RELATIONSHIP OF THE WHEAT-PRODUCTION TO THE OECOLOGICAL POTENTIAL IN THE SOUTHERN PLAIN, HUNGARY

by

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A búzatermesztés és az ökológiai potenciál kapcsolata a Dél-Alföldön. A Dél-Alföldön a búzatermesztés szempontjából fontos három megyében megvizsgáltuk 25 mezőgazdasági termelőszövetkezet három éves termésátlagait faktor- és path-analízissel. Megállapítottuk, hogy a termésátlagot befolyásoló fő ökológiai faktorok fontossági sorrendben a következők: a talaj minősége, a júniusi középhőmérséklet és az áprilisi csapadékösszeg. A búzatermesztés szempontjából legkedvezőbb területek kiválasztásánál e tényezők figyelembe vétele alapvető fontosságú.

Three-year average fields of agricultural co-operatives in 25 villages of three important wheat-producing South-Plain counties are examined with factor- and path-analysis. It has been established that the main oecological factors influencing average yield are, in order of importance, as follow: the quality of the soil, the average June temperature and April rainfall. This emphasises the importance of taking all these factors into consideration, when selecting the most favourable areas from the aspect of wheat production.

The southern part of the Great Hungarian Plain yields more than 23% of the country's wheat crop. (*Fig. 1*). Here average yields are always higher than the national average. In the future oecological factors have to be observed to a greater extent so that this territory, too, could contribute to the execution of the cereals program. Our present study offers to contribute to the efficiency of the production of this plant by exploring the relationship of wheat production and eocological factors.

The investigation was based upon the production data of agricultural cooperatives. A full-scale survey has been done on cooperative fields of the southern Plain.

The most important oecological factors — from the point of view of wheat production — are soil and climatic factors. Soil quality used to be characterised with gold crown value — a widely used expression even now, from climatic factors temperature and precipitation were put into the highlight. This latter was investigated first of all in its April, May, June and July distribution and volume. In case of temperature the mean temperatures of the same periods were considered.

Speaking of gold crown value we have to state that that wheat is not grown in the best soil in our territory. In Csongrád county the average gold crown values of wheat growing areas and the gold crown value of the total arable land of the cooperatives were compared and the result was a shift of 36 gold crowns into negative direction.

Wheat is planted in soil of lesser quality because it has less demands on soil as maize or sugar-beet. (It has to be stated, however, that the average wheat crop would be even more favourable on a more valuable soil.)

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gold crown value: index number of soil classification expressing netto income of the unit of area in 1875 money value. Higher value means better quality. Hungarian average: 11.

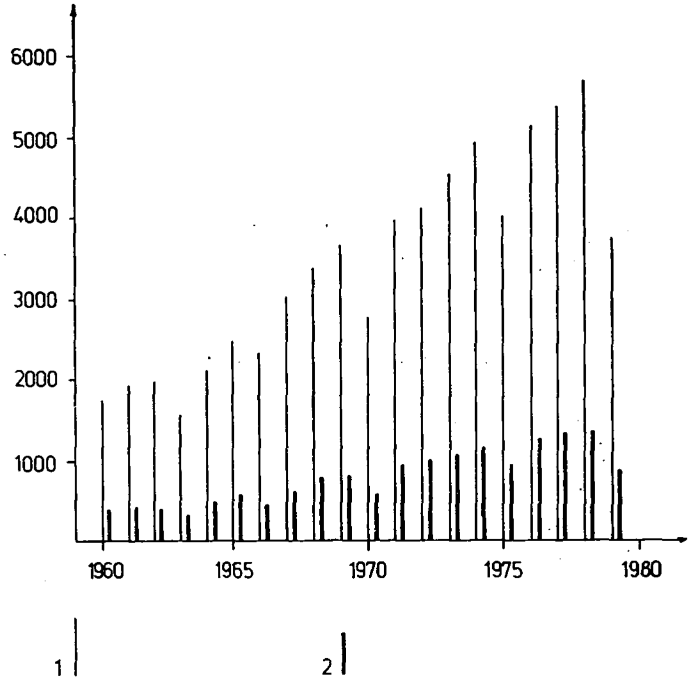

Fig. 1. Rate of national crops on the Southern Plain (1966—1980)
1 = national data
2 = Southern Plain

As it is known, the quality of soil may show quite big differences on the areas of individual counties with a surface of 4,2—8,4 km² each. From the numerous factors classifying soil quality one was put into the highlight, the gold crown value (which is justly criticized, but for the time being can't be replaced with a more adequate term) and this was confronted with average crop. The obtained result showed that the correlation relationship was 0,773 between gold crown value and the average per hectare crop. This straight relationship means that in our area yields are in 59,7% determined by the quality of the soil characterised by the gold crown value.

