THE SPATIAL AND TEMPORAL VARIABILITY OF DROUGHT IN THE SOUTHERN PART OF THE GREAT HUNGARIAN PLAIN

by

L. Makra—Á. Kiss—Yolande Palotás

Az aszály tér- és időbeli változékonysága a Dél-Afföldön. A tanulmány a Dél-Alföld három megyéjében (Bács-Kiskun, Békés és Csongrád), valamint Szolnok megyében az aszály tér- és időbeli változásait elemzi, továbbá egyes haszonnövények terméseredményeinek az időjárási tényezőkkel való kapcsolatát vizsgálja. A vizsgálatok 14 állomás 1953—1983 közötti 31 éves idősorait, valamint a búza, a kukorica és a cukorrépa megyénkénti átlagos terméshozamának 1960—1983 közötti 24 éves idősorait dolgozzák fel.

A Dél-Alföldön a vízellátottság — bár térben és időben igen változékony — minden esztendőben negatív mérleggel zárul, sőt egyes években félsivatagi jelleggel párosul. A szeszélyes vízellátottság a termőtalaj vízkészletének változásaiban élesen tükröződik; a nyári félévben is várható maximális víztelítettség, de a nyár közepétől egyre gyakoribb az aszálykárt okozó szűkös talajnedvesség.

Megállapítható, hogy a fentebb említett haszonnövények terméshozama az agrotechnika színvonalának emelkedése ellenére is erősen függ a természeti tényezőktől. tehát az öntözés és a megbízható öntözőbázis kiépítése a Dél-Alföldön feltétlenül kívánatos.

The study analyses the spatial and temporal changes of drought in three counties of the southern part of the Great Hungarian Plain (Bács-Kiskun, Békés and Csongrád counties) as well as in Szolnok county, furthermore it investigates the relationship of the crop results of certain cultivated plants to the meteorological factors. In this study have been processed the time series of the 31 years for the period 1953—1983 at 14 stations, as well as the time series of the 24 years for the period 1960—1983 of the average yield of wheat, corn and sugar-beet in each county.

The water supply in the southern part of the Great Hungarian Plain — although it is spatially and temporally very changeable — has a negative balance in each year, in some years it is even accompanies with a semi-desert character. The changeable temporal course of precipitation strongly manifests itself in the stock of soil water; the greatest water saturation can be expected even in the summer half-year, but the poor soil humidity causing drought damage is more and more frequent from the middle of the summer season on.

It can be set down that the crop results of the above-mentioned cultivated plants considerably depend on natural factors even in spite of the rise of agrotechnics, consequently the irrigation and the extension of a reliable irrigation base in the southern part of the Great Hungarian Plain is by all mean desirable.

Plant cultivation is that branch of our economy which responds in the most sensitive way to the changes of weather. The changeable weather of the recent period has emphasized the different problems connected with this question, first of all how the quantity and quality of agricultural production and so the economic output are modified to negative or positive direction from the average of many years by the changes of certain weather components.

The change of different factors of weather independently results in remarkable deviations in the yields but if the different factors change simultaneously their economical effect can be manifested in a stronger way.

As compared to the past the nowadays widespread modern methods of agriculture may moderate the increase or decrease of agricultural yield caused by weather changes, but the use of these methods means a substantial increase of expenses. This means that we have to remain competitive in every respect among more unfavourable international marketing circumstances and facing higher expenses. And this requires even more *the most effective utilization of our natural resources.* It must be noted that we have huge unexploited resources in this respect. In order to mobilize these resources the deep knowledge of individual or simultaneous effects of different elements of weather on plant production is necessary. According to the present state of science we know very little about this extremely complex system which has direct and indirect influence on agriculture with a lot of uncertainty factors, not speaking about the practical utilization. During our studies we have narrowed down this complicated relationship because of practical reasons.

The amount of precipitation during the growing season and related to this the variation of the water content in the upper layer of the soil have a crucial importance in the agricultural production. Since the greatest part of the root of our cultivated plants can be found in the top one-meter thick soil, it is mainly the water-content changes of this one-meter thick soil stratum is which is important, for the large scale cultivation. The experiences of a number of years show that on our arid plain the water content of the soil decreases so much during the vegetation period that it must be irrigated in order to gain a plentiful yield. At the same time it is characteristic of our changeable climate that often, sometimes even in the summer-time, because of the abundant amount of precipitation the upper soil stratum gets saturated by water, for a longer or shorter period there is excess water, and because of this a large amount of inlandwater shows up in the deeper regions of the Plain. After all we have to take into account both extremities, the destroying drought and harmful excess water, and one of the most important tasks of the Hungarian climatology is to document these phenomena and their interactions.

The drought as well as the abundant water is the complex result of different meteorological processes, thus it would be a one-sided and wrong point of view to study the occurance of these events on the basis of only amount of precipitation. Their real manifestation is reflected in the amount of soil water, which is determined by the uptake and release of water of the soil with a given structure and set of physical parameters. The uptake of water is supplied by the precipitation among natural conditions while the release of water is a result of the evaporation and flow of water. In flat areas the flow is negligible so we will not take it into account.

In our studies we consider a simplified soil structure model at every sampling point reaching from the surface to the depth of one meter and we consider its utilizable (available) water capacity [1], which can be accepted as competent to the soils around the examined points. Furthermore we suppose in our model that there is no lateral upward or downward transport of water (capillarity effect) in a given volume. The first assumption is reasonable for plain regions but the second one is a necessary simplification of reality (assumption of isolated soil volume) still as working hypothesis it can be well used. With these assumptions the uptake of water, V_b, during a given time-period can be taken to be equal to the amount of precipitation while the loss of water, V_k, is supposed to be equal to the evaporated amount, so that for a given period there exists the relationship:

$$V_b - V_k = \pm V_t \tag{1}$$

where V_t stands for the storage of water during the time-period (in our case this means the change of water content in the one-meter thick soil stratum). If the soil is saturated by water and a continuous supply of evaporated water is guaranteed, V_k will be equal to the so-called potential evaporation, and in the case of soil covered by vegetation it will be equal to the potential evapotranspiration.

If the soil is not saturated to its whole capacity the actual evapotranspiration will be less than the potentional one and it can even disappear if the available water supply of the soil stratum disappears and there is no water supply (precipitation) [2].

The determination of the variation of the water content in the soil stratum requires regular measurements of the soil humidity. But there are no long data sets concerning soil humidity so we use different mathematical methods. In the following we present shortly the principle of the calculation used in the simplified soil model [3].

If V_0 stands for the amount of water in the soil at the beginning of a given time-period and V means that at the end of the time-period, then:

$$V = V_0 + C - P \tag{2}$$

where C is the amount of precipitation, P is the evaporated amount of water (evapotranspiration) during the time-period considered. The quantity "C" appearing in the equation comes from the precipitation measurements, the value of V_0 can be determined in the simplest way by a single measurement of the soil humidity or by choosing a precipitation-rich period in the winter season when because of the negligible level of evaporation we can assume that the soil stratum is completely saturated, so V_0 can be taken to be equal to the total available water capacity. In this case the value of P is assumed to be equal to the P_p potential evapotranspiration as long as $C > P_p$ holds. The potential evapotranspiration was given by *Antal*'s relationship:

$$P_p\,(\text{mm/day}) = 0{,}9(E-e)^{0{,}7}\left(1+\frac{t}{273}\right)^{4{,}8} \tag{3}$$

where "E" and "e" are the saturation vapour pressure and the actual vapor pressure respectively, belonging to the average air-temperature of the season or month studied, and t is the average air-temperature of that period (°C).

