Production Process in Old and Modern Spring Barley Varieties

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Ertragsbildung von alten und modernen Sommergerstesorten

1. Introduction

Breeding of spring malting barley varieties has a long tradition in the Czech Republic, going back to the second half of the 19th century. Particularly barley varieties from the region of Haná in Moravia reached a reputation of highest-quality malting-barley varieties, and were used in breeding of other varieties having the attribute Haná (Hannchen type). Emanuel Proskowetz contributed to their fame; he selected the best regional varieties (Proskowetz Hanna Pedigree). Prof. Erich Tschermak (Tschermks Hanna Kargyn) continued in their breeding. Kneifel was another distinguished variety. A lot of varieties originated from combinations of these varieties with regional and some foreign ones,

Zusammenfassung

Drei Versuchsserien wurden durchgeführt, um die Ertragsbildung älterer sowie neuerer Sommergerstesorten *(Hordeum vulgare* L. var. nutans) zu untersuchen. Besondere Aufmerksamkeit galt der Sorte Diamant, einer kurzhalmigen Röntgenmutante, die den Grundstein für 173 europäische Sorten legte. Spezielle Merkmale der biologischen und ökonomischen Ertragsbildung der Sorte Diamant wurden vergleichen mit Landsorten aus der Region Haná (Valtický), der historischen Sorte Nürnberg aus dem Jahr 1832 und mit modernen Sorten aus den 1990er Jahren.

Die Ertragsbildung wurde mittels klassischer Wachstumsanalyse, durch Messung der Trockenmassezuwächse und des Blattflächenindex (LAI) untersucht. Wiewohl die Sorte Diamant und von ihr abstammende Sorten unter den Bedingungen im Böhmen keine Steigung in der Gesamttrockenmasseproduktion zeigten, änderte sich die Verteilung der Trockenmasse im Falle dieser Sorten zugunsten generativer Organe – v. a. Ähren- und Körner-Trockenmasse. So stieg der Ernteindex (HI) auf 0.40-0.44, vergleichen mit der historischen Sorte, die einen HI von lediglich 0.32 erreichte. Das wirkt sich auf die Dynamik der Trockenmassebildung aus, wenn diese Sorten höhere Gehaltssteigerungen im generativen Stadium aufwiesen als die älteren.

Jedoch war während der gesamten Wachstumsperiode keinerlei direkter Zusammenhang zwischen den Maximalwerten des LAI bzw. dem Blattflächenintegral (LAD) und dem Kornertrag nachzuweisen. Trotzdem existiert nach dem Ährenschieben eine Beziehung zwischen Blattflächenintegral (LAD) und Korngewicht (Tausendkorngewicht).

Im Falle historischer Sorten trat anfänglich ein schneller Blattflächenzuwachs aber im Nachblütenstadium ein rascher Verlust an aktiver Blattfläche auf.

Diamant legte einen kurzen Halm und höhere Bestockung an, d. h. eine größere Zahl fruchtbarer Bestockungstriebe. Diesbezüglich hat sich der Charakter der ökonomischen Ertragsbildung folgendermaßen geändert: Moderne Sorten bilden den Ertrag durch den Ertrag der Seitensprosse, die alten durch den Ertrag des Haupthalmes.

Folglich hat sich auch die Zahl der Ähren pro Flächeneinheit geändert, ebenso wie die Kapazität der Assimilatspeicherstelle, während sich fast die gleiche Zahl an Körnern in einer Ähre zeigt. Ein anderer Züchtungserfolg lag in der gesteigerten Fähigkeit von Assimilatquellen, die höhere Speicherkapazität zu füllen. Verbesserungen der Malzqualität stellen ebenso einen signifikanten genetischen Gewinn dar. Der Gehalt an Protein sank, der an Extrakten nahm zu und genauso ereichten andere Kriterien den Optimalbereich im Hinblick auf Anforderungen der Mälzerei.

Der künftige Züchtungsfortschritt wird abgesehen von anderen Kriterien, weiterhin auf eine Verbesserung des Ernteindex und ebenso auf eine Hebung des Gesamttrockenmasseertrages pro Flächeneinheit gerichtet sein.

