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QUANTIFICATION OF THE EFFECTS OF WEATHER CONDITIONS PRIOR TO THE GROWING SEASON ON CROP YIELDS

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SUMMARY

It was shown mathematically that crop yields are affected by the climatic conditions of earlier periods. In a moderate humid climate, as is found in The Netherlands and in eastern England, an appreciable part of total variance can be explained by the amounts of earlier rainfall. The effects are most pronounced with crops which received either no or only moderate amounts of nitrogen.

The correlations of yields with rainfall in the previous summer period (July-October) are negative. Yields of winter and spring cereals are also negatively affected by rainfall in the preceding winter period (November-February) and yields of industrial potatoes by rainfall in the period preceding crop emergence (1 March-20 May). Peas are characterized by a high sensitivity to rainfall which occurs in the growing season.

The negative correlation between amounts of earlier rainfall and crop yields is due to the effect of rainfall on the fertility status of the soil. Probably nitrogen plays an important role in carrying the effects of past weather over to the crop.

INTRODUCTION

Previous papers indicated that crop yields are affected by the rainfall in periods preceding the growing season of the crop. This relation is due to detrimental or beneficial effects of high or low rainfall respectively, on the fertility status of the soil [11 13 14 19]. This, in particular, applies to nitrogen. It has also been suggested that soil structure and the organic-matter cycle are influenced by the distribution of rainfall over the years [15].

In contrast with a more qualitative treatment in previous papers, the present paper deals with *quantification*, by means of multiple regression analysis, of the relationships between amounts of rainfall (total precipitation) in periods prior to the growing season and crop yields. The purpose of the analysis was to determine what percentage of the variance in yield differences between years could be explained. In this respect the variation of the weather coinciding with the growing season, which interferes with the effects of preceding periods, can be considered as a disturbing factor. To diminish its effect, the sums of rainfall in periods coinciding with the growing season were included in the same model, though meteorological conditions during crop growth can only be incompletely characterized by amounts of rainfall. As the effect of climatic conditions on crop yields through the intermediary of the soil may be obscured by the effects of nitrogen dressings, the amounts applied have to be taken into consideration.

YIELD DATA

Series of consecutive yield data derived from long-term field trials treated similarly over all years, or average yields obtained in practical farming, were used.

The following selection was made:

(1) *Yields of potatoes and rye from two long-term field trials during 1947–1967*

Both trials were laid out on reclaimed peaty soils (a humic sand over a subsoil of peat). From 1947 to 1953 rye (*Secale cereale* var. Petkuser) and industrial potatoes (var. Voran) were grown simultaneously on two strips; in 1954 a third strip cropped to oats was added, which changed the rotation to potato-rye-oats. Only the results obtained with potato and rye will be dealt with.

(a) Field trial Pr 934 is located near Veendam (Province of Groningen). The soil was reclaimed about 3 centuries ago, contains 26 per cent of organic matter, and has a pH–KCl of 4.4. The amount of soluble nitrogen present in the soil in the early spring varies from year to year, depending on the intensity of rainfall in the preceding winter.

(b) Field trial Pr 935 is located near Emmen (Province of Drenthe). The soil was reclaimed half a century ago. It contains 17 per cent of organic matter, and has a pH–KCl of 4.2. The soil is different from the former soil that it has a thinner arable layer and a higher permeability to water. In contrast with Pr 934, almost the whole stock of soluble nitrogen built up during the autumn leaches out of the root zone in winter; this happens also in relatively dry winters.

On these field trials 6 rates of nitrogen were applied (with 2 or 3 replications each) ranging from zero up to amounts exceeding the optimum. Yields at any of the application rates can be estimated from the yield curves. Yields obtained with high, moderate and no nitrogen applications were used.

Yields of all years are comparable, as a cumulation of nitrogen effects was precluded by changing the design of the experiment every year.

(2) *Yields of winter wheat grown continuously on the Broadbalk Field of the Rothamsted Experiment Station, Harpenden, eastern England, in the period 1843 (first year) up to 1902*

This field trial was selected for comparison with both field trials in The Netherlands, mentioned above. In contrast with the Dutch trials, there was no crop rotation and the same fertilizer treatments were repeated yearly on the same plots.

Yields of the manured plot and those of the nondressed plot were used.