The calculations were carried out according to the meteorological data of fourteen meteorological stations from the Great Hungarian Plain. The main parameters, the dominant soil types and the length of the time series can be found in *Table 1.*

Table 1

The parameters of the stations considered

Stations	Period under survey	Co-ordinates h	φ	λ	Soil types
Ásotthalom	1953—1971	117	46°12′	19°47′	blown sand
Baja	1931—1983	109	46°10′	18°58′	shedding
Békéscsaba	1931—1983	90	46°40′	21°07′	fields
Kalocsa	1931—1983	96	46°32′	18°59′	meadow, fields
Karcag	1951—1971	87	47°18′	20°55′	fields
Kecskemét	1947—1983	112	46°54′	19°43′	blown sand
Kiskunfélegyháza	1953—1971	102	46°43′	19°51′	blown sand
Kiskunhalas	1973—1983	132	46°26′	19°29′	blown sand
Mezőhegyes	1935—1983	100	46°19′	20°49′	sodic, fields
Orosháza	1931—1983	90	46°34′	20°40′	fields
Szarvas	1952—1983	85	46°52′	20°32′	meadow
Szeged	1931—1983	79	46°15′	20°09′	shedding, meadow
Szolnok	1952—1983	95	47°11′	20°13′	shedding, fields
Túrkeve	1953—1983	89	47°07′	20°45′	fields

During the evaluation we processed 50 000 data. The longest processed time series come from Baja, Békéscsaba, Kalocsa, Orosháza and Szeged (1931—1983, 53 years), while we have only fraction time series from Ásotthalom, Kiskunfélegyháza and Kiskunhalas, so the results that we got from the latter group are considered only informative. In order to get uniform survey — where it was possible — we analyzed the time series of different stations for the period of 31 years between 1953—1983.

For the solution of equation (2) we have to know the value of the actual evapotranspiration P as well. This depends on the amount of water available for the evaporation and on the potential evapotranspiration, and after some simplification as a good approximation we can accept the following relationship:

$$P = \frac{V}{V_d} P_p \tag{4}$$

where V stands for the water content of the soil stratum studied and V_d stands for the value of available water capacity. In our calculations on the first of March after the wet winter season in 1952/53 we assumed for the individual water content (for different soil types): $V_0 = V_d$(mm), and knowing the P_p and C values we determined the value of the water content V continuously for the first day of each month, and expressing them as the fraction of available water content in percent we got the percentage of water content of the upper one meter. (Each of the starting data was preceeded by a wet winter season.)

The data we got represent properly the characteristics of the water budget of the upper soil stratum, but at the same time they are appropriate to inform us about the frequency of arid and humid years. For the determination of humid character of climate we can use the Budiko's index of aridity [4]

$$H = \frac{P_p}{C}, \tag{5}$$

where we take into account the yearly amount of potential evapotranspiration and the yearly amount of precipitation. If $H > 1$ more water can evaporate from the soil than is supplied by precipitation, so the climate becomes arid, while in the case of $H < 1$ the uptake of water is higher than the release, so there is abundance of water so the climate is humid.

According to our estimations the characteristic average value of the index of aridity for our Plain region is between 1,46—1,80 which in *Budiko*'s classification corresponds to the prairy, what's more that type of it with unfavourable precipitation supply. When calculating the yearly aridity index on the basis of the yearly sums of P_p and C we find values which deviate significantly from the average (1,65). While the minimal average index value (1,07) is characteristic of the border between arid and humid climate territories, the maximal average aridity index (2,59) corresponds in the plant geographical sense to the half desert or even its drier type *(Table 2)*, It can be stated that — although in Mezőhegyes in about 10% of the years studied the humid character dominated — in this territory with typically arid climate the appearence of humid years is occasional. The average relative frequency of values $1 < H \leqq 1{,}5$ in this territory is even less than 50% (these values correspond in a plant geographical sense to a prairy with relatively favourable precipitation conditions), while the values $1{,}5 < H \leqq 2$ (dry steppe) appear in every third year in average and we can expect a half-desert-like climate ($H > 2$) almost in every four year in the Southern Great Plain *(Table 2)*.

Table 2

Characteristics of the aridity index ($H=P/C$) and that of the lack of water (P_p-C) in the summer half-year

Stations	Hmin	$\bar{H}$	Hmax	P_p-C min	$\overline{P_p-C}$	P_p-C max	$H>2$ %	$1,5<H\leqq 2$ %	$1<H\leqq 1,5$ %
Ásotthalom	1,13	1,65	2,39	158	371	628	21	37	42
Baja	1,06	1,57	2,87	77	345	606	16	32	52
Békéscsaba	1,04	1,63	2,29	100	354	615	16	42	42
Mezőhegyes	0,95	1,46	2,11	46	312	573	3	42	52
Kalocsa	0,99	1,56	2,24	−21	325	575	16	39	45
Karcag	0,98	1,68	2,57	97	339	526	26	26	48
Kecskemét	1,15	1,73	2,62	106	362	566	32	26	42
Kiskunfélegyháza	1,21	1,72	2,59	189	398	601	32	37	31
Kiskunhalas	1,14	1,42	2,43	4	280	544	9	18	73
Orosháza	0,94	1,66	2,72	70	361	654	29	35	36
Szarvas	1,12	1,65	2,89	108	348	553	23	39	38
Szeged	1,03	1,79	2,88	90	370	657	29	39	32
Szolnok	1,12	1,72	2,46	85	357	617	26	35	39
Túrkeve	1,15	1,80	3,14	120	404	664	42	23	35
Average	1,07	1,65	2,59	88	352	599	23	34	44

Abbreviations used: $\bar{H}$, $\overline{P_p-C}=$ the reginal average of the aridity index and that of the lack of water in the summer half- year

$H_{\min}$, $H_{\max}$, $(P_p-C)_{\min}$, $(P_p-C)_{\max}=$ the extremes of the parameters mentioned above

Using the calculated aridity index values we have plotted the isoarid curves (*Fig. 1.*) which give the rough approximation of the water supply of this region. According to these the worst water supply conditions can be found in the lower Tisza region and the territories north of the Körös rivers.

The meteorological value of shortage of water is well characterized by the difference of the values P_p and C corresponding to the summer season. It can be seen by