Schlagworte: *Hordeum vulgare* L., Gerste, genetische Verbesserung, Ertragsbildung, Braugerste.

Summary

Three series of experiments were carried out to study production processes of older as well as newly bred varieties of spring barley (*Hordeum vulgare* L. var. nutans). Special attention was paid to the variety Diamant, a short-stemmed radiomutant that laid the foundation for 173 European varieties. Special features of Diamant's biological and economic yield formation were compared with original varieties from the region of Haná (Valtický), with a historical variety Nürnberg from the year 1832, and with modern varieties of 1990s.

Production processes were studied by a classic growth analysis, measuring of dry matter increments and the leaf area index (LAI). The variety Diamant and varieties originating from it under conditions of Bohemia did not show any increase in total production of dry matter, however, the distribution of dry matter changed in the case of these varieties in favour of generative organs – i.e. dry matter of ears and grains. Thus, the harvest index (HI) increased to 0.40–0.44, as compared with the historical variety having HI of only 0.32. That bore also on the dynamics of dry matter creation, when these varieties showed higher increments in the generative stage than the old ones.

However, any direct relation of maximum values of LAI and the integral leaf area (LAD) during the whole growing period with the grain yield did not prove. Nevertheless, there is a relation of the integral leaf area (LAD) after earing with grain weight (with the weight of 1000 grains = TGW). In the case of the historical variety, the initial increase in the leaf area was quick, but a rapid loss of active leaf area appeared in the postfloral period.

Diamant was a donor of a short stem and higher tillering, i.e. a higher number of fertile tillers. The character of economic yield formation has changed in this way; modern varieties create the yield through the yield of tilles, the old ones through the yield of the main stem. Hence, the number of ears per area unit has changed, as well as the capacity of the sink, while showing nearly the same number of grains in an ear. Another success of breeding was also the increase in the capacity of assimilate sources to filling the higher storing capacity. Improvement of the malting quality pictures a significant genetic gain too. Protein content declined, extract increased, and also other criteria got into the optimum range of malthauses' requirements.

The future progress in breeding will, apart of other criteria, continue in going for an increase in the harvest index, and also for a rise in the yield of total dry matter per area unit.

Key words: *Hordeum vulgare* L., barley, genetic improvement, yield formation, malting barley.

both in the Czech Republic and in the neighbouring countries (LEKEŠ, 1985). After 1945, the variety Valtický became the supreme one, and it again gave rise to many other varieties. The most important was Diamant, selected as a positive X-Ray mutation, that has laid the foundation for a new stage of breeding of spring barley intensive varieties. This variety was by 15 cm shorter in height than standard varieties; it is a strongly tillering variety of a good malting quality. Accordingly, it became a donor for many (60) Czech and Slovak varieties and more than 113 foreign varieties, including important varieties such as Trumpf (Triumph) (BOUMA and OHNOUTKA, 1990).

The aim of our study was to assess in detail the character of production processes, formation of biological and economic yield of the variety Diamant compared with primary varieties, as well as with varieties bred from this variety later. Our study originated in the years 1968 and 1969, followed by the years 1970 to 1972, and in 1990–1992, when we studied new varieties also in comparison with the historical variety Nürnberg (Norimberský), going back to 1832. In 1956, glass tubes with grains, few of them being germinable, were withdrawn from the foundation stone of the Nürnberg theatre. Professors G. Aufhammer and G. Fischbeck propagated the grains, described the plants (AUFHAMMER and SIMON, 1956; TAMM and OTTERMANN, 1964; AUFHAMMER and FISCHBECK, 1964, 1970), and in 1968 they offered us the material for our experiments.

Such a comparison of production processes of old and new varieties and evaluation of contributions of breeding can be found in the work of many authors, the most important of which is the paper by RIGGS et al. (1981). They reviewed the contribution of breeding of spring barley varieties cultivated in England and Wales from 1880 until 1980. They proved that the genetic gain was 0.39 % per year during the 100-year period, and even 0.84 % per year between 1953 and 1980. The root of the rise in grain yield was shortening of the straw, an increase in the number of fertile tillers, and above all, a change in the harvest index in favour of the proportion of grain to the total above-ground biomass. During this 100-year period, varieties that significantly enhanced the production process were bred. These were e.g. the varieties Kenia, Proctor and Triumph; the last one comes from the Czech variety Diamant, contribution of which we study in this paper.