(3) *Average yields of various crops obtained in practical farming*

The crops were wheat, oats and peas in the northern region of the Province of Groningen on marine alluvial soils during 1919–1941; for comparison, yields of wheat grown in the same period in the Province of Zeeland on similar soils, and, in addition, yields of industrial potatoes, grown between 1922 and 1941 on reclaimed peat soils in the southern part of Groningen were used.

These periods were taken, because they were least confounded by effects resulting from political circumstances.

The yield data were gathered from agricultural statistics. They represent the weighted averages of estimations of local commissions of experts and may be considered fairly trustworthy.

RAINFALL DATA

Rainfall data were obtained from official weather stations near the experimental areas. For the field trials Pr 934 and Pr 935 these were the stations at Veendam and Emmen.

For the Broadbalk Field monthly rainfall data were taken from London (Greenwich) 1843–1863, London (Campden Town) 1864–1865, Ware 1866, Northhampton 1867–1870, Bayfordbury 1871–1874, St. Albans (Bayfordbury) 1875–1880, Hetford (Bayfordbury) 1881–1891, Rothamsted Experimental Station 1892–1900, Hertford 1901–1902.

The yields in practical farming were studied in relation to the average rainfall data of the districts Groningen or Vlissingen.

SELECTED PERIODS

The selection of distinct rainfall periods was guided by experience and reasoning. Periods coinciding with and prior to the growing season were selected (Table 1).

To determine whether the yields might be influenced by a year trend, in some cases the sequence of years was also included as one of the independent variables of the model. This was not done for the Dutch field trials, where the experimental lay-out was presumed to be identical in all years.

TABLE 1

Rainfall periods used

	Crop					
	Potato	Rye	Wheat		Oats	Peas
			Netherlands	England		
A. During the growing season						
(1) whole period	21 May–31 Aug.	—	—	—	—	—
(2) late growth phase	—	11 May–20 July	21 May–31 July	1 May–31 July	21 May–31 July	11 May–20 July
(3) early growth phase	—	1 Mar.–10 May	1 Mar.–20 May	1 Mar. 30 Apr.	1 Mar.–20 May	1 Mar.–10 May
B. Previous to growing season						
(1) prior to crop emergence	1 Mar.–20 May	—	—	—	—	—
(2) 4 months preceding (1)	1 Nov.–28 Feb.	1 Nov.–28 Feb.	1 Nov.–28 Feb.	1 Nov.–28 Feb.	1 Nov.–28 Feb.	1 Nov.–28 Feb.
(3) 4 months preceding (2)	1 July–31 Oct.	1 July–31 Oct.	1 July–31 Oct.	1 July–31 Oct.	1 July–31 Oct.	1 July–31 Oct.
(4) 12 months preceding (3)	1 July–30 June	1 July–30 June	—	—	—	—

PRESENTATION OF RESULTS

Tables 2–4 show the multiple regression coefficients which indicate the change in yield (grain or tubers in kg/ha) effected either by 1 mm of rain in the respective periods, or by a difference of 1 year (trend) (Tables 3 and 4). Regression coefficients with a very low probability level ($P > 20$) are not mentioned. The probability (P-value) and the percentages of total yield variance explained by rainfall sums in the various periods are also listed. As the part of the variance explained by year trend is not essential for an understanding of climate–crop yield relationships, the part explained by the various rainfall sums is also expressed as a percentage of the variance left after elimination of the trend.

To preclude overestimation of the results, these percentages were computed only when the value of P was < 10.

RESULTS

Long-term field trials on reclaimed peaty soils

The relation between rainfall sums and crop yields was negative in all cases (Table 2).

A marked effect of rainfall in the November–February period was only found with rye at Pr 934. A considerable part of the variance in crop yields of the unfertilized and the moderately fertilized plots was explained by this factor (61 and 31 per cent, respectively).

Yields of both rye and potatoes were affected by rainfall in the preceding 'summer' (July–October = B3). This was most pronounced in the control plot, whereas it occurred only once, and then weakly, in the case of the high nitrogen treatment. A rather important part of the total variance of crop yield was explained by rainfall in this period (12 to 34 per cent in the case of the control).

A slight indication of an effect of rainfall during a still earlier period (12 preceding months = B4) was only found with rye in the control plot of Pr 934.

Weak negative effects of rain which fell in the period between the winter and the time of potato crop emergence (1 March–20 May = B1) were found in the control plots of both field trials.

