

VĚDECKÝ ČASOPIS



# ROSTLINNÁ VÝROBA

EKOLOGIE POLNÍCH ROSTLIN

Экология полевых растений

ECOLOGY OF FIELD PLANTS

ÖKOLOGIE DER FELDPFLANZEN

8

ROČNÍK 21 (XLVIII)

PRAHA

SRPEN 1975

CENA 18 Kčs

ROYAM 21 (8)

797—920 (1975)

CS ISSN 0035—8371

ČESKOSLOVENSKÁ AKADEMIE ZEMĚDĚLSKÁ

ÚSTAV VĚDECKOTECHNICKÝCH INFORMACÍ

## ROSTLINNÁ VÝROBA

Řídí redakční rada

Prof. ing. František Hron, CSc. (předseda), ing. Jiří Apłtauer, CSc., ing. Ivo Bareš, CSc., akademik Ctibor Blatný, prof. ing. Karel Červenka, CSc., doc. ing. Mikuláš Derco, CSc., dr. Zbyněk Facek, CSc., ing. Josef Habovštiak, CSc., prof. ing. dr. Ladislav Hruška, DrSc., ing. Karel Jelínek, CSc., prof. dr. ing. Václav Káš, DrSc., prof. dr. ing. Vladimír Kosil, DrSc., doc. ing. Anton Kováčik, DrSc., ing. Jaroslav Lekeš, DrSc., člen korespondent CSAV ing. František Mareček, ing. František Mráz, CSc., doc. ing. Jaroslav Prugar, CSc., prof. ing. Václav Rybáček, CSc., doc. ing. Vladimír Segefa, CSc., ing. Miloslav Schmied, CSc., ing. Vladimír Skládál, ing. Josef Slepíčka, CSc., ing. Ján Švihra, CSc., ing. Juraj Uhliar, CSc., RNDr. ing. Jaroslav Zakopal.

Vedoucí redaktorka Milena Sovová

© Ústav vědeckotechnických informací, Praha 1975

■  
Vědecký časopis ROSTLINNÁ VÝROBA uveřejňuje studie, rozboru a vědecká pojednání o vyřešených úkolech výzkumu z oboru rostlinné výroby. Vydává Ústav vědeckotechnických informací. Vychází měsíčně. Redakce: 120 56 Praha 2, Slezská 7. Telefon 257541. Celoroční předplatné Kčs 216,—.

■  
Научный журнал ROSTLINNÁ VÝROBA публикует обзоры, анализы и научные статьи о решенных заданиях по научному исследованию в области растениеводства. Издает Институт научно-технической информации. Выход в свет ежемесячно. Редакция 120 56 Прага 2, Слеска 7.

■  
The scientific journal ROSTLINNÁ VÝROBA publishes studies, analyses and scientific treatises about the solved research tasks in the line of the plant production. Published by the Institute of Scientific and Technical Information. Issued monthly. Editorial office 120 56 Prague 2, Slezská 7.

■  
Die wissenschaftliche Zeitschrift ROSTLINNÁ VÝROBA veröffentlicht Studien, Analysen und wissenschaftliche Abhandlungen über die gelösten Forschungsaufgaben auf dem Gebiete der pflanzlichen Produktion. Herausgegeben von Institut für wissenschaftlich-technische Informationen. Erscheint monatlich. Redaktion 120 56 Praha 2, Slezská 7.

■  
Le journal scientifique ROSTLINNÁ VÝROBA publie les études, analyses et traités scientifiques concernant les tâches de recherches résous dans le domaine de production végétale. Publié par l'Institut des Informations Scientifiques et Techniques. Publié chaque mois. Rédaction 120 56 Prague 2, Slezská 7.

The International Biological Program contributed to quick development of ecology all over the world. The second special issue „Ecology“ of the scientific journal „Rostlinná výroba“ which comprises papers concerning the problems of agriculture, namely crop production, documents the contribution of Czechoslovak institutions to this project. The ecology itself, once a describing and static branch of science, has come to the fore of interest in the last decades; it has brought a great deal of new knowledge on agriculture and function of biological systems on higher as well as highest levels of the organization (population – association – ecosystem – biosphere). Ecology also tried to integrate biological information with knowledge concerning social as well as economic problems. At the present stage of information, man becomes a controlling factor which alternates considerably the functions of most ecosystems on the earth, and creates distinctly divergent new types of ecosystems.

One of the aims of the IBP was to ascertain the real potential and upper limits for plant production, namely in the sphere of cultivated plants. Not only stating certain values but also causal explaining the processes were searched for. In spite of an immense progress in physiology, molecular biology, biochemistry and other branches of science, and also in agriculture, we have not yet been able to explain sufficiently all biological bases of the production within the whole ecosystem; so much further research work is needed in this field.

The excess or insufficiency in heat and rainfall, air composition, duration and quality of light, biological activity, physical as well as chemical conditions of the soil, manuring and fertilizing, crop rotations, cultivars employed, weeds, diseases and pests, and many other factors are those numerous and variable quantities by which the primary production and yield are affected.

Examining of these factors and their effect on production demonstrated that yields could be equal, higher or lower even under considerably divergent constellation of various factors. The effect of individual factors can be summarized or compensated in various ways, and various combinations of them can exert a positive or negative influence from the point of view of man. Therefore, it is necessary not only to examine each factor individually but to ascertain also its function to the other factors. It may be noted, however, that, in various growth stages of the plant, each factor or complex of them is not of equal importance to the plant. The reaction of plant to the environment has been connected with its ontogeny; this means that the reaction is changeable according to stages. Its quantity and quality being equal, the same factor that induces positive influence in one developmental stage may exert indifferent or even negative effect in another stage of development. The effect of environment is only exceptionally direct (e. g. mechanical effect of the wind). The influence of the locality is essentially realized by alternations of the inner „environment“ of the plant, because the plant does not represent any passive object.

Differences between theoretically possible and real yields of crops have still been considerable. The cause of this consists, among others, in the fact that factors of the production process have not been optimized yet. The farmer himself, of course, is able to influence them. Thus all cultural practices and also breeding aims may be interpreted as forming favourable conditions for maximum exploiting vegetation factors, locality and intensity of the photosynthetic process, which results in optimum transmission of assimilates into economically important organs of crops.

The International Biological Program is being closed up. Its essential ideas, however, will be present in the further program and level of the research for many future years. It is also connected, to a certain extent, with the further program Man and Biosphere.

In the course of ten-year lasting International Biological Program the research workers have gathered an immense amount of actual results; at present, compiled data are being evaluated. The Program provided not only many theoretical but also practical answers which have been directly exploited by agricultural practice as well as pedagogic activity.

The special issue of „Rostlinná výroba“ dealing with ecology of crops and problems investigated within the framework of IBP in Czechoslovakia cannot but to present only a part of research results which were obtained in various areas in the last ten years. The issue links up with preceding papers published namely in Rostlinná výroba, 1973, Vol. 19, No. 8 and PT-PP Report No. 1 (Prague 1970, Productivity of Terrestrial Ecosystems - Production Processes) and papers comprised in references listed by individual authors participating in this issue.

Finally I should like to express my gratitude to all organizations and active participants in the IBP, namely to the Czechoslovak National Committee for IBP headed by Prof. Dr. E. H a d a ě, Dr. Sc., corresponding member of the Czechoslovak Academy of Sciences, for their assistance as well as means that could be devoted to this research program.

Doc. Ing. V. Č e r n ý, CSc.

**M**ezinárodní biologický program podpořil rychlý rozvoj ekologie v celém světě. Dokladem tohoto vlivu je i druhé monotematické číslo na úseku zemědělství - rostlinné výroby - v rámci účasti československých institucí na tomto projektu. Ekologie sama, původně popisná, statická vědní disciplína, se v posledních desetiletích dostala do popředí zájmu a přinesla mnoho nových poznatků o struktuře a funkci biologických systémů na vyšších a nejvyšších úrovních organizace (populace - společenstvo - ekosystém - biosféra) a také se pokusila o integraci těchto přírodovědných poznatků se znalostmi ze sféry společensko-ekonomické. V současné úrovni poznání vystupuje totiž člověk jako činitel řídicí nebo

výrazně pozměňující funkce valné většiny ekosystémů na zemi a také vytváří výrazně odlišné, nové typy ekosystémů.

Jedním z hlavních cílů IBP bylo zjistit skutečné možnosti a horní hranice rostlinné produkce, v daném případě v oblasti kulturních rostlin. Přitom nešlo jen o konstatování určitých hodnot, ale o vysvětlení a příčiny procesů. V porovnání s nesmírným pokrokem fyziologie, molekulární biologie a biochemie i jiných disciplín, ale i s celkovým pokrokem v zemědělství stále ještě nemáme dostatečně vysvětleny všechny biologické základy produkce v rámci celého ekosystému a bude ještě zapotřebí mnoho další významné práce na tomto úseku.

Přebytek i nedostatek tepla a srážek, složení vzduchu, doba osvětlení a jeho kvalita, biologická činnost, fyzikální a chemický stav půdy, organické a minerální hnojení, způsob střídání plodin, odrůdy, plevele, choroby, škůdci a řada dalších faktorů, to jsou velmi početné a značně proměnlivé veličiny, působící na primární produkci i výnosy.

Výzkumem těchto faktorů a jejich účinků na produkci se můžeme přesvědčit, že sklizeň může být stejná, popřípadě vyšší i nižší při určité třeba i značně odlišné konstelaci různých skupin zmíněných faktorů. Jednotlivé faktory se mohou sumarizovat nebo kompenzovat různým způsobem, čímž z hlediska člověka může jejich kombinacemi vzniknout pozitivní nebo negativní efekt. Proto je nutné studovat nejen vliv každého faktoru jednotlivě, ale stanovit jej současně jako funkci dalších faktorů. Přitom každý faktor nebo jejich komplex nemá pro rostliny stejný význam v různých fázích růstu. Reakce rostlin na prostředí souvisí i s ontogenezí, je tedy stadijní. Stejný faktor může mít při své stejné kvalitě i kvantitě pozitivní vliv v jednom stadiu vývoje, ale indiferentní nebo dokonce negativní ve stadiu jiném. Vliv prostředí bývá jen výjimečně přímý (mechanický – např. vítr). Vliv stanoviště se ve své podstatě projevuje změnou vnitřního „prostředí“ rostliny, neboť rostlina není jen pasivní objekt.

Rozdíly mezi teoreticky možnými a skutečně dosahovanými produkcemi kulturních rostlin jsou dosud značné. Příčiny lze mimo jiné spatřovat i v tom, že nejsou dostatečně optimalizovány faktory produkčního procesu, které má možnost ovlivnit i samotný zemědělec. Všechna agrotechnická opatření i šlechtitelské cíle lze tudíž interpretovat jako vytváření podmínek pro maximální využití vegetačních faktorů, stanoviště a intenzity fotosyntetického procesu s optimálním převodem asimilátů do hospodářsky významných orgánů rostlin.

Mezinárodní biologický program je postupně uzavírán, i když jeho základní myšlenky se promítanou v práci a její úrovni po mnoho dalších let a určitá návaznost je i v dalším celosvětovém programu 'Man and Biosphere'. Během desetiletého trvání IBP bylo výzkumníky shromážděno nepřeberné množství faktologického materiálu, který byl postupně zpracován a v současnosti je kompletizován. Přinesl a přináší řadu nejen teoretických, ale i praktických výsledků, které jsou používány jak přímo v zemědělské praxi, tak i při pedagogické činnosti. V předloženém čísle Rostlinné výroby, které je věnováno ekologii kulturních rostlin a problematice řešené v rámci IBP v Československu, je podán jen krátký výsek z prací, které byly v posledním desetiletí vykonány na různých úsecích. Tento výtisk navazuje na předchozí práce publikované především v časopise Rostlinná výroba, 1973, Vol. 19 No. 8, PT – PP Report No. 1 (Prag

1970, *Productivity of Terrestrial Ecosystems Production Processes*), a na příspěvky uvedené v seznamech literatury jednotlivých autorů tohoto vý-  
tisku.

Závěrem děkuji všem organizátorům a aktivním spolupracovníkům  
IBP, zejména Československému národ. komitétu pro IBP, vedenému prof.  
dr. E. Hadačem Dr.Sc., členem korespondentem Československé akademie  
věd, za jejich pomoc a prostředky, které tomuto výzkumnému programu  
věnovali.

Doc. Ing. V. Č e r n ý, CSc.

## DRY MATTER PRODUCTION OF FIELD CROPS AT SOME LOCALITIES IN BOHEMIA

V. CERNÝ



CERNÝ V. (Research Institutes for Crop Production, Institute of Genetics and Plant Breeding, Praha-Ruzyně). *Dry Matter Production of Field Crops at Some Localities in Bohemia*. Rostlinná výroba (Praha) 21 (8) : 801-808, 1975.

The production processes of six crop species were intensively investigated by the use of growth analyses at three localities in a ten-years' period. Experiments were established in the framework of IBP. On a relatively small area (of 1,635 km<sup>2</sup> only) a considerable vertical heterogeneity as well as diversity of the environmental conditions of the localities were ascertained that affected dry-matter production in winter wheat, spring barley, oats, sugar beet, potato, and horse bean. Sugar beet proved the maximum rate of dry-matter production at all localities. Fertilizers were able to reduce considerably the influence of the locality. The maximum efficiency of solar energy utilization by crops amounted to 3.0% in sugar beet while in other crops it fluctuated between 1.1 and 2.0% in the course of vegetation period. Under very favourable conditions the examined crops were able to produce as much as 0.45 t. ha<sup>-1</sup> per one day.

dry-matter production; productivity; winter wheat; spring barley; oats; sugar beet; potatoes; horse bean

Ecosystems have always been of an enormous importance to man providing himself foodstuffs, most raw materials and sources of energy as well. Exploiting the possibilities of natural environment by various ecosystems has been considered an essential problem of providing food for people. From the point of view of the ecosystem-existence it is apparent that, on a certain area, each species occurs on the places where ecological conditions favour its further development, its survival under competition of other species etc. The complex of light, heat, water, air as well as nutrient conditions of each locality exert its influence on the soil-forming processes; it is also decisive for the nutrient and water uptake, quantitative ratio and interrelations among plants, as well between plants and animals. Reversely, flora and fauna realize a strong influence on the locality by taking up nutrients and water, by accumulating litters, shading the soil surface etc.; in this way the soil-forming processes are changed in a certain direction. This is also the reason why changes, sometimes slow, sometimes rather quick, in the whole ecosystems take place. Agriculture and claims for high production exert their strongest influence namely on arable land. The crop rotation or monocultures, manuring and fertilizing, irrigation, ploughing or zero-tillage, weed, disease and pest control can involve, together with other measures employed, great direct alternatives in the biological balance. The fundamental aim is, of course, to maintain the stability of the ecosystem and its proper function so that the primary productivity of all terrestrial ecosystems on the arable land and thus also the energy balance of agricultural systems could be increased.

Problems of the primary productivity of terrestrial ecosystems became one of the topics of the International Biological Program both in countries with highly developed agriculture and in developing countries, and also in non-man-modified vegetation. Since 1964, much information on the primary productivity of field crops, their yield structure, efficiency of solar energy etc. has been gathered by the team of research workers in Research Institutes for Crop Production in Praha-Ruzyně.

## MATERIAL AND METHODS

In polyfactorial field experiments carried out at three localities (see Table I and Fig. 1) following six crop species were investigated: winter wheat, spring barley, oats, sugar beet, potato, and horse bean. Plants were analysed at various stages of development and time intervals by the use of growth-analysis method (by Š e s t á k et al. 1966), and dried out at 75 °C. Experimental variants were as follows: different crop rotations, fertilized or non-fertilized, deep or shallow ploughing, high or low sowing rate, intensive or older cultivars. This paper gives data on the best forecrop, deep ploughing, high sowing rate, intensive cultivar, fertilized and non-fertilized variants; data represent the average values of ten experimental years. Dry-matter production ( $W_p$ ) in cereals and horse bean is expressed as dry-matter weight of the whole overground phytomass while in sugar beet and potatoes,  $W_p$  is expressed as dry-matter weight of leaves, stems, roots or tubers at the harvest time.

## RESULTS AND DISCUSSION

Winter wheat: Quick growth of dry-matter at the tillering as well as shooting stages proved to be unfavourable for achieving a high final value of  $W_p$ . Higher values of  $W_p$  were obtained in the years when plant growth



1. Localities — Research stations. — Rozmístění pokusných stanic

Locality	Čáslav	Ruzyně	Lukavec
Latitude	49° 55'	50° 04'	49° 37'
Longitude	15° 25'	14° 26'	15° 03'
Above sea level (m)	250	350	600
Great soil group	degraded chernozem (Luvic Chernozem <sup>+</sup> )	gray-brown podzolic soil (Orthic Luvisol <sup>+</sup> )	brown soil (Cambisol <sup>+</sup> )
Texture class (topsoil)	loam	clay loam	silty loam
Humus (%)	2.5	2.3	1.5
pH (KCl)	7.0	6.1	4.8
P mg per 1 000 g soil	62.9	27.3	8.4
K mg per 1 000 g soil	79.7	124.5	219.9
average of annual temperature (C°)	8.3	7.7	7.4
average of precipitations per year (mm)	577	473	685
sunshine per year (hours)	1680	1750	1556

(<sup>+</sup>) = FAO

at mentioned developmental stages was slow. Calculations of the productivity (C) are summarized in Table II. In all cases the maximum rate of dry-matter production per day (C<sub>max</sub>) amounted to as much as 40 g · m<sup>-2</sup> · day<sup>-1</sup>, namely at the shooting – heading stage. The W<sub>p</sub> values obtained before the harvest time are summarized in Table III. The highest natural productivity of the locality (without fertilizing) was ascertained at Ruzyně while the lowest at Lukavec. Fertilizing induced increasing in W<sub>p</sub> amounting to 56.0 %, 23.0 %, and 113.4 % at Čáslav, Ruzyně and Lukavec, respectively.

**Spring barley:** Differences in the dry-matter gain of individual experimental variants did not occur before the tillering stage; they increased up to the period of 10–15 days prior to full maturity. In the years when drilling had been made in later spring, the W<sub>p</sub> proved an increasing tendency up to the harvest time. The maximum rate of dry-matter production per day amounted to 30–35 g · m<sup>-2</sup> · day<sup>-1</sup>. The values in non-fertilized variants were by 3–10 g lower at Čáslav and Ruzyně, and by 12 g at Lukavec. As apparent from Table III, the highest W<sub>p</sub> values were observed on fertilized and non-fertilized plots at Ruzyně while lower ones at Čáslav and the lowest at Lukavec. Fertilizing resulted in respective increases by 30.1 %, 41.8 % and 120.2 %. On fertilized plots at Lukavec, dry-matter production was only by 3.8 % lower than at Čáslav, while in winter wheat the difference achieved even 21.4 %.

**Oats:** As in summer barley, the maximum values of C per day were found in the stage after heading; on non-fertilized and fertilized plots

II. Primary productivity (C) during the whole vegetation period in  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ .  
 — Primární produktivita (C) během celé vegetační doby v  $\text{g} \cdot \text{m}^{-2} \cdot \text{den}^{-1}$

Crop	Locality	O	NPK
Winter wheat	Čáslav	4.5	7.1
	Ruzyně	5.3	6.6
	Lukavec	2.2	4.7
Summer barley	Čáslav	3.6	5.2
	Ruzyně	5.9	7.6
	Lukavec	3.6	5.2
Oats	Čáslav	5.8	6.9
	Ruzyně	7.5	8.5
	Lukavec	5.4	10.5
Sugar beet	Čáslav	7.0	8.8
	Ruzyně	8.4	11.0
	Lukavec	4.8	8.4
Potatoes	Čáslav	3.3	5.1
	Ruzyně	4.0	5.6
	Lukavec	4.3	5.9
Horse beans	Ruzyně	3.6	3.7
	Lukavec	3.6	4.0

they amounted to 25 and 40  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ , respectively. In the course of the whole vegetation period, the highest values of C in fertilized variants were at Lukavec (see Table II). The absolutely highest  $W_p$  value was ascertained at Lukavec where fertilizing induced an increase of dry-matter weight amounting to 95.3 % (Tab. III).

**Sugar beet.** This crop manifested the maximum dry-matter production per day at Čáslav and Ruzyně at the end of June while at Lukavec it was by a fortnight later. On non-fertilized plots at Ruzyně, Čáslav and Lukavec, the respective values were 21.5, 59.9, and 31.3  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ . In fertilized variants, the maximum values at Čáslav and Lukavec were 65.7  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$  and 52.3  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ , respectively, while at Ruzyně only 26.5. In the course of the vegetation, the highest C was noted at Ruzyně (Tab. II). The highest natural productivity of locality, as expressed by the  $W_p$  value (Tab. III), was found at Čáslav while the lowest one at Lukavec (-25.2 %). Fertilizing resulted in a considerable diminishing the differences, the difference between Čáslav and Lukavec being only 1.7 %.

**Horse bean.** This crop was examined at two localities only. The C values (Tab. II) were considerably steady; fertilizing induced an increase

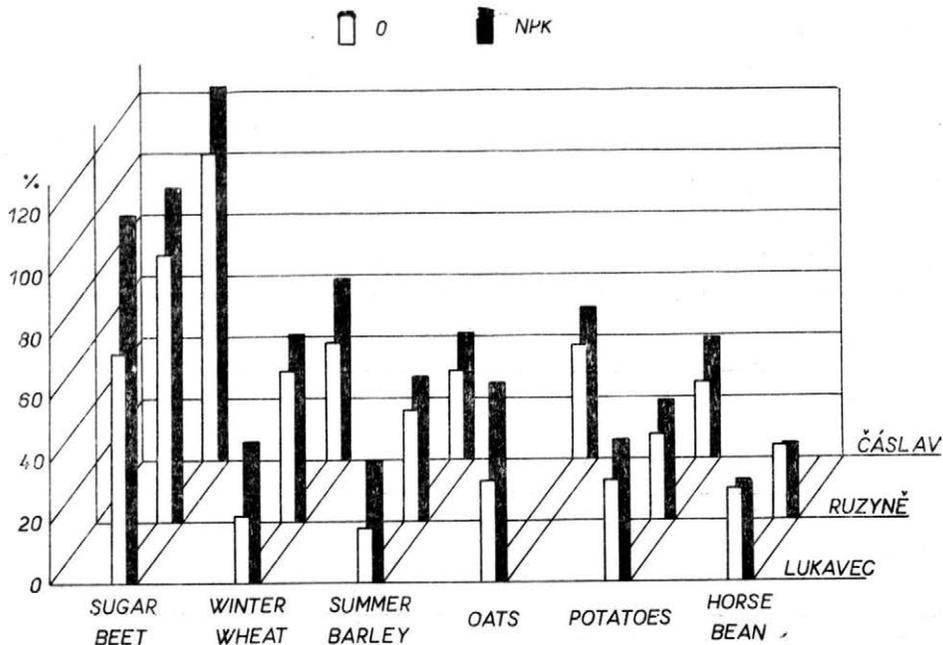
by 11.1 % and 2.8 % at Lukavec and Ruzyně, respectively. The highest values of  $W_p$  (Tab. III) were observed at Lukavec.

Data on  $W_p$  make possible to compare the productivity of individual localities, crops and fertilizing effects, as well. Relative numbers are given in Fig. 2. Data are related to  $W_p = 100$  % of non-fertilized sugar beet on chernozem at Čáslav.

III. Dry matter production ( $W_p$ ) in  $g \cdot m^{-2}$ . — Produkce sušiny ( $W_p$ ) v  $g \cdot m^{-2}$

Crop	Locality	O	NPK
Winter wheat	Čáslav	700	1092
	Ruzyně	910	1120
	Lukavec	402	858
Summer barley	Čáslav	536	760
	Ruzyně	661	860
	Lukavec	332	731
Oats	Čáslav	689	902
	Ruzyně	886	996
	Lukavec	613	1197
Sugar beet	Čáslav	1845	2253
	Ruzyně	1605	2008
	Lukavec	1380	2216
Potatoes	Čáslav	469	723
	Ruzyně	509	716
	Lukavec	612	843
Horse beans	Ruzyně	442	445
	Lukavec	556	617

Considering the  $W_p$  of non-fertilized winter wheat as 100 %, it is apparent that at Čáslav, a higher production was obtained only in sugar beet (263 %) while in the other crops as oats, summer barley, and potatoes, the production was lower: 98 %, 77 %, and 67 %, respectively. Somewhat similar situation was concerning the production at Ruzyně: sugar beet 176 %, winter wheat 100 %, oats 97 %, summer barley 73 %, potatoes 56 %, and horse bean 49 %. Quite different picture was observed at Lukavec, i. e. on soils manifesting a lower natural fertility, higher rainfall and lower average temperature. At this locality, following  $W_p$  values were ascertained on non-fertilized plots: in sugar beet 343 %, oats 153 %, potatoes 152 %, horse bean 138 %, winter wheat 100 %, and summer barley 83 %. A similar evaluation of fertilized plots provided approximately equal relations.



2. Production of dry matter. — Produkce sušiny

Evaluating natural productivity of the localities documented very apparently the function of fertilizers which were able to diminish considerably differences between the primary productivity of the localities. Results from Čáslav and Lukavec have been compared as an example. Fertilizing was able to reduce the difference in  $W_p$  value from 42.6 to 21.4 % in winter wheat, from 38.1 % to 3.8 % in summer barley, and from 25.2 to 1.7 % in sugar beet. On non-fertilized oat plots the  $W_p$  was by 11% lower at Lukavec than at Čáslav while on fertilized plots the production at Lukavec was by 32.7 % higher. Non-fertilized potatoes manifested by 30.5 % higher  $W_p$  at Lukavec as at Čáslav, on fertilized plots the difference being only 16.6 %.

At the same locality, the differences concerning the  $W_p$  value of experimental crops (except for horse bean) were on non-fertilized and fertilized plots as follows: 315.3 % and 280.4 % at Ružyně, 393.4 % and 311.6 % at Čáslav, 415.7 % and 303.2 % at Lukavec, respectively. Comparison of all crops (except for horse bean) and localities showed differences in the natural primary production  $W_p$  555.7 % and on fertilized plots 311.6 %. Comparing the  $W_p$  values of all localities and crops (except for horse bean) showed a relative difference of 678.6 %.

Further results obtained from our experiments also demonstrated that the maximum efficiency of solar energy in the vegetation period was found in fertilized sugar beet (about 3 %). Also in non-fertilized sugar beet the values were usually higher than in other crops. For achieving the highest values of  $W_p$  during the vegetation period cereals exploited about 2 % of radiation while potato 1.5–1.9 %, and horse bean 1.1–1.4 %. The maximum values of radiation efficiency (5.0–6.5 %) were

noted in the period subsequent to abundant rainfall and higher temperature. Under such favourable conditions, most examined crops are able to produce as much as 0.45 t of dry-matter/ha per day.

Further data are given in detail in papers by Kříšťan, Strnad, Vrkoč, and Šimon.

## References

- CERNÝ, V.: Einfluß der Bestandesdichte der Pferdebohne auf die Bodenfeuchtigkeit. Vědecké práce VÚRV, 1969, p. 177-184.
- CERNÝ, V. — BELZOVA, E.: (Dynamics of the changes in the amounts of roots in three winter wheat varieties with different rates of fertilizing.) Rostlinná výroba, 17, 1971, No. 8, p. 819-826.
- CERNÝ, V. — KRÍŠŤAN, F. — STRNAD, P. — VRKOČ, F.: (The contribution of some cultural practices to the yields of field crops.) Rostlinná výroba, 18, 1972, No. 9, p. 905-916.
- CERNÝ, V. — VRKOČ, F. — KRÍŠŤAN, F. — STRNAD, P.: Yield formation in crop rotations in ecologically different regions of Bohemia, as affected by cultivation practices. PT-PP Rep. 1970, Czechosl. Nat. Comit. for the IBP, Praha 1970, p. 2-3.
- KRÍŠŤAN, F. — CERNÝ, V.: (The effect of some agrotechnical measures on the yields of potatoes.) Rostlinná výroba, 16, 1970, No. 4, p. 375-384.
- KRÍŠŤAN, F. — CERNÝ, V.: (The effect of some cultural practices on the yields of spring barley grown on brown soil.) Rostlinná výroba, 17, 1971, No. 3, p. 293-302.
- KRÍŠŤAN, F. — CERNÝ, V.: (The effect of some cultural practices on the yield structure of horse bean on brown soil.) Rostlinná výroba, 18, 1972, No. 2, p. 187-196.
- KRÍŠŤAN, F. — CERNÝ, V.: (The response of sugar beet yields, to the main agrotechnical measures in the potato-growing region.) Rostlinná výroba, 18, 1972, No. 8, p. 821-830.
- KRÍŠŤAN, F. — CERNÝ, V.: (The effect of some cultural practices on the yields of winter wheat on brown forest soil.) Rostlinná výroba, 19, 1973, No. 1, p. 41-49.
- STRNAD, P. — CERNÝ, V.: (The influence of basic agricultural measures on the sugar beet yields on degraded chemozems.) Rostlinná výroba, 17, 1971, No. 1, p. 89-96.
- SESTÁK, J. — ČATSKÝ, J.: (Methods for studying photosynthetic production of plants.) Praha, Nakladatelství ČSAV, 1966, p. 394.
- VRKOČ, F. — CERNÝ, V.: (The effect of some cultural practices on the yields of spring barley in brown soils.) Rostlinná výroba, 16, 1970, No. 4, p. 367-374.
- VRKOČ, F. — CERNÝ, V.: (The effect of some agricultural measures on the yield of sugar beet in brown soils.) Rostlinná výroba, 15, 1969, No. 7, p. 721-728.
- VRKOČ, F. — CERNÝ, V.: (The effect of some agrotechnical measures on the structure of spring barley yield.) Poľnohospodárstvo, 17, 1971, No. 10, p. 852-860.

8. 4. 1975

CERNÝ V. (Ústav genetiky a šlechtění, VÚRV, Praha-Ruzyně). *Produktivita polních plodin některých stanovišť v Čechách*. Rostlinná výroba (Praha) 21 (8) : 801-808, 1975.

V rámci IBP byly po dobu 10 let intenzivně studovány produkční procesy u šesti druhů polních plodin na 3 lokalitách pomocí růstových analýz. Na poměrně malém území (1,635 km<sup>2</sup>) se výrazně projevil vertikální členitost spolu s dalšími podmínkami prostředí lokalit v produkci sušiny ozimé pšenice, jarního ječmene, ovsa, cukrovky, brambor a koňského bobu. Na všech stanovištích byla maximální produkce sušiny u cukrovky. Průmyslová hnojiva značně eliminovala vliv stanovišť. Maximální využití sluneční energie rostlinami za vegetační období bylo u cukrovky kolem 3,0 %, u ostatních plodin bylo od 1,1 do 2 %. Maximální přírůstky sledovaných plodin mohou dosáhnout při optimálních podmínkách až 0,45 t · ha<sup>-1</sup> · den<sup>-1</sup>.

produkce sušiny; přírůstek sušiny; ozimá pšenice; jarní ječmen; oves; cukrovka; brambory; bob

ЧЕРНЫ В. (Институт генетики и селекции, НИИР, Прага-Рузыне). Урожайность полевых культур в некоторых местах произрастания Чехии. Rostlinná výroba (Praha) 21 (8) : 801-808, 1975.

В рамках ИВР в течение 10 лет интенсивно изучали процессы образования продукции с помощью анализов роста у 6 видов полевых культур в 3 местах произрастания. На сравнительно малой территории (1,635 км<sup>2</sup>) отчетливо проявилось себя вертикальное расчленение наряду с другими условиями местной среды в продукции сухого вещества озимой пшеницы, яр. ячменя, овса, сах. свеклы, картофеля и конского боба. На всех участках максимальную продукцию сухого вещ. дала сах. свекла. Минеральные удобрения значительно устранили влияние мест произрастания. Солнечную энергию во время вегетации в максимальной мере использовали растения сах. свеклы (около 3,0 %), а остальные культуры от 1,1 до 2 %. Эти культуры могут достичь максимальных приростов в оптимальных условиях в размере до 0,45 т. га<sup>-1</sup>. день<sup>-1</sup>.

продукция сухого вещества; прирост сухого вещества; озимая пшеница; яровой ячмень; овес; сахарная свекла; картофель; боб

---

*Adresa autora:*

Doc. ing. Vladimír Černý, CSc., Ústav genetiky a šlechtění, VÚRV, 161 06 Praha-Ruzyň

---

## PRODUCTIVITY OF MAIN FIELD CROPS IN SOUTHERN MORAVIA

L. HRUSKA, J. JANÍČEK, E. BEDNÁŘOVÁ

HRUSKA L., JANÍČEK J., BEDNÁŘOVÁ E. (University of Agriculture Brno, Institute for the International Biological Programme). *Productivity of Main Field Crops in Southern Moravia*. Rostlinná výroba (Praha) 21 (8) : 809-816, 1975.

The aim of this study was to obtain data for comparisons of the productivity of a field ecosystem with that of grasslands and other natural associations of Southern Moravia. Main attention was paid to dynamics of dry matter production and distribution, growth characteristics, and utilization of solar energy by field crops. In all the crops investigated, dynamics of dry matter production was characterized by a slow initial increase occurring within the first third of the vegetation period after emergence. Within this period the lowest dry matter production was observed in barley, the highest in maize. In the period of intensive growth the highest increment per  $m^2$  was observed in sugar beet. In the last growth period the highest increment per  $m^2$  was found in wheat. The highest utilization of solar energy during the whole vegetation period was observed in sugar beet while the lowest in potatoes. In Southern Moravia the most productive crops were sugar beet, maize for grain, first-crop-year lucerne, and cereals.

field crops; dynamic distribution of dry matter; growth characteristics; solar energy; field and grassland ecosystems

The biomass production of a plant population results from the process of photosynthesis; this process is dependent on the growth and activity of the assimilating organs (Watson 1963), intensity of solar radiation, respiratory losses of saccharides (Monteith 1965), and conversion of energy of solar radiation per unit of crop area during the production process (Šesták, Čatský et. al. 1966).

The aim of this study was to obtain data for comparisons of the productivity of artificial associations of a field ecosystem with that of grasslands and other natural associations of Southern Moravia. The experiment was established on an experimental plot of the Institute for the International Biological Programme, Department of Field Crops (University of Agriculture, Brno) in Lednice (Moravia) within the period of 1970 to 1972. The altitude, latitude, and longitude of the site were 164 m, 48° 48' N., and 16° 48' E., resp. The soil of the experimental plot was classified as chernozem on loess (the humus horizon approx. 65 cm, 2.3 % of humus, pH (H<sub>2</sub>O) 6.5 with good reserves of easily available nutrients CaO, P<sub>2</sub>O<sub>5</sub>, and N and with a lower content of available K<sub>2</sub>O. The average annual temperatures over fifty years and over the vegetation period are + 9° and + 16°C, resp. The average annual precipitations ranged between 500 and 550 mm (524 mm); for the vegetation period they amounted to 350 mm. The average annual sunshine ranged between 1,800 and 2,000 hours (1873 hours), the annual sum of global solar radiation was 362,737.02 kJ.m<sup>-2</sup> (this value being a four-year average).

## MATERIAL AND METHODS

The field ecosystem consisted of artificial associations arranged in a nine-crop rotation with the following main crops: winter wheat (cultivar 'Mironovskaya'), summer barley (cv. 'Dvoran'), maize (hybrid 'CE V'), sugar beet (cv. 'Dobrovická A'), and early potatoes (cv. 'Hera').

Main attention was paid to dynamics of dry matter (DM) production and distribution, growth characteristics estimated in two-week intervals according to the growth analysis method (Šesták et al., 1966), and utilization of solar energy by field crops. Results obtained were evaluated from the viewpoint of production of individual crops of the field ecosystem as compared with the production of the grassland ecosystem. The production of this crop rotation was compared with the production of the Lednice School Farm and with the average production of the Břeclav district.

## RESULTS AND DISCUSSION

### DYNAMICS OF DRY MATTER FORMATION (TABLE I)

In all the crops investigated the dynamics of dry-matter formation (Fig. 1) was characterized by a period of initial slow growth (the first third of the vegetation period). In this period barley produced the lowest proportion of the final dry matter production, namely 6.5 %; the highest dry matter production was observed in maize (10.9 % of the total dry matter). In potatoes, sugar beet, and wheat these values were 9.1; 7.7 and 7.6 %, resp. The lowest daily increment of dry matter per m<sup>2</sup> was observed in potatoes, barley, and sugar beet (2.78; 3.16 and 3.83 g., resp.) while the highest ones were registered in maize and wheat (3.95 and 3.97 g., resp.).

During the period of intensive growth, corresponding to 40.4 to 57.5 % of the vegetation period, 94.8; 78.3; 71.1; 64.5 and 56.4 % of total dry matter were produced by maize, sugar beet, potatoes, barley, and wheat, resp. During this period the highest daily increment of dry matter per m<sup>2</sup> was observed in sugar beet (27.75 g., i. e. 25-times more than in the period of slow growth) followed by barley (25.39 g., i. e. 8.03-times more), wheat (22.69 g., i. e. 5.72-times more), maize (19.60 g., i. e. 4.96-times more), and potatoes (16.14 g., i. e. 5.82-times more).

During the final stage of growth which ranged from 9.6 to 27.0 % for the individual crops, the highest proportion of total dry matter was produced in wheat and barley (36.0 and 29.0 %, resp.) indicating their high storage capacity; in potatoes and sugar beet this production corresponded to 19.8 and 14.0 %, resp., while in maize to 5.7 % only. The low storage capacity observed in maize resulted from a reduced size of productive and transport organs. The daily increment of organic matter per m<sup>2</sup> in wheat was 32.39 g. (i. e. 8.16-times more than during the period of initial growth) followed by barley (17.08 g., i. e. 5.42-times more), sugar beet (10.17 g., i. e. 2.65-times more), potatoes (6.97 g., i. e. 2.5-times more), and maize (-7.12 g., i. e. 1.80-times less).

### GROWTH CHARACTERISTICS

The evaluation of growth characteristics was carried out on the basis of fitted curves (Kvěť, Nečas, Ondok 1971). In Tab. II only the maximum values are presented with the number of days from emergence.

The leaf area index (LAI) reached the maximum value in cereals

and early potatoes, maize, and sugar beet after 48 to 59, 89 and 93 days, resp. In all crops, excepting maize, these values were higher than those presented in earlier studies (Nichiporovich 1967). Our values approached or slightly exceeded the maximum values observed by Vrkoč (1974). The low value of LAI in maize suggests that a low crop density was selected (48,500 plants per hectare).

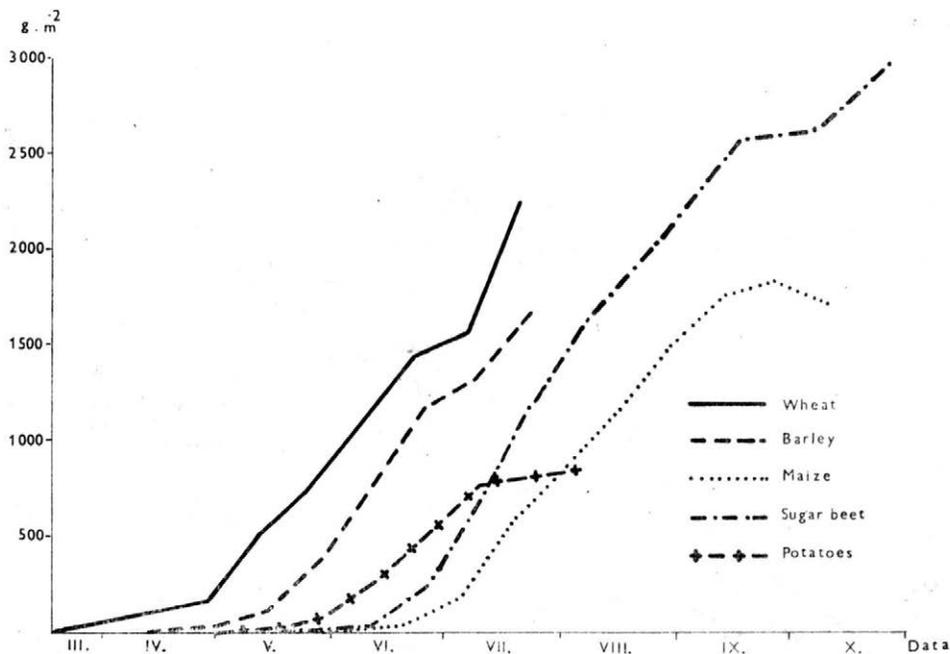
The highest value of leaf area duration (LAD) was registered in sugar beet and maize (159 and 117 days, resp.) while in cereals and early potatoes the maximum LAD was attained after 74 to 86 days.

Sugar beet and maize showed the highest values of net assimilation rate (NAR) and, thus, the highest production of dry matter in  $g \cdot m^{-2}$  (Tab. III). In wheat a low value of NAR was considerably influenced by an unaccountably low value registered in 1972; for that reason it does not correspond to other characteristics.

The maximum values of relative growth rate (RGR) were observed in early potatoes which showed low dry matter increments at the beginning of vegetation (Tab. I); the other crops showed higher daily increments and for that reason their RGR values were lower.

The highest productivity (C) was observed in wheat; this coincides with data published by Vrkoč (1974). A high C rate was observed in sugar beet followed by barley, maize, and potatoes. In wheat, barley, and potatoes the maximum C was attained sooner (within 48 to 59 days) than in sugar beet and maize (93 and 84 days, resp.).

Fig. 1



I. Dynamics of dry matter production in individual crops in  $g \cdot m^{-2}$  (1970 to 1972). — Dynamika nárůstu sušiny u jednotlivých plodin v  $g \cdot m^{-2}$  (1970—1972)

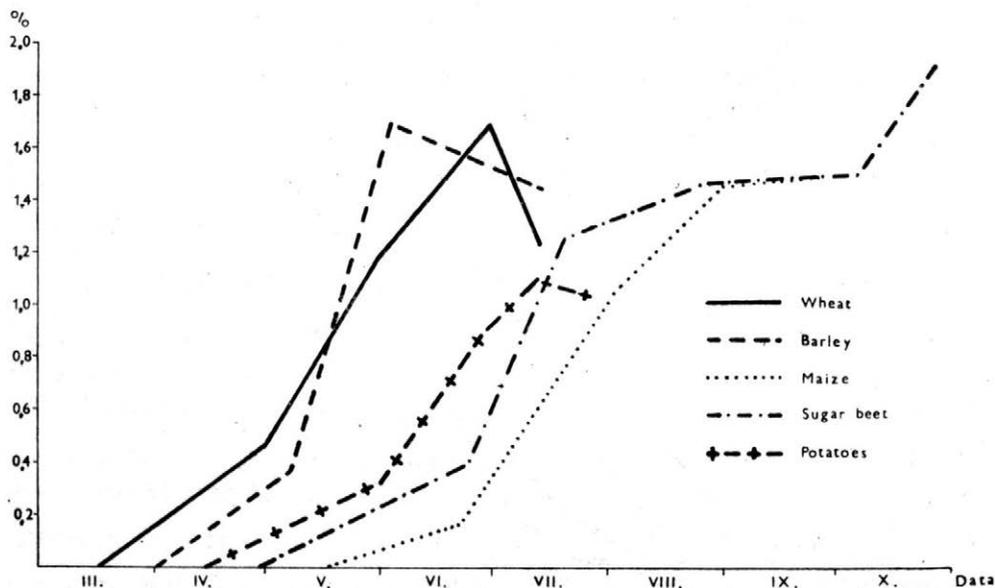
The percentual utilization of incident solar radiation was followed in winter wheat, spring barley, and maize within the period of 1971 to 1972 while in early potatoes and sugar beet within the years of 1970 to 1972.

Dry matters of individual plant organs were combined, according to their percentages in the total dry matter, into an average dry matter sample which was used for the estimation of the content of energy in the total dry matter of selected crops. The percentual utilization of solar radiation available to the crop within the period from emergence (in winter wheat from emergence at temperature over 6 °C) to sampling was calculated from the combustion heat of the individual samples (kJ · g. dry matter<sup>-1</sup>). The utilization of photosynthetically active radiation (PhAR) which corresponds to 45 % of global radiation (GR) (Šesták et al. 1966) was also calculated.

During the vegetation period the percentual utilization of solar radiation ranged, in winter wheat from 0.30 to 1.68 % (at the beginning of the spring vegetation and to the peak vegetation, resp.); in summer barley, maize, potatoes, and sugar beet these values were 0.37 to 1.92; 0.13 to 1.62; 0.17 to 1.09, and 0.39 to 1.89 %, resp. (Fig. 2).

Data obtained (Tab. 3) indicated differences between the individual crops. Within the period investigated the average energetic value of 1 g. of DM was 17.58; 17.58; 17.50; 15.87 and 15.32 kJ in winter wheat, summer barley, maize, sugar beet, and early potatoes, respectively.

Fig. 2



2. Utilization of global radiation by some crops during the period of vegetation (1971).  
— Využití globálního záření některými plodinami během vegetačního období (1971)

I. Dry matter production and daily increments during the individual growth periods (average 1970 to 1972). — Vytvořená hmota a denní přírůstek v jednotlivých fázích růstu (průměr 1970—1972)

Crop	Slow growth						Intensive growth						Final growth					
	Days	% of the veget. period	DM produced		Daily increment		Days	% of the veget. period	DM produced		Daily increment		Days	% of the veget. period	DM produced		Daily increment	
			g . m <sup>-2</sup>	%	g . m <sup>-2</sup>	%			g . m <sup>-2</sup>	%	g . m <sup>-2</sup>	%			g . m <sup>-2</sup>	%		
Wheat	43	34.7	170.58	7.6	3.97	0.18	56	45.2	1,270.79	56.4	22.69	1.01	25	20.1	809.70	36.0	32.39	1.44
Barley	34	32.7	107.54	6.5	3.16	0.19	42	40.4	1,066.49	64.5	25.39	1.53	28	26.9	478.36	29.0	17.08	1.04
Maize	48	32.9	189.67	10.9	3.95	0.23	84	57.5	1,646.79	94.8	19.60	1.13	14	9.6	-99.69	-5.7	-7.12	-0.41
Sugar beet	60	32.4	229.90	7.7	3.83	0.13	84	45.4	2,331.06	78.3	27.75	0.93	41	22.2	417.36	14.0	10.17	0.34
Potatoes	31	31.0	86.12	9.1	2.78	0.29	42	42.0	677.88	71.1	16.14	1.70	27	27.0	188.17	19.8	6.97	0.73

DM = Dry matter

II. Maximum growth characteristics (average 1970 to 1972). — Maximální hodnoty růstových charakteristik (průměr 1970—1972)

Crop	Days after emergence	LAI m <sup>2</sup> . m <sup>-2</sup>	C (g . m <sup>-2</sup> . day <sup>-1</sup> )	Days	LAD (dm <sup>2</sup> . plant <sup>-1</sup> )	Days	RGR (g . g <sup>-2</sup> . day <sup>-1</sup> )	NAR (g . cm <sup>2</sup> . day <sup>-1</sup> )
Wheat	59	6.06	31.41	86	79.43	30	0.202	0.0023
Barley	48	4.52	27.77	74	53.83	33	0.166	0.0034
Maize	84	2.56	25.49	117	4085.77	43	0.168	0.0068
Sugar beet	93	5.15	30.74	159	6248.08	70	0.121	0.0070
Potatoes	57	4.34	19.90	77	3087.42	39	0.359	0.0017

III. Utilization of global and photosynthetically active radiation by some crops. — Využití globálního a fotosynteticky účinného slunečního záření některými plodinami

Crop	Cultivar	DM prod. (g . m <sup>-2</sup> )	Energetic value (kJ . g . DM <sup>-1</sup> )	Incident solar radiation (kJ . m <sup>-2</sup> )	Energy prod. (kJ . m <sup>-2</sup> ) of stand	Utilization of solar radiation to the end of vegetation	
						GR	PhAR
Winter wheat	Mironovskaya*	1348.62	17.58	1897916.80	23704.15	1.25	2.76
Summer barley	Dvoran**	1283.52	17.58	1483529.77	22601.47	1.52	3.39
Maize	CE 380**	1839.20	17.50	2168971.74	32253.68	1.49	3.30
Sugar beet	Dobrovicka A***	3120.87	15.87	2586292.17	47054.60	1.81	3.86
Potatoes	Hera***	946.63	15.32	1460824.76	14539.91	0.99	2.21

Note: \*\*\* average 1970 to 1972

\*\* average 1971 to 1972

\* from emergence at temp. over 6 °C

GR = Global radiation

PhAR = Photosynthetically active radiation

10

Year	...	...	...	...
1950	...	...	...	...
1951	...	...	...	...
1952	...	...	...	...
1953	...	...	...	...
1954	...	...	...	...
1955	...	...	...	...

the ... of ... and ...

