DATA CONCERNING MAXIMUM TEMPERATURES IN VARIOUSLY FERTILIZED RICE CROPS

by

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Összefoglalás: *(Adatok különböző kezelésű rizsállományok maximum hőmérsékletéhez).* A bőven trágyázott és a műtrágyázás nélküli rizsállományok különböző szintjeiben mért maximum hőmérsékleteket összehasonlítottuk a területen működő makroklima állomás maximumaival. Az állományok zárórétege alatt a relatív maximum szoros összefüggésben van az állomány fejlődésével, sűrűségével. A relatív maximum segítségével közelítőleg megállapítható az állományok különböző szintjeinek maximum hőmérséklete, s ez az állományokban végbemenő biológiai folyamatok előrejelzéséhez adhat segítséget.

Zusammenfassung: *(Beiträge zu den Maximaltemperaturen in auf verschiedener Weise behandelten Reisbeständen).* Maximaltemperaturen, welche in verschiedenen Höhen über dem Boden in reichlich mit Kunstdünger versehenen und kunstdüngerlosen Reisbeständen gemessen worden sind, wurden mit den Angaben der zuständigen makroklimatischen Beobachtungsstation verglichen. Die relativen Maxima weisen unterhalb der Sperrschicht der Bestände einen engen Zusammenhang mit der Entwicklung und der Dichte des Reisbestandes auf. Mit Hilfe des relativen Maximums können die Maximaltemperaturen der verschiedenen Höhenlagen des Bestandes abgeschätzt werden, welche dann zu einer Vorhersage der biologischen Vorgänge, die sich im Bestande abspielen, verwertet werden können.

Summary: We compared maximum temperatures measured at various levels of abundantly fertilized and non-fertilized rice crops to the maximum temperatures observed on a macrometeorological station which has been erected on the experimental site. The so-called relative maxima are exhibiting, below the crop canopy, a close connection to the development and the density of the crop. By using the concept of relative maxima, there is a possibility of estimating the maximum temperatures existing at various levels of the crop, the knowledge of which may yield some support for the forecasting of the biological phenomena occurring within the crops.

In research work concerning rice production and the plant breeding of rice, as well as in the producing practice, the requirement arises of investigating crop development and the changes of the qualitative and quantitative indices of crop yield in connection to the meteorological elements.

Many problems may be solved by using data of a macroclimatic station or by the knowledge of the synoptic weather situation. However, the biological phonemena, which are largely depending on crop climate (such as the multiplication of animal or plant pests, the chemical and biological processes occurring in the soil, the development and fertilization of the plant, etc.) could be elucided only in the knowledge of the crop climate. Average values of the meteorological elements, calculated for various phenological phases, ten-day or five-day periods, or some occassionally executed measurements of the crop climate are unable to yield an answer on the processes occurring within the crops. This is the reason, why *M. Dzapvasbaev* (1969), *P. C. Owen* (1969), *D. Berényi* (1962, 1958), *N. Bacsó* (1962) and *R. Wagner* (1966) emphasized in their respective papers the importance of a continuous and detailed measurement of crop climate.

This work is based on microclimatological measurements carried out by the staff of the Chair of Climatology of the József Attila University at Szeged, during the years 1971 and 1972, the execution of these measurement being the result of an excellent co-operation with the Rice Research Programme of the Irrigation Research Institute at Szarvas.

In the course of these investigations, we carried out in both years microclimatical measurements during the period July 1—August 31, a period which is enclosing the most important part of the generative phase of the rice plant.

The measurements were taken in the rice plantation Káka II at Szarvas on a solonietz meadow soil, on the variety „Kákai 203" in fertilized and non-fertilized crops as well as on an adjacent submerged, but plant-free site which will be referred as „free water". The fertilized crop has been treated with ammonium sulphate fertilizer corresponding to a dose of

170 kg/hectare

of sodium and further with a super-phosphate fertilizer corresponding to

85 kg/hectare

of P_2O_5. These amounts of fertilizer were applied before seeding, after several years of previous rice culture.

In spite of the fact, that the fertilized crop and the control crop received both the same amount of seed-grain and the same kind of agrotechnics, in the course of the growing season, rather important differences occurred in the crop development and in crop density, having their repercussion also on the crop yield. The two crops may be characterized by the data contained in Table 1 and Fig. 1.

