Contribution to the Knowledge of Atmospheric Humidity Conditions in Rice Crops Subjected to Various Treatments

by

J. Boros and *I. Bárány*

Adatok különböző kezelésű rizsállományok légnedvességviszonyaihoz. Intenzíven műtrágyázott és műtrágyázás nélküli kontroll rizsállományban mért légnedvességértékeket hasonlítottunk össze különböző fenofázisokban szabad vízfelszín és száraz terület feletti nedvességértékekkel.

Megállapítottuk, hogy az állományok légterének nedvességtartalma szoros összefüggést mutat az állomány növekedésével. Az intenzív növekedés időszakától kezdve a trágyázott, sűrűbb rizsállományban egész napon át a telítési érték körül van a relatív nedvességtartalom, s ez magyarázatot adhat az ilyen állományok intenzív gombafertőződésére.

Angaben zu den Luftfeuchtigkeitsverhältnissen in Reisbeständen, die in verschiedener Weise bebaut wurden. Luftfeuchtigkeitsmessergebnisse in Reisbeständen mit Kunstdüngerbehandlung und un ungedüngerten Kontrolbeständen wurden verglichen während verschiedenen Phenophasen mit Messwerten, welche über einer freien Wasseroberfläche bzw. über einen trockenen Boden beobachtet wurden.

Es konnte festgestellt werden, dass der Feuchtigkeitsgehalt des Luftraumes der Bestände in einem Zusammenhang steht mit der Entwicklung des Bestandes. Anfangend mit der Phenophase des intensiven Wachstums, hat man im gedüngerten und dichteren Bestande fast am ganzen Tage eine relative Feuchtigkeit, die nahe an der Sättigung liegt. Dies könnte als eine Erklärung gelten für die intensive Pilzentwicklung innerhalb dieses Bestandes.

Relative humidity values observed in fertilized rice crops and in reference crops which received no fertilization, during various phenophases of the crop, were compared to values measured over a free water surface and over a dry soil area.

We found that the humidity of the air space of the crops is exhibiting a close correlation to the growth of the crop. From the beginning of the phenophase of intense growth, we have, within the fertilized and denser rice crop during the greatest part of the day, a relative humidity which is approximating saturation and this could yield an explanation for the intensive fungus infection of these crops.

In connection to the production and the selection of rice, the requirement arouses that crop development and the qualitative and quantitative characteristics of the factors influencing this development should be studied in relation to various meteorological elements.

The use of the data series obtained on a macroclimatological station and a detailed knowledge of the synoptic weather situation may yield answers to a number of questions. However the very problems, which are immediately related to crop climate, can be solved only by a detailed study of crop climate itself.

Occasionally or periodically executed measurements or the measurements undertaken only in the course of peculiar phenophases are unsuitable for obtaining an answer concerning the physical and biological processes that are taking place within the plant crop. This is the reason why many authors are emphasizing the necessity of a continuous measurement of crop climate, among them *M. Dzapbasbaev* (1969), *P. C. Owen* (1969), *D. Berényi* (1962, 1958), *N. Bacsó* (1962), and *R. Wagner* (1966).

An intensive proliferation of animal pests and plant diseases of the crop is occurring only under optimal conditions which are indeed determined by the weather conditions and by the crop climate. The temperature optimum may vary within a relatively wide range, however, e. g. in the case of fungi, almost without exception the presence of a high degree of atmospheric humidity is a characteristic feature. (*Hermansen, J. E.*, 1968, *Riley, J. A.*, 1965).

The fungus species *Piricularia oryzae Cav.*, as well as the bacteria *Pseudomonas sp.* are, according to the work carried out by *Szirmai, J.* (1949), *Podharszky, J.* (1954), *Vámos, R.* (1958) infesting either healthy plants or, as an alternative, plant specimens which have lost their vigour as a consequence of an unfavourable development of the soil-biological conditions. For their proliferation, they are requiring a high degree of atmospheric humidity.

