ECOLOGICAL FACTORS INFLUENCING THE CULTURE OF SZEGED PAPRIKA

by

DR. EMIL KORPÁS

and

DR. ISTVÁN PÉNZES

Introduction

One of the major aims of socialist reorganization of our agriculture is to effectively increase the average yield of crop plants, to raise by leaps the productivity of labour and to achieve thereby the production of larger quantities. Beyond the introduction of new agrotechnical methods and of the mechanization of labour, increasing of average crops and of volumes very much depends also on the application of experimental results. According to plans, great care is taken, besides plants of nation-wide interest, to increase the average yield of special crops, to improve their quality and to augment the acreage, etc. as is the case, e. g. with paprika.

In Hungary paprika has been grown since the Turkish occupation and since then has been utilized as a favourite spice to flavour our food. Hungarian paprika as a spice has a wide market. More than once, demand exceeds offer, because in the regions that in the course of history specialized in this culture, average crops and qualities fluctuate and largely depend on weather conditions.

The Agricultural Experimental Institute for the South Plain has already been of great help to the development of paprika growing. Particularly in improving the quality of crops have we achieved appreciable results. The Institute has studied the possibilities of increasing average yields and of improving the quality. According to their experiments and our own research work, such amendments are greatly influenced by climatic factors (rain, insolation, temperature), soil features (nutritive agents, pH, content of available fertility, thickness of the fertile layer, etc.) and organized irrigation. Climatic factors have proved particularly decisive in the development of spicy properties.

In the present paper we have analysed the bearing of climatic elements on and their correlation with the growing of paprika.

I.

Correlation between Compounds Producing the Spicy Effect and Climatic Conditions

The large number of species, subspecies and varieties of the paprika genus are classified, according to utilization, into three main groups:

1. edible paprika,
2. exotic paprika and
3. spice paprika.

Fruits belonging to the group of *edible paprika* have a thick marrow and loose texture, are juicy and consequently unsuitable for drying and grinding i. e. to produce spices. In general they are consumed in the unripe, green state.

Exotic paprikas have small fruits with thin walls and are equally unsuitable for grinding and making of spices. They are particularly rich in capsaicin which makes them highly pungent, on the other hand they are poor in colouring agents.

The same properties for which „sweet choice" or exotic paprikas are appreciated are not always considered as an advantage in the breeding of *spice paprika.* Consequently, higher average yields should not be strived for if this means a loss in spicy properties. Spice paprika owes its specific flavour, colour and pungency to the compounds it contains and which may be divided into two large groups:

1. compounds producing and essentially influencing the spicy effect and
2. compounds secondary or indifferent as regards to spicy effect.

To the first group belong the pigments, the volatile oils and the capsaicin. The second group comprises the carbohydrates, the proteins, the fatty oils, the vitamins, the minerals and water.

Climatic factors are important determinants in the formation of compounds. Favourable or unfavourable effects of temperature, rain and sunshine greatly influence the extent, quality and proportion in the formation of these compounds. Consequently in the case of spicy paprika, in opposition to edible and exotic paprika, the crop may be called excellent only if abundance of these compounds is combined with a rich crop (30—40 q per cadastral yoke). A large average yield combined with poor spicy qualities is a bad crop, no less than the reverse. Yet Low average yield coupled with richness in spicy properties is better, since the smaller crop still yields more high quality ground paprika than in the first instance.

In determining the required climatic conditions, we have to examine first of all the relations between climatic elements and the compounds determining the spicy properties of paprika, the ratio between water and dry matter content, but also compounds though of no consequence to the spicy effect, but of biological significance.

1. Pigments

The most conspicuous property of the fruit — and ground fruit — of spice paprika is the vivid red colour due both in the fruit and in the ground product to pigments belonging to the class of catotinoids. Of the pigments contained in the fruit, capsantin ($C_{40}H_{58}O_3$), and capsorubin ($C_{40}H_{60}O_4$) are responsible for the red colouring, the rest of the pigments: zeaxantin ($C_{40}H_{56}O$) and carotene ($C_{40}H_{56}$) being yellow, they play a minor role in colouring. Capsantin and capsorubin predominate in the fruit, their colouring power being the tenfold of yellow.

