—	—	—	16	—0.18	—	—	—	—
»	starch yield *tärkkelyssato*	13	0.17	—	—	—	—	16	—0.15	—	—	—	—
Aquila *Akvila*	tuber yield *mukulasato*	11	—0.31	—	—	8	0.19	—	—	—	—	—	—
»	starch yield *tärkkelyssato*	11	—0.41	—	—	8	—0.05	—	—	—	—	—	—
Frühnudel *Nuutti*	tuber yield *mukulasato*	—	—	—	—	10	0.01	—	—	—	—	11	—0.70*
»	starch yield *tärkkelyssato*	—	—	—	—	10	0.09	—	—	—	—	11	—0.70*
Jaakko	tuber yield *mukulasato*	9	0.17	—	—	9	—0.49	14	—0.75**	11	0.48	9	—0.56
»	starch yield *tärkkelyssato*	9	—0.10	—	—	9	—0.30	14	—0.44	11	0.37	9	—0.51

In other words, these varieties were the most resistant ones, in relation to their earliness, or relatively resistant. The other varieties in the table were approximately equal in resistance to Rosafolia; Paul Wagner and Sieglinde were perhaps slightly more susceptible and Aquila perhaps slightly more resistant.

In Fig. 11 an attempt has been made to depict the relative resistances as lucidly as possible, with the aid of regression analysis. Compared with the yields of Rosafolia and Ostbote, those of Jaakko were greater when the blight epidemic commenced early. From the data of Table 15, Jaakko appeared to be the most susceptible variety of the three, and Ostbote the most resistant to leaf blight. When resistance was measured in terms of yield, Jaakko was found to be the most resistant and Ostbote the most susceptible. Thus it is seen that earliness proved to be a more important trait than actual resistance to leaf blight.

Another striking example of the significance of earliness can be found in Table 17, which shows the yields of four varieties, Harbinger, Rosafolia, Eigenheimer and Ostbote, in different years at the Experimental Station at Ruukki. In the years with early frosts, Harbinger, an early variety, had understandably produced the highest yields and Ostbote, a late variety, the lowest yields. Also, in the blight years of 1938 and 1943, Harbinger was approximately equal in yield to the varieties Rosafolia and Eigenheimer, which were both more resistant to leaf blight, whereas Ostbote had no chance to manifest its blight resistance. In years favourable for late varieties Harbinger had fallen slightly behind Rosafolia and Eigenheimer. The four varieties were not all included in the trials in all the years for which the data were analysed.

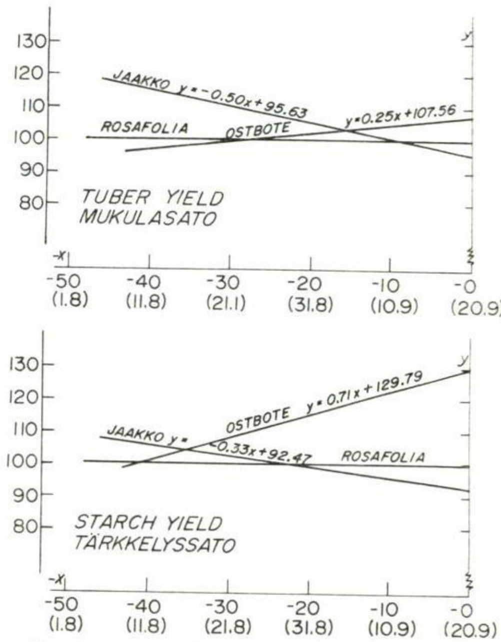


Fig. 11. Regressions between the relative tuber yield (upper graph) and relative starch yield (lower graph) (Rosafolia = 100) of Jaakko and Ostbote and the time of late blight outbreaks. The earlier the onset of the blight epidemic, the higher the yields of Jaakko relative to those of Rosafolia and Ostbote. Data from trials at Pälkäne.

Kuva 11. Jaakon ja Ostboten suhteellisten mukula- ja tärkkelyssatojen (Ruusulehti = 100) ja ruttoepidemian puhkeamisaikojen välinen regressio. Jaakko on voittanut Ruusulehteä ja Ostbotea sadoissa sitä enemmän mitä aikaisemmin ruttoepidemia on alkanut. Tulokset ovat Pälkäneen kokeista.

Discussion

The data presented are sufficiently ample to give a general idea of the incidence of leaf blight. Blight had occurred almost every year, particularly in southern Finland. The earliest epidemic outbreaks had been recorded at the end of July; usually outbreaks did not occur until the latter half of August even in the most susceptible varieties, and in Rosafolia the average date was about August 25. The results reveal that blight was more frequent in the south of Finland than in the north, where its occurrence was somewhat restricted by the greater frequency of frost. Blight epidemics as a rule started in southerly localities, and the impression was gained from the results that the disease spreads from south to north. Analogous observations have been made by Cox and Large (1960) in regard of the occurrence of blight in Great Britain and Sweden. The statement made by Rainio (1937) that blight first appears in the county of Vaasa (Ylistaro and Ruukki) and that Uusimaa (Tikkurila, Tammisto and Anttila) is infected last of all, has to be dismissed, in the light of the present study, as an erroneous inference drawn from inadequate evidence.

Table 17. Yields of Harbinger, Rosafolia, Eigenheimer and Ostbote in frost and blight years and in good potato years, at the Experimental Station of North-Ostrobothnia at Ruukki.

Taulukko 17. Vesijärven, Ruusulehden, Eigenheimerin ja Ostboten satotuloksia halla- ja ruttovuosilta sekä suotuisilta vuosilta Pohjois-Pohjanmaan koeasemalla Ruukissa.

	Yield — *Sato*, tn/ha			
	Harbinger *Vesijärvi*	Rosafolia *Ruusulehti*	Eigenheimer	Ostbote
Frost years — *Hallavuodet*				
1941	8.4	—	5.8	—
1942	25.8	14.6	16.2	8.6
1944	23.6	20.1	17.8	10.2
1950	31.2	27.7	32.2	—
Blight years — *Ruttovuodet*				
1938	26.0	29.6	29.4	—
1943	31.3	28.8	31.9	23.9
1953	—	47.7	48.3	—
1954	—	18.2	16.8	—
Good potato years — *Suotuisat vuodet*				
1946	35.9	40.1	37.6	—
1947	35.0	40.1	—	—
1949	39.3	36.9	41.6	—
1960	—	38.0	40.0	—

Rosafolia was about average in its level of resistance to leaf blight. When the areas under different varieties as reported by SAKSA (1955), are taken as a basis of comparison, the incidence of blight in Rosafolia can be said to correspond approximately to the incidence of blight in general.

Information on tuber blight is incomplete, and for reasons given earlier there have not been adequate data for statistical treatment. It follows that the drawing of inferences is risky. It is likely, however, that the importance of tuber blight was less than that of leaf blight. We can assume that the proportion of infected tubers averaged, about 5, and did not exceed 10 per cent.

The resistance of the varieties to leaf blight was measured by the differences from Rosafolia, which were then converted into scores. The results were fairly similar to those obtained by KOSKINEN 1932, WIRRI 1935, BRUMMER 1950, LINJA-AHO 1955, VARIS 1960, KÖYLIJÄRVI 1962, YLLÖ 1965, SEPPÄNEN 1967.

A more descriptive way of indicating the differences in resistance between the varieties would be to express them in days (cf. VARIS 1960, MÄKELÄ 1966). The haulms of Early Rose, Sieglinde and Harbinger were destroyed by blight on the average one week earlier than those of Rosafolia. Eigenheimer, Up-to-Date, Paul Wagner and Olympia did not differ from Rosafolia by more than a couple of days. Ostbote, Alpha, Frühnudel, Record and Aquila were more resistant by 5 to 10 days. Owing to the differences between epidemics and the meagre data, these differences were statistically significant in only a very few cases.