Negative effects of rainfall during the growing season were found with potatoes (A1) at Pr 934 and with rye (A2, 3) and potatoes (A1) at Pr 935. With potatoes at Pr 934 the effect was most marked for the high-nitrogen treatment (14 per cent of yield variance accounted for by this factor). For rye at Pr 935 the effect of rainfall in this period explained 14 and 20 per cent for the nonfertilized and the moderately fertilized plots, respectively.

The rather small influence on yield of meteorological conditions during crop growth (A) might be due to the fact that the total amount of rainfall does not adequately describe these conditions.

Broadbalk Field, England

The fact that the yields from the manured plot showed a positive year trend and those from the control a negative trend, may be attributed to changes in the soil-fertility status. About 20 per cent of the total variance was explained by this factor (Table 3). This computation is based on the assumption that the trend effects are linear, which probably is incorrect. In this case the unexplained resteffects are too large; consequently, the effects of climatological factors may be underestimated.

In many respects the results of this English field trial are similar to those of the Dutch trials as well as those obtained in practical farming, mentioned below.

TABLE 2

Multiple regression analysis of crop yields, grain and tubers in kg/ha, from two field trials (Pr 934 near Veendam, and Pr 935, near Emmen) at three levels of N-dressing in relation to rainfall, in mm, in periods coinciding with or previous to crop growth

Period (as in Table 1)	Rainfall in period	Regression coefficient ($kg/ha^{-1}mm^{-1}$)			Probability (P in per cent)			Per cent of total variance explained		
Pr 934, rye, 1947–1967										
		0	50 N	100 N	0	50 N	100 N	0	50 N	100 N
A2	1 May–20 July	—	—	—	—	—	—	—	—	—
A3	1 Mar.–10 May	—	—	—	—	—	—	—	—	—
B3	1 Nov.–28 Feb.	−5.701	−2.899	—	0.1	1.5	—	60.6	31.1	—
B3	1 July–31 Oct.	−2.377	−2.224	—	7	10	—	11.9	16.4	—
B4	1 July*–30 June	−1.071	—	—	16	—	—	—	—	—
Pr 934, industrial potatoes, 1947–1967										
		0	100 N	200 N	0	100 N	200 N	0	100 N	200 N
A1	21 May–31 Aug.	—	−28.52	−37.03	—	10	9	—	6.0	13.6
B1	1 Mar.–20 May	−49.30	—	—	11	—	—	—	—	—
B2	1 Nov.–28 Feb.	—	—	—	—	—	—	—	—	—
B3	1 July–31 Oct.	−33.78	−26.70	−24.09	1	2	14	33.5	27.4	—
B4	1 July*–30 June	—	—	—	—	—	—	—	—	—
Pr 935, rye, 1958–1967										
		0	50 N	100 N	0	50 N	100 N	0	50 N	100 N
A2	11 May–20 July	−5.472	−4.453	—	5	4	—	13.7	19.8	—
A3	1 Mar.–10 May	—	—	—	—	—	—	—	—	—
B2	1 Nov.–28 Feb.	—	—	—	—	—	—	—	—	—
B3	1 July–31 Oct.	−2.725	−1.701	—	3.5	11	—	23.2	—	—
B4	1 July*–30 June	—	—	—	—	—	—	—	—	—
Pr 935, industrial potatoes, 1947–1967 (without 1948)										
		0	100 N	200 N	0	100 N	200 N	0	100 N	200 N
A1	21 May–31 Aug.	−37.46	−35.55	−33.23	12	19	16	—	—	—
B1	1 Mar.–20 May	−84.84	—	—	15	—	—	—	—	—
B2	1 Nov.–28 Feb.	—	—	—	—	—	—	—	—	—
B3	1 July–31 Oct.	−40.17	−34.51	—	4.5	11	—	26.2	—	—
B4	1 July*–30 June	—	—	—	—	—	—	—	—	—

* 2 years ago.

TABLE 3

Multiple regression analysis of wheat yields in kg grain/ha* at Broadbalk Field, Rothamsted Experimental Station in relation to amounts of rainfall, in mm, in periods coinciding with or previous to crop growth on manured plot and control in 1843–1902

Period (as in Table 1)	Rainfall in period	Regression coefficient ($kg/ha^{-1}mm^{-1}$)		Probability (P in per cent)		Per cent of total variance explained			
						Not corrected		Effect of trend eliminated	
		Control	Manure	Control	Manure	Control	Manure	Control	Manure
A2	1 May–31 July	−1.11	− 1.54	<0.1	1	12.3	5.8	15.1	7.3
A3	1 Mar.–30 Apr.	−1.08	–	4.5	–	6.0	–	7.5	–
B2	1 Nov.–28 Feb.	−0.609	− 2.52	5	<0.1	8.0	16.9	10.0	21.4
B3	1 July–31 Oct.	−0.406	–	12	–	–	–	–	–
	Years	−4.25	+10.2	<0.1	<0.1	19.9	20.9		

* 1 bushel/acre = 50.8 kg/ha.