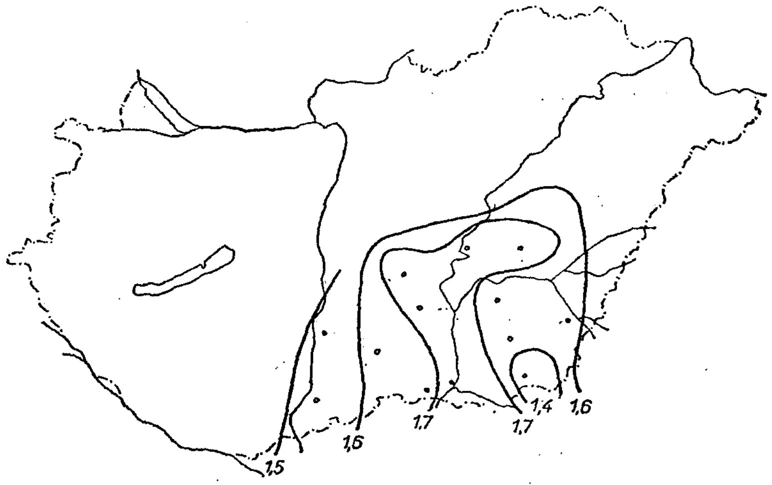

Fig. 1. The average values of the aridity index, 1931—1980

calculating and plotting these values that they strongly fluctuate from year to year. The average minimal lack of water is as little as 90 mm, (only in Kalocsa and in the summer season of only one year was the lack of water negative which means that there was abundance of water), and the average maximum value is 600 mm. The aridity index and the time series of the lack of water in the summer season as well show *(Figs 1—23)* that the driest years in the Southern Great Plain appeared between 1946—1951, and though since that time the degree of aridity with significant fluctuations has decreased it has been increasing since 1982 again. The plot of the lack of water in the summer season *(Fig. 2)* is similar to the isoarid curves *(Fig. 1)*: the driest regions in the summer season are the Lower Tisza Region and the region immediately north of the Körös Rivers. The yearly average of the potential evapotranspiration in the Southern Great Plain is 863 mm. This means that the calculated values of x the potential evapotranspiration by *Antal*'s method and by *Turc*'s equation are in fair agreement [5]. The regional average of the yearly precipitation is 551 mm, and comparing this value to that of mentioned above we obtain that we can expect 300 mm as average lack of precipitation in the Southern Hungarian Plain.

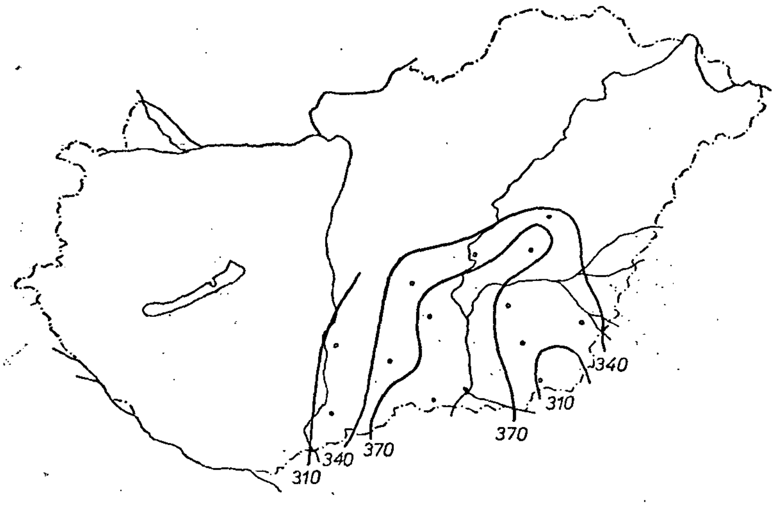

Fig. 2. The development of water deficiency in the summer season, 1931—1980

The data informing about the changes of the water content in the soil yield further information for the agriculture. According to the experience there is a need for irrigation when the water content of the soil becomes less than 80% of the available water capacity and drought exists when the water content is even less then 50% of the available water capacity [6]. The relative frequency of these soil watercontent values varies during the growing period as follows *(Table 3, Figs. 3—10, Table 4, Figs 11—18)*. In each month of the growing period the territories with the strongest necessity of irrigation are the middle part of the Great Plain and the Lower Tisza Region *(Figs. 3—18)*. In about one-third of the years from the middle of March and in 75% of the years or so from the middle of June, irrigation is necessary. Although the drying out of the soil starts at the end of summer or at the beginning of autumn, those species with earlier growing periods can be grown among much better soil humidity conditions; in about 10% of the years drought damage can be expected

Table 3

The relative frequency (%) of the event that in the growing period the water content of the soil becomes less than 80% of the available water capacity

Stations	IV	V	VI	VII	VIII	IX	X	summer half-year
Ásotthalom	11	37	74	89	74	79	89	89
Baja	13	39	61	77	71	94	84	87
Békéscsaba	29	39	58	84	68	90	97	74
Kalocsa	32	45	65	74	77	84	90	84
Karcag	42	47	58	79	79	84	89	79
Kecskemét	19	42	71	84	68	90	94	87
Kiskunfélegyháza	16	37	79	89	84	100	89	89
Kiskunhalas	9	36	36	82	55	82	91	82
Mezőhegyes	32	29	48	65	68	84	97	65
Orosháza	42	39	71	74	74	90	94	84
Szarvas	29	42	65	77	68	100	90	87
Szeged	48	58	68	81	84	94	90	94
Szolnok	52	68	77	87	84	97	90	90
Túrkeve	58	61	71	71	84	90	97	87

Table 4

The relative frequency (%) of the event that in the growing period the water content of the soil becomes less than 50% of the available water capacity

Stations	IV	V	VI	VII	VIII	IX	X	summer half-year
Ásotthalom	0	0	16	37	58	58	63	5
Baja	0	0	10	35	42	71	71	6
Békéscsaba	0	3	6	16	29	52	61	0
Kalocsa	0	0	0	23	35	45	68	0
Karcag	5	5	5	26	26	58	53	5
Kecskemét	0	6	10	52	55	58	68	6
Kiskunfélegyháza	0	0	11	42	47	79	79	5
Kiskunhalas	0	0	9	45	27	45	55	0
Mezőhegyes	0	3	3	6	23	29	52	3
Orosháza	0	3	13	23	35	58	55	6
Szarvas	0	6	10	29	32	55	74	10
Szeged	0	6	10	32	39	58	65	6
Szolnok	3	6	6	16	29	48	61	6
Túrkeve	3	3	13	29	42	58	68	10

even from the middle of May and almost in every third June there is dangerous lack of precipitation. At the end of summer the soil humidity conditions are much more unfavourable (in Aug. and in September the average relative frequency of aridity is 55—60%), which is harmful for meadow culture mostly.

In the following we would like to present the tendency of the changes of aridity in the future. To this purpose we use the method of harmonic analysis of mathematical statistics, the essence of which is that a given $y(x)$ periodical function is approximated by another function $f(x)$ which is equal or almost equal to $y(x)$:

$$f(x) = \bar{y} + \sum_{i=1}^{n} A_i \sin\left(\frac{2\pi}{T_i} x + U_i\right).$$