In the case of rice production by the flooding method, the constant presence of water is exerting a decisive influence on the pattern of crop climate. This influence consists partly in a cooling and partly in a heating effect, and, as a consequence, the diurnal temperature amplitude is decreased within the crop, and, in addition, temperature variations induced by an abrupt change of the macrosynoptical weather situation are moderated and protracted in time .The presence of water is assuring the maximum value of potential evaporation. Potential evaporation is in the case of a free water surface mainly depending on the amount of radiated and transported energies, including the turbulence effect of the air layer situated above the water surface (*Montheit., J. L.* 1965). In the case of a rice crop, however, the water amount of evapotranspiration should be taken into account, a quantity which is determined partly by the life processes of the plant and partly by the pattern of crop climate.

By the *Chair for Climatology of József Attila University,* microclimatological measurements were carried out during the period 1971—1973 on the site of the *Irrigation Research Institute at Szarvas* (rice-growing site Káka II) in the frame of variety breeding and fertilizing experiments. Among other microclimatological elements, we measured atmospheric humidity by using an Assmann psychrometer at the heights of 10 and 150 cm, in rice crops consisting of the same variety ("Kákai 203") but receiving different amounts of fertilizer, and on sites situated, in one case, over a free water surface, and, in the other, over a sodic soil.

One of the crops used in the fertilizer experiments, which will be referred shortly as "fertilized crop", received, as basic fertilization, ammonium sulphate corresponding to a N-content of 170 kg/hectare as well as a superphosphate fertilizer corresponding to a P_2O_5 content of 90 kg/hectare. On the solonecic meadow soil characteristic for this area, basic fertilization has produced such a developed kind of vegetation which can be regarded as characteristic also under the conditions of a farming on large scale. Among all the experiments, this one yielded the largest crop. The other rice crop in which we carried out measurements, will be referred to as the "unfertilized crop", as it received no fertilizer. Using the same crop density and the same flooding pattern, the obtained crop was considerably sparser, because the vegetative organs were rather weakly developed. The two crops are characterized by the data listed in *Table 1.*

The measurements were carried out during the period from 1st July to August 31, a period which is including the most important phases of the generative development in rice.

In this paper, we are dealing with the atmospheric humidity conditions at the 10 cm level, on the basis of comparisons among the peculiar crops, the free water surface and the dry soil area, with a particular attention to the growth of the rice crop.

At the 150 cm level, there are no significant differences consequently we are omitting the discussion of the conditions prevailing at this level.

On *Figs. 1—2*, we are presenting, on the basis of data collected in 1971, the five-day average values of the true diurnal means of the relative humidity and of the vapour pressure as well as of the extreme values of these quantities.

The vapour pressure data are well reflecting the temperature conditions that prevailed during the two months of the year 1971 which have been investigated. Above the dry area and over the free water surface, the values are nearly identical ones. The maxima of the vapour pressure, and thus also the amplitudes are considerably higher within the crops; from mid-July, the amplitude is about by 50 per cent higher in the fertilized crop than over the free water surface. The high value in the maximum is a result, on the one hand, of the illimited possibility of evaporation, and, on the other hand, of a decrease in turbulence.