Table 1

Yield of fertilized and non-fertilized rice crops (variety Kákai 203) at Szarvas, 1971, 1972.

Year	Fertilized	Plant height cm	Number of panicles/m²	Number of grains on a panicle	Sterility %	Grain yield q/ha
1971		76	637	37	11	29.9
	N+P	94	799	57	12	47.6
1972		80	534	43	19	29.4
	N+P	102	648	60	16	50.0

The measurements were taken with electrical resistance thermometers at the following levels: 200 cm above the water surface; in the actual leaf canopy zone; 10 cm above the water surface; below the water surface at a depth of 1 cm; and on the water bottom. All the observations were carried out hourly during the whole

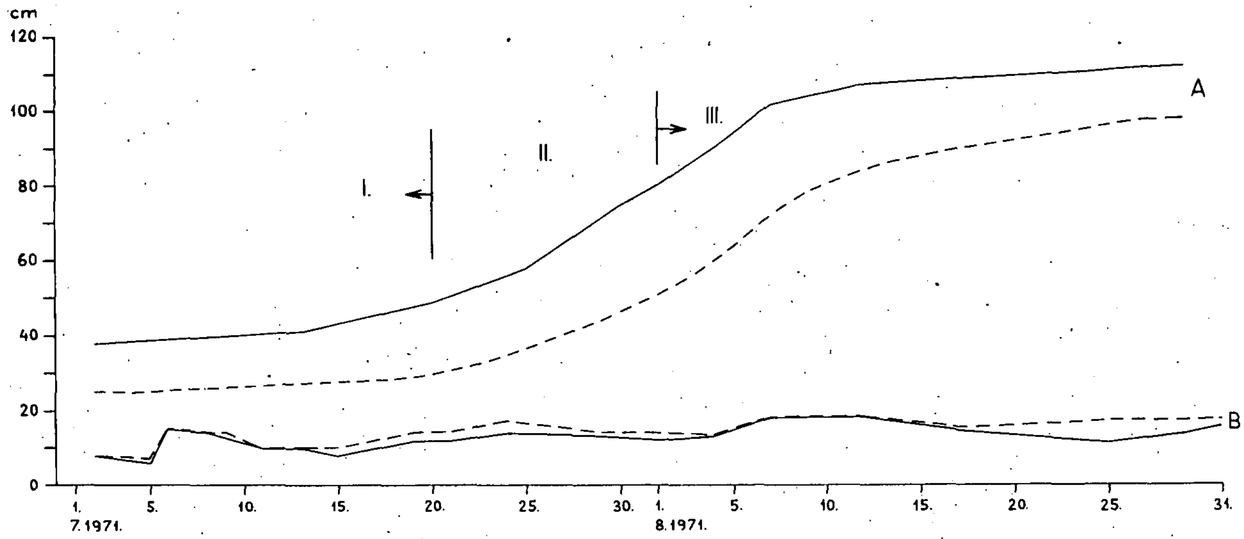


Fig. 1. Height of the canopy level (A) and of the submersion water level (B) in the two rice crops (Szarvas, 1971)
— — — —= non-fertilized crop, ———— = fertilized crop
Phenophases: I = sprouting, II = panicling-flowering, III = maturation

1. ábra. Az állományzáró szint (A) és az árasztóvíz (B) magassága a két rizsállományban (Szarvas, 1971)
— — — —= trágyázás nélküli, ———— = trágyázott állomány
Fenofázisok: I = szárba indulás, II = bugázás-virágzás, III = érés

24-hour period. On the research site, also a macroclimatological station was installed, equiped with recording and direct-reading instruments. We measured the duration of insolation as well as global radiation.

In the course of an earlier investigation on the vertical cross-section (*I. Bárány, J. Boros,* 1972, 1973) we found that the effective surface is, with the development of the plant, transferred into the canopy zone, and below this zone the diurnal amplitude of air temperature is diminishing. In the case of the fertilized crop, the closed consistence of the crop is strongly influencing the water temperature and the soil temperature as well. Among the various components of the thermal balance, radiation effects are overshadowed by thermal conduction and by mixing, a circumstance which is increasing the phase shift of temperature maxima.

According to *D. Berényi* (1962) it is imperative to determine, on the basis of crop climate data, the connection existing with the macroclimate and the local climate, as crop climate is a close function of these.