A negative effect of rainfall in the November–February period (B2), which was very pronounced for the manured plot, accounted for 17 and 8 per cent (21 and 10 per cent after elimination of trend) of the total variance in the manured and control plots respectively.

A weak indication of a negative effect of rainfall in the preceding July–October period (B3) was evident only in the control.

The fact that a considerable part of the variance is accounted for by the annual trend (20 per cent or more) may be the reason why the part of the variance explained by rainfall in these early periods is still smaller (also after elimination of trend effect) than that found with rye at the Dutch field trial Pr 934. Significant negative correlations between crop yields and rainfall during the growing season of the crop (A2, 3) were found. It was apparent that wheat was most sensitive to rainfall in the second half (May–July = A3) of the period.

Yields of crops obtained in practical farming (Table 4)

(1) Wheat. A positive trend in yields for the period 1919–1941 was most pronounced in the Province of Zeeland. Here, the year trend explained 24 per cent of the variance compared with only 4 per cent of the variance in the Province of Groningen.

Negative effects of rainfall occurring in November–February (B2) and July–October of the previous year (B3) were found in Groningen, explaining together 28 per cent (29 per cent) of the total variance.

TABLE 4

Multiple regression analysis of crop yields in practical farming, grain, seed and tubers in kg/ha, in relation to amounts of rainfall, in mm, in periods coinciding with or previous to crop growth

Period (as in Table 1)	Rainfall in period	Regression coefficient (kg/ha^{-1}mm^{-1})	Probability (P in per cent)	Per cent of total variance explained: Not corrected	Per cent of total variance explained: Effect of trend eliminated
Wheat, Province of Groningen, 1919–1941					
A2	21 May–31 July	− 3.664	2.5	24.5	25.5
A3	1 Mar.–30 May	− 2.490	18	—	—
B2	1 Nov.–28 Feb.	− 2.351	3	13.5	14.1
B3	1 July–31 Oct.	− 1.715	5.5	14.1	14.7
	Years	+ 15.25	9	4.0	
Wheat, Province of Zeeland, 1919–1941					
A2	21 May–31 July	− 2.193	18	—	—
A3	1 Mar.–20 May	− 3.371	9	8.9	12.1
B2	1 Nov.–28 Feb.	− 1.826	6	10.3	14.0
B3	1 July–31 Oct.	− 1.268	20	—	—
	Years	+31.22	0.3	23.7	
Oats, Province of Groningen, Noorderkwartier only, 1919–1941					
A2	1 June–31 July	—	—	—	—
A3	1 Mar.–31 May	—	—	—	—
B2	1 Nov.–28 Feb.	− 2.195	9	11.3	12.1
B3	1 July–31 Oct.	− 2.410	3	19.4	20.8
	Years	+ 19.47	7	6.7	
Peas, Province of Groningen, 1919–1941					
A2	11 May–20 July	− 9.164	0.1	44.7	48.0
A3	1 Mar.–10 May	− 4.172	14	—	—
B2	1 Nov.–28 Feb.	—	—	—	—
B3	1 July–31 Oct.	—	—	—	—
	Years	+25.25	5	6.9	
Industrial potatoes, Province of Groningen, 1922–1941					
A1	21 May–31 Aug.	−60.21	0.1	52.0	52.0
B1	1 Mar.–20 May	−46.82	1.0	14.2	14.2
B2	1 Nov.–28 Feb.	+15.90	13	—	—
B3	1 July–31 Oct.	−14.33	12	—	—
	Years	—	—	—	

Similar effects were found in Zeeland, but their statistical significance was lower.

In agreement with the results of the Broadbalk Field there was a negative effect of rainfall occurring during the growing season (A2) in Groningen. In Zeeland this negative relation was not convincing.

(2) Oats. The responses to rainfall in past periods (B2, 3) of this spring grown crop were rather similar to those of winter wheat. Yields of oats, unlike those of other crops, showed no relation to rainfall during the growing season (A2, 3).