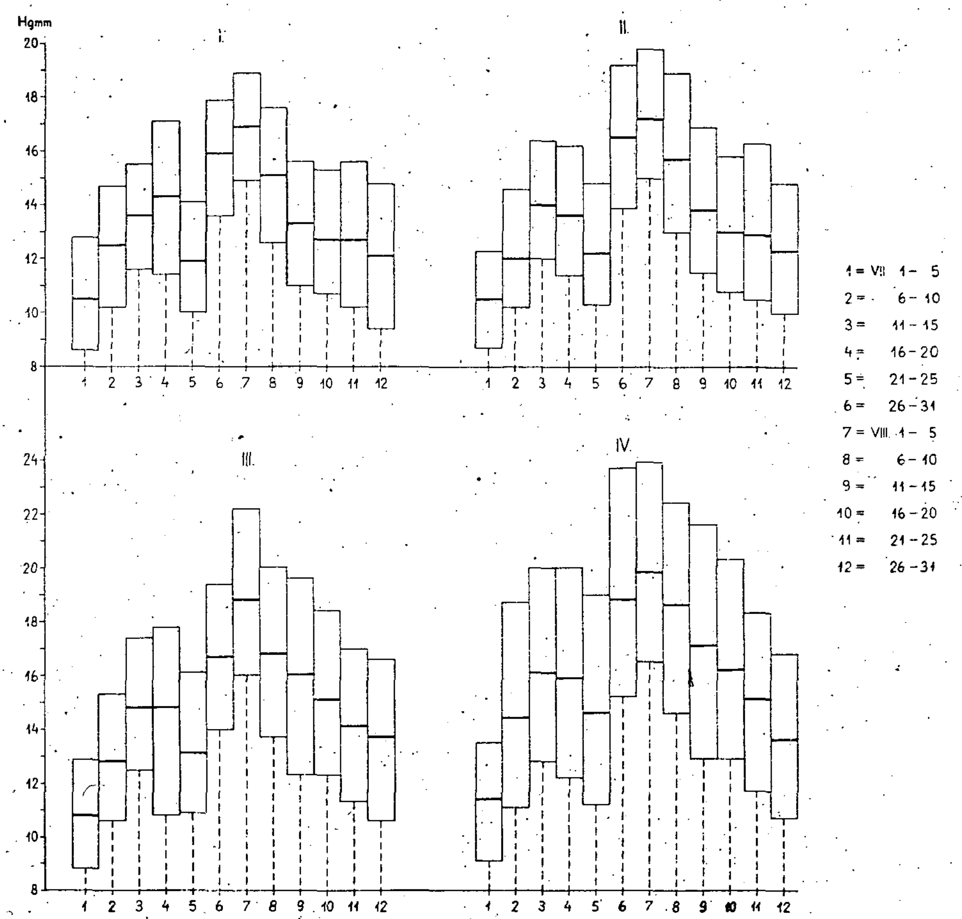
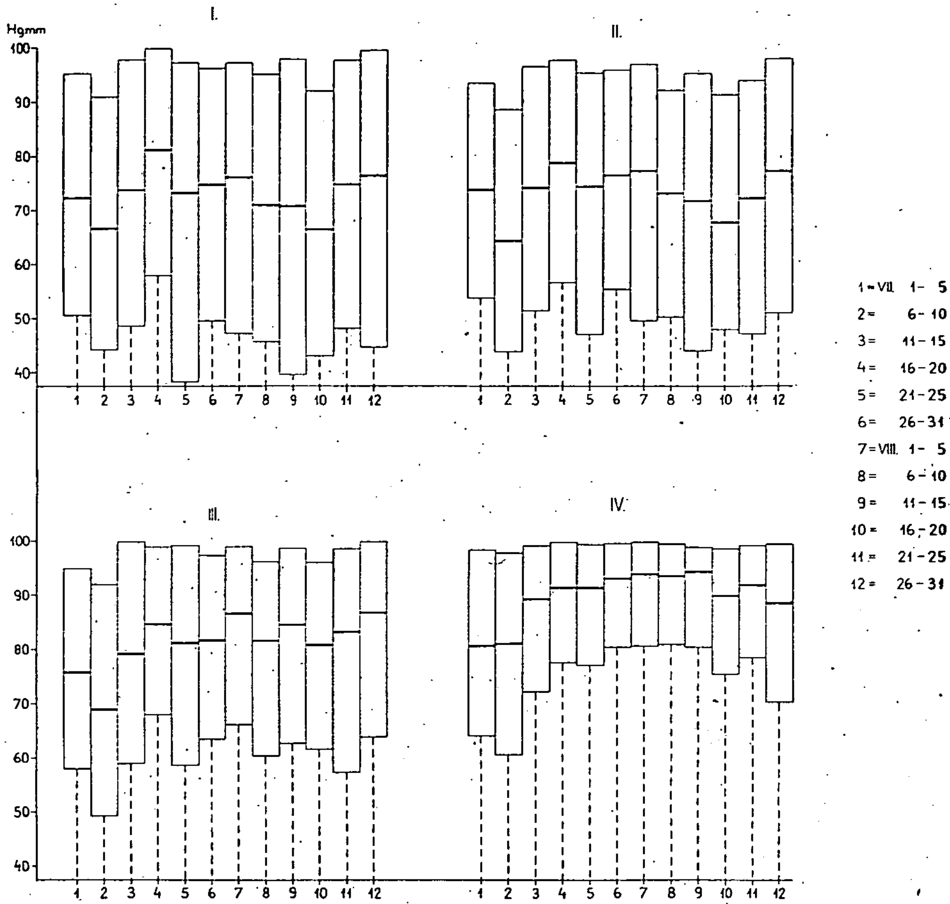