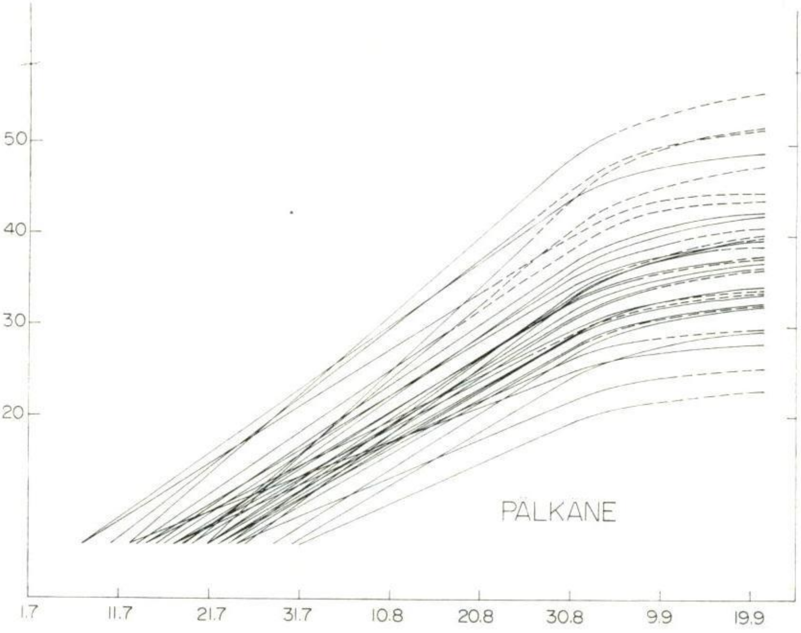
The best way to obtain reliable data on resistance to leaf blight and especially to tuber blight would be to carry out a series of trials with artificial infections.

Establishment of the relative resistance of the different varieties to leaf blight is especially important in Finland, because of the shortness of the growing season. This means that earliness is an important characteristic and also that it is often questionable whether chemical control is profitable. Although these preliminary results on relative resistance were only rough scores, they nevertheless deserve notice.

INFLUENCE OF BLIGHT ON YIELDS

Reduction of yield

It is by premature defoliation of the haulm that blight reduces the yield of potatoes. Attempts have been made to estimate the extent of this reduction and of its annual fluctuations by calculating, in the manner described above, the yield curve of each year, which reveals the actual yield and the potential yield (Fig. 12). By potential yield is meant the yield which would



— — — *yield loss caused by late blight — ruton aiheuttama satotappio*
x x x *yield loss caused by frost — hallan aiheuttama satotappio*

Fig. 12. Curves for yields of Rosafolia in the trials at Pälkäne and Maaninka. Solid lines indicate the actual yield and dotted lines the potential yield.
Kuva 12. Ruusulehden satokäyrät Pälkäneen ja Maaningan kokeissa. Yhtenäinen viiva osoittaa todellisen, katkoviiva potentiaalisen sadon.

Table 18. Yield losses due to curtailment of growing period caused by blight in the variety Rosafolia at some localities in 1931—1962.

Taulukko 18. Ruton aiheuttama kasvuajan lyhenemisestä johtuva satotappio Ruusulehti-lajikkeessa eräissä koepaikoissa v. 1931—62.

Locality *Koepaikka*	Number of years *Vuosien luku*	Period *Jakso*	Range of yield losses, *Satotappion vaihtelu*		Average yield losses, *Keskimääräinen satotappio*		Corrected value of losses *Tappion korjattu arvo*
			tn/ha	%	tn/ha	%	
Tikkurila	30	1931—62	0—19.6	0—40	3.8	8.9	8.6
Tammisto	15	1931—48	0— 8.7	0—24	1.3	3.6	7.4
Pälkäne	32	1931—62	0—14.5	0—33	3.0	7.1	7.1
Maaninka	16	1945—62	0—27.0	0—39	3.9	7.0	4.9
Ylistaro	30	1932—62	0—11.6	0—25	1.6	3.9	3.9

Table 19. Mean values of the actual and potential yields, and correlation coefficients between the time of cessation of growth and the tuber yield of Rosafolia.

Taulukko 19. Todellisten ja potentiaalisatojen keskiarvot sekä kasvun päättymisajan ja Ruusulehden mukulasadon väliset korrelaatiokertoimet.

Trial locality *Koepaikka*	Actual yield *Todellinen sato*		Potential yield *Potentiaalisato*		Correlation coefficient *Korrelaatio kerroin*
	Mean *keski-sato* tn/ha	S.D. *keski-hajonta*	Mean *keski-sato* tn/ha	S.D. *keski-hajonta*	
Tikkurila	32.0	7.47	35.8	9.23	—
Tammisto	34.0	8.65	35.3	8.68	2.21
Pälkäne	35.0	6.54	38.0	8.08	0.16
Maaninka	40.1	5.34	43.5	9.53	—0.25
Ylistaro	31.5	6.80	34.6	7.38	—0.11

probably have been attained if no blight had occurred. The yield loss is, of course, the difference between the potential and actual yields.

The yield loss caused by blight could be calculated from the yields of Rosafolia at five trial localities (Table 18). The loss was greatest at Tikkurila, where it averaged about 9 %, with a range from 0 to 40 %, and lowest at Ylistaro, where it averaged about 4 %, with a range from 0 to 25 %. The corrected figures for losses are presented in the last column of Table 18. The correction applied eliminates the influence of the period from which the yield results were recorded; it thus serves to render the results from the different localities mutually comparable. The correction had no notable influence except at Tammisto and Maaninka. As regards individual years, the greatest losses were incurred in 1953 and 1961. The loss in the former year varied from 9 to 20 tons per hectare and in the latter year from 6 to 27 tons per hectare; the corresponding percentages were 20—40 % and 11—39 %, respectively. Among the other years specific mention may be made of 1934 (losses 3—18 %), 1942 (1—24 %), 1943 (2—31 %), 1954 (4—29 %), 1960 (11—34 %), and 1962 (0—30 %). Moreover, it has to be noted that in the years 1934, 1938 and 1961 blight was more destructive in the northerly trial localities, and in the years 1942, 1943, 1945, 1953, 1960 and 1962 in the southerly localities.

Blight as a yield equalizer

In the preceding section the great importance of blight as a yield-reducing factor was noted. Since the earliness of the crop has a decisive influence on the yield, it is important to know the extent to which blight contributes to the yield variations. To find the answer to this question two approaches were adopted: firstly, the dispersion of the values calculated for the yield losses was studied; secondly, the correlations between the yield and the time of termination of growth were calculated. The results are presented in Table 19. It is seen that according to the first mode of calculation, blight tended to equalize the yields rather than add to their variation, although there is not a sufficient basis for generalizations. There is no correlation between the yield and the time of cessation of growth.

Discussion

The influence of blight on tuber yields could only be considered in the light of the results of five trial localities. However, the uniformity of the results indicates that they are fairly reliable, although they are considered to give a conservative rather than an exaggerated estimate of the magnitude of the losses. It goes without saying that the results for individual years have to be taken with great reserve, but they are believed to demonstrate fairly reliably the order of magnitude of the losses incurred in each instance. Moreover, it should be noted that the calculated losses produce a picture which shows strong similarities to the findings concerning the prevalence of blight. The picture is merely supplemented by taking into account the influence of the earliness of the individual crops. Furthermore, the results obtained for Rosafolia can be considered to give a fairly representative idea of the importance of blight in Finnish potato growing as a whole. By and large, our crops seem to have been more susceptible to blight than Rosafolia during the first half of the period under consideration, while in the latter half they seem to have been more resistant, when all our varieties and the areas in which they are cultivated are considered.

The yield losses in individual years varied greatly. In five trial localities, the highest losses varied from 24 to 40 %. For the southerly trial localities the worst blight year was 1953, and for the northerly localities 1961. In general, however, the losses in the different localities were of roughly the same order in a given year. In the years with the highest yield losses (tons/ha), the actual yields were above the average besides a few exceptional cases. In fact, the greatest losses occurred in years in which losses could be afforded.