...	...	...	...
...	...	...	...
...	...	...	...
...	...	...	...
...	...	...	...

Notes: ...  
 - average ...  
 - ...  
 - ...

In winter wheat the utilization of global solar radiation corresponded to 1.22 and 1.27 % in 1971 and 1972, resp.; a two-year average observed towards the end of vegetation was 1.25 %. In summer barley these values in 1971 and 1972 were 1.45 and 1.59 %, resp., the average being 1.52 %. In sugar beet these values were 1.81; 1.89 and 1.73 % in 1970, 1971, and 1972, resp., with a three-year average of 1.81 %. In maize the utilization of solar radiation was 1.49 % in both years (1971 and 1972). The lowest utilization of solar energy was observed in early potatoes, viz. 0.87; 1.04 and 1.07 % in 1970, 1971, and 1972, resp.: the three-year average was 0.99 %. The utilization of photosynthetically active radiation observed in winter wheat, summer barley, maize, sugar beet and early potatoes was 2.76; 3.39; 3.30; 3.86 and 2.21 %, respectively.

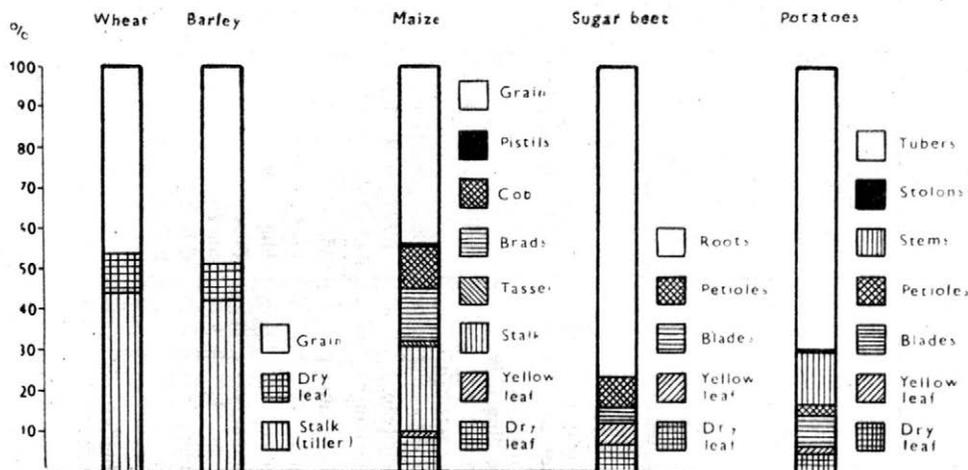
#### DRY MATTER PRODUCTION

As compared with the dry matter production of sugar beet, (23.10 t.ha<sup>-1</sup>, i. e. 100 %) maize, first-crop-year lucerne (I), wheat after lucerne, wheat after potatoes, barley with the underseeding after sugar beet, second-crop-year lucerne (II), and tuber potatoes produced 60.94; 55.36; 51.77; 50.33; 39.71; 35.89 and 29.20 %, resp. (Tab. IV).

As far as the yields of the original biomass are concerned the highest production was observed in sugar beet (111.33 t.ha<sup>-1</sup>) followed by potatoes, maize, lucerne I, winter wheat after lucerne, winter wheat after potatoes, barley without the underseeding after maize, barley with the underseeding after sugar beet, and lucerne II (35.24; 16.64; 15.05; 14.09; 13.70; 10.79; 10.79 and 9.75 t.ha<sup>-1</sup>, resp.).

The two-year average yield of the biomass of catch crops was 22.77 and 16.85 t.ha<sup>-1</sup> in mixtures and stubble lucerne, resp.

Fig. 3



3. Percentual distribution of dry matter into individual plant organs prior to the harvest. — Procentické rozmístění sušiny v jednotlivých orgánech rostliny před sklizní

IV. Comparison of economic and dry matter yields with those of the Lednice School Farm and the Břeclav district (1970 to 1972) — Přehled hospodářského výnosu a sušiny sledovaných plodin, jejich porovnání v pokusu s přihlédnutím k produkci školního podniku a okresu Břeclav v roce 1970—1972

Crop	Yield (t . ha <sup>-1</sup> )		Converted biomass (t . ha <sup>-1</sup> )	Rank	DM yield (t . ha <sup>-1</sup> )	Rank	% of the sugar beet yield	% of the maize grain DM yield	Average daily product. after emergence (kg DM/ha)	Rank	Field crops	DM production (t . ha <sup>-1</sup> )		School Farm (t . ha <sup>-1</sup> )		Břeclav District (t . ha <sup>-1</sup> )		
	Grain	Straw Beet leaves										Grassland Fertilized	Grassland Unfertilized	Field crops	Grassland	Field crops	Grassland	
Winter wheat after potatoes	4.76	8.96	13.70	6	11.63	5	50.33	65.21	93.76*	4	—	—	—	—	—	—	—	
Winter wheat after lucerne	4.94	9.15	14.09	5	11.96	4	51.77	67.65	96.45*	2	—	—	—	—	—	—	—	
Barley with the underseeding after sugar beet	4.89	5.90	10.79	8	9.17	7	39.71	67.31	88.19	6	—	—	—	—	—	—	—	
Barley without the underseeding after maize	4.67	6.12	10.79	7	9.18	6	39.73	64.32	88.25	5	—	—	—	—	—	—	—	
Maize for grain	7.43	9.21	16.64	3	14.08	2	60.94	100.00	96.42	3	—	—	—	—	—	—	—	
Sugar beet-root	64.81	46.52	111.33	1	23.10	1	100.00	—	124.86	1	—	—	—	—	—	—	—	
Potatoes — tubers	35.24	—	35.24	2	6.74	9	29.20	—	67.45	7	—	—	—	—	—	—	—	
Lucerne I	Hay	15.05	15.05	4	12.79	3	55.36	—	66.95	8	—	—	—	—	—	—	—	
Lucerne II	Hay	9.75	9.75	9	8.29	8	35.89	—	43.40	9	—	—	—	—	—	—	—	
Stubble lucerne	Green matter	—	16.85	—	1.29	—	—	—	—	—	—	—	—	—	—	—	—	
Catch crops	Green matter	—	22.77	—	—	—	—	—	—	—	—	—	—	—	—	—	—	
∅ Production of dry matter . ha <sup>-1</sup>					11.88						11.88	9.68	6.83	7.16	1.95	7.18	2.04	
Total					13.17						%	100.00	81.49	57.50	60.24	16.41	60.48	17.19

\*) in course of days at temp. over 5 °C

Coefficients of efficiency (Fig. 3) of ear yields in wheat, spring barley and maize were 0.46; 0.49 and 0.55, resp., the coefficient of efficiency of the grain yield in maize was 0.45, while those of roots and tubers in sugar beet and potatoes were 0.77 and 0.70, resp.

In Southern Moravia the most productive crops were sugar beet, maize for grain, lucerne I, and cereals. Due to a low production of dry matter potatoes are suitable only as a very early crop in this region. According to yields obtained on experimental plots the average daily production after emergence in sugar beet, wheat after lucerne, wheat after potatoes, barley without the underseeding, barley with the underseeding potatoes, lucerne I, and lucerne II corresponded to 124.86; 96.45; 93.76; 88.25; 88.19; 67.45; 66.95 and 43.40 kg of DM per hectare resp.

The average DM production per hectare was 11.88 t. Catch crops and stubble lucerne further increased this average production by 1.29 t.ha<sup>-1</sup> so that the total value of DM production was 13.17 t.ha<sup>-1</sup>.

As compared with the grassland ecosystem the field ecosystem produced 11.88 t of DM per 100 ha while the former 9.68 t only (i.e. 81.49 %). It can be concluded that the production of the field ecosystem was higher by nearly one fifth.

#### COMPARISON OF EXPERIMENTAL RESULTS WITH FIELD DATA

As compared with DM productions of the same ecosystems established on the Lednice School Farm and in the Břeclav district the calculated DM production of this experimental ecosystem was higher by 39.76 and 39.52 %, resp. If DM production of this ecosystem was held for 100 %, then that obtained on the School Farm and in the Břeclav district was 60.24 and 60.48 %, resp. A greater difference was found in the grassland ecosystem where the DM productions of the School Farm and Břeclav district corresponded only to 16.41 and 17.19 %, resp., of the experiment (100 %).

As one can see the intensity of plant production shows a satisfactory level under field conditions of this region; however, there are still some reserves, especially as far as the grassland ecosystem is concerned.

#### References

- KVĚT, J. — NEČAS, J. — ONDOK, P.: Growth analysis methods. Praha, ÚVTI, SI, základní a pomocné vědy v zemědělství, 1971, 111 p.
- MONTEITH, J. L.: Light and crop production. In: Field crop abstracts, 18, 1965, p. 213-219.
- NÍČIPOROVIC, A. A.: Fotosintez — osnovnoj proces pitaniya rastenij. Nauč. sovet po fotosintezu AN SSSR, Moskva 1967.
- SESTÁK, J. — CATSKÝ, J.: (Methods for studying photosynthetic production of plants.) Praha, Nakladatelství CSAV, 1966, p. 394.
- VRKOC, F.: (The growth dynamics and productivity of some field crops in the beet production type.) Rostlinná výroba, 20, 1974, No. 4, p. 325-333.
- WATSON, D. J.: Climate, weather and plant yield. In: Evans, L. T.: Environmental control of plant growth. Acad. Press, N. York—London, 1963.

HRUŠKA L., JANÍČEK J., BEDNÁŘOVÁ E. (Vysoká škola zemědělská, Ústav pro mezinárodní biologický program, Brno). *Produktivita hlavních polních plodin na jižní Moravě*. Rostlinná výroba (Praha) 21 (8) : 809-816, 1975.

Cílem výzkumu bylo získat podklady pro porovnání produktivity polního ekosystému s produktivitou lučních a ostatních přirozených společenstev v oblasti jižní Moravy. Ve zhodnocení byla věnována pozornost dynamice nárůstu a distribuci sušiny, charakteristikám růstu a využití sluneční energie polními plodinami. Dynamiku tvorby sušiny u všech sledovaných plodin lze charakterizovat pomalým počátečním růstem v první třetině vegetační doby od vzejití. V tomto období vytvořil nejméně hmoty ječmen, nejvíce kukuřice. V období intenzivního růstu vytvořila největší přírůstek na 1 m<sup>2</sup> cukrovka. V posledním období růstu dosáhla největší přírůstek na 1 m<sup>2</sup> pšenice. Nejvíce využila slunečního záření během vegetačního období cukrovka a nejméně brambory. Neproduktivnějšími plodinami v oblasti jižní Moravy byly cukrovka, kukuřice na zrno, vojtěška v prvním užitkovém roce a obilniny.

zemědělské plodiny; dynamika sušiny; růstové charakteristiky; sluneční záření; polní a luční ekosystém

ГРУШКА Л., ЯНИЧЕК Й., БЕДНАРЖОВА Э. (Сельскохозяйственный институт; Институт международной биологической программы, Брно). *Урожайность главных полевых культур в южной Моравии*. Rostlinná výroba (Praha) 21 (8) : 809-816, 1975.

Цель работ состояла в приобретении данных для сравнения продуктивности полевой экосистемы с продуктивностью луговых и остальных естественных сообществ в области южной Моравии. Обобщали динамику нарастания и распределения сухого вещ., характеристики роста и использование солнечной энергии полевыми культурами. Динамику образования сухого вещества у всех изучаемых культур можно охарактеризовать замедленным начальным ростом в первой трети вегетационного периода после появления всходов. В этот период наименьшую массу образует ячмень, а наибольшую кукуруза. В период интенсивного роста образуется самый высокий прирост сах. свеклы на м<sup>2</sup>. В последний период роста наибольшего прироста на м<sup>2</sup> достигает пшеница. Солнечную энергию в течение вегетации больше всего использует сах. свекла, меньше всего картофель. Самые урожайные культуры в южной Моравии следующие: сах. свекла, кукуруза на зерно, люцерна в I году пользования, зерновые.

сельскохозяйственные культуры; динамика сухого вещества; характеристики роста; солнечная энергия; полевая и луговая экосистема

---

**Adresa autorů:**

Prof. ing. dr. Ladislav Hruška, DrSc., ing. Josef Janíček, ing. Emilie Bednářová, Vysoká škola zemědělská, Ústav pro mezinárodní biologický program, 662 65 Brno

---

# THE EFFECT OF CULTURAL PRACTICES AND CONDITIONS OF LOCALITY ON GROWTH – DYNAMICS AND PRODUCTIVITY OF MAIN FIELD CROPS

F. VRKOC

VRKOC F. (Research Institutes for Crop Production, Institute of Genetics and Plant Breeding, Praha-Ruzyně). *The Effect of Cultural Practices and Conditions of Locality on Growth – Dynamics and Productivity of Main Field Crops*. Rostlinná výroba (Praha) 21 (8) : 817-823, 1975.

The quickest increase in dry-matter of the overground phytomass W was observed in winter wheat, namely in spring at all four localities, while the slowest one was noted in potatoes. In sugar beet and other crops, maximum daily gains in dry-matter of overground phytomass C were attained at different periods, not achieving, however, in most favourable days, the values  $40-45 \text{ g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$  on fertilized plots of different localities. On non-fertilized plots, the respective values were by  $5-15 \text{ g} \cdot \text{m}^{-2}$  lower. On fertilized plots, the higher dry-matter production of the phytomass W was realized rather via higher LAI values while on non-fertilized plots, rather via higher values of NAR. Up to the period of maximum values, a positive correlation was observed between LAI and NAR values; while later on, the correlation was negative. It was ascertained that in cereals about 50–70% of final amounts of phytomass were produced in a period of three weeks about heading – time, when maximum LAI were observed. Fertilizing prolonged the leaf area duration by a few days. Fertilizing positively affected the proportion of leaves, stems and ears in the total phytomass. There was ascertained a mostly direct relation between LAD and final yields. High C values prior to heading time did never result in high yields of cereals. In more intensive cultivars the yields were more closely connected with dry-matter yields of the overground phytomass. These cultivars exhibited not only more favourable distribution of dry-matter in favour of crop yield, but also higher dry-matter yields in the overground phytomass W. Maximum yields in sugar beet and potatoes were obtained in the years in which a quick increase in LAI values was ascertained in the first half of vegetation period; in this way, it was possible to attain higher LAI values in summer time.

growth-analysis; cereals; root and tuber crops; growth-characteristics; productivity

Cultural practices may be interpreted as forming conditions for maximum exploiting vegetation factors for the optimum transmission of assimilates into agriculturally important parts of plants. The grower thus aims to get the maximum production of dry-matter of plants, namely of their parts that are important for yielding capacity.

At present, no satisfactory data and results of analyses are available concerning the influence of various cultural practices on production processes in the course of vegetation period and in certain environment. It is clear that each cultivating measure has to tend to secure more suitable accordance between processes of dry-matter production in the phytomass and supply of the solar energy.

Most domestic as well as foreign papers examined some problems of growth – dynamics and productivity of field crops, mainly from the point of view of physiology and genetics; variety – differences were mostly stated by them. We aimed to exploit growth – analysis for

investigating production processes also from the point of view of fertilization and other cultural practices, effect of the year and locality as well; the course of variation in individual factors was studied during the vegetation period.

## LOCALITY AND METHODS

Experiments were carried out in the period of 1965–1974 at following four localities: Praha-Ruzyně, Čáslav (district Kutná Hora), Lukavec (district Pelhřimov), and Tišice (district Mělník). Conditions of the localities are given in the paper by Černý (1975) and Šimon (1975).

Examining of production processes was made by the use of growth-analysis on fertilized and non-fertilized plots of polyfactorial field experiments. Moreover, experiments at Ruzyně comprised two experimental cultivars while at Tišice winter wheat was grown either under irrigation or without it. Following eight crops were examined: winter wheat, summer wheat, summer barley, oats, rye, sugar beet, potatoes, and horse bean. Survey on experimental cultivars and variants of fertilizing is given in the paper by Křišťan (1975) and Šimon (1975).

Overground parts of plants (inclusive of roots and tubers in sugar beet and potatoes) were analyzed in 10–14 days' intervals in the course of vegetation period. We employed analyzing methods that were commonly used in the research of IBP.

## RESULTS AND DISCUSSION

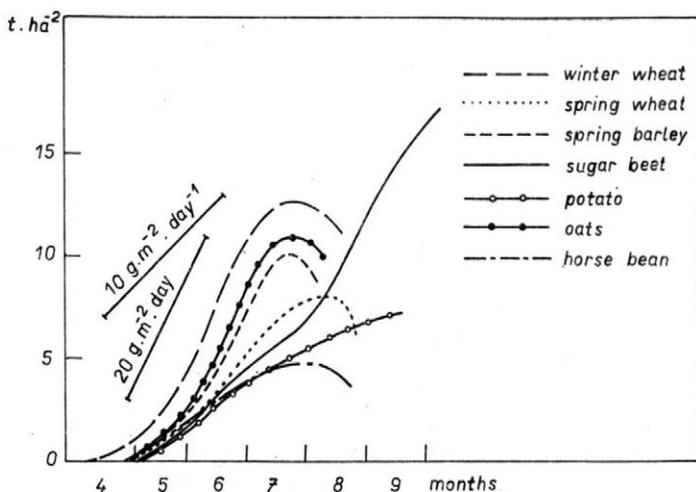
Some partial results were discussed in our previous papers (see References).

On the basis of long – term investigation we tried to interpret and model the course of some growth – characteristics (in field crops) in the course of vegetation period (Vrkoč 1974).

The influence of localities and experimental years was expressed namely in some shifting of curves and in an earlier starting as well as later finishing of the vegetation period of individual crops. Duration of the vegetation period in the same crop and year differed as much as 10–20 days at various localities. From graph 1 it is apparent that, at all localities, the highest amounts of dry-matter in the total phytomass were attained in sugar beet at harvest time. Phytomass production in individual crops was studied in greater detail in the paper by Vrkoč (1974b), and the influence of natural productivity of the locality was discussed in the paper by Černý (1975).

In spring, the quickest increase of values was always found in winter wheat. On the contrary, the slowest course of curves was in potatoes and horse bean at all localities. The gain in overground phytomass amounting to 10, resp. 20  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$  during a greater part of vegetation period (as shown in the direction of straight lines in graph 1) should be also considered a goal of crop production under our conditions.

Individual crops achieved their maximum daily gains in dry-matter of overground phytomass (C) at various periods; they did never exceed, of course, the limit of 40–45  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ . This value may be considered the maximum possible productivity of field crops, namely in days with most favourable conditions (Vrkoč, 1974b). Mentioned gain was reached under most favourable meteorological and cultivating conditions



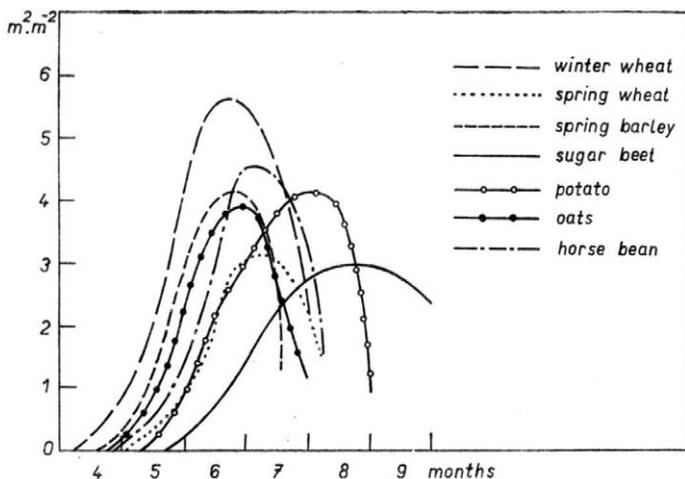
1. The average course of alternations in phytomass production (W) in main crops during the vegetation period. — Průměrný průběh změn produkce biomasy W u hlavních plodin v průběhu vegetace

on fertilized plots, and more frequently at localities Ruzyně and Čáslav than at Lukavec with soils of lesser fertility. On non-fertilized plots the values were, dependently on the crop and locality, by  $5-15 \text{ g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$  lower. Crops differed only very slightly. In general, it may be stated that not only sugar beet but also other investigated crops, when fertilized, are able to reach the maximum C value of  $40-45 \text{ g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ , in most favourable days, of course. Periods in which plants exhibit maximum C — values are, however, relatively short. It will be thus necessary to prolongate them, namely through prolongating the vegetation period and by cultural practices as well. Also breeding should aim for plants with a longer period of highest productivity.

In all crops, maximum values of leaf area index LAI (graph 2) were attained nearly at the same time as maximum C, or some days later. At all localities the highest values were got in winter wheat due to its high yields and high numbers of stems per unit of area.

Generally it can be derived from our long — term investigation on growth of field crops that, on fertilized plots, higher production of phytomass was realized rather via higher values of LAI while, on non-fertilized plots, rather via higher value of NAR.

Our experiments did not confirm any proportion between dry-matter production of the phytomass and LAI. From graphs 1 and 2 it is apparent, however, that, in all crops and localities, maximum values of LAI were attained considerably earlier than maximum values of dry-matter in the phytomass W. Up to the period with maximum values, there was observed a positive correlation between LAI and NAR; later on, however, the correlation changed into negative.



2. The average course of leaf area index (LAI) in main crops during the vegetation period. — Průměrný průběh změn pokryvnosti listoví LAI u hlavních plodin v průběhu vegetace

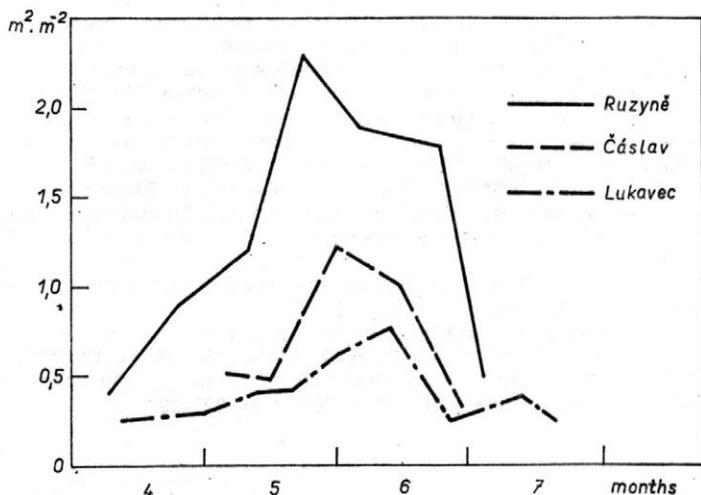
Though considerable variability took place, we confirmed that NAR differed to some extent according to cultivars, fertilizing variants, years, and localities, no remarkable relations being stated, however, between NAR and crop yield.

In our experiments it was demonstrated that, as a rule, fertilizing increased all values ascertained by growth — analysis, namely on soils with lower fertility or when combined with irrigation. Only on more fertile soils or after favourable preceding crop, cultivars differed sometimes more than fertilizing variants. Fertilizing thus proved to be a decisive factor which is able to eliminate differences between cultivars, localities and years. On fertilized plots, however, the intensive cultivar manifested a greater increase in values of growth analysis than the less productive cultivar did.

Examining the group of cereals in greater detail showed that, at the period of three weeks about heading time, when maximum values of C and LAI were obtained, plants produced about 50–70 % of the final content of dry-matter in the overground phytomass. First yellow leaves appeared already at the beginning of shooting stage their number per plant being higher namely on non-fertilized plots. Fertilizing prolonged the duration of green leaf area by about 2–5 days; localities differed, however, much more. In all cereals maximum values of dry-matter production attained in leaves were observed about heading time while in stems by about a fortnight later. Proportion of dry-matter in ears (panicle) increased quickly from milk up to wax ripeness. At this period even about 80 % of the total dry-matter in ear were sometimes produced in the course of only four weeks. Proportion of dry-matter in ears from the total overground phytomass fluctuated about 50 % as dependent on fertilizing, locality, year and cultivar.

Distribution of dry-matter in the total overground phytomass of cereals was typically steady being not expressively influenced neither by localities nor by fertilizing and years. Difference was stated only between dwarf and longstem cultivars. Fertilizing thus caused an increase in the proportion of leaves, stems as well as ears in the phytomass.

Among cereals, the highest increase in dry-matter of the total phytomass C was found in non-fertilized plots of winter wheat. It attained as much as 25–30 during the period of 10–14 days after heading stage. In some days it reached even 40–45  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ . Non-fertilized plots provided by 5–15  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$  lower values. Also leaf area index (LAI) reached its maximum value at this time, being increased by fertilizing by 1–2  $\text{m}^2 \cdot \text{m}^{-2}$ . An example of the course of LAI in winter wheat cv. „Jubilar“, on non-fertilized plots at individual localities in 1971, is given in graph 3. The maximum values of LAI in wheat attained 5–6, in some years with extremely high yields and numbers of stems even 8  $\text{m}^2 \cdot \text{m}^{-2}$ ; they were obtained on most fertile soil or under irrigation. In some cases, however, high values of LAI in former winter wheat cultivars proved to be unuseful from the point of view of their productivity. When ascertained after heading, leaf area duration in winter wheat or summer barley on fertilized plots was as much as several times higher showing always a direct relation to grain yield produced.



3. The course of alternations in leaf area index (LAI) in winter wheat cv. 'Jubilar' in 1971. Data on non-fertilized plots of three different localities. — Průběh změn pokrývnosti listovní LAI u ozimé pšenice odrůdy 'Jubilar' v r. 1971 v průběhu vegetace na nehojených dílcích tří různých stanovišť

In latest cereal cultivars grain yields were mostly closely connected with dry-matter yield of the total overground phytomass than in former cultivars. It was demonstrated that breeding was able not only to alternate distribution of dry-matter in the phytomass in favour of crop yield,

but also to increase the yield of dry-matter in the overground phytomass of latest intensive cultivars.

From examining the growth of sugar beet it was deduced (V r k o č 1971a) that maximum yields of roots were obtained in the years, when the first half of vegetation period was characterized by quick growth of LAI values; this made possible to attain high C values in July and namely in August.

In potatoes highest C – values were noted in the period between 15. 7. and 15. 8. Fertilizing induced, by a few days later, starting of tuber formation; the growth of total leaf area, however, was enhanced by it.

## References

- CERNÝ, V.: (Dry matter production of field crops at some localities in Bohemia.) Rostlinná výroba, 21, 1975, No. 8, p. 000-000.
- CERNÝ, V. – VRKOČ, F. – KRISTAN, F., STRNAD, P.: Yield formation in crop rotations in ecologically different regions of Bohemia as affected by cultivation practices. In: Productivity of terrestrial ecosystems in production processes. Czechoslovak Academy of Sciences – Czechoslovak National Committee for the IBP, PT-PP, Report No. 1, Praha 1970, p. 225-226.
- KRISTAN, F.: (Cultivation practices and phytomass production in field crops at some localities in Bohemia.) Rostlinná výroba, 21, 1975, No. 8, p. 826-836.
- KRISTAN, F. – VRKOČ, F.: (Contribution for study of potato yield formation.) Rostlinná výroba, 16, 1970, No. 7, 741-750.
- KRISTAN, F. – VRKOČ, F.: (The influence of the weather course on growth dynamics and potato yield.) Rostlinná výroba, 16, 1970, No. 7, p. 751-758.
- SIMON, J.: (Production of the phytomass in some field crops under irrigation on light soils.) Rostlinná výroba, 21, 1975, No. 8, p. 845-860.
- VRKOČ, F.: (Contribution to the study of formation of sugar-beet yield in relation to the course of the weather.) Listy cukrovarnické, 87, 1971a, No. 2, p. 28-32.
- VRKOČ, F.: (Some knowledge of yield formation and share of cultural practices factors on yield of horse bean on brown soil in the beet – production type.) In: Souhnn referátů a diskusních příspěvků přednesených na vědeckém semináři Pěstování bobu. obecného 17. 3. 1971. ČSAZ - ÚVTI Praha, 1971b, No. 110, p. 76-82.
- VRKOČ, F.: Some new knowledge from the study of yield formation of spring barley. In: Proceedings of the International Symposium held on June 26-30th 1972 at Kroměříž. 1, p. 461-486.
- VRKOČ, F.: (Some growth characteristics of the main crops grown in central Bohemia.) Rostlinná výroba, 19, 1973, No. 8, p. 787-798.
- VRKOČ, F.: (Contribution to the study of yield formation of spring wheat in central Bohemia.) Vědecké práce VÚRV Praha-Ruzyně, 1974a, No. 18, p. 133-141.
- VRKOČ, F.: (The growth dynamics and productivity of some field crops in the beet production type.) Rostlinná výroba, 20, 1974b, No. 4, p. 325-333.

8. 4. 1975

VRKOČ F. (Ústav genetiky a šlechtění, VÚRV, Praha-Ruzyně). *Vliv agrotechnických opatření a stanovištních podmínek na dynamiku růstu a produktivitu hlavních polních plodin.* Rostlinná výroba (Praha) 27 (8) : 817-823, 1975.

Nejrychlejší vzestup hodnot sušiny nadzemní biomasy W na jaře byl ve všech čtyřech stanovištích zaznamenán u ozimé pšenice, nejpozdější u brambor. Maximální denní přírůstek sušiny nadzemní biomasy C byl u cukrovky i ostatních plodin a stanovišť dosahován v různou dobu a nepřekročil v jednotlivých příznivých dnech hodnoty 40–50 g. m<sup>-2</sup>. den<sup>-1</sup> na hnojených dílcích. Na nehnojených dílcích byly tyto hodnoty o 5–15 g. m<sup>-2</sup>. den<sup>-1</sup>. Vyšší produkce sušiny biomasy W byla na hnojených dílcích realizována spíše přes vyšší hodnoty LAI, zatímco na nehnojených dílcích spíše přes vyšší hodnotu NAR. Mezi LAI a NAR byla do doby jejich maximálních hodnot kladná později však již negativní závislost. U obilnin se ukázalo, že v období

třech týdnů kol metání s maximy LAI a C vytvořily 50–70 % z konečných hodnot nadzemní biomasy. Hnojení prodlužovalo dobu trvání zelených listů o několik dnů. Vliv hnojení se projevovat proporcionálním zvýšením biomasy listů, stébel i klasů. Mezi LAD a konečnými výnosy byl většinou přímý vztah. Vysoké hodnoty C do období metání nevedly nikdy k vysokým výnosům obilnin. Výnosy novějších odrůd byly většinou těsněji spjaty s výnosem sušiny nadzemní biomasy. Novější odrůdy se vyznačovaly nejen příznivější distribucí sušiny ve prospěch hospodářského výnosu, ale niely i vyšší výnos sušiny nadzemní biomasy W. Maximální výnosy cukrovky i brambor byly dosaženy v letech, kdy v prvé polovině vegetace byl zjištěn rychlý vzestup hodnot LAI, který umožnil dosahování vysokých hodnot v letním období.

růstová analýza; obilniny; okopaniny; růstové charakteristiky; produktivita

ВРКОЧ Ф. (Институт генетики и селекции, НИИР, Прага-Рузыне). Влияние агротехники и местных условий на динамику роста и продуктивность главных полевых культур. Rostlinná výroba (Praha) 21 (8) : 817-823, 1975.

Самый скорый рост сухого вещества наземной биомассы весной на всех 4 местах произрастания отмечен у оз. пшеницы, а самый медленный — у картофеля. Максимальный суточный прирост сухого вещества наземной биомассы как у сах. свеклы, так и у остальных культур и объектов имел место в разное время и не превышал в благоприятные дни 40–45 г. м<sup>-2</sup>. день<sup>-1</sup> на удобренных делянках, а на неудобренных на 5–15 г. м<sup>-2</sup>. день<sup>-1</sup> меньше. Повышенная продукция сухого вещества биомассы W на удобренных делянках получена скорее за счет повышения значений индекса площади листьев, а на неудобренных — за счет повышенных значений чистой продуктивности ассимиляции. До периода максимальных значений вышеупомянутых индекса и продуктивности корреляция положительная, а позднее — отрицательная. У зерновых в течение 3 недель выколашивания максимальные их значения вместе с сухим вещ. наземной биомассы составили 50–70 % от финальных значений наземной биомассы. Удобрение продляло состояние зеленых листьев на несколько дней. Влияние удобрения проявило себя в пропорциональном росте биомассы листьев, стеблей и колосов. Между индексом площади листьев и финальными урожаями существует, как правило, прямо пропорциональное отношение. Высокие значения сухого вещ. биомассы до периода выколашивания никогда не приводят к высоким урожаям зерновых. Урожай более новых сортов обычно теснее связаны с продукцией сухого вещ. наземной биомассы. Эти сорта не только лучше распределяют сухое вещ. в пользу урожая, но и дают больше сухого вещ. биомассы. Максимальные урожай сах. свеклы и картофеля собраны в те годы, когда в первой половине вегетации обнаруживали быстрый рост индекса площади листа, позволяющий достичь высоких значений в летний период.

анализи роста; зерновые; пропашные; характеристики роста; производительность

Adresa autora:

Ing. František V r k o č, CSc., Ústav genetiky a šlechtění, VÚRV, 161 06 Praha-Ruzyňe

**Výběr z nových přírůstků**  
**Ústřední zemědělské a lesnické knihovny ÚVTI**  
**z úseku rostlinné výroby**

Uvedené publikace je možné si zapůjčit osobně nebo písemně v ÚZLK, výpůjční oddělení, 120 56 Praha 2, Slezská 7. Výpůjční doba: pondělí až pátek od 9 do 18 hodin. U každé žádané publikace uveďte signaturu.

McKenna, J. R. — Brown, C. S. — Carpenter, P. N. D 30.298/703  
Fertility content of fluid manure from Maine dairy farms. Orono (Maine), University — Life sciences and agric. exp. station 1973. 16 s. 1 obr. 8 tab. Bulletin 703. (Hnojiva tekutá — statková — mléčná hospodářství — ži-  
viny — obsah — výzkum — USA).

D 28.577/140  
Współdziałanie wody i nawozów w produkcji roślinnej. Materiały z kraj. sympozjum nauk. wrocławiu — 27.—28. 9. 1971 r. (Souhrny rus., angl.). Warszawa, PWN 1973. 640 s. obr. tab. Zeszyty problemowe postępów nauk rolniczych zes. 140. (Hnojení — zavlažování — vztahy — sborníky — Polsko).

D 63.724  
Udobrenije polevyh kultur pri orošenii. Perv. s bolg. Moskva, Kolos 1974. 227 s. 29 obr. 67 tab. (Hnojení — zavlažování — příručky).

C 19.815/21  
L'irrigation et les problèmes de fertilisation qu'elle pose. B. m. SCPA 1974. 31 s. obr. Le document technique de la SCPA 21. (Zavlažování — hnojení — vztahy — výzkum — Francie).

Rivoira, G. — Bullitta, P. — Caredda, S. D 55.447/174  
Esperienze di concimazione e utilizzazione diretta del pascolo. Sassari, Ist. di agronomia generale e coltivazioni erbacee 1973. 13 s. 2 obr. 6 tab. Estr. „Studi sassaresi“ vol. 21. 1973. (Pastviny — hnojení — výzkum — Itálie — Sardinie).

Rivoira, G. — Bullitta, P. — Caredda, S. D 55.447/175  
Esperienze di concimazione dei pascoli. Risultati ottenuti su terreni granitici della Sardegna centrale. Sassari, Ist. di agronomia generale e coltivazioni erbacee 1973. 18 s. 5 obr. 6 tab. Estr. da „Studi sassaresi“ sez. III. Annali della Fac. di agraria vol. 21. 1973. (Pastviny — hnojení — výzkum — Itálie — Sardinie).

## CULTURAL PRACTICES AND PHYTOMASS PRODUCTION IN FIELD CROPS AT SEVERAL LOCALITIES IN BOHEMIA

F. KRISTAN

KRISTAN F. (Institute of Genetics and Plant Breeding, Research Station of Plant Production, Lukavec). *Cultural Practices and Phytomass Production in Field Crops at Several Localities in Bohemia*. Rostlinná výroba (Praha) 21 (8) : 826-836, 1975.

In the period of 1963-1973 polyfactorial field experiments were carried out on brown-grey podzolic soil (Ruzyně), on degraded chernozem (Čáslav) and on brown soil (Lukavec). They were to reveal the influence of some cultural practices on the production process and on phytomass production in main field crops. The increase in dry-matter production in individual crops was mostly affected by fertilizing and favourable crop rotation. On soils with higher natural fertility, appropriate crop rotation influenced the phytomass production relatively more intensively than fertilizing did; fertilizing, however, proved to be a stronger factor than intensive cultivar, density of plants etc. Fertilizing stabilized dry-matter production in the phytomass (W) in individual years. The highest increase induced by fertilizing was observed in sugar beet (2.28; 2.68; 6.65 t. ha<sup>-1</sup> at Ruzyně, Čáslav, and Lukavec, respectively) while the lowest one in horse bean (0.33 t. ha<sup>-1</sup>). Under worse natural conditions, dry-matter production in the phytomass increased more considerably by the complex of cultural practices, namely in more pretentious cereal species (in winter wheat + 140%, in summer barley + 196%). As compared with crop rotations, the average dry-matter production of the phytomass in rotations with non-fertilized cereals only, was lower by 2.3-2.8 t. ha<sup>-1</sup>. In the case of appropriate crop rotation, fertilizing continued to increase dry-matter production by 2.0-2.4 t. ha<sup>-1</sup> per year. On more fertile soils (at Ruzyně and Čáslav), if optimal cultural practices were employed, even the average dry matter production in the phytomass amounting to 10.0 t. ha<sup>-1</sup> was attained. On less fertile soil (at Lukavec) the differences due to cultural practices were reduced from 1.62 t. ha<sup>-1</sup> to 0.75 t. ha<sup>-1</sup>. The worse the natural conditions for phytomass production in the field ecosystem, the higher should be the claims not only for the optimization of the production factors controlled by the farmer, but also for necessary material sources.

dry-matter production; crop rotation; fertilizing; wheat; summer barley; oats; rye; sugar beet; potatoes; horse bean; silage maize

Crop yields as well as the total phytomass production of crops reflect and also integrate the effect of all factors which prove their influence during the whole vegetation period of field crops. Many examples from literature and from agricultural practice exist which demonstrate that the yields of phytomass or crop yields can be either equal, or higher or lower, even if the constellation of environmental factors - as locality, influence of man, as well as various inner factors conditioned by genetic characters of individual crops - are very divergent (Černý 1974).

Man effects a distinct influence on agricultural soils; therefore considerably different all - world data on primary productivity of arable land exist. For instance from data by Du vign eau (1968) high reserves are apparent concerning production potential of individual crops as

well as of whole soil – climatic areas. Differences between real and possible crop yields are caused, among others, by the fact that factors of production process which can be influenced by the farmer, are not sufficiently optimized yet (V r k o ě 1974).

In this paper the phytomass production in field crops has been evaluated on the basis of long – lasting stationary field experiments with regard to cultural practices employed at three localities with divergent soil and climate conditions.

## LOCALITY AND METHODS

In the period 1964–1974 extensive polyfactorial experiments were established at three localities in Bohemia (Ruzyně – Ru, Čáslav – Čá, Lukavec – Lu) according to a uniform scheme (Č e r n ý 1972).

The characteristics of localities is given in Table I (Č e r n ý 1975). In eight years' crop rotations four fundamental factors were investigated (preceding crop, fertilizing, density of stand, and depth of sowing, each of them in two variants) in eight crop species. At the locality Ruzyně the variant depth of ploughing was substituted by examining intensive and standard cultivars. Investigated crops and employed criteria for individual factors are given in Table I. Dry-matter (Wp) in cereals, maize and horse bean was represented by the total overground phytomass while in sugar beet by the weight of leaves, stems and roots; in potato by leaves, stems and tubers. Dry matter (W) was represented by the weight of grain, roots, tubers or overground phytomass (in silage maize).

## THE INFLUENCE OF SOME CULTURAL PRACTICES ON INCREASING PHYTOMASS PRODUCTION

Average data from long – term experiments make it possible to compare differences between individual crops and localities as well as to determine the influence of factors which are controlled by man, on increasing the phytomass production under divergent conditions. Increase in dry-matter production of the phytomass was most strongly influenced by fertilizing and appropriate inserting the crops into crop rotation (Table II).

The complex of cultivating factors contributed most distinctly to increasing phytomass production in cereals under less favourable soil and climate conditions at Lukavec (W: 101–183 %; W<sub>p</sub>: 103–129 %). In the total (more than double) increase in the phytomass production at Lukavec intensive fertilizing (109–114 % in summer barley, 71–75 % in oats) and also favourable preceding crop (92–102 % in summer wheat, 62 % in winter wheat) participated most intensively. As a rule, fertilizing proved higher effect on the total dry-matter production of the phytomass while favourable preceding crop increased namely the agriculturally important proportion of the phytomass. A relatively lower effect of cultural practices in winter rye at Lukavec was connected with its less intensive reaction to fertilizing caused by susceptibility to lodging.

Cultural practices manifested a relatively poor influence on increasing dry-matter production in the phytomass of horse bean (Ru: 19 %, Lu: 18 %), the density of stand being a decisive factor for production increase (Ru: 10 %, Lu: 13 %).

In root and tuber crops, the increase in dry-matter production of the phytomass was influenced namely by fertilizing and at Ruzyně,

## I. Variants of cultural practices in individual crops. — Stupně agrotechnických opatření u jednotlivých plodin

Cultural practices	Winter wheat (Kaštická os.)	Winter rye (České)	Summer barley (Valtický)	Oats (Český)	Sugar beet (Dobrovická)	Potatoes (Krasava)
Preceding crop $p_1$	Horse bean	Horse bean (for grain)	Sugar beet, potatoes	Potatoes	Summer wheat + white clover as undercrop for green manuring	Summer wheat + white clover as undercrop for green manuring
$p_2$	Summer wheat	Summer wheat	Summer barley	Oats	Summer wheat	Summer wheat
Fertilizing $f_1$	40, 20, 83 kg NPK . ha <sup>-1</sup> after horse bean	40, 20, 83 kg NPK . ha <sup>-1</sup> after horse bean	30, 20, 59 kg NPK . ha <sup>-1</sup> after sugar beet, potatoes	20, 20, 59 kg NPK . ha <sup>-1</sup> after potatoes	90, 29, 97 kg NPK . ha <sup>-1</sup> + 30 t farmyard manure	70, 23, 97 kg NPK . ha <sup>-1</sup> + 30 t farmyard manure
$f_0$	60, 23, 83 kg NPK . ha <sup>-1</sup> after summer wheat	60, 23, 83 kg NPK . ha <sup>-1</sup> after summer wheat	60, 20, 75 kg NPK . ha <sup>-1</sup> after summer barley	50, 20, 75 kg NPK . ha <sup>-1</sup> after oats	non-fertilized	non-fertilized
non-fertilized	non-fertilized	non-fertilized	non-fertilized	non-fertilized	non-fertilized	non-fertilized
Sowing rate (spacing) $s_1$	5.1 mil. of germ. grains . ha <sup>-1</sup>	4.2 mil. of germ. grains . ha <sup>-1</sup>	4.5 mil. of germ. grains . ha <sup>-1</sup>	4.5 mil. of germ. grains . ha <sup>-1</sup>	45 × 20 cm (111 thousand of plants . ha <sup>-1</sup> )	62.5 × 30 cm (53,400 plants . ha <sup>-1</sup> )
$s_2$	3.4 mil. of germ. grains . ha <sup>-1</sup>	2.8 mil. of germ. grains . ha <sup>-1</sup>	3.0 mil. of germ. grains . ha <sup>-1</sup>	3.0 mil. of germ. grains . ha <sup>-1</sup>	45 × 35 cm (63,000 plants . ha <sup>-1</sup> )	62.5 × 40 cm (40,000 plants . ha <sup>-1</sup> )
Ploughing (Čáslav, Lukavec) $pl_1$	26–29 cm	25–30 cm	26–29 cm	28–30 cm	28–30 cm	26 cm
$pl_2$	13–15 cm	14–16 cm	13–15 cm	14–16 cm	14–16 cm	14 cm
Cultivar (Ruzyně) $c_1$	Heines VII	—	Diamant	HAG	Dobrovická A	Jizera
$c_2$	Kaštická osin.	—	Valtický	Český žlutý	Dobrovická C	Krasava

II. Increase in dry — matter production of the phytomass (in relative values). —  
 Zvýšení produkce sušiny biomasy v relativních hodnotách

Crop	Locality	W			W <sub>p</sub>		
		increase attained by the complex of cultural practices (in %)	the most efficient factor		increase attained by the complex of cultural practices (in %)	the most efficient factor	
			factor	increase in %		factor	increase in %
Winter wheat	Ru	35.5	p	18.6	46.9	p	26.9
	Čá	57.2	p	37.5	57.3	p	37.3
	Lu	127.2	p	61.8	113.9	f	61.7
Summer wheat	Ru	140.9	p	113.6	93.1	p	62.6
	Čá	73.6	f	47.1	48.5	f	43.9
	Lu	183.7	p	102.4	127.5	p	91.9
Summer barley	Ru	64.8	c	29.6	43.1	f	23.4
	Čá	42.4	f	24.9	43.7	f	37.4
	Lu	146.3	f	114.4	129.7	f	109.0
Oats	Ru	25.9	p	15.6	37.2	p	12.0
	Čá	19.2	p	13.3	31.8	f	19.3
	Lu	101.8	f	71.2	103.0	f	74.8
Winter rye	Lu	53.2	p	31.0	64.1	p	25.4
Horse bean	Ru	50.8	s	28.9	19.1	s	10.3
	Lu	21.4	p	13.0	18.1	s	13.3
Sugar beet	Ru	39.8	c	13.0	51.5	f	19.6
	Čá	20.9	f	14.0	27.8	f	18.9
	Lu	67.3	f	31.6	94.9	f	50.3
Potatoes	Ru	69.8	c	29.4			
	Čá	59.0	f	37.2			
	Lu	47.5	f	43.0			
Silage maize	Čá				41.1	p	15.0

p — preceding crop,  
 f — fertilizing,  
 s — sowing rate,  
 c — cultivar

also by a more productive cultivar. The complex of cultural practices proved important for dry-matter production in sugar beet at Lukavec. ( $W_p$  94 %,  $W$  67 %) and in potato at Ruzyně (70 %). As compared with cereals, in root and tuber crops only a half effect of optimum cultural practices on increasing production was ascertained at Lukavec. The fact that at all localities non-fertilized sugar beet produced higher amounts of dry-matter in the phytomass as cereals under optimum cultural practices, may be considered an important finding.

#### THE EFFECT OF FERTILIZING ON INCREASING DRY-MATTER PRODUCTION AND ITS INTERACTION WITH THE PRECEDING CROP

Fertilizing resulted in considerably increased dry-matter production of most crops, namely after unfavourable preceding crops (Table III). Intensive fertilizing could not eliminate, however, a reduction in dry-matter production caused by unfavourable crop rotation.