For the quality of ground paprika the quantity and ratio of pigments in the fruit is of dicisive importance. Because it is a requisite that ground paprika lend a fine, brilliant red colour to the dishes, that it be substantial, i. e. the colour be ensured by a minimum of ground substance, which depends exclusively on the quantity and ratio of pigments present in the ground paprika. The quantity and proportion of pigments of the identical varieties grown on identical soils is a function primarily of the quantity of insolation during vegetation, of the mean temperature and in the third line of the quantity of precipitation. The correlations between the formation of pigments and climatic factors are shown in Table 1.

Table 1.

Year	Total pigments in caps g/kg		Vegetation *(April—October)*		
	Spice pungent	paprika non pungent	mean temperature	rain mm	sunshine hours
1952	7,55	6,40	18,97	246,3	1889,6
1953	6,50	5,80	18,1	340,1	1738,3
1954	5,46	4,86	17,5	384,0	1667,3
1955	5,57	4,62	16,7	448,0	1616,7
1956	7,72	6,40	17,6	276,0	1847,9

(Cont.)

Year	Vegetation *(August—September—October)*		
	mean temperature	rain mm	sunshine hours
1952	18,2	166,4	679,5
1953	17,8	58,0	746,7
1954	17,7	110,0	701,6
1955	16,9	161,0	604,6
1956	17,7	47,0	827,2

The ratio between pigments causing red and yellow colouring respectively will be favourable when of the total of pigments 70 to 80% fall to capsantin.

and capsorubin and 20 to 30% to yellow pigments. The ratio between the variously colouring pigments are also dependent, though to a lesser degree, on the quantity of insolation, the mean temperature, the properties of the soil and the quantity of rain during vegetation. Ratio and quantity of pigments are unfavourable when there are many cloudy and rainy days, less sunshine during vegetation and when insolation and mean temperature values are lower in August, September and October.

A favourable pigment content and pigment ratio in spice paprika requires a minimum of 1750 hours sunshine and a mean temperature of about 18,2 °C during vegetation.

Irrigation experiments made with spice paprika gave similar results and demonstrated that pigments are perceptibly reduced by excessive watering, particularly if watering is copious in August. In years when there is much rainfall, average crops are high, yet crop quality is poorer, for the very reason that pigments, volatile oils and capsaicin are developing in smaller quantities. In such cases the bulk of the crop is third rate. Observations and experience support our statement that sunshine and temperature play an important role in the development of pigments and that excessive rainfall has an unfavourable influence.

2. *Capsaicin* ($C_{18}H_{27}O_3N$)

The second chief compound exercising a spicy effect is the capsaicin which lends the ground fruit an agreeably pungent taste. This is a particularly important requisite, hence the factors influencing the development of capsaicin should not be disregarded by growers of spice paprika. Lately medical circles have also shown a vivid interest in this respect. The capsaicin content of ground spicy paprika fruit is generally lower than in the fresh fruit, since the ribs carrying the pungent property are removed „by splitting" before grinding and the desired quantity of capsaicin is added during processing. L. Benedek has established in 0,2% the average capsaicin content of field crops of Szeged pungent spice paprika. However, certain qualities of ground paprika require smaller quantities, rose and strong paprika, on the other hand, may contain even more.

The capsaicin content of paprika strains selected by breeding is variable, but it may even vary within the same strain from one year to the other. According to tests and observations of E. Obermayer the more capsaicin the plant produces the more it suffers from scorching sun and drought. (1) Too high capsaicin content is undesirable in the majority of ground products, yet, in view of its gaining ground in pharmaceutics, experiments are being made to produce more capsaicine, particularly by the selection of varieties and of soil.