If late development of the crops and an early, severe blight epidemic were to coincide in any given year, a general crop failure would be likely. In such a case the percentage yield loss would be very high, even though, on a weight basis, it might remain much less than in a so-called good year. Indeed, the worst blight year is one in which the average yield of a given area is low, irrespective on whether the loss is measured in tons per hectare or as a percentage. A typical example was the year 1954, particularly in northern Finland. Owing to the late development of the crops, this year, in fact, was one of the very worst blight years.

The average yield loss percentages due to leaf blight are mean values of the annual loss figures, for which reason they differ from the average loss expressed in tons. The average losses never exceeded 10 % at any trial locality. The differences between different localities are not great in percentage units, but the losses at Maaninka and Ylistaro were only half of those at Tikkurila. At Ruukki the corresponding losses appear to have been only one or two per cent, and at Apukka quite negligible. If the yield losses of the whole country are estimated from these results, they will probably be between 5 and 10 %. If these losses are added to the losses caused by tuber blight, the average losses caused by late blight can be estimated at 10—15 %. Considering the average yield per hectare in Finland, this implies an average loss of about 2 tons per year and per hectare.

Comparison of the results obtained in the yield loss calculation with the estimates presented by Rainio (1937) reveals that the average losses are hardly as great as he assumed, although the results relating to the worst blight years do not differ much.

The comparison is greatly hampered by the fact that in Rainio's study the data for all varieties were combined, and the losses due to tuber blight was not considered separately. The average increase in yield obtained by YLIMÄKI (1960) in the chemical control of blight during the 1950s was 13.2 %. This is somewhat higher than the figures for losses found here, but the varieties used in his spraying trials were more susceptible to blight than Rosafolia.

The uniformity of the yields was hardly influenced by blight. The results from Maaninka suggest that blight is a factor tending to equalize the yields of different years, while the results from the other localities afford no evidence either in favour of or against this contention.

SUMMARY

The present paper is a statistical study of the influence of weather conditions on the yields of potatoes, and of the occurrence of late blight and its effect on the yields of potatoes in Finland. The study is based on potato variety trials carried out in 1931—62. The following conclusions were reached.

The tuber yield was most strongly dependent on the earliness of the crop. The earlier the plants reached the flowering stage, the greater was the yield. The first important factor was an early, warm spring, which created favourable conditions for early planting. Warm spring months were usually succeeded by higher than normal temperatures in June, and the development of the plants to the flowering stage was accelerated. Of the weather factors during the growing season, the effective illumination after the onset of flowering was the most important. Its significance depends on the fact that if the crop reaches the flowering stage — the stage at which incremental growth of the tubers starts — at a comparatively early date, plant has at its disposal twice as much light for augmentation of its tuber yield as a crop that is very late in development.

The starch content was most strongly dependent on the effective temperature sum and rainfall after the onset of flowering. The starch content was positively correlated with the former and negatively correlated with the latter.

The starch yield displayed a stronger correlation with tuber yield than with starch content. It was, therefore, mainly affected by the same factors as the tuber yield. The effect of a warm late summer in increasing the starch content was also reflected in figures for the starch yield.

Leaf blight occurred nearly every year, in four out of five on the average. In southern Finland one year in three was a severe blight year, i.e. the blight epidemic had started by August 20 and destroyed most of the haulm in 2—3 weeks, or a year in which a severe outbreak started before September 1 and tuber development was delayed. Further north, at latitude 63°N, the importance of leaf blight was considerably reduced, primarily owing to the more frequent occurrence of frost and of weather conditions less favourable to blight. At this latitude frost and blight were of approximately equal significance. In northern Finland and Lapland blight was only occasionally of any importance whereas frost occurred in these localities almost every year.

Tuber blight was encountered less often, and appeared to be of less importance than leaf blight. In certain years the tuber infection of the most susceptible varieties was almost total, especially on clay soils. The average proportion of tubers infected with blight was less than 5 %. One year in three, on the average, was a severe blight year, with more than 10 % of infected tubers. Frost was of importance as an agent destroying the haulm and thus restricting the incidence of tuber blight.

The values obtained for the resistance of varieties differed somewhat from previous estimates. In particular, the old second

early, maincrop and late varieties were found to have poor resistance to leaf and tuber blight.

A study of the relative resistance of the varieties to leaf blight revealed that there were few varieties whose resistance to this disease was sufficient to compensate for a longer growing time they required. Earliness may, at least in part, have compensated for poor resistance to blight.

The influence of blight on the yield figures varied greatly. In the worst years the lowering of tuber yield due to premature defoliation amounted to more than 20 tons per hectare (40 %) at some of the trial localities. However, at all localities the average yield losses were below 10 %. The magnitude of the losses decreased from south to north. At the northernmost localities they were negligible. The proportion of blight-damaged tubers was thought to average less than 5 % of the total yield. The average yield losses due to blight, including tuber blight, were estimated at 10—15 %.

Blight was found not to contribute to the annual variations in the yields. The worst blight years were those in which the combined effect of blight and late development of the crop reduced the yield to a level remarkably below the average.

Blight affected the quality of the tubers not only by damaging the tubers, but also by lowering the starch content and increasing the proportion of small tubers.

REFERENCES

Anttinen, O. 1963. Perunan lajikekokeet Pohjois-Pohjanmaan koeasemalla. Summary: Variety trials on potatoes. Maatal. ja Koetoim. 17: 127—137.

— Köylijärvi, J. 1961. Pohjois-Pohjanmaan koeaseman tuloksia rehunauriin viljelystä. Summary: Results of experiments with fodder turnip at the North Ostrobothnia agricultural experiment station. Rep. Finn. State Agric. Res. Board 186: 1—30.

Baerug, R. 1965. Nitrogen og kalium till tidligpoteter. Forsk. og Forsøk i Landbr. 16: 277—290.

Borah, M. N., Burt, R. L., Headford, D. W. R., Milthorpe, F. L. & Sadler, E. M. 1960. Growth of the potato plant. Ann. Appl. Biol. 48: 433—434.

Brummer, V. 1961. Sokerijuurikkaan hehtaarisatojen ja säätekijöiden välisestä yhteydestä Suomessa. Summary: On the relations between sugar beet yields and certain climatic factors in Finland. Acta Agr. Fenn. 98: 1—180.

Carlsson, H. 1964. Utvecklingsförlopp och tillväxt hos potatis under vegetationsperioden. Lantbr. Högsk. Medd. (A) 1964, 23: 1—70.

Christie, W. 1910. Forsøk med forskjellig saettetid for poteter 1906—1910. Ber. om Hedemarkens Amts Fors.sta. Virks. i 1910: 5—19. (Ref. Frogner, S. 1964 b).

Cox, A. E. & Large, E. C. 1960. Potato blight epidemics throughout the world. Agriculture Handbook 174. Washington, D.C. 230 p.

Dyke, G. V. 1956. The effect of date of planting on the yield of potatoes. J. Agr. Sci. 47: 122—128.

Frogner, S. 1964 a. Potetforsøk på Opplandene 1945—62. Forskn. og Forsøk i Landbr. 15: 311—339.

— 1964 b. Vaerlagets inflytelse på potetenes avkastning. Ibid 15: 227—237.

Grotenfelt, G. 1910. Perunarutto ja sen esiintyminen Suomessa. Maahenki II: 484—492.

Hallgren, G. 1947. The influence of precipitation on crop yield. Kungl. Lantbr.högsk. Ann. 14: 173—289.

Helimäki, U. I. 1967. Tables and maps of precipitation in Finland during 1931—60. Supplement Meteorol. Yearb. Finl. 66,2: 1—22.