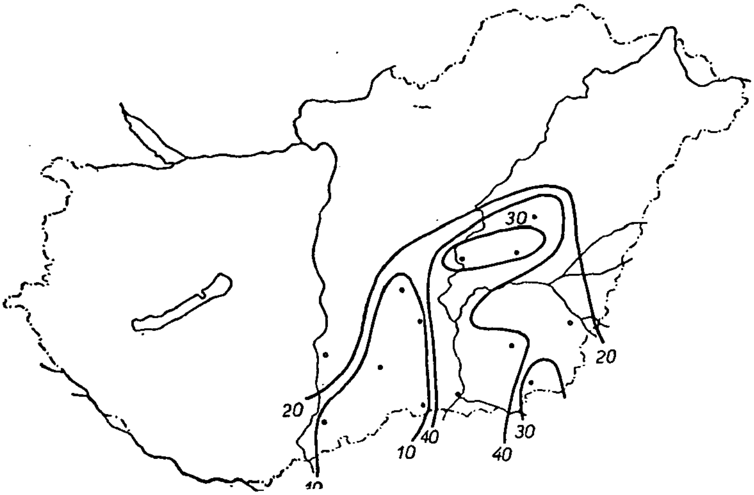

Fig. 3. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, 1st April

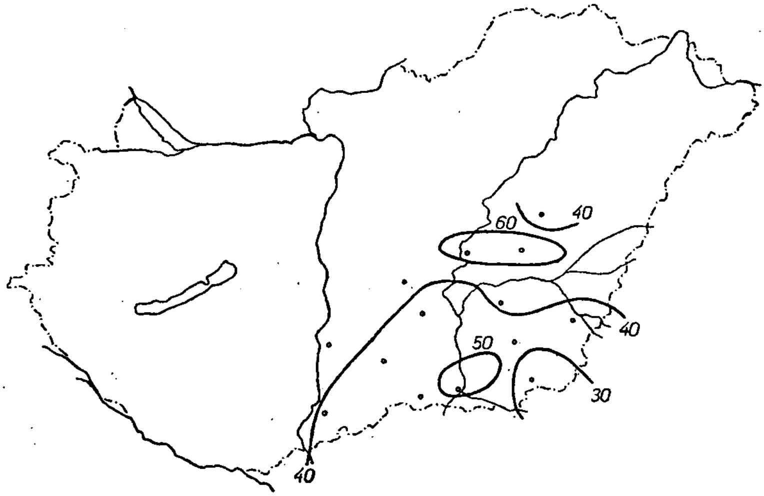

Fig. 4. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, 1st May

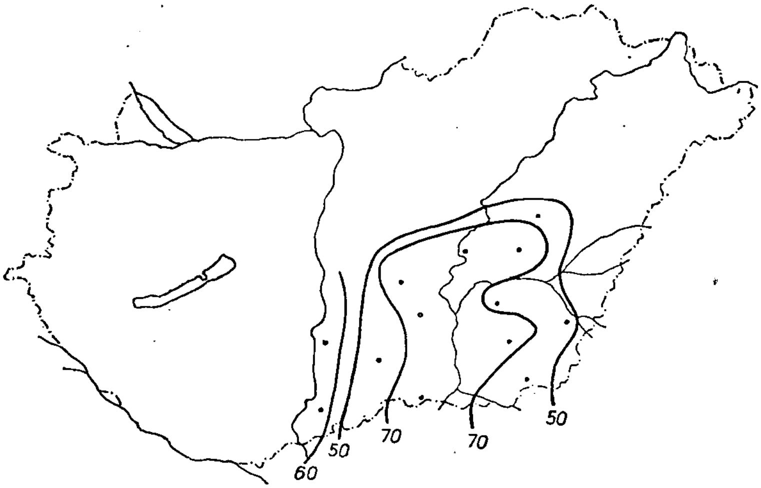

Fig. 5. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, 1st June

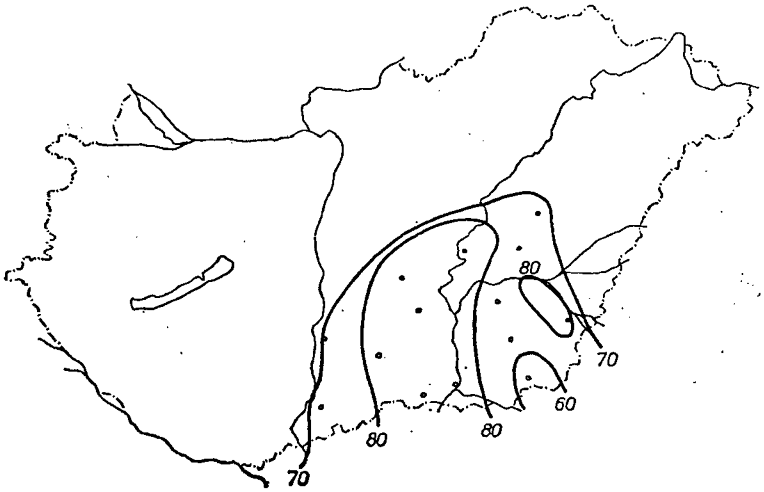

Fig. 6. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, 1st July

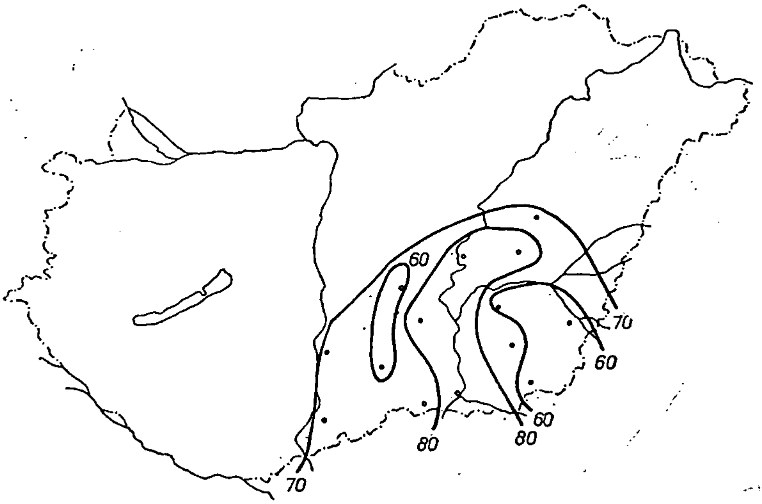

Fig. 7. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, 1st August

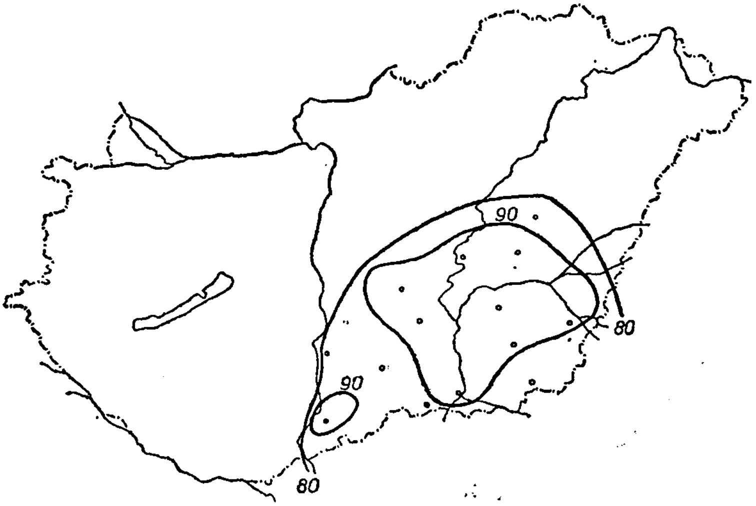

Fig. 8. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, 1st September

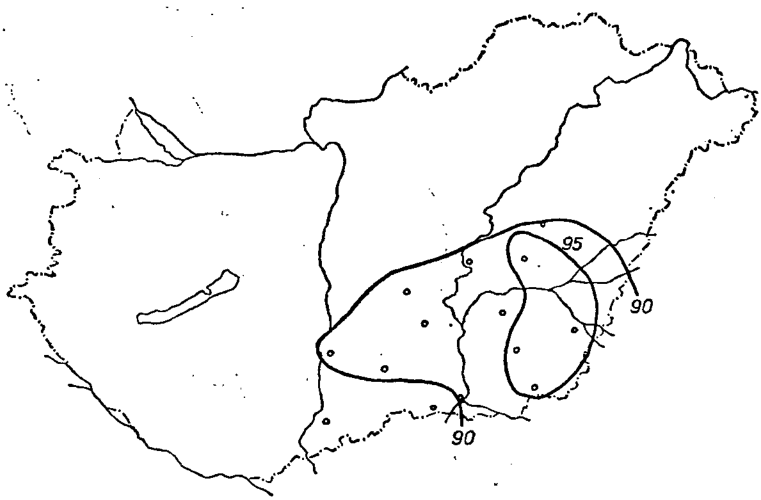

Fig. 9. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, 1st October

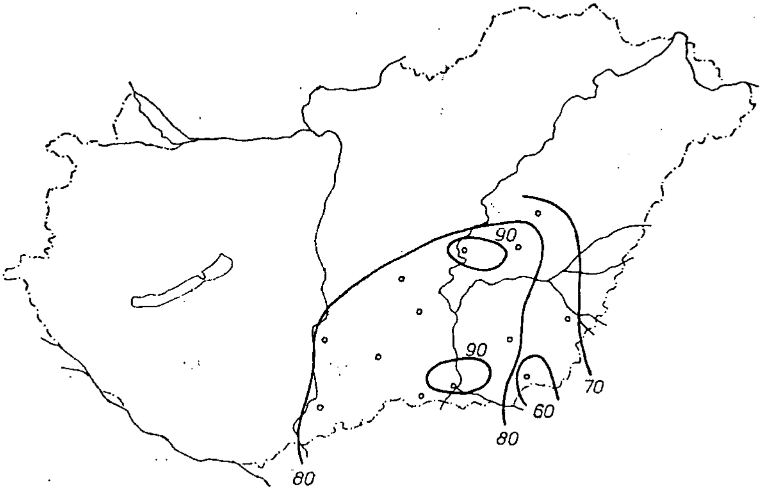

Fig. 10. The relative frequency (%) of the soil water content less than 80% of the available water capacity, 1931—1980, summer half-year

Fig. 11. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, 1st April

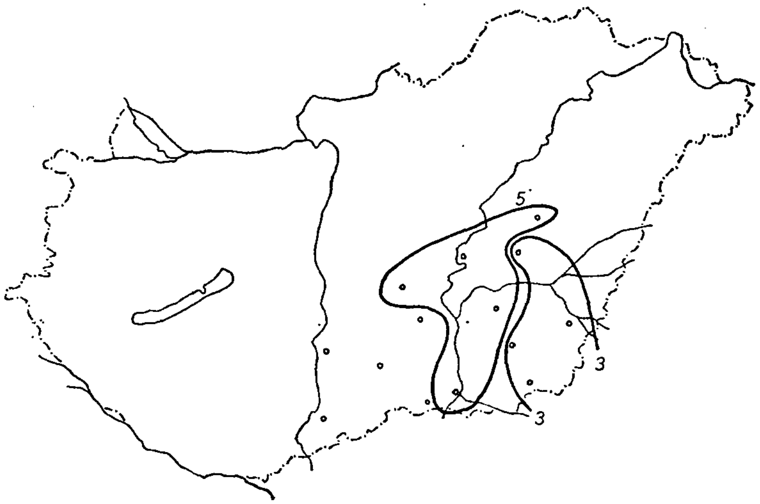

Fig. 12. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, 1st May