Fig. 1. Five-day average values of the maximum, minimum and diurnal mean values of the vapour pressure at Szarvas (Hungary); 1971.
I=dry area, II=free water surface, III=unfertilized crop, IV=fertilized crop.
1. ábra. A páranyomás maximumának, minimumának és napi középértékének pentádjai. Szarvas 1971. I=száraz terület, II=szabad vízfelszín, III=trágyázás nélküli állomány, IV=trágyázott állomány.

Five-day average values of relative humidity are reflecting the peculiarities of the crop climate and of the micro-climate. The maxima are nearly identical, having a value of 95 to 100 per cent. As a consequence of an increase of the minima, average



Sig. 2. Five-day average values of the maximum, minimum and diurnial mean values of the relative humidity at Szarvas (Hungary), 1971.
I-dry area, II=free water surface, III=unifertilized crop, IV=fertilized crop.
2. ábra. A relatív nedvesség maximumának, minimumának és napi középértékének pentádjai. Szarvas 1971.
I=száraz terület, II=szabad vízfelszín, III=trágyázás nélküli állomány, IV=trágyázott állomány.

diurnal amplitude is steadily decreasing within the dense, fertilized crop. In the fertilized crop, the true diurnal mean values are shifted towards the maximum, signifying that the hourly values, from which the diurnal mean value is calculated, are values lying near the maximum, that is, during a considerable part of the day, relative humidity of the air is near to saturation. Diurnal true mean values and minima are in the fertilized crop not influenced by changes in the macrosynoptical situation, they are rather adjusting themselves to a nearly constant level in the course of the crop becoming dense and with its growth.

On the basis of hourly psychrometric measurements we are presenting the diurnal variation of relative humidity on the days during the phenophase of insolation and flowering, at a time when the period of vehement growth is terminated in the crop. (Figs. 3—4)

August 6, 1972 represents the beginning of an anticyclonal situation; true mean temperature, 17,4 centigrade; true mean value of relative humidity, 73%; duration of insolation, 10,0 hours; in the time between 07 a.m. and 20 p.m., a strong wind from the North is prevailing.

August 9, in the middle of the anticyclonal period, has a clear and calm weather; true mean temperature, 24,5 centigrade; true mean relative humidity, 78%, duration of insolation, 10,2 hours.