Another important study was the work of BULMAN et al. (1993), who studied improvement of spring barley varieties through breeding in east Canada in the years 1910 to 1988. They determined an annual increase in yield of 30 kg per year. They believe this is due to an increased production of dry matter, a decrease in the height of plants, and thus a better resistance to lodging, and also due to a change in the harvest index. The contribution of tillers to the yield formation changed as well. New varieties had also lower protein content in grain, despite of a generally higher nitrogen harvest index. Breeding improvement during a definite time period was studied also in the work of WYCH and RASMUSSON (1983) bearing out the above-mentioned findings. Similar works were carried out also for winter wheat (AUSTIN et al., 1980) and oats (LAWES, 1977).

2. Materials and methods

Production processes were studied during a two-year experiment for the varieties Valtický representing an original variety of the Haná region, Branišovický C (Valtický x Freya) and Jantar (Valtický x Heines Haisa). These varieties were compared to Diamant, a selection of irradiated Valtický seeds. In further three years, we studied Dvoran (Hodonínský kvas x Slovenský jemný) and Denár (Čelechovický hanácký x Bavaria) of the group varieties from the Haná region as well as the historical variety Nürnberg (Norimberský). This old variety resembles in its properties ancient Bohemian barley varieties cultivated in the 19^{th} and in the beginning of the 20^{th} century near Plzeň and in western Bohemia. It had long stems with great grains. Malt for the well-known Plzeň type of beer (Pilsner) was prepared from it. Diamant was used for a comparison.

Variety experiments were designed according to the methodology of the State Variety Experiments in Central Bohemia on medium-heavy, clay soils, with the average temperature of 8.3 °C and the mean precipitation of 575 mm. Experiments were not fertilized. The seed was sorted on a 2.5 mm mesh sieve. The plot size was 15 m^2 in four replications in a split plot design. The seeding rate was 350-400 grains per 1 m^2. In the subsequent experiment, the seeding rate of 300 and 500 grains per 1 m^2 was also applied. The experiments were sown in the first decade of April. In several experiments, special features of production processes of the historical variety Nürnberg were compared with modern varieties that were most spread and of the highest quality in their time – in the last experimental series, these were Rubín together with Perun and Malvaz.

Production processes were studied by the method of the classic growth analysis (ŠESTÁK and ČADSKÝ, 1966), when dry matter increments of ten average plants were measured in fortnight intervals. In addition, leaf area was measured in the same set of plants by a photoplanimeter. All these data were related to an area unit according to the number of plants (studied continuously as well). Growth was studied by registration of growth phases according to the Feekes scale (PETR, 1966), and by measuring of the plant length. Development was studied according to differentiation of the growth apex using the Kuperman scale (KUPERMAN, 1962).

The following growth characteristics were calculated from the experimental data: leaf area index (LAI), photosynthetic potential (FP), i.e. the integral value below the LAI curve, and leaf area duration after ear emergence (LAD), dynamics of dry matter production and its distribution, and harvest index (HI).

3. Results and discussion

Leaf area index differed in years. In the first year, the maximum LAI values ranged between 3.8 and 4.7 for the set of varieties; in the second year, they were between 2.5 and 3.5; in the third year, the interval was 3.4 to 4.6. In the fifth

Table 1: Leaf area index (LAI) of modern barley varieties and of the historical variety Nürnberg
Tabelle 1: Blattflächenindex (LAI) moderner Gerstesorten und der historischen Sorte Nürnberger

Variety Date	7.5.	26.5.	9.6.	23.6.	9.7.	24.7.
Nürnberg	0.84	0.90	5.65	5.25	4.60	1.29
Rubín	0.19	0.51	3.76	5.96	5.07	3.16
Malvaz	0.29	0.73	3.99	5.44	4.99	3.22
Perun	0.37	0.83	4.17	6.13	5.70	4.13

experimental year (1972), LAI amounted to 4.0–5.8 at the sowing rate of 300 grains per 1 m^2, and to 5.2–6.3 at the sowing rate of 500 grains per 1 m^2. In the experiments with new varieties, LAI was 5.4 to 6.2 (Table 1).