In this paper, the extreme temperatures observed at the various levels of the rice crops were compared to the extreme values observed at the macroclimatic station and we expressed the values as percentages of the extreme temperatures observed in the thermometer screen, all values being taken in centigrades, and in this way we searched for the connection existing between crop climate and macroclimate. However, from the two kinds of extreme values (maxima and minima) we considered only the maxima, for, in the different crops, the maxima are determining the temperature differences existing, while the differences of the minima, at identical levels, are comporting only some tenths of a degree (centrigrade), these differences having varying signs. The slightness of the differences between the minima may be explained by the peculiar radia-

Table 2

Difference of temperature maxima between fertilized and non-fertilized rice crops on some clear and overcast days (centigrade), Szarvas 1971

	Date	Relative insolation	Crop canopy	10 cm over water	1 cm below water	Water bottom
Overcast	14.7	15	0.8	0.0	0.0	0.4
	27.7	15	1.0	0.7	0.8	0.9
	17.8	2	0.4	1.3	0.5	1.1
	24.8	30	−0.5	2.5	1.8	1.3
Clear	12.7	83	−0.5	1.7	2.8	2.7
	27.7	91	−0.4	1.9	1.3	1.3
	20.8	84	0.4	4.2	1.4	1.7
	29.8	88	0.1	4.8	1.3	1.6

tion balance of the crops and by the complex effect of the other factors of the thermal balance (Fig. 2). The percentage values obtained will be referred to as „relative maxima".

On Fig. 2, which is containing the maximum and minimum temperatures obtained in the course of the reiterated experiment in 1972 for the whole measuring period, it appears, that largest differences between the maxima are occurring on clear days with a radiation type of weather, as these differences are indeed the results of the different radiation balances of the two crops. On the other hand, on cloudy or overcast days, the differences are lower (Fig. 2, Table 2).

Our investigations were limited to clear days with a radiation weather type i.e. to days, on which the duration of insolation was higher than 70% of the astronomically possible duration. The total number of such days was of 34, and they are well distributed over the whole observation period.

Plotting the so-called relative maxima in a co-ordinate system, we traced for every observation level a smoothed curve, and these curves are exhibiting a close connection (mainly as a consequence of the leaf canopy) to the growth of the crop (Fig. 3).

Temperature at the 200 cm level is, during the whole period, a uniform one, it is independent from the crop and its development, and the same conditions hold for the maxima of the leaf canopy level as well. In both crops, it is at this level that is found the largest diurnal amplitude. This is indeed the effective surface, however the masses and the developments of the crops are not influencing the values of the maximum temperature occurring at this level.

Within the crops, ot the 10 cm level, the differences are already important ones and even they reach here their highest values, and a clear-cut relation exists to the various phases of crop development. On Fig. 1, which is illustrating the development of the crop, the following phenophases may be distinguished: sprouting, panicling-flowering and maturation. Correspondingly, the curve of relative maxima is possessing equally three segments. At the time of sprouting, there are no important differences, and the values of the relative maxima are higher than 100%. The two curves are parting from each other during the phenophase of panicling and flowering, namely, in the fertilized crop, the relative maximum is decreasing in the course of 10 days by 10 to 15%, a decrease which is decelerated during the phase of maturation, the whole decrease throughout this phase being equal to 2 to 3% only. In the fertilizer-less crops, the relative maxima are not falling below 100%.

The temperature of the submersion water is equally changing with the crop development. The upper layers of the free water are, during the whole measurement period, warmer than the air above. Within the crops, however, this condition holds only until the intensive development begins. In the lower layers of the free water, an important temperature increase is occurring as a consequence of a strong prolification of algae.

It can be stated, that *the presence of the rice crop is not causing any important change in the maximum temperatures within the air space above the crops, however, there are rather important differences below the canopy layer.* At the beginning of maturation, the relative maximum is reaching a nearly constant value, which is characteristic for the peculiar crop. The relative maxima of this phenophase were further investigated. We determined the mean values and standard deviations of the relative maxima, and carried out a statistical „t"-test for values of the free water and both crops as well as for the values of the two crops (Table 3).