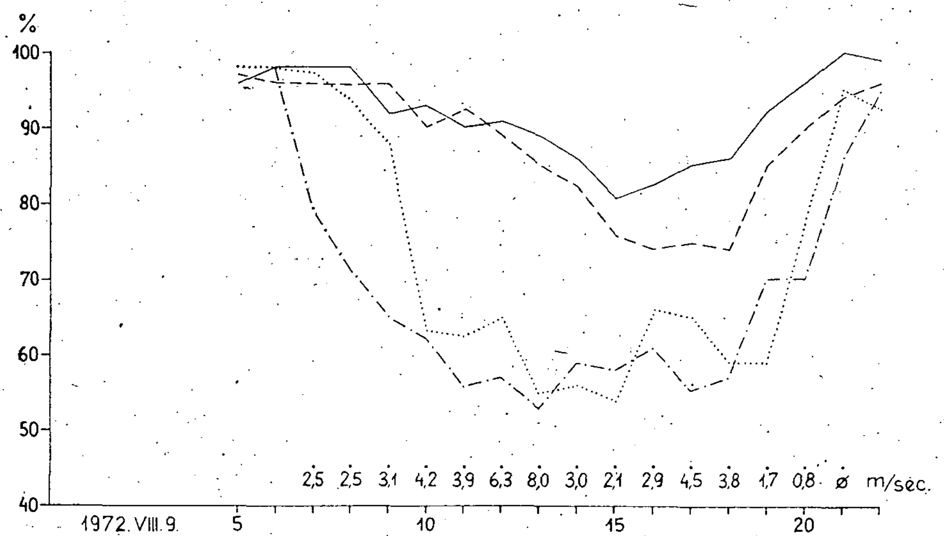


Fig. 3. Diurnial variation of relativ humidity on a windy day.
—.—.—. =dry area, ... =water, ---------------- =unfertilized crop, ———— =fertilized crop.

3. ábra. A relatív nedvesség napi járása szeles napon.
—.—.—. =száraz terület, ... =víz, --------- =trágyázatlan állomány, ———— =trágyázott állomány.

It is seen that relative humidity conditions within the closed crop may be influenced only by a strong wind, as the crop is ventilated only by a higher air velocity. In calm weather, relative humidity is not decreasing below a value of 90%.

In the case of the more sparse, unfertilized crop the minimum of relative humidity is decreasing below 70 per cent even on calm days as a consequence of the following factors: lack of total closing, insolation, micro-airflow within the crop itself and micro-airflow originating from the vicinity.

The discrepancy of the extreme values of relative humidity from those observed on the dry area is highest on the clear days, and it is manifesting itself mainly in the minima. Accordingly, we selected, from the measurements obtained during the three years of this research work, the clear days possessing more than ten hours of insolation, and compared the minima of relative humidity to those observed on the dry area. The period has been divided into three subperiods, namely: 1) from the end of growing thick to the commencement of sprouting (July 1—18); 2) from the development of panicles to the commencement of flowering (July 19—31); 3) from the intensive flowering to the beginning of maturation (August 1—20), and investigated these phenophases separately. In the growth of the plant, the development of vegetative and generative organs, these three sub-periods are clearly separated.