In all crops, fertilizing proved a higher increase in dry-matter production in the phytomass under worse soil and climate conditions (at Lukavec). Comparison of the influence of fertilizing on dry-matter production in summer barley and winter wheat showed summer barley to be more strongly affected at Ruzyně while winter wheat at Čáslav.

Higher average gains in dry-matter production per 1 kg of N from fertilizers (+ PK) were found in cereals after favourable preceding crops and in root and tuber crops. As compared with Ruzyně and Čáslav localities, the gain in dry-matter yield per 1 kg of N was higher almost in all crops at the locality Lukavec. The highest values were attained in oats (84.6 kg  $W_p$ ) and summer barley (67.8 kg  $W_p$ ) at Lukavec; in winter wheat (50.7 kg  $W_p$ ) and oats (41.6 kg  $W_p$ ) at Čáslav; and in summer barley (56.7 kg  $W_p$ ) at Ruzyně.

#### VARIABILITY IN THE PHYTOMASS PRODUCTION AND IN MORPHOLOGICAL CHARACTERS OF CEREALS

As a rule, fertilizing reduced fluctuations in dry-matter production in individual years as well as yield components of all crops. The lowest fluctuation of phytomass – production values and yield components, as influenced by the year, was observed in non-fertilized summer barley at Ruzyně and in winter wheat at Čáslav. What concerns dry-matter production of the grain at Lukavec, fluctuations between years were greater in winter cereals than in summer cereals. The highest number of ears per  $m^2$  was always found at Ruzyně while the lowest one at Lukavec the variability of years being higher there. At Ruzyně, fertilizing reduced the variability of years namely in the character number of ears per  $m^2$ ; this fact was mostly expressed in winter wheat.

Fertilizing did not affect the number of grains per head in cereals but it increased considerably the number of grains per panicle in oats.

At all localities, fertilizing resulted in a reduced variability of thousand kernel weight in oats but, on the contrary, the variability of this yield component in winter wheat was increased. As compared with the



III. The average increase in dry - matter yield of phytomass as influenced by fertilizing. - Průměrné zvýšení výnosu sušiny biomasy vlivem hnojení

Crop	Locality	After unfavourable forecrops						After favourable forecrops					
		W			W <sub>p</sub>			W			W <sub>p</sub>		
		t . ha <sup>-1</sup>	%	kg . kg N <sup>-1</sup>	t . ha <sup>-1</sup>	%	kg . kg N <sup>-1</sup>	t . ha <sup>-1</sup>	%	kg . kg N <sup>-1</sup>	t . ha <sup>-1</sup>	%	kg . kg N <sup>-1</sup>
Winter wheat	Ru	0.43	10.4	7.2	1.36	17.1	22.7	0.15	2.9	3.7	0.75	7.1	18.7
	Čá	1.02	36.8	16.9	2.48	35.3	41.2	0.76	21.5	19.0	2.03	22.8	50.7
	Lu	0.54	36.7	6.7	2.18	53.2	27.2	0.76	31.5	12.7	2.46	40.2	41.0
Summer barley	Ru	0.56	18.0	9.3	1.68	27.5	28.0	0.79	20.5	26.3	1.70	23.8	56.7
	Čá	0.27	10.0	4.5	0.36	6.7	6.1	0.08	2.4	2.7	0.01	0.1	0.2
	Lu	1.36	91.5	19.4	2.97	89.3	42.4	1.25	57.6	27.8	3.05	71.5	67.8
Summer wheat	Ru	0.58	24.4	9.7	0.94	24.4	15.7	0.22	5.1	3.7	0.56	7.8	9.3
	Čá	0.75	33.7	12.5	0.55	7.7	9.1	1.02	35.7	17.0	1.45	16.2	24.2
	Lu	1.41	98.2	30.4	2.92	74.1	60.1	0.99	37.8	16.1	2.47	39.6	40.1
Oats	Ru	0.21	8.0	4.6	0.87	10.8	17.4	0.27	8.9	13.5	1.13	12.6	56.5
	Čá	0.39	14.7	7.8	1.22	17.7	24.4	0.37	10.1	18.4	0.83	10.1	41.6
	Lu	1.45	74.6	17.6	4.41	71.2	54.6	1.52	74.6	25.4	5.07	71.2	84.6
Winter rye	Lu	0.40	19.9	6.6	2.09	33.9	34.8	0.42	16.3	8.4	1.93	25.1	38.6
Sugar beet	Ru	1.23	13.2	14.8	2.86	21.7	31.8	0.81	7.3	9.0	2.0	13.5	22.2
	Čá	1.40	15.8	15.6	2.69	23.8	29.8	1.10	11.4	12.2	2.08	15.5	23.1
	Lu	3.89	63.7	32.4	6.64	83.3	55.4	2.33	31.5	18.8	4.58	43.9	37.5
Potatoes	Ru	0.58	11.4	6.4	0.53	8.9	6.8	1.14	20.4	16.3	1.35	20.3	19.3
	Čá	0.81	20.2	9.0	0.95	22.7	10.6	0.41	13.0	5.8	0.48	7.0	6.9
	Lu	1.82	34.9	20.3	2.14	34.9	23.8	1.51	25.7	16.7	1.78	25.8	19.6
Horse bean	Ru	-0.11	-5.4	-4.5	0.29	6.5	16.5	0.01	0.4	0.5	0.10	1.2	5.0
	Lu	0.11	5.6	3.5	0.33	5.9	11.1	0.01	0.6	0.4	0.11	1.6	4.2
Silage maize	Čá	0.97	15.8	10.8	0.97	15.8	10.8	0.79	112.2	9.9	0.79	112.2	9.9

locality at Lukavec, cereals at locality Čáslav (the area of sugar beet growing) produced by 12–13 cm longer stems carrying greater numbers of grains per ear (by 4–9).

#### DRY-MATTER PRODUCTION OF THE PHYTO MASS IN INDIVIDUAL CROPS AS GROWN UNDER OPTIMUM CULTURAL PRACTICES AT VARIOUS LOCALITIES

From comparing the maximum dry-matter production of the phytomass which had been obtained by using a complex of optimum cultural practices at three localities, it is apparent (see graphs 1 and 3) that sugar beet produced the throughout highest dry-matter amounts (Ru: 18.1, Čá: 15.7, Lu: 15.5 t.ha<sup>-1</sup>). Concerning dry-matter production in the total overground phytomass, winter wheat at Ruzyně (11.5 t.ha<sup>-1</sup>) and Čáslav (11.0 t.ha<sup>-1</sup>) as well as oats at Lukavec (12.3 t.ha<sup>-1</sup>) were on the second place. The second highest amounts of dry-matter in the main product (W) were produced by potatoes at Ruzyně and Lukavec (Ru: 7.8, Lu: 7.6 t.ha<sup>-1</sup>) and by silage maize at Čáslav (9.3 t.ha<sup>-1</sup>). Dry-matter production in summer wheat was also remarkable providing the highest production of the agriculturally important proportion of dry-matter (4.05 t.ha<sup>-1</sup>) at Lukavec; also at Čáslav summer wheat was more productive (3.87 t.ha<sup>-1</sup>) than summer barley was (3.77 t.ha<sup>-1</sup>).

#### THE AVERAGE DRY-MATTER PRODUCTION OF THE PHYTO MASS IN VARIOUS CROP ROTATIONS

In six years lasting crop rotations, dry-matter production in the phytomass ( $W_p$ ) (Table IV) fluctuated on non-fertilized plots from 6.17 up to 8.99 at Ruzyně and from 6.49 up to 8.73 t.ha<sup>-1</sup> at Čáslav. Higher rates of fertilizing employed increased dry-matter production up to 7.28–10.88 at Ruzyně and up to 7.86–9.87 t.ha<sup>-1</sup> at Čáslav. On soils with lower natural fertility at Lukavec, the basic dry-matter production in crop rotations was lower (4.84–7.14 t.ha<sup>-1</sup>); intensive fertilizing, however, made it possible to reduce considerably the variations of localities, namely from 1.65 t.ha<sup>-1</sup> up to 0.67 t.ha<sup>-1</sup>. A similar tendency concerning dry-matter production of the agriculturally important proportion was apparent.

Further the values of average dry-matter production of the phytomass in various crop rotations show that appropriate crop rotation affects the phytomass production (inclusive of the proportion of the main product) more intensively than fertilizing does. Only dry-matter production at Lukavec was exceptional, fertilizing inducing there a stronger effect than crop rotation. Relative comparison demonstrated that fertilizing increased phytomass production in rotations of cereals by 17.3 %, 21 % and 58 % at Ruzyně, Čáslav, and Lukavec, respectively.

Even if cereals were cultivated six years without any crop rotation, intensive fertilizing did not bring their phytomass production up to the level of those grown under rotation of cereals, and other crops; the average differences amounted to 2.13 t.ha<sup>-1</sup>, 1.72 t.ha<sup>-1</sup>, and 1.01 t.ha<sup>-1</sup> at Ruzyně, Čáslav and Lukavec, respectively.

IV. The average dry - matter production of the phytomass in various crop rotations at three localities (years 1964-1970). - Průměrná produkce sušiny biomasy na třech stanovištích v různých osevních postupech (r. 1964-1970)

Crop rotation	Locality	Wp (t . ha <sup>-1</sup> )		W (t . ha <sup>-1</sup> )	
		non-fertilized	fertilized	non-fertilized	fertilized
Cereals only	Ru	6.18 (100 %)	7.28 (117.9)	2.73 (100 %)	3.21 (117.5)
	Čá	6.49 (100)	7.86 (121.1)	2.57 (100)	3.12 (121.4)
	Lu	4.84 (100)	7.66 (158.3)	1.70 (100)	2.70 (158.8)
50 % cereals 16.6 % root and tuber crops 33.3 % leguminous crops	Ru	8.99 (100)	10.88 (121.0)	5.29 (100)	6.12 (115.8)
	Čá	7.84 (100)	9.37 (119.5)	4.27 (100)	5.34 (125.1)
	Lu	5.72 (100)	8.10 (141.6)	2.97 (100)	4.14 (139.4)
50 % cereals 16.6 % leguminous crops 33.3 % root and tuber crops	Ru	7.56 (100)	8.28 (109.5)	4.17 (100)	4.53 (108.8)
	Čá	8.08 (100)	9.51 (117.7)	5.14 (100)	5.95 (115.8)
	Lu	6.67 (100)	8.67 (130.0)	3.64 (100)	4.75 (130.5)
50 % cereals 16.6 % leguminous crops 33.3 % root and tuber crops + green manuring	Ru	7.99 (100)	9.06 (113.3)	4.93 (100)	5.31 (107.6)
	Čá	8.73 (100)	9.87 (113.1)	5.59 (100)	6.16 (110.2)
	Lu	7.14 (100)	9.20 (128.9)	3.70 (100)	4.79 (129.5)

## DISCUSSION

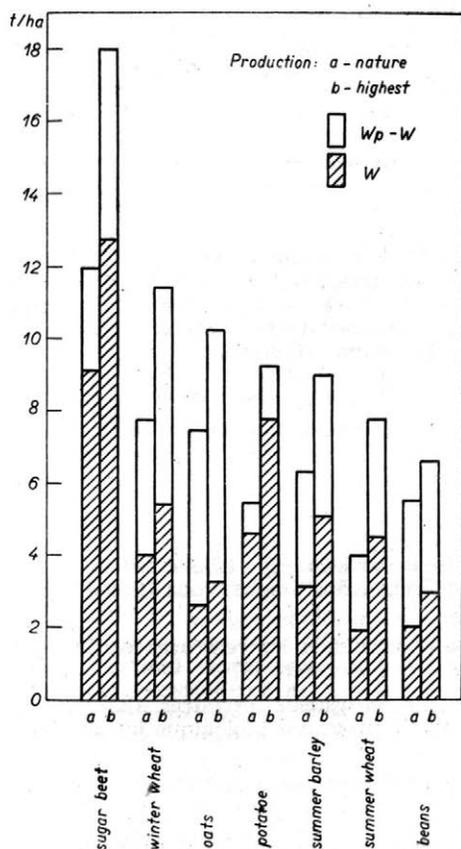
It was stated that, as compared with Čáslav, cultural practices at Lukavec proved a positive effect so that the negative influence of less favourable soil and climate conditions could be reduced in this way.

The relative gain in dry-matter production obtained as a result of optimum cultural practices employed was considerably highly pronounced on the soils with lower natural fertility, especially in more pretentious crop species (in winter wheat at Lukavec 113.9 %, while at Ruzyně 46.9 % and Čáslav 57.3 %; in summer barley at Lukavec 129.7 % while at Ruzyně 43.1 % and at Čáslav 43.7 %; in summer wheat at Lukavec 127.5 % while at Ruzyně 93.1 % and at Čáslav 48.5 %).

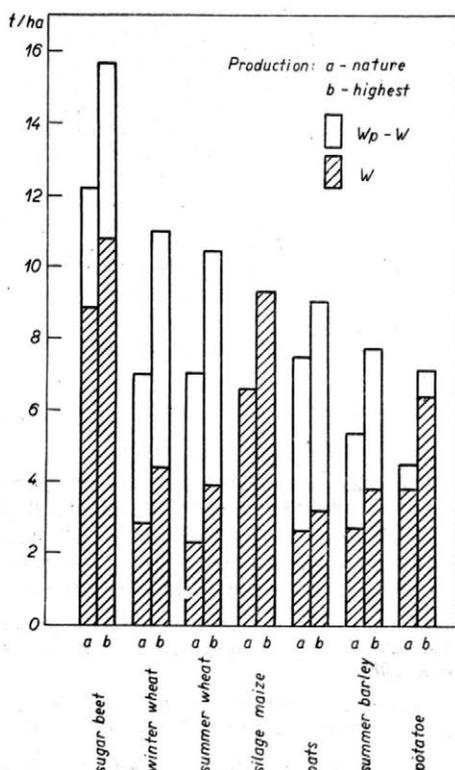
Differences in phytomass production at various localities were reduced namely by fertilizing (by 9-15 %); the production of total over-ground dry-matter was increased by it by 19-21 % on chernozem at

Čáslav while by 28–58 % on brown forest soil at Lukavec. As it was demonstrated in numerous papers (Černý 1972), the reaction of crops to fertilizing as well as to other cultural practices, as measured by the phytomass yield, was different according to crop and cultivar.

At both localities sugar beet proved most productive crop species; this is in consent with findings obtained in the area of southern Moravia (Hruška 1973) and on brown – grey podzolic soils at Ruzyně (Vrkoč 1973). It is remarkable that, even on brown forest soil in the area of potato growing (600 m above the sea level), this crop was the most productive and, as compared with potatoes, it produced almost double yield (Kříšťan, 1973). In the experiments by Hruška (1973) sugar beet reached on an average  $23.1 \text{ t}\cdot\text{ha}^{-1}$  W while at Ruzyně, Čáslav nad Lukavec only  $18.10 \text{ t}\cdot\text{ha}^{-1}$  (*Vrkoč* 1973),  $15.7 \text{ t}\cdot\text{ha}^{-1}$  and  $15.54 \text{ t}\cdot\text{ha}^{-1}$   $W_p$ , respectively. Among examined crop species, the very high dry-matter production ( $W_p$ ) was manifested in winter wheat at Čáslav ( $11.02 \text{ t}\cdot\text{ha}^{-1}$ ), and Ruzyně ( $11.48 \text{ t}\cdot\text{ha}^{-1}$ ) (*Vrkoč* 1973), and also in southern Mora-



1. Biomass dry matter production on gray-brown podzolic soil in sugar-beet production (Ruzyně). — Produkce sušiny biomasy na hnědozemí v řepářském výrobním typu (Ruzyně)

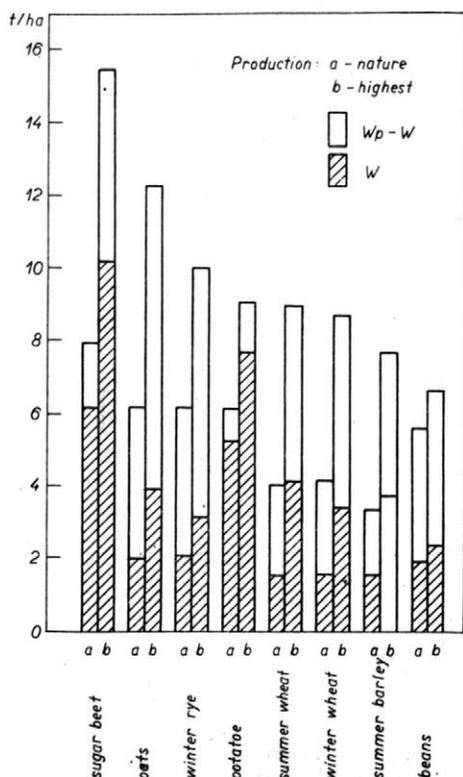


2. Biomass dry matter production on chernozem soil in sugar-beet production type (Čáslav). — Produkce sušiny biomasy na černozemí v řepářském výrobním typu (Čáslav)

via (11.08 t.ha<sup>-1</sup>) (Hruška 1973). At Lukavec oat was the most productive crop (12.29 t.ha<sup>-1</sup>) while winter wheat that produced 8.74 t.ha<sup>-1</sup> was on the sixth place. The latter one, even if fertilized, did not reach there the yield of non-fertilized plots at Čáslav.

We confirmed the formerly revealed compensating effect of favourable complex of cultural practices (mainly the influence of intensive fertilizing) on reducing the fluctuations in dry-matter production between individual years (Křišťan 1965). Eliminating the unfavourable effect of climatic conditions (namely temperature and sunshine) by cultural practices is, however, much more difficult than eliminating the unfavourable influence of soil conditions.

3. Biomass dry matter production on brown forest soil in potato production type (Lukavec). — Produkce sušiny biomasy na hnědé půdě v bramborářském výrobním typu (Lukavec)



## References

CERNÝ, V. — KRISTAN, F. — STRNAD, P. — VRKOČ, F.: (The Contribution of Some Cultural Practices to the Yields of Field Crops). *Rostlinná výroba* 19, 1972, No. 9, p. 905-916.

CERNÝ, V.: Problémy primární produkce v podmínkách koncentrace rostlinné výroby. Referát na zasedání I. a II. odboru ČAZ o ekosystémech, 1974.

DUVIGNEAUD, P.: La productivité primaire des écosystèmes terrestres. Extrait de la Publication sous les auspices du Comité français du programme biologique international. Paris, 1968.

HRUŠKA, L.: Výzkum produktivity hlavních polních plodin v podmínkách jižní Moravy. [Závěrečná zpráva.] Brno, VŠZ, 1973, p. 59.

KRISTAN, L.: Účinek stupňovaných dávek dusíku u píceňin, obilovin a okopanin při řádném jejich střídání na půdě v bramborářské oblasti. [Závěrečná zpráva.] Praha-Ruzyně, VÚRV, 1965.

KRISTAN, F.: (The Comparison of the Productivity of Potatoes and Sugar Beet under Conditions of the Czech-Moravian Uplands.) *Rostlinná výroba*, 19, 1973, No. 8, p. 777-786.

KRISTAN, L.: Vliv různých agrotechnických opatření na produkci biomasy na hnědé půdě a černozemi. [Závěrečná zpráva.] Praha-Ruzyně, 1973, VÚRV.

VRKOC, F.: Vliv některých agrotechnických opatření na produkci biomasy na hnědozemí. [Závěrečná zpráva.] Praha-Ruzyně, 1974, VÚRV.

8. 4. 1975

KRISTAN F. (Ústav genetiky a šlechtění, VÚRV, Výzkumná stanice rostlinné výroby, Lukavec). *Zvýšení produkce biomasy hlavních polních plodin na několika lokalitách v Čechách*. Rostlinná výroba (Praha) 21 (8) : 826-836, 1975.

V letech 1963—1973 byl v polyfaktoriálních pokusech konaných na hnědozemní půdě (Ruzyně), degradované černozemi (Čáslav) řepařského výrobního typu a na hnědé půdě (Lukavec) bramborářského výrobního typu sledován vliv některých agrotechnických opatření na produkční proces a tvorbu biomasy hlavních polních plodin. Vzestup produkce biomasy u jednotlivých plodin byl nejvíce ovlivněn hnojením a vhodným střídáním plodin v osevním postupu. Na úrodnější půdě vhodné střídání plodin ovlivnilo produkci biomasy relativně více než hnojení, které se ukázalo jako faktor působící výrazněji než byl vliv výkonnější odrůdy nebo hustoty porostu apod. Hnojení stabilizovalo produkci sušiny biomasy (W) v ročních a zvýšilo ji nejvíce u cukrovky (Ruzyně: 22,8; Čáslav: 26,8; Lukavec: 66,5 q. ha<sup>-1</sup>) a nejméně u bobu obecné (1,6 — 3,3 q. ha<sup>-1</sup>). Celý soubor agrotechnických opatření zvyšoval produkci sušiny biomasy výrazněji v horších přírodních podmínkách, zejména u náročnějších druhů obilnin (oz. pšenice + 140 %, jar. ječmen + 196 %). Průměrná produkce sušiny biomasy v obilních sledech bez hnojení byla nižší oproti osevním sledům se střídáním plodin o 23—28 q. ha<sup>-1</sup>. Hnojení však při vhodném střídání plodin produkci sušiny biomasy dále ročně zvýšilo o 20—24 q. ha<sup>-1</sup>. Na úrodnějších půdách (Ruzyně, Čáslav) při optimální agrotechnice bylo dosaženo průměrné produkce cca 100 q. ha<sup>-1</sup> sušiny biomasy. Na méně úrodné půdě (Lukavec) byl rozdíl (16,2 q. ha<sup>-1</sup>) uplatněním agrotechnických opatření snížen až na 7,5 q. ha<sup>-1</sup> sušiny biomasy. Ukázalo se, že čím horší jsou podmínky pro tvorbu produkce biomasy v polním ekosystému, tím vyšší jsou nároky na optimalizaci faktorů produkčního procesu řízeného člověkem i na k tomu potřebné materiální zdroje.

produkce sušiny; střídání plodin; hnojení; pšenice; ozimý ječmen; oves; žito; cukrovka; bob obecný; kukuřice na siláž

КРЖИШТЯН Ф. (Институт генетики и селекции, НИИР, НИ станция растениеводства, Лукавец). *Увеличение продукции биомассы главных полевых культур на нескольких местах Чехии*. Rostlinná výroba (Praha) 21 (8) : 826-836, 1975.

V 1963—73 гг. в ходе полифакторных полевых опытов на буроземной почве (Рузине), деградированном черноземе (Часлав) свекловодческого производственного типа и на бурой почве (Лукавец) картофельного производственного типа изучали влияние некоторых агротехнических мероприятий на процесс образования продукции и биомассы главных полевых культур. Рост продукции биомассы отдельных культур в наибольшей мере обуславливается удобрением и правильным чередованием культур в севообороте. На урожайной почве правильное чередование культур обусловило продукцию биомассы больше, чем удобрение, которое, в свою очередь, влияет сильнее, чем урожайный сорт или густота посева и пр. Удобрение стабилизирует продукцию сухого вещества в биомассе и увеличивает ее больше всего у сах. свеклы (Рузине: 22,8; Часлав: 26,8; Лукавец: 66,6 ц. га<sup>-1</sup>), а меньше всего у боба конского (1,6—3,3 ц. га<sup>-1</sup>). Весь этот комплекс агротехнических мер увеличивает продукцию сухого вещества в биомассе особенно заметно в неблагоприятных природных условиях и у требовательных видов зерновых (оз. пшеница + 140 %, яр. ячмень + 196 %). Средняя продукция биомассы в зерновых севооборотах без удобрения по сравнению с чередующимися севооборотами меньше на 23—28 ц. га<sup>-1</sup>, тогда как в условиях удобрения и правильного чередования культур она больше

на 20—24 ц. га<sup>-1</sup>. На плодородных почвах (Рузынь, Часлав) при оптимальной агротехнике средняя продукция составляет около 100 ц. га<sup>-1</sup> сухого вещества биомассы. На менее плодородных почвах (Лукавец) разница (16,2 ц. га<sup>-1</sup>) благодаря агротехнике была сокращена до 7,5 ц. га<sup>-1</sup> сухого вещества биомассы. Как установлено, чем хуже природные условия для образования биомассы в полевой экосистеме, тем нужнее оптимализация факторов процесса образования продукции под руководством человека и материальные ресурсы.

продукция сухого вещества; чередование культур; удобрение; пшеница; оз. ячмень; овес; сах. свекла; боб конский; кукуруза на силос

---

*Adresa autora:*

Ing. František Kříšťan, CSc., Ústav genetiky a šlechtění, VÚRV, Výzkumná stanice rostlinné výroby, Lukavec

---

# DEPENDENCE OF THE PRODUCTION PROCESS ON CHANGES OF CLIMATIC FACTORS

J. REPKA, A. KOSTREJ

REPKA J., KOSTREJ A. (University of Agriculture, Nitra). *Dependence of the Production Process on Changes of Climatic Factors*. Rostlinná výroba (Praha) 21 (8) : 837-844, 1975.

By method of the sequential sowing experiments production characteristics of spring barley, maize, sugar beet, sunflower and horse bean were tested in the conditions of Southern Slovakia. Mean and maximum values of net assimilation rate, relative growth rate, crop growth rate and their dependence on incident global radiation and mean daily temperature were determined. By regression analysis and equations we characterize the course of production indices during the vegetation. The results obtained give information on production possibilities in the given ecological region under the conditions of sufficient water supply and mineral nutrients.

growth analysis; crops; temperature; radiation; net assimilation rate; relative growth rate; crop growth rate; leaf area rate; barley; maize; sugar beet; sunflower; horse bean

In the conditions of intensive mineral nutrition and sufficient water supply of plants, an increase of crop production is easily affected by ecological and biological factors. In conditions like this the production efficiency of every species and variety is considerably dependent on climatic factors (especially temperature, incident global radiation) in the given ecological region.

In literature the causal dependence of the production efficiency of crops on temperature and incident global radiation is sufficiently documented (Blackman 1961, Watson 1963, Ničiporovič 1970, Budyko, Gandin 1972). The quantitative values of production indices are variable not only during the vegetation season, but also between individual ecological regions in dependence on the total input of these factors and their distribution during the vegetation season (Waren, Wilson 1966, Hogson 1967, Burian 1969, Murata 1969, Murata 1972, and others).

In this sense every ecological region and every species or variety form a specific ecological and biological unit, requiring individual analysis, especially for understanding the potential production efficiency of crops.

## MATERIAL AND METHODS

In 1965-1971 at the initiative of the International Biological Programme we made an analysis of growth and production processes of agricultural crops as dependent on variability of climatic factors. In our study we used the method of the sequential sowing experiments. The principle of the method required a series of

experiments during the whole vegetation. In each of the experiments plants of the same stage of development were submitted to test for 7–10 days. The effect of climatic factors was being studied in the given period of vegetation on the growth of leaf area and total dry matter weight. On the basis of the changes of leaf area and total dry matter weight increments the following growth characteristics were calculated: net assimilation rate (NAR) in  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ , relative growth rate (RGR) in  $\text{g} \cdot \text{g}^{-1} \cdot \text{day}^{-1}$ , crop growth rate (CGR)  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ , leaf area index (LAI), leaf area ratio (LAR)  $\text{dm}^2 \cdot \text{g}^{-1}$  and specific leaf area (SLA)  $\text{dm}^2 \cdot \text{g}^{-1}$ .

Of climatic factors the daily amounts of incident global radiation (by Bellani – type pyranometer) and mean daily temperature were measured. Meteorological data were obtained from the Meteorological Station of the University of Agriculture at Nitra, situated 1000 m from the experimental site.

The region studied is situated 160 m above sea level (48°18' geographical longitude, 18°05' geographical latitude) with mean annual daily temperature 9 °C, mean annual yearly rainfall about 600 mm. The growing season (1. Apr. – 30. Sep.) is characterized with mean daily temperature 16 °C and rainfall 337 mm and total sunshine duration of 1,600 hrs.

The experiments included spring barley (1965–1966), maize (1965–1966), sugar beet (1969–1970), sunflower (1965–1970), horse bean (1970). For each crop 10–14 tests were conducted during the vegetation period from May to October.

## RESULTS AND EVALUATION

Plants submitted to tests were first grown to the phase of four true leaves in barley, 3 pairs of true leaves in maize, sugar beet, sunflower and horse bean.

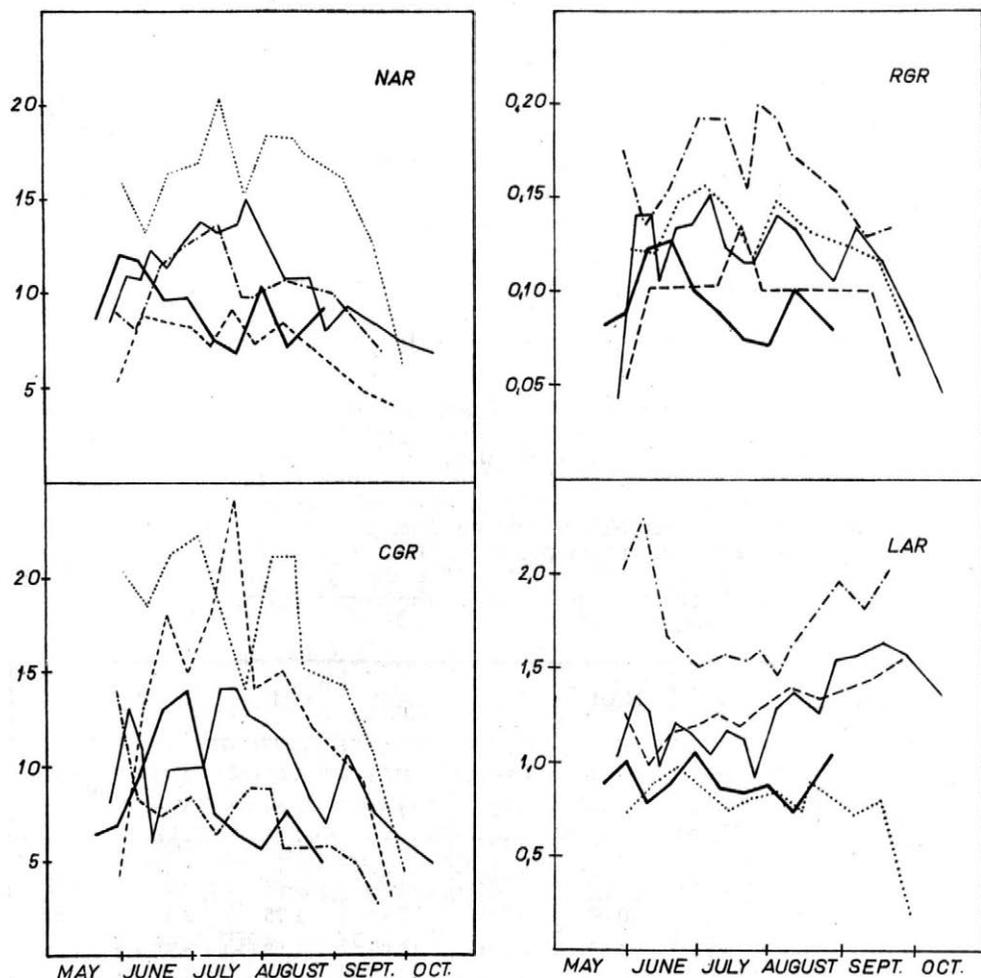
The changeability of climatic factors in natural conditions caused that plants included in the experiment were not uniform in growth.

Under favourable temperature conditions the plants with the same stage of development had sometimes greater weight or leaf area. This growth heterogeneity existed also between the experimental years. For illustration of this phenomenon the mean weight and leaf area of plants exposed to the experiments are in Tab. I for sunflower. This fact holds true in general for each of the plants studied.

I. Average ( $\bar{x}$  – arithmetic mean) of the initial total dry weight ( $W_1$ , g) and leaf area ( $A_1$ ,  $\text{cm}^2$ ) per box ( $x = 4$  plants); and their significance intervals ( $x \pm 2s_x$ ) for the experiments conducted in individual years from 1966 to 1970 for sunflower. – Priemery ( $\bar{x}$  – aritmetický priemer východiskovej váhy sušiny ( $W_1$ , g) a listovej plochy ( $A_1$ ,  $\text{cm}^2$ ) v nádobe ( $x = 4$  rastliny); intervaly preukaznosti ( $x \pm 2s_x$ ) pre pokusy konané v jednotlivých rokoch od roku 1966–1970 so slnečnicou

Year	$W_1$ , g		$A_1$ , $\text{cm}^2$	
	$\bar{x}$	$\bar{x} \pm 2s_x$	$\bar{x}$	$\bar{x} \pm 2s_x$
1966	3.29	3.77–2.82	236.57	274.47–198.67
1967	4.21	5.76–2.66	438.59	569.50–360.50
1968	2.96	3.68–2.22	549.78	800.26–299.30
1969	2.53	4.25–0.80	352.00	379.54–324.46
1970	2.59	3.84–1.34	266.79	476.04–157.45

In contradiction to the suppositions of the authors of this method (Blackmann, Wilson 1951) it is necessary to take into account that under such changeable climatic conditions it is very hard in natural conditions to gain for experiment morphologically and physiologically equivalent plants in all experiments performed during one growing



1. Average values of the net assimilation rate (NAR,  $g \cdot m^{-2} \cdot d^{-1}$ ), crop growth rate (CGR,  $g \cdot m^{-2} \cdot d^{-1}$ ) for the experiments with Sunflower (—), Spring barley (---), Maize (.....), Sugar beet (-.-.-.-) and Horse bean (.....). — Priemerné hodnoty čistého výkonu fotosyntézy (NAR,  $g \cdot m^{-2} \cdot d^{-1}$ ), rýchlosť prírastku sušiny na plochu (CGR,  $g \cdot m^{-2} \cdot d^{-1}$ ) v pokusoch so slnečnicou (—), jačmeňom jarným (---) kukuricou (.....), cukrovkou (-.-.-.-) a bôbom obecným (.....)

2. Average values of the relative growth rate (RGR,  $g \cdot g^{-1} \cdot d^{-1}$ ), leaf area rate (LAR,  $dm^2 \cdot g^{-1}$ ), for the experiments with Sunflower (—), Spring barley (---), Maize (.....), Sugar beet (-.-.-.-) and Horse bean (.....). — Priemerné hodnoty špecifickej rýchlosti rastu (RGR,  $g \cdot g^{-1} \cdot d^{-1}$ ), pomerná olistenosť (LAR,  $dm^2 \cdot g^{-1}$ ), v pokusoch so slnečnicou (—), jačmeňom jarným (---), kukuricou (.....), cukrovkou (-.-.-.-) a bôbom obecným (.....)

season. Herein lies one of the difficulties of the generally suitable method for following the effect of climatic factors on growth and production processes.

We have solved this problem by introducing into the regression equations, describing the effects of radiation supply and temperature on growth characteristics, the initial leaf area ratio ( $LAR_1$ ). The experiments with individual crops were performed in the course of several years. Explanation of all the results would be very extensive. For this reason we have calculated mean values of growth characteristics for each crop of the vegetation period (Fig. 1, 2).

Graphs of growth characteristics confirm dynamic changes during the vegetation which can be attributed to changes of meteorological factors. In short-term periods conditions can be created by which the growth and production efficiency of crops can be greatly increased or decreased respectively. It is at the same time confirmed that periods of maximum values are not found for every crop in the same interval of the vegetation period. For easier orientation average and maximum values of the main growth characteristics are presented in Tab. II.

II. Average (ave) and maximum values (max) of the net assimilation rate (NAR,  $g \cdot m^{-2} \cdot d^{-1}$ ), relative growth rate of total dry weight (RGR,  $g \cdot g^{-1} \cdot d^{-1}$ ), crop growth rate (CGR,  $g \cdot m^{-2} \cdot d^{-1}$ ), leaf area ratio (LAR  $dm^2 \cdot g^{-1}$ ), specific leaf area (SLA,  $dm^2 \cdot g^{-1}$ ) and leaf area index (LAI,  $dm^2 \cdot dm^{-2}$ ) found in the experiments with spring barley, maize, sugar beet, sunflower and horse bean. — Priemerné (ave) a maximálne hodnoty (max) čistého výkonu fotosyntézy (NAR,  $g \cdot m^{-2} \cdot d^{-1}$ ), špecifická rýchlosť prírastku sušiny na plochu (CGR,  $g \cdot m^{-2} \cdot d^{-1}$ ), pomerná olistenosť (LAR,  $dm^2 \cdot g^{-1}$ ), špecifická listová plocha (SLA,  $dm^2 \cdot g^{-1}$ ), index listovej pokrývnosti (LAI,  $dm^2 \cdot dm^{-2}$ ), zistené v pokusoch s jačmeňom jarným, kukuricou, cukrovkou, slnečnicou a bôbom obecným

Crop		NAR	RGR	CGR	LAR	SLA	LAI
Spring barley	ave	9.34	0.094	8.22	1.03	2.00	0.88
	max	12.13	0.127	14.06	1.09	2.17	1.44
Maize	ave	7.20	0.102	14.18	1.27	2.55	1.66
	max	9.11	0.135	24.01	1.54	3.80	2.35
Sugar beet	ave	10.08	0.165	7.44	1.75	2.33	0.80
	max	13.73	0.201	14.00	2.28	3.34	1.55
Sunflower	ave	10.90	0.116	9.76	1.26	2.67	0.82
	max	13.85	0.152	14.06	1.63	3.74	1.09
Horse bean	ave	15.71	0.128	16.75	0.75	2.37	1.13
	max	20.35	0.156	22.11	0.97	2.56	1.61

From May 16th to Sep. 2nd, the spring barley reached the average value of NAR  $9.34 g \cdot m^{-2} \cdot d^{-1}$ , the maximum values of  $11.7 - 12.1 g \cdot m^{-2} \cdot d^{-1}$  being in the period from May 26th to June 14th. The maximum values of CGR  $13.8 - 14.6 g \cdot m^{-2} \cdot d^{-1}$  were in the period from May 14th to July 5th. The maximum values of RGR were found in this period, too. The

curve of growth characteristics does not follow the curves of temperature and incident global radiation. It is also reflected in the correlation coefficients which for NAR and radiation had the values of 0.15 and for temperature 0.61, and 0.5 and 0.41 for RGR respectively.

LAR values are also influenced by changes of climatic factors. Its dependence on incident total radiation and mean daily temperature was expressed by the following regression equation:

$$\text{LAR} = 0.5881 - 0.0072 T + 0.0025 R + 0.3148 \text{LAR}_1 \text{ dm}^2 \cdot \text{g}^{-1}$$

For thermophilic plants, such as maize, experiments in the period of lower temperatures (beginning and end of vegetation period) give very low growth and production values. Maximum values of NAR (10.79; 1965), CGR (24.18; 1965), RGR (0.144; 1965) were obtained in July. Typical of maize is a very high correlation of NAR, RGR with incident global radiation ( $r = 0.92$ ) and a lower one with temperature (0.69).

The regression equation for LAR in maize has assumed this form:

$$\text{LAR}_2 = 0.3483 - 0.00045 T_2 + 0.0013 R + 0.5032 \text{LAR}_1 \text{ dm}^2 \cdot \text{g}^{-1}$$

Production values of sunflower are the average of 5 experimental years. The highest maximum value of NAR (16.5) and CGR (30.80) was found in 1967. In all years the maximum values of growth characteristics were in July and at the beginning of August. The coefficients of correlation had the following values: 0.56 for temperature, and 0.52 for radiation and NAR, and 0.55 and 0.39 for RGR respectively.

The values of LAR ranged from 0.97 to 1.56  $\text{dm}^2 \cdot \text{g}^{-1}$  with higher values in the second half of the vegetation period. The dependence of LAR on temperature and radiation is expressed by the equation:  $\text{LAR}_2 = 1.138 + 0.0114 T - 0.0764 R + 0.2685 \text{LAR}_1 \text{ dm}^2 \cdot \text{g}^{-1}$

In comparison with the rest of the crops, sugar beet shows high values of NAR, RGR and LAR and low values of CGR. This fact may be caused by relatively low values of LAI. Correlation coefficients for NAR and temperature were 0.50 and for radiation 0.67. The dependence of RGR on these factors was not significant ( $r = 0.10, 0.14$ ).

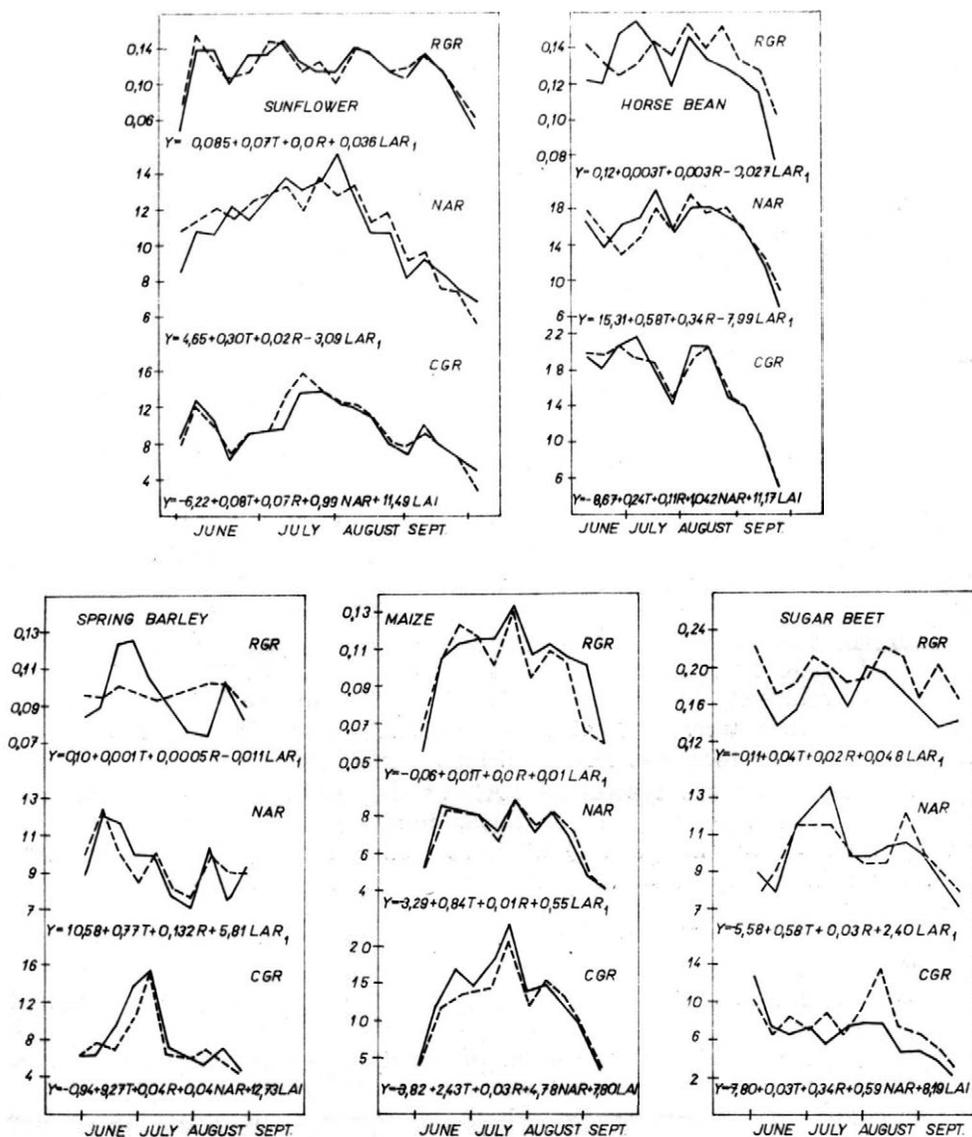
Higher values are typical of LAR at the beginning and at the end of the vegetation season i.e. at lower temperatures. A great effect of temperature on the changes of LAR is confirmed also by the high negative coefficient in the regression equation in contrast to the other crops:

$$\text{LAR}_2 = 2.7596 - 0.0394 T - 0.0392 R + 1.698 \text{LAR}_1 \text{ dm}^2 \cdot \text{g}^{-1}$$

Horse bean was included into the experiment in 1970. With the average value of LAI  $1.13 \pm 0.4$  high growth characteristics were obtained in comparison with the other crops (See Tab. II). The correlation coefficients confirm a high dependence of NAR ( $r = 0.78$ ) and RGR ( $r = 0.51$ ) on temperature and a lower one on radiation ( $r = 0.29$ ).

On the basis of data of the individual experimental years for a more general characterization of the course of NAR, RGR and CGR we made the regression analysis of their dependence on mean daily temperature and incident total radiation and  $\text{LAR}_1$  of the plants used in the experiments. Also the values of NAR and LAI were included in the regression equation for CGR.

Comparison of experimental values with those fitted from regression are given in Fig. 3 and 4. Average values calculated on the basis of regression equations are close to experimental ones with the exception of RGR and CGR of sugar beet. Greater differences are in maximum values, which must be taken into account in the interpretation of maximum values of growth characteristics.



3., 4. Seasonal course of relative growth rate of total dry weight (RGR,  $g \cdot g^{-1} \cdot d^{-1}$ ), net assimilation rate (NAR,  $g \cdot m^{-2} \cdot d^{-1}$ ), crop growth rate (CGR,  $g \cdot m^{-2} \cdot d^{-1}$ ), comparison of experimental values (—), with those fitted from regression equations (---). — Sezónny priebeh špecifickej rýchlosti rastu celkovej váhy sušiny (RGR,  $g \cdot g^{-1} \cdot d^{-1}$ ), čistý výkon fotosyntézy (NAR,  $g \cdot m^{-2} \cdot d^{-1}$ ), rýchlosť prírastku sušiny na plochu (CGR,  $g \cdot m^{-2} \cdot d^{-1}$ ), porovnanie nameraných hodnôt (—), s odvedenými, pomocou regresných rovníc (---)

## DISCUSSION

Analysis of the production process of crops confirms specificity of reactions of individual crops to climatic factors in the given area. The applied method reflects the effect of climatic factors on the growth and productivity of plants. It lays high demands on the preparation of plants for an experiment and obtaining plants with the same values of LAI. This was also pointed out by Hodgson (1967) who included LAR in the regression analysis.

From the point of view of the specificity of reaction of crops to climatic factors the fact deserves attention that maximum values of growth characteristics are not obtained in the period of maximum radiation and temperature. For instance, for barley the maximum values of NAR, RGR and CGR are to the beginning of July i. e. in the period, in which the natural vegetation rhythm is phylogenetically established. In the second part of vegetation period lower values were found at a higher input of radiation and temperature. Comparison of the rest of crops shows that maximum values of growth characteristics are coincidental with the period, when in the natural ontogenesis there is maximum accumulation of the biomass. For sugar beet in comparison with barley it is therefore possible to find high values also till the beginning of September. Disharmony between the distribution of maximum values of growth characteristics and the maximum values of radiation and temperature is reflected also in lower values of correlation coefficients, in our case especially for global radiation. The lower values of correlation coefficients may be due to the fact that global radiation does not express the effect of light on photosynthesis and it would be necessary to measure the photosynthetic active radiation. At the same time it is necessary to mention that in this type of experiments no competition for light occurs and consequently the effect of radiation becomes more manifest in crops requiring more light, such as maize. The correlation coefficients for temperature are in conformity with other authors (Binová, Ondok 1970, Murata 1972).

At the same time it is necessary to say that though in this type of experiments optimum water saturation is maintained, yet in the conditions of high daily temperature water deficiency may occur which can cause a decrease of the production efficiency (Repka, Kostrej 1972).

The data obtained show that production efficiency of crops is reflected through different production characteristics. In the given ecological region high values of NAR were found in horse bean, sunflower and sugar beet, higher values of RGR in sugar beet and those of CGR in maize.