The forceful effect of soil quality in influencing crops is demonstrated from different aspects by the resemblance of the respective maps of the three territories each classified by their different soil characteristics — that of wheat crops and the gold crown value map of wheat producing areas (*Fig. 2, 3*).

According to our aims we investigated to what extent wheat crops depend on the chosen variables in Békés and Csongrád counties. The investigation was extended to the cooperatives of 25 villages. These villages are as follows:

1. Apátfalva
2. Ásotthalom
3. Battonya
4. Békés
5. Békéscsaba
6. Békéssámson
7. Békésszentandrás
8. Csongrád
9. Csorvás
10. Földeák
11. Gyoma
12. Gyula

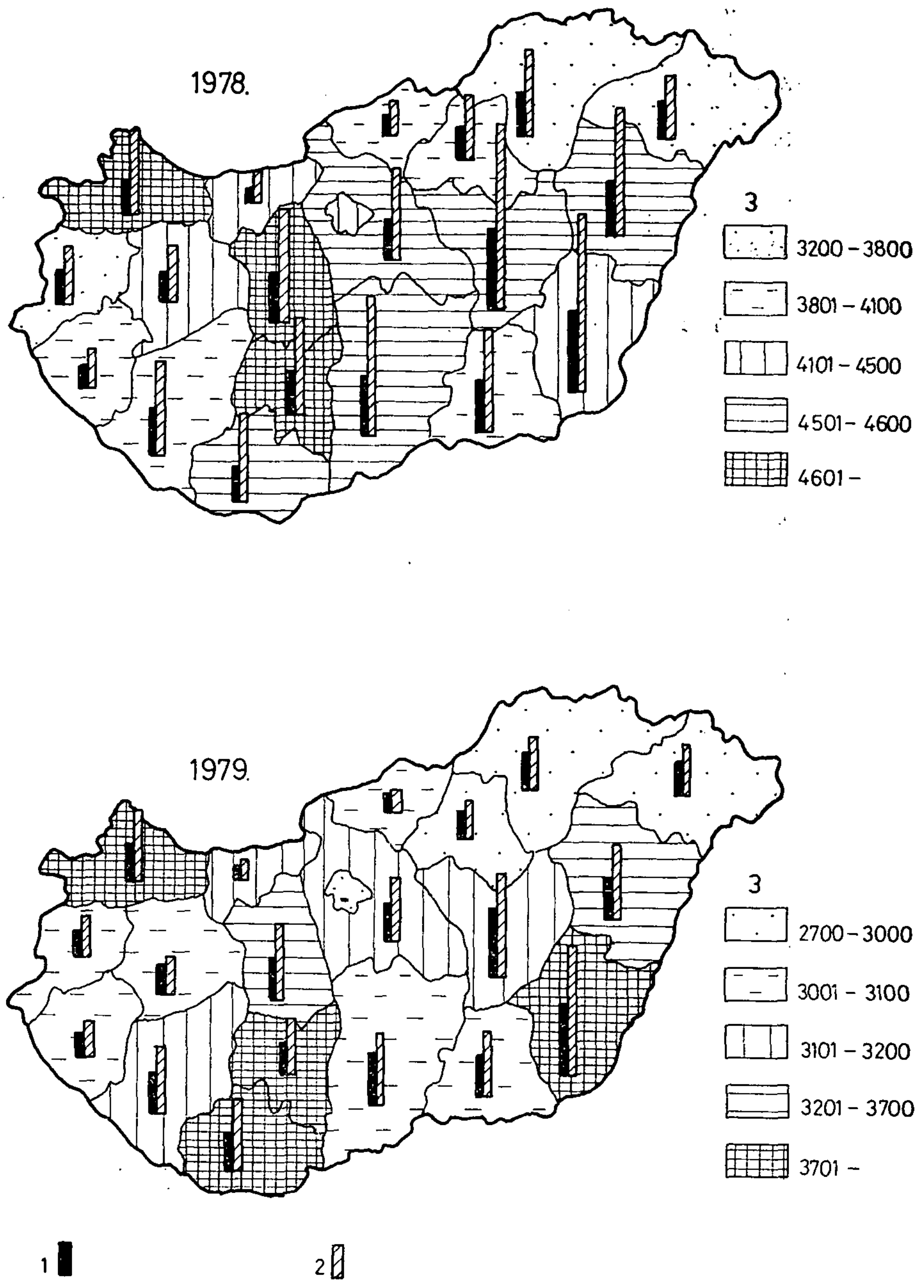