where x stands for time and its actual values are: $x=0, 1, 2, \dots, T-1$. U_i means the phase angle belonging to T_i, where $T_1=\frac{T}{2}, \dots, T_m=\frac{T}{m}$, $\bar{y}$ is the mean value of the series.

This method is suitable for the analysis of a given time series with a given length. Increasing the length of period, the number of waves running through the time series decreases, and above a certain limit also the statistical reliability of the characteristics of statistical fluctuations decreases (amplitude, phase angle).

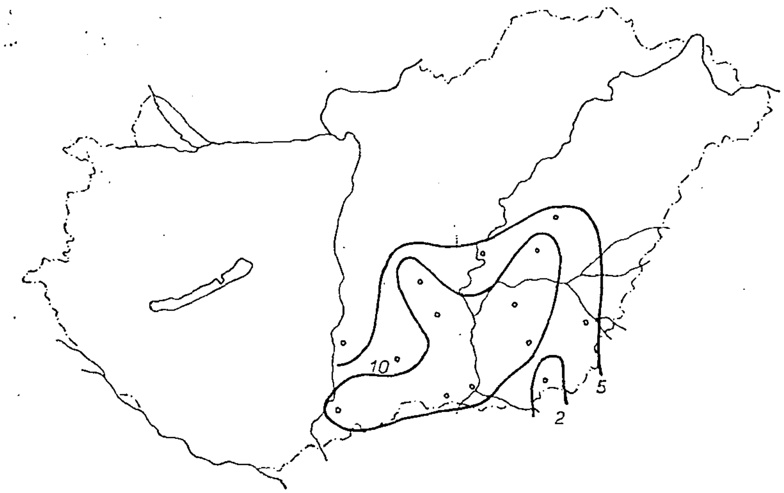

Fig. 13. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, 1st June

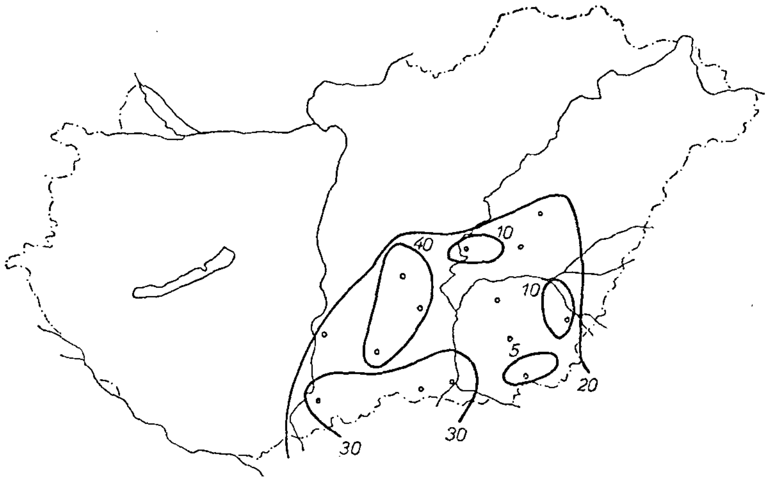

Fig. 14. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, 1st July

By the harmonic analysis of the time series of the areal average of aridity index instead of the $\frac{A}{E}$ values of the periodical component waves we have taken into account the $\frac{A}{\text{amplitude-average}}$ values especially those, greater than one (those amplitudes greater than the average) and the corresponding phase angles were chosen. (Because of the high distorsion of expectance we used the average of the amplitudes.) Using the latter we reconstructed the time series of the areal average of the aridity index.