## References

- BINOVA, J. — ONDOK, I. T.: The sequential sowing experiments at Třeboň. In: PP-PT Report No. 1, Productivity of Terrestrial Ecosystems. Production Processes. Praha, 1 BP national committee, 1970.
- BLACKMAN, G. E.: Responses to environmental factors by plants in the vegetative phase. In: Zarov M. X. (Ed.): Growth in living systems. Proc. internat. Symp. Growth Purdue Univ. New York, 1961.
- BLACKMAN, G. E. — WILSON, G. L.: Physiological and ecological studies in the analysis of plant environment IV. The interaction between light intensity and mineral nutrient supply on the uptake of nutrients by the bluebell. Ann. Bot. N. S. 1951.

BUDYKO, M. I. — GANDIN, L. S.: Vlijanije meteorologičeskich faktorov na fotosintez. In: Teoretičeskije osnovy fotosintetičeskoj produktivnosti. Moskva, Izd. Nauka, 1970.

BURIAN, K.: Produktion und Strahlungsnutzung bei *Helianthus annuus*, *Zea mays* und *Phaseolus vulgaris* während der gessamnten Vegetationszeit. Sitzungsberichte d. mathem. Kl. Abt. J Heft. Wien, 1969.

HODGSON, G. L.: Physiological and ecological analysis of plant environment XIII. A comparison of the effect of seasonal variations in light energy and temperature on the growth of *Helianthus annuus* and *Vicia faba* in the vegetative phase. Ann. Bot. N. S., 1967.

MURATA, Y.: The productivity and the efficiency of solar energy utilization in some crop species. In: Theoretical foundations of the photosynthetic productivity. Moscow, Nauka 1972.

NICIPOROVIC, A. A.: Nekotoryje principy kompleksnoj optimizacii fotosintetičeskoj dejatel'nosti rastenij. In: Važnejšie problemy fotosinteza v rastenovodstve. Moskva, Izd. Kolos, 1970.

REPKA, J. — KOSTREJ, A.: Seasonal changes of net photosynthetic production in plants under climatic conditions of South Slovakia. Biolog. práce XVIII, 1972, č. 8.

WATSON, D. J.: Climate, weather and plant yield. In: Evans, L. T. (Ed.): Environmental control of plant growth. New York, 1963.

WARREN WILSON, J.: Effects of seasonal variation in radiation and temperature on net assimilation and growth rates in an arid climate. Ann. Bot. N. S., 1966, 33, p. 40-57.

8. 4. 1975

REPKA J., KOSTREJ A. (Vysoká škola poľnohospodárska, Nitra). *Závislosť produkčného procesu na zmenách klimatických faktorov*. Rostlinná výroba (Praha) 21 (8) : 837-844, 1975.

Metódou postupných výsevov sme testovali produkčné vlastnosti jarného jačmeňa, kukurice, cukrovej repy, slnečnice a bôbu v podmienkach južného Slovenska. Stanovili sme priemerné a maximálne hodnoty čistého výkonu fotosyntézy špecifickej rýchlosti rastu, rýchlosti prírastku sušiny na plochu a ich závislosti na toku globálneho žiarenia a priemernej dennej teplote. Regresnou analýzou a vypočítanými regresnými rovnicami charakterizujeme priebeh produkčných ukazovateľov počas vegetácie. Dosiahnuté údaje poskytujú informácie o produkčných možnostiach v danej ekologickej oblasti v podmienkach dostatočnej zásobenosti vodou a minerálnymi živinami.

rastová analýza; plodiny; teplota; žiarenie; čistý výkon fotosyntézy; rýchlosť prírastku sušiny na plochu; špecifická rýchlosť rastu; pomerná olistenosť; jačmen; kukurica; cukrová repa; slnečnica; bôb

РЕПКА Й., КОСТРЕЙ А. (Сельскохозяйственный институт, Нитра). *Зависимость процесса образования продукции от перемены климатических факторов*. Rostlinná výroba (Praha) 21 (8) : 837-844, 1975.

По методу постепенных высевоv оtestировали продуктивные свойства яр. ячменя, кукурузы, сах. свеклы, подсолнечника и боба в условиях Ю. Словакии. Определены средние и максимальные значения чистой продукции фотосинтеза, специфической скорости роста, скорости прироста сухого вещества с площади, их зависимость от потока глобального излучения и среднесуточной температуры. С помощью анализа регрессии и уравнений регрессии охарактеризована кривая показателей продукции в период вегетации. Данные показывают потенциальную продуктивность данной экологической области в условиях достаточного запаса воды и минеральных веществ.

анализ роста; культуры; температура; излучение; чистая продуктивность фотосинтеза; скорость приростов сухого вещества; с площади; специфическая скорость роста; среднее олистевание; ячмень; кукуруза; сахарная; свекла; подсолнечник; боб

*Adresa autorů:*

Doc. ing. Jozef Repka, CSc., ing. Anton Kostrej, CSc., Vysoká škola poľnohospodárska, 949 09 Nitra

# PRODUCTION OF PHYTOMASS IN SOME FIELD CROPS UNDER IRRIGATION ON LIGHT SOILS

J. SIMON

SIMON J. (Research Institutes for Crop Production, Praha-Ruzyně). *The Production of Phytomass in Some Field Crops under Irrigation on Light Soil*. Rostlinná výroba (Praha) 27 (8) : 845-860, 1975.

In the period of 1971—1974 the production of phytomass in winter wheat, horse bean, sugar beet, and silage maize was investigated on light soils at VÚRV Praha 6-Ruzyně and Tišice localities. Various variants of irrigation (z) and fertilizing with N (h) were compared with a non-irrigated variant. The course of following basic growth characteristics was examined by means of the growth — analysis at various terms of the vegetation period: dry-matter production in the overground phytomass  $W_p$ , distribution of the total dry-matter, daily gains in dry-matter of individual plant organs. The yield of dry-matter in irrigated sugar beet was 29.2 t. ha<sup>-1</sup> in the average of four years, the average daily gain per vegetation period (C) being 14—19 g. m<sup>-2</sup>. day<sup>-1</sup>; the gain in winter wheat was 14—18 t. ha<sup>-1</sup> (the C value being 13—15 g. m<sup>-2</sup>. day<sup>-1</sup>); in silage maize 16.8 t. ha<sup>-1</sup> (the C value being 14—16 g. m<sup>-2</sup>. day<sup>-1</sup>), and in horse bean 8.2—10.5 t. ha<sup>-1</sup> (the C value being up to 8 g. m<sup>-2</sup>. day<sup>-1</sup>). As compared with the non-irrigated variant, employing irrigation on light soils resulted in increased productivity of winter wheat, horse bean, sugar beet, and silage maize by 24 %, 17 %, 70 %, and 45 %, respectively.

irrigation; fertilizing with N; growth analysis; winter wheat; horse bean; sugar beet; silage maize

At present, irrigation of field crops proves to be one of decisive factors which affect the phytomass production as well as productivity in drier areas and on light soils. Under mentioned conditions, water has often been a limiting factor of exploiting the other intensification factors as fertilizing, employing intensive cultivars etc. Thus a high attention is to be paid not only to yields of irrigated crop but also to the problems of phytomass production and its interaction with other cultural practices.

## LOCALITY AND METHODS

The paper discusses data obtained from field experiments performed in the period of 1971—1973 at VÚRV Praha-Ruzyně and Tišice localities. Main data on both localities are given in Tab. I. Weather conditions of individual experimental years are described in Tab. II.

Dynamics of the plant growth and productivity were investigated in the following crops: winter wheat cv. 'Jubilar', horse bean cv. 'Chlumecký', sugar beet cv. 'Dobrovická A', and silage maize cv. 'CE 250'. The course of basic growth characteristics was studied by means of the growth-analysis method during the whole vegetation period. Sampling was made at the intervals of 14—21 days (see Tab. III). Experiments comprised following variants:

Crop	Irrigation system $x_1$				Fertilizing with N ( $\text{kg} \cdot \text{ha}^{-1}$ )			Rate of K ( $\text{kg} \cdot \text{ha}^{-1}$ )
	$z_0$	$z_1$	$z_2$	$z_3$	$h_1$	$h_2$	$h_3$	
Winter wheat	$x_2$	15	30	50	40	80	120	100
Horse bean	$x_2$	40	60	80	0	100	150	125
Sugar beet	$x_2$	20	40	60	120	180	240	125
Silage maize	$x_2$	30	50	70	140	210	280	116

Expl.  $x_1$ ) irrigation system as expressed in % of the available water capacity (AWC) of the soil, AWC representing the difference between the field water capacity and the wilting point of the soil profile

$x_2$ )  $z_0$  - natural rainfall, i. e. non-irrigated control

I. Characteristics of experimental field at Tišice. — Charakteristika pokusného miesta v Tišicích

Data	Values
Latitude	50° 16'
Longitude	14° 33'
Above sea level	168 m
Great soil group	Haplic Phaeozems formed on loamy sand terrace (FAO)
Texture class	loamy sand
Agrochemical properties of topsoil	
Humus %	2.5
pH (KCl)	7.0
P (Egner) mg per 1000 g soil	250–300
K (Schachtschabel) mg per 1000 g soil	80–150
Mg mg per 1000 g soil	45–80
CaCO <sub>3</sub> %	0.4–1.2
Average of annual temperature °C	8.5
Average of precipitation mm	537
Sunshine in hours per year	1551

II. Meteorological data . — Meteorologické údaje

Year	Average air temperature °C		Precipitation total mm	
	annual	in vegetation period (IV–IX)	annual	in vegetation period (IV–IX)
1971	8.7	15.1	436.7	322.7
1972	8.5	14.7	515.9	421.4
1973	8.6	14.7	350.2	241.8

III. Dates of sampling in studied crops. — Přehled o termínech odběrů vzorků rostlin za vegetace

Crop	Sample No. Intervals*)	1	2	3	4	5	6	7
		I.	II.	III.	IV.	V.	VI.	
Dates of sampling								
Winter wheat								
	1971	16.4	30.4	14.5	28.5	11.6	25.6	9.7
	1972	2.5	5.6	21.6	3.7	17.7	—	—
	1973	10.5	1.6	21.6	6.7	13.7	27.7	—
Horse bean								
	1971	21.5	4.6	18.6	2.7	16.7	30.7	13.8
	1972	1.6	16.6	30.6	14.7	26.7	4.8	—
	1973	4.6	22.6	27.6	12.7	26.7	8.8	—
Sugar beet								
	1971	5.7	19.7	2.8	16.8	30.8	13.9	27.9
	1972	10.7	25.7	7.8	21.8	4.9	18.9	2.1
	1973	9.7	24.7	6.8	21.8	3.9	17.9	26.9
Maize for silage								
	1971	1.7	15.7	30.7	12.8	14.9	—	—
	1972	27.6	12.7	27.7	11.8	28.8	—	—
	1973	10.7	25.7	10.8	24.8	6.9	—	—

Interval\*) — period between two individual samplings (sample No.)

The survey on main cultural practices is given in Tab. IV.

Data on total rainfall and amounts of irrigating water in experimental crops are listed in Table V.

## RESULTS AND DISCUSSION

The survey on the course of changes in the overground phytomass growth-rate ( $W_p$ ) of stands ( $g \cdot m^{-2}$ ) in individual crops is given in graphs 1–4. Data on the distribution of dry matter of the total phytomass into individual organs are expressed in graphs 5 and 6. Tables VI and VII give data on daily dry-matter gain in individual plant-organs in the course of the vegetation period (C) in sugar beet and silage maize. Yields ( $t \cdot ha^{-1}$ ), values of dry-matter in the total overground phytomass ( $t \cdot ha^{-1}$ ) as well as average daily gains in dry-matter during the whole vegetation period are listed in Tables VIII and IX.

The dynamics of changes in dry-matter content in the overground phytomass of winter wheat was changeable in individual experimental years and variants (see graph 1). In the average of years, the maximum values of dry-matter in the total overground phytomass were by 16 %

## IV. Basic data on the cultural practices applied to the studied crops. —

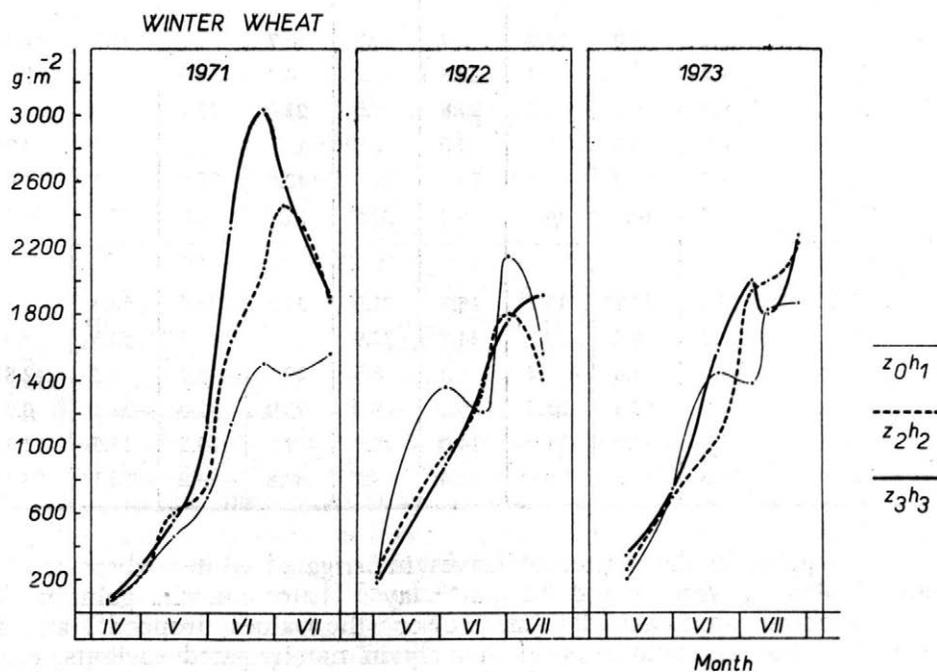
Data	Crops	
	Winter wheat	Horse bean
Preceding crop	Red clover	Winter wheat
Sowing rate (mill. per ha)	4.5	0.45
Row — spacing (cm)	12.5	27. —
Data of sowing (1971, 1972, 1973)	4. 10.; 5. 10.; 4. 10.;	9. 4.; 28. 3.; 23. 3.
Beginning of emergence (1971, 1972, 1973)	18. 10.; 17. 10.; 17. 10.	23. 4.; 14. 4.; 10. 4.
Harvest (1971, 1972, 1973)	29. 7.; 3. 8.; 1. 8.	24. 8.; 9. 8.; 15. 8.
Vegetation period in days (1971, 1972, 1973)	296, 300, 301	138, 135, 146

## V. Precipitation and irrigations during vegetation period. — Přehled o srážkách a dávkách závlahové vody za vegetace

Crops Year	Rainfall (mm) $z_0$	Irrigation regime (total amount of water) mm		
		$z_1$	$z_2$	$z_3$
<b>Winter wheat</b>				
1971	422.1	40.7	49.1	44.5
1972	456.4	—	—	67.9
1973	311.4	53.0	54.5	43.9
<b>Horse bean</b>				
1971	321.1	79.3	158.4	156.0
1972	338.0	46.6	134.3	170.0
1973	226.6	49.0	38.5	30.9
<b>Sugar beet</b>				
1971	373.3	254.0	223.0	335.7
1972	404.4	46.2	41.6	157.0
1973	228.8	293.8	345.3	411.6
<b>Maize for silage</b>				
1971	168.8	181.6	174.6	265.1
1972	295.2	76.2	117.4	172.6
1973	133.3	254.1	239.5	329.1

Sugar beet	Maize for silage
Maize for silage	Forage winter rye
0.08	0.09
45.—	60.—
13. 4; 10. 4; 7. 4.	2. 6; 24. 5; 30. 5.
26. 4; 25. 4; 28. 4.	8. 6; 4. 6; 8. 6.
12. 10; 12. 10; 5. 10.	16. 9; 13. 9; 20. 9.
183, 186, 182	107, 113, 114

and 30 % higher than in a non-fertilized variant. Maximum values of  $W_p$  were observed mostly at the end of June. In a non-irrigated variant, the maximum dry-matter production in leaves ( $W_1$ ) amounted, in the average of years, to  $293 \text{ g}\cdot\text{m}^{-2}$ . In comparison with the non-irrigated variant, the  $W_1$  values in variants  $z_2h_2$  and  $z_3h_3$  were by 27 % and 38 %



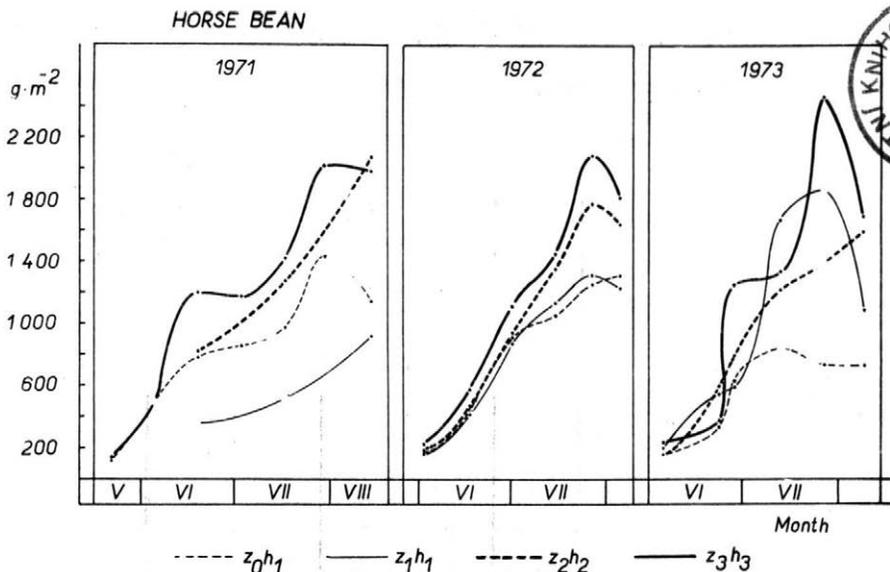
1. The survey on the course of changes in the overground phytomass growth-rate ( $W_p$ ) of stand in winter wheat ( $\text{g}\cdot\text{m}^{-2}$ ). — Přehled o průběhu změn v tvorbě sušiny nadzemní biomasy ( $W_p$ ) porostu pšenice ozimé ( $\text{g}\cdot\text{m}^{-2}$ )

higher respectively. At the end of vegetation period, decrease in dry-matter of the leaf-phytomass was stronger in irrigated variants. As compared with the maximum  $W_1$  values the decrease was about 60 % while in the non-irrigated variant only 45 %. In spite of this, at the end of vegetation period, the absolute  $W_1$  values were higher in irrigated variants.

VI. Daily overground dry matter increments of plant organs in sugar beet at different intervals during growth season ( $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ ). — Denní přírůstky sušiny biomasy jednotlivých částí cukrovky v jednotlivých intervalech během vegetace ( $\text{g} \cdot \text{m}^{-2} \cdot \text{den}^{-1}$ )

Year Intervals	Leaves			Roots			Total plant		
	Variant			Variant			Variant		
	$Z_0h_1$	$Z_2h_1$	$Z_3h_3$	$Z_0h_1$	$Z_2h_1$	$Z_3h_3$	$Z_0h_1$	$Z_2h_1$	$Z_3h_3$
1971									
I.	25.1	—	8.5	22.1	12.9	17.3	47.2	—	8.8
II.	-21.4	8.0	17.3	1.1	11.3	27.6	-20.3	19.4	44.7
III.	-10.5	-8.0	-8.4	1.3	-1.4	20.0	-9.2	-9.3	11.5
IV.	-7.0	2.1	5.5	-6.3	33.4	6.3	-13.2	35.5	11.8
V.	8.5	8.2	4.3	14.2	33.5	33.7	22.7	41.6	38.1
VI.	-2.1	8.1	-14.7	13.5	17.2	-1.2	11.3	25.3	-15.8
1972									
I.	6.8	25.0	18.9	7.9	11.3	18.7	14.8	36.4	37.7
II.	9.2	14.0	-5.4	20.8	15.2	4.4	30.0	1.4	1.0
III.	9.4	8.1	4.5	29.8	35.5	23.0	22.7	27.5	27.5
IV.	0.1	16.8	7.1	0.0	-2.3	12.1	0.1	14.5	19.2
V.	-3.2	16.2	-4.1	28.2	22.0	42.8	25.0	7.5	38.6
VI.	-3.3	10.1	14.7	9.4	30.5	21.7	6.0	40.0	36.4
1973									
I.	10.8	30.7	15.7	15.7	21.6	26.8	26.5	52.3	42.5
II.	11.9	19.4	23.7	34.7	32.9	24.2	46.6	52.3	47.9
III.	-9.2	-1.6	20.2	1.2	8.9	22.7	-8.0	7.3	42.8
IV.	-6.2	-28.9	-25.6	-25.8	-3.2	25.9	-32.0	-32.1	0.3
V.	4.9	-9.0	-11.3	14.0	26.5	-2.1	19.5	17.5	-13.4
VI.	-14.8	-33.8	8.6	11.4	7.7	69.8	-26.2	-26.1	78.4

Daily gains in dry-matter of leaves in irrigated winter wheat fluctuated in May between 5 and 10  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ . Later on, the gain in the leaf dry-matter phytomass became slower (the values dropped), and at the end of the vegetation period, namely in non-irrigated variants, even reduction of the phytomass took place. In some irrigated variants, daily gains in the total dry-matter of the overground phytomass in winter wheat amounted up to 50  $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$  due to high gains in dry-matter



2. The survey on the course of changes in the overground phytomass growth-rate ( $W_p$ ) of stand in horse bean ( $g \cdot m^{-2}$ ). — Přehled o průběhu změn v tvorbě sušiny nadzemní biomasy ( $W_p$ ) porostu bobu obecného ( $g \cdot m^{-2}$ )

of haulms and ears (density of the stand). In the stand of non-irrigated winter wheat maximum values of C fluctuated between 30 and 40  $g \cdot m^{-2} \cdot day^{-1}$ .

From the course of changes in the total overground phytomass ( $W$ ) in horse bean (see graph 2) the dependence of the production on the irrigation has been apparent in all experimental years. In the variant  $z_3h_3$  the maximum  $W_p$  values achieved as much as  $2,500 g \cdot m^{-2}$ . As compared with the non-irrigated variant ( $1,205 g \cdot m^{-2}$ ), the maximum dry-matter production of overground phytomass was by 50–60% higher in horse bean under irrigation in the average of experimental years. In the average of three years, dry-matter production of leaves ( $W_1$ ) in non-irrigated variants amounted to  $326 g \cdot m^{-2}$  being lower by 6%, 22%, and 34% than in irrigated variants  $z_1h_1$ ,  $z_2h_2$ , and  $z_3h_3$ , respectively. At the end of the vegetation period, dry-matter contents of the leaf-phytomass, as compared with the maximum values, were only 10.4%, 16.5%, 32.2%, and 13.7% in variants  $z_0h_1$ ,  $z_1h_1$ ,  $z_2h_2$ , and  $z_3h_3$ , respectively. At the end of the vegetation period, the variant  $z_2h_2$  proved also the highest absolute  $W_1$  values  $135 g \cdot m^{-2}$  in the average of three years.

Maximum daily gains in leaves of irrigated horse bean did not mostly surpass the value of  $15 g \cdot m^{-2} \cdot day^{-1}$  in June. In non-irrigated horse bean the maximum values of C fluctuated up to  $10 g \cdot m^{-2} \cdot day^{-1}$ . In July reduction of C values in leaves, in non-irrigated variants even reduction of the total phytomass took place. The maximum daily gains in total dry-matter of overground phytomass in non-irrigated horse bean were found in June, the maximum values amounting to  $30-35 g \cdot m^{-2} \cdot day^{-1}$ . Later on, the gains were localized namely into pods. In irrigated horse bean daily

VII. Daily overground dry matter increments of plant organs in maize for silage at biomass jednotlivých částí kukuřice na siláž v jednotlivých intervalech během

Year	Leaves				Stems			
Intervals	Variant				Variant			
	Z <sub>0</sub> h <sub>1</sub>	Z <sub>1</sub> h <sub>1</sub>	Z <sub>2</sub> h <sub>2</sub>	Z <sub>3</sub> h <sub>3</sub>	Z <sub>0</sub> h <sub>1</sub>	Z <sub>1</sub> h <sub>1</sub>	Z <sub>2</sub> h <sub>2</sub>	Z <sub>3</sub> h <sub>3</sub>
1971								
I.	19.1	2.6	2.5	2.7	1.3	1.4	1.3	1.5
II.	3.4	9.4	7.2	12.0	7.1	11.2	20.4	1.6
III.	8.1	2.7	9.4	4.0	9.0	15.8	0.4	10.3
IV.	0.4	-0.1	-0.5	0.1	3.3	4.8	7.9	2.8
1972								
I.	7.6	10.6	10.3	7.6	7.2	7.6	6.2	4.9
II.	8.3	6.3	8.1	8.9	12.8	15.8	14.0	17.0
III.	-0.8	-10.3	-3.1	-4.7	12.0	18.0	6.3	8.6
IV.	2.8	9.4	0.3	4.4	7.5	-5.4	3.5	5.2
1973								
I.	5.6	2.4	7.2	6.6	6.7	8.9	14.5	39.0
II.	5.1	0.7	3.0	2.9	23.2	24.7	17.2	-5.0
III.	2.2	8.4	1.5	7.5	-0.3	5.4	24.4	12.4
IV.	-3.7	-0.2	-1.0	-7.9	-2.0	-0.1	-17.3	-8.8

gains in dry-matter of the total overground phytomass achieved 30–40 g.m<sup>-2</sup>.day<sup>-1</sup>. Mentioned level of C values was maintained up to mid-July.

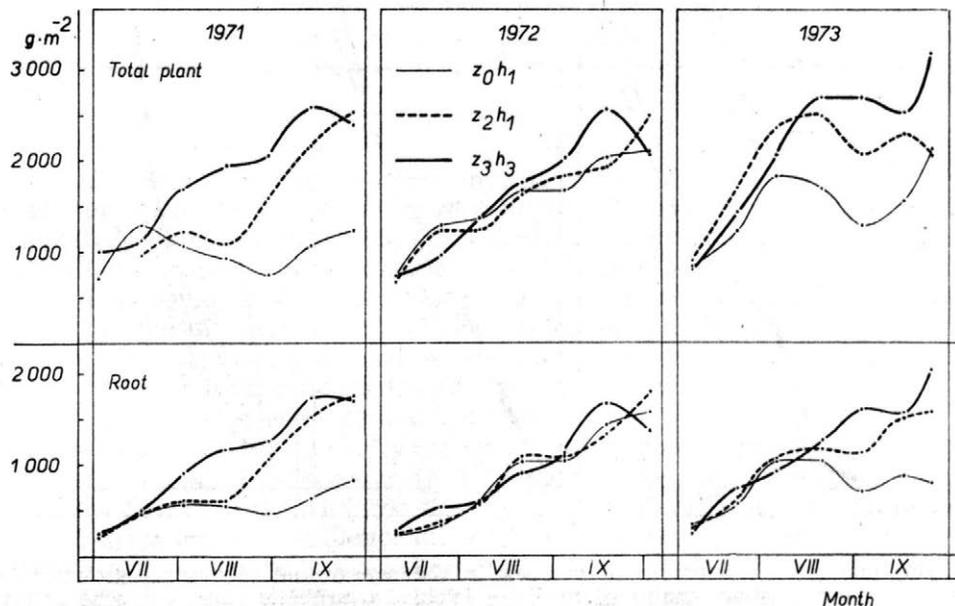
The course of changes in the total dry-matter of the sugar beet phytomass (graph 3) was considerably affected by irrigation (except for the year 1972) even since the beginning of August. Since this period, the increase of W<sub>p</sub> values in non-irrigated sugar beet was already slower and irregular. A similar tendency may be followed also in the course of root-phytomass production (W<sub>r</sub>). Maximum values of dry-matter in leaf-phytomass amounted, in the average of experimental years, to 763 g.m<sup>-2</sup> in the non-irrigated variant; the maximum W<sub>1</sub> values in irrigated variants z<sub>2</sub>h<sub>2</sub> and z<sub>3</sub>h<sub>3</sub> were by 12% and 36% higher, respectively. Besides irrigation, also fertilizing with nitrogen proved great influence on increasing W<sub>1</sub> values. The interaction of N-fertilizing with irrigation resulted in the equal level of the phytomass production in the course of the whole vegetation period so that almost no difference took place between maximum W<sub>1</sub> values and those observed at the end of the vegetation. In the average of three experimental years, the W<sub>1</sub> value of non-irrigated variant dropped by 40% as compared with the maximum W<sub>1</sub> values at the end of vegetation period.

In sugar beet under irrigation the daily dry-matter gains amounted to their maximum values of 25–30 g.m<sup>-2</sup>.day<sup>-1</sup> in July. Later on, decrea-

different intervals during growth season ( $\text{g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ ). — Denní přírůstky sušiny  
vegetace ( $\text{g} \cdot \text{m}^{-2} \cdot \text{den}^{-1}$ )

Ears				Total plant			
Variant				Variant			
$Z_0h_1$	$Z_1h_1$	$Z_2h_2$	$Z_3h_3$	$Z_0h_1$	$Z_1h_1$	$Z_2h_2$	$Z_3h_3$
—	—	—	—	3.1	4.0	3.7	4.2
—	—	—	—	10.6	20.5	27.6	28.2
—	—	—	—	17.2	18.5	9.8	14.4
8.2	14.5	13.7	18.4	11.9	4.7	21.0	21.3
—	—	—	—	14.8	18.2	16.5	15.2
—	—	—	—	21.1	22.1	22.1	21.5
—	—	—	—	24.1	14.4	22.1	18.4
14.6	24.9	18.2	23.5	24.9	28.9	22.0	33.1
—	—	—	—	12.3	11.3	21.7	45.5
—	—	—	—	24.8	34.0	28.3	7.2
0.4	16.4	17.9	18.7	2.2	28.2	43.7	38.6
-0.8	17.0	23.5	3.1	-8.5	14.1	5.2	-16.5

### SUGAR BEET

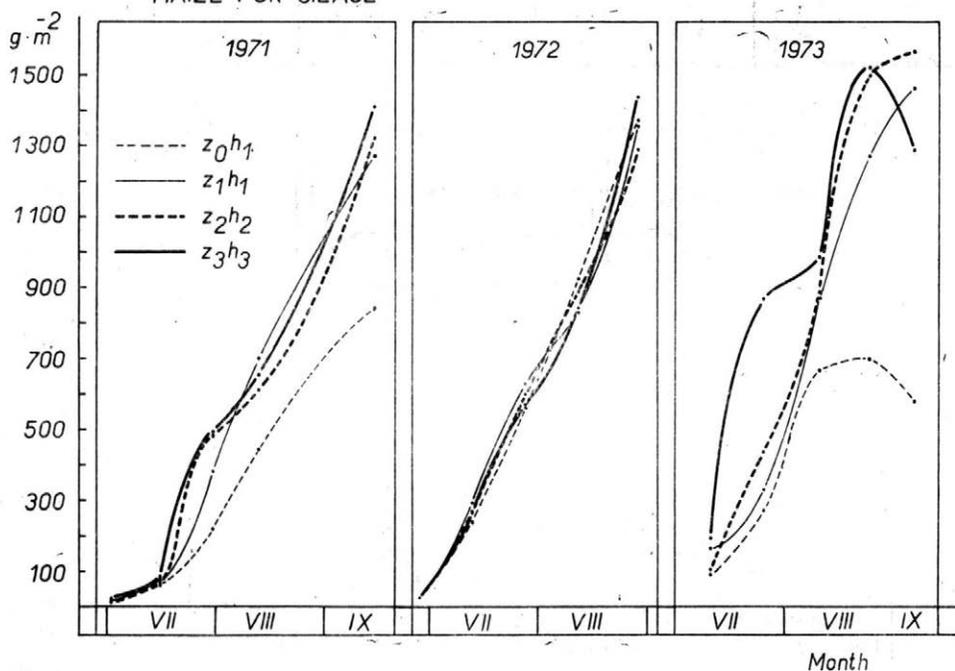


3. The survey on the course of changes in the phytomass growth-rate ( $W$ ) of stand in sugar beet ( $\text{g} \cdot \text{m}^{-2}$ ). — Přehled o průběhu změn v tvorbě sušiny biomasy ( $W$ ) porostu cukrovky ( $\text{g} \cdot \text{m}^{-2}$ )

## VIII. Crop yields. — Hospodářské výnosy plodin

Crop	Variant	Grain, roots, silage matter (t.ha <sup>-1</sup> )				Straw, leaves (t.ha <sup>-1</sup> )			
		1971	1972	1973	1974	1971	1972	1973	1974
Winter wheat	Z <sub>0</sub> h <sub>1</sub>	4.33	7.40	5.30	5.90	7.20	10.00	10.50	8.52
	Z <sub>2</sub> h <sub>2</sub>	5.92	7.20	8.00	6.72	11.02	9.28	14.15	12.70
	Z <sub>3</sub> h <sub>3</sub>	6.56	6.37	5.82	5.88	10.67	15.57	13.77	11.63
Horse bean	Z <sub>0</sub> h <sub>1</sub>	1.81	3.58	2.30	3.62	6.31	6.52	3.42	7.13
	Z <sub>1</sub> h <sub>1</sub>	2.50	4.45	3.80	3.51	7.08	6.03	6.65	7.43
	Z <sub>2</sub> h <sub>2</sub>	2.89	4.25	4.35	2.78	6.95	7.60	7.35	7.63
	Z <sub>3</sub> h <sub>3</sub>	2.97	3.77	3.67	3.17	7.40	5.82	7.18	5.97
Sugar beet	Z <sub>0</sub> h <sub>1</sub>	28.68	58.04	25.74	45.02	16.21	43.17	14.40	32.75
	Z <sub>2</sub> h <sub>1</sub>	34.44	74.95	60.82	60.07	45.40	54.94	54.41	42.24
	Z <sub>3</sub> h <sub>3</sub>	74.05	73.55	68.46	58.85	56.14	68.11	65.39	50.69
Maize for silage	Z <sub>0</sub> h <sub>1</sub>	35.27	63.90	21.42	40.80	—	—	—	—
	Z <sub>1</sub> h <sub>1</sub>	62.75	64.82	60.55	44.68	—	—	—	—
	Z <sub>2</sub> h <sub>2</sub>	68.30	69.43	59.53	42.58	—	—	—	—
	Z <sub>3</sub> h <sub>3</sub>	70.72	77.15	68.45	40.37	—	—	—	—

## MAIZE FOR SILAGE



4. The survey on the course of changes in the overground phytomass growth-rate ( $W_p$ ) of stand in silage maize ( $g \cdot m^{-2}$ ). — Přehled o průběhu změn v tvorbě sušiny nadzemní biomasy ( $W_p$ ) porostu silážní kukuřice ( $g \cdot m^{-2}$ )

IX. Dry matter yields (W) and primary productivity during the whole vegetation period (C) — Výnosy sušiny biomasy ( $W_p$ ) a průměrné denní přírůstky celého vegetačního období u sledovaných plodin (C)

Crop	Variant	$W_p$ (t . ha <sup>-1</sup> )					C (g . m <sup>-2</sup> . day <sup>-1</sup> )				
		1971	1972	1973	1974	∅	1971	1972	1973	1974	∅
Winter wheat	Z <sub>0</sub> h <sub>1</sub>	9.86	14.90	13.55	12.38	12.70	7.4	10.7	9.9	10.1	9.5
	Z <sub>2</sub> h <sub>2</sub>	14.49	14.12	18.94	15.90	15.86	10.9	10.2	13.8	12.9	11.9
	Z <sub>3</sub> h <sub>3</sub>	14.74	18.06	16.73	14.97	16.13	11.1	13.1	12.2	12.2	12.1
	max*)	15.35	18.74	20.75	17.94	18.20	11.5	13.5	15.1	14.6	13.7
Horse bean	Z <sub>0</sub> h <sub>1</sub>	6.95	8.68	4.92	9.24	7.45	5.7	7.4	3.9	6.6	5.9
	Z <sub>1</sub> h <sub>1</sub>	8.21	9.03	8.99	9.40	8.91	6.7	7.7	7.1	6.7	7.1
	Z <sub>2</sub> h <sub>2</sub>	8.45	10.19	10.07	8.92	9.41	6.9	8.7	7.9	6.4	7.5
	Z <sub>3</sub> h <sub>3</sub>	8.89	8.26	9.32	7.85	8.58	7.2	7.1	7.3	5.6	6.8
	max	8.89	10.49	10.07	9.40	9.71	7.2	9.0	7.9	6.7	7.7
Sugar beet	Z <sub>0</sub> h <sub>1</sub>	10.33	22.62	9.25	17.42	14.90	6.1	13.3	5.3	10.2	8.9
	Z <sub>2</sub> h <sub>1</sub>	24.63	25.25	25.97	25.14	25.25	14.6	14.8	16.3	14.8	15.1
	Z <sub>3</sub> h <sub>3</sub>	29.03	30.88	29.07	24.07	28.26	17.3	18.2	18.3	14.2	17.0
	max	29.45	30.88	29.07	27.39	29.20	17.4	18.2	18.3	16.1	17.5
Maize for silage	Z <sub>0</sub> h <sub>1</sub>	8.96	16.23	5.44	10.36	10.22	8.9	16.1	5.2	9.8	10.0
	Z <sub>1</sub> h <sub>1</sub>	15.94	16.46	15.38	11.35	14.78	15.9	16.3	14.8	10.7	14.4
	Z <sub>2</sub> h <sub>2</sub>	17.34	17.71	15.12	10.82	15.25	17.3	17.5	14.5	10.2	14.9
	Z <sub>3</sub> h <sub>3</sub>	17.96	19.60	17.39	10.25	16.30	18.0	19.4	16.7	9.7	15.9
	max	18.33	19.60	17.39	11.90	16.80	18.3	19.4	16.7	11.2	16.4

\*) Maximum yield from the whole experiment.

ses in C values of leaves, namely in a non-irrigated variant, took place. Maximum gains in dry-matter of root phytomass in non-irrigated variants fluctuated about 30 g.m<sup>-2</sup>.day<sup>-1</sup>, namely at the beginning of August. Maximum C values under irrigation were about 35–40 g.m<sup>-2</sup>.day<sup>-1</sup> being attained, as usual, at the end of August and at the beginning of September. Regarding the different course of the phytomass production in the leaves or roots, sugar beet produced maximum gains in the total phytomass 45 g.m<sup>-2</sup>.day<sup>-1</sup> in the non-irrigated variant z<sub>0</sub>h<sub>1</sub> while in variants under irrigation the gains were 40–50 g.m<sup>-2</sup>.day<sup>-1</sup>.

Production of the total dry-matter in overground phytomass in silage maize (graph 4) was apparently affected by irrigation (except for the humid vegetation period of the year 1972); increasing rates of N, however, did not exert any influence on the  $W_p$  production. Variants under irrigation exhibited namely a quicker dry-matter growth-rate of leaves.

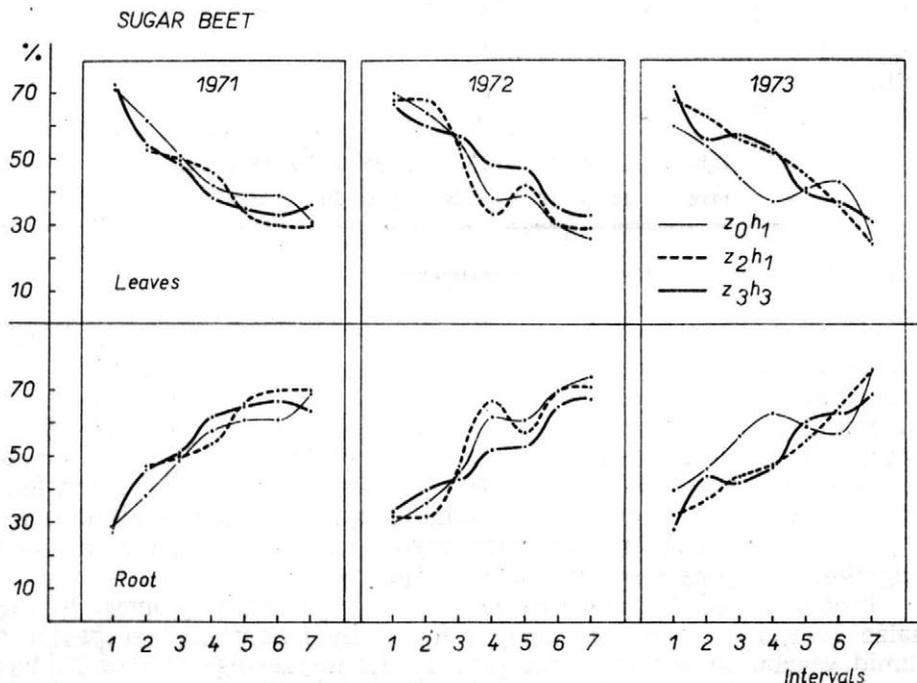
Average daily dry-matter gains of silage maize fluctuated in the range of 10–25 g.m<sup>-2</sup>.day<sup>-1</sup> in non-irrigated variants; they were mostly pronounced in the period between mid-July and the harvest. Values of daily dry-matter gains in the phytomass of irrigated maize were rather

balanced, their value fluctuating from 20–35 g.m<sup>-2</sup>.day<sup>-1</sup> since mid-July. Maximum C values achieved even 45 g.m<sup>-2</sup>.day<sup>-1</sup> in some years.

Maximum daily gains in dry-matter of the phytomass in investigated crops and terms of growth under conditions without irrigation respond in general to findings by Hruška (1975), Vrkoč (1973) and other authors. The maximum values of C in sugar beet, winter wheat and in some years also in maize under irrigation, surpass the value of 41 g.m<sup>-2</sup>.day<sup>-1</sup> which is mentioned by de Wit (1959) as the upper limit for field crops. High daily gains in dry-matter that were obtained in irrigated wheat as well as sugar beet seem to be in connection with a high density of the stand which is always higher under irrigation than without it. This fact has also been emphasized by Repka and Kostrej (1970) who gave evidence that in stands of higher plant density also the maximum values of C were higher.

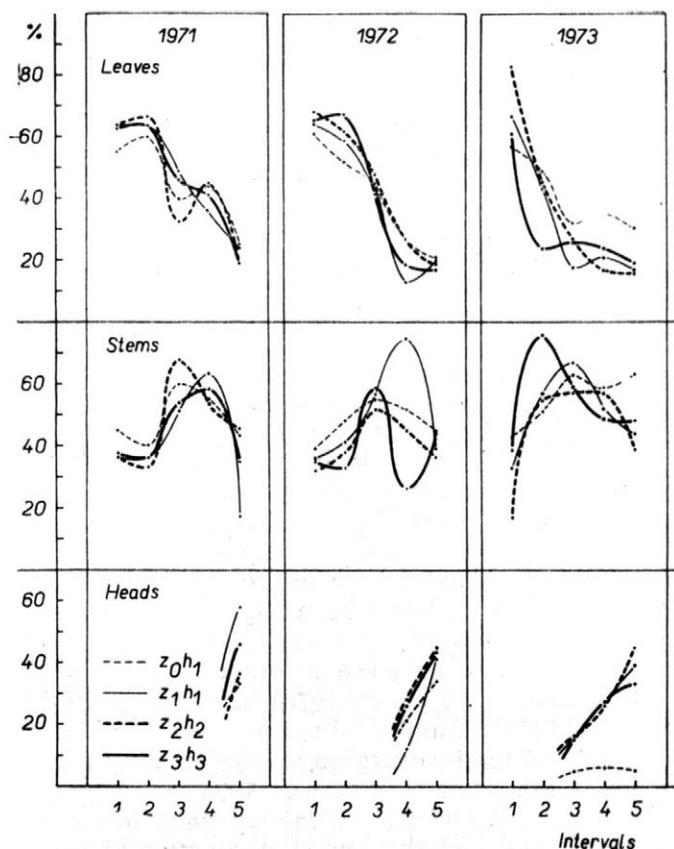
Dry-matter distribution into individual organs of winter wheat was markedly influenced neither by irrigation nor by increasing rates of N. More distinct differences in dry-matter distribution were observed only in sugar beet and silage maize (see graph 5, 6).

As it is apparent from our experiments (Table IX), dry-matter yields per ha under irrigation fluctuated in winter wheat from 14.5 up to 20.7 t.ha<sup>-1</sup> the average of four years being 16–18 t.ha<sup>-1</sup>, while the non-irrigated variant produced by 26–40 % lower amounts (i. e. by 3.3–5.5 t.ha<sup>-1</sup>). In horse bean, yield of dry-matter in the overground phytomass



5. The distribution of dry-matter of the total phytomass into individual organs in sugar beet. — Distribuce sušiny celkové biomasy do jednotlivých orgánů u cukrovky

## MAIZE FOR SILAGE



6. The distribution of dry-matter of the total phytomass into individual organs in silage maize. — Distribuce sušiny celkové biomasy do jednotlivých orgánů u silážní kukuřice

was 5–9 t.ha<sup>-1</sup> under irrigation while 8.2–10.5 t.ha<sup>-1</sup> without it. In the average of four years irrigation resulted in increased dry-matter yields by 20–30 %. As compared with non-irrigated winter wheat the average dry-matter yield of the most productive variant of irrigated horse bean was by 13 % lower. Comparison of W values of irrigated winter wheat and horse bean demonstrated wheat to be by 73 % more productive than horse bean. The highest amounts of dry-matter in the phytomass were produced by sugar beet. In non-irrigated variants the W values achieved 10–20 t.ha<sup>-1</sup> while under irrigation 25–30 t.ha<sup>-1</sup>, the average maximum yield being 29.2 t.ha<sup>-1</sup>. Non-irrigated sugar beet produced on an average higher yields of dry-matter than horse bean did, namely by 5.2 t.ha<sup>-1</sup>, i. e. by 15 %; as compared with the maximum W values in irrigated wheat, this yield was by 3.3 t.ha<sup>-1</sup> (18 %) lower. Yields of dry-matter in overground phytomass of silage maize, grown as subsequent crop after non-irrigated rye, were 10.2 t.ha<sup>-1</sup> in the average of years. The maximum W values in silage maize under irrigation amounted to 16.8 t.ha<sup>-1</sup>; this

means that, as a result of irrigation, the W values were increased by 65 %. Concerning dry-matter production in the overground phytomass, silage maize surpassed not only the yields of horse bean but even those of winter wheat.

The lowest average daily gains (up to  $8 \text{ g.m}^{-2}.\text{day}^{-1}$ ) in the course of the whole vegetation period (see Tab. IX) were found in horse bean. The values of C in irrigated sugar beet and silage maize were almost balanced during the vegetation, fluctuating about  $14-19 \text{ g.m}^{-2}.\text{day}^{-1}$ . Daily gains in irrigated winter wheat that provided maximum yields of dry-matter amounted to the values of about  $13-15 \text{ g.m}^{-2}.\text{day}^{-1}$ , too.

Yields of dry-matter as well as obtained average daily gains in examined crops in the course of vegetation period seem to indicate that, on light soils, irrigation results in increased productivity of wheat, horse bean, sugar beet and silage maize by 24, 17, 70, and 45 %, respectively. As compared with the variant  $z_1h_1$ , the interaction of N fertilizing with irrigation (maximum yields in  $z \times h$ ) made it possible to achieve following increases in dry-matter yields: 15 %, 8 %, 15 %, and 13 % in winter wheat, horse bean, sugar beet and silage maize, respectively. As compared with the maximum yields of dry-matter per ha produced by sugar beet (100 %), the maximum yields of W in other crops were as follows: winter wheat 62.5 %, horse bean 33.2 %, and silage maize 57.5 %.