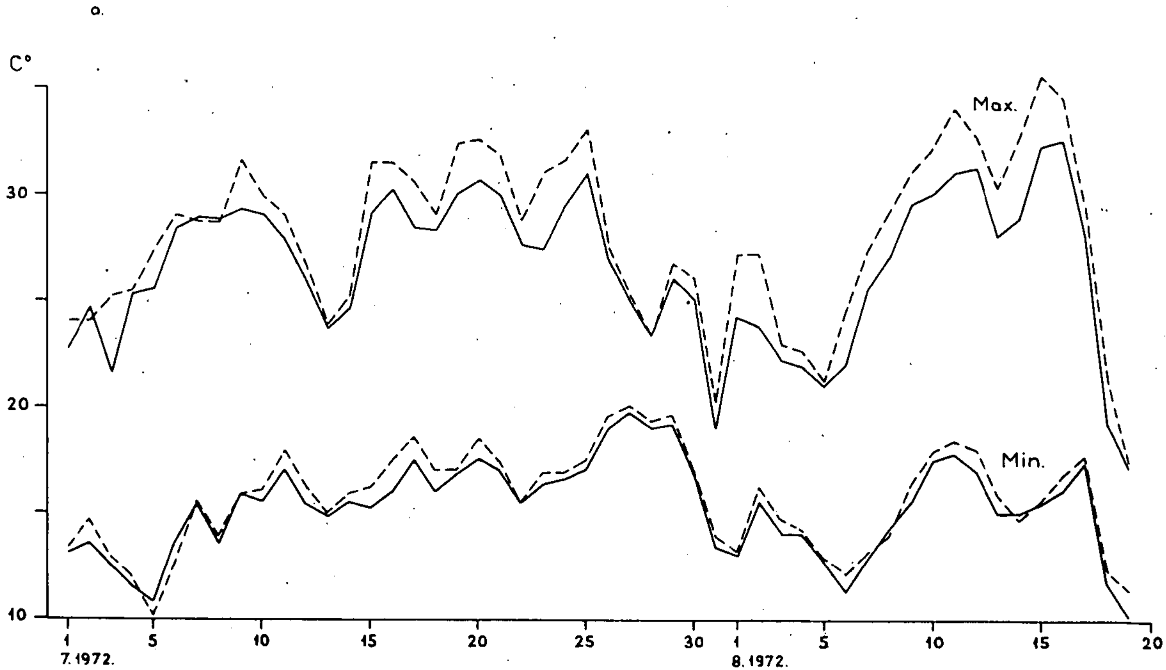
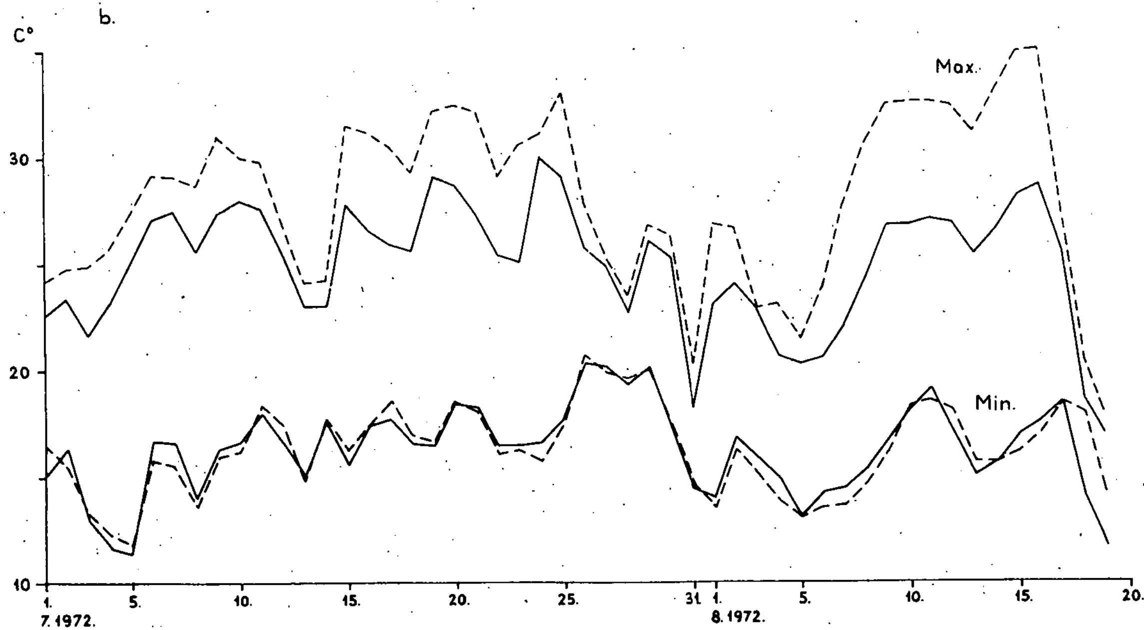