Fig. 2. Characteristics of wheat production in the different counties
1 = area where wheat is grown (50 000 ha)
2 = crop (100 000 t)
3 = average wheat yield (kg/ha)

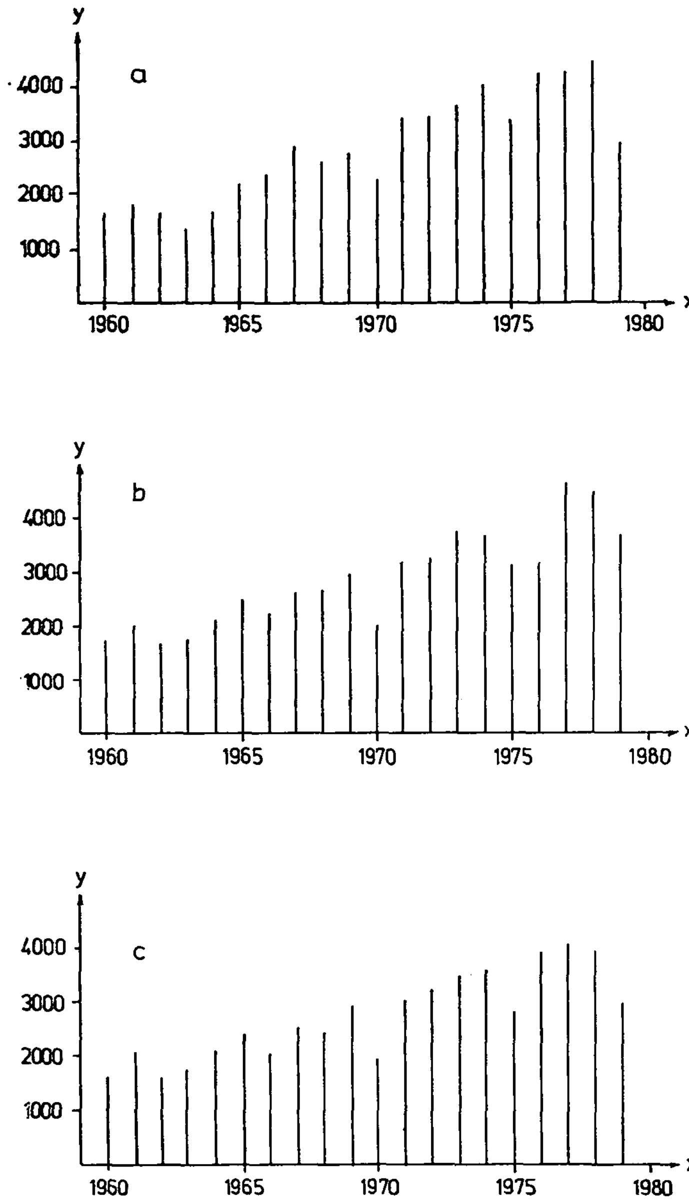

Fig. 3. Average wheat yields in the counties of the Southern Plain
x = year
y = kg/ha
a = Bács-Kiskun county
b = Békés county
c = Csongrád county

13. Hódmezővásárhely
14. Kistelek
15. Kondoros
16. Köröstarcsa
17. Lökösháza
18. Makó
19. Méhkerék
20. Mezőkovácsháza
21. Orosháza
22. Sarkad
23. Szarvas
24. Szeged
25. Szentes

The choice of the sample was motivated by the existence of the necessary data. The index of the average values of 3 years between 1977—79 were taken as a basis of our calculations *(Tab. 1)*. The following variables were considered:

Table 1

Average values of the variables considered (1977—1979)

x_0	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}
4756	39	2423	13,2	86	14	36	68	9,2	16,6	19,3	20,0
2145	10	1200	20,0	49	41	50	38	10,5	17,2	20,6	21,5
4608	31	510	77,0	97	33	57	55	9,5	16,8	19,9	20,8
5805	37	2467	34,4	83	21	87	40	9,4	17,4	20,6	21,0
5475	27	2712	48,2	57	13	34	36	9,4	16,7	19,9	20,4
4348	30	470	42,0	57	48	30	45	8,9	15,9	19,5	20,3
4405	24	620	40,0	51	17	51	25	9,7	17,1	20,2	20,7
4763	39	2423	69,7	53	83	118	59	10,0	13,5	17,6	18,7
2035	10	2743	12,7	60	124	129	48	11,1	14,7	19,0	20,0
4727	31	2094	99,2	44	74	88	56	10,7	14,5	18,7	19,6
5314	37	2467	33,4	42	81	148	50	10,8	14,5	18,8	20,1
5784	27	2712	100,0	21	98	131	59	10,0	13,8	18,0	18,9
3959	29	2630	99,2	41	114	123	48	9,9	13,7	18,2	19,4
4454	26	2045	99,2	34	118	184	70	10,6	14,3	18,8	19,5
4247	39	2423	69,7	45	59	68	51	9,3	16,7	21,3	18,5
782	11	1938	70,0	18	34	72	34	10,2	17,8	22,6	19,5
4370	31	1061	66,0	35	25	68	51	9,6	17,2	22,1	19,6
4715	37	2467	34,0	40	35	86	38	10,0	17,6	21,9	19,1
3676	27	2712	100,0	21	14	62	44	9,5	17,1	21,8	18,7
2810	29	1233	69,0	21	12	78	38	9,6	17,4	21,7	18,8
2880	24	1142	89,0	16	31	77	50	9,9	17,3	22,2	19,3
2308	10	1870	20,0	64	89	83	38	9,1	13,8	19,6	20,5
5274	31	580	99,0	73	49	46	39	8,9	13,9	19,4	20,7
4469	31	600	90,0	67	46	73	24	8,1	13,4	18,5	19,7
4694	23	760	99,0	64	52	73	20	9,0	13,8	19,4	20,3

1. Resultvariable x_0: *wheat crop (kg/ha)*
2. variable x_1: *gold crown value of the soil*
3. variable x_2: *production cost of wheat (Ft/q)*
4. variable x_3: *Being part of a production system (in the percentage of total wheat growing area)*
5. variable x_4: *rainfall in April (mm)*
6. variable x_5: *rainfall in May (mm)*
7. variable x_6: *rainfall in June (mm)*
8. variable x_7: *rainfall in July (mm)*
9. variable x_8: *mean temperature in April* (°C)
10. variable x_9: *mean temperature in May* (°C)
11. variable x_{10}: *mean temperature in June* (°C)
12. variable x_{11}: *mean temperature in July* (°C)

In dataprocessing the method factoranalysis was employed.

The *R* matrix of the simple correlation coefficients was first determined, as demonstrated in *Tab. 2*.

Table 2

Correlation matrix formed from wheat producing indexes of some villages in the Southern Plain
0 : p≦0,05 , x : p≦0,01 , # : p≦0,001
n = 25

	1	2	3	4	5	6	7	8	9	10	11	12
1.	1											
2.	0,773 #	1										
3.	0,076	0,125	1									
4.	0,208	0,174	−0,157	1								
5.	0,332	0,200	−0,239	−0,347	1							
6.	−0,051	—0,206	0,345	—0,135	—0,090	1						
7.	0,052	0,000	0,465*o*	0,200	−0,323	0,789 #	1					
8.	0,197	0,335	0,421*o*	0,064	−0,059	0,378	0,426*o*	1				
9.	−0,260	−0,260	0,473*o*	−0,152	−0,405*o*	0,461*o*	0,604*x*	0,421*o*	1			
10.	−0,257	−0,001	−0,052	−0,328	−0,173	−0,752 #	−0,496*o*	−0,105	0,047	1		
11.	−0,438*o*	−0,149	−0,133	−0,107	−0,381	−0,655 #	−0,417*o*	−0,270	−0,045	0,859 #	1	
12.	0,035	−0,324	−0,419*o*	−0,446*o*	0,645 #	−0,164	−0,346	−0,325	−0,101	0,051	−0,120	1