Dry-matter yields produced by sugar beet on light soils under irrigation surpassed even those achieved at other localities with fertile soils in Bohemia ( $17.1 \text{ t.ha}^{-1}$ , Vrkoč 1974) as well as in Moravia ( $23.1 \text{ t.ha}^{-1}$ , Hruška 1973). Similar situation was also in winter wheat whose yields of dry-matter in overground phytomass on brown-grey podzolic soil at Ruzyně ( $11.2 \text{ t.ha}^{-1}$ , Vrkoč 1974) were by 30% lower and in Moravia ( $12 \text{ t.ha}^{-1}$ , Hruška 1975) by 24% lower than at Tišice. Though horse bean produced the lowest dry-matter yields in the phytomass throughout the experiments, it was still by 31% more productive than for instance at Lukavec ( $6.17 \text{ t.ha}^{-1}$ , Černý 1975).

The average daily gains in dry-matter of the phytomass achieved by non-irrigated sugar beet on light soils during the vegetation period were lower than those at localities Ruzyně and Lukavec. The average values of C in horse bean at Tišice were consistent to those at mentioned localities while C values in wheat at Tišice were by about  $2.5-3 \text{ g.m}^{-2}.\text{day}^{-1}$  (Černý 1975) higher as compared with Čáslav and Ruzyně localities. The average daily gains in dry-matter of the phytomass that had been got in irrigated wheat and horse bean during the vegetation period were twice greater than at mentioned localities. Though the soils at Tišice are light, the C values in irrigated sugar beet during the vegetation period were there by 50-100 % higher than on chernozem and brown-grey podzolic soils.

Our experiments thus confirmed that, providing the irrigation is employed, the productivity of examined crops on light soils could be very high, namely in sugar beet and winter wheat. From results it was also deduced that it was possible not only to equalize the intensity of crop production under mentioned conditions to the intensity of areas with higher soil fertility but even to surpass it.

## References

CERNÝ, V.: (Dry Matter Productivity of Field Crops at Some Localities in Bohemia.) Rostlinná výroba, 21, 1975, No. 8, p. 000-000.

HRUŠKA, L.: Výzkum produktivity hlavních polních plodin v podmínkách jižní Moravy. [Závěrečná zpráva.] VŠZ Brno, 1973, 59 s.

HRUŠKA, L.: (Productivity of Main Field Crops in Southern Moravia.) Rostlinná výroba 21, 1975, No. 8, p. 809-816.

REPKA, J. — KOSTREJ, A.: (An Analysis of the Production Process of Cultivated Plants in the Conditions of Southern Slovakia. II Manuring and Various Leaf Area Index Rates in relation to the Production of Dry Matter.) Poľnohospodárstvo, 16 1970, No. 10, p. 830-841.

VRKOC, F.: (Some Growth Characteristics of the Main Crops Grown in Central Bohemia.) Rostlinná výroba 19, 1973, No. 8, p. 787-796.

VRKOC, F.: (The Growth Dynamics and Productivity of Some Field Crops in the Beet — Growing Region.) Rostlinná výroba 20, 1974, No. 4, p. 325-333.

WIT, C. T. de.: Potential photosynthesis of crop surfaces. Neth. J. Agric. Sci., 1959, č. 7, s. 141-149.

8. 4. 1975

SIMON J. (Výzkumné ústavy rostlinné výroby, Praha-Ruzyně). *Produkce biomasy některých polních plodin při závlaze na lehké půdě*. Rostlinná výroba (Praha) 21 (8) : 845-860, 1975.

V letech 1971-1974 se ve VÚRV Praze-Ruzyni na pracovišti v Tišicích sledovala na lehkých půdách produkce biomasy pšenice ozimé, bobu obecného, cukrovky a silážní kukuřice při různých variantách závlahy (z) a hnojení dusíkem (h) ve srovnání s variantou bez závlahy. Během vegetace se v časových intervalech hodnotil průběh základních růstových charakteristik metodou analýzy růstu (tvorba sušiny nadzemní biomasy  $W_p$ , distribuce celkové sušiny, denní přírůstek sušiny jednotlivých orgánů rostlin). Výnos sušiny zavlažované cukrovky činil v průměru 4 let 29,2 t. ha<sup>-2</sup> s průměrným denním přírůstkem za celé vegetační období (C) 14-19 g. m<sup>-2</sup>. den<sup>-1</sup>, pšenice ozimé 14-18 t. ha<sup>-1</sup> s hodnotou C 13-15 g. m<sup>-2</sup>. den<sup>-1</sup>, silážní kukuřice 16.8 t. ha<sup>-1</sup> s hodnotou C 14-16 g. m<sup>-2</sup>. den<sup>-1</sup> a u bobu obecného 8,2-10,5 t. ha<sup>-1</sup> s hodnotou C do 8 g. m<sup>-2</sup>. den<sup>-1</sup>. Uplatněním závlahy na lehkých půdách se zvýšila produktivita pšenice o 24 %, bobu o 17 %, cukrovky o 70 % a silážní kukuřice o 45 % v porovnání s variantou bez závlahy.

závlaha; hnojení N; růstová analýza; pšenice ozimá; bobu obecný; cukrovka; kukuřice na siláž

ШИМОН Й. (Научно-исследовательские институты растениеводства, Прага-Рузыне). *Производство биомассы некоторых полевых культур в условиях орошения легких почв*. Rostlinná výroba (Praha) 21 (8) : 846-860, 1975.

В 1971-74 гг. в НИИР в Праге 6-Рузыне в объекте Тишице на легкой почве изучали продукцию биомассы оз. пшеницы, боба конского, сах. свеклы и кукурузы на силос в разных вариантах орошения (z) и азотного удобрения (h) и сравнивали с вариантом без орошения. В течение вегетации в определенные интервалы обобщали ход основных характеристик роста с помощью метода анализа роста (образование сухого вещества в надземной биомассе  $W_p$ , его общее распределение и суточные приросты в отдельных органах растений). В среднем по 4 годам продукция сухого вещества орошаемой сах. свеклы составляла в среднем 29,2 т. га<sup>-2</sup> со среднесуточным приростом за весь вегетационный период (C) 14-

-19 г. м<sup>-2</sup>. день<sup>-1</sup>, у оз. пшеницы 14-18 т. га<sup>-1</sup> с величиной С = 13-15 г. м<sup>-2</sup>. день<sup>-1</sup>, у кукурузы на силос 16,8 т. га<sup>-1</sup> с величиной С 14-16 г. м<sup>-2</sup>. день<sup>-1</sup> и у боба 8,2-10,5 т. га<sup>-1</sup> с величиной С до 8 г. м<sup>-2</sup>. день<sup>-1</sup>. Благодаря орошению легких почв продуктивность пшеницы возросла на 24 %, боба на 17 %, сах. свеклы на 70 %, кукурузы на силос на 45 % по сравнению с вариантами без орошения.

орошение; азотное удобрение; анализ роста; озимая пшеница; боб конский; сахарная свекла; кукуруза на силос

---

**Adresa autora:**

Ing. Josef Šimon, CSc., Výzkumné ústavy rostlinné výroby, 161 06 Praha-Ruzyně

---

# PHYSIOLOGICAL CHARACTERISTICS AND VARIETAL GROWING TECHNOLOGY OF HIGH YIELDING SPRING BARLEY AND WINTER WHEAT VARIETIES

M. KOPECKY, L. NATR, J. PEŠÍK, M. ZEMÁNEK, L. ZENIŠČEVA

KOPECKY M., NATR L., PEŠÍK J., ZEMÁNEK M., ZENIŠČEVA L. (Cereal Research Institute, Kroměříž). *Physiological Characteristics and Varietal Growing Technology of High Yielding Spring Barley and Winter Wheat Varieties*. Rostlinná výroba (Praha) 21 (8) : 861-873, 1975.

A survey is given on the research carried out in the scope of the International Biological Programme. The most important factors affecting the remarkable increase in grain yield in Czechoslovakia are represented by new high yielding varieties, higher fertilizer doses and chemical substances controlling pests, weeds and diseases, and by the realization of the complex varietal growing technology. The principles of physiological characteristics of individual varieties are described as well as their utilization in the determination of growing technology. Changes are discussed that characterize the breeding during the last century.

yield formation; physiological characteristics of varieties; growing technology; winter wheat; spring barley; breeding

The total cereal production and the average ha-yields have been showing an increasing trend in this country in recent years. For instance, cereal grain yields in the whole ČSSR were in the years 1972, 1973 and 1974 31.0; 34.8 and 38.2 q/ha, respectively. In the Western Slovakia region in 1974 the yield amounted to 51.9 q/ha and the yields gained in some agricultural enterprises are as high as about 70 q/ha.

The increased ha-yields in recent years were mainly due to the three factors, as follows:

1. Growing of new high yielding spring barley and winter wheat varieties.
2. Increased doses of mineral fertilizers and of substances for chemical protection against weeds, diseases and pests.
3. Complex system using varietal growing technology.

It is obvious that the above mentioned factors with their effects cannot be separated from each other. Effect of each of the factors depends on the other ones. But in the paper we should like to deal mainly with the third factor, i. e. varietal technology of growing because of the following reasons:

a) It is a new approach to agronomical practices based on considering the biological varietal peculiarities and forming a complex of all cultural practices in order to use yielding ability of individual varieties to the greatest extent. The cultural practices are aimed at establishing sufficient stand density having a great number of large caryopses per area unit. From that view significance of individual plant organs and possibility of their accurate regulation for getting high yields are considered.

b) Just the mentioned field of scientific work of our institute was integrated into the International Biological Programme in order to use

knowledge from abroad in the study of physiological characteristics and theory of crop yield formation. Simultaneously we are of the opinion that some parts of our own results can be used also in other institutions in the sense of one of the goals of IBP.

Therefore, we are presenting in the work the review of partial results which are essential for the complex varietal growing technology of spring barley and winter wheat.

## MATERIAL AND METHODS

The experiments were carried out on experimental fields of the institute. The soil-climatological characteristics are as follows:

Production type: sugar-beet growing

Altitude: 202 m

Soil type: degraded chernozem

Soil: loamy

Saturation of the colloidal complex:  $V = 85.6\%$

Sorption capacity – middle T = 20 mval.

Average temperature during the year: 8.6 °C

Average temperature during October-March: 2.2 °C and April-September: 15.1 °C

Average rainfall during year: 599 mm

Average rainfall during October-March: 210 mm and April-September: 389 mm.

For the detailed methods of individual experiments and individual partial results see publications as follows: K o p e c k ý 1973, P e š í k 1970, L e k e š et al. 1973.

## RESULTS

### Spring barley

Spring barley varieties of the Czechoslovak collection can be divided essentially into groups as follows:

1. Varieties having middle long stem and lower lodging resistance and lower ability of using higher doses of nutrients ('Dvoran', 'Denár', 'Topas', 'Dukát'). The decisive yielding component in varieties of that type is ear productivity. They respond very susceptibly to the direct nitrogen fertilization and to the higher rate of nitrogen release from the soil during the stem elongation.

2. Short-stemmed varieties, having high productivity and higher lodging resistance ('Ametyst', 'Favorit', 'Hana' and 'Diamant'). They are superior to the varieties of the first group in having more effective ability of using nitrogen for grain yield formation. The decisive yielding component in varieties of that type is the ear number per area unit. Cultural practices aiming at formation of productive tillers are favourable for yield formation (Tab. I).

A special group of varieties, valuable for further intensification of production is represented by the so called nitrogenous barley types. The first line of barley ('KM 1192'), bred at the institute at Kroměříž differs from the contemporary short-stemmed varieties in having higher produc-

I. Influence of nitrogen fertilization on grain yield in long- and short-stawed varieties. (Kroměříž 1971–1973). — Vliv hnojení dusíkem na výnos zrna u dlouhostébelných a krátkostébelných odrůd (Kroměříž 1971–1973)

Doses of N kg/ha of pure nutrients	Grain yield q/ha			Ear number/m <sup>2</sup>		
	Dvoran	Ametyst	KM 1192	Dvoran	Ametyst	KM 1192
—	61.2	68.8	73.4	747	789	855
30	61.5	70.4	75.5	799	879	918
60	62.5	71.2	79.3	841	922	960

*P* 0.05–2.0

*P* 0.01–2.9

43

57

tivity, higher nutrient uptake and their using in yield formation, maximum dry matter production from area unit, narrower ratio grain: straw, prolonged period of photosynthetical activity, disease resistance and higher stem stiffness. The decisive yielding component in addition to the ear number per area is 1,000 kernel weight. It was proved in experiments, carried out at Kroměříž, that in the average of 1971–1973 'KM 1192' used at the dose of 60 kg/ha of p. n. by 60 % more N in comparison to Ametyst. On soils, having lower soil fertility in conditions of higher rainfall 'KM 1192' used still the dose of 120 kg N, while the same dose caused highly significant yield depression in Ametyst variety.

Concerning the long-stawed varieties, placed in rotation after manured root crop, or maize, it is more convenient to use nitrogen for forecrops on soils having high supply of nutrients. In the short-stawed varieties it is better to use nitrogen fertilization directly. Based on our knowledge the best nitrogen using takes place in the 2nd growing phase by Feekes (beginning of tillering), especially in the more humid regions (tab. II.).

II. Influence of nitrogen application on grain yield. — Vliv aplikace dusíku na výnos zrna

Date of N-application	Grain yield q/ha	Increment
before sowing	42.2	—
after sowing	43.2	1.0
at the beginning of stem elongation	45.5	3.3

*P* 0.05–1.2

*P* 0.01–2.0

In regions having less rainfall, where soil nutrients are less movable and available, it is better to use nitrogen as pre-sowing application or to use urea spraying in the 2nd growing phase by Feekes. Using higher nitrogen doses (over 30 kg) it is better to divide it for applying before sowing and at the beginning of tillering.

Potassium and phosphorus doses are differentiated in accordance with forecrops and ecological conditions. The most favourable using of those nutrients is ensured by ploughing in of commercial fertilizers simultaneously with the manure as supplying fertilization. Based on our results the short-stawed varieties need in spite of supplying fertilization the starting dose of phosphorus and potassium fertilizers.

A very important factor for yield formation and barley quality is the forecrop. The best forecrops for spring barley are the manured root crops and maize. In a higher proportion of cereals in the rotation it is not possible to avoid barley growing after cereal crop. Results from our experiments showed that the present spring barley varieties are less susceptible to growing them in the rotation after cereals in comparison to the present wheat varieties. Spring barley is more resistant to diseases, attacking stem bases which are the main cause of yield depressions in extending cereal acreages. There were proved marked differences in varietal reaction to forecrops (tab. III).

III. Response of spring barley varieties to forecrop (Kroměříž 1971—1973). — Odrůdová reakce jarního ječmene na předplodinu (Kroměříž 1971—1973)

Varieties	Grain yield q/ha		Difference
	after root crop	after cereal crop	
Long-stawed var. (Topas, Dukát, Dvoran)	64.5	57.9	— 6.6
Ametyst	68.9	63.1	— 5.8
Diamant	66.1	53.7	—12.4
KM 1192	74.6	71.7	— 2.9

$P 0.05-2.4$

$P 0.01-3.3$

The short-stawed varieties are more susceptible to growing them after cereal crops than long-stawed ones. Of the short-stawed varieties the most sensitive variety concerning less convenient forecrop is Diamant, the least sensitive is Ametyst. KM 1192 also shows less sensitivity. Favorit-variety is in this respect similar to Diamant.

Spring barley sensitivity to a forecrop is increasing with lower soil fertility. Higher doses of fertilizers, in the first place of nitrogen ones, are able to soften the adverse effect of the less convenient forecrop, but in the varieties only, which are able to use higher nitrogen doses (tab. IV.).

In experiments dealing with spring barley growing in monoculture it was shown that the compensation for the negative monoculture effect was most effective with co-operation of higher nitrogen doses and manuring (green manuring, straw). So it was possible to eliminate fully the negative effect of 5-year cereal monoculture, alternating barley and winter wheat (tab. V).

IV. Interaction effect between nitrogen and forecrop on grain yield. (Kroměříž 1971–1973). — Vliv interakce dusíku a předplodiny na výnos zrna (Kroměříž 1971–1973)

N-doses	KM 1192		Ametyst	
	forecrop			
	sugar beet	wheat	sugar beet	wheat
0	73.4	67.9	65.6	60.6
20	75.5	72.6	69.0	63.4
60	79.3	73.8	68.9	66.1

$P 0.05-3.0$

$P 0.01-4.6$

Deeper soil cultivation ensures higher yielding stability in all varieties grown after cereal crop. Shallow loosening makes the effect of less convenient forecrop still more pronounced. Fast acting decomposition of post-harvest remains including growth inhibiting substances in deeper cultivated soil would be one of the essential factors ensuring yielding stability of barley, grown after cereal crop. The less convenient cultural practices in the short-strawed varieties grown after cereal crop are also the heavy soil compaction with the heavy roller after sowing.

V. Influence of organic manuring and N-doses on yield of short-strawed spring barley varieties: Diamant, Ametyst (Kroměříž 1970–1974). — Vliv organického hnojení a dávek N na výnos krátkostébelných odrůd jarního ječmene odrůd Diamant a Ametyst (Kroměříž 1970–1974)

Rotation	Org. manuring	N-dose kg/ha pure nut.	Yield q/ha
Sugar beet — barley Monoculture	—	30	63.9
Wheat — barley	green manuring	60	62.1

$P 0.05-3.5$

$P 0.01-4.7$

Cultural practices of the recent high yielding varieties cannot be confined to only above mentioned „traditional“ measurements. Along with yield growing it is justified to expect using of further scientific knowledge, too. Great deal of attention is paid to the influence of active growth substances on development and productivity of cereals. It is justified to suppose that solving of these problems would indicate one of the ways of regulating grain yield formation.

In our experiments dealing with spring barley influences of succinic acid, Ethrel, Atonik, Metalik, BAS 0660 W preparation, indolyl acetic acid, gibberellic acid, kinetine etc. on forming grain yield in different conditions of supplying water and nitrogen were investigated.

Concerning the practical application of results the most elaborated is the question of semi-dry seed treating with succinic acid; especially in the arid conditions of maize growing production type positive results were gained in the exact field experiments (tab. VI).

From the above results it follows that active substances from biological point of view may have essential role in plant production concerning both intensification and stabilization of the achieved cereal yields in the less favourable growing conditions.

VI. Influence of increasing doses of succinic acid and increasing nitrogen doses on grain yields of 'Ametyst' and 'Elgina' varieties in a maize growing region (co-operative Dolní Bojanovice) in 1973 and 1974. — Vliv stupňovaných dávek kyseliny jantarové při stupňovaných dávkách dusíku na výnos zrna odrůd 'Ametyst' a 'Elgina' v kuřičném výrobním typu (JZD Dolní Bojanovice) v r. 1973 a 1974

Year	Variety	Nitrogen dose kg/ha	Doses of succinic acid in g/l q of seed				
			0 (control)	4	6	10	
			grain weight q/ha				
1973	Ametyst	0	53.60	56.90	51.80	57.40	
		55	50.20	62.20**	61.00**	62.80**	
		80	50.40	59.90**	57.80**	61.30**	
		average	51.40	59.67**	56.87*	60.50**	
	Elgina	0	58.80	56.60	61.80	53.30*	
		55	55.20	52.50	60.40*	65.20**	
		80	51.00	59.40**	56.40*	65.00**	
		average	55.00	56.17	59.60	61.17*	
	1974	Ametyst	0	66.54	71.54**	69.38*	70.00**
			55	63.33	67.46**	66.54*	69.26**
80			62.00	64.35	63.67	66.82**	
average			63.96	67.78**	66.53	68.66**	
Elgina		0	64.08	64.86	62.28*	71.16**	
		55	66.05	63.91*	64.32*	63.34*	
		80	65.59	64.58	62.64*	66.62	
		average	65.24	64.45	63.08	67.04	

1973  $P_{0.01} = 6.68$  (characterized by\*\*)

$P_{0.05} = 5.01$  (characterized by\*)

1974  $P_{0.01} = 3.51$

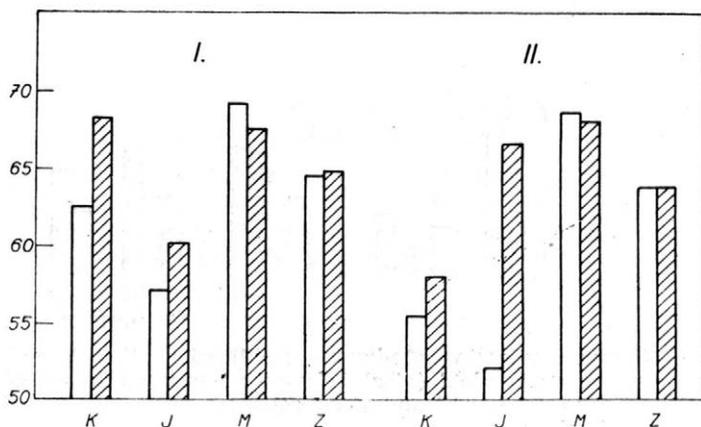
$P_{0.05} = 2.63$

## Winter wheat

Sowing of individual varieties is orientated from the point of view of the convenient forecrop, sowing date, sowing rate and fertilizing in order to ensure a high number of well developed and wintered plants.

In spring, individual varieties differ in dry matter formation in individual developmental phases. Therefore in that period the technology of growing is aimed at favourable influencing of yielding components in different agro-ecological conditions and considering the course of meteorological conditions.

Regionalized varieties, especially short-stawed high yielding Soviet ones ('Kavkaz', 'Jubilejnaja') have great ability of using nutrients both from the soil and from the direct application. But after ill wintering it is very difficult for plants to dense stand with the ear bearing tillers. The great number of plants to dense stand with the ear bearing tillers, a great number of plants is essential in the above varieties for yield formation, high yield being predominantly dependent on ear productivity from the main stem. Great number of plants and high yield in 'Kavkaz' and 'Jubilejnaja' varieties are due not only to general soil cultivation, nutrition and sowing date, but mainly to higher seeding rate amounting to 6 mil. viable seeds per ha. Lower seeding rate depresses yield especially in an unfavourable season. The most suitable seeding rate in 'Mironovskaya', 'Zora', 'Oska' and 'Jubilar' varieties amounts to 4.5 mil. viable seeds per ha. Further seeding rate increasing in conditions of appropriate sowing time and nutrition does not increase yield (Fig. 1).



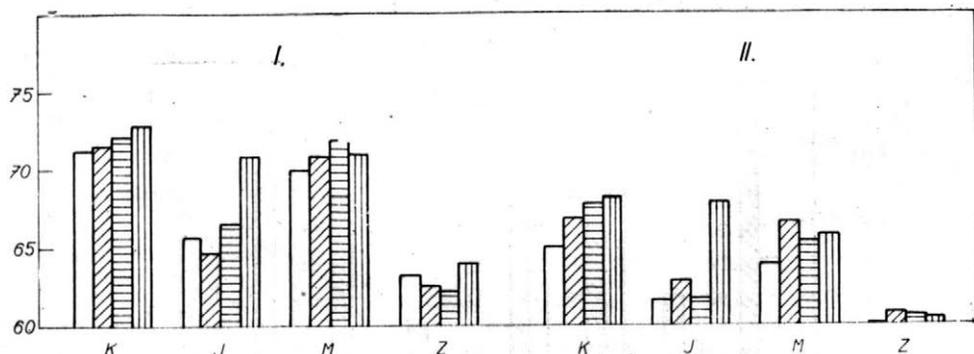
1. Grain yield (q/ha) at seeding rate of 4.5 mil (□) and 6 mil (///) of viable seeds per ha and after clover-like (I) and cereal (II) forecrops in four winter wheat varieties: 'Kavkaz' (K), 'Jubilejnaya' (J), 'Mironovskaya' (M) and 'Zora' (Z). — Výnos zrna (q/ha) při výsevku 4,5 miliónů (□) a 6 miliónů (///) klíčivých zrn na hektar a po předplodině jetelovině (I) a obilnině (II) u čtyř odrůd ozimé pšenice: 'Kavkaz' (K), 'Jubilejná' (J), 'Mironovská' (M) a 'Zora' (Z)

In spite of the fact that the high yielding varieties are able to a great degree to use soil nutrients, the most important of the intensification factors is the proper fertilizer application, especially that of nitrogen. Nitrogen need index for yield formation is represented first of all by the dry matter increase and nutrient intake in individual varieties during vegetation period. Nitrogen is favourable not only for dry matter increase but also for the total nutrient level in plants. The appropriate nitrogen

application is essential for promoting growth of organs, having decisive influence on grain yield. The improper nitrogen application affects increasing of non-productive tillering, changing of stand density and shortening of photosynthetic productivity period.

The 'Mironovskaya' variety in comparison to the other ones shows lower dry matter increase from the time of emergence to tillering. But at the time of full shooting it is reaching the greatest dry matter increments. After satisfactory wintering and in the case of appropriate forecrops the main period of spring nitrogen fertilizing is at the end of tillering. (The 5th phase by Feekes). The variety responds well to nitrogen fertilization when done during tillering time. It is possible to use this feature after worse or in weaker stands due to the worse forecrops. The spring tillers will close the stand and the productivity of those tillers will be good, too.

The short strawed varieties like 'Kavkaz', 'Jubileynaya' and 'Aurora' are characterized by more intensive growth both in autumn and in spring. During tillering and at the beginning of shooting they reach dry matter weight and intake of N P K nutrients in rates which are double



2. Influence of different application of nitrogen fertilization after clover-like (I) and cereal (II) forecrops on grain yield (q/ha) in winter wheat varieties: 'Kavkaz' (K), 'Jubileynaya' (J), 'Mironovskaya' (M) and 'Zora' (Z).

Way of nitrogen application:

- 100 % N before sowing
- /// 50 % N before sowing and 50 % N at the beginning of tillering (2nd-3rd phase by Feekes)
- ≡ 50 % N before sowing and 50 % N at the end of tillering (5th phase by Feekes)
- ≡ 50 % N before sowing, 25 % N at the beginning of tillering (2nd-3rd phase by Feekes) and 25 % N at the end of tillering (5th phase by Feekes).

– Vliv různého způsobu aplikace dusíkatého hnojení po předplodině jetelovině (I) a obilnině (II) na výnos zrna (q/ha) odrůd ozimé pšenice 'Kavkaz' (K), 'Jubilejná' (J), 'Mironovská' (M) a 'Zora' (Z).

Způsob aplikace dusíkatého hnojení:

- 100 % N před setím
- // 50 % N před setím a 50 % na začátku odnožování (2-3 fáze podle Feekese)
- ≡ 50 % N před setím a 50 % N na konci odnožování (5. fáze podle Feekese)
- ≡ 50 % N před setím, 25 % na začátku odnožování (2-3 fáze podle Feekese) a 25 % N na konci odnožování (5. fáze podle Feekese)

as high as those of 'Mironovskaya' variety. Therefore the nitrogen fertilization in spring is useful not only at the beginning of vegetation (2nd - 3rd phase by Feekes) but also at the end of tillering (5th phase by Feekes).

By fair wintering are characterized 'Zora', 'Oska' and 'Jubilar' varieties. The high dry matter increments as early as in autumn are decisive for yield forming. The most important nitrogen fertilization time is, therefore, before sowing. Especially in the case of higher nitrogen dose used before sowing it is not necessary to fertilize fairly wintered stands on fertile soils in spring. On soils, which are not so fertile and after less convenient forecrops it is useful to use a smaller nitrogen dose at the end of tillering (5th phase by Feekes). In not fairly wintered stands it is convenient to use a nitrogen dose in early spring (2nd - 3rd phase by Feekes) in order to promote the productive tillering (Fig. 2).

Due to the enlargement of cereal acreage and to narrowing of rotations in conditions of concentration and specialization it is inevitable to grow cereals after themselves. The most sensitive to such a forecrop is winter wheat. Based on our results it is possible to minimize, eventually compensate for the adverse influence of the forecrop with higher doses of fertilizers and with manuring.

## DISCUSSION

The above mentioned results point out the essentiality of the complex varietal technology of growing and the importance of seeding time and seeding rate and crop rotation and nitrogen fertilization. The varietal technology accentuates the general importance of varietal specificity. Therefore, in our opinion it would be useful to characterize briefly changes brought about in creation of new genotypes of barley and wheat and the main aspects in breeding.

The main goal of breeding is to create highly productive intensive forms resistant to lodging. The intensive type is characterized by high yielding potential with genetic fixation, favourable reaction upon high fertilizer doses, further intensification factor of the recent agriculture and fair adaption to growing conditions.

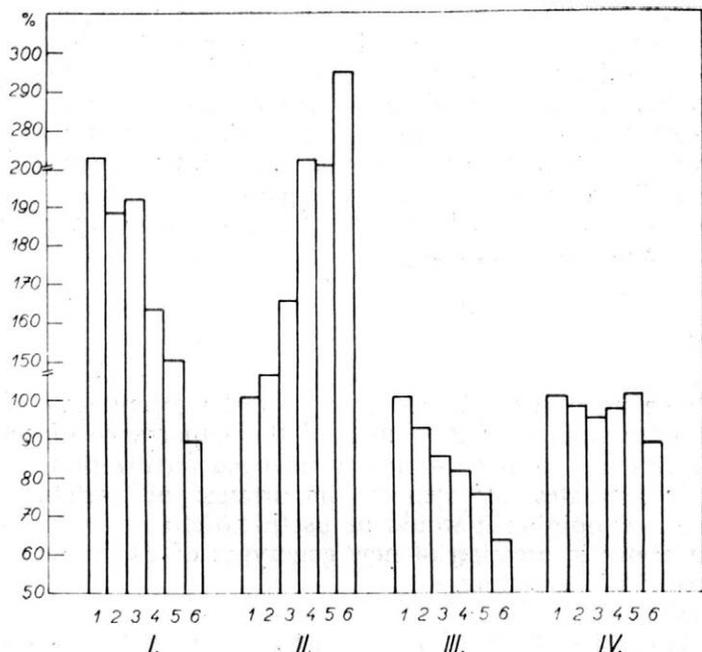
Breeding almost in all cereals is aiming at plant height shortening, the short type (70-80 cm) is enabling the most effective using of the decisive intensification factors, i. e. high nutrient doses and irrigation. At the same time the formation and distribution of the assimilation apparatus, notably of the leaves in short-stawed forms are important for better using of solar radiation in stands. Due to these outstanding characteristics the short stemmed varieties are gaining victory all over the world as stated by Svenson (cit. Jakubciner 1969).

Results of the breeding during the last century in this country are pointing to the fact that in the last decade it was only due to the short-stawed high productive X-rayed mutation named 'Diamant'-variety that it was possible to shorten the plant height almost by 40 % and to change essentially grain/straw ratio (from 1 : 2.20 to 1 : 0.7) in favour of grain. Also the grain yield in q/ha during the above epoch increased as much

as threefold in comparison to the original local varieties and the first bred ones (Fig. 3).

Breeding of varieties of the new type from the viewpoint of their morphology and ecological adaptability which would have high yielding capacity amounting to cca 100 q/ha and fixed in genetic manner necessitates elaboration of model plant (ideotype) for the given growing conditions.

The outstanding breeder of the winter wheat varieties from the Soviet Union, Lukjaněnko, used in elaborating the plant model that of Vavilov from 1935 (high productivity, uniformity of the tillers, high



3. Results of the centenary aimed spring barley breeding in ČSSR. Relative values of straw weight are given in % of grain weight (I), grain yield (II), plant height (III) and stem stiffness (IV) in % of the original local varieties.

- Compared varieties:
1. Original local varieties
  2. 'Proskowetz Hana Pedigree'
  3. Barley from Jarohněvice ('Jarohněvický')
  4. Kneifel - 'Opavský' (from Opava)
  5. 'Valtický' (from Valtice)
  6. 'Diamant'.

Výsledky stoletého cílevědomého šlechtění jarního ječmene v ČSSR. Uvedeny relativní hodnoty váhy slámy v % váhy zrna (I), výnos zrna (II), výšky rostliny (III) a pevnosti stébla (IV) v % původních krajových odrůd.

- Srovnávané odrůdy:
1. Původní krajové odrůdy
  2. 'Proskowetz Hana Pedigree'
  3. 'Jarohněvický'
  4. Kneifl - 'Opavský'
  5. 'Valtický'
  6. 'Diamant'

mass weight and high weight of grain). The original ideotype was enlarged by L u k j a n ě n k o, who included in it essential features of decisive importance for high yielding stability i. e. disease resistance, lodging resistance, winter killing resistance etc. Model of a perspective winter wheat variety valid for the Krasnodar region would be as follows:

1. short and stiff stem (70–80 cm)
2. high ear productivity (kernel weight/ear about 2 g)
3. great number of ear bearing tillers (400–500/m<sup>2</sup>)
4. high grain productivity in % of the total biomass per area unit
5. resistance to fungal diseases, especially to powdery mildew and rusts
6. robust and physiologically active root system
7. well developed assimilating apparatus having high productivity of photosynthesis
8. awned ear.

According to Donald (1968) the decisive influence on plant ideotype forming has requirements as follows:

- economic (yield and quality of grain)
- ecological (variety requirements for temperature, rainfall, solar radiation etc.)
- phytopathological (given by the region of pest and disease harmfulness)
- susceptibility to chemical control (pesticides).

Breeding of short stemmed varieties in the world was done in using starting material of dwarfed and semi-dwarfed forms from Japan and some induced mutations. In wheat the source of short-strawedness was 'Norin 10' on the base of which the first short-strawed variety 'Ordito' in the 20's had been bred. It was the high yielding short-strawed variety 'Bezostaya 1', taking the first rank concerning acreage and yield in the world, which in some degree took part in the pedigree of Ordito. At present it is the most used variety as a genetic source of high productivity and lodging resistance.

Great success in breeding spring barley for short strawedness and productivity is shown by the variety 'Diamant'. Based on that variety the range of perspective varieties like 'Amethyst', 'Favorit', 'Hana', 'Trumpf' were released in this country and in GDR. 'Diamant' variety is being largely used as a genetic source in the most recent breeding programmes in all European countries. The Diamant-like varieties differ highly significantly from the varieties of classical type ('Valtický') in being more lodging resistant, more yielding and in more effective utilization of fertilizers for grain production.

Further stage in spring barley breeding in this country was creating of short-strawed variety of intensive (nitrogenous) type. These new bred varieties are outstanding in their yielding capacity. In the field experiment using slowly acting nitrogen in favourable climatic conditions in 1974, 'KM 1192' yielded more than 100 q of grain per ha. This line is characterized by rapid enlargement of assimilating leaf area and high

photosynthesis rate in early vegetation, long period of active assimilation (outstanding health of plants) and high capacity in intake of mineral nutrients during ontogenesis (Lekeš at al., 1973).

It is obvious that the above demanded features and characteristics of highly yielding varieties can be valuable only in the respective growing conditions. Just the best harmony between „demands“ of individual varieties and the actual conditions, created to a certain degree by individual conditions of nutrition and cultural practices means the decisive condition for gaining high yields. And this is the main goal of the complex varietal technology of cereal growing.

## References

- DONALD, C. M.: The breeding of crop ideotypes. *Euphytica* 17, 1968, p. 385-403.
- JAKUBCINER, M.: Novoje v selekcii i vzdělyvanii pšenicy za rubežom. *Selsk. Choz. za Rubežom, Rast.*, 15, 1969, p. 38-50.
- KOPECKÝ, M.: Some Findings in Variety Cultivation Practices in Malting Barley. In: Breeding and Productivity of Barley. Proceedings of the International Symposium held on June 26-30th 1972 at Kroměříž. Institute of Cereal Crops, Kroměříž 1973, p. 581-598.
- KOPECKÝ, M.: (The Effect of the Preceding Crop on the Yield and Quality of Spring Barley). *Rostlinná výroba*, 19, 1973, p. 953-962.
- KOPECKÝ, M.: (The Varietal Response of Spring Barley to N with Different Forecrops and in Different Cultural Practices). *Rostlinná výroba* 19, 1973, p. 1245-1251.
- LEKES, J. aj.: Pěstujeme obilniny v ČSR. Státní zemědělské nakladatelství Praha, 1973, 269 p.
- LEKES, J. — ZENIŠČEVA, L. — BEZDĚK, V.: Voprosy vysokoj produktivnosti korotkostebeľnych sortov jačmenja. *Rostlinná výroba*, 19, 1973, p. 549-558.
- LUKJANENKO, P.: Selekcija vysokourožajnych nizkostebeľnych sortov ozimoj pšenicy. *Selskochoz. Biol.*, 4, 1969, p. 483-492.
- NÁTR, L.: (Varietal Differences in the Effect of the Deficiency of Mineral Nutrients on the Rate of Photosynthesis and Transpiration). *Rostlinná výroba*, 17, 1971, p. 411-418.
- NÁTR, L.: The effect of plant density on grain yield and photosynthetic characteristics of spring barley varieties. *Rostlinná výroba*, 19, 1973, p. 839-846.
- PEŠÍK, J.: (Effect of the Application of Nitrogen on the Yields of Winter Wheat Varieties of Different Types). *Rostlinná výroba*, 16, 1970, p. 855-859.
- PEŠÍK, J. — BEZDĚK, V.: (The Effect of Seeding Rate on Grain Yield in High-Yielding Winter Wheat Varieties). *Rostlinná výroba*, 20, 1974, p. 951-957.
- PEŠÍK, J. — BEZDĚK, V.: (The Effect of Graded Potassium Rates on Winter Wheat Yield). *Rostlinná výroba*, 20, 1974, p. 959-964.
- ZEMÁNEK, M.: Dry matter production and water relations after application of decenylsuccinic acid on wheat plants. In: Productivity of Terrestrial Ecosystems Production Processes. PT — PP Report No. 1 (1964—1969), Praha 1970, p. 211-213.

8. 4. 1975

KOPECKÝ M., NÁTR L., PEŠÍK J., ZEMÁNEK M., ZENIŠČEVA L. (Výzkumný ústav obilnářský Kroměříž). *Fyziologická charakteristika a odrůdová technologie pěstování vysoce výnosných odrůd jarního ječmene a ozimé pšenice*. *Rostlinná výroba* (Praha) 21 (8) : 861-873, 1975.

Je podán přehled výzkumu prováděného ve VÚOb v rámci Mezinárodního biologického programu. Významný vzestup výnosů zrna v ČSSR byl způsoben hlavně zavedením nových vysoce výnosných odrůd, vyššími dávkami minerálních hnojiv

a chemických látek proti plevelům, chorobám a škůdcům a v neposlední řadě uplatněním komplexní odrůdové technologie pěstování. Jsou popsány základy fyziologické charakteristiky jednotlivých odrůd a její využití při sestavování technologie pěstování. Diskutovány jsou i změny, které charakterizují vývoj šlechtění obilnin v uplynulých 100 letech.

jarní ječmen; ozimá pšenice; fyziologie; ekologie; agrotechnika; odrůdy

КОПЕЦКИЙ М., НАТР Л., ПЕШИК И., ЗЕМАНЕК М., ЗЕНИЦЕВА Л. (Научно-исследовательский институт зернового хозяйства). Физиологическая характеристика и сортовая агротехника высокоурожайных сортов ярового ячменя и озимой пшеницы. Rostlinná výroba (Praha) 21 (8) : 861-873, 1975.

Дается перечень данных об исследованиях, проводимых Научно-исследовательским институтом зернового хозяйства на основе Международной биологической программы. Значительное повышение урожая зерна в ЧССР достигнуто в основном за счет внедрения новых высокоурожайных сортов, использования более высоких норм минеральных удобрений и ядохимикатов в борьбе с сорной растительностью, болезнями и вредителями, а также путем применения комплексной сортовой агротехники. Описываются основы физиологической характеристики отдельных сортов и ее применение для составления технологии их возделывания. Обсуждаются также сдвиги, характерные для развития селекции зерновых культур за последнее столетие.

яровой ячмень; озимая пшеница; физиология; экология; агротехника; сорта

---

*Adresa autorů:*

Ing. Milan Kopecký, CSc., dr. Lubomír Nátr, CSc., Ing. J. Pešík, CSc., ing. M. Zemánek, CSc., ing. L. Zeniševa, CSc., Výzkumný ústav obilnářský, 767 41 Kroměříž

---

**Výběr z nových přírůstků**  
**Ústřední zemědělské a lesnické knihovny ÚVTI**  
**z úseku rostlinné výroby**

Uvedené publikace je možné si zapůjčit osobně nebo písemně v ÚZLK, výpůjční oddělení, 120 56 Praha 2, Slezská 7. Výpůjční doba: pondělí až pátek od 9 do 18 hodin. U každé žádané publikace uveďte signaturu.

E 36.369

Azot v zeměděli nečernozemnoj polosy. Leningrad, Kolos 1973. 329 s. obr. tab. (Dusíkaté hnojení — metody — příručky / Dusík — půda — přetváření — příručky).

D 63.862

Fertilizer nitrogen. Its chemistry and technology. New York, Reinhold publ. Co. 1964. 424 s. obr. tab. (Dusíkatá hnojiva — sborníky — USA).

C 22.993/2

Stevenson, C. K.  
Nitrogen fertilizer materials. Ottawa, Canada Min. of agric. and food 1974. 2 s. 2 tab. Factsheet 2. (Dusíkatá hnojiva — letáky).

D 31.783/377

Frizen, H. W.  
Flüssige Stickstoffdüngung. Bonn, Land- u. hauswirtschaftl. Auswertungsu. Informationsdienst (1974). 23 s. 10 obr. tab. AID 377. (Hnojiva dusíkatá — tekutá — hnojení — mechanizace / Hnojiva tekutá — dusíkatá — skladování).

D 39.343/223

Bengtsson, A.  
Kombinerade sort- och kvävegödslingsförsök med höstvetete. — Grain yield and quality of winter wheat cultivars fertilized with different amounts of nitrogen. Uppsala, Lantbrukshögskolan 1974. 33 s. 14 obr. 16 tab. Lantbrukshögskolans meddelanden nr. 223. (Pšenice ozimá — hnojení dusíkaté — výzkum / Pšenice ozimá — jakost — hnojení dusíkaté — vliv — výzkum — Švédsko).

## PHYTOMASS PRODUCTION IN CEREALS CULTIVATED IN MONOCULTURE

P. STRNAD

STRNAD P. (Institute of Genetics and Breeding, Research Institutes for Plant Production Praha - Ruzyně, Research Station of Plant Production, Čáslav). *Phytomass Production in Cereals Cultivated in Monoculture*. Rostlinná výroba (Praha) 21 (8) : 874-883, 1975.

On illimerized chernozem at Čáslav (sugar-beet growing region) summer barley cv. Diamant was grown in four years lasting monoculture as 9th-12th cereal in crop rotation of cereals only. Its average phytomass production achieved 5.23 t. ha<sup>-1</sup> and 7.92 t. ha<sup>-1</sup> in non-fertilized and intensively fertilized variants, respectively. Dry-matter production in summer barley after sugar beet reached in the average of four years 5.29 t. ha<sup>-1</sup> and 7.73 t. ha<sup>-1</sup> on non-fertilized and properly fertilized plots, respectively. Increase in phytomass production, however, was not explicit, being considerably variable in individual years. As compared with monoculture, summer barley after sugar beet proved more favourable dry-matter differentiation in favour of the main product, while in the monoculture of long-term cereal rotation rather the by-product mostly shared in increased phytomass production. Winter wheat cv. Jubilar, when grown in four years lasting monoculture as 9th-12th cereal in rotation of cereals only, produced 4.86 and 7.51 t. ha<sup>-1</sup> of the phytomass in non-fertilized and intensively fertilized variants, respectively. In a crop rotation after horse bean, phytomass production in non-fertilized winter wheat achieved 7.49 t. ha<sup>-1</sup> while under optimum fertilizing 8.85 t. ha<sup>-1</sup>. Only in some years a considerable reduction was observed in monoculture under intensive fertilizing. Inserting non-fertilized winter wheat after horse bean or cultivating winter wheat in intensively fertilized monoculture resulted in equal phytomass production. As compared with monoculture, the increased phytomass production in winter wheat after horse bean concerned first of all the main product, dry-matter production of the by-product remaining rather unchanged.

summer barley; winter wheat; monoculture; phytomass production

Self-sufficiency in food production has become one of fundamental tasks of present agricultural science the results of which have been already intensively exploited in farming practice. To solve this task it is necessary to approach, in a complex, essential problems of energetic processes. Analysing the production processes in plants has thus proved more and more urgent, because the high phytomass production is to be achieved namely by means of maximum exploiting vegetation factors to ensure optimum transportation of assimilates into agriculturally important parts of plants (Petr 1971, a, b). It is clear that great reserves exist in production potential as to localities and individual crops, which can be influenced in considerable extent by the farmer (Černý 1974). Main reserves consist in optimum complex of external as well as inner factors in given ecosystems; this is, of course, highly dependent on degree of information. Under conditions of the ČSR phytomass production of field crops was evaluated by Hruška (1973) and Křišťan (1973). Production potential of crops in monocultures has been discussed in world

literature rather intensively, mainly from the point of view of crop yield. This paper has been intended to study the total phytomass production in two main cereal crops as winter wheat and summer barley under the conditions of monoculture.

## LOCALITY AND METHODS

In linkage to polyfactorial field experiments established in 1963, monocultures of summer barley (cv. 'Diamant') as well as winter wheat (cv. 'Jubilar') were investigated at Čáslav in the period of 1971–1973. Two variants of monoculture, namely  $f_0$ - non-fertilized and  $f_2$ - with an increased rate of N, were compared with controls represented by usual crop rotations as follows: summer barley after sugar beet and winter wheat after horse bean. Fertilizing variants in both crop rotations are given in Table I.

I. Rates of fertilizing with commercial fertilizers. — Intenzita hnojení průmyslovými hnojivy

Year	Monoculture of cereals (total number of years)	Rates of fertilizers in kg of nutrients per ha		
		N	P	K
<b>SUMMER BARLEY</b>				
1971	9	70	31.7	116.2
1972	10	80–100	31.7	116.2
1973	11	100	31.7	116.2
1974	12	100	31.7	116.2
1971– 1974	after sugar beet	40	19.8	66.4
<b>WINTER WHEAT</b>				
1971	9	70–80	31.7	116.2
1972	10	110–130	31.7	116.2
1973	11	130–150	31.7	116.2
1974	12	150–170	31.7	116.2
1971– 1974	after horse bean	60	19.8	74.7

Both monocultures – of summer barley as well as winter wheat – were inserted into rotation of cereals only as the 9th–12th cereal crop.

Experimental plots were 3 × 5m; five replications were employed for harvest purposes while the sixth one served for sampling. At harvest time determined dry-matter amounts were then converted to ascertain the total phytomass production.

In 1974, data on growth characteristics were determined from the area of 3 rows 50 cm apart, in the intervals of 10–14 days. Leaf area was determined by the use of planimetry.

Characteristics of the Čáslav locality is given in the paper by Černý (1957).

Survey on weather conditions in the months of March—July:

Year	Temperature in °C	Rainfall in mm	Sunshine in hrs
1971	12.1	338.5	877.1
1972	13.1	316.6	950.0
1973	12.1	297.9	835.9
1974	12.7	272.2	816.1

## EXPERIMENTAL RESULTS

### Summer barley

In the average of four years lasting monoculture of summer barley that had been cultivated as 9<sup>th</sup>–12<sup>th</sup> cereal in rotation of cereals only, dry-matter production in the phytomass of summer barley (W) attained 5.23 t.ha<sup>-1</sup> in the course of vegetation period. The respective value for summer barley cultivated after sugar beet was 5.29 t.ha<sup>-1</sup>. The average difference in favour of the variant summer barley after sugar beet was thus negligible; it fluctuated, however, considerably in individual years, being in the variant after sugar beet twice higher (by 19.2 % and 16.7 %), and twice lower (by 31.7 % and 10.8 %).