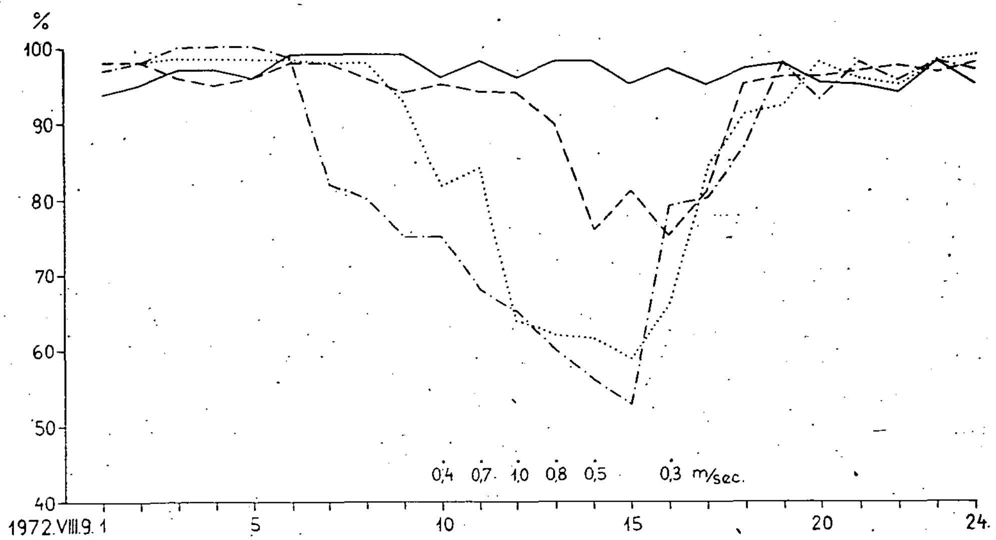


Fig. 4. Diurnial variation of relativ humidity on a calm day.
—.—.—. *=dry area,* .... *=water,* --------- *; =unfertilized crop,*
——————— *=fertilized crop.*

4. ábra. A relatív nedvesség napi járása szélcsendes napon.
—.—.—. *=száraz terület,* .... *=víz,* -------- *; =trágyázatlan állomány,*
——————— *= trágyázott állomány.*

At the time of the development of panicles and at the beginning of flowering, the intensive growth of the crop is terminated and the most decisive peculiarities of the crop are already formed.

The differences have been plotted as functions of time in a co-ordinate-system (Figs. 5—6). The data points are suggesting a straight line, which is yielding, within the limits of data scatter, the discrepancies of relative humidity as compared to those observed in the dry area, as a function of time, or, respectively, of the development of the plants. Scatter is a relatively high one, a circumstance which is attributed to the fact that, detailed wind data lacking, we were unable to separate the data according to wind conditions.

In *Tables 2A and 2B,* we are presenting the statistical analysis data of the discrepancies as compared to the dry area on the basis of the clear days which have occurred during the three years of research, separately according to the three phenophases.

The differences between the minima of the fertilized crop are in every case and in each phenophase significant ones on the 0,1% probability level, according to the results of the statistical "t"-test. Similarly strong significances are possessing the differences also in the unfertilized crop, with the exception of the vapour pressure values, which are exhibiting no significant difference as compared to the data of the free water surface, in the case of the first phenophase.

In the case of the crops, relative humidity is possessing a high scatter, which is indicating the important role of advective influences.

It can be stated that the relative humidity and the vapour pressure of the atmosphere within a rice crop are related to the density of the crop. In dense crops,

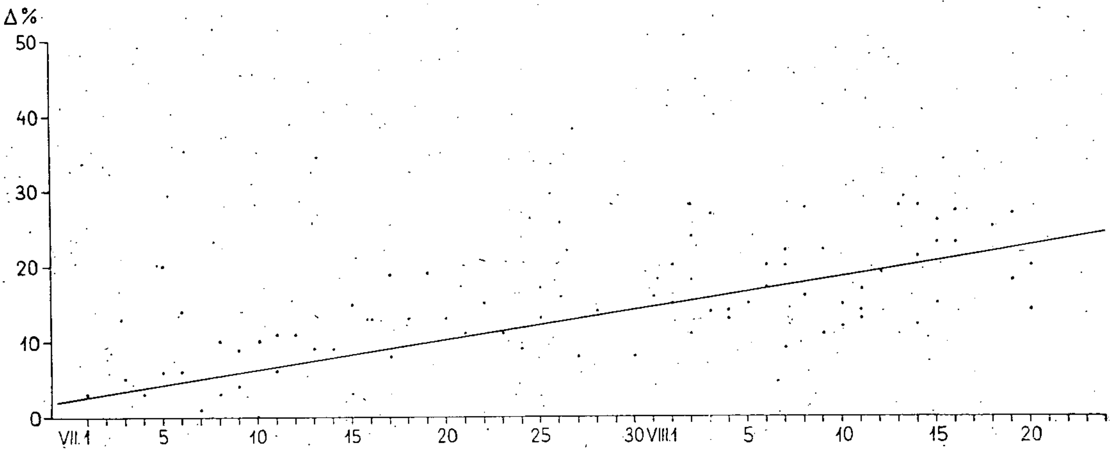


Fig. 5. Differences in the minimum values of relativ humidity between the dry area and the unfertilized crop on clear days. Szarvas (Hungary), 1978—1973.