When analysing this correlational matrix special attention has to be devoted to the cost of production. Generally it can be stated that it has a loose connection with the other variables. The cost of production is in the closest relationship with the mean temperature in April ($r=0,473$) and with the rainfall in July ($r=0,465$). The correlation coefficient between soil quality and the cost of production gave the value of 0,125. This rather loose connection reflectes that the quality of soil cannot be overvalued from the point of view of wheat growing, because this is not the main factor in forming of production costs. Generally, the upper limit of production costs cannot be determined on the basis of soil quality — because of factors beyond human influence, among others. (e. g. foliage manure used in case of drought increases the endurance of the plant, but if there is no rainfall within 4—5 days, the increase in cost does not give a subsequent increase in outcome.

There are however, possibilities, as for example providing modern appliances making possible to finish sowing and reaping in 10—10 days if started at a given optimal moment.

As it is well-known, the establishments belonging to a production system have better results as those not acting in its frameworks. This is due on one hand to eventually more favourable natural endowments, on the other hand it is a consequence of better technical provisions and a set discipline in technology. The production system provides general technological frames, which have to be adapted to the different establishments, even to individual fields considering local experience. According to this, the maximal allowed value of different types of costs is rather varying in space and time. The issue is further complicated by the fact that harmony plays an essential role among the factors of production. Investigating the crop/belonging to a production system rate resulted in an "r" of *0,208.*

For dataprocessing the main factor method of factor-analysis was applied. Four factors were selected on the basis of eigenvalues and the appertaining eigenvectors essential to this method, which are represented with their factor-weights in *Tab. 3.*

Table 3

Factor gravities

Factors	$f(1)$	$f(2)$	$f(3)$	$f(4)$
Yield (kg/ha)	0,194	0,730	0,472	0,192
Gold crown	0,125	0,492	0,768	0,270
Cost of production (Ft/q)	0,570	−0,294	0,172	0,480
System of production (%)	0,289	0,084	0,437	−0,733
Rainfall in April (mm)	−0,250	0,766	−0,314	0,345
Rainfall in May (mm)	0,867	0,025	−0,407	−0,119
Rainfall in June (mm)	0,882	−0,169	−0,093	−0,015
Rainfall in July (mm)	0,606	−0,032	0,270	0,434
Temperature in April (°C)	0,535	−0,564	−0,232	0,354
Temperature in May (°C)	−0,665	−0,509	0,300	0,389
Temperature in June (°C)	−0,638	−0,646	0,296	0,026
Temperature in July (°C)	−0,443	0,382	−0,659	0,245

(The number of the elements is 25. On 1% of significance level the threshold value of the correlation coefficient is 0,49.)

As it can be seen from above factor 1 strongly correlates with production costs (x_2), with the rainfall in May (x_5), June (x_6) and July (x_7), and with the mean temperature in April (x_8), May (x_9) and in June (x_{10}) — though with these latter two in a negative sense. Factors *2* and *3* seem to be more important, since they are in a significant correlation with the target quantity. If a factor strongly relates to the target quantity and the variables gravitate towards these factors, the same variables consequently correlate with the target quantity. This would mean that crop is in a significant positive correlation at high factor gravities with the soil's gold crown value (x_1) — factor *2* and *3*, with rainfall in April (x_4) — factor *2* while in a similarly negative correlation with the mean temperatures in April (x_8), May (x_9), June (x_{10}) — factor 2 and in July (x_{11}). — factor 3. At factor *4* only the production system has a special gravity.

To give a special classification of the influence of variables $x_1, x_2, \ldots, x_{11}$, factor gravities of factors F_2, F_3 and F_4 have to be transformed for factor F_1. (*Tab. 4*).