The variety Diamant showed a different development of leaf area than the other studied varieties, because of delayed growing (Figs. 1, 2). The highest-yielding variety Jantar had the largest LAI values in the first two years, but this has not been confirmed in the following years. Hence, high values of LAI cannot be directly related to grain yield.

Modern varieties show lower LAI values in the beginning; nonetheless, they stayed at the maximum level for a longer time before falling down. In the case of the historical variety, it attained its maximum level (9.6) early and then was rapidly falling (Table 1). These Nürnberg's values correspond to results of experiments with other cereal species (PETR et al., 1988).

In an effort to assess the relation of assimilation area to economic yield, we evaluated the value below the LAI curve, which is, in fact, leaf area duration for the whole period of measurement. NIČIPOROVIČ (1965) denoted these values as "photosynthetic potential" (FP). Leaf area duration from ear emergence to ripeness, often used as a criterion for leaf area duration (LAD), was assessed separately. The results are presented in Table 2.

The relation between the leaf area duration from the whole vegetation (LAD) to the grain yield did not manifest itself, nor the relation between maximum LAI values and the grain yield. However, positive correlations between LAD values after ear emergence and grain weight (TKW) were found during the first and second year; they were high and significant (r = 0.85 and r = 0.75). The size and length of the assimilation apparatus played an important role here in the time of grain formation. This is obviously associated with a great proportion of plants' upper sphere and quantity of assimilates transferred into grains (STOY, 1973).

When evaluating varieties in the first two years, long-stemmed varieties had higher LAD values. In further years, the variety Diamant was equal to them. It has been verified by FP values in the years 1971 and 1972 as well as by LAD values. However, TGW was lower for Diamant than for the other varieties.

Fast starting growth of leaf area was evident for Nürnberg. The soil was covered in a relatively short time, which is important for weed suppression. However, another special feature is too early losing of leaf area in the post-floral period and in the time of ripening.

It can be clearly seen from Table 2 that Diamant had the highest values of leaf area duration for the whole vegetation. This variety shows strong tillering, and hence, it forms a

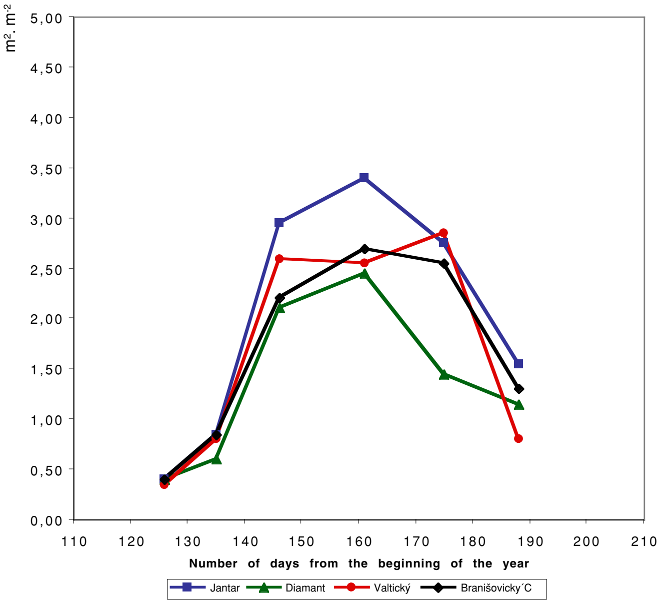

Figure 1: Leaf area index of the varieties Jantar, Diamant, Valtický and Branišovický C in the second experimental year (1969)
Abbildung 1: Blattflächenindex der Sorten Jantar, Diamant, Valtický und Branišovický C im zweiten Versuchsjahr (1969)