Fig. 2. Maximum and minimum temperatures of the (————) fertilized and the non-fertilized (— — — —) crop (Szarvas, 1972)
a= canopy layer, b= 10 cm above the water surface, c= at 1 cm depth below the water surface, d= water bottom

2. ábra. A trágyázott (————) és a trágyázás nélküli állomány (— — — —) maximum és minimum értékei (Szarvas, 1972)
a= állományzáró réteg, b= vízszint felett 10 cm, c= vízfelszín alatt 1 cm, d= vízfenék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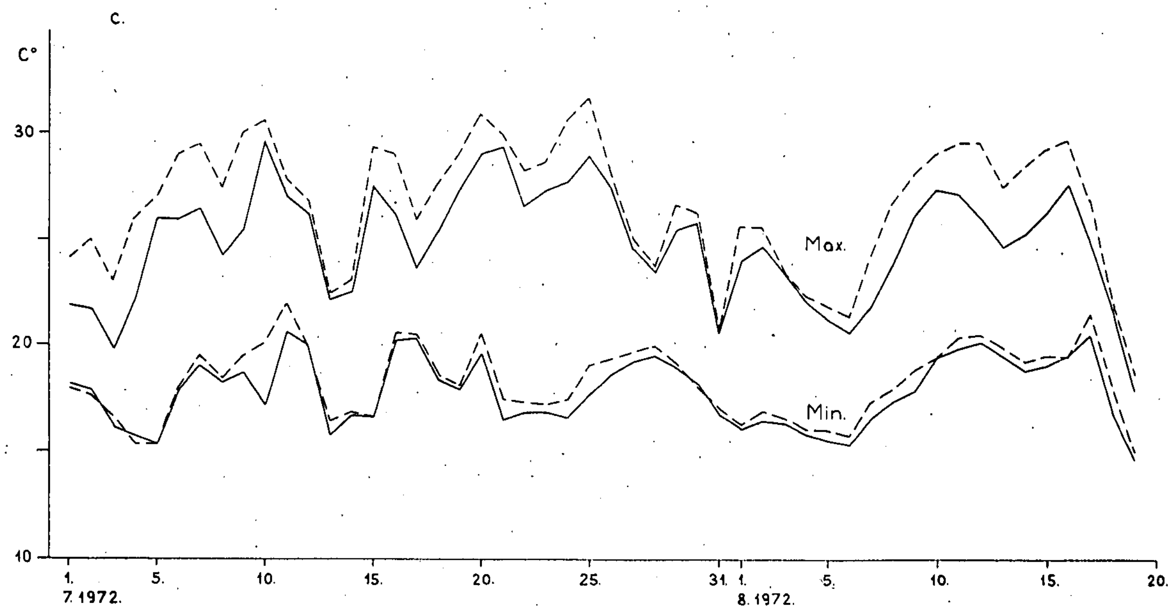
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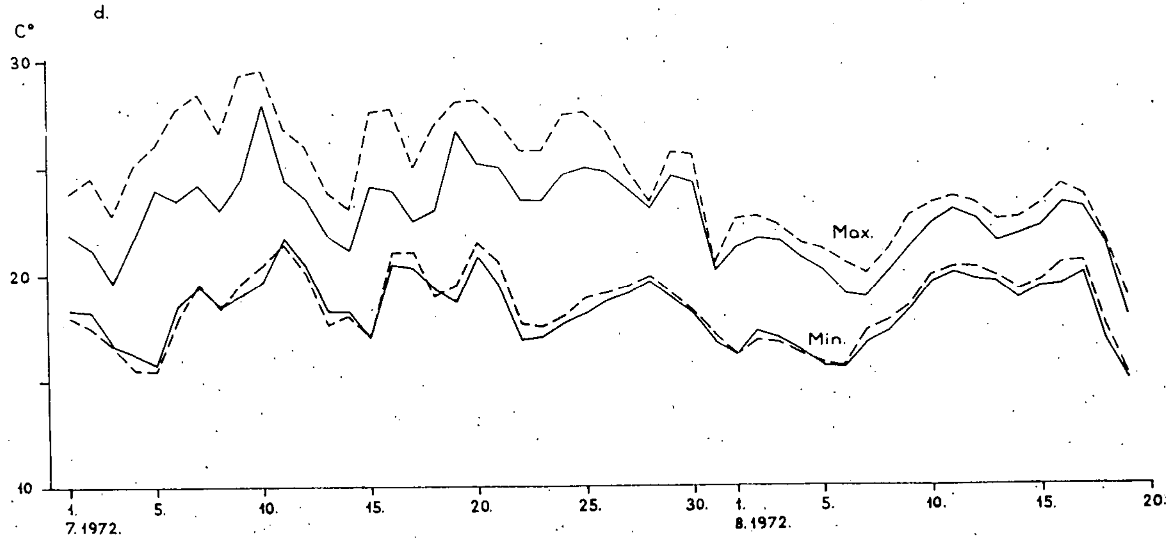
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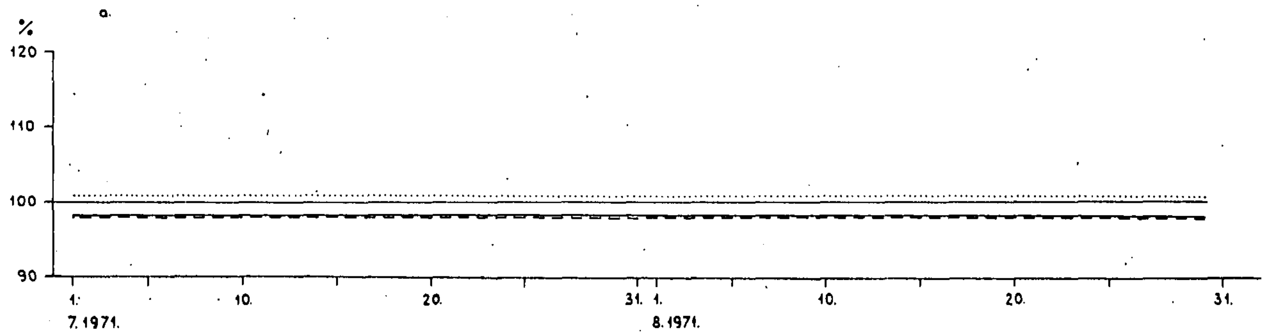
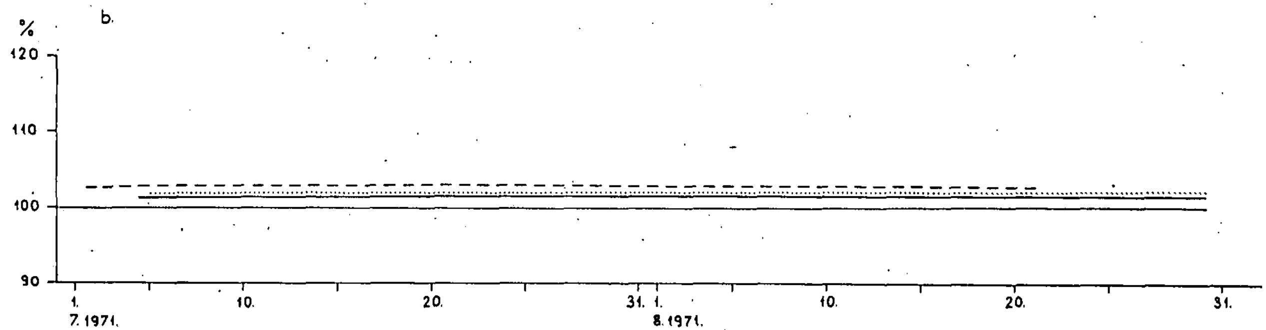