5. ábra. A relativ nedvesség minimum értékeinek különbségei a száraz terület és a trágyázatlan állomány között, derült napokon. Szarvas 1971—73.

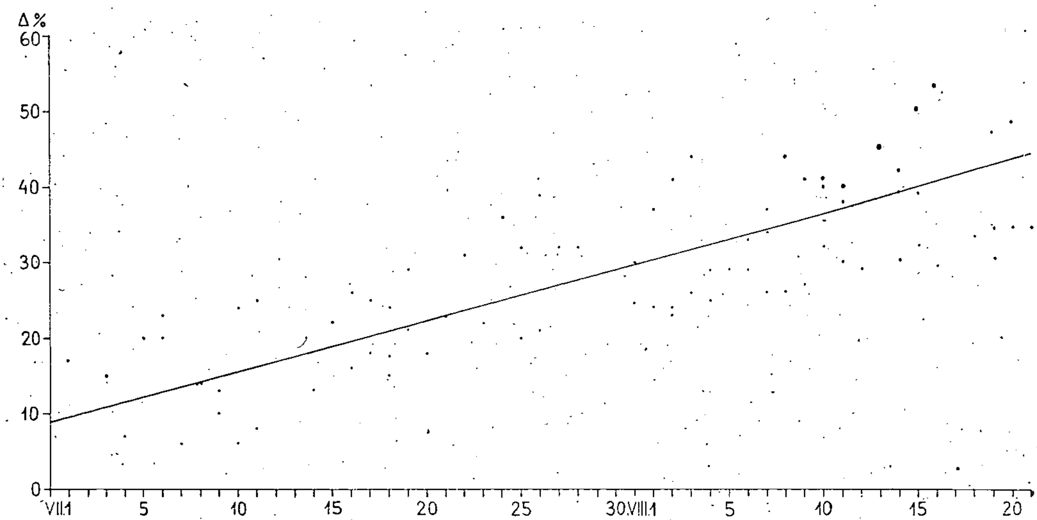


Fig. 6. Differences in the minimum values of relativ humidity between the dry area and the fertilized crop on clear days. Szarvas (Hungary), 1971—73)

6. ábra. A relativ nedvesség minimum értékeinek különbségei a száraz terület és a trágyázott állomány között, derült napokon. Szarvas 1971—73.

air is mixed only under the influence of stronger air movements. Variation of humidity content is, as demonstrated, not only on clear days, but also in the five-day average values, detached of the pattern of macrosynoptic changes, and is exhibiting an increasing tendency.

The intensive growth of the crop is coinciding with the frequent occurrence of anticyclonic weather situations in this country during the month of August. Accordingly, within the crops, relative humidity may remain during protracted periods of time in the vicinity of the saturation value, yielding optimal opportunities for the proliferation of animal pests and plant diseases.

Table 1

Production data of rice crops with and without the use of fertilizer (variety "Kákai 203") at Szarvas, Hungary, 1971—1973

Year	Fertilizer	Plant height, cm	Number of panicles per cm^2	Number of corns per panicle	Sterility	Corn crop q/hectare
1971	∅	84	637	37	5	29,9
	N+P	96	713	50	18	47,6
1972	∅	89	534	34	10	29,4
	N+P	102	648	46	16	50,0
1973	∅	90	283	58	11	25,4
	N+P	106	424	54	17	37,4

Table 2

Statistical investigation.
Discrepancies of the minimum values of the relative humidity (Table 2A) and of the vapour pressure (Table 2B) as compared to the data observed on a dry area

a) for a water surface, b) for the unfertilized crop, c) for the fertilized crop

Table 2A

Phenophasis	Crop	$\bar{x}$	δ	„t"-test		
				crop	t	significance level
From the end of growing thick to the commencement of sprouting	a	1,7	3,77	a—b	5,387	xxx
	b	8,5	5,19	a—c	10,064	xxx
n=24	c	17,4	6,91	b−c	5,205	xxx
From the development of panicles to the commencement of flowering	a	2,9	5,03	a−b	6,145	xxx
	b	13,9	4,69	a−c	9,149	xxx
n=15	c	24,4	7,47	b−c	4,217	xxx
From the intensive flowering to the beginning of maturation	a	4,5	3,31	a−b	12,632	xxx
	b	18,9	5,71	a−c	20,629	xxx
n=40	c	34,0	7,74	b−c	9,264	xxx