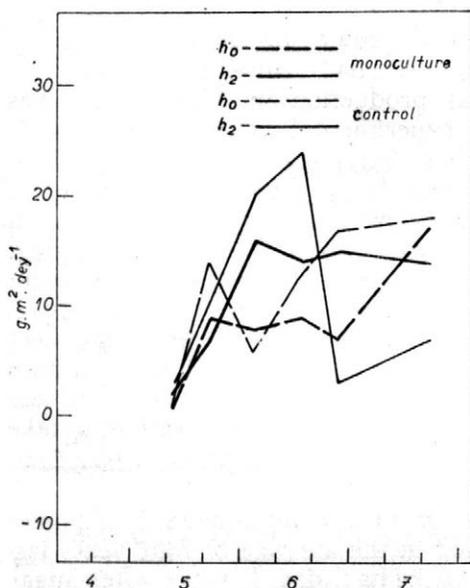
In spite of the fact that the total phytomass production was practically not divergent, differentiation took place in the yield formation. As compared with monoculture, dry-matter of grain in summer barley after sugar beet was by 230 kg.ha<sup>-1</sup> higher; in contrast to it, dry-matter of straw was in monoculture by 170 kg.ha<sup>-1</sup> higher.

Under intensive fertilizing, phytomass production of summer barley in monoculture attained on an average 7.92 t.ha<sup>-1</sup> while after sugar beet 7.73 t.ha<sup>-1</sup>. The increase in phytomass production in monoculture was not, however, regular, being in three experimental years by 1.3–2.6 % lower and in on eyebar by 16.2 % higher. Similarly as on non-fertilized plots, also in intensively fertilized variants dry-matter production in grain was on an average by 70 kg.ha<sup>-1</sup> lower in monoculture and, in contrast to it, dry-matter production in straw was by 260 kg.ha<sup>-1</sup> higher. Similar results concerning the differentiation of the phytomass were obtained also in individual experimental years, except for the year 1971. In this year, the lower grain yield of both variants after sugar beet reflected the high yields of sugar beet precrop, and thus lower residues of N after sugar beet. Lower dry-matter production after non-fertilized sugar beet in 1974 may be explained by more intensive nutrient uptake from soil reserves in given crop rotation in which also other crops than cereals were inserted.

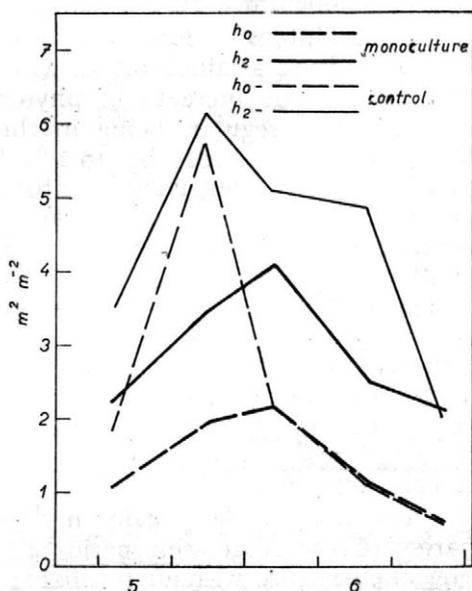
The average daily gain in dry-matter of the phytomass in summer barley (C) per vegetation period attained in the average of four years lasting monoculture without fertilizing, 42.9 kg.ha<sup>-1</sup>.day<sup>-1</sup>, while after sugar beet on an average 42.4 kg.ha<sup>-1</sup>.day<sup>-1</sup> (Table II). On non-fertilized plots, the average daily dry-matter gain decreased with increasing number of years of monoculture; decreases in average daily dry-matter gains were observed, however, even in non-fertilized summer barley in usual crop rotation after sugar beet since 1972.

II. Dry matter production of the phytomass (W) and average daily gains in phytomass (C) of summer barley. — Produkce sušiny biomasy (W) a průměrný denní přírůstek biomasy (C) u jarního ječmene

Year	Variant	Monoculture		After sugar beet		Relation in % to variant after sugar beet = 100	
		W t . ha <sup>-1</sup>	C kg . ha <sup>-1</sup> . day <sup>-1</sup>	W t . ha <sup>-1</sup>	C kg . ha <sup>-1</sup> . day <sup>-1</sup>	W	C
1971	f <sub>0</sub>	6.02	51.0	4.57	39.0	131.7	130.8
	f <sub>2</sub>	8.37	70.9	7.20	61.5	116.2	115.3
1972	f <sub>0</sub>	5.50	45.4	6.81	51.6	80.8	88.0
	f <sub>2</sub>	7.86	64.9	8.07	61.1	97.4	106.2
1973	f <sub>0</sub>	4.48	36.7	5.38	44.5	83.3	82.5
	f <sub>2</sub>	6.97	57.1	7.07	58.4	98.6	97.8
1974	f <sub>0</sub>	4.90	38.6	4.42	34.5	110.8	111.9
	f <sub>2</sub>	8.49	66.8	8.60	67.2	98.7	99.4
1971— 1974	f <sub>0</sub>	5.23	42.9	5.29	42.4	98.7	101.2
	f <sub>2</sub>	7.92	64.9	7.73	62.0	102.4	104.7



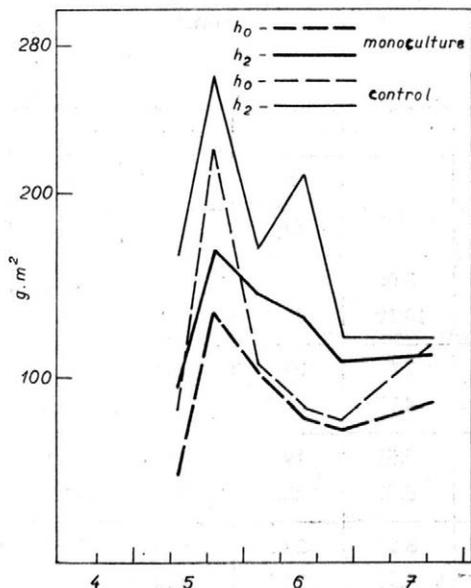
1. Average daily gains in dry-matter of the phytomass (C) in summer barley in the course of vegetation period. — Průměrný denní přírůstek sušiny biomasy (C) během vegetace u jarního ječmene.



2. Leaf area indices (LAI) in summer barley. — Pokryvnost listoví (LAI) u jarního ječmene

Under intensive fertilizing, the average daily dry-matter gain (C) per vegetation period in summer barley, when cultivated for 4 years in monoculture, attained  $64.9 \text{ kg} \cdot \text{ha}^{-1} \cdot \text{day}^{-1}$ , while the variant after sugar beet achieved  $62.0 \text{ kg} \cdot \text{ha}^{-1} \cdot \text{day}^{-1}$  in the average of four years. In the first two years the average daily gains in dry-matter were higher in summer barley under monoculture while in two subsequent years in summer barley after sugar beet.

In the course of vegetation period of 1974, daily gains in dry-matter attained their maximum values in the first and second decades of June on nonfertilized variant after sugar beet ( $24.2 \text{ g} \cdot \text{m}^{-2} \cdot \text{day}^{-1}$ ); later on, a very fast decrease took place. The lowest daily dry-matter gains were observed in non-fertilized summer barley in monoculture. In both variants of monoculture as well as in non-fertilized variant after sugar beet, daily dry-matter gains proved an increasing tendency with proceeding vegetation period (Fig. 1).



3. Dry-matter in leaves ( $W_i$ ) in summer barley. — Sušina listů ( $W_i$ ) u jarního ječmene

In 1974, a similar course was noticed also in the dry-matter of leaves ( $W_e$ ) (Fig. 3); its maximum values were attained in the third decade of May, namely in fertilized variants after sugar beet ( $265 \text{ g} \cdot \text{m}^{-2}$ ) and in monoculture ( $170.5 \text{ g} \cdot \text{m}^{-2}$ ); on non-fertilized plots the respective values were  $224.6 \text{ g} \cdot \text{m}^{-2}$  after sugar beet and  $136.4 \text{ g} \cdot \text{m}^{-2}$  in monoculture.

## Winter wheat

Data on the total overground dry-matter phytomass production in winter wheat (W) per vegetation period are given in Table III. In the average of four years lasting monoculture which was inserted as the 9<sup>th</sup>

-12<sup>th</sup> cereal in rotation of cereal crops, the amount of 4.86 t.ha<sup>-1</sup> was produced. Phytomass production of non-fertilized winter wheat after horse bean in usual crop rotation attained 7.49 t.ha<sup>-1</sup> in the average of four years. Thus in the monoculture of winter wheat the phytomass production was reduced by 2.63 t.ha<sup>-1</sup>, i. e. by 35.1 %. In the total reduction of phytomass production, the main product shared 59 % while the by-product 41 %. Decrease was considerable as well as explicit in all experimental years.

III. Dry-matter production of the phytomass (W) and average daily gains in phytomass (C) of winter wheat. — Produkce sušiny biomasy (W) a průměrný denní přírůstek biomasy (C) u ozimé pšenice

Year	Variant	Monoculture		After sugar beet		Relation in % to variant after sugar beet = 100	
		W	C	W	C	W	C
		t . ha <sup>-1</sup>	kg . ha <sup>-1</sup> . day <sup>-1</sup>	t . ha <sup>-1</sup>	kg . ha <sup>-1</sup> . day <sup>-1</sup>		
1971	f <sub>0</sub>	5.26	18.3	8.06	28.0	65.3	65.3
	f <sub>2</sub>	6.04	21.0	10.10	35.1	59.8	59.8
1972	f <sub>0</sub>	5.25	18.0	7.88	27.0	66.6	66.7
	f <sub>2</sub>	8.79	30.1	8.77	30.0	100.2	100.3
1973	f <sub>0</sub>	3.88	13.7	5.51	19.0	70.4	72.1
	f <sub>2</sub>	7.26	25.6	6.62	22.8	109.7	112.3
1974	f <sub>0</sub>	5.06	17.4	8.53	29.3	59.3	59.4
	f <sub>2</sub>	7.96	27.3	9.93	34.1	80.2	80.0
1971— 1974	f <sub>0</sub>	4.86	16.8	7.49	25.8	64.9	65.1
	f <sub>2</sub>	7.51	26.0	8.85	30.5	84.8	85.2

Under intensive fertilizing the phytomass production of winter wheat in monoculture was expressively increased having attained on an average 7.51 t.ha<sup>-1</sup>. Though this rate of production exceeds considerably the production of non-fertilized variant, it attained, however, only the phytomass production of non-fertilized variant after horse bean. In contrast to it, the maximum phytomass production in winter wheat (8.85 t.ha<sup>-1</sup>) was obtained on fertilized variant in crop rotation after horse bean. As compared with monocultural cultivating, the total average dry-matter production of the phytomass in fertilized winter wheat, when inserted into crop rotation after favourable preceding crop, was increased by 1.34 t.ha<sup>-1</sup>, i. e. by 15.2 %. It is of special importance that above all the main product

participated in this increase, dry-matter production of the by-product remaining almost unchanged.

As compared with the crop rotation with horse bean, the total phytomass production in fertilized winter wheat in monoculture did not prove any decrease in the average of all years; this was caused by a number of other factors that influenced to a various extent the production in individual years.

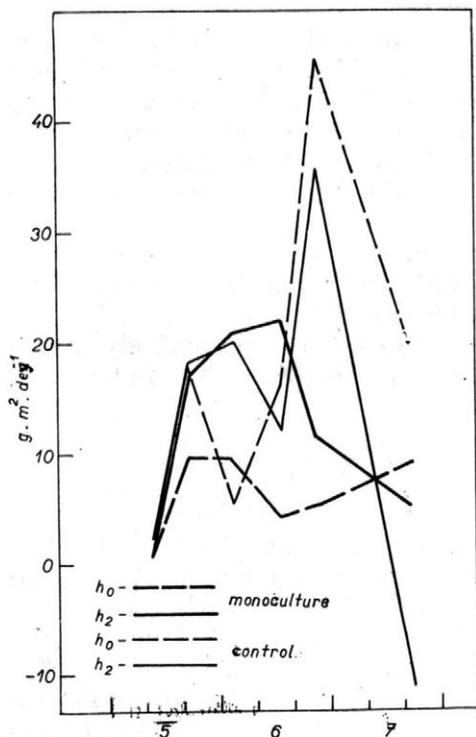
In non-fertilized winter wheat in monoculture the average daily gain in phytomass production (C) per vegetation period achieved on an average  $16.8 \text{ kg} \cdot \text{ha}^{-1} \cdot \text{day}^{-1}$ . When winter wheat had been cultivated after horse bean, the respective value was on an average  $25.8 \text{ kg} \cdot \text{ha}^{-1} \cdot \text{day}^{-1}$ , the increase representing 15.4 % (Table III).

After the application of commercial fertilizers dry-matter gains in phytomass were considerably higher, having attained in monoculture and in wheat after horse bean on an average  $26.0$  and  $30.5 \text{ kg} \cdot \text{ha}^{-1} \cdot \text{day}^{-1}$ , respectively. The average daily dry-matter gain in non-fertilized winter wheat after favourable preceding crop was almost equal to that in monoculture under intensive fertilizing. The maximum average daily gain in phytomass produced in individual years (the length of vegetation period being almost equal) responded, as a rule, to a higher crop yield.

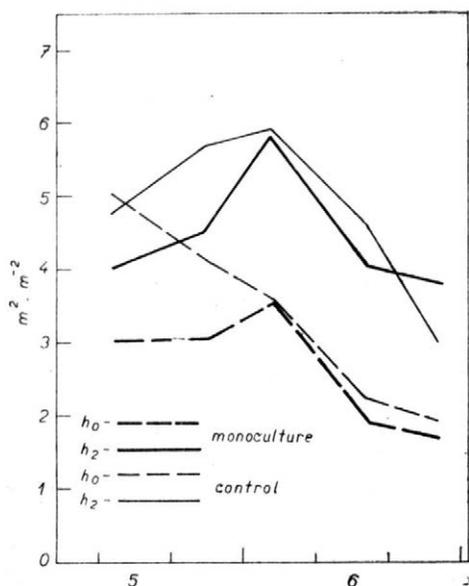
Total dry-matter production in straw of intensively fertilized winter wheat was on an average very close to that of winter wheat after horse bean (difference being  $0.21 \text{ t} \cdot \text{ha}^{-1}$ ) while the difference between dry-matter production in grain was on an average  $0.78 \text{ t} \cdot \text{ha}^{-1}$ .

Under intensive fertilizing a decreasing tendency in total dry-matter production with increasing number of years of monocultural cultivating was apparent; variations between experimental years were, however, remarkable.

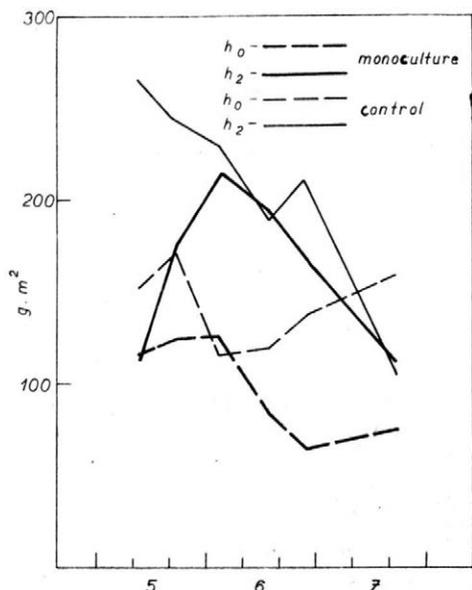
In the course of vegetation period of 1974, maximum daily dry-matter gains were ascertained in winter wheat after horse bean ( $46.3 \text{ g} \cdot \text{m}^{-2}$  and  $36.1 \text{ g} \cdot \text{m}^{-2}$ ) in the third decade of June, while the lowest daily gains were observed in



4. Average daily gains in dry-matter of the phytomass (C) in winter wheat in the course of vegetation period. — Průměrný denní přírůstek sušiny biomasy (C) během vegetace u ozimé pšenice



5. Leaf area indices (LAI) in winter wheat. — Pokryvnost listoví (LAI) u ozimé pšenice



6. Dry-matter in leaves ( $W_1$ ) in winter wheat. — Sušina listů ( $W_1$ ) u ozimé pšenice

non-fertilized winter wheat in monoculture, maximum values ( $9.95 \text{ g}\cdot\text{m}^{-2}$ ) being noticed in the third decade of May (Fig. 4).

Development of leaf area index (LAI) of winter wheat in the course of vegetation period of 1974 is given in Fig. 5. Maximum leaf area indices were achieved in the first decade of June on fertilized variants; in monoculture and after favourable preceding crop the respective values were  $5.83 \text{ m}^2\cdot\text{m}^{-2}$  and  $5.93 \text{ m}^2\cdot\text{m}^{-2}$ . Later on, leaf area index decreased considerably. Non-fertilized monoculture proved the lowest values of leaf area index.

Dry-matter in leaves ( $W_e$ ), as given in Fig. 6, attained its maximum in the second decade of May 1974; in intensively fertilized winter wheat after horse bean, and in fertilized monoculture the values obtained in the first decade of June were  $266.0 \text{ g}\cdot\text{m}^{-2}$  and  $215.4 \text{ g}\cdot\text{m}^{-2}$ , respectively. Again the lowest dry-matter production of leaves was ascertained in non-fertilized monoculture.

## DISCUSSION

Phytomass production in summer barley on illimerized fertile chernozem proved practically equal values, when barley was cultivated for four years in monoculture under intensive fertilizing, as when cultivated after sugar beet under optimum intensity of fertilizing. Although phytomass production in the monoculture fluctuated in individual years, being sometimes even lower than after sugar beet, decrease did not attain but 2.6 %. In no case, however, the maximum phytomass production of sum-

mer barley in monoculture could ensure equal grain production as in barley after sugar beet. It is of great importance that phytomass production in summer barley after sugar beet and in monoculture was differentiated; this indicates, in consent with Černý (1974), a dependence on other external factors. This suggestion was supported e. g. by the positive effect of saturation fertilizing with P, K described in the paper by Strnad (1974). This is also in consent with findings by Cooke (1970) who recommended to apply higher rates of all essential nutrients (N, P, K) in growing of cereals, mainly at the beginning of vegetation period. We suppose that, providing the other factors are at their optimum, much higher yields might be produced by improving the stage of plant nutrition which had limited the phytomass differentiation. It may be emphasized, however, that limiting factors considerably differ in individual years, even at similar localities.

In spite of intensive fertilizing, phytomass production in winter wheat was considerably lower in monoculture than in wheat after horse bean. The reduction is remarkable (15.2 %) and represents a considerable loss. The positive effect of favourable preceding crop on dry-matter in grain may be especially emphasized.

Data on reduced total dry-matter production in the phytomass of winter wheat under monoculture are in consent with latest findings on impossibility of favourable preceding crop to be substituted (Černý et al., 1972). The fact is of great importance that first of all main product shared in increased phytomass production in wheat after favourable preceding crop. This indicates the necessity of complex investigating the problems of transportation of assimilates into agriculturally important organs of plants, inclusive of studies on analyses of growth dynamics as well as claims of crops to uptake and exploiting nutrients in the course of ontogeny, etc.

## References

- COOKE, G. W.: Soil fertility problems in cereal growing in temperate zones. Proc. of the 9th Congr. of the Int. Potash. Inst. Antibes, 1970, p. 123-133.
- ČERNÝ, V.: Problémy primární produkce v podmínkách koncentrace rostlinné výroby. Referát na zasedání I. a II. odboru ČAZ o ekosystémech 1974, Praha.
- ČERNÝ, V. a kol.: (The Contribution of Some Cultural Practices to the Yields of Field Crops). Rostlinná výroba, 18, 1972, No 9, p. 905-916.
- HRUŠKA, L.: Porovnání produkce hlavních plodin v podmínkách jižní Moravy. Úroda, 21, 1973, No 12, p. 453-456.
- KŘIŠŤAN, F.: Vliv různých agrotechnických opatření na produkci biomasy na hnědé půdě a černozemi. [Závěrečná zpráva.] Praha - Ruzyně, 1973, 55 p. VÚRV.
- PETR, J.: Obilní problém a jeho řešení v ČSSR. Institut pro vzdělávání pracovníků v zemědělství a výživě Praha, 1971 a., 147 p.
- PETR, J.: Některá hlediska tvorby výnosů obilnin. Genetika a šlechtění, 7, 1971 b., No. 1, p. 1-12.
- STRNAD, P.: Studium možnosti regenerace půdní úrodnosti jako důsledek jejího jednostranného vyčerpání. [Závěrečná zpráva.] Praha - Ruzyně, 1974, 52 p. VÚRV.
- VRKOC, F.: Vliv některých agrotechnických opatření na produkci biomasy na hnědozemí. [Závěrečná zpráva.] Praha - Ruzyně, 1974, 33 p. VÚRV.

STRNAD P. (Ústav genetiky a šlechtění, VÚRV Praha - Ruzyně, Výzkumná stanice rostlinné výroby, Čáslav). *Produkce biomasy obilnin při jejich pěstování v monokultuře*. Rostlinná výroba (Praha) 21 (8) : 874-883, 1975.

Na illimerizované čemozemi v Čáslavi v řepářském výrobním typu dosáhla u jarního ječmene odrůda 'Diamant' ve čtyřleté monokultuře v osevním sledu jako 9-12 obilnina v průměru produkce biomasy bez hnojení 5,23 t. ha<sup>-1</sup>. Produkce biomasy jarního ječmene, který byl zařazován po cukrovce dosáhla ve čtyřletém průměru bez hnojení 5,29 t. ha<sup>-1</sup>, při optimálním hnojení 7,73 t. ha<sup>-1</sup>. Vyšší produkce biomasy nebyla však jednoznačná a v jednotlivých letech značně kolísala. U jarního ječmene po cukrovce bylo dosaženo proti monokultuře příznivější diferenciace ve prospěch sušiny hlavního produktu, zatímco v monokultuře v dlouhodobém obilovinovém sledu se na vyšší produkci biomasy podílel více vedlejší produkt. Produkce biomasy ozimé pšenice odrůda 'Jubilar' ve čtyřleté monokultuře v osevním sledu jako 9-12 obilnina dosáhla v průměru bez hnojení 4,86 t. ha<sup>-1</sup>, při intenzivním hnojení 7,51 t. ha<sup>-1</sup>. V osevním sledu po bobu bez hnojení produkce biomasy dosáhla 7,49 t. ha<sup>-1</sup>, při optimálním hnojení 8,85 t. ha<sup>-1</sup>. K podstatnému snížení došlo v monokultuře při intenzivním hnojení pouze v některých letech. Stejná produkce biomasy byla dosažena při zařazování ozimé pšenice bez hnojení po bobu jako při intenzivním hnojení v monokultuře. Na vyšší produkci biomasy ozimé pšenice se po bobu proti monokultuře podílel hlavní produkt, produkce sušiny vedlejšího produktu se podstatněji nezměnila.

jarní ječmen; ozimá pšenice; monokultury; produkce biomasy

СТРНАД П. (Институт генетики и селекции, Прага - Рузыне, Научно-исследовательская станция растениеводства, НИИР, объект Часлав). *Производство биомассы зерновых при их выращивании в монокультуре*. Rostlinná výroba (Praha) 21 (8) : 874-883, 1975.

На иллимеризованном черноземе Часлава, в свекловодческом производственном типе, в 4-летней монокультуре севооборота, в качестве 9-12-й зерновой культуры яр. ячмень сорта 'Диама́нт' дал среднюю продукцию биомассы = 5,23 т. га<sup>-1</sup>, а при интенсивном минеральном удобрении 7,92 т. га<sup>-1</sup>. В среднем по 4 годам продукция биомассы яр. ячменя после сах. свеклы без удобрения составила 5,29 т. га<sup>-1</sup>, а в условиях оптимального удобрения 7,73 т. га<sup>-1</sup>. Более высокая продукция уже не однозначна и значительно неравномерна по годам. Разница продукции яр. ячменя после сах. свеклы говорит в пользу сухого вещества главного продукта, тогда как в монокультуре в рамках долгосрочного зернового севооборота больший % биомассы приходится на побочные продукты. Продукция биомассы оз. пшеницы сорта 'Юбиля́р' в 4-летней монокультуре в порядке 9-12-я зерновая культура составила в среднем без удобрения 4,86 т. га<sup>-1</sup>, а при интенсивном удобрении 7,51 т. га<sup>-1</sup>. В севообороте после боба без удобрения продукция биомассы достигла 7,49 т. га<sup>-1</sup>, а при оптимальном удобрении 8,85 т. га<sup>-1</sup>. Лишь в некоторые годы при интенсивном удобрении монокультуры продукция биомассы резко сокращалась. Такая же продукция биомассы достигнута при включении оз. пшеницы без удобрения после боба, как и при интенсивном удобрении монокультуры. Наибольшая продукция биомассы оз. пшеницы после боба (по сравнению с монокультурой) приходится на главный продукт; продукция сухого вещества побочного продукта остается без резких изменений.

яровой ячмень; озимая пшеница; монокультуры; продукция биомассы

---

#### Adresa autora:

Ing. Přemysl Strnad, CSc., Ústav genetiky a šlechtění, VÚRV, Praha - Ruzyně, Výzkumná stanice rostlinné výroby, 286 01 Čáslav

## PHOTOSYNTHETIC PRODUCTIVITY OF TALL AND DWARF VARIETIES OF PEA (*PISUM SATIVUM* L.)

J. PETR

PETR J. (University of Agriculture, Praha). *Photosynthetic Productivity of Tall and Dwarf Varieties of Pea (Pisum sativum, L.)*, Rostlinná výroba (Praha) 21 (8) : 885-895, 1975.

In three-year experiments the productivity of dwarf and tall varieties of pea was investigated by means of classical growth analysis according to the methods of the International Biological Programme. The experiments showed that tall pea varieties were characterized by a fast rate of dry matter production at the early stage of growth, whereas in dwarf varieties higher productivity of the dry matter was observed at the stage of fruit and seed formation. Dwarf varieties of pea are more economical in their dry matter distribution. Both groups of varieties were found to produce almost the same amount of dry matter, tall ones, however, deposited a large proportion of dry matter in their stems and leaves, which is convenient for their utilization as green matter. Dwarf varieties have a substantially lower proportion of dry matter in stems but, as they have more branches, these participate to a larger degree in total dry matter than in the case of tall varieties. In dwarf varieties, however, the proportion of dry matter in generative organs is important. It exceeds 50 % of total dry matter. In tall varieties it is by 10 % lower. Leaf area index was higher in varieties with long stems, but dwarf varieties exhibited higher values of leaf area index at the generative stage. A positive significant correlation was found between leaf area duration and the fruit and seed forming stage and the yield of seeds. The net assimilation rate was higher in dwarf varieties. A higher yielding capacity of dwarf seed pea, as compared with tall varieties, was due to a more economical distribution of assimilates in favour of generative organs, higher values of leaf area duration (LAD), net assimilation rate (NAR) and, consequently, higher dry matter production at the stage of pod and seed formation. In addition to these production characteristics the productivity of dwarf pea is due to a lesser dependence on external conditions as regards the reduction of generative organs.

pea; dwarf and tall varieties; yield formation; growth analysis; photosynthetic production

Pulse crops with their high protein content of their seeds occupy an outstanding place in the protein programme of both world and Czechoslovak agriculture. In regions of Central and Northern Europe it is pea that is of great importance in this respect. That's why in the last 15 years great attention has been paid by researchers to the processes of productivity in various varieties of pea. Until the time when dwarf varieties of pea were selected in Holland, tall varieties were grown with stems as long as 120-180 cm. In this paper attention has been focussed to the study of photosynthetic productivity of both varieties.

According to Šesták and Čatský (1966) the study of photosynthetic productivity is based on the biomass increments which are conditioned by the size of assimilation leaf area, the duration of the function of assimilation area and the intensity of photosynthesis and the activity of the root system.

The optimum size of the assimilation area, according to Popov and Goršikov (1966) in the variety Torsdar is  $5 \text{ m}^2$  per  $1 \text{ m}^2$  of land. Kornilov (1968) states for early varieties and the yield level of 40–50 q/ha that the leaf area index is 7–9  $\text{m}^2 \cdot \text{m}^{-2}$ . Like in cereals the rate and duration of active assimilation area during the generative period will be of importance in pulse crops as well.

An overall picture of the production processes in pea can be obtained by growth analysis. However, the relationship between the biological yield and commercial yield in pea, like in all cereals, is very complex because the yield organs lie inside the assimilation organs and they themselves assimilate as well. At the same time, the formation of generative organs is apparently highly dependent on external conditions and the results is a strong fluctuation in their reduction (Petř 1974).

## MATERIAL AND METHODS

The basis of the method of the study of production processes was growth analysis of three varieties of pea: (1) 'Raman' — a dwarf variety with large green seeds; (2) 'Liblice bastard' — a tall variety with middle-sized seeds, an older variety as a typical representative of the varieties grown up to now in Czechoslovakia both for seeds and green matter; (3) 'Pyram' — a latest tall variety with large yellow seeds.

The trials were carried out in the years 1967 – 1969 at Uhříněves research station of the University of Agriculture in Prague, situated in the sugar-beet growing region with annual rainfall of 567 mm (during the growing season 384 mm). The yearly average of temperature during the day is  $8.5^\circ\text{C}$ , during the growing season  $14.8^\circ\text{C}$ . The soil is of the clayloam type.

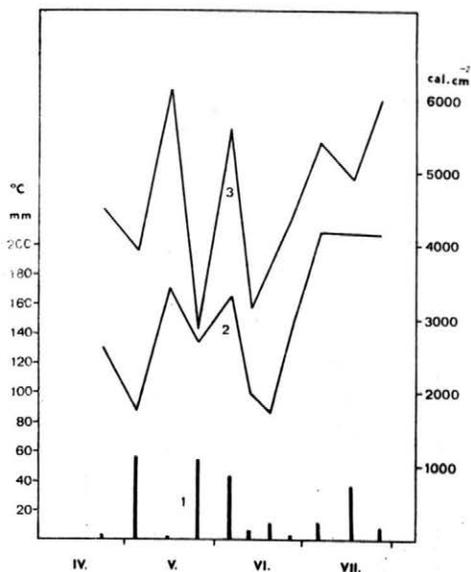
The trial itself was conducted by the split-plot method. The sowing rate was 100 viable seeds per  $1 \text{ m}^2$  in rows with 12.5 spacing. The number of plants that came up differed in individual varieties and years. In 1967, 70 plants per  $1 \text{ m}^2$  of the 'Raman' variety and 90 plants of the 'Pyram' and 'Liblice bastard' varieties respectively were taken as the basis for the calculation of the values for growth analysis. In 1968 it was 100 plants of all three varieties and in 1969 it was 110 plants per  $1 \text{ m}^2$ . Growth analysis was performed according to the method of the International Biological Programme, as the research task was a part of the Czechoslovak programme of the IBP.

The samples were collected in 10-to-11-day intervals and, if the dry matter increment of one collection exceeded 100%, the interval was shortened to 7 days.

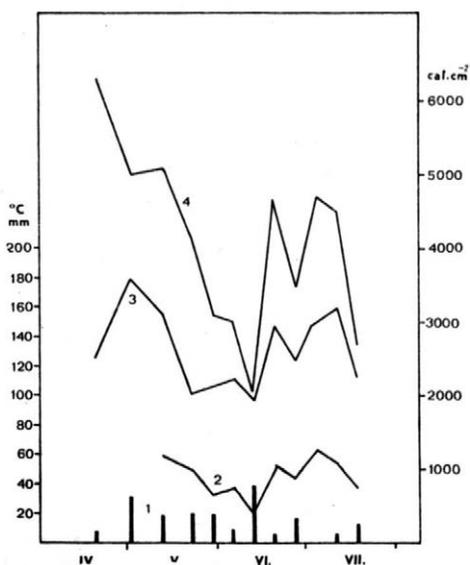
Besides the dry matter increment (W) also dry matter of individual organs was measured as well as assimilation areas (A) determined by means of the photoplanimeter. On the basis of these values individual characteristics of growth analysis were calculated:

- (1) RGR — (relative growth rate)
- (2) NAR — (net assimilation rate)
- (3) C — (crop growth rate)
- (4) LAI — (leaf area index)
- (5) LAR — (leaf area ratio)
- (6) LAD — (leaf area duration)

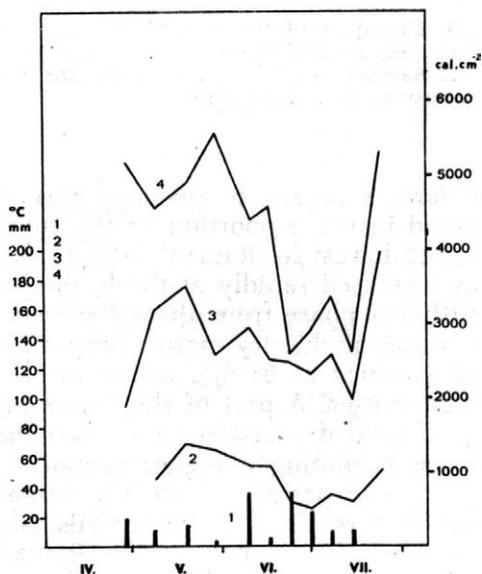
The formulae used are quoted in the Review of the methods of growth analysis (Sesták, Čatský, 1966 and Květ, Nečas and Ondok, 1971). The weather data during the trials are given in Figs. 1, 2, 3.



1. Total precipitations (1), temperature (2) and global radiation (3) between collections in 1967. — Úhrn srážek (1), teplota (2) a globální záření (3) mezi jednotlivými odběry v r. 1967



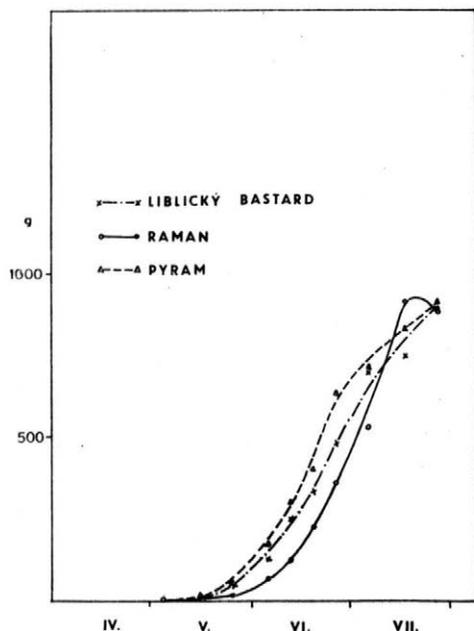
2. Total precipitations (1), photosynthetically active radiation (2), temperature (3), and global radiation (4) between collections in 1968. — Úhrn srážek (1), fotosynteticky aktivní záření (2), teplota (3), a globální záření (4) mezi jednotlivými odběry v r. 1968



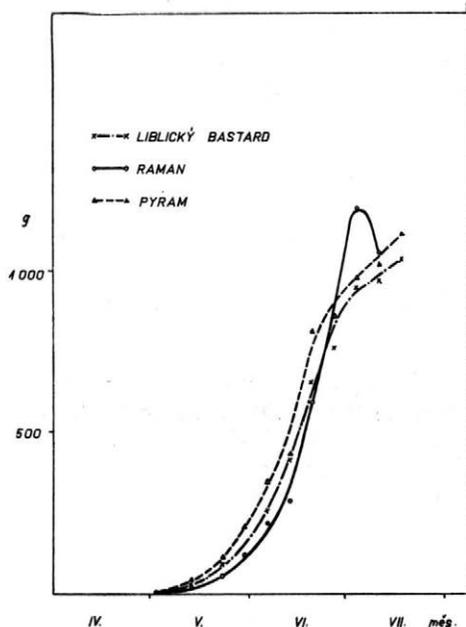
3. Total precipitations (1), photosynthetically active radiation (2), temperature (3), and global radiation (4) between collections in 1969. — Úhrn srážek (1), fotosynteticky aktivní záření (2), teplota (3) a globální záření (4) mezi jednotlivými odběry v r. 1969

## RESULTS

Dry matter increments in individual varieties are given in Figs. 4 and 5. A faster rate of dry matter production can be observed in tall varieties. The dwarf variety Raman started with a slower rate of overground biomass production, but later on, when seeds developed, its dry matter increments were higher, except in the year 1969.

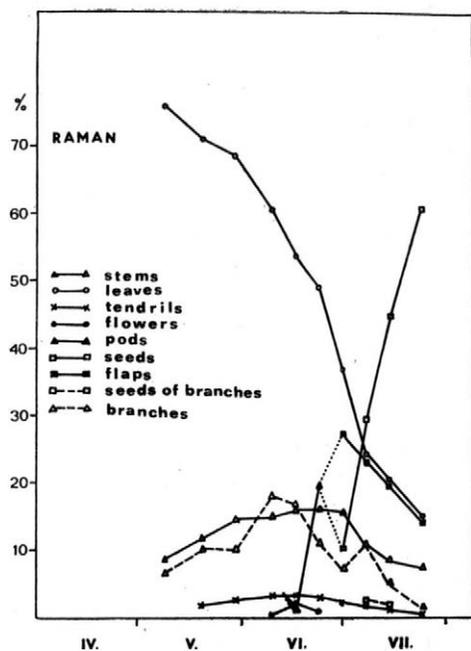


4. Dynamics of dry matter formation of aboveground biomass per 1 m<sup>2</sup> in 1967. — Dynamika tvorby sušiny nadzemní biomasy na 1 m<sup>2</sup> v r. 1967

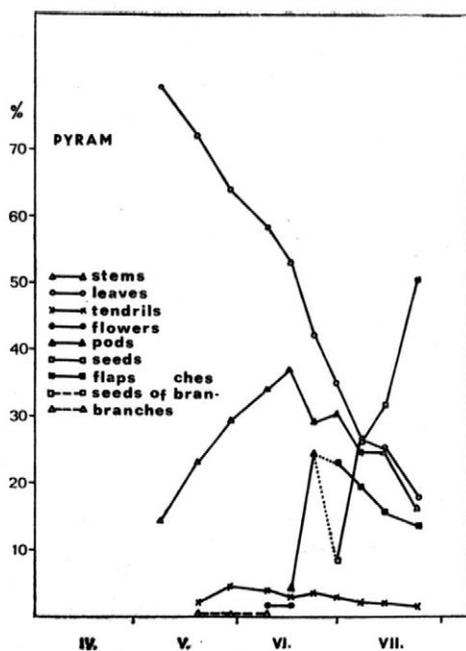


5. Dynamics of dry matter formation of aboveground biomass per 1 m<sup>2</sup> in 1968. — Dynamika tvorby sušiny nadzemní biomasy na 1 m<sup>2</sup> v r. 1968

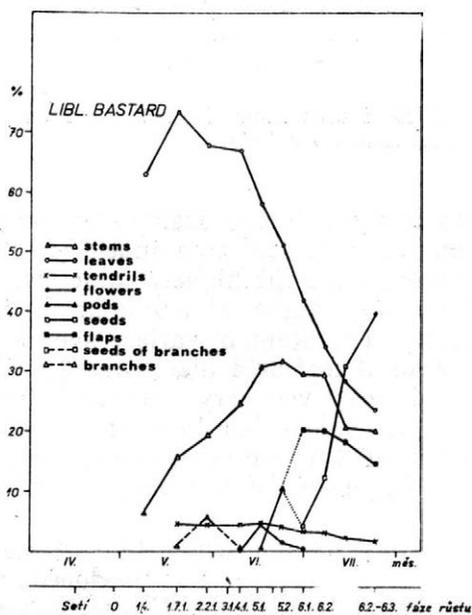
The proportion of dry matter of various organs is given in Figs. 6, 7, 8. The greatest difference can be found in the proportion of the stems which is higher in 'Pyram' (35–50%) and lowest in 'Raman' (10–15%). The proportion of dry matter of leaves increased rapidly at the beginning and reaches its maximum during the fifth-leaf phase from about the beginning of May to Mid-May. The highest value of the dry matter proportion was found in 'Liblice bastard' (in 1968 as much as 85%), which stressed its importance as a crop grown for green matter. A part of the leaves are the tendrils which account for 2–4% of total dry matter in all varieties and all years. Tall varieties show at the beginning a higher proportion of tendrils, but later on during the generative period the variety Raman has larger tendrils, this being a positive feature because the tendrils take part in photosynthesis and respiration. Also, the tendrils of the 'Raman' variety keeps the plants in a compact (less lodged) form.



6. Dry matter of various organs in percentage of total dry matter 'Raman'. — 1969. — Sušina jednotlivých orgánů v procentech z celkové sušiny odrůdy 'Raman'. — 1969



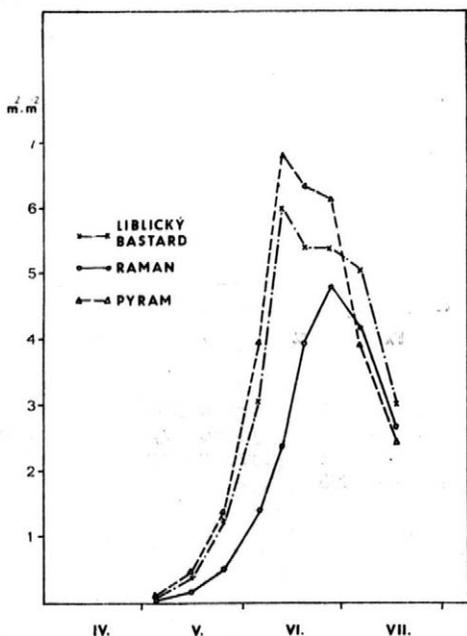
7. Dry matter of various organs in percentage of total dry matter 'Pyram' — 1969. — Sušina jednotlivých orgánů v procentech z celkové sušiny odrůdy 'Pyram' — 1969



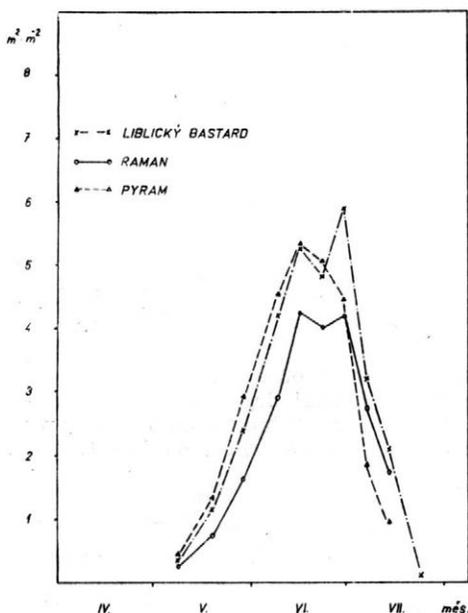
8. Dry matter of various organs in percentage of total dry matter 'Liblický Bastard' — 1969. — Sušina jednotlivých orgánů v procentech z celkové sušiny odrůdy 'Liblický Bastard' — 1969

The proportion of dry matter of branches is small in tall varieties, in the 'Raman' variety, however, it is very high and varies between 15 to 20 %, in 1968 it was much as 35 %.

At the end of June a very fast growth of the dry matter of fruits set in. The fastest rate of fruit formation can be observed in 'Raman' and in the final period of their formation the proportion of the dry matter exceeds 50 % of total dry matter of overground biomass. In 1969, when the fruit yield of this variety was highest, the dry matter proportion exceeded 60 %. In tall varieties the dry matter production was slower and its proportion of total dry matter was smaller than that of 'Raman' variety.



9. Leaf area index in 1967. — Pokryvnost listoví v r. 1967



10. Leaf area index in 1969. — Pokryvnost listoví v r. 1969

Another basic indicator of growth analysis is the assimilation area of plants which is most frequently expressed as leaf area index (LAI). These data are given in Figs. 9, 10. In most years the highest values were obtained in Pyram and Liblice bastard: they averaged  $6.9 \text{ m}^2 \cdot \text{m}^{-2}$  (in 1968 as much as 8.5) and 6.5 respectively. The 'Raman' variety averaged  $5.8 \text{ m}^2 \cdot \text{m}^{-2}$ , but in 1968 its maximum level of leaf area index was  $8.3 \text{ m}^2 \cdot \text{m}^{-2}$ . In tall varieties the rate of LAI in all years was very fast and similar. 'Pyram', however, reached somewhat higher values but loses them more quickly, whereas 'Liblice bastard's' level of LAI persists longer. More precise data about this can be obtained by means of leaf area duration, whose values are given in Table 1.

From the data it can be seen that it was 'Raman' which in 1967 showed the highest values following the green pod stage. It also produced the highest yield of seeds per plant (similarly in 1968). In 1969 the highest

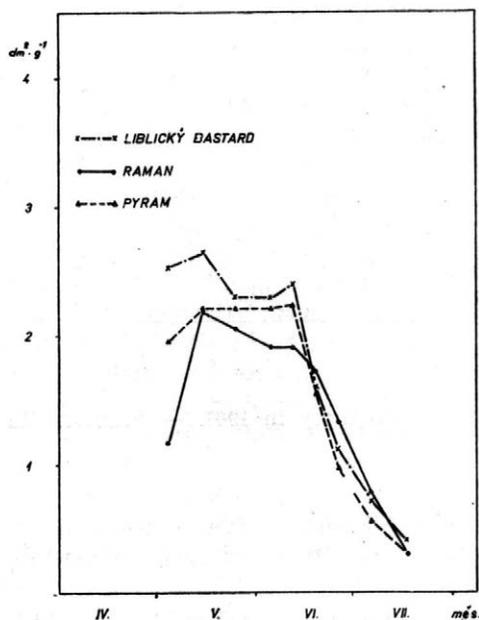
I. Leaf area duration (LAD) following the stage of green pods. — Integrovaná listová plocha od fáze zelených lusků

Varieties	1967		1968			1969		
	26. 6. — 6. 7.	6. 7. — 17. 7.	20. 6. — 27. 6.	27. 6. — 4. 7.	4. 7. — 11. 7.	23. 6. — 30. 6.	30. 6. — 7. 7.	7. 7. — 14. 7.
Raman	548.5	510.5	511.0	389.0	179.5	281.0	237.0	165.0
Pyram	497.5	378.0	484.0	312.5	155.0	319.5	216.0	108.0
Liblický Bastard	522.5	465.0	453.5	339.0	194.5	364.5	307.5	199.0

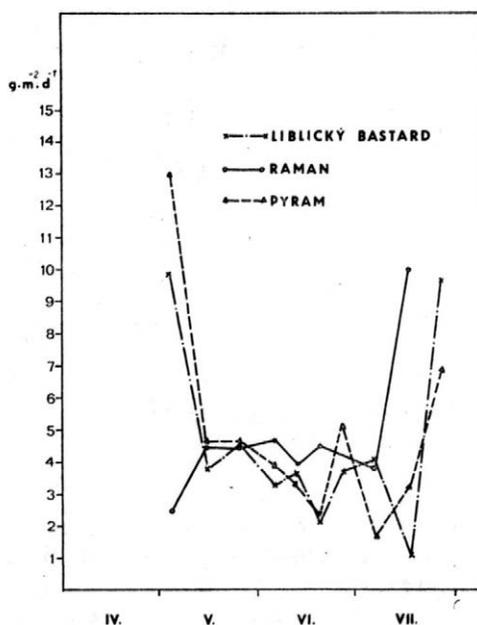
values of LAD were found in 'Liblice bastard', in which, due to a long rainy period at the stage of ripening, the growth in length of generative organs continued. The above mentioned factors show that in pea, too, the same relationship exists between the values of LAD and the weight of the seeds, and, consequently, the yield.

The leaf area ratio expressing the relative power of the active assimilation apparatus (Fig. 11) showed at the beginning higher values in tall varieties, particularly in 'Liblice bastard', later on the dwarf 'Raman' variety catches up and in the years 1967 and 1968 it exceeds even the tall varieties in the level of LAR. Otherwise, however, the differences between the varieties are relatively small.