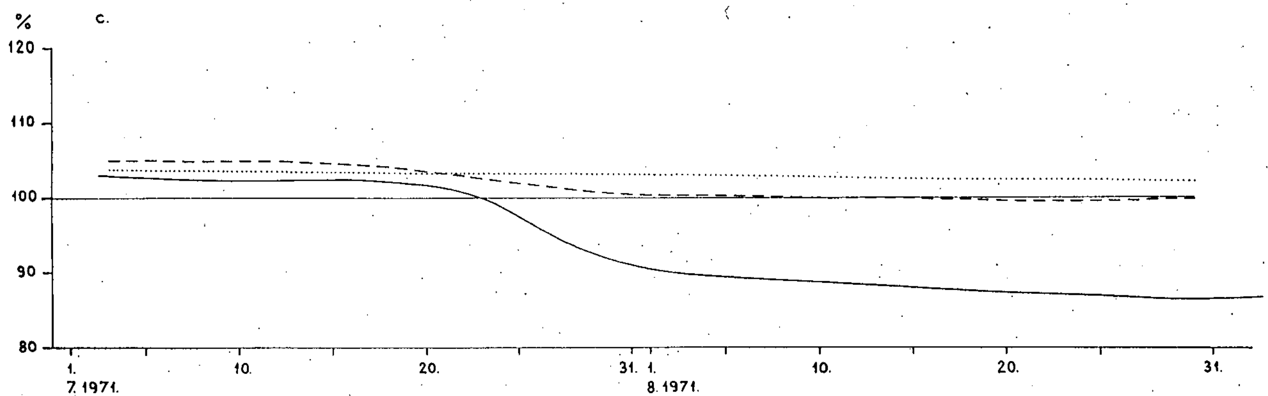
Fig. 3. Smoothed curves of the so-called relative maxima in the fertilized (————) crop, in the non fertilized crop (— — — —) and in the free water (. . . .). (Szarvas, 1971)

a=200 cm level, b=canopy level, c=10 cm above the water surface, d=at 1 cm depth below the water surface, e=water bottom

3. ábra. A relatív maximum kiegyenlített görbéi a trágyázott (————), a trágyázás nélküli (— — —) állományban és a szabad vizen (. . . .) (Szarvas, 1971)

a=200 cm, b=állományzáró réteg, *c*=vízfelszín felett 10 cm, d=vízfelszín alatt 1 cm, *e*=vízfenék

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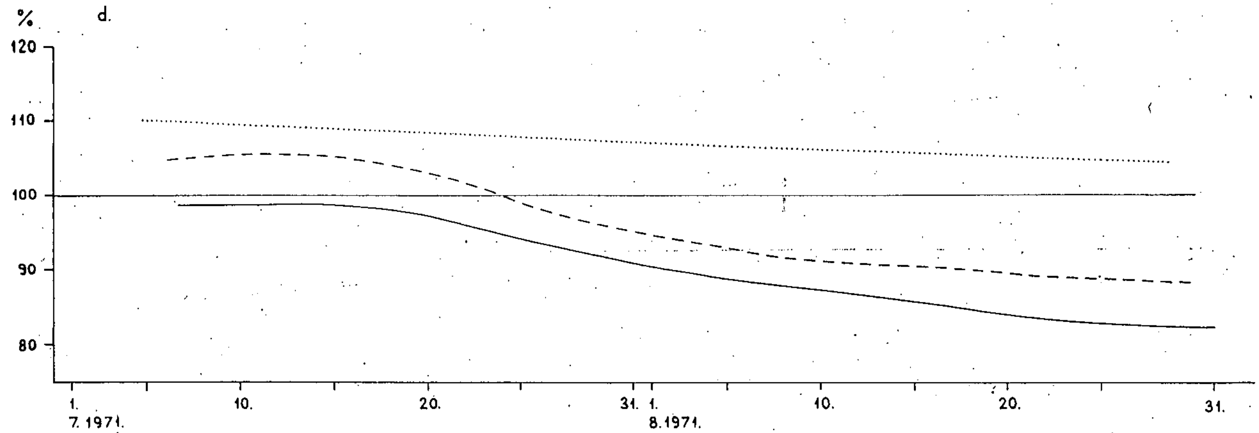
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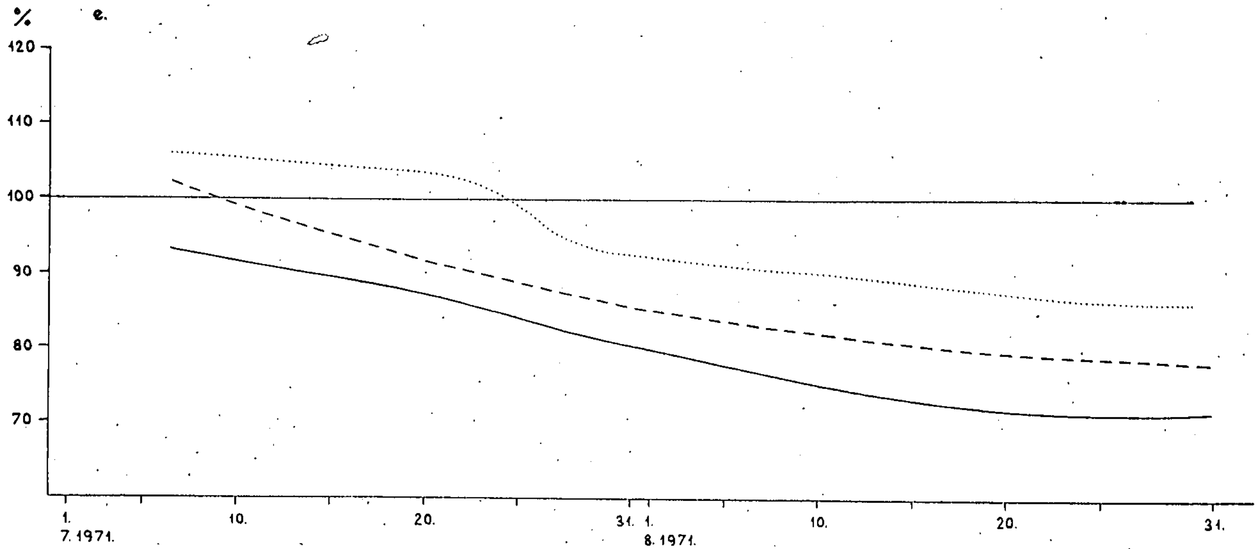
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Table 3