Table 4

The special transformation of the variables considered

	F_1	Classification
1.	0,911	—
2.	0,876	1
3.	0,076	9
4.	0,201	7
5.	0,470	3
6.	−0,031	10
7.	0,001	11
8.	0,335	5
9.	−0,384	4
10.	−0,312	6
11.	−0,495	2
12.	−0,078	8

As expected, soil's gold crown value (x_1) is in the first place. The second from the variables considered is the influence of mean temperature in June (x_{10}) on the target quantity. On places 3—4 are the rainfall (x_4) and mean temperature in April (x_8). According to available data minimal influence is due to appertaining to a production system (x_3) and to rainfall in May (x_5). In both cases a signifant role is played by the different soil characteristics (quality, type, water tendencies of the soil etc.).

With the help of factoranalysis it can be recognized, to what extent variables reflect a target quantity. To obtain a result, the determination coefficient R^2 of the target quantity has to be calculated which is the square of the correlation coefficient belonging to the target quantity — calculated after a special transformation of factor gravities (square of communality h_1^2): $R^2 = h_1^4 = 0{,}689$, which means that the variation of the target quantity is due in 68,9% to the variance of variables.

We introduce an analysis of same basic data with a few theoretical consideration. In a regression analysis it is often expected from a binary correlational coefficient to reveal to what extent independent variable x influences dependent variable y. If, however, independent variable x is dependent from one or more independent variables influencing y, correlation coefficient r_{yx} contains the influence of these too.

In order to reveal a deeper connection between the dependent variable (y=yield) analysed in course of our survey and the independent variables (x_i; $i=1, 2 \ldots 11$) the observed connections are broken up into the direct influence of the independent variable plus the indirect influence of other variables. This breaking up, which method is a special case of pathanalysis by *S. Wright* (1921), will be calculated for the multiple correlational coefficient R^2. When breaking up R^2, the whole correlational system is broken up into direct and common influences. The indirect influences are melting into the common influences of independent variables. Formula of breaking up:

$$R^2 = \sum p_i^2 + \sum 2p_i p_j r_{ij},$$

where p_i is the path-coefficient (standardised partial regressional coefficient). In our original formula p_i^2 expresses the direct influence of variable x_i; component $2p_i p_j r_{ij}$ can be explained as the joint influence of x_i and x_j; r_{ij} is the correlational coefficient of variables x_i and x_j $(i=j;\ i, j=1, 2,..., 11)$ (*Sváb J. 1973*).

The obtained direct and joint effects show that the distribution of dependent variable y (yield) in what percentage was directly influenced by the individual independent variables x_i $(i=1,2, ..., 11)$ and what was their joint effect. The sum of direct and joint effects in pairs gives the multiple determinational coefficient R^2. Adding to this the square of path-coefficient of deviation component P_E^2, 1 or 100% is obtained. It is obvious that P_E^2 expresses the quantity that cannot be explained with the method of multiple regression analysis from a variation of dependent variable y:

$$P_E^2 = 1 - R^2.$$

Our data were processed with the path-analysis, the obtained results are understood on the basis of data in *Tab. 5* and *6*. Analysing direct and joint effects in pairs it can be stated that the dispersion of wheat crops (*Fig. 4*) was conclusively due to the direct influence of the soil's gold crown value (80,5%) on the investigated area during the given period. A strong direct influence can be observed in the cases of mean temperature in July (50,6%), rainfall in April (13,7%), as well as in the case of mean temperature in June (12,9%).

Table 5

Breaking up of the multiple determinational coefficient R^2
Path-analysis

	p_i	p_i^2		total effect
Gold crown	p(1)= 0,897	(80,5%)	r(Y,1)= 0,7726	69,3%
Cost of production	p(2)= 0,266	(7,1%)	r(Y,2)= 0,0763	2,0%
Production system	p(3)= 0,221	(4,9%)	r(Y,3)= 0,2075	4,6%
Rainfall in April	p(4)= −0,370	(13,7%)	r(Y,4)= 0,3315	−12,3%
Rainfall in May	p(5)= −0,036	(0,1%)	r(Y,5)= −0,0505	0,2%
Rainfall in June	p(6)= 0,062	(0,4%)	r(Y,6)= 0,0519	0,3%
Rainfall in July	p(7)= −0,031	(0,1%)	r(Y,7)= 0,1965	−0,6%
Temperature in April	p(8)= −0,223	(5,0%)	r(Y,8)= −0,2597	5,8%
Temperature in May	p(9)= 0,048	(0,2%)	r(Y,9)= −0,2572	−1,2%
Temperature in June	p(10)= −0,358	(12,9%)	r(Y,10)= −0,4377	15,7%
Temperature in July	p(11)= 0,712	(50,6%)	r(Y,11)= 0,0349	2,5%
				86,3%

On the basis of all the influences which are the resultant of direct and joint effects in pairs it can be observed that the dispersion of crops is conclusively caused by the soil's gold crown value (69,3%); the role of mean temperature in June (15,7%) as well as that of the rainfall in April (−12,3%) can be mentioned.