Jamalainen, E. A. 1933. Perunaruton esiintymisestä ja torjuntatoimenpiteistä maassamme. Suom. Kasvinsuoj. seur. Julk. 2: 6—10.

Johansson, O. V. 1922. Sambandet mellan väderlek och årväxt i Finland. Första Periodiska Forskarmöte III: 102—115.

Keränen, J. 1925. On the dependence of the harvest upon the temperature in the foregoing winter and May. Valt. Meteorol. Keskusl. Toim. 15: 1—8.

— 1931 a. Kasvukauden säiden ja vuodentulon keskinäisestä riippuvaisuudesta maassamme vuosina 1921—28. Tal. Neuvottelukunnan Julk. 13: 1—38.

— 1931 b. Vuodentulon riippuvaisuudesta kasvukauden lämpö- ja sadeoloista Suomen eri lääneissä. Acta Agr. Fenn. 23: 1—32.

Kolkki, O. 1966. Tables and maps of temperature in Finland during 1931—60. Supplement Meteorol. Yearb. Finl. 65, 1 a: 1—42.

— 1969. Katsaus Suomen ilmastoon. Ilmatiet. Lait. Tied. 18: 1—64.

KOSKINEN, Y. K. 1932. Perunan laatukokeiden tuloksia vuosilta 1920—1930. Valt. Maatal.koetoim. Julk. 44: 1—121.

KÖYLIJÄRVI, J. 1962. Perunalajikkeet Lounais-Suomessa. Summary: Potato varieties in southwest Finland. Maatal. ja Koetoim. 16: 56—67.

LARGE, E. C. 1952. The interpretation of progress curves for potato blight and other plant diseases. Pl. Path. 1: 109—117.

LAURILA, K. & ANTILA, S. 1956. Perunan mukulain kuiva-ainepitoisuuden vaihtelusta. Referat: Über Schwankungen im Trockensubstanzgehalt der Kartoffelknollen. J. Sci. Agric. Soc. Finl. 28: 179—187.

LINJA-AHO, M. 1955. Peruna. Summary: Potato. Siemenjulkaisu 1955: 52—68.

LUNELUND, H. 1941. In Finnland eingestrahlte Lichtmengen. Soc. Sci. Fenn. Comm. Phys. Mat. 11,3: 1—15.

— 1943. Über Klimafaktoren und Ernteerträge in Finnland. Ibid. 12,10: 1—48.

LÄHDE, V. 1944. Perunan istutusajasta. Valt. Maatal. koetoim. Tied. 199: 1—13.

MURPHY, P. A. 1939. A study of the seasonal development of the potato in relation to blight attack and spraying. Sci. Proc. R. Dublin Soc. (N.S.) 22: 69—82.

MÄKELÄ, K. 1966. Factors influencing the epidemics of *Phytophthora infestans* (Mont.) de Bary in Finland. Acta Agr. Fenn. 104,2: 1—100.

NEENAN, M. 1965. Effect of premature haulm destruction on yield, tuber size and dry matter content of potatoes. Irish J. Agric. Res. 4: 67—80.

PESSI, Y. 1957. On the influence of the time of sowing upon the crop yields of spring cereals. Rep. Finn. State Agric. Res. Board 156: 1—38.

— 1958. Hallojen esiintymisestä ja niiden aiheuttamista vahingoista Suomessa. Acta Agr. Fenn. 93,3: 1—44.

RAINIO, A. 1937. Perunaruton aiheuttamat tuhot Suomessa ja sen esiintymiseen vaikuttavista tekijöistä. Referat: Die durch den Kartoffelschimmel verursachten Schäden in Finnland und über die auf sein Auftreten einwirkender Faktoren. Staatl. Landw.-schaftl. Vers.tät. Veröff. 95: 1—47.

RYYNÄNEN, A. 1958. Kevätviljojen kylvöajoista kokeiden valossa. Koetoim. ja Käyt. 15: 9.

SAKSA, P. J. 1955. Maamme perunalajikkeiden viljelylaajuus ja viljelyalueet. J. Sci. Agric. Soc. Finl. 27: 41—52.

SALOHEIMO, H. 1936. Perunan istutusajasta. Suom. Suovilj.yhd. Vuosik. 39: 157—170.

SALONEN, T. 1962. Perunan viljelyopas. Kasvinsuoj. seur. Julk. 26: 1—55.

SCHOLTE UBING, D. W. 1958. De invloed van de watervoorziening en de totale instraling op de opbrengst van aardappelen. Landbouwk. Tijdschr. 70: 453—464.

SEPPÄNEN, E. 1967. Perunalajikkeidemme rutonkestävyys. Summary: Resistance of potato varieties to late blight. Maatal. ja Koetoim. 21: 116—120.

SIMOJOKI, P. 1961. Perunan istutusaika. Koetoim. ja Käyt. 18: 14.

— 1963. Kasvitaudeista Pohjois-Pohjanmaalla. Summary: On plant diseases in North Ostrobothnia. Maatal. ja Koetoim. 17: 218—222.

SIMOLA, E. F. 1926. Maanlaatujen ja kosteussuhteiden vaikutuksesta eräiden viljelyskasvien morfologisiin ominaisuuksiin, satoihin ja veden kulutukseen. Referat: Über den Einfluss den Bodenart und der Feuchtigkeitsverhältnisse des Bodens auf die morphologischen Eigenschaften, Ernteerträge und den Wasserverbrauch gewisser Kulturpflanzen. Valt. Maatal.koetoim. Julk. 2: 1—15.

THORNE, G. N. 1960. Variations with age in net assimilation rate and other growth attributes of sugar beet, potato, and barley in a controlled environment. Ann. Bot. 24: 356—371.

TÄHTINEN, H. 1960. Sokerijuurikkaanviljelystä Salon Sokeritehtaan alueella ja satotasoon vaikuttavista seikoista v. 1957 suoritetun tilastotutkimuksen valossa. Sason Uutiset 2: 2—4.

— 1962. Säätekijät ja perunasato. Mimeogr. 105 p. [Available at Maanviljelyskemian ja -fysiikan laitos, Viikki.]

UMAERUS, M. 1970. Influence of environmental conditions on potatoes with special reference to plant breeding under Swedish conditions. Acta Acad. Reg. Sci. Upps. 13: 1—196.

WATSON, D. J. 1947. Comparative physiological studies on the growth of field crops. I. Ann. Bot. 2: 41—76.

VARIS, E. 1960. Peruna. Summary: Potatoes. Siemenjulkaisu 1960: 67—85.

— 1970. Variation in the quality of table potato and the factors influencing it in Finland. Acta Agr. Fenn. 118,3: 1—99.

VIK, K. 1914. Veirlagets betydning for potetdyrkning. 24:e Aarsber. Norges Lantbr.høisk. Akervekstfors. 1914: 11—40.

— 1915. 5 aars forsøk med forskjellig saettetid for potetes. 26:e Aarsber. Ibid. 1915: 12—25.

WIRRI, T. J. 1935. Satakunnan kasvinviljelykoeasemalla suoritettujen perunan laatukokeiden tuloksia vv. 1930—34. (Summary.) Rep. Finn. State Agric. Res. Board 100: 1—11.

YLIMÄKI, A. 1960. Perunaruton kemiallinen torjunta. Summary: Chemical control of potato blight. Maatal. ja Koetoim. 14: 234—242.

YLLÖ, L. 1963 a. Einfluss von Temperatur und Niederschlag auf Knollenertrag und Stärkegehalt bei Kartoffeln. Ann. Agric. Fenn. 2: 59—72.

— 1963 b. Perunan lajikekokeiden tuloksia Kasvinviljelylaitoksella Tikkurilassa v. 1931—58. Summary: Results

of variety trials on potato at the Department of Plant Husbandry in Tikkurila, 1931—58. Ibid. 2: 109—133.
— 1964. Einfluss von Temperatur und Niederschlag auf den Kartoffelertrag von Sortenversuchen in Finnland. Ibid. 3: 256—264.
— 1965. Perunan lajikekokeiden tuloksia Maatalouden tutkimuskeskuksen laitoksilla ja koeasemilla vuosina 1931—63. Summary: Results of potato variety trials at the departments and experiment stations of the Agricultural Research Centre in 1931—63. Ibid. 4: 59—90.