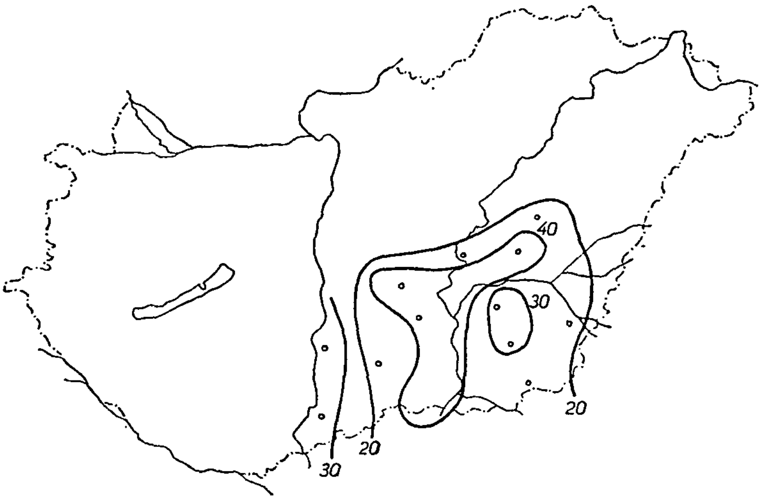

Fig. 15. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, 1st August

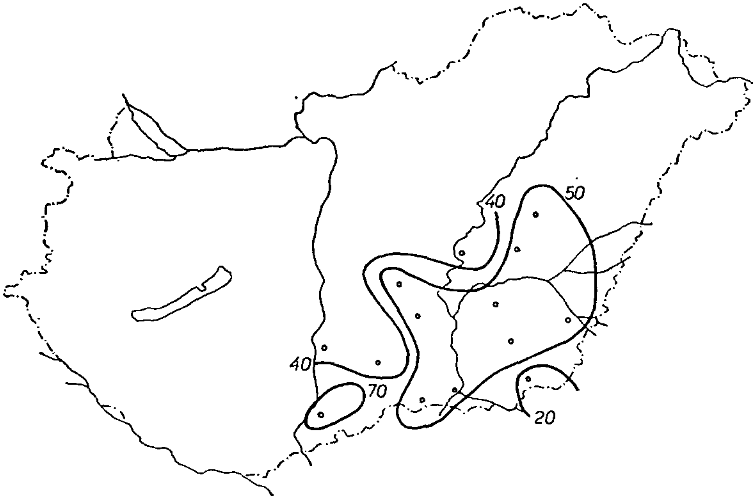

Fig. 16. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, 1st September

The next step was to correlate the original and the calculated time series: $r=0{,}2404$, which is significant at the 5% probability level. From these results it follows that the extension of the component waves in time beyond the present provides a good approximation to the areal average of aridity index of the future. We have performed the extrapolation for the next five years, including 1984.

By taking into account the areal average (1,65) of the aridity index of the 31 years between 1953—1983 we may give a rough forecast of the tendency. According to this

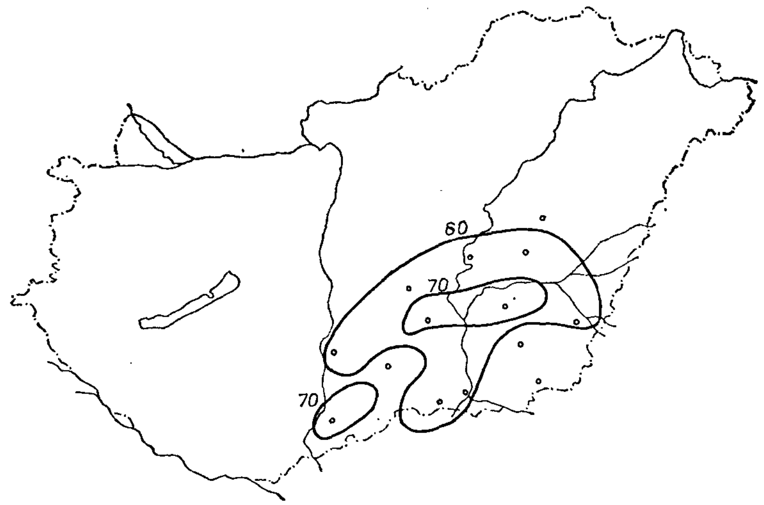

Fig. 17. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, 1st October

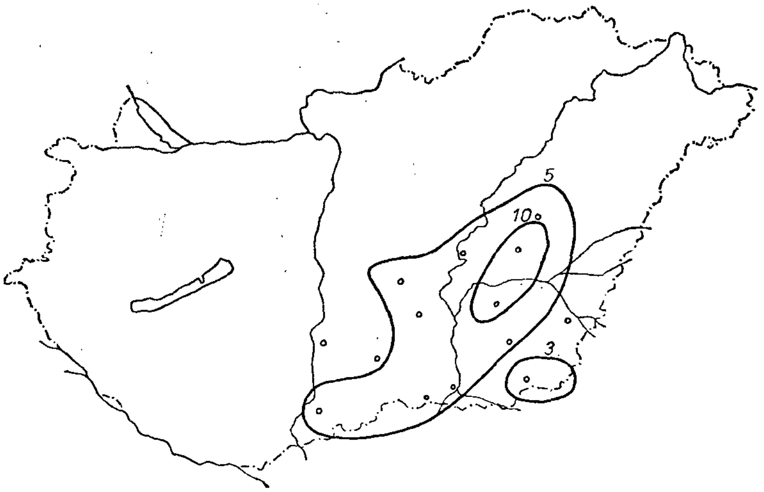

Fig. 18. The relative frequency (%) of the soil water content less than 50% of the available water capacity, 1931—1980, summer half-year

we can expect years with close to average but a little lower level of precipitation. (It must be noted however that we have to handle this type of tendency prediction carefully. The reason of it is that we can only take into consideration a substential but limited amount of reasons causing the change of a given meteorological parameter. The reliability of prediction would be greatly increased if we knew the physical origins, periodicities of the climate and we could explore their possible relations to the circulation of atmosphere.)

The next step was to examine these climatological factors in connection with some most important plant cultures. Since the regional distribution of the 14 involved stations in the four Great-Plain counties (Bács-Kiskun, Békés, Csongrád and Szolnok) is more or less uniform, and as the statistical information basis is similar, we correlated the above mentioned climatological factors to the average yields of these counties. We analyzed the time series of the average yields between 1960—83 (24 years). The examined plants were: wheat, corn and sugar-beet. The reason to choose these plants is that the 33,0% of the country's wheat producing fields and 33,6% of the country's total production of wheat belong to this territory and also the