To produce capsaicin in abundance the plant again needs more sunshine, a higher mean temperature, less overcast skies, less rainfall and also mature soil rich in humus. The most favourable conditions to this effect are when during vegetation the following values are not exceeded: 1750 hours sunshine, 18,2 °C mean temperature and 200 to 350 mm rainfall, the latter varying from 200 to 250 mm on alluvium, 250 to 300 mm on loess-and 350 to 450 mm on sand. Similarly as for pigments, too much rainfall is unfavourable.

2 Volatile Oils

To the third group of compounds bearing the spicy properties belong the volatile oils which lend the ground product made from paprika an agreeable, delicately spicy flavour. I. Horváth has established that spicy paprika contains from 0,10 to 0,15%, in some cases even 0,25 to 0,30% volatile oils. According to the results of I. Horváth and E. Obermayer the formation of volatile oils in the fruit also much depends on the amount of sunshine and on temperature. Percentage of volatile oils increases or decreases as a function of these factors.

For the production of condiments a certain quantity and quality of compounds producing the spicy effect are required. Hence the conditions of the development of the latter to a higher degree cannot be neglected. Consequently the climatic and soil needs of spice paprika must not be determined on the base of average crops alone. Account has to be taken of the amount and ratio of compounds responsible in determining the quality, in the formation of which sunshine and temperature have the lead.

4. Compounds Indifferent with Regard to Spicy Effect

(a) Fatty oils; the bulk accumulates in the seeds. Their presence in the ground product is provided for by adding a certain amount of seeds. By diluting the pigments contained in the wall of the capsules fatty oils brighten the colour of the ground product and simultaneously intensify adhesion between the particles, thereby reducing dust loss during grinding.

(b) Since vitamins and proteins play a more significant role in the living organism, their presence in larger amounts in the ground product is rather of biological importance.

According to the test made by the Agricultural Experimental Station for the South Plain, the dominant role in the accumulation of fatty oils, vitamins and proteins is that of sunshine and temperature, the same as with the formation of compounds carrying the spicy effect. As a general rule, more sunshine produces more fatty oils, vitamins, etc.

5. Solids and Water

The ratio between solids and water contained in the spice paprika is influenced by several factors. It depends among others on the variety, the soil, atmospheric conditions, etc. It has been observed that in years of much rainfall or when it is cultivated in irrigated fields spice paprika contains less solids than in years poor in rain or when grown without watering.

The chief component of spice paprika is water, present in an average of 80%. Air-dry condition of spice paprika is attained only after 4 or 5 months. From the industrial point of view the solid content of the fruit is of extreme importance, since it determines the quantity of ground product obtained from the fresh fruit. Consequently it is essential for breeders and growers to increase the solid content, i. e. the yield of solids of the paprika.

In the formation of larger amounts of solids sunshine and temperature are again of primary importance.

Too much rainfall has a decreasing influence. As regards to the formation of solids, sunshine and temperature during the months of August, September and October are particularly decisive. In general, aboundant rain produces less solids and a higher proportion of water.

Table 2.

Year	Pungent solids	Non-pungent solids	Mean temperature during vegetation °C	Rainfall during vegetation mm
1955	15,37	18,98	16,7	448,0
1956	18,15	22,21	17,6	276,0

(Cont.)

Year	August October °C	August October rainfall mm	Sunshine during vegetation hours	Sunshine in August-October hours
1955	16,9	181,0	1616,7	604,6
1956	17,7	47,0	1847,9	827,2

Naturally, the above figures do not mean that crops are excellent only in years when the value of solids is high, the crop is good, when solids, pigments, capsaicin, volatile oils, etc. i. e. the quality indexes attain a certain level and these figures are accompanied by an average yield of 30 to 40 q per cadastral yoke.

II.