(3) Peas. In contrast with oats, peas were characterized by a strong response to rainfall which occurred during the growing season (A2, 3), especially to that in the second half of the season (A2). Unlike the cereals, peas showed only very weak effects of rainfall in earlier periods (B2, 3) ($P > 20$).

(4) Industrial potatoes. For this crop rainfall during the growing season (A1) proved to be the most important factor, which explained 52 per cent of the total variance.

Effects of rainfall in November–February (B2) and July–October (B3) can be observed but their statistical significance is low. In contrast with other findings, the relation with winter rainfall was positive.

A much stronger effect of rainfall was found for the 1 March–20 May period (B1). It was more pronounced than that found on a similar soil in field trial Pr 934 (Table 2).

DISCUSSION

The relations between earlier weather conditions and crop yields, described qualitatively in previous papers, have been quantified. It became clear that the effects on crop yields of the weather in periods prior to the growing of the crop (measured as amounts of rainfall) are considerable and may account for an appreciable part of the total-variance in many cases. It was shown earlier that the effects can be ascribed to the unfavourable influence of meteorological conditions characterized by high rainfall on the fertility status of the soil. The effects were most apparent with crops grown without nitrogen dressing. The application of nitrogen tended to weaken the influence exerted by the soil.

Distinct differences between the responses of various crops were found. The yields of cereals were most markedly effected by rainfall during the preceding winter. In this respect there was no difference between winter and spring cereals. In the case of winter wheat it remains dubious whether the crop or the soil was affected by winter rainfall, but for a spring cereal it is almost certain that the effects of rainfall were indirect and must have been carried over through the intermediary of the soil. Industrial potatoes and peas were not affected by winter rainfall. For potatoes a negative correlation with rainfall in the period between winter and the emergence of the crop was found. With the exception of peas, the crops investigated responded more or less strongly to rainfall in the preceding summer period (July–October).

The negative relation with rainfall in the preceding winter period found for cereals was earlier attributed to differences in amount and distribution of soluble soil nitrogen available in the early spring. In the winter the stock of soluble nitrogen, which is usually built up in the autumn, is leached down at varying rates depending on rainfall in this period [1 2 3 7 8 9 10 12 16 18 22 23 24 25].

The effect of winter rainfall was very pronounced for rye at Pr 934 near Veendam, for wheat at the Rothamsted Broadbalk field trial, and in practical farming.

In the case of the Broadbalk Field the effect was stronger for the manured plot than for the control, which may have been due to the autumn application of manure. This treatment may have given rise to mineralisation of considerable amounts of nitrogen in the surface layer of the soil. Accumulation of nitrogen to the same extent cannot be expected for the control which remained unfertilized for a very long time.

The results of our computation agree with those obtained by Fisher [4] in a detailed analysis of data from the same field trial. The fact that no effect of winter rainfall was found with rye in field trial Pr 935 near Emmen is due to the high permeability to water of this soil. Almost all nitrogen in soluble form is lost, even in relatively dry winters.

The absence of a response of potatoes to winter rainfall can probably be attributed to the late growing season of this crop. Soil nitrogen which is still available in the early spring may be affected by the weather during the period between the winter and the time of crop emergence. From related research it became clear that losses of nitrogen may be considerable during this period. They result from leaching during exceptionally wet springs and, more commonly, from denitrification [15]. On the other hand, nitrification may occur when the soil is warming up. In fact, a negative effect of rainfall in this period was found most clearly with potatoes in practical farming and, less pronounced, in field trial Pr 934. Negative effects of rainfall in this period have also been noted by Judel and Kürten [7 8].

The absence of a response to past rainfall found with peas might be ascribed to the high sensitivity of this crop to rainfall during the growing season, which may have obscured possible weaker effects of rainfall in earlier periods. Another reason may be that peas are less sensitive to slight differences in available soil nitrogen, owing to their ability to fix gaseous nitrogen.

The negative response of nearly all crops to rainfall in the preceding summer period (July–October) seems to confirm the hypothesis that the effects are carried over through the intermediary of the soil, as other explanations appear to be very unlikely. It is not acceptable to ascribe this effect to differences in the amount of soluble soil nitrogen, carried over into the next season. This is especially impossible in field trial Pr 935, because of the high permeability to water of the soil. A more likely explanation lies in the possible occurrence of differences in the amount of insoluble nitrogen compounds, resulting from different weather conditions in the preceding summer. Such compounds might remain unchanged in the soil during the winter period and become mineralised in the following season. The probability of a carry-over of nitrogen in this way has been shown earlier [18].