An important calculated value of growth analysis is the net assimilation rate (NAR) expressing the dry matter increment per unit of the



11. Leaf area ratio in 1967. — Poměrná pokrývnost v r. 1967

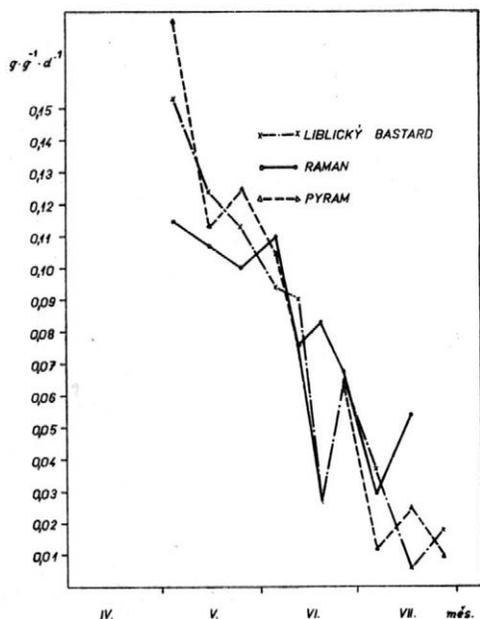


12. Net assimilation rate in 1967. — Čistý výkon fotosyntézy v r. 1967

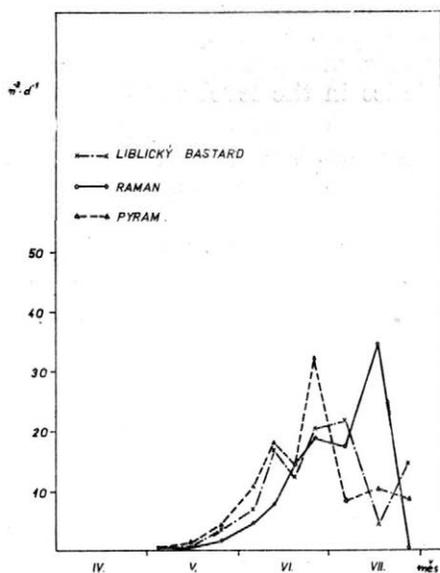
assimilation area and time. The values of NAR (Fig. 12) show unambiguously that 'Raman' is better in most measurements than the tall varieties. It is true that the latter possess a more powerful assimilation apparatus and, consequently, a higher photosynthetic intensity, but at the same time also a higher rate of respiration so that net assimilation product is smaller. In 'Raman' the increase of NAR at the stage of pod formation is important for its yield. It is due to the fact that in 'Raman' its growth in length at the reproductive stage is not so intensive and that, unlike in the all varieties, no excessive number of additional flowers appears during the growth.

The relative growth rate (RGR) expressed the dry matter increments in relation to the weight unit of the dry matter. The values of RGR basically confirm the facts known about the net assimilation rate (Fig. 13).

The same applies to productivity (C) expressing the dry matter increments of overground biomass per time unit and  $1 \text{ m}^2$ . The values showed that at the early stage of the growth tall varieties exhibited



13. Relative growth rate in 1967. — Speci-  
fická rychlost růstu v r. 1967



14. Productivity in 1967. — Produktivita  
v r. 1967

higher productivity, whereas 'Raman' was more productive in the second half of the growing period, particularly at the time of pod formation (Fig. 14).

Net assimilation rate, relative growth rate and productivity are closely related to external conditions, particularly to the rate of photosynthetically active or global radiation, the amount of rainfall and temperature.

## DISCUSSION

The results of growth analysis have shown that all the varieties under study (both tall and dwarf) produce almost the same amount of dry matter per 1 m<sup>2</sup> and per plant. In the dwarf variety 'Raman' the production of dry matter was higher during two years (1967 and 1968). Tall varieties were characterized by a faster initial growth of dry matter, which is an important fact if they are to be grown for green matter. In 'Raman' the production of dry matter is higher in the generative phase, which is more advantageous for the seed yield. This is confirmed by Stanfield et al. (1966).

The dry matter production is affected in a decisive way by temperature and rainfall. Experiments with pea conducted by Stanfield et al. (1966) under controlled phytotron conditions showed that the optimum dry matter production was observed at the stage of the 6th–10th node at 21<sup>0</sup>/13<sup>0</sup> (day/night), at the stage of flowering at 16<sup>0</sup>/10<sup>0</sup> and at the stage of ripeness at 16<sup>0</sup>/13<sup>0</sup> C. Our observations are in agreement with the above findings. The general formulation of Wang (1962) says that from the point of view of the yield of pea warm spring (growing stage) and colder summer (flowering stage) are most favourable.

In the dry matter distribution in various aboveground parts of the plants there is a great difference between dwarf and tall varieties in the proportion of dry matter in the stems, which in tall varieties is by 20–30 % higher than in 'Raman'. Fletcher et al. (1966) came to an earlier conclusion that a high production of dry matter in the stems correlated with a lower seed yield.

Again, in the 'Raman' variety a large proportion of dry matter (over 50 %) is deposited in fruits and seeds, which is important for the yield formation. A similar conclusion was arrived at by Juza (1971) in 'Raman' and 'Borek' varieties whose dry matter exceeded 50 % whereas in the tall variety 'Pyram' and intermediate variety 'Jupiter' the generative organs produced only a little over 30 % of total dry matter. This showed that dwarf varieties of pea are more economical in the distribution of assimilates in economically important organs.

The dynamics of dry matter production is connected with leaf area duration. In tall varieties leaf production is faster and more intensive. LAI values are basically in agreement with the findings of Kornilov (1968) and Ničiporovič (1966). Extreme values of leaf area duration (highest in 1968 and lowest in 1969) were affected by temperature and rainfall. According to Kornilov (1968) a higher temperature affects leaf area at an early stage of the growth, whereas at later stages leaf area is affected rather by lower temperature and plenty of rainfall.

Like in cereals (Simpson 1968, Stickler and Pauli 1961 and others) an important relationship was found between leaf area duration and seed yield in pea. The same relationship was found in our experiments and proved to be an important factor affecting a high-yielding capacity of dwarf seed pea.

In assessing the photosynthetic production of the varieties of pea under investigation it was proved that the net assimilation rate and other calculated values of growth analysis largely depend on rainfall

conditions, temperature and, above all, on photosynthetically efficient and global radiation.

The above characteristics of processes of productivity, particularly the rate of dry matter production and its distribution of leaf area duration and assimilation rate affect the actual yields. The three-year average yield of seeds of the 'Raman' variety was 39.4 q per ha, 'Pyram' 33.9 q and 'Liblice bastard' 27.8 q per ha.

**Acknowledgements.** The author is thankful to Ing. Josef Vrabec and Jan Lipavský, prom. med., for their help in performing the experiments.

## References

- FLETCHER, H. F., — ORMOND, D. P., — MAURER, A. R., — STAFIELD, B.: Response of peas to environment I. Planting date and location. *Can. J. Plant. Sci.*, 46, 1966, pp. 77-85.
- JÚZA, J.: The role of some biological and commercial properties of selected varieties of peas. [Dissertation.] University of Agriculture Prague 1971 Czech.
- KORNILOV, A. A.: Biological bases of high yields of pulse crops. Publ. House „Kolos“ Moscow 1968 Russ.
- KVĚT, J., — NEČAS, J., — ONDOK, J. P.: Methods of Growth Analysis. (Review) UVTI, Prague, 1971 Czech.
- NICIPOROVIC, A. A.: Photosynthesis and yield. Publ. House „Znanie“ Moscow 1966 Russ.
- PETR, J.: Effect of the environment conditions on the reduction of the generative organs in pea (*Pisum sativum* L.). *Rostlinná výroba* (Praha) 20, 1974, 11, pp. 1157-1172. Czech with Engl. Res.
- POPOV, K. J., — GORŠEVIKOVA, O. L.: Yield-formation in peas as affected by varying sowing times. *Vestnik sel'skochozjajstvennoj nauki*, 1966, pp. 104-107. Russ.
- SIMPSON, G. M.: Association between grain yield per plant and photosynthetic area above the flag leaf node in wheat. *Canad. J. Pl. Sci.*, 48, 1968, pp. 253-260.
- STENFIELD, B. — ORMOND, D. P. — FLETCHER, H. F.: Response of peas to environment. II. Effect of temperature in controlled — environment cabinets. *Can. J. Plant. Sci.*, 46, 1966, pp. 195-203.
- STICKLER, F. C. — PAULI, A. W.: Leaf removal in grain sorghum I. Effect of certain defoliation treatments on yields and components. *Cer. Jour.*, 53, 1966, 1, 99-104.
- SESTÁK, Z. — ČATSKÝ, J. a kol.: Methods of Studying Photosynthetic Production of Plants. Publ. House „Akademia“ Prague 1966, Czech.

8. 4. 1975

PETR J. (Vysoká škola zemědělská, Praha-Suchdol). *Fotosyntetická produktivita nízkých a vysokých odrůd hrachu* (*Pisum sativum* L.). *Rostlinná výroba* (Praha) 21 (8) : 875-895, 1975.

V tříletých pokusech byla sledována produktivita nízkých a vysokých odrůd hrachu klasickou růstovou analýzou podle metodiky Mezinárodního biologického programu. Pokusy prokázaly, že pro vysoké odrůdy hrachu je typická rychlá tvorba sušiny na počátku vegetace, zatímco u nízkých odrůd je vyšší tvorba sušiny v období tvorby plodů a semen. Nízké odrůdy hrachu jsou ekonomičtější v distribuci sušiny. Při téměř stejném množství vyprodukované sušiny u obou skupin odrůd se ukázalo, že vysoké odrůdy investují velký podíl sušiny do lodyh a listů, což je vhodné pro jejich případné využití na zelenou hmotu. Nízké odrůdy mají podíl sušiny lodyh podstatně nižší, ale více větví, takže větve se více podílí na celkové sušině než u vysokých hrachů. Významný je však podíl sušiny generativních orgánů, který dosahuje u nízkých hrachů přes 50 % z celkové sušiny, vysoké hrachy investují do generativních orgánů o 10 % méně. Pokryvnost listové (LAI) byla větší u odrůd s dlouhou lodyhou, ale nízké odrůdy měly vyšší hodnoty listové plochy v generativním období. Byl prokázán vztah integrální listové plochy v době tvorby plodů a semen k výnosu semen. Čistý výkon asimilace byl vyšší u nízkých odrůd. Vyšší výnosová výkonnost nízkých hrachů na semeno je ve rovnání s vysokými odrůdami podmíněna lepší (ekonomičtější) distri-

bucí asimilátů ve prospěch generativních orgánů, vyššími hodnotami integrální listové plochy (LAD), vyšším čistým výkonem asimilace (NAR) a tím i vyšší tvorbou sušiny v období tvorby lusků a semen. Vedle těchto produktivních kritérií je výnosnost nízkých zrnových hrachů podmíněna i menší závislostí na vnějších podmínkách z hlediska redukce generativních orgánů.

hrách; nízké a vysoké odrůdy; tvorba výnosu; růstová analýza; fotosyntetická produkce

**ПЕТР Й.** (Сельскохозяйственный институт, Прага-Сухдол). **Фотосинтетическая продуктивность низко- и высокостебельных сортов гороха (*Pisum sativum* L.). Rostlinná výroba (Praha) 21 (8) : 885-895, 1975.**

В ходе продолжавшихся 3 года опытов с помощью классического анализа роста по методике Международной биологической программы изучали продуктивность низко- и высокостебельных сортов гороха. Опыты показали, что для высоких сортов гороха типично быстрое образование сухого вещества в начале вегетации, тогда как низкие сорта усиливают это образование в период завязывания плодов и семян, более экономично распределяя сухое вещество. При почти одинаковом количестве образованного сухого вещества в обеих группах сортов высокие сорта расходуют большой его процент в стебли и листья, что может пригодиться при их использовании как зеленую массу. У низких сортов доля сухого вещества в стеблях меньше, но зато они сильнее ветвятся, ввиду чего их ветви содержат больший % сухого вещества, чем у высоких сортов. Значительна, однако, доля сухого вещества в генеративных органах: у низких сортов свыше 50 % от общего сухого вещ., у высоких на 10 % меньше. Индекс площади листьев больше у высоких сортов, но у низких установлены более высокие значения листовой поверхности в генеративный период. Доказана связь между интегральной листовой поверхностью в период завязывания плодов и семян и урожаем семян. Чистая продуктивность ассимиляции у низких сортов больше. У низких сортов гороха на семена более высокая урожайность обусловлена: лучшей (более экономной) дистрибуцией ассимилятов в пользу генеративных органов, повышенными значениями интегральной листовой поверхности, повышенным чистым эффектом ассимиляции и, следовательно, повышенным образованием сухого вещества в период завязывания стручков и семян. Наряду с этими критериями продукции, урожайность низкостебельных сортов обусловлена меньшей зависимостью от внешних условий с точки зрения редукции генеративных органов.

горох; низкостебельные и высокостебельные сорта; образование урожая; анализ роста; фотосинтетическая продукция

---

**Adresa autora:**

Doc. ing. Jiří Petr, CSc., Vysoká škola zemědělská, 160 21 Praha - Suchdol

---

## Výběr z nových přírůstků

### Ústřední zemědělské a lesnické knihovny ÚVTI

#### z úseku rostlinné výroby

Uvedené publikace je možné si zapůjčit osobně nebo písemně v ÚZLK, výpůjční oddělení, 120 56 Praha 2, Slezská 7. Výpůjční doba: pondělí až pátek od 9 do 18 hodin. U každé žádané publikace uveďte signaturu.

Marčenko, N. M. — Litvinov, M. A. — Verchovskij, V. M. E 37.440  
Kompleksnaja mehanizacija prigotovlenija i vnesenija udobrenij. Moskva, Kolos 1974. 399 s. 160 obr. 65 tab. (Hnojení — mechanizace — příručka / Strojená hnojiva — výroba — mechanizace — příručka).

Demes, G. C 22.466/53  
Mütrágya kezelés és kiszórás. Gödöllő, Mezög. gépkísérleti intézet 1974. 23 s. 9 obr. 7 tab. Értesítő termeléséstechnológiák műszaki vizsgálatáról 53. (Strojená hnojiva — hnojení — mechanizace — výzkum / Strojená hnojiva — skladování — mechanizace — výzkum — Maďarsko).

Vylkov, I. D. — Nikolov, G. P. C 16.787/1974/25  
Sooruzenija dlja chranenija i mašiny dlja podgotovki i vnesenija nasypnyh mineralnyh udobrenij. Sofija, Centăr za nauč.-techn. i ikonom. inf. po selsko i gorsko stopanstvo pri ASN 1974. 72 s. obr. tab. (Strojená hnojiva — hnojení — mechanizace — studijní zprávy — Bulharsko).

Achorn, F. P. — Baley, H. L. C 22.880/51  
Application of fluid fertilizers. Muscle Shoals (Alabama), Tennessee valley authority 1970. 8 s. fot. Repr. from the Agric. Chemicals, 1970. May and June. (Hnojiva tekutá — hnojení — mechanizace).

White, R. K. — Hamdy, M. Y. — Short, T. H. D 28.422/197  
Systems and equipment for disposal of organic wastes on soil. Wooster (Ohio), Agric. research and dev. center 1975. 31 s. 26 obr. 4 tab. Research circular 197. (Hnojiva organická — hnojení — mechanizace — výzkum — USA — Ohio).

# WATER POTENTIAL IN LEAF BLADES OF FIELD-GROWN SUGAR BEET PLANTS AND THE ACTUAL TO POTENTIAL EVAPOTRANSPIRATION RATIO

J. ULEHLA, L. ZICHOVÁ

ULEHLA J., ZICHOVÁ L. (Agricultural Research Institute, Hrušovany near Brno). *Water Potential in Leaf Blades of Field-Grown Sugar Beet Plants and the Actual to Potential Evapotranspiration Ratio*. Rostlinná výroba (Praha) 21 (8) : 897-995, 1975.

Water potential deficit was measured in the leaves of field-grown sugar beet plants in about weekly intervals for several growing seasons. Good correlation was found between the results of such measurements and the coefficients of moisture availability calculated from weather data as the ratio of actual to potential evapotranspiration.

sugar beet; plant water relations; water potential of leaves; potential evapotranspiration; actual evapotranspiration

The yields of agricultural crops are often depressed in the subhumid region of Southern Moravia (Pospíšil 1934, Ulehla 1947, Baňoch 1952, Baňoch, Slepíčka 1963). In Pohořelice (southern Moravia) sugar beet was used as a model plant in laboratory and field studies concerning the water relations, growth and yield (Ulehla, Zichová, Baňoch 1965, Ulehla and Zichová 1968, Ulehla 1971a). Concurrent studies pertained to potential evapotranspiration estimates (Ulehla 1971b) and to comparisons of actual irrigation regimes, based on soil moisture data, with those calculated from weather data (Ulehla 1972). In the present paper the data on water potential in leaf blades of field-grown sugar beet plants are correlated with the actual to potential evapotranspiration ratios derived by means of a simple model.

## METHODS

Sugar beet was cultivated in a crop rotation comprising 10 crops, on experimental fields at Pohořelice u Brna ( $\phi = 48^{\circ}59'$ ,  $\lambda = 16^{\circ}31'$ ). Three irrigation regimes (including the non-irrigated control) combined with 2 levels of fertilizing represented 6 experimental variants (Baňoch 1962, Matějčková 1970).

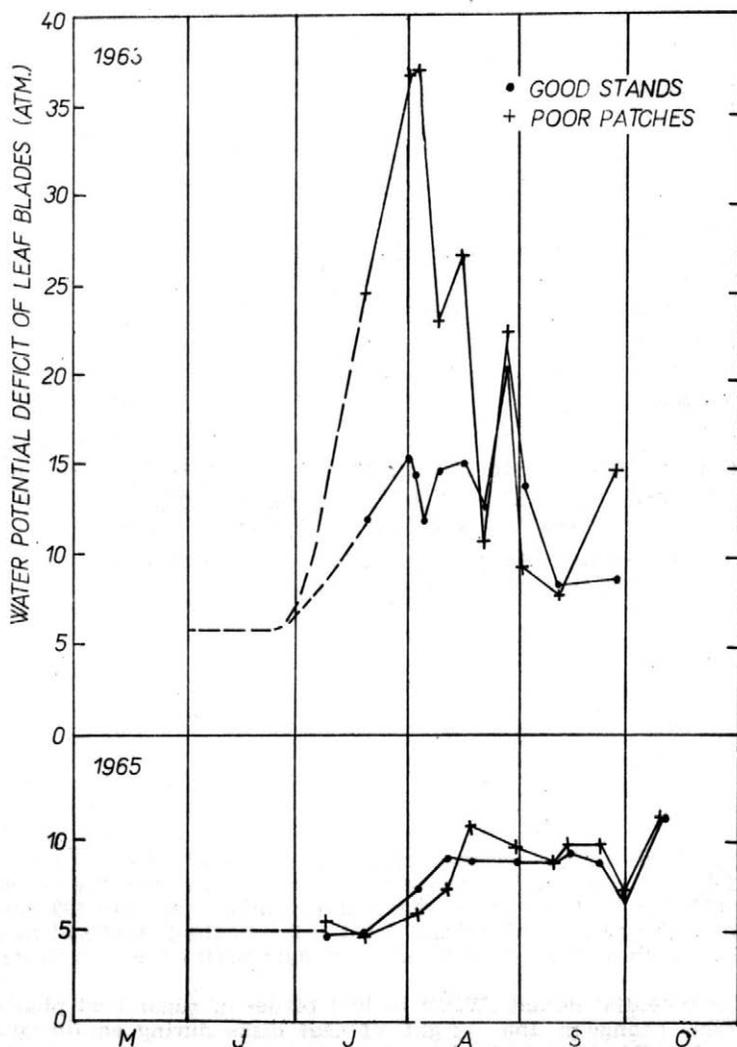
The soil is a typical chernozem on loess passing at the depth of 110 cm into yellowish sandy loam with occasional intrusions of gravel (Talařantová 1970). The hydrogeological characteristics as given in or derived from the report by Matějčková (1970) are as follows: the maximum capillary capacity 190 mm, the field capacity 180 mm, the permanent wilting point 100 mm, the lowest soil moisture content observed beneath a plant stand 90 mm, all data pertaining to a 60 cm deep soil layer.

The water potential deficit (WPD) in leaf blades of sugar beet plants was estimated from the change in the weight of leaf disks during equilibration against flowing (Ulehla, Zichová, Baňoch 1965) or stationary (Kreeb 1960) sodium chloride solutions of known osmotic potential. The water potential of leaf blades was subsequently identified with the osmotic potential resulting in no change of the weight of the disks, found by interpolating the data.

The potential evapotranspiration according to Penman (1963) and water balance were calculated from weather data measured at the meteorological station at Pohořelice, about 3 km distant from the experimental fields.

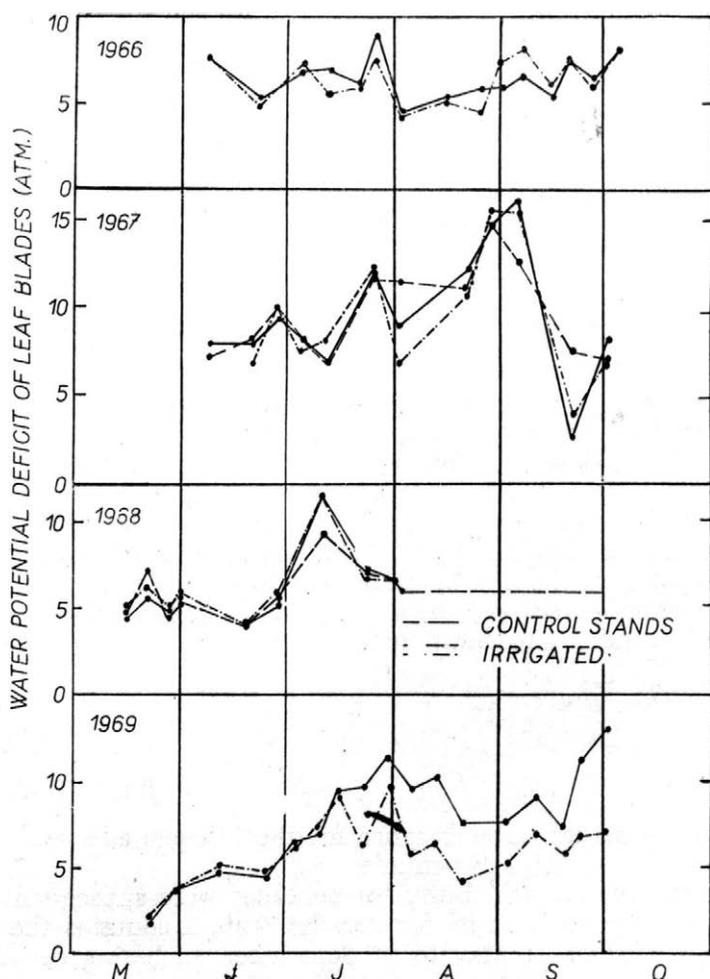
## RESULTS

The water potential deficits in leaf blades of non-watered plants followed courses more or less characteristic of each year as shown in Fig. 1 and 2. The measured values ranged from 1.8 to 20.5 atm (data for „poor“ patches not included) with maximum values occurring mostly during the summer months. Extremely high values were observed in 1963 and 1967 towards the end of August and the beginning of September. The water potential deficits measured in plants from poor patches reached considerable



1. The changes of water potential deficit (atm) in the leaf blades of sugar beet plants in the course of the growing season 1963 and 1965 on good (O) and poor (+) sites. — Změny deficitu vodního potenciálu (atm) v listových čepelích cukrovky během vegetačního období 1963 a 1965 na dobrých (O) a výpalových (+) stanovištích

rably higher values (37 atm) during the drought of 1963 than in plants from good but also non-watered stands (Fig. 1). The differences between poor and good sites were considerably less conspicuous in the year 1965 with more favourable weather conditions. Low water potential deficits, from 4.0 to 9.0 atm, were consistently recorded during the relatively wet year 1966. The water potential deficit was also measured for some irrigated variants (plots) during 1966 to 1969. The results for 1969 may be considered as typical. The measured data for 1963, 1965 and 1968 do not



2. The changes of water potential deficit (atm) in the leaf blades of sugar beet plants in the course of the growing season 1966 to 1969 on non-irrigated control plots (OH, OHH) and on irrigated plots (ZH, ZHH, ZZH, ZZHH). — Změny deficitu vodního potenciálu v listových čepelích cukrovky během vegetačního období 1966 až 1969 na dílcích nezavlažovaných, kontrolních (OH, OHS) a na dílcích zavlažovaných (ZH, ZHH, ZZH, ZZHH)

cover the whole growing season. The presumed courses of water potential deficit during the periods with lacking data are represented in Fig. 1 and 2 by dashed lines.

The water balance calculations for the 0 to 60 cm soil layer showed that the potential evapotranspiration had to be multiplied by a coefficient of 0.85 or 0.90 (according to the respective irrigation regime simulated) to attain practical coincidence of the calculated irrigation regime with those based on soil moisture measurements (Úlehla 1972). However, the soil profile conditions are such as to permit the roots to penetrate below the 0 to 60 cm layer. It has been therefore assumed in this study that a closed stand of sugar beet, well supplied with water, deprives of it the soil profile with a rate corresponding to the potential evapotranspiration. Of the transpired water, 85 to 90 p. c. were supposed to come from the layer 0 to 60 cm and the remaining 15 to 10 p. c. from the deeper layers.

Different relations were tested to express the dependence of calculated actual evapotranspiration on total deficit (Baier 1969). Here a simple linear relation is used.

$$KA_i = 1.0 \quad , \text{ when} \quad TDA_{i-1} - R_i \leq 0, \text{ and}$$

$$KA_i = \frac{200 + R_i - TDA_{i-1}}{200}, \text{ when} \quad TDA_{i-1} - R_i > 0$$

$KA_i$  is the coefficient of soil moisture availability (the calculated actual to potential evapotranspiration ratio) for the  $i$ -th pentade,  $TDA_{i-1}$  the total deficit for the  $(i - 1)$ -th pentade,  $R_i$  the rainfall for the  $i$ -th pentade. The relation indicates that the plant stand is supposed to eventually remove 200 mm of water from the whole soil profile under extreme conditions of long lasting drought. By the coefficient of availability,  $KA_1$ , the potential evapotranspiration was multiplied to obtain the calculated actual evapotranspiration required in the calculation of the actual total deficit for the pentade under consideration:

$$BA_i = R_i - ET_i \cdot KA_i$$

$$TDA_i = TDA_{i-1} - BA_i \quad , \text{ if} \quad BA_i < TDA_{i-1} \quad , \text{ and}$$

$$TDA_i = 0 \quad , \text{ if} \quad BA_i \geq TDA_{i-1} \quad ,$$

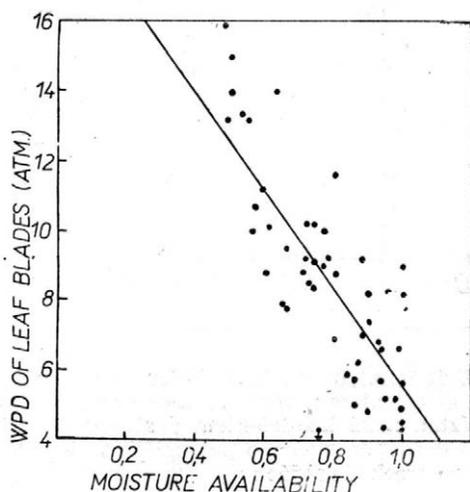
where  $BA_i$  is the actual water balance for the  $i$ -th pentade, and  $TDA_i$  the total actual deficit in the  $i$ -th pentade.

The coefficients of availability for pentades were subsequently paired to calculate average coefficients for decades. Tab. 2 contains the resulting data for the period of 31 May to 27 September, including decades 16 to 27, for the years 1963 and 1965 to 1969. Tab. 1 presents the corresponding data on water potential deficits in sugar beet leaves. These were obtained by reading the water potential deficits for the 5th day of each decade from the respective curves on Fig. 1 and 2 for good stands.

The 56 pairs of complete data were used to calculate the highly significant correlation coefficient  $r_{xy} = 0.79$ ,  $t = 9.54$ . The regression of water potential deficit in the leaves on the coefficient of availability is shown in Fig. 3.

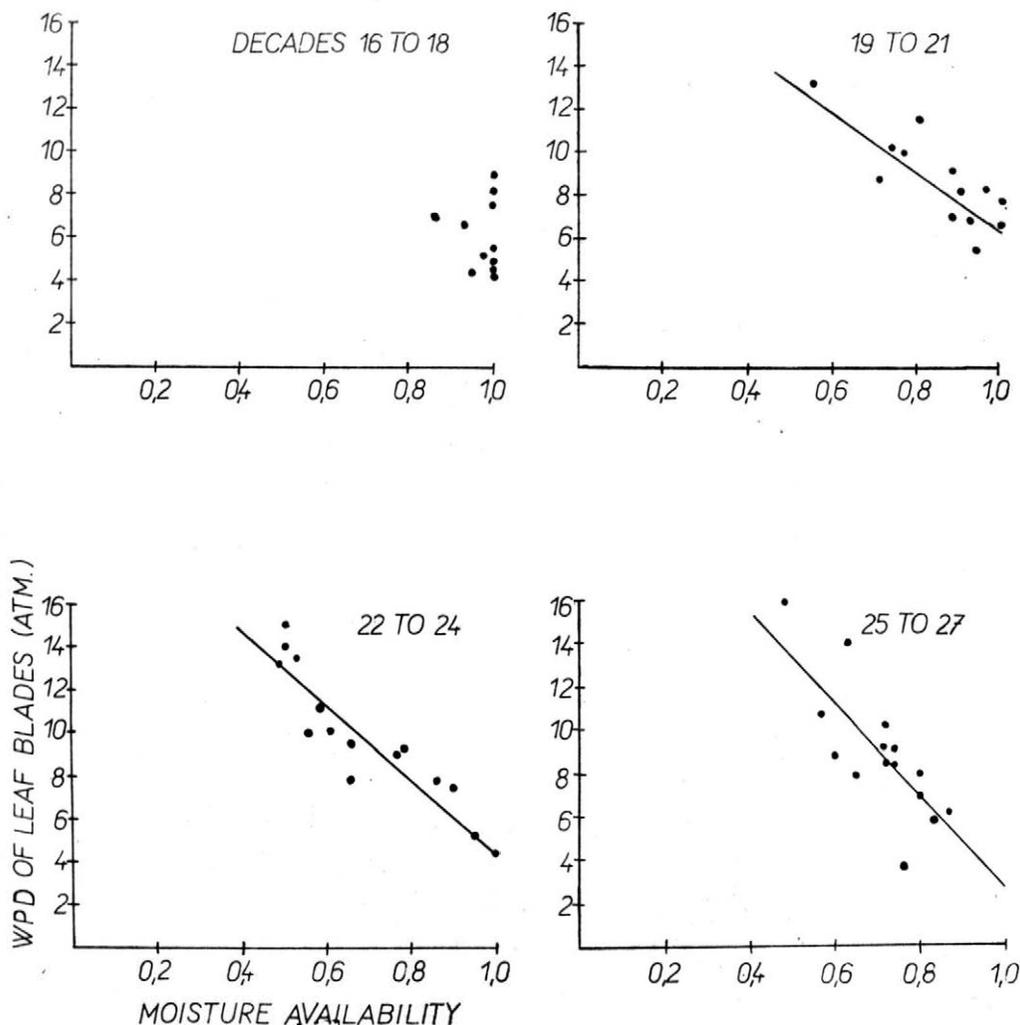
I. The water potential deficits (atm) in sugar beet leaves. — Deficit vodního potenciálu (atm) v čepelích cukrovky po dekádách podle roků. Hodnoty získány interpolací z grafů na obr. 1 a 2

Decade	1963	1965	1966	1967	1968	1969	Aver.
16	—	—	7.6	8.2	5.2	4.3	6.0
17	—	—	6.6	8.2	4.4	4.9	5.8
18	—	—	5.6	9.0	5.0	4.5	5.8
19	—	—	7.0	8.3	8.8	6.6	7.2
20	—	4.8	6.8	8.2	10.0	9.2	8.2
21	13.2	5.4	7.8	11.6	—	10.2	9.3
22	14.0	7.4	4.5	9.5	—	10.1	8.6
23	15.0	9.2	5.2	11.2	—	10.0	9.4
24	13.2	9.0	5.7	13.4	—	7.8	9.2
25	14.0	8.8	6.2	15.9	—	7.9	9.8
26	8.4	9.1	5.9	10.2	—	8.8	8.1
27	8.5	9.2	8.9	3.7	—	10.7	7.5



3. The regression of the water potential deficit (atm) in the leaf blades of sugar beet plants on the coefficient of water availability calculated from weather data for decades 16 to 27 of 1963, 1965-1969. — Vztah mezi koeficientem dostupnosti vody vypočítaným z povětrnostních údajů a mezi deficitem vodního potenciálu (atm) v listových čepelích cukrovky pro 16. až 27. dekádu.

To find out whether seasonal trends affected the regression, the original set of data pairs was split in four subsets for decades 16 to 18, 19 to 21, 22 to 24, and 25 to 27, corresponding roughly to the months of June to September (Fig. 4). Tab. 4 presents the regression coefficients  $a$  and  $b$ , averages  $\overline{KA}$  and  $\overline{WPD}$  and the  $t$  values, as well as the sums of potential evapotranspiration for the respective periods. No regression was calculated for the „June“ subset where both the  $KA$  and  $WPD$  values are more or less clustered and indicated good soil moisture availability.



4. The regression of the water potential deficit (atm) in the leaf blades of sugar beet plants on the coefficient of water availability calculated from weather data for four periods each including three decades. — Vztah mezi koeficientem dostupnosti vody vypočítaným z povětrnostních údajů a mezi deficitem vodního potenciálu v listových čepelích cukrovky (atm) pro čtyři období po třech dekadách

## DISCUSSION

Different possible sources of variance unaccounted for in the calculations can be expected to affect the correlation between the moisture availability, derived from the water balance, and the water potential deficit in the leaf blades of field-grown sugar beet plants. A quite obvious source of inaccuracy is e. g. the uncertainty concerning the rainfall distribution during the pentades. The closeness of the overall correlation between the weather and the biological data may be therefore regarded as

II. The coefficients of water availability (KA). — Koeficienty dostupnosti vody (KA), odvozené jako poměry vypočítané evapotranspirace aktuální k evapotranspiraci potenciální, po dekádách podle roků

Decade	1963	1965	1966	1967	1968	1969	Aver.
16	0.96	1.00	0.99	0.97	0.98	1.00	0.98
17	0.85	1.00	0.93	1.00	0.95	1.00	0.96
18	0.95	1.00	1.00	1.00	0.86	1.00	0.97
19	0.78	1.00	0.88	0.96	0.71	0.99	0.89
20	0.68	0.90	0.93	0.90	0.77	0.88	0.84
21	0.55	0.94	1.00	0.80	0.76	0.74	0.80
22	0.50	0.90	1.00	0.66	0.96	0.61	0.77
23	0.50	0.78	0.95	0.59	1.00	0.56	0.73
24	0.49	0.77	0.86	0.53	1.00	0.66	0.72
25	0.63	0.80	0.87	0.48	1.00	0.65	0.74
26	0.74	0.74	0.84	0.72	0.94	0.60	0.76
27	0.73	0.72	0.80	0.76	0.89	0.57	0.74

III. The relations between the water availability coefficients and the water potential deficits for four periods. — Vztahy mezi koeficienty dostupnosti vody a mezi deficitem vodního potenciálu pro čtyři trojice dekád

Decade	N	$\overline{KA}$	$\overline{WPD}$	$r_{xy}$	a	b	t	$\overline{ET}$
16–18	11	0.97	5.93	—	—	—	—	108
19–21	14	0.85	8.44	-0.77	20.5	-14.1	4.25 <sup>+</sup>	113
22–24	15	0.69	9.68	-0.92	21.6	-17.2	8.66 <sup>++</sup>	96
25–27	15	0.71	8.94	-0.76	24.5	-21.9	4.33 <sup>++</sup>	60

N — number of pairs,  $\overline{KA}$  — the average water availability,  $\overline{WPD}$  — the average water potential deficit in leaves,  $r_{xy}$  — the correlation coefficient, a and b — the characteristics of the regression of WPD on KA (a the intercept, b the slope), t — the statistics,  $\overline{ET}$  — the average potential evapotranspiration for the period

+ — significant at the 0.01 level, ++ significant at the 0.001 level

satisfactory. The results may be further considered as corroborating the applicability of similar water balance calculations to the scheduling of irrigation regimes of agricultural crops in the region of southern Moravia (Úlehla 1974a, b).

Differences in slopes of regression lines for three of the four subsets can be observed in Fig. 4. The differences are not statistically significant. Nevertheless the increase of slope with decade numbers suggests the regressions of subsets and the closeness of the overall regression to be affected by a further factor or factors related to the seasonal trend of weather changes. Such changes can be demonstrated by the averages of potential

evapotranspiration sums, given in the last column of Tab. III, integrating other pertinent weather data. The different slopes of regression lines can be therefore supposed to indicate in agreement with general evidence that the WPD values depend rather on the weather conditions at high values of KA, i. e. at good soil moisture conditions, than at low values of KA. Thus, under the conditions of good soil moisture supply a smaller gradient of WPD between soil and leaf is necessary in September, when the evapotranspiration is low, than in July, when evapotranspiration is at its peak, to provide for the adequate water flow from the soil to the leaves.

These conclusions do not contradict the observation that the WPD values depend above all on the soil properties during the periods of prolonged drought as evidenced by the comparison of data for poor and good stands and for the contrasting years of 1963 and 1965 (Fig. 1).

The data presented in this paper point to some problems concerning the irrigation regimes. The WPD values for the irrigated variants in 1969 were considerably higher than the WPD values for the non-irrigated variant in the wet year 1966. It is impossible to decide whether this is a consequence of differences in average evapotranspiration rates, or whether the data reflect differences in soil moisture contents of the deeper layers of the soil profile.

The information on the close relation between the water balance calculations, based on potential evapotranspiration estimates, and between the water potential in leaf blades is of importance regarding the close relation of transpiration to photosynthesis (Brix 1962) and therefore also between the growth and yields.

## References

- BAIER, W.: Concepts of soil moisture availability and their effect on soil moisture estimates from a meteorological budget. *Agric. Meteorol.*, 1969, No. 6, p. 165-178.
- BAŇOCH, Z. — SLEPIČKA, J.: Závlaha jako prostředek zintenzivňující zemědělskou výrobu v tepelně příznivých oblastech ČSSR (Irrigation of crops as a factor intensifying the agricultural production in the regions of ČSSR with favourable temperature). *Rostlinná výroba*, 9, 1963, No. 4, p. 399-422.
- BRIX, H.: The effect of water stress on the rates of photosynthesis and respiration in tomato plants and loblolly pine seedlings. *Physiol. Plantarum*, 1962, No. 15, p. 10-20.
- KREEB, K.: Ueber die gravimetrische Methode zur Bestimmung der Saugspannung und das Problem des negativen Turgors. I. *Planta*, 1960, No. 55, p. 274-283.
- MATEJÍKOVÁ, O.: Vyhodnocení diferencovaných závlahových režimů u hlavních polních plodin (The evaluation of differential irrigation regimes for the main agricultural crops). *Res. rep. Agric. Res. Inst., Hrušovany u Brna* 1970.
- POSPÍŠIL, K.: Vodohospodářské poměry jižní Moravy z hlediska zemědělce (The hydrological conditions of southern Moravia as seen by the agriculturist). *Hodonín* 1934.
- TALAFANTOVÁ, A.: Podrobná hydrofyzikální charakteristika černozemí (A detailed hydrophysical characteristics of chernozems). *Res. rep. Agric. Res. Inst., Hrušovany u Brna* 1970.
- ÚLEHLA, J.: Potenciální evapotranspirace v letech 1952-1969 v Pohořelicích (Potential evapotranspiration at Pohořelice in 1952 to 1969). *Rostlinná výroba*, 17, 1971, No. 2, p. 191-200.
- ÚLEHLA, J.: Calculation of water balance of irrigated sugar beet stands from potential evapotranspiration, rainfall and date of sowing. *Scientia Agric. Bohemoslovaca*, 4, 1972, No. 1, p. 1-12.
- ÚLEHLA, J.: Výpočet závlahového režimu ozimé pšenice z potenciální evapotranspirace a srážek (Calculation of irrigation regime for winter wheat from potential evapotranspiration and rainfall). *Proc. Symp. Irrigation of Cereals, Kutná Hora*, 1974, p. 157-173.

ULEHLA, J.: Využití výpočetní techniky při určování režimu doplňkových závlah na jižní Moravě (Computer programmed irrigation regimes in southern Moravia). Proc. Conf. 55th Anniversary Agric. Univ., Brno 1974b.

ÚLEHLA, J. — ZICHOVÁ, L.: Actual and growth deficits in leaf disks from a sugar beet plant during a cycle of water stress. Folia Fac. Sci. Nat. Univ. J. E. Purkyně IX, Biol., 18, 1968, p. 111-118.

ULEHLA, J. — ZICHOVÁ, L. — BAŇOCH, Z.: Influence of soil heterogeneity on water regime and yields of lucerne, sugar beet and wheat. Biologia Plantarum, 7, 1965, p. 449-462.

ULEHLA, V.: Napojme prameny (Let the springs refill). Brno 1947.

8. 4. 1975

ULEHLA J., ZICHOVÁ L. (Výzkumný ústav základní agrotechniky, Hrušovany u Brna). *Vodní potenciál v čepelích cukrovky pěstované v polních podmínkách a poměr a aktuální a potenciální evapotranspirace*. Rostlinná výroba (Praha) 21 (8) : 897-905, 1975.

Deficit vodního potenciálu v listových čepelích cukrovky, která se pěstovala v polních podmínkách, určoval se přibližně v týdenních intervalech po několik vegetačních období. Zjistila se dobrá korelace mezi výsledky těchto měření a mezi dostupností vody vypočítanou z údajů o počasí jako poměr aktuální a potenciální evapotranspirace.

cukrovka; vodní provoz rostlin; vodní potenciál čepelí; potenciální evapotranspirace; aktuální evapotranspirace

УЛЕГЛА Й., ЗИХОВА Л. (Научно-исследовательский институт основной агротехники, Грушованы у Брно). *Водный потенциал в пластинках листьев сахарной свеклы, выращиваемой в полевых условиях, и отношение между актуальной и потенциальной эвапотранспирациями*. Rostlinná výroba (Praha) 21 (8) : 897-905, 1975.

Дефицит водного потенциала в пластинках листьев сахарной свеклы, которая выращивалась в полевых условиях, определялся приблизительно в недельных интервалах в течение нескольких вегетационных периодов. Была установлена хорошая корреляция между результатами этих измерений и между доступностью воды, вычисленной из данных о метеорологических условиях, как отношение актуальной и потенциальной эвапотранспирации.

сахарная свекла; водный режим растений; водный потенциал листьев; потенциальная эвапотранспирация; актуальная эвапотранспирация

ULEHLA J., ZICHOVÁ L. (Forschungsinstitut für Anbautechnik, Hrušovany bei Brno). *Die Beziehung zwischen dem Wasserpotentialdefizit in Blättern der unter Feldbedingungen kultivierten Zuckerrübe und dem Verhältniss der effektiven zu der potentiellen Evapotranspiration*. Rostlinná výroba (Praha) 21 (8) : 897-905, 1975.

Das Wasserpotentialdefizit in Blättern der unter Feldbedingungen kultivierten Zuckerrübe wurde während mehreren Vegetationsperioden ungefähr einmal pro Woche bestimmt. Eine gute Korrelation zwischen dem beobachteten Wasserpotentialdefizit und einem als Verhältniss der effektiven zur potentiellen Evapotranspiration berechnetem Koeffizienten der Wassererreichbarkeit wurde gefunden.

Zuckerrübe; Wasserhaushalt der Pflanzen; Wasserpotential der Blätter; potentielle Evapotranspiration; effektive Evapotranspiration



Adresa autorů:

Dr. J. Úlehlá, CSc., Dr. L. Zichová, Výzkumný ústav základní agrotechniky, 664 62 Hrušovany u Brna

# RECENZE

## SOUBORNÉ PRÁCE O POKROKU V EKOLOGICKÉM VÝZKUMU

*Sborník Advances in ecological research, sv. 8, 1974, vydavatel A. Macfadyen. Vydal Academic Press, London and New York, 1974, 418 s.*

Osmý svazek sborníku obsahuje čtyři souborné studijní práce s ekologickou tematikou různých objektů. Naši pozornost vzbuzuje zejména druhá ze čtyř studií, věnovaná ekosystému obilnin, a poslední, zabývající se populačními cykly drobných savců, a to hračbošů a lumíků.

V úvodu ke sborníku se vydavatel (A. Macfadyen) zmiňuje o úzké specializaci ekologického výzkumu nejen s ohledem na různé objekty, ale i na použité metody a sledovaný cíl. To vede k tomu, že mnoho prací ztrácí svůj širší význam a mohou být sledovány jen velmi úzkým okruhem specialistů. Jejich význam se ztrácí v malé návaznosti na širší a důležitější problematiku. Proto jsou nutné souborné studie, zpracovávající širší ekologická témata ze světové literatury. Přehledné zpracování umožňuje širší i hlubší pohled a čtenář má možnost podle potřeby v citované literatuře vyhledat podrobnosti, které jej speciálně zajímají. Lze poznamenat, že podobná situace se v současné době jeví i v jiných biologických disciplínách. U ekologie k tomu přistupuje skutečnost, že souvisí v mimořádném rozsahu s jinými vědními obory, jako je obecná biologie, taxonomie, fyziologie a morfologie, genetika, populační genetika, etologie, i nebiologickými obory zabývajícími se faktory, vytvářejícími prostředí živých organismů.

Souborné ekologické práce jsou proto důležité pro pracovníky různých oborů základního i aplikovaného výzkumu, které se navzájem prolínají.

První příspěvek v rozsahu 105 stran (G. L. Young) včetně 17 stran literatury se zabývá ekologií člověka s interdisciplinární koncepcí, která přesahuje rámec přírodních věd a navazuje nejen na sociální vědy, ale mj. také na aplikovanou humánní ekologii v technice, architektuře, ochraně prostředí, zdravotnictví atd., aniž by si autor činil nároky na úplnost zpracování, které prakticky není možné.

Z našeho hlediska nejdůležitější částí sborníku je studie G. R. Pottse a G. P. Vickermana o ekosystému obilnin. Práce zaujímá 90 stran včetně lite-

ratury (8 stran), na rozdíl od předcházející práce obsahuje četné tabulky (23), grafy, mapy a fotografie (celkem 24). Studie se zabývá oblastí o ploše asi 50 km<sup>2</sup> v jihovýchodní Anglii (hrabství West Sussex), má však svým zaměřením širší a obecnější význam.

Téměř celá oblast byla v letech 1939 až 1945 používána jen pro vojenský výcvik, v letech 1947 až 1954 byla postupně rekultivována na zemědělskou půdu. Do roku 1967 se provozoval v této oblasti intenzivní chov ovcí a při pěstování rostlin se používal modifikovaný norfolkský systém. Tento tradiční způsob hospodaření některé farmy od r. 1967 opouštěly. Poklesl chov ovcí, zaváděly se olejnin a luskoviny, jarní ječmen se pěstoval dvakrát po sobě na téže ploše. Systém se stával méně komplexním a méně stabilním. K největšímu poklesu chovu ovcí došlo v letech 1969 a 1970, nyní se očekává určité oživení. Největší plochu zaujímá jarní ječmen (51,1 %) a ozimá pšenice (29,9 %). Ozimý ječmen je na 9,2 % plochy, jarní pšenice na 4 %, ozimý oves na 5,2 % a jarní oves na 0,6 % plochy, obilniny se pěstují celkem na 66 % polí. Podíl jednotlivých obilnin se značně podobá poměrům ve Velké Británii jako celku.