Relation between Climatic Factors and the Average Yield of Szeged Spice Paprika

In addition to climatic factors and soil properties an important role among factors influencing the average crop is played by proper nursery practice, by well-timed setting, etc. Thus, besides studying and analysing the climatic factors and soil properties, these factors have also to be taken into account. The more so, since there is a substantial difference between the two paprika regions (*Szeged* and *Kalocsa*) as regards to planting of the seedlings and to their raising. Thus, e. g. at *Kalocsa* seedlings are raised in temperate beds, while at *Szeged* cold beds are of general use in nurseries. There is a marked difference in time and result between the two nursery practices influencing considerably the average yield of crops. E. OBERMAYER (4) has proved by his experiments that the well chosen time for planting (between May 5 and 15) — which depends on nursery practice — is equivalent to a surplus yield of 8 to 12 q of fresh fruit per cadastral yoke, and, at the same time, an increased amount of pigments.

Therefore, it is advisable to raise the seedlings in temperate or hot beds, for they produces a larger crop of better quality.

In the determination of mutual relations, in establishing the correlation between climatic factors and average crops it is essential to take into consideration differences between the specific properties of varieties, for the difference in crop may amount to several quintal (1 q = 100 kg), even under analogous ecological conditions. The non-pungent spice paprika bred at Kalocsa in the 1930s had as everybody knows, a longer vegetation period, lower pigment content, higher sugar content and higher average yield than the pungent variety of Szeged, which, on the other hand, contains capsaicin.

Taking into consideration the differences in nursing practice, and the different properties of the two varieties, we have plotted below average crops of fresh fruit over 20 years (between 1934 and 1957) against temperatures. Estimation of the crops is based on the following categories of quality: Excellent 30 to 40 q per cadastral yoke, good 25 to 30 q per cadastral yoke, mediocre 20 to 25 q per cadastral yoke, less than mediocre 15 to 20 q per cadastral yoke, poor less than 15 q per cadastral yoke.

Table 3.

Year	Average crop of fresh fruit q/c. y.	Rainfall during vegetation mm	April	Rainfall during May mm	June
1934	24,5	246,0	30,0	16,0	79,0
1935	24,3	250,6	58,0	47,0	49,0
1936	33,9	407,8	42,0	66,0	24,0
1937	34,1	472,2	45,1	123,6	101,5
1938	34,2	369,5	13,7	100,2	24,5
1939	26,8	556,9	22,0	196,9	60,0
1940	25,6	602,5	50,3	71,7	97,0
1941	28,5	471,8	59,9	53,5	86,5
1942	39,0	311,3	132,5	23,5	54,0
1943	22,5	265,2	20,0	62,0	91,5
1947	17,1	194,4	24,6	28,5	30,6
1948	16,6	297,2	39,8	17,5	80,4
1950	8,0	275,2	48,7	44,0	25,3
1951	35,0	385,3	44,6	71,7	88,0
1952	6,5	246,3	12,3	36,5	21,1
1953	24,0	340,1	59,6	102,7	79,1
1954	26,5	394,1	34,3	108,7	110,8
1955	22,3	448,0	59,0	24,0	43,0
1956	23,2	276,0	35,0	71,0	63,0
1957	35,2	365,7	20,9	135,5	58,2

(Cont.)

Year	July	Rainfall during August	September mm	October	Classification of crop
1934	65,0	19,0	27,0	10,0	mediocre
1935	18,0	46,0	35,0	27,6	mediocre
1936	64,0	64,0	107,0	112,0	excellent
1937	44,8	80,6	52,4	24,2	excellent
1938	36,3	130,9	28,7	35,2	excellent
1939	15,0	90,0	35,0	138,0	good
1940	111,2	84,4	107,9	80,0	good
1941	21,5	106,4	58,4	82,6	good
1942	15,1	54,1	5,4	27,7	excellent
1943	52,9	6,1	29,0	3,7	mediocre
1947	72,3	9,7	4,0	24,7	less than mediocre
1948	62,2	29,4	46,1	21,8	„ „
1950	34,0	3,7	45,7	73,8	poor
1951	99,0	34,1	27,9	20,0	excellent
1952	10,0	13,0	90,0	63,2	poor
1953	40,3	39,9	10,5	7,6	mediocre
1954	30,2	50,7	33,1	26,3	good
1955	141,0	66,0	46,0	69,0	mediocre
1956	0,0	17,0	10,0	20,0	mediocre
1957	70,1	27,4	27,9	25,7	excellent

1. Temperature

Mutual relation between mean temperature during vegetation and average crops is easily established by a simple confrontation of figures contained in Table 3. Figures in Table 4. prove the same statement and show at the same time the mean temperature of the vegetation period required for yielding excellent or good crops and which can be fixed at 17—18 °C.