SELOSTUS

Sääolojen ja perunaruton vaikutus perunasatoihin Suomessa 1931—62

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Tutkimus perustuu koelaitoksillamme ja -asemillamme (kuva 1) v. 1931—62 järjestettyjen perunan lajikekokeiden tuloksiin ja koekasvustoista tehtyihin havaintoihin. Aikaisempien kokeiden poisjättäminen on johtunut siitä, että v. 1928 kauppaan tullut saksalainen lajike Ruusulehti otettiin melkein kaikkiin lajikekokeisiin jo 1930-luvun alussa ja myöhemmin verrannelajikkeeksi. Sen tuolloin alkanut koesarja muodostaa yhtenäisen rungon sekä ruton esiintymisen selvittämistä että lajikkeiden keskeistä vertailua varten; melko aikaisena ja lehtirutolle kohtalaisen alttiina lajikkeena Ruusulehti on erinomainen vertailuperusta sekä eri vuosia että eri lajikkeita verrattaessa.

Sääolojen vaikutus perunan satoihin

Mukulasato riippuu eniten kasvuston kehityksen aikaisuudesta. Mitä aikaisemmin kasvusto saavuttaa kukinta-asteen, sitä runsaammaksi sato muodostuu. Ensimmäinen tärkeä tekijä on aikainen, lämmin kevät, joka luo edellytykset aikaiselle istutukselle. Lämpimiä kevätkuukausia seuraa yleensä keskimääräistä lämpimämpi kesäkuu, mikä nopeuttaa kasvuston kehittymistä kukinta-asteelle. Kasvukauden aikaisista säätekijöistä osoittautui tärkeimmäksi kukinnan alkamista seuranneen ajan tehoisa valomäärä. Sen merkitys perustuu siihen, että kasvuston saavuttaessa suhteellisen aikaisessa vaiheessa kukinta-asteen, jolloin mukuloiden lisäkasvu on alkanut, sillä on käytettävissään lähes kaksi kertaa se valomäärä, minkä myöhään kehittyvä kasvusto voi mukulasadon kartuttamiseksi saada.

Tärkkelyspitoisuuteen vaikuttivat eniten kukinnan alkamista seuranneen ajan tehoisa lämpötilasumma ja sademäärä. Edellisen suuretessa tärkkelyspitoisuus kohosi ja jälkimmäisen lisääntyessä se aleni.

Tärkkelyssato oli korreloitunut vahvemmin mukulasadon kuin tärkkelyspitoisuuden kanssa. Näin ollen se on pääasiallisesti riippuvainen samoista tekijöistä kuin mukulasatokin. Lämpimän syyskesän tärkkelyspitoisuutta kohottava vaikutus heijastui myös tärkkelyssadoissa.

Ruton esiintyminen

Lehtiruttoa esiintyy Etelä-Suomessa lähes joka vuosi, ainakin neljänä vuotena viidestä. Pahoja ruttovuosia on keskimäärin joka kolmas vuosi. Sellaisiksi on katsottu vuodet, joina ruttoepidemia alkaa 20. 8. mennessä ja leviää 2—3 viikossa läpi kasvuston, sekä sellaiset vuodet, joina ankara epidemia alkaa ennen 1. 9. ja jolloin perunan kehitys on normaalia myöhemmässä. Maaningan ja Ylistaron korkeudella lehtiruton merkitys on jo huomattavasti vähäisempi. Tämä johtuu ennen kaikkea hallan yleisemmästä esiintymisestä, mutta osittain myös rutolle epäedullisemmista sääoloista. Ruton ja hallan merkitys on tällä korkeudella suunnilleen yhtä suuri. Ruukissa ja Apukassa on ruton mainittava esiintyminen ollut sattumanvaraista, mutta halla on ollut melkein jokavuotinen vieras.

Mukularuttoa esiintyy harvemmin ja sen merkitys näyttää vähäisemmältä kuin lehtiruton, mutta joinakin vuosina — etenkin savimailla — se voi turmella altteimpien lajikkeiden sadon jopa lähes kokonaan. Keskimäärin lienee ruton turmelemien mukuloiden osuus sadosta vähemmän kuin 5 %, ja pahoja ruttovuosia — alttiissa lajikkeissa ruttoisia vähintään 10 % — enintään joka kolmas vuosi. Syyshallojen merkitys varsiston hävittäjänä ja siten mukularuton esiintymisen rajoittajana on huomattava.

Lajikkeiden kestävyys

Lajikkeiden kestävyys poikkeaa jossakin määrin aikaisemmin esitetyistä tiedoista. Etenkin vanhojen, melko myöhäisten lajikkeiden sekä lehti- että mukularuton kestävyys osoittautui verraten heikoksi.

Lajikkeiden suhteellisen rutonkestävyyden tutkiminen osoitti, että vain harvojen lajikkeiden lehtirutonkestävyys vastaa niiden vaatimaa pitempää kasvuaikaa. Aikaisuus voi ainakin osittain korvata heikon rutonkestävyyden.

Ruton vaikutus satoihin

Ruton vaikutus sadon määrään oli hyvin vaihteleva. Pahimpina vuosina lehdistön ennenaikaisesta tuhoutumisesta johtuva mukulasadon aleneminen oli joissakin koepaikoissa yli 20 tn/ha eli 40 %. Keskimääräinen satotappio jäi kuitenkin kaikissa koepaikoissa alle 10 %:n. Tappion suuruus pieneni etelästä pohjoiseen, pohjoisimmissa koepaikoissa tappio oli merkityksetön. — Ruton vioittamien mukuloiden osuus sadosta lienee keskimäärin alle viiden prosentin. Tulosten perusteella voidaan ruton aiheuttama satotappio arvioida keskimäärin 10—15 prosentiksi, mihin sisältyy myös mukularutto.

Ruton ei todettu vaikuttavan satojen vuosivaihteluun. Pahimpina ruttovuosina on pidettävä vuosia, jolloin perunan myöhäisen kehityksen ja ruton yhteisvaikutuksen vuoksi sato jää mainittavasti alle maan keskisadon.

Sadon laatuun rutto vaikuttaa — paitsi mukuloita turmelemalla — tärkkelyspitoisuutta alentavasti ja pienten mukuloiden osuutta lisäävästi.

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Appendix 1. Monthly mean temperatures (°C) and sums of rainfall (mm) during the growing season at different trial localities. (Data of 1931—60).

Liite 1. Kasvukauden lämpötilan ja sademäärän kuukausikeskiarvot eri koepaikoissa v. 1931—60.

Trial locality *Koepaikka*	Temperature *Lämpötila*					Rainfall *Sademäärä*				
	V	VI	VII	VIII	IX	V	VI	VII	VIII	IX
Tammisto	9.0	14.0	16.8	15.2	10.2	37	46	69	70	65
Tikkurila	9.3	14.3	17.0	15.4	10.4	40	48	73	75	69
Piikkiö	9.2	14.0	17.3	15.9	11.0	29	43	63	76	64
Jokioinen	8.8	13.5	16.4	14.7	9.8	39	42	70	74	61
Peipohja	8.7	13.6	16.6	14.8	9.9	31	45	69	72	51
Pälkäne	8.8	13.9	17.0	15.3	10.4	40	48	66	71	54
Mikkeli	8.6	13.9	16.7	14.6	9.4	40	57	69	73	61
Tohmajärvi	7.7	13.4	16.1	13.9	8.6	39	57	74	74	66
Ylistaro	8.3	13.5	16.6	14.4	9.3	30	56	71	68	56
Maaninka	7.7	13.7	16.7	14.8	9.4	35	56	67	65	58
Ruukki	7.3	12.8	16.2	14.0	8.4	32	57	71	71	57
Apukka	5.7	12.0	15.1	13.0	7.3	33	55	67	74	54

Appendix 2. Incidence of tuber blight in Anttila, 1957—62.