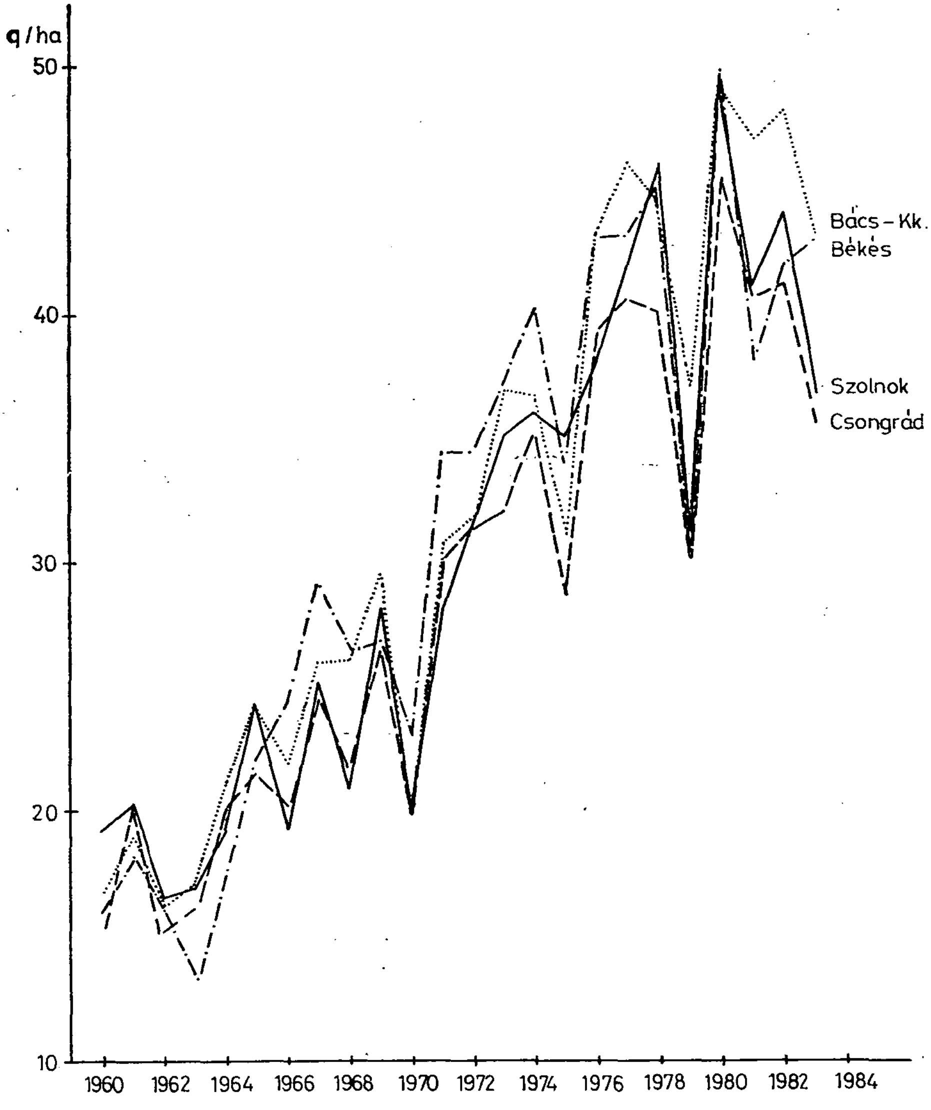

Fig. 19. The county average yeald of wheat (q/ha)

30,7% of corn fields and the 30,3% of corn yield comes from here whereas 40,1% of sugar-beet fields and the 39,1% of production come from these counties. At the same time only 31,2% of the country's total tillage land can be found here while it has only 29,2% of the total agricultural territories.

In the following we present the time series of the county-average yields of wheat, corn and sugar-beet, respectively *(Figs, 19, 20, 21)*. The figures show that the weather dependence of these plant cultures in these territories is similar to each-other. It is interesting however that the variance of these yields ($R_{\max}-R_{\min}$) which is characteristic of the weather dependence shows significant deviations from county to county. While for instance in the case of wheat the variance caused by the weather dependence is the biggest in Bács-Kiskun County ($R=36{,}2$ q/ha), it is the biggest for corn in Békés county ($R=53{,}2$ q/ha), and for sugar-beet in Csongrád county ($R=261{,}0$ q/ha). The high value of these parameters also show that the climate

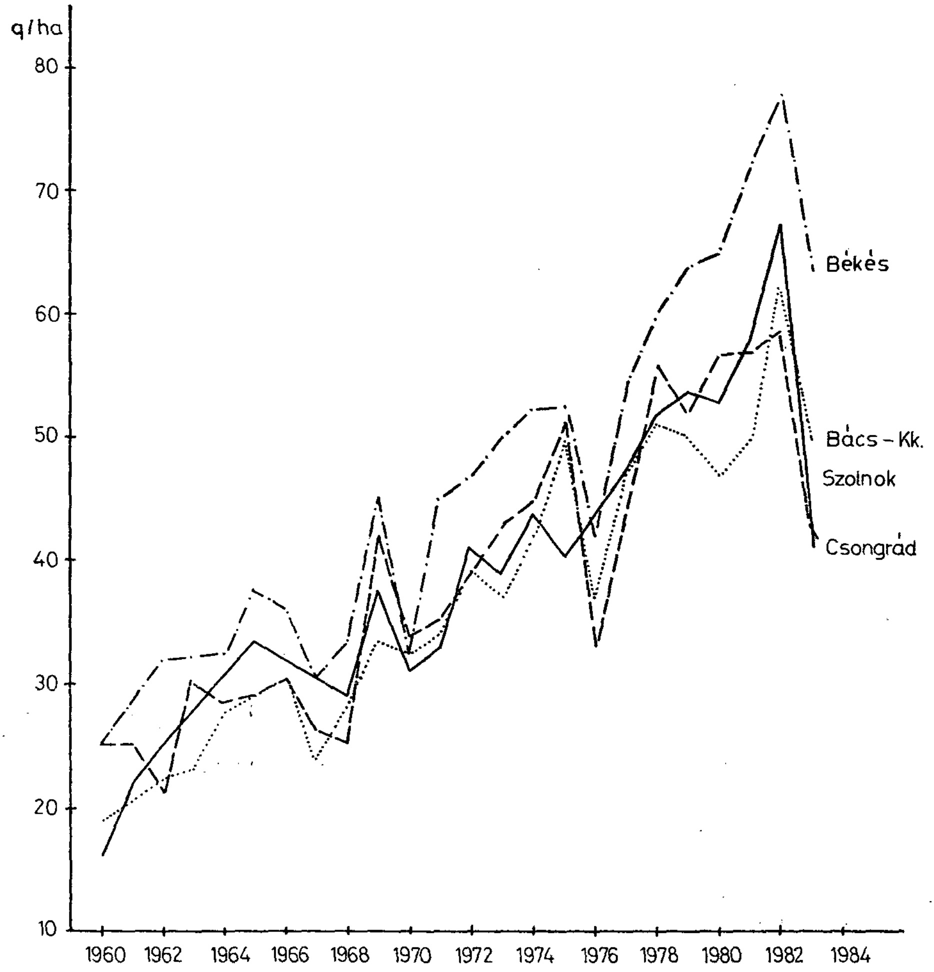

Fig. 20. The county average yeald of corn (q/ha)

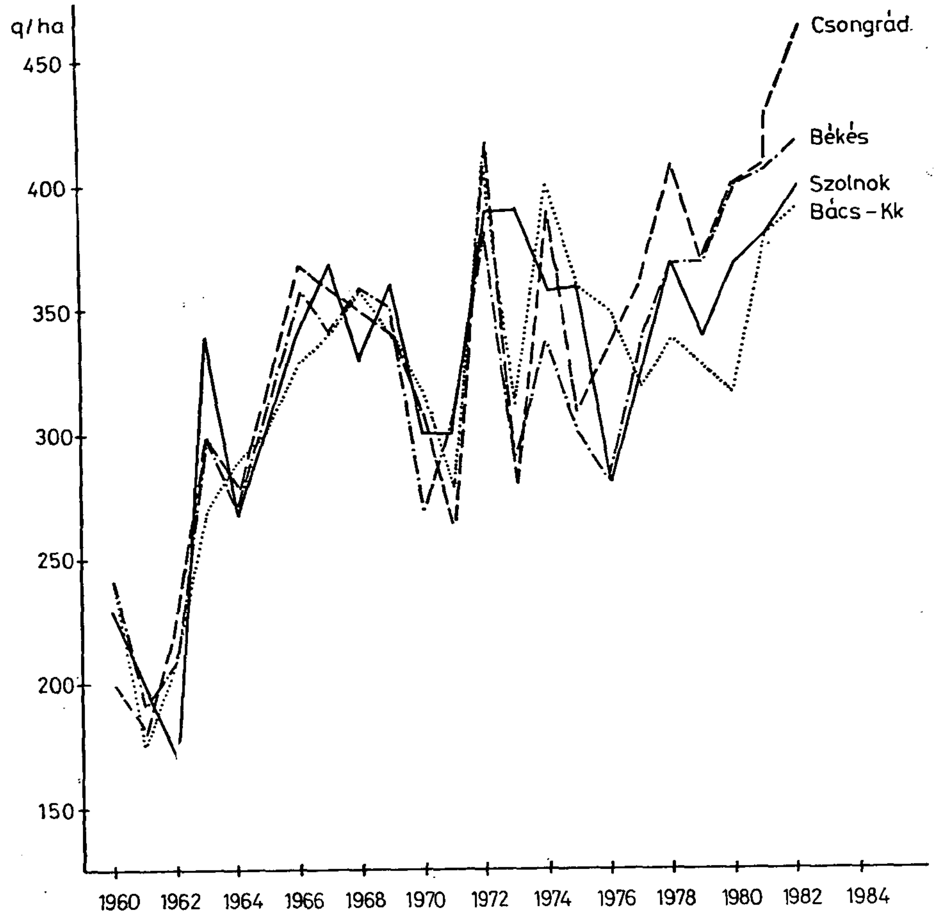

Fig. 21. The county-average yeald of sugar-beet (q/ha)

factors also play a crucial role in the development of yields even among today's modern agrotechnical circumstances.