Table 4.

Year	Average crop of fresh fruit q/c. y.	Mean temperature of vegetation period (April—October) °C	Classification of crop
1936	33,9(*)	18,2	excellent
1937	34,1(*)	18,2	excellent
1938	34,2(*)	17,7	excellent
1939	26,8(*)	18,8	good
1940	25,6(*)	16,6	good
1941	28,5(*)	16,4	good
1942	39,0(*)	18,4	excellent
1951	35,0	18,1	excellent
1954	26,5	17,5	good
1957	35,2	17,2	excellent

(*) Retraced with correction from data concerning ground product.

Mean temperature values below or above 17 and 18 °C yield feebler average crops, considering that when mean temperature values are low, strong fall in temperature during April, late spring and early autumn frosts, and a cloudy, cold, rainy vegetation period are to be expected. E. g. in 1955.

High mean temperatures point in general to dry and hot periods in the summer season, which is also of great disadvantage for the fertilization and development of the fruit. See: 1934, 1943, 1948, 1950 and 1952.

This correlation is, however, not always unequivocal, since we have contradictory figures, for instance in the years 1935, 1947, 1953 and 1956, when the mean temperature during vegetation should have produced excellent crops, yet they remained but mediocre and less than mediocre respectively.

In the years 1940 and 1941 however we have instances of mean temperature during vegetation having remained below 17 °C and the crop has averaged nonetheless from 25 to 30 q/c. y.

These exceptions require a closer investigation of mean temperatures during each month. It is necessary to identify the months which have the most marked influence on the average yield of crops.

(a) May

Of the 20 years examined, crop has been excellent and good respectively in 10, while in the other 10 years it was mediocre or even poorer. The relation between mean temperature in the month of May and average crop was the following during the 20 years in question:

The crop was excellent or good with a mean temperature in May		mediocre or poor
above 17 °C	in 2 years	in 3 years
between 16 and 17 °C	in 4 years	in 3 years
below 16 °C	in 4 years	in 4 years

This simple comparison and proportion shows that the chances of excellent and good on the one hand, of mediocre and poor crops on the other hand are approximately equal be the mean temperature in May either below 16° C or above 16° C. Neither is a high mean temperature (above 17° C) in May propitious, as it implies the probability of a poor crop. The optimum mean temperature in May should be put from 14 to 17° C, though these figures are not the limits of a rigid category, deviations being always allowed.

(b) June

Comparing the figures of years when crops have been excellent and good, or mediocre and poor respectively, show approximately analogous correlations as in May. Although temperature conditions above 22° C are more propitious for an excellent or good crop (7 : 6), than below (4 : 3), still this difference is negligible.

The optimum mean temperature may be put approximatively between 18,5 and 22,5° C in June, which statement is supported by the figures referring to excellent and good crops. In fact, mean temperature for the latter has varied between 18,0 and 22,0° C.

(c) July

Mean temperature in July is the best when it ranges between 21,0 and 22,5° C. At such mean temperatures in July, growers gather excellent or good crops. Of course there had been years when mean temperature was favourable in July, yet crop still remained poor. According to available data mean temperature in July above 22° C is neither favourable, for in such weather conditions droughts of longer or shorter duration which increase the chance of poor crops may be expected to occur in summer. The relation stated was further supported by the ratio 5 : 2 between better and poorer crops.