Peas, wheat and industrial potatoes proved to be negatively affected by high rainfall in the growing season. Total amounts of rainfall used here as an index of the weather, stands for a complexity of interrelated factors, such as water, light intensity, temperature *etc.* It is uncertain to what extent each of these factors was directly responsible.

The effect of rainfall in periods coinciding with or prior to crop growth always proved to be harmful to yield. This statement is valid for a moderate humid climate, as is found in The Netherlands and in England, in combination with soils not susceptible to drought. A favourable effect of rainfall was found in a field trial on a drought-sensitive soil [20]. Similarly, a positive effect of rainfall on the fertility

TABLE 5

Yield differences in kg/ha and in percentages of average yield, as effected by rainfall in different periods coinciding with and previous to crop growth

Crop	Period	Average rainfall in same period and standard deviation (S) in mm	Average yield in kg/ha (grain or tubers)	Yield differences effected by different rainfall: By 100 mm in kg/ha	By 2 × S mm in kg/ha	By 2 × S mm in % of average yield
	Vegetation period					
Ind. potato, Groningen	21 May–31 Aug.	243 ± 54.4	30,100	6,020	6,550	21.7
Wheat, Groningen	21 May–31 July	152 ± 39.7	3,040	366	290	9.5
Wheat, Broadbalk Field (manure)	1 May–31 July	161 ± 55.9	2,390	146	163	6.8
Peas, Groningen	11 May–20 July	134 ± 38.1	2,480	916	715	28.8
	Preceding 'spring'					
Ind. potato, Groningen	1 Mar.–20 May	133 ± 35.6	30,100	4,680	3,280	10.9
	Preceding 'winter'					
Wheat, Groningen	1 Nov.–28 Feb.	209 ± 56.2	3,040	235	264	8.7
Wheat, Broadbalk Field (manure)	1 Nov.–28 Feb.	204 ± 63.0	2,390	239	299	12.5
Oats, Groningen	1 Nov.–28 Feb.	209 ± 56.2	3,840	219	235	6.1
Rye, Pr 934 (50 N)	1 Nov.–28 Feb.	262 ± 93.9	3,370	290	544	16.2
	Preceding 'summer'					
Wheat, Groningen	1 July–31 Oct.	303 ± 69.8	3,040	171	239	7.9
Oats, Groningen	1 July–31 Oct.	303 ± 69.8	3,840	241	336	8.8
Rye, Pr 934 (50 N)	1 July–31 Oct.	312 ± 85.2	3,370	222	378	11.2
Ind. potato, Pr 934 (100 N)	1 July–31 Oct.	312 ± 85.2	41,900	3,300	5,620	13.4

status of the soil has been reported by Hoffmann and Bahn [5] in a relative dry region of Eastern Germany.

The effect of rainfall in periods prior to the growing season is considerable. To emphasize its importance some examples derived from Tables 2 to 4 have been collected (Table 5).

Yield differences effected by a difference of 100 mm of rainfall in the respective periods are shown. In addition, the effects of differences in rainfall corresponding to twice the standard deviation (S) of rainfall in these periods, are given. The results are presented in absolute amounts as well as in percentages of the average yields.

Obviously, the effects of rainfall in past periods are almost as important as those of rainfall during the growing season. It is quite clear that past weather has to be taken into consideration for a complete agrometeorological analysis of annual yield differences [17].

The importance of fluctuations of past weather to crop yields will be especially high, if the rate of nitrogen dressing is low, as will be the case in an extensive type of agriculture. Here, considerable advantage may be expected from fitting the rate of nitrogen application to soil conditions as affected by past weather. In the U.S.S.R. the still limited industrial production of nitrogen fertilizers was with priority directed to those regions, where, depending on preceding weather conditions, nitrogen dressing could be expected to be most needed [6].

Where higher amounts of nitrogen are normally applied, the advantage of adapting the rate lies especially in the prevention of excessive dressing of cereals after dry winters, which could result in lodging of the crop. However, moderate increases in yield can still be obtained by additional dressing of nitrogen after wet winters [3 10 12 16].

It has yet to be investigated whether or not it will also be possible to eliminate the detrimental effects of unfavourable weather conditions in the past summer by taking appropriate measures with respect to fertilization or soil treatment. Also the damage caused in the spring prior to potato emergence might be reduced by taking appropriate measures.

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