During our studies we compared the yields to the total amount of precipitation of the summer season. Our investigations involved the precipitation dependence of the yields of corn and sugar-beet. On the basis of the 24 years long time series between 1960—1983 we can conclude the followings. The correlation coefficients between the yield of corn and the total precipitation of the summer season are as follow:

in Bács-Kiskun county	0,0727
in Békés county	0,2458
in Csongrád county	0,2558
in Szolnok county	0,3403

It is only in Szolnok county where we obtained a real precipitation dependence in the case of corn *(Fig. 22)*.

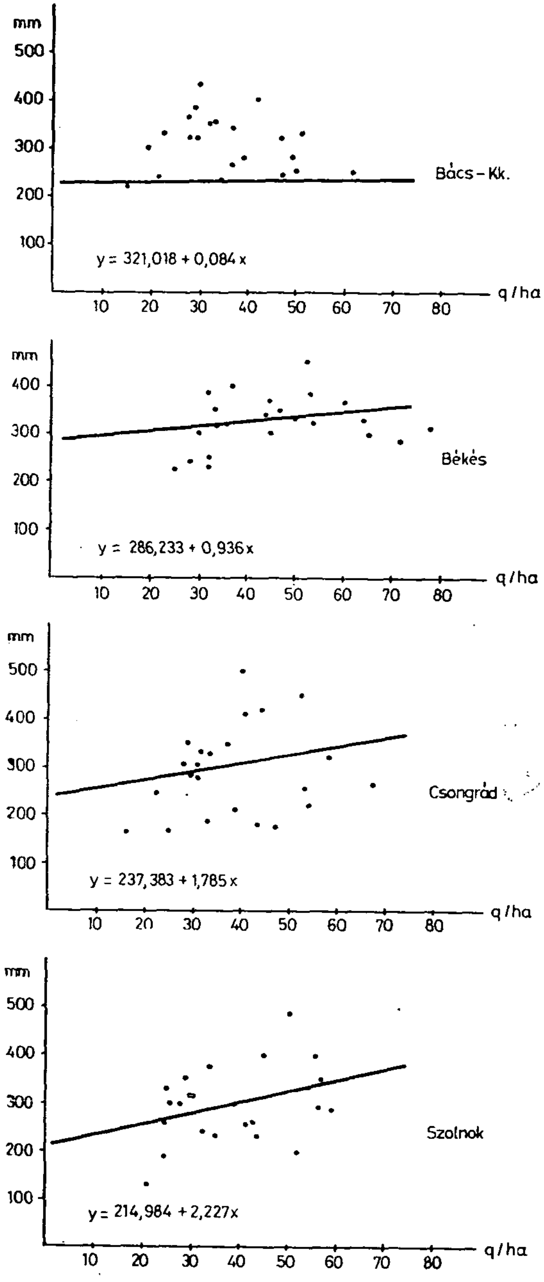

Fig. 22. Connection between the county-average yealds (q/ha) and the summer half-year precipitation totals (mm), corn, 1960—1983

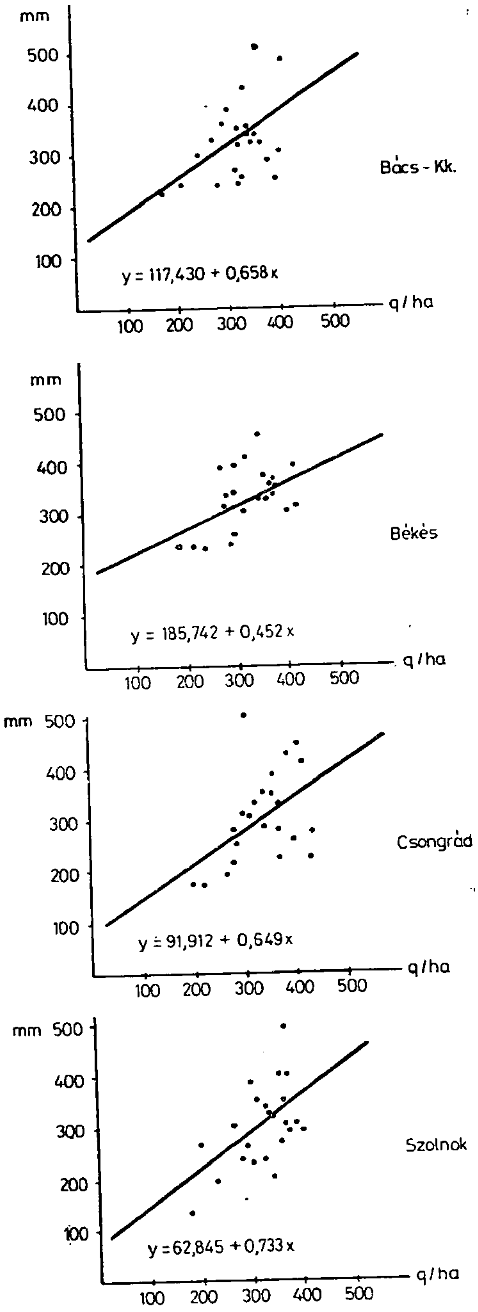

Fig. 23. Connection between the county-average yealds (q/ha) and the summer half-year precipitation totals (mm), sugar-beet, 1960—1983

The correlation coefficients between the yield of sugar-beet and the total precipitation of the summer-season are as follow

in Bács-Kiskun county	0,5010
in Békés county	0,2665
in Csongrád county	0,5263
in Szolnok county	0,5545

It is evident from the time data sets that in the case of sugar-beet the total summer season precipitation plays a crucial role among the different natural factors in the variation of yield *(Fig. 23.)*, whereas in the case of corn the summer season rain is not exclusively determining. It is well-known that corn is especially sensitive to the great fluctuations of temperature.

In summary we can conclude that the amount of precipitation in the Southern Great Plain — although it is rather changeable in space and time — ends with a negative balance each year and in extremely arid years it has a half-desert character. The changeable water supply is strongly reflected in the variation of the soil-water content as we can expect maximal water saturation also in the summer season but from the middle of the summer the low level of water content causing aridity is more and more frequent. We can also conclude that despite of the improving quality of agrotechnics the dependence of the yield of the studied plant cultures on the natural factors shows still very significant deviations. We can emphasize that the yearly repeating long-lasting lack of water showing regional variations must be retrieved by irrigation. In order to compensate the dry periods which are rather frequent according to our studies and to improve the inclination of cooperatives to irrigate the economical regulations can also be used (much improvement has been made in this direction in 1984).

Because of the complexity of the subject we could only discuss some of its aspects but these seem to be enough to draw the following conclusion: the cooperatives must build their own reliable irrigation facilities in the future.

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