Statistical investigation of the maximum temperatures of the two rice crops and the free water during the phenophase of maturation
(Szarvas, 1971)

Level	n=24					
	crop	X%	σ	Crops	„t"	Significance level
200 cm	a	100.4	1.98	a—c	4.035	+++
	b	98.1	1.68	a—b	4.356	+++
	c	98.1	2.01	b—c	0	–
Crop canopy	a	102.6	2.34	a—c	0.361	–
	b	101.5	3.05	a—b	1.406	–
	c	102.3	3.34	b—c	0.869	–
10 cm over water	a	103.0	2.24	a—c	1.115	–
	b	90.3	5.81	a—b	10.023	+++
	c	102.1	3.28	b—c	8.695	+++
1 cm below water surface	a	105.8	5.54	a—c	8.383	+++
	b	88.7	5.80	a—b	10.477	+++
	c	93.3	4.79	b—c	3.005	++
Water bottom	a	90.4	7.32	a—c	3.928	+++
	b	77.1	5.75	a—b	7.022	+++
	c	83.0	5.67	b—c	3.588	+++

a = free water
b = fertilized crop
c = non-fertilized crop
– = no significant difference
++ = significant on the 1% probability level
+++ = significant on the 0.1% probability level

In terms of mean values, it appears, that in the free water, the surface is the warmest layer, its maximum being nearly by 6% „higher" than the maximum observed at the climatological station. In the crops, the warmest layer is transferred to the canopy level. The insolation of the inner space of the crop depends on a complex effect of the following factors: incidence angle of the solar rays, their azimuth, the diurnal variation of insolation as a consequence of cloudiness, and the degree of closedness of the drops. Accordingly, at the 10 cm level of the fertilized crop, the standard deviation of the relative maxima is the highest. The fertilizer-less crop is rather an open one, there, the double effective layers at 10 cm and at canopy level are very probably exerting their influence during the whole day, and the vertical maximum is appearing at one time on the lower and at one time on the higher level, according to the insolation, and, consequently, these two levels are exhibiting nearly identical mean values and standard deviations, and there is no significant difference to the conditions prevailing at the 10 cm level of free water.

At the 200 cm level, there is a difference among the free water and the two crops of at most 2 to 3%, however, because of the low value of the standard deviation, the „t"-test yields a significancy of the difference.

In our opinion, the mean values are (within the limits determined by the standard deviation) suitable during the generative phase of the crop for yielding, by using the maximum temperatures observed on a near-by macroclimatological station, a knowledge of the maximum temperatures at various levels of the crops and for preparing, on this basis, a forecast on the biological phenomena of the rice crops.

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