Direct and joint influences explain crop dispersion in 86,3%. Accordingly:

$$P_E^2 = 1 - 0{,}863 = 0{,}137 = 13{,}7\%.$$

That is, the total crop dispersion as dependent variable only in 13,7% cannot be accounted for with the linear effect of independent variables x_i $(i=1,2, ..., 11)$.

Table 6

Breaking up of the multiple determinational coefficient R^2

	$2p_ip_jr_{ij}$
Gold crown-cost of production	5,9%
Gold crown-production system	6,9%
Gold crown-rainfall in April	−13,3%
Gold crown-rainfall in May	1,3%
Gold crown-rainfall in June	0,0%
Gold crown-rainfall in July	−1,9%
Gold crown-temperature in April	10,4%
Gold crown-temperature in May	0,0%
Gold crown-temperature in June	9,6%
Gold crown-temperature in July	−41,3%
Cost of production-production system	− 1,8%
Cost of production-rainfall in April	4,7%
Cost of production-rainfall in May	− 0,7%
Cost of production-rainfall in June	1,5%
Cost of production-rainfall in July	− 0,7%
Cost of production-temperature in April	− 5,6%
Cost of production-temperature in May	− 0,1%
Cost of production-temperature in June	2,5%
Cost of production-temperature in July	−15,8%
Production system-rainfall in April	5,7%
Production system-rainfall in May	− 0,2%
Production system-rainfall in June	0,5%
Production system-rainfall in July	− 0,1%
Production system-temperature in April	1,5%
Production system-temperature in May	− 0,7%
Production system-temperature in June	1,7%
Production system-temperature in July	−14,0%
Rainfall in April-rainfall in May	− 0,2%
Rainfall in April-rainfall in June	1,5%
Rainfall in April-rainfall in July	− 0,1%
Rainfall in April-temperature in April	− 6,7%
Rainfall in April-temperature in May	0,6%
Rainfall in April-temperature in June	−10,1%
Rainfall in April-temperature in July	−34,0%
Rainfall in May-rainfall in June	− 0,4%
Rainfall in May-rainfall in July	0,1%
Rainfall in May-temperature in April	0,7%
Rainfall in May-temperature in May	0,3%
Rainfall in May-temperature in June	− 1,7%
Rainfall in May-temperature in July	0,8%
Rainfall in June-rainfall in July	− 0,2%
Rainfall in June-temperature in April	− 1,7%
Rainfall in June-temperature in May	− 0,3%
Rainfall in June-temperature in June	1,9%
Rainfall in June-temperature in July	− 3,1%
Rainfall in July-temperature in April	0,6%
Rainfall in July-temperature in May	0,0%
Rainfall in July-temperature in June	− 0,6%
Rainfall in July-temperature in July	1,4%
Temperature in April-temperature in May	− 0,1%
Temperature in April-temperature in June	− 0,7%
Temperature in April-tempearature in July	3,2%
Temperature in May-temperature in June	− 3,0%
Temperature in May-temperature in July	0,3%
Temperature in June-temperature in July	6,1%