Práce dále uvádí podrobnosti o půdních podmínkách a dalších pěstovaných rostlinách, zejména jetelovinách a travách. Jsou uvedeny podrobné údaje o flóře obilních polí (počet pozemků, na kterých se vyskytují jednotlivé plevele), způsoby kultivace a boje proti všem škodlivým činitelům.

Třetí kapitola se zabývá změnami v ekologické rozmanitosti při přechodu zatravněných porostů na obilní. Snaha o eliminaci všech jiných rostlinných druhů mimo příslušné obilniny vede také ke změnám v zastoupení jednotlivých druhů škodlivé i užitečné fauny. Mezi rozmanitostí flóry a fauny a změnami v kvantitativním i kvalitativním zastoupení druhů existují vzájemné vztahy, které jsou podrobně zpracovány. Zvláštní pozornost věnují autoři prostorovému i časovému výskytu plevelů.

*Ing. J. Kučera, CSc.*

# THE INFLUENCE OF BIOLOGICAL AGE ON SOME GROWTH AND REPRODUCTION CHARACTERISTICS IN THREE-YEAR OLD HOP PLANTS (*HUMULUS LUPULUS* L.)

V. RYBÁČEK

RYBÁČEK V. (University of Agriculture, Praha-Suchbát). *The Influence of Biological Age of Some Growth and Reproduction Characteristics in Three-Year Old Hop Plants (*Humulus lupulus* L.)*. Rostlinná výroba (Praha) 21 (8) : 907-919, 1975.

In the experiments in the years 1972–1973 with three-year old hop plants (Osvald clone 72) growth analysis of the overground organs and whole plants was conducted in two-week intervals from May 29 to September 4. From the end of May up to mid-August a similar course of the growth characteristics was found in the overground systems and whole hop plants. This evidence makes it possible to replace, in the above mentioned period, the laborious growth analysis of whole three-year old and older plants by growth analysis of their overground organ system. After mid-August and in one-year and two-year plants even before this term, marked changes of dry matter amounts in the underground organs distorting the results of the growth analysis appear. For the growth period of the overground reproductive organs (in hop from July 10 to September 4) a method of reproduction analysis was worked out. The method can also be used for determining formation dynamics of the underground reproductive organs. In confronting the course of several indices determined by the growth and reproduction analyses with the course of biological age (BA) it was found out that the net assimilation rate (NAR) was negatively influenced by increasing leaf biological age. The coefficient of the reproduction process (KPR) is similarly influenced by the stalk and leaf biological age.

Photosynthesis; respiration; hop; growth analysis; reproduction analysis; age analysis; overground and underground reproductive organs; biological age — BA; net assimilation rate — NAR; coefficient of the reproduction process — KRP

The prognosis of actual agricultural crop production requires, besides plant cover density, also a production study of the plants represented in the stand. In the climber hop (*Humulus lupulus* L.) stands the spacing is stabilized and therefore — in careful treatment — the number of set up hop vines per area unit is also stabilized. Under these conditions the production of hop stands is directly proportional to plant production. This depends on the dynamics of dry-matter formation and its distribution into the individual organs, especially hop cones which are the main hop-picking product.

Our study was focused on the investigation into the relations between biological age of the whole hop plants and their parts, dry-matter increase and its distribution into the reproductive organs. Biological age was determined according to the balance intensity of aging and rejuvenescence processes (Rybáček 1966). Intensity of the aging processes was determined according to a calcium content which is the indicator of plant cell and tissue aging. According to Confort (1969) nail calcium content is a suitable aging index in human gerontology because it increases parallelly with the calcium content in arteries. The intensity of the rejuvenescence processes is characterized by the content of organic nitrogenous substances determined according to the content of organic nitrogen.

The dynamics of plant dry matter increase and its characteristics were studied by means of growth analysis methods surveyed in the monograph by Šesták et al. (1966). Their application in hop is presented in the paper by Pichl and Rybáček (1974). No method suitable for characterizing the distribution dynamics of plant dry matter into the reproductive organs enabling a comparison with the results of growth analysis was found in the available literature and that is why we used our own method designated as reproduction analysis.

## MATERIAL AND METHODS

In order to fulfil the tasks set up growth reproduction and age analyses of the whole three-year old hop plants (variety 'Osvald clone No. 72') were accomplished in the years 1972 and 1973. The plants were withdrawn in two weeks' intervals from the Experimental Hop Garden stand at Uhřetěves. Throughout the whole period from May 29 to September 4, identical agronomical practices, and disease and pest control measures were maintained in the stand. Against suckling insect plant watering with a long-term active insecticide Terra-Syton was employed.

The initial values for growth analysis (green matter, plant dry-matter and leaf area) were obtained for two weeks' withdrawals of an average plant group consisting of 8–10 vines, without external pathological symptoms. Before hop drying the overground parts were divided according to organ classification into vines, axils, vine leaves, axil leaves and generative organs. Similarly also the underground organs were divided into new wood (vine and sucker wood), old wood (also vine and sucker wood), and roots. The dry matter weight of the whole hop plants, their underground and overground organs, was obtained by adding together the dry-matter of the respective organs. Leaf area was determined photoplanimetrically. Growth characteristics were calculated according to mathematical relations given in the paper by Šesták et al. (1966). An analogical procedure was used in reproduction analysis the initial values of which (leaf and stalk dry-matter and reproductive organ dry-matter) were obtained in two weeks' withdrawals from July 10 to September 4.

For the calculation of biological age, the total organic nitrogen content in the individual organs was determined according to Kjeldahl, as well as the calcium content by means of X-ray fluorescent analysis using VAR-2 apparatus manufactured by Zeiss, Jena.

The degree of biological age (BA) was calculated according to the formula  $BA = \frac{10 \text{ Ca}}{N}$  given in the paper by Rybáček (1975).

Structural changes of the overground and underground hop plant systems were calculated according to percentual dry-matter representation of the individual organs present in the given system.

## RESULTS

The basic precondition for accomplishing the individual analyses included in the growth, reproduction and age methodology as well as for the evaluation of certain relations between their results was a quantitative dry-matter determination of all overground and underground organs of three-year old hop plants. The results are presented in Tab. I indicating that the dry-matter of the underground organ system changed only slightly in the period from May 29 to August 7, varying less than  $\pm 5\%$ . The overground organ dry-matter steadily increased up to September 4. Some changes of its growth rate are connected with the appearance of the main phenological indices given in Tab. II.

The initial values for growth analysis of the whole hop plants are given in Tab. III, those of their overground parts in Tab. IV. Tab. III indicates that in the overground organ system the dry-matter increments (CW) up to July 10 amounted to more than a double in two weeks' time. The comparison of the two tables implies that up to August 7 there were no substantial differences in the increments of the overground parts and whole plant increments due to nearly balanced dry-matter of the underground organ system.

I. Relative dry matter amounts (in g) in three years old hop plants in the years 1972–1973. — Průměrné množství sušiny (v g) u tříletých chmelových rostlin v letech 1972–1973.

Date	29. 5.	12. 6.	26. 6.	10. 7.	24. 7.	7. 8.	21. 8.	4. 9.
Sh M	11.34	30.39	59.22	138.22	170.96	166.71	197.65	200.16
Sh L	0.11	3.76	19.72	51.06	85.35	90.15	95.54	125.64
Sh	11.45	34.15	78.94	189.28	256.30	256.85	293.19	325.80
LM	12.78	43.37	116.51	153.48	155.99	114.47	137.03	131.51
LL	—	2.66	23.42	70.37	92.69	104.24	136.31	149.43
L	12.78	46.03	139.92	223.85	248.68	218.71	273.34	280.94
C	—	—	—	6.17	101.68	199.75	235.57	255.96
C + L	12.78	46.03	139.92	230.01	350.36	418.46	508.91	536.89
OP	24.23	80.17	218.86	419.29	606.66	675.31	802.09	862.69
SO	31.38	27.85	25.58	24.23	25.23	21.28	27.47	29.11
SN	1.56	2.90	6.26	2.25	4.37	8.18	16.39	18.55
SO + SN	32.94	30.75	31.84	26.48	29.60	29.46	43.86	47.66
R	63.86	60.16	62.89	63.96	68.25	58.62	80.62	141.36
UP	96.80	90.91	94.72	90.43	97.84	88.08	124.48	189.01
OP + UP	121.03	171.08	313.57	509.72	704.49	763.39	926.53	1051.70

Explanations: Sh M main shoots  
 Sh L lateral shoots  
 LM main leaves  
 LL lateral leaves  
 C cones  
 OP overground portion  
 SO old stem  
 SN new stem  
 R roots  
 UP underground portion

II. Phenology of three years old hop plants in the years 1972–1973. — Fenologie tříletých chmelových rostlin v letech 1972–1973

Phenological index	Term of appearance		Interval between appearances (days)	
	1972	1973	1972	1973
Cutting	18. 4.	9. 4.	—	—
Beginning of budding	3. 5.	30. 4.	15	21
Three internodes	19. 5.	21. 5.	16	21
Lateral formation	7. 6.	8. 6.	19	18
Appearance of clubs	28. 6.	30. 6.	21	22
Appearance of female flowers	10. 7.	13. 7.	12	13
Cone formation	3. 8.	5. 8.	24	23
Picking maturity	24. 8.	25. 8.	21	20

III. Initial data for growth analysis of three years old whole hop plants in the years 1972–1973. — Výchozí údaje pro růstovou analýzu tříletých celých chmelových rostlin v letech 1972–1973

Date	$t_2 - t_1$	W	$C_W$		A	$C_A$	
			g	g		%	dm <sup>2</sup>
29. 5.	14	121.03			28.05		
12. 6.	14	171.08	50.05	29.26	82.25	54.20	65.90
26. 6.	14	313.57	142.49	45.44	233.04	150.79	64.71
10. 7.	14	509.72	196.15	38.48	312.95	79.91	25.53
24. 7.	14	707.49	194.77	27.65	480.31	167.36	34.84
7. 8.	14	763.39	58.90	7.72	519.17	38.86	7.49
21. 8.	14	926.53	163.14	17.61	770.38	251.21	32.61
4. 9.	14	1051.70	125.17	11.90	971.18	200.80	20.68

$t_2 - t_1$  = days

W = dry matter

$C_W$  = dry matter increment

A = assimilation area

$C_A$  = assimilation area increment

IV. Initial data for growth analysis of three years old (overground part) hop plants in the years 1972–1973. — Výchozí údaje pro růstovou analýzu tříletých rostlin (nadzemní část) chmelových v letech 1972–1973

Date	$t_2 - t_1$	W	$C_W$		A	$C_A$	
			g	%		dm <sup>2</sup>	dm <sup>2</sup>
29. 5.	14	24.23			28.05		
12. 6.	14	80.17	55.94	69.78	82.25	54.20	65.90
26. 6.	14	218.86	138.69	63.37	233.04	150.79	64.71
10. 7.	14	419.29	200.43	47.80	312.95	79.91	25.53
24. 7.	14	606.66	187.37	30.89	480.31	167.36	34.84
7. 8.	14	675.31	68.65	10.17	519.17	38.86	7.49
21. 8.	14	802.09	126.78	15.81	770.38	251.21	32.61
4. 9.	14	862.69	60.60	7.02	971.18	200.80	20.68

That is why the main characteristics of the growth analysis of whole hop plants and their organs given in Tabs. V and VI show a nearly identical course in the period from May 29 to August 7. After this term, the net assimilation rate had an identical tendency, but its values were higher in whole plants. As in the withdrawal period (May 29, June 12, June 26) the leaf area increments amounted to more than a double, it was necessary to take into consideration the relation of leaf area to dry-matter. This relation is expressed by the following equation:  $W = a + bA^x$ .

V. Main results of growth analysis of three years old whole hop plants in the years 1972–1973. — Hlavní výsledky růstové analýzy tříletých chmelových rostlin v letech 1972–1973

Date	$t_2 - t_1$	WL/W	A/WL	LAR	R	$R_A$	NAR
29. 5.	14	0.11	2.19	0.23			
12. 6.	14	0.27	1.79	0.48	0.025	0.077	0.071
26. 6.	14	0.45	1.67	0.74	0.043	0.074	0.070
10. 7.	14	0.46	1.40	0.61	0.035	0.021	0.052
24. 7.	14	0.35	1.93	0.68	0.057	0.031	0.030
7. 8.	14	0.29	2.37	0.68	0.005	0.006	0.008
21. 8.	14	0.30	2.82	0.83	0.012	0.038	0.018
4. 9.	14	0.27	3.46	0.92	0.010	0.017	0.010

VI. Main results of overground part growth analysis of three years old hop plants in the years 1972–1973. — Hlavní výsledky růstové analýzy nadzemních částí tříletých chmelových rostlin v letech 1972–1973

Date	$t_2 - t_1$	WL/W	A/WL	LAR	R	$R_A$	NAR
29. 5.	14	0.53	2.19	1.16			
12. 6.	14	0.57	1.79	1.03	0.086	0.077	0.079
26. 6.	14	0.64	1.67	1.06	0.074	0.072	0.068
10. 7.	14	0.56	1.34	0.75	0.046	0.021	0.053
24. 7.	14	0.52	1.93	0.79	0.022	0.031	0.029
7. 8.	14	0.42	2.37	0.77	0.008	0.006	0.010
21. 8.	14	0.34	2.82	0.96	0.013	0.028	0.014
4. 9.	14	0.33	3.46	1.13	0.005	0.017	0.005

$t_2 - t_1$  = days  
 WL = leaf dry matter  
 W = total dry matter  
 A = assimilation area  
 LAR = relative foliation  
 R = specific growth rate of the overground part  
 $R_A$  = specific growth rate of the leaf area  
 NAR = net assimilation rate

The exponent expresses the relation between the specific growth rate ( $R$ ) and the specific growth rate of the leaf area ( $R_A$ ), i. e.  $\alpha = \frac{R}{R_A}$ . As it was possible from the calculated exponents to assume a linear relation (the value of the calculated exponents approached 1,  $\alpha \doteq 1$ ) we used Williamson's equation for calculating net assimilation rate:

$$NAR = \frac{(W_2 - W_1) \cdot (\ln A_2 - \ln A_1)}{(A_2 - A_1) \cdot t_2 - t_1}$$

In the cases where the assimilation leaf area increased to less than a double between the subsequent withdrawals, a simpler equation was used, viz.:

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} \cdot \frac{1}{\bar{A}}$$

$\bar{A}$  = average assimilation area between two subsequent withdrawals.

In 1972 and 1973 the alternation tendency of net assimilation rate ( $NAR$ ), similarly as the tendency of the growth characteristics indices was identical with the two years' average. This is also true for the decreased dry weight increment ( $CW$ ) to less than a double after the withdrawal performed on July 10 and for balanced dry weight increments of the overground system and the whole plant up to August 7.

The initial and resulting values of the reproduction analysis are presented in Tab. VII. As the overground dry-matter has never reached a double increase in the withdrawals performed in the period from July 10 to September 4, the following formula was used for the calculation of the reproduction result coefficient:

$$KRP = \frac{WR_2 - WR_1}{t_2 - t_1} \cdot \frac{100}{W_{L+S}}$$

$W$  = average leaf and stalk dry matter between two subsequent intervals.

VII. Main results of reproduction analysis of the overground organs of three years old hop plants in the years 1972 - 1973. - Hlavní výsledky reprodukční analýzy nadzemních orgánů tříletých chmelových rostlin v letech 1972-1973

Date	$t_2 - t_1$	$W_{00x}$	$CW_{00x}$	$W(L + Sh)$	KRP
10. 7.	14	6.17		413.13	
24. 7.	14	101.68	95.51	504.98	1.3510
8. 8.	14	199.75	98.07	475.56	1.4730
21. 8.	14	235.57	35.82	566.53	0.4516
4. 9.	14	255.96	20.39	606.73	0.2400

$t_2 - t_1$  = days

$W_{00x}$  = cone dry matter

$CW_{00x}$  = cone dry matter increment

$W(L + Sh)$  = leaf and shoot dry matter

KRP = coefficient of the reproduction process

In the overground and underground organs in which the dry-matter was determined the biological age was stated as well. As the calcium level was determined to a thousandth of percent exactness, the following formula was used for the biological age determination:  $BA = \frac{10 Ca}{N}$ . The results are given in Tab. VIII. The table indicates that from July 10 an intensive biological age increase took place in the overground organ system, whereas in the underground organ system its considerable decrease was recorded.

VIII. Age analysis results of three years old hop plants in the years 1972–1973 according to biological age. — Výsledky věkové analýzy tříletých chmelových rostlin v letech 1972–1973 podle biologického věku (BA)

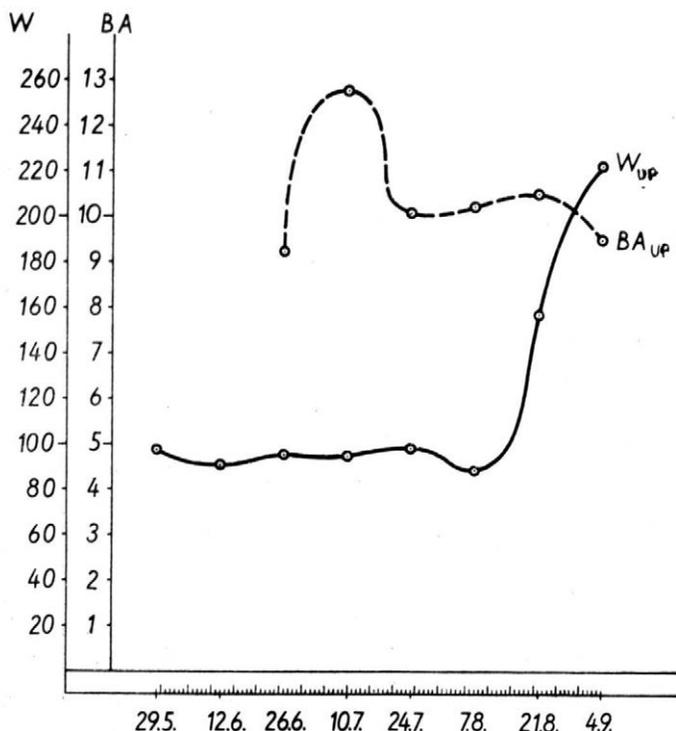
Date	29. 5.	12. 6.	26. 6.	10. 7.	24. 7.	7. 8.	21. 8.	4. 9.
Sh M	3.57	5.24	7.87	11.64	15.59	19.66	21.81	23.20
Sh L	—	—	4.92	9.55	13.17	12.46	15.61	21.81
Sh	3.57	5.24	6.90	11.12	14.74	17.07	18.85	22.73
LM	—	—	7.20	9.73	14.86	13.69	16.32	20.61
LL	—	—	—	5.58	8.56	10.49	14.11	16.96
L	—	—	7.21	8.28	12.45	12.05	15.14	18.60
C	—	—	—	—	4.01	3.96	4.24	4.76
C + L	—	—	7.21	8.28	10.04	8.20	10.14	11.90
OP	3.57	5.24	7.08	9.57	11.91	11.50	13.26	16.29
SO	—	—	9.15	13.64	6.97	8.60	12.23	12.40
SN	—	—	—	—	—	—	6.44	6.54
SO + SN	—	—	9.15	13.64	6.97	8.60	10.25	10.20
R	—	—	9.25	12.21	11.47	11.14	10.54	9.09
UP	—	—	9.22	12.74	10.08	10.21	10.44	9.47
OP + UP	—	—	7.73	10.13	11.66	11.35	12.89	15.07

Explanations: Sh M main shoots  
 Sh L lateral shoots  
 SM main leaves  
 LL lateral leaves  
 C cones  
 OP overground portions  
 SO old stem  
 SN new stem  
 R roots  
 UP underground portions

The above mentioned fact is even more evident from Figs. 1 and 2 in which the dry-matter contents ( $W$ ) and their changes and the biological age (BA) and its changes in the overground and underground systems are compared.

Main results of the growth, reproduction and age analysis of the overground hop plant organs are presented in Figs. 3 and 4.

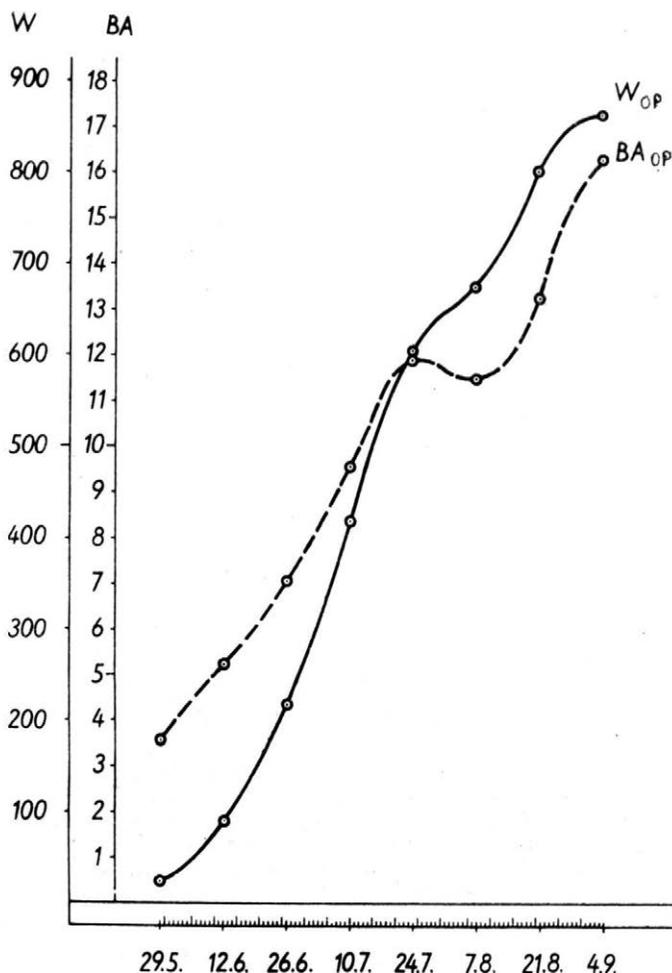
Dynamic changes of the main growth elements found out by growth analysis and hereditarily coded changes of the biological age determined by age analysis doubtless influence the distribution of the dry-matter produced, which is manifested in the structural changes of the system of overground and underground organs as well as the whole hop plants. The dry matter structure is shown in Tab. IX.



1. Relation between dry-matter (W) and biological age (BA) of the underground parts (UP) of the three-year old hop plants. — Vztah mezi sušinou (W) a biologickým věkem (BA) podzemních částí (UP) tříletých chmelových rostlin

## DISCUSSION

A comparison of the growth analysis of whole hop plants and their overground systems demonstrates that the results of growth analyses, especially the net assimilation rate (*NAR*), have the same course up to August 3. This evidence is a significant methodical contribution which was utilized already in the study by Pichl and Rybáček (1974) in 5 years old plants. It namely makes possible to perform in mature (3 years old and older) hop plants with a vigorous underground system growth analysis of the overground system in the period from the end of May to mid-August without the necessary dry-matter correction according to the changes of the dry-matter amounts in the underground organ system. Out of the mentioned period there are necessary, even in mature plants, corrections according to the changes of the dry-matter amount in the underground organs. In young (one and two years old) plants in which the underground system considerably increases it is essential to perform growth analysis according to the amount of the whole plant dry-matter, i. e. including the whole underground system. Growth analysis is an approved and elaborated method for the general follow-up of the results of photosynthesis. It was successfully employed in numerous scientific studies investigating the influence of external environmental factors on the results of photo-

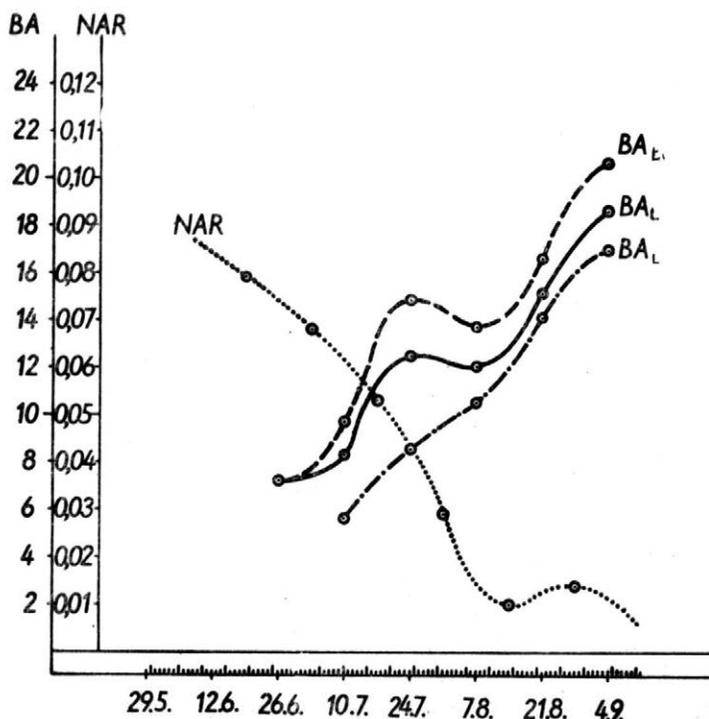


2. Relation between dry-matter (W) and biological age (BA) of the overground parts (OP) of the three-year old hop plants.  
 — Vztah mezi sušinou (W) a biologickým věkem (BA) nadzemních částí (OP) tříletých chmelových rostlin

synthesis. The effect of internal physiological changes in plants, e. g. of such an important change as the transition from vegetative into generative phase in plant life and the growth rate of reproductive organs, was nevertheless studied to a lesser extent. In his model of plant association, Donald (1961) includes reproductive organs into the system of non-assimilating tissues participating in the respiration volume.

Ničiporovič (1963) states that there are several factors decisive for whether fertility and dry-matter production in general will be materialized through the leaf area or through an increased activity of the photosynthetic apparatus.

From the prognostic point of view of stand production the staple product of which overground or underground reproductive organs usually are, knowledge of the course

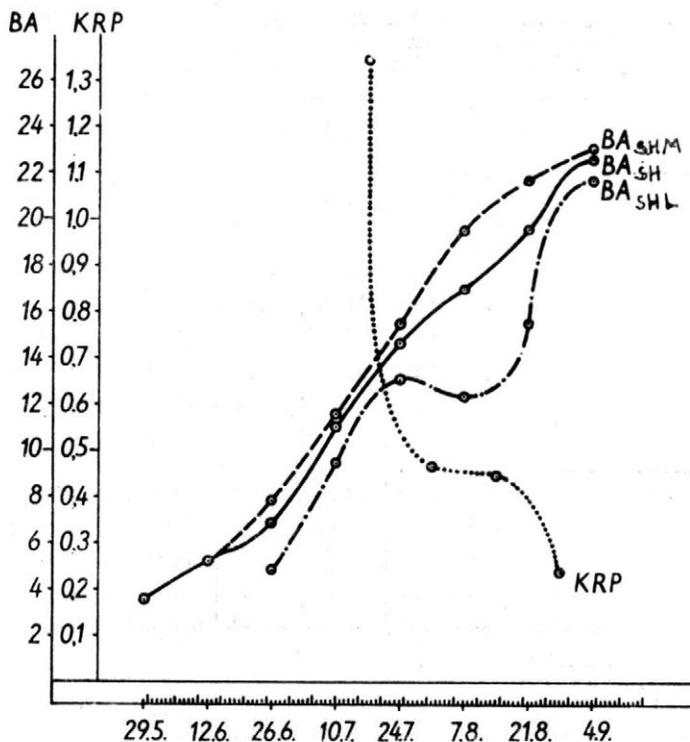


3. Relation between net assimilation rate (NAR) and biological age (BA) of the vine leaves (LM), axil leaves (LL) and all leaves (L) of three-year old hop plants. — Vztah mezi čistým výkonem fotosyntézy (NAR) a biologickým věkem (BA) révových listů (LM), pazochových listů (LL) a všech listů (L) tříletých chmelových rostlin

of growing of these organs is important. The evaluation so far according to the ratio of total biomass and market crops is scarcely comparable with the results of growth analysis in the individual intervals. That's why we have selected reproduction analysis through which we determine what dry matter proportion is transferred from the dry-matter of the other overground organs into the overground reproductive organs. The above mentioned coefficient of the reproductive process allows to conclude about the intensity of the reproductive process in hop cones. According to the same principles of reproduction analysis the intensity of the underground reproductive organ formation (in hop new wood and new suckers) can be determined.

Some authors, e. g. Thorne (1960) and others mention that increasing of the calendar age of the plants decreases the net assimilation rate (NAR). In our study the course of net assimilation rate was compared with the course of the biological leaf age; a negative correlation was found as evident from Fig. 3.

The dependence of the overground reproductive organ yield on the biological age of stalks (vines and axils) is similar. The biological age determined according to the



4. Relation between coefficient of reproduction process (KRP) and biological age (BA) of the vines (ShM), axils (ShL) and stalks (Sh). — Vztah mezi koeficientem reprodukčního procesu (KPR) a biologickým věkem (BA) rév (ShM), pazochů (ShL) a stonků (Sh)

calcium-nitrogen index  $\frac{10 \text{ Ca}}{\text{N}}$  is based on the determination of the older and younger

tissue ratio and thus also on the ratio of older and younger cells in the individual organs.

Numerous studies have namely demonstrated that in the older plant tissue calcium is accumulated in the form of inorganic and organic salts deposited in the cellular membranes and vacuoles. At the same time protein regeneration in the protoplasm is decreased. These antagonistic processes are reflected in the altered correlation between calcium and organic nitrogen in older and younger plant tissues which can thus be well distinguished from each other and utilized for the determination of the changes of biological age (BA). In hop the differences in the rate of biological aging are especially conspicuous in vines and axils and in vine and axil leaves.

IX. Structure of overground and underground systems in dry matter percentage in three years old hop plants in the years 1972–1973. — Struktura nadzemní a podzemní soustavy v % sušiny u tříletých chmelových rostlin v letech 1972–1973

Date	29. 5.	12. 6.	26. 6.	10. 7.	24. 7.	7. 8.	21. 8.	4. 9.
Sh M	46.80	38.79	30.69	34.43	28.11	24.83	24.16	22.32
Sh L	0.45	4.02	7.29	11.27	13.31	13.11	12.96	14.39
Sh	47.26	42.81	37.98	45.70	41.42	37.94	37.12	36.71
LM	52.74	53.93	38.57	25.92	17.18	14.70	14.70	16.02
LL	—	3.25	8.09	14.39	14.69	15.23	17.17	15.35
L	52.74	57.19	62.02	52.96	40.61	32.41	31.96	31.37
C	—	—	—	1.34	17.97	29.65	30.92	31.92
C + L	52.74	57.19	62.03	54.30	58.38	62.06	62.88	63.34
SO	32.42	33.37	28.85	28.74	26.31	24.42	20.15	17.08
SN	1.61	2.53	4.98	2.26	4.08	9.34	12.30	10.51
SO + SN	34.03	35.90	33.83	31.00	30.39	33.76	32.45	27.59
R	65.97	64.10	66.17	69.00	69.61	66.24	67.55	72.41

Explanations: Sh M main shoots  
 Sh L lateral shoots  
 LM main leaves  
 LL lateral leaves  
 C cones  
 SO old stem  
 SN new stem  
 R roots

## References

- CONFORT, A.: Theories of Aging. In: Proc. 8th Int. Congr. Coront., Washington 1969.  
 DONALD, C. M.: Symposium Soc. Exptl. Biol., 1961, No. 15, p. 282-313.  
 NICIPOROVIC, A. A.: Fotosyntezirujuščije systemy vysokej produktivnosti. Izd. Nauka, Moskva 1966.  
 PICHL, I. — RYBÁČEK, V.: (Growth Analysis of the Overground Organs of Five-year Old Hop Plants in Relation to the Changes of the Content of Some Macroelements.) Rostlinná výroba, 20, 1974, No. 7, p. 681-688.  
 RYBÁČEK, V.: (The Effect of the Light Intensity on the Aging of the Leaves and Cones of Hop Plants.) Rostlinná výroba, 12, 1966, No. 12, p. 1289-1302.  
 RYBÁČEK, V.: (Some changes in the nitrogen metabolism and of the biological age of hop seedlings.) Rostlinná výroba, 21, 1975, No. 4, p. 451-458.  
 SESTÁK, Z. a kol.: Metody studia fotosyntetické produkce rostlin. Praha, ČSAV 1966.  
 THORNE, G. N.: Variations with age in net assimilation rate; the growth attributes of sugar beet, potato and barley in a controlled environment. Ann. Bot. N. S. 24.

8. 4. 1975

RYBÁČEK V. (Vysoká škola zemědělská, Praha-Suchdol). Vliv biologického věku na některé růstové a reprodukční charakteristiky u tříletých rostlin chmele (*Humulus lupulus* L.). Rostlinná výroba (Praha) 21 (8) : 907-919, 1975.

V pokusech konaných v letech 1972 a 1973 s tříletými chmelovými rostlinami ('Osvaldův klon 72') jsme prováděli růstovou analýzu soustavy nadzemních orgánů a celých rostlin ve čtrnáctidenních lhůtách od 29. 5. do 4. 9. Od konce května až do poloviny srpna jsme zjistili obdobný průběh růstových charakteristik u nadzemních soustav a celých chmelových rostlin. Tento poznatek umožňuje v uvedeném období nahradit pracovní růstovou analýzu celých tříletých a starších rostlin růstovou analýzou jejich soustavy nadzemních orgánů. Po polovině srpna a u jednoletých a dvouletých rostlin ještě dříve před tímto termínem dochází k markantním změnám množství sušiny v podzemních orgánech, které zkreslují výsledky růstové analýzy. Pro období narůstání nadzemních reprodukčních orgánů (u chmele od 10. 7. do 4. 9.) jsme vypracovali metodu reprodukční analýzy. Tuto metodu lze též použít pro stanovení dynamiky vytváření podzemních reprodučních orgánů. Při konfrontaci průběhu některých ukazatelů zjištěných růstovou a reprodukční analýzou s průběhem biologického věku (BA) jsme zjistili, že čistý výkon fotosyntézy (NAR) je negativně ovlivňován stoupajícím biologickým věkem listů. Podobně je ovlivňován koeficient reprodukčního procesu (KRP) biologickým věkem stonků a listů.

chmel; fotosyntéza; respirace; růstová analýza; věková analýza; nadzemní a podzemní reprodukční orgány; biologický věk BA, čistý výkon fotosyntézy — NAR; koeficient reprodukčního procesu KRP

РЫБАЧЕК В. (Сельскохозяйственный институт, Прага-Сухдол). Влияние биологического возраста на некоторые характеристики роста и воспроизводства у 3-летних растений хмеля (*Humulus lupulus* L.). Rostlinná výroba (Praha) 21 (8) : 907-919, 1975.

В ходе опытов на 3-летних растениях хмеля ('Освальдов клон 72') в 1972 и 1973 гг. мы провели анализ роста системы наземных органов и всех растений в 14-дневные сроки с 25. V. по 4. IX. В период от конца мая до первой половины августа мы установили одинаковый ход характеристик роста у наземных систем и у целых растений. Это установление позволяет заменить в данный период трудоемкий анализ роста целых 3-летних и старших растений анализом роста их системы наземных органов. Во второй половине августа, а у однолетних и двухлетних растений еще раньше происходят чувствительные изменения количества сухого вещества в подземных органах, которые искажают данные анализа роста. На период наращивания наземных органов размножения (у хмеля с 10. VII. по 4. IX.) мы составили метод воспроизводственного анализа. Этим же методом можно воспользоваться и для определения динамики образования подземных органов размножения. Сравнение хода некоторых показателей, определенных по методу анализа роста и размножения, с ходом биологического возраста (BA) показало, что на чистый эффект фотосинтеза (NAR) отрицательно влияет увеличивающийся биологический возраст листьев. Подобному влиянию подвержен и коэффициент репродуктивного процесса (KRP) со стороны биологического возраста стеблей и листьев.

хмель; фотосинтез; респирация; анализ роста; анализ репродукции; анализ возраста; надземные и подземные органы размножения; биологический возраст BA, чистый эффект фотосинтеза — NAR; коэффициент репродуктивного процесса KRP

---

Adresa autora:

Prof. ing. Václav Rybáček, CSc., Vysoká škola zemědělská, 165 03 Praha-Suchdol

---

# RECENZE

## SOUBORNÉ PRÁCE O POKROKU V EKOLOGICKÉM VÝZKUMU

*Sborník Advances in ecological research, sv. 8, 1974, vydavatel A. Macfadyen. Vydal Academic Press, London and New York, 1974, 418 s.*

(Pokračování recenze, jejíž první část je uvedena na str. 906.)

Čtvrtá kapitola je věnována výskytu a vzájemným vztahům nižších živočichů, zejména hmyzu. Podle systematického rozřídění se uvádějí druhy užitečné a škodlivé, resp. druhy jiné hubicí. Jsou uvedeny korelace mezi parazity a hostiteli i další vzájemné vztahy mezi druhy.

Pátá kapitola se zabývá speciálně koroptvemi, jejich šířením, příčinami úbytku a opětného zlepšení stavů vlivem různých opatření, pro něž byl získán podklad výzkumem. Z praktického hlediska je tedy práce zaměřena na biologický boj proti škodlivým činitelům a na ochranu přírody. Zkoumá však mnohostranné vztahy koroptví k jejich živočišné i rostlinné potravě, jejíž výběr je činí pro zemědělství tak užitečnými, k prostředí a podmínkám, za kterých se vyskytují ve větší či menší míře, a k druhům, které je pronásledují.

Autoři zpracovávají problematiku ekologie obilí z komplexního hlediska, v závěru uvádějí příčiny vzrůstu výnosů vlivem šlechtění a moderní agrotechniky a všech prostředků, kterých se využívá, a upozorňují na možné dlouhodobě působící faktory, které mohou ovlivňovat produktivitu a jsou zatím mimo možnost přímého usměrnění člověkem.

Autoři předpokládají, že další ekologické studie poskytnou údaje, umožňující další zvyšování zemědělské produktivity, aniž by byly zbytečně narušovány ekologické procesy a prostředí u travních a jetelotravních porostů (luk a pastvin), kde se očekává značné zvýšení produktivity použitím pesticidů, které se na tomto úseku zemědělské výroby dosud používají poměrně málo.

Další práce (W. Streifer) je věnována realistickým modelům v populační ekologii. Práce zpracovává matematicky problematiku vztahů vzhledem k velikosti a stáří členů populace uvnitř druhu a dále interakce dvou a více druhů.

Poslední práce ve sborníku se týká populačních cyklů u drobných savců (C. J. Krebs, J. H. Mayersová). Zaujímá

131 stran včetně deseti stran literatury. Práce se zabývá malými hlodavci, hraboši a lumíky a v souvislosti s tím některými jinými druhy savců. Cyklické přemnožování hrabošů je známé již celá tisíciletí, přesto se posud populační cykly nepodařilo uspokojivě vysvětlit. U malých hlodavců jsou obvyklé populační cykly v období tří až čtyř let.

Autoři se zabývají podrobně údaji o populačních cyklech hrabošů, včetně hraboše polního *Microtus agrestis*, vlastní citované práce a pokusy se zabývají americkými druhy. Shrnují a hodnotí dosavadní poznatky o příčinách populačních cyklů. Různé hypotézy vysvětlují populační cykly ve vztahu k potravním možnostem, vlivu organismů živících se drobnými hlodavci, vlivu klimatu a průběhu počasí a hledají vysvětlení podstaty pravidelného vzniku přemnožení a opětného poklesu, která spočívá v biologickém charakteru jednotlivých druhů. Zabývají se proto zejména hypotézami vlivu stresu, chování a dědičnosti. Tyto vlivy vzájemně souvisejí, protože stres ovlivňuje chování, které je závislé na dědičných faktorech a při růstu populace, dosažení vrcholu i opětném poklesu se uplatňuje různé selekce podle chování i jiných znaků a vlastností. Při růstu populace se zřejmě uplatňují a množí produktivní a „učelnivé“ typy, s přemnožením se pravděpodobně uplatňuje vyšší agresivita na úkor produktivity. Populační cykly vznikly evolučně a mají zřejmě význam pro zachování a evoluci druhu. Lze předpokládat, že tento autoregulační systém se udržuje přírodním výběrem v závislosti na genetické podmíněnosti a výhodnosti cyklických změn populací.

Práce je zaměřena na základní výzkum problematiky, ale má bezprostřední význam pro výzkum aplikovaný.

Sborník je doplněn autorským a věcným rejstříkem. Lze ocenit důkladnost jednotlivých prací a kritický přístup k dosud získaným poznatkům včetně vlastních výzkumných prací jednotlivých autorů.

*Ing. Jirí Kučera, CSc.,*

*UVTI, oddělení pro studium světového zemědělství a lesnictví, Praha*

Černý V.: Úvodník . . . . .	798
Černý V.: Produktivita polních plodin některých stanovišť v Čechách	807
Hruška L., Janíček J., Bednářová E.: Produktivita hlavních polních plodin na jižní Moravě . . . . .	816
Vrkoč F.: Vliv agrotechnických opatření a stanovištních podmínek na dynamiku růstu a produktivitu hlavních polních plodin . . . . .	822
Křišťan F.: Zvýšení produkce biomasy hlavních polních plodin na několika lokalitách v Čechách . . . . .	835
Repka J., Kostrej A.: Závislost produkčního procesu na změnách klimatických faktorů . . . . .	844
Šimon J.: Produkce biomasy některých polních plodin při závlaze na lehké půdě . . . . .	859
Kopecký M., Nátr L., Pešík J., Zemánek M., Zeniščeva L.: Fyziologická charakteristika a odrůdová technologie pěstování vysoce výnosných odrůd jarního ječmene a ozimé pšenice . . . . .	872
Strnad P.: Produkce biomasy obilnin při jejich pěstování v monokultuře	884
Petr J.: Fotosyntetická produktivita nízkých a vysokých odrůd hrachu ( <i>Pisum sativum</i> L.) . . . . .	894
Úlehla J., Zichová L.: Vodní potenciál v čepelích cukrovky pěstované v polních podmínkách a potenciální evapotranspirace . . . . .	905
Rybáček V.: Vliv biologického věku na některé růstové a reprodukční charakteristiky u tříletých rostlin chmele ( <i>Humulus lupulus</i> L.) . . . . .	919
Recenze	
Souborné práce o pokroku v ekologickém výzkumu . . . . .	906 a 920

## СОДЕРЖАНИЕ

Черны В.: Передовая статья . . . . .	797
Черны В.: Урожайность полевых культур в некоторых местах произрастания Чехии . . . . .	808
Грушка Л., Яничек Й., Беднаржова Э.: Урожайность главных полевых культур в южной Моравии . . . . .	816
Вркоч Ф.: Влияние агротехники и местных условий на динамику роста и продуктивность главных полевых культур . . . . .	823
Кржиšťян Ф.: Увеличение биомассы главных полевых культур на нескольких местах Чехии . . . . .	835
Repka J., Kostrej A.: Зависимость процесса образования продукции от перемены климатических факторов . . . . .	844
Šimon J.: Продукция биомассы некоторых полевых культур в условиях орошения легких почв . . . . .	859
Kopecký M., Nátr L., Pešík J., Zemánek M., Zeniščeva L.: Физиологическая характеристика и сортовая агротехника высокоурожайных сортов ярового ячменя и озимой пшеницы . . . . .	873
Strnad P.: Продукция биомассы зерновых при их выращивании в монокультуре . . . . .	884
Petr J.: Фотосинтетическая продуктивность низко- и высокостебельных сортов гороха . . . . .	895
Úlehla J., Zichová L.: Водный потенциал в пластинках листьев сахарной свеклы, выращиваемой в полевых условиях, и отношение между актуальной и потенциальной эвапотранспирациями . . . . .	905
Rybáček V.: Влияние биологического возраста на некоторые характеристики роста и воспроизводства у 3-летних растений хмеля . . . . .	919

## Рецензия

Совокупная работа о прогрессе в экологическом научном исследовании	906 и 920
--	-----------

## CONTENTS

Černý V.: Editorial	977
Černý V.: Dry Matter Production of Field Crops at Some Localities in Bohemia	801
Hruška L., Janíček J., Bednářová E.: Productivity of Main Field Crops in Southern Moravia	809
Vrkoč F.: The Effect of Cultural Practices and Conditions of Locality on Growth — Dynamics and Productivity of Main Field Crops	817
Křišťan F.: Cultural Practices and Phytomass Production in Field Crops at Several Localities in Bohemia	825
Repka J., Kostrej A.: Dependence of the Production Process on Changes of Climatic Factors	837
Simon J.: The Production of Phytomass in Some Field Crops under Irrigation on Light Soils	845
Kopecký M., Nátr L., Pešík J., Zemánek M., Zeniščeva L.: Physiological Characteristics and Varietal Growing Technology of High Yielding Spring Barley and Winter Wheat Varieties	861
Strnad P.: Phytomass Production in Cereals Cultivated in Monoculture	875
Petr J.: Photosynthetic Productivity of Tall and Dwarf Varieties of Pea ( <i>Pisum sativum</i> L.)	885
Úlehla J., Zichová L.: Water Potential in Leaf Blades of Field-Grown Sugar Beet Plants and the Actual to Potential Evapotranspiration Ratio	897
Rybáček V.: The Influence of Biological Age on Some Growth and Reproduction Characteristics in Three-Year Old Hop Plants ( <i>Humulus lupulus</i> L.)	907
<b>Book-Review</b>	
Advances in Ecological Research	906 and 920

## INHALT

Černý V.: Einleitung	(res. E/797)
Černý V.: Die Produktivität von Feldfrüchten einiger Standorte in Böhmen	(res. E/801)
Hruška L., Janíček J., Bednářová E.: Die Produktivität von wichtigsten Feldfrüchten in Südmähren	(res. E/809)
Vrkoč F.: Der Einfluß von anbautechnischen Maßnahmen und Standortbedingungen auf die Wachstumsdynamik und Produktivität der wichtigsten Feldfrüchte	(res. E/817)
Křišťan F.: Die Erhöhung der Biomasseproduktion bei wichtigsten Feldfrüchten an einigen Lokalitäten in Böhmen	(res. E/825)
Repka J., Kostrej A.: Die Abhängigkeit des Produktionsprozesses von den Veränderungen der klimatischen Faktoren	(res. E/837)
Simon J.: Die Biomasseproduktion einiger Feldfrüchte bei Bewässerung auf leichtem Boden	(res. E/845)
Kopecký M., Nátr L., Pešík J., Zemánek M., Zeniščeva L.: Die physiologische Charakteristik und die Sortentechnologie des Anbaus von hoch ertragreichen Sommergersten- und Winterweizensorten	(res. E/861)
Strnad P.: Die Biomasseproduktion der Getreidearten bei deren Anbau in Monokultur	(res. E/875)
Petr J.: Die photosynthetische Produktivität der niedrigen und hohen Erbsensorten ( <i>Pisum sativum</i> L.)	(res. E/885)
Úlehla J., Zichová L.: Das Wasserpotential in den Blattflächen bei der Feldbedingungen angebauten Zuckerrübe und das Verhältnis der aktuellen und potentiellen Evapotranspiration	(res. E/897)
Rybáček V.: Der Einfluß des biologischen Alters auf einige Wachstums- und Reproduktionscharakteristiken bei dreijährigen Hopfenpflanzen ( <i>Humulus lupulus</i> L.)	(res. E/907)
<b>Buchbesprechung</b>	
Umfassende Arbeiten über den Fortschritt in der ökologischen Forschung	(res. E/906 und 920)

Rozšiřuje Poštovní novinová služba. Objednávky a předplatné přijímá PNS — ústřední expedice tisku, administrace odborného tisku, Jindřišská ulice 14, 110 00 Praha 1. Lze též objednat u každé pošty i poštovního doručovatele. Objednávky do zahraničí vyřizuje PNS — ústřední expedice tisku, oddělení vývozu tisku, Jindřišská ulice 14, 110 00 Praha 1. Vytiskl MÍR, novinářské závody, n. p., závod 6, Legerova ulice 22, 120 00 Praha 2.