Liite 2. Mukularuton esiintyminen Anttilassa v. 1957—62.

Variety *Lajike*	Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*				
	1957	1958	1960	1961	1962
Rosafolia — *Ruusulehti*	0	0	0	0	0
Alpha — *Alfa*	1.2	4.0	—	—	—
Tammiston aikainen	22.5	3.2	—	—	—
Up-to-Date — *Upto*	3.0	8.2	—	—	—
Frühnudel — *Nuutti*	6.1	6.5	0	1.4	—
Record — *Rekord*	1.0	0	0	7.0	—
Sientje	8.9	3.4	4.7	10.4	—
Aquila — *Akvila*	1.6	25.1	0	0	1.1
Eigenheimer	8.2	0	5.4	1.8	14.3
Jaakko	6.3	3.6	4.6	0	7.3
Olympia	4.9	0	2.3	14.6	2.3
Ostbote	2.2	15.9	0.7	1.2	0.9
Sieglinde — *Siikli*	9.2	2.4	5.7	6.4	1.3

Appendix 3. Incidence of tuber blight in the variety trials at Jokioinen, 1942—62.

Liite 3. Tiedot mukularuton esiintymisestä kasvinjalostuslaitoksen lajikekokeissa Jokioisissa v. 1942—62.

Variety *Lajike*	Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*						
	1943	1950	1953	1954	1957	1960	1961
Rosafolia — *Ruusulehti*	9.2	0	1.0	1.0	1.7	1.0	2.4
King George V — *Kuningas Yrjö V*	37.2	1.5	19.0	5.0	2.3	14.0	11.1
Eigenheimer	67.6	—	20.0	35.0	5.4	22.0	34.5
Ostbote	28.9	—	11.0	7.0	0	4.0	0.5
Jaakko	—	0	20.0	8.0	1.0	11.0	14.4
Olympia	—	0.8	19.0	8.0	15.9	11.0	2.1
Frühnudel — *Nuutti*	—	—	18.0	2.0	5.0	16.0	—
Aquila — *Akvila*	—	—	8.0	6.0	2.0	18.0	0.8
Koto	—	—	19.0	9.0	0	8.0	13.4
Record — *Rekord*	—	—	13.0	7.0	0.8	1.0	6.2
Bintje	—	—	21.0	44.0	—	57.0	34.3
Sieglinde — *Siikli*	—	—	13.0	17.0	—	—	2.8
Alpha — *Alfa*	—	—	11.0	—	—	12.0	2.2

Appendix 4. Incidence of tuber blight in the variety trials at Tikkurila, 1931—62. S = clay soil, Hk = sandy soil.
Liite 4. Mukularuton esiintyminen lajikekokeissa Tikkurilassa v. 1931—62. S = savimaa, Hk = hiekkamaa.

Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*

Variety *Lajike*	1934 S	1936 S	1937 S	1938 S	1939 S	1942 S	1942 Hk	1943 S
Rosafolia — *Ruusulehti*	0.7	1.9	0	0	0	0	0	1.8
Up-to-Date — *Upto*	36.5	—	—	—	—	—	—	—
Harbinger — *Vesijärvi*	15.4	31.3	—	—	—	—	—	—
King George V — *Kuningas Yrjö V*	4.7	1.3	0.6	0.5	2.6	4.4	0.7	10.0
Ben Lomond	—	12.7	13.6	1.4	20.4	—	—	—
Eigenheimer	—	18.7	33.0	—	—	—	10.0	—
Paul Wagner — *Pauli*	—	13.7	—	—	—	—	0.5	—
Goldwährung	—	—	2.5	1.2	—	—	—	—
Ostbote	—	—	0.9	0.2	0	2.9	2.0	13.3
Alpha — *Alfa*	—	—	—	—	—	—	—	4.6
Olympia	—	—	—	—	—	—	—	—
Aquila — *Akvila*	—	—	—	—	—	—	—	—
Jaakko	—	—	—	—	—	—	—	—
Koto	—	—	—	—	—	—	—	—
Amyla	—	—	—	—	—	—	—	—
Barima	—	—	—	—	—	—	—	—

Variety *Lajike*	1943 Hk	1944 S	1944 Hk	1945 S	1945 Hk	1946 S	1946 Hk	1953 S	1954 S	1961 S	1962 S
Rosafolia — *Ruusulehti*	0.2	0.1	0	0.1	0	0	0	0.8	0	2.0	4.0
Up-to-Date — *Upto*	—	—	—	—	6.8	—	—	—	—	—	—
Harbinger — *Vesijärvi*	—	—	—	—	8.7	—	—	—	—	—	—
King George V — *Kuningas Yrjö V*	0.8	8.0	2.0	3.9	0.3	0	5.3	—	—	—	—
Ben Lomond	5.5	—	—	—	—	—	—	—	—	—	—
Eigenheimer	3.7	—	—	—	15.0	—	—	—	—	—	—
Paul Wagner — *Pauli*	1.1	—	—	3.6	4.0	6.7	—	—	—	—	—
Goldwährung	—	34.9	16.0	—	11.4	—	15.7	—	—	—	—
Ostbote	—	5.0	5.0	6.1	0.4	0	0.5	2.1	0.6	—	—
Alpha — *Alfa*	—	17.0	6.0	2.4	0.1	0.7	3.2	6.8	2.7	—	—
Olympia	—	—	—	1.4	0.1	0	0	3.8	2.3	—	—
Aquila — *Akvila*	—	—	—	0.3	0	1.5	0	0.7	0	5.0	—
Jaakko	—	—	—	—	—	—	—	14.3	26.4	34.0	53.0
Koto	—	—	—	—	—	—	—	—	9.4	20.0	23.0
Amyla	—	—	—	—	—	—	—	—	—	7.0	13.0
Barima	—	—	—	—	—	—	—	—	—	44.0	78.0

Appendix 5. Incidende of tuber blight in the variety trials at Piikkiö, 1932—55. S = clay soil, Hk = sandy soil.
Liite 5. Mukularuton esiintyminen lajikekokeissa Piikkiössä v. 1932—55. S = savimaa, Hk = hiekkamaa

Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*

Variety *Lajike*	1932 S	1932 Hk	1933 Hk	1934 S	1934 Hk	1935 S	1935 Hk	1936 S	1936 Hk
Rosafolia — *Ruusulehti*	—	—	—	0	—	0	—	0.5	0.5
Magnum bonum	12.0	—	—	15.7	—	—	—	—	—
Up-to-Date — *Upto*	26.1	8.7	0	9.7	27.8	1.8	0	29.9	—
Deodara	3.8	—	—	2.7	—	1.2	—	3.7	—
Eldorado	1.0	—	—	0.9	—	5.3	—	2.8	—
Pepo	9.9	1.6	0	—	7.9	1.6	0.9	5.0	—
Harbinger — *Vesijärvi*	6.4	2.9	1.2	10.9	11.1	1.9	2.1	—	12.7
Early Puritan — *Puritaani*	—	5.5	2.5	—	6.4	—	1.5	—	—
Early Rose — *Aikainen ruusu*	—	12.3	1.4	—	—	—	—	—	—
Tammiston aikainen	—	1.5	1.7	—	2.4	—	2.8	—	10.3
Eigenheimer	—	—	0	—	15.6	—	3.5	22.7	21.0
King George V — *Kuningas Yrjö V*	—	—	—	—	—	—	—	7.9	—
Ostbote	—	—	—	—	—	—	—	—	—
Sieglinde — *Siikli*	—	—	—	—	—	—	—	—	—
Jaakko	—	—	—	—	—	—	—	—	—
Bintje	—	—	—	—	—	—	—	—	—