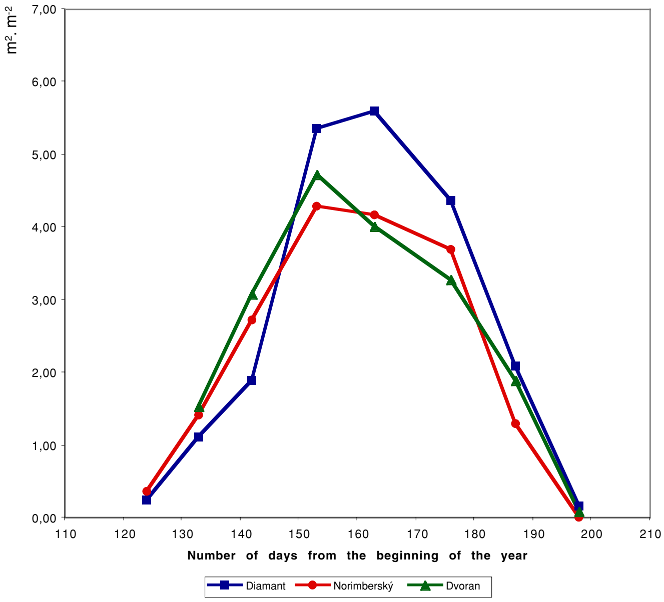

Figure 2: Leaf area index of the varieties Diamant, Dvoran and Nürnberg at the sawing rate of 300 grains per 1 m^2
Abbildung 2: Blattflächenindex der Sorten Diamant, Dvoran und Nürnberger bei Saatdichte 300 Körner pro 1 qm

Table 2: Photosynthetic potential (FP) and leaf area duration (LAD), TGW (g) and grain yield ($t.ha^{-1}$)
Tabelle 2: Photosynthetisches Potential (FP) und leaf area duration (LAD), TKW (g) und Kornertrag ($t.ha^{-1}$)

Variety	Year	FP	LAD after ear emerg.	TKW	Yield
Valtický	1968	25 000	7 000	41.2	4.00
Branišovický C		25 000	7000	42.8	4.32
Diamant		21 600	4 500	40.0	4.35
Jantar		29 200	8 200	46.4	4.64
Valtický	1969	20 500	1 200	40.1	4.11
Branišovický C		19 500	2 300	39.8	4.69
Diamant		15 700	800	33.2	4.82
Jantar		25 000	2 500	43.6	4.99
Diamant	1971	13 974	3 713	40.7	5.96
Dvoran (after 99 days)		12 408	3 029	43.8	6.16
Nürnberg		13 531	2 790	49.7	3.58
Jantar		13 261	3 671	45.8	6.01
Diamant	1972	23 443	7 994	29.1	4.25
Dvoran(after 125 days)		21 096	7 740	39.7	5.20
Nürnberg		20 072	7 126	35.8	2.81

FP-photosynthetic potential = leaf area duration below the LAI curve for the whole vegetation
LAD – leaf area duration below the LAI curve from heading

greater assimilating apparatus. However, its grain yield was not the highest. We should note that the historical variety Nürnberg is in a way similar, i.e. it is a long-stemmed variety with high FP values (in the 1971 trial), but with low grain yield. The relation between maximum LAI values and the total leaf size, expressed as FP divided by the grain yield, did not prove, whereas we can accept the hypothesis expressed particularly for wheat (PETR et al., 1988) that a certain size of leaf area is necessary for a definite level of grain yield.

In searching for a relation between different weather factors and the size of leaf area, we did not succeed in proving unambiguous effects of temperature or precipitation. The effect of temperature was prevailing in one year, total precipitation was dominant the other time, which would require a more detailed analysis. Effects of fertilization, sowing rate and irrigation to leaf area development are well known from literature (BERÁNEK, 1975).

There are also detailed data from the second part of the experiments concerning proportions of different parts of plants in the total size of leaf area, which was studied in mid-May, mid-June and mid-July. Three-year average data from the latest measurements (6 to 15 July) are presented in Table 3.