(d) August

In the years when crops have been excellent and good respectively mean temperature varied between 19,3 and 21,8° C in the month of August, with the exception of 1951, when it attained 23,7° C. The high mean temperature in August did no harm in 1951, for weather conditions have been ideal in June and July — high frequency of fertilization — and at the same time in August the plants received sufficient quantities of rain for the process of ripening (34,1 mm). In the years when average crops have been rather poor the mean temperature in August was generally above 22° C, though here too there were exceptions, e. g. 1935, 1953, 1955. The ratio between excellent and good, mediocre and poor crops respectively has been 1 : 7 in years when mean temperatures in August exceeded 22° C, and 9 : 3 in years when it remained below 22° C.

The effect of mean temperatures for each month are shown together with the annual average crops in Table 5.

Table 5.

Classification of crop	May above 16 °C	May below 16 °C	June above 20 °C	June below 20 °C	July above 22 °C	July below 22 °C	August above 22 °C	August below 22 °C
Excellent and good	6	4	7	3	5	5	1	9
Mediocre, feeble and poor	6	4	6	4	8	2	7	3

The months of the vegetation period according to the importance of their respective mean temperatures should be established as follows: 1 July, 2 August, 3 June, 4 May, 5 April, 6 September, 7 October.

2. *Insolation*

The quality of the fruit depends essentially on the amount of sunshine; average crop, on the other hand, depends on it only so far that sunshine quickens up the maturing process and thereby allows for larger quantities of red ripe fruits to be harvested before the first autumn frost. The correlation between average crop and insulation is too vague for any conclusions to be drawn from it. The amount of insolation during vegetation is generally above 1730 hours in the years which yield the best crops, yet poor crops have been recorded in years when insolation totalled more than 1850 hours, while good average crops have been harvested in years when total insolation during vegetation did not reach 1600 hours. The same could be stated for the total insolation of the months of August, September, and October, which on the average varies between 650 and 710 hours.

3. *Rain*

In the formation of fruit an essential part is due to rain. There is no doubt that high crops depend primarily on the amount and distributions of rainfall. In this context we refer to one of our papers (7), in which we emphasized the importance of rainfall, its decisive influence on average yield.

In an analysis of rainfall per pentads we have demonstrated that the irrigation of spice paprika is a very important and essential problem to be solved, considering the fact that in the Szeged region about every second year rainfall is scarce, or at least there is during vegetation a more or less long period of drought. Owing to drought, crops are poorer and unfortunately this is the case in every second year. On account of poor crops we are often unable to fulfill our export plan and even domestic demand cannot be satisfied without a hitch. At such junctures we are regrettably compelled to import paprika. The introduction of irrigation of field crops would eliminate such difficulties.

Of course this does not mean that because paprika needs water, the growing of this plant should be transferred to a region where rainfall is more frequent, it would even be wrong to infer the unsuitability of the Szeged region for the cultivation of spice paprika. Although an analysis of rainfall has explicitly proved the vegetation period to be drier every second year, or more exactly: more or less prolonged periods of drought recurring almost annually during vegetation, we must nevertheless affirm that climatic conditions (temperature, insolation, etc.) in the environs of Szeged are very favourable for the growing of spice paprika. As a matter of fact paprika is the basic material of a special Hungarian spice, in the production of which quality is of higher importance than quantity, and the effect of cloudy, cool, rainy weather is worse than warmth and sunshine with scarce rainfall. Consequently the presence of many such climatic factors is of greater importance, which are more difficult to substitute or whose noxious effect is easier to compensate.

There should be no misunderstanding, in the growing of spice paprika *water is indispensable, but easy to supplement by irrigation, in contrast to sunshine or warmth.* In dry seasons rich in sunshine the prerequisites of high quality subsist and with irrigation we are able to provide for a good yield. Since the high quality indexes do not need temperature and insolation relations of dry steppes or near-desert climate (actual needs are lower), climatic conditions of the Szeged region are propitious to excellent and good crops in 75 or 90% of the seasons. Naturally soil, proper plant management, the best juncture to plant the seedlings, etc. have also their bearing upon quality.