Variety *Lajike*	1937 S	1937 Hk	1938 S	1938 Hk	1939 Hk	1942 Hk	1943 Hk	1944 Hk	1945 Hk	1946 Hk	1949 Hk	1952 Hk	1953 Hk	1954 Hk
Rosafolia — *Ruusulehti*	0.9	1.7	0	0	0	0	0.2	0.3	1.2	0	0	0	0.3	0
Magnum bonum	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Up-to-Date — *Upto*	36.3	—	—	—	—	—	—	—	—	—	—	—	—	—
Deodara	12.9	—	1.9	—	1.0	0	3.1	7.1	8.5	—	—	—	—	—
Eldorado	6.2	—	0	—	0.9	0	5.1	0.9	2.5	—	—	—	—	—
Pepo	22.5	—	1.7	—	1.0	0	1.3	4.1	18.8	—	—	—	—	—
Harbinger — *Vesijärvi*	—	6.9	—	—	—	—	—	—	—	—	—	—	—	—
Early Puritan — *Puritaani*	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Early Rose — *Aikainen ruusu*	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Tammiston aikainen	—	2.0	—	3.9	2.3	0	10.6	2.7	11.3	5.8	1.2	1.4	37.4	—
Eigenheimer	63.1	9.6	—	—	—	—	—	—	—	—	—	—	—	—
King George V — *Kuningas Yrjö V*	12.4	—	4.2	—	0.6	0.5	3.8	3.6	—	—	—	—	—	—
Ostbote	—	1.5	0.8	—	3.1	0.5	3.1	1.2	2.5	—	—	—	—	—
Sieglinde — *Siikli*	—	—	—	—	—	—	—	—	3.1	3.9	0	0.2	4.7	3.2
Jaakko	—	—	—	—	—	—	—	—	—	—	0	0.6	12.5	14.4
Bintje	—	—	—	—	—	—	—	—	—	—	—	—	41.8	37.3

Appendix 6. Incidence of tuber blight in the variety trials at Mikkeli, 1932—62.
Liite 6. Mukularuton esiintyminen perunan lajikekokeissa Mikkelissä v. 1932—62.

Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*

Variety *Lajike*	1932	1933	1934	1935	1936	1937	1938	1939
Rosafolia — *Ruusulehti*	0.1	0	0	0.4	0.1	0.1	0	0
Deodara	0.2	0.1	0.3	0.3	0.2	0.6	0.6	—
Green Mountain	2.7	0.9	2.3	5.3	2.2	1.7	12.7	—
Early Rose — *Aikainen ruusu*	3.7	0.3	5.8	3.1	0.4	0.3	13.0	—
Harbinger — *Vesijärvi*	0.2	0.3	0.2	0.9	0.6	0.8	3.6	1.4
Up-to-Date — *Upto*	1.0	0.1	0.7	0.7	1.7	0.3	6.4	—
Paul Wagner — *Pauli*	—	1.0	0.2	0.1	0.1	0.2	1.1	0.5
Eigenheimer	—	—	—	0.5	1.4	0.7	6.5	2.4
King George V — *Kuningas Yrjö V*	—	—	—	0.8	2.4	1.1	3.3	1.5
Ostbote	—	—	—	—	—	0.5	2.7	0
Alpha — *Alfa*	—	—	—	—	—	—	—	—
Sieglinde — *Siikli*	—	—	—	—	—	—	—	—
Jaakko	—	—	—	—	—	—	—	—

Variety *Lajike*	1943	1944	1945	1946	1952	1953	1954	1955	1956	1957	1958	1960	1961
Rosafolia — *Ruusulehti*	0	0	0	0	0	0.1	0	0	0	0	0	0	0
Deodara	—	—	—	—	—	—	—	—	—	—	—	—	—
Green Mountain	—	—	—	—	—	—	—	—	—	—	—	—	—
Early Rose — *Aikainen ruusu*	—	—	—	—	—	—	—	—	—	—	—	—	—
Harbinger — *Vesijärvi*	—	—	—	—	—	—	—	—	—	—	—	—	—
Up-to-Date — *Upto*	2.3	0.1	7.9	2.8	3.9	9.8	4.1	1.1	1.1	2.8	0.6	—	—
Paul Wagner — *Pauli*	—	—	—	—	—	—	—	—	—	—	—	—	—
Eigenheimer	1.3	0	12.2	2.4	—	—	—	—	—	—	—	—	—
King George V — *Kuningas Yrjö V*	0.4	0.3	0	0	0.2	1.8	0.4	—	—	—	—	—	—
Ostbote	0.5	0	0	2.3	0.3	7.0	0.3	0	0.1	2.8	0	—	—
Alpha — *Alfa*	0	0	0.6	0	0.9	2.2	0.2	—	—	—	—	—	—
Sieglinde — *Siikli*	—	—	0	0	0.2	1.8	0.1	0	0.1	0.4	0.1	3.2	3.0
Jaakko	—	—	—	—	0.7	1.8	0.2	0	0.2	0.7	—	5.9	3.6

Appendix 7. Incidence of tuber blight in the variety trials at Ylistaro, 1932—62.
Liite 7. Mukularuton esiintyminen perunan lajikekokeissa Ylistarossa v. 1932—62.

Variety *Lajike*	Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*																					
	1932	1934	1935	1936	1937	1938	1939	1940	1944	1945	1946	1949	1950	1951	1952	1953	1954	1955	1956	1957	1960	1961
Rosafolia — *Ruusulehti*	1.5	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	1.0	0.7	0	1.1	0	1.3
Magnum bonum	18.1	2.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Eldorado	2.6	0	0	1.3	5.9	1.7	0.7	—	0	0	0	0	1.6	0	0	—	—	—	—	—	—	—
Harbinger — *Vesijärvi*	7.3	4.4	3.4	8.6	36.4	6.2	4.0	11.5	1.7	0	1.8	2.7	6.4	0.3	3.3	8.3	41.7	—	—	—	—	—
Eigenheimer	9.7	2.6	2.4	20.9	62.5	13.5	9.0	16.1	0.3	0	3.3	1.2	8.4	3.1	0	4.9	17.6	15.9	1.3	11.7	15.6	6.5
Ben Lomond	—	—	4.0	6.0	40.2	10.0	3.0	2.3	0	0.9	5.3	—	—	—	—	—	—	—	—	—	—	—
King George V — *Kuningas Yrjö V*	—	—	—	2.3	17.9	—	—	0	—	—	0	0	1.9	0	0	0.8	20.0	4.9	0.7	2.9	—	—
Ostbote	—	—	—	—	—	—	0.7	—	0	0	0.5	0	0.3	0.3	0	—	—	—	—	—	—	—
Frühbote	—	—	—	—	—	—	—	—	0	0	0	0	1.0	0.3	0	1.0	3.0	—	—	—	—	—
Olympia	—	—	—	—	—	—	—	—	0	0	0.6	0	0.1	0	0	2.4	20.0	0.6	0	3.7	—	—
Frühnudel — *Nuutti*	—	—	—	—	—	—	—	—	0	0	0.5	0	0	0.3	0	2.9	11.4	4.0	0	2.3	0	1.0
Early Rose — *Aikainen ruusu*	—	—	—	—	—	—	—	—	—	7.1	1.7	3.4	16.2	3.3	0	—	—	—	—	—	—	—
Jaakko	—	—	—	—	—	—	—	—	—	—	—	0	0	1.3	0	2.5	26.9	7.3	2.0	6.6	13.0	2.9

Appendix 8. Incidence of tuber blight at Peipohja, 1931—39 and 1945—62.
Liite 8. Tietoja mukularuton esiintymisestä Peipohjassa v. 1931—39 ja 1945—62.