Legend:

− = there is no significant difference
xx = significance at the 1% probability level
xxx = significance at the 0,1% probability level

Table 2B

Phenophasis	Crop	$\bar{x}$	δ	„t"-test		
				crop	t	significance level
From the end of growing thick to the commencement of sprouting	a	0,3	1,10	a−b	1,333	—
	b	0,7	0,72	a−c	6,216	xxx
n=24	c	2,6	1,48	b−c	5,758	xxx
From the development of panicles to the commencement of flowering	a	0,1	0,62	a−b	3,429	xx
	b	1,3	1,17	a−c	6,923	xxx
n=15	c	3,7	1,88	b−c	4,138	xxx
From the intensive flowering to the beginning of maturation	a	0,7	0,98	a−b	4,286	xxx
	b	1,9	1,33	a−c	9,630	xxx
n=40	c	3,3	1,22	b−c	4,516	xxx

References

Bacsó, N. (1962): A folyamatos mérések jelentősége az állományklíma kutatásában (Importance of Continuous Measurements in the Investigation on crop Climate) MTA agr. Tud. Oszt. Közl. XXI. 3—4.

Barényi, D. (1958): Az állományklímát kialakító tényezők. (The Factors Determining a Crop Climate) MTA Agrártudományok Oszt. Közl. 1—3.

Berényi, D. (1962): Hozzászólások Bacsó N.: A folyamatos mérések jelentősége az állományklíma kutatásában. (Discussion on the paper of N. Bacsó „Importance of Continuous Measurements in the Investigation of Crop Climate")

Dzaphasbaev, M. (1969): Agroklimaticheskie uslovija proizrastanija risa v kontinentalnom klimate (Agricultural-Climatological Conditions of Rice Production under Conditions of a Continental Climate) Gidrometeor. Izdat. Leningrad.

Hermansen, I. E. (1968): Studies on the Spread and Survival of Cereal Rust and Mildew Diseases in Denmark Hertz — Bogtrykkergaarden, Copenhagen

Monteith, I. L. (1965): Evaporation and Environment Symp. Soc. Exp. Biol. 19.

Owen, P. C. (1969): The Growth of Four Rice Varieties as Affected by Temperature and Photoperiod with Uniform Daily Periods of Daylight. Exp. Agric. Londen 85—90 p.

Podharszky, I. (1954): Szántóföldi növényvédelem. A rizs bruzone betegsége és a betegség elleni védekezés a hazai kutatások tükrében. (Plant Protection on the Arable Land. Bruzone Disease of Rice and the Protection Against this Disease as Reflected by Research Work Done in this Country). A növényvédelem időszerű kérdései. (Actual Problems of Plant Protection) Mezőgazdasági Könyvkiadó, Budapest.

Riley, I. A. (1965): Meteorology and Crop Pests. Symposium on Weather and Plant Disease. Lafayette, Indiana. Phytopathology, 55. 9. Worcester, Mass.

Szirmai, I. (1949): A rizs bruzone betegsége, különös tekintettel a hazai vonatkozásokra. (The Bruzone Disease of Rice, with Particular Attention to the Conditions on this Country). Mezőgazdasági Tud. Közl. Budapest. 124—145 p.

Vámos, R. (1958): Talajbiológiai folyamatok szerepe a rizs bruzone betegségében (Role of Soil-Biological Processes in the Development of the Bruzone Disease of Rice). MTA Agrártud. Oszt. Közl.