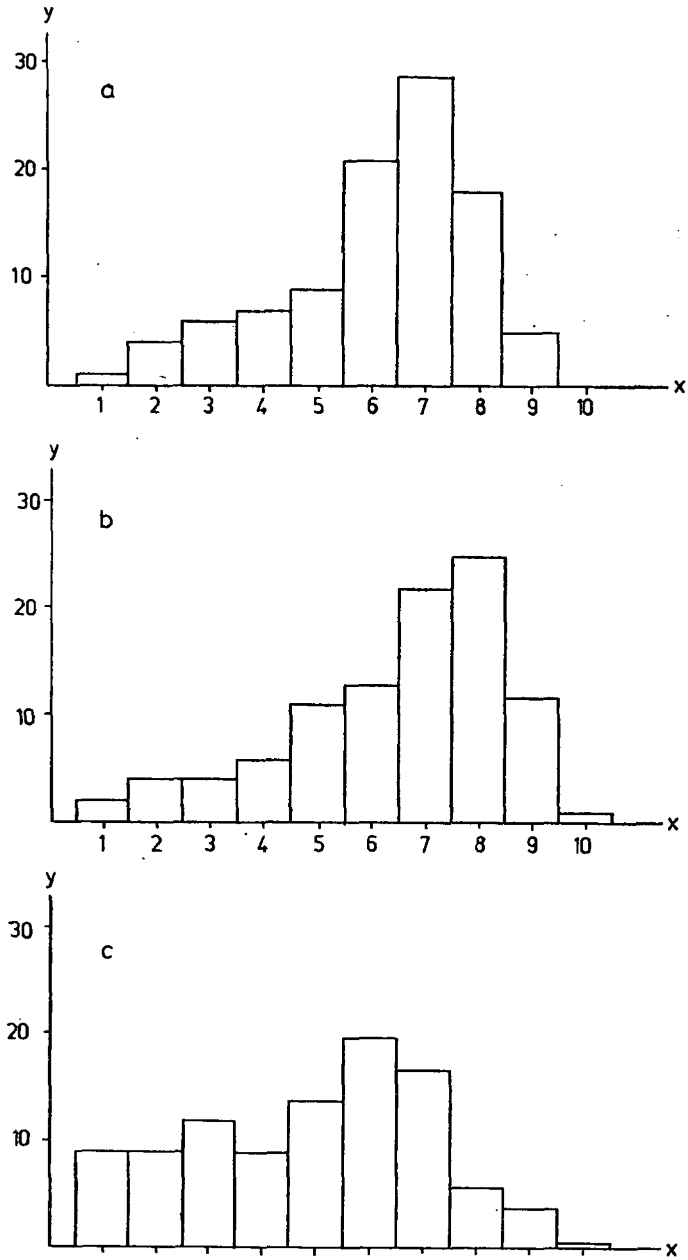

Fig. 4. Frequency polygon of the dispersion of average wheat crops in the different cooperatives (1980)
x=kg/ha
y=%
a=Bács-Kiskun county
b=Békés county
c=Csongrád county

Dataprocessing was executed with two different methods and with the help of computer type HP 9831. Both obtained results reflect that wheat crops stand in close relationship with the soil's gold crown value, rainfall in April and with mean temperature in June. The path-analysis, however, attributes more significance to the variables considered at the dispersion of crops.

References

[1] *Abonyiné Palotás, J.:* Hozzászólás a búza terméseredményének értékeléséhez. (Remarks to the appraisement of the wheat crop.) Acta Agronomica Martonvásár, 1980,

[2] Bács-Kiskun, Békés és Csongrád megye statisztikai évkönyvei. KSH 1962—1980. (Statistical year-books of Bács-Kiskun, Békés and Csongrád counties.)

[3] *Bernát, T.—Enyedi, G.:* A magyar mezőgazdaság területi problémái. (Regional problems of the Hungarian agriculture.) Akadémiai Kiadó, Budapest 1977.

[4] *Péczely, G.:* Éghajlattan. (Climatology) Tankönyvkiadó, Budapest 1979.

[5] *Sváb, J.:* Biometriai módszerek a kutatásban. (Biometrical methods in research.) Mezőgazdasági Kiadó, Budapest 1973.

[6] *Jahn, W.—Vahle, H.:* A faktoranalízis és alkalmazása. (The factor analysis and its application.) Közgazdasági és Jogi Kiadó, Budapest 1974.

[7] *Varga-Haszonits, Z.:* Az őszi búza területi termésátlagának előrejelzése meteorológiai paraméterek alapján. (Forecasting of the regional average yield of autumn wheat on meteorological parameters.) Időjárás **83** (1979), 6. 332— pp.

[8] *Varga-Haszonits, Z.:* Agrometeorológia. (Agrometeorology). Mezőgazdasági Kiadó, Budapet, 1977.