Variety *Lajike*	Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*														
	1931	1932	1934	1937	1938	1946	1948	1952	1953	1954	1956	1957	1958	1961	1962
Rosafolia — *Ruusulehti*	0	0	0	0	0.7	0.7	1.2	0.1	1.0	0	0	0	2.6	3.5	0.3
Deodora	0.8	0.5	1.4	1.0	1.0	—	—	—	—	—	—	—	—	—	—
King George V — *Kuningas Yrjö V*	0	0.3	1.2	1.3	0.7	—	—	—	—	—	—	—	—	—	—
Sieglinde — *Siikli*	—	—	—	—	—	1.1	4.0	0.5	9.9	1.5	1.0	—	—	—	—
Johanna	—	—	—	—	—	0.3	0.8	0.9	12.0	2.7	0.2	0	2.5	—	—
Olympia	—	—	—	—	—	0	3.3	0	4.7	1.1	0	0.3	4.0	1.0	0.2
Jaakko	—	—	—	—	—	—	4.2	24.3	5.7	0.7	—	—	—	—	—
Koto	—	—	—	—	—	—	—	—	—	3.4	0.9	1.5	0.8	8.7	0.2

Appendix 9. Incidence of tuber blight at Pälkäne, 1931—62.
Liite 9. Mukularuton esiintyminen Pälkäneellä v. 1931—62.

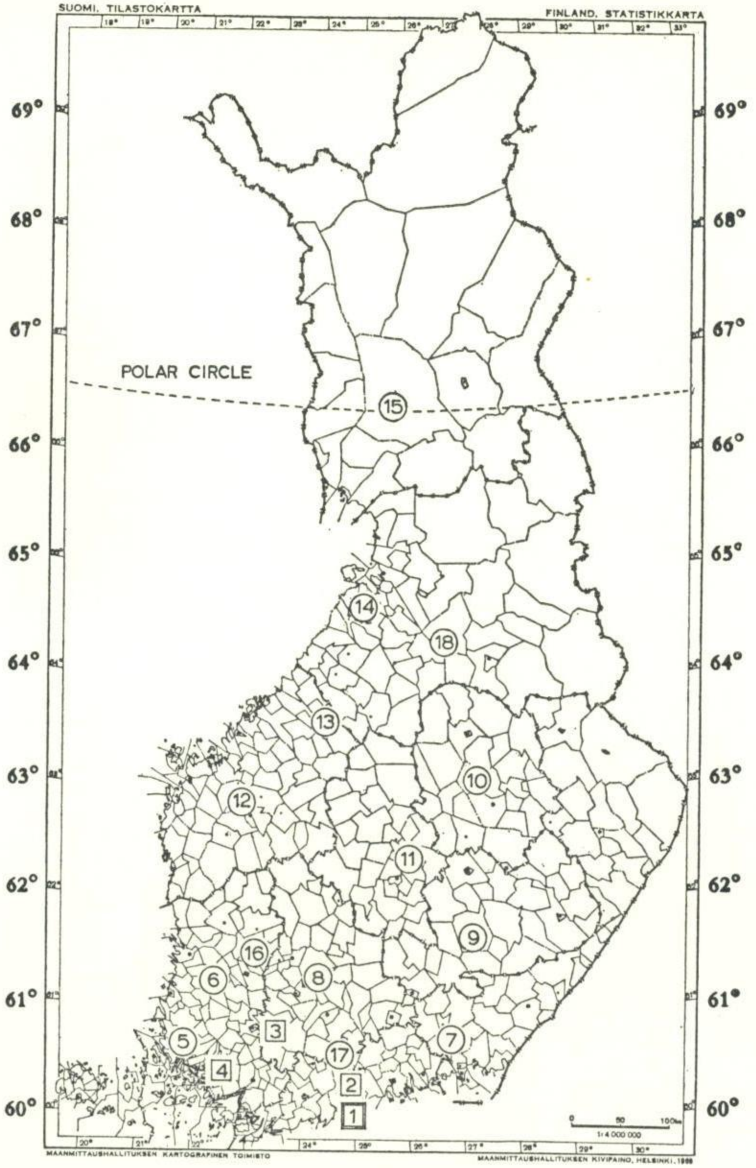
Variety *Lajike*	Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*								
	1936	1938	1939	1943	1945	1950	1954	1957	1961
Rosafolia — *Ruusulehti*	0	0.4	0.5	0	0	0	0	0	2.0
Deodara	0.6	11.7	0	—	—	—	—	—	—
Eigenheimer	0	0.6	0.4	—	—	—	—	—	—
Paul Wagner — *Pauli*	0.1	0	0.2	—	—	—	—	—	—
Harbinger — *Vesijärvi*	0.5	8.7	0.4	—	—	—	—	—	—
Myttäälän peruna	1.4	2.0	1.7	0.4	19.6	—	—	—	—
Ostbote	—	0	3.6	0	0	0	0.3	0	9.0
Goldwährung	—	—	0	0	5.1	14.7	—	—	—
Alpha — *Alfa*	—	—	—	0	0	0	0	0.3	16.0
Olympia	—	—	—	—	1.0	0	0.3	—	—
Sieglinde — *Siikli*	—	—	—	—	—	6.7	—	0.3	—
Jaakko	—	—	—	—	—	18.7	0	0.3	27.0
Record — *Rekord*	—	—	—	—	—	—	0	0	4.0

Appendix 10. Incidence of tuber blight at Maaninka, 1931—62.
Liite 10. Mukularuton esiintyminen Maaningalla v. 1931—62

Variety *Lajike*	Tubers infected with blight (weight %) — *Ruttoisia mukuloita painoprosenttia*															
	1931	1932	1933	1934	1935	1936	1938	1939	1943	1946	1952	1953	1954	1956	1957	1961
Rosafolia — *Ruusulehti*	0	0	0.1	0.1	0.2	0.2	0.1	0	0	0.1	0	0	0.1	0	0	0.1
Early Puritan — *Puritaani*	28.0	6.0	9.5	28.1	4.1	3.4	7.6	1.6	5.0	—	—	—	—	—	—	—
Harbinger — *Vesijärvi*	5.4	0.5	1.3	5.0	1.0	1.0	1.3	0.7	1.1	0.3	—	—	—	—	—	—
Up-to-Date — *Upto*	1.7	0.6	2.5	14.0	0.3	0.8	6.8	0.1	—	1.5	12.2	5.4	4.5	8.5	—	—
Eigenheimer	—	—	2.6	9.2	0.2	0.8	6.0	0	5.6	1.0	—	—	—	—	—	—
Early Rose — *Aikainen ruusu*	—	—	4.7	30.9	2.1	1.3	10.4	1.6	3.0	1.4	0	0.4	—	—	—	—
Ostbote	—	—	—	—	—	—	—	0.2	1.6	0	—	—	—	—	—	—
King George V — *Kuningas Yrjö V*	—	—	—	—	—	—	—	—	—	0.1	0.5	1.8	0.9	0.3	—	—
Sieglinde — *Siikli*	—	—	—	—	—	—	—	—	—	—	0.1	0.2	0.1	0.1	0.5	—
Jaakko	—	—	—	—	—	—	—	—	—	—	6.7	1.4	0.2	0.9	0.9	2.8
Record — *Rekord*	—	—	—	—	—	—	—	—	—	—	—	—	—	0	0	0

Appendix 11. Incidence of tuber blight in the variety trials at Ruukki, 1931—62.
Liite 11. Mukularuton esiintyminen lajikekokeissa Ruukissa v. 1931—62.

Variety *Lajike*	Tubers infected with blight (weight %) *Ruttoisia mukuloita painoprosenttia*			
	1936	1953	1954	1961
Rosafolia — *Ruusulehti*	0	0	0	0.3
Liminka	64.3	—	—	—
Early Rose — *Aikainen ruusu*	5.5	—	—	—
Harbinger — *Vesijärvi*	0.9	—	—	—
Eigenheimer	2.0	7.0	18.0	—
Peippo	—	0	19.0	—
Jaakko	—	0	31.0	0
Barima	—	—	—	5.0



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