In this district our task is to ensure excellent and good average crops when temperature and insolation relationships are favourable. Analysing the amount and distribution of rainfall it is observed that in the Szeged region the prerequisites of *average crops* classified as excellent and good are less frequently existing than those of high quality. Our observations and experiences are plainly demonstrated in Table 3.

Figures for rainfall during vegetation in years of excellent or good crops have varied from 311,3 to 602,5 mm. Within these limits rainfall recorded parallel to excellent crops varied from 311,3 to 472,2 mm and from 394,1 to 602,5 mm with good crops. The latter figure already points at the possible unfavourable influence of excessive rainfall. For instance in 1940 the weather was cool and the sky overcast during florescence and fertilization, which resulted in a correspondingly feebler crop.

In years when rainfall is abundant the period of vegetation may be intersected by intervals of drought which again reduces the yield, as it was the case in 1939, 1941 and 1954. Drought during July in the said years had a catastrophic effect which the frequent rainfall in August could but mitigate: eventually the more favourable August weather produced only a good crop. Unfortunately the surplus crop due to the abundant rainfall in August was of poor quality and for the most part suitable only to make pepper surrogate. Note: excessive rianfall does not necessarily impair quality in the first half of August, but does to in the sceond half of it! *The latter is harmful!* From data obtained by analysing a series of 55 years (7) we know that mid-August is drier in the *Szeged* region and this is one argument more in favour of the reasonableness in assigning the *Szeged* district for the growing of spice paprika, i. e. in favour of the *Szeged* district being suitable for spice paprika culture.

The rest of the years figuring in the table show poorer (mediocre, less than mediocre and poor) average crops and the reason for this seems obvious enough. There was a shortage of water in all these years, as the amount of rainfall varied in general between 200 and 300 mm. 1953 and 1955 were the only exceptions, when rainfalls of 340,1 and 448 mm respectively hadve been recorded. The reason for poorer crops can be found in too much rainfall in spring and not enough rain in July 1953, while in 1955 rainfall was insufficient in May and excessive in July. Abundant rainfall in July went with cool, cloudy weather, which impaired fertilization. A comparison of average crops and rainfall data relieves the importance of May, June, July and August during the period of vegetation.

In *May* little rainfall is unfavourable, for it causes the soil to dry, the seedlings to take root poorly or to wilt or to stunt to say the least. We have a very good example in the year 1958 when e. g. at *Kalocsa* the planting of nursery stock had to be repeated several times over on açcount of the drought. May drought has caused severe damages at Szeged too, as the soil dried up so much that planting in early June seemed impossible, immense quantities of water have been required for watering, but the seedlings were nonetheless unable to develop properly. Drought in May had a damaging influence also in the years 1934, 1935, 1938, 1947, 1950, 1952 and 1955.

Abundant rainfall in May has sometimes an unfavourable effect, since in general it goes with cool weather and an overcast sky, and seedlings planted at this juncture are „cold", „choked" ro stop growing. This condition is perfectly exemplified in the year 1953. The ideal relationship for weather in May is an agreeably temperate atmosphere, not too cool nights and a sufficient amount of rainfall (from 60 to 100 mm). Such May weather is fairly common in the Szeged region, with a probability of 50 to 60%. Of course May might be drier and completed by abundant rainfall in April and June; the amount of rainfall might also be higher and accompanied by warmer weather. More than one example testify to abundant crops after such May weather (1937, 1938, 1939, 1957).

June is the crucial period for the development, for the growth of the plant and at the same time for the beginning of florescence. The two chief factors influencing plant growth are water and warmth. Too little water checks the normal development of the plant, hence scarcity of water is a crop reducing factor. Abundant rainfall in May or in July may be a partial relief for the scarcity of water in June, but it is no more than a subsidiary relief.

Scarcity of rainfall in *July* is certain to produce less good crops, both in quantity and quality. The deterioration in quality is highly probable, since under such conditions the crop cannot be excellent or good without more abundant rainfall in August, and in September. Now, the surplus crop produced in such circumstances is unfortunately inferior in quality to fruit resulting from fertilization in July. Too much rainfall in July might also have a damaging effect. For instance in 1940 and 1955 the large amount of rainfall had been accompanied by heavy drops in temperature, which hindered fertilization and increased the incidence of shedding.

Between *August* 12 and 15 the fruits begin to ripen. Mass ripening takes place also in August. This month is an essential as well as the last phase during which quality indexes take shape. A cloudy and rainy August slackens the pace of ripening and depreciates the quality. In such cases slowing down of the ripening process is due partly to the lack of sunshine and partly to further fertilization taking place, which latter absorbs to some extent the material needed by the plant for ripening. This is the reason why abundant rainfall in August is unfavourable for spice paprika culture. True, little rain is also detrimental, for it impedes absorption, causes wilting and damping off, etc. Moreover, drought in the first half of August reduces the yield of the crop. It has been observed that at Szeged rainfall is rather abundant in the first half of August, while in the second half of the month dry periods are frequent. Such a distribution of rainfall is extremely favourable as it both improves the quality and increases the quantity.

Rainfall in *September and October* is immaterial, though it still may increase the yield. This surplus, however, carries no weight, since the fruit of fertilization taking place in September and October has hardly time to ripen and even if it does, it is of very poor quality. September and October should be preferably mildly dry, for such atmospheric conditions produce high quality indexes. It may even happen that the second or third harvest are of better quality than the first. In most cases the reason is to be found in the abundance of rainfall in August which hindered the accumulation in the fruit of sufficient quality influencing compounds.

Research work done up to date permits to determine approximately the rainfall conditions, taking soil features into consideration, which are the prerequisites of crops falling in the excellent and good categories: rainfall during May—June—July—August should total from 150 to 300 mm.

III.

Summary

The order of importance of climatic elements determining the quantity of spice paprika crops is not easy to establish. According to our analyses and calculations climatic factors enter for about 50 to 60% in the determination of yields, such as the variety, soil, and methods of culture: manuring, the date of planting the seedlings, culture and husbandry, etc. Of the 50 to 60% climatic elements about 30 to 35% fall to precipitation, about 15 to 20% to temperature and about 5% to insolation and other atmospheric factors.

Climatic factors determine in a larger measure the quality than the volume of spice paprika crops. Their share in the quality of crops is approximately 65 to 70%, while the remaining 30 to 35% are due to variety, soil and agrotechnique. Of the climatic factors totalling 65 to 70%, 35 to 40% fall to insolation, 20 to 25% to temperature and 5 to 10 to rainfall and other atmospheric elements.

The below statement is a recapitulation of the influence of climatic factors estimated at 50 to 60% in the yield and at 65 to 70% in the quality of spice paprika respectively:

	Mean value of volume	Mean value of quality	Total volume + quality
rainfall	32,5%	7,5%	40,0%
temperature	17,5%	22,5%	40,0%
insolation	5,0%	37,5%	42,5%
total in mean value	55,0%	67,5%	122.5%

The share of each element in the joint result achieved in volume and quality is about the same. Consequently, it is not easy to establish an order, but considering the priority due to quality, the order of importance may be the following:

1—2 insolation
1—2 temperature
3 rainfall
4 other climatic factors.

„Other climatic factors“ may temporarily take precedence with regard to yield (e. g. surface frost, hail, etc.). If the joint contribution totalling 122,5% of elements influencing the quality and volume of spice paprika crops is taken equal to 100%, about 55 units fall to quality and 45 units to volume.

Our series of average crops — which really is composed of a 10 years, a 2 years and an 8 years series — shows that the probability of excellent and good crops is 50%, that of mediocre crops 30%, while the probability of less than mediocre and poor crops is 20%.

The data relating to the 8 years period are reliable in every respect. According to the latter the respective values of *probability* are 37,5% for excellent and good, 37,5% for mediocre, 25% for less than mediocre and poor crops.

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