When applying the sowing rate of 300 grains, the number of plants of Diamant was 292 per 1 m^2; when applying the sowing rate of 500 grains, the number of plants of Dia-

Table 3: Percentage of different parts of plants of the total assimilation area in %
Tabelle 3: Prozentzahl verschiedener Pflanzenteile von der gesamten Assimilationsfläche (in %)

Variety	leaves	stems and leaf sheats	two upper leaves	spike	Total cm^2
Diamant	18	53	15	14	254
Dvoran	15	54	14	17	207
Nürnberg	14	57	14	15	190
Diamant					
300 seeds m^{-2}	21	53	16	12	338
500 seeds m^{-2}	20	51	15	11	257
Nürnberg					
300 seeds m^{-2}	13	64	13	10	316
500 seeds m^{-2}	9	74	8	9	201

Seed rates 300 and 500 seeds per 1 m^2

mant was 437 per 1 m^2 in the time of measurement. These figures were 314 and 437 plants per 1 m^2 in the case of Nürnberg. At the higher sowing rate of 500 grains, a decrease of assimilation area per plant occurred. It was 24 %

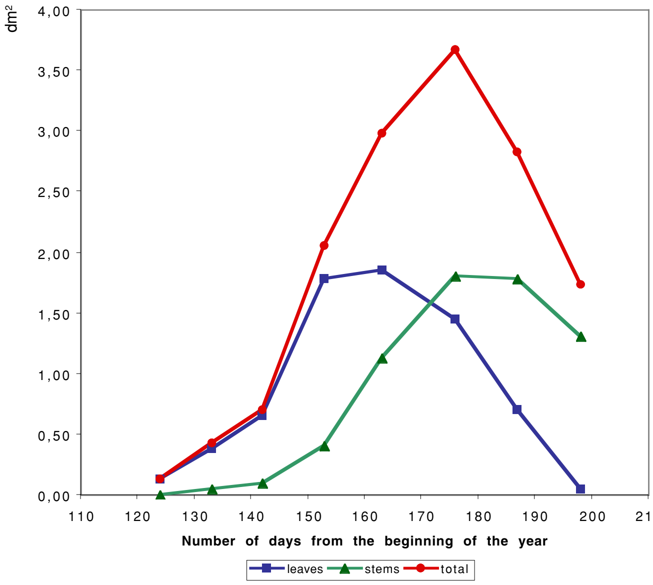

Figure 3: Mean assimilative area per plant of the Diamant variety at sowing rate of 300 grains per 1 m^2
Abbildung 3: Durchschnittliche Assimilationsfläche pro Pflanze bei der Sorte Diamant bei Saatdichte 300 Körner pro 1 qm

for Diamant, and 36 % for Nürnberg (Figs. 3, 4). The control variety Denár manifested a similar structure of proportions.

Dynamics of dry matter production in the studied varieties differ in individual years. The highest values of dry matter of above-ground biomass were reached by Jantar in the first year (1968). In the second year, it was even the variety Diamant that reached the maximum production. In the trials, the experimental values of total dry matter per 1 m^2 did not manifest significant differences for individual varieties, but they were always the lowest for the variety Nürnberg, particularly in 1971. It should be also stressed that this variety reached maximum values by 14 to 21 days earlier

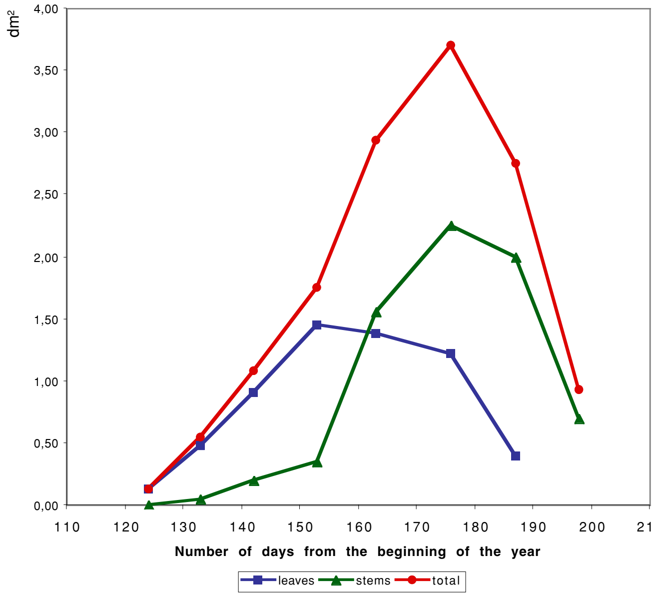

Figure 4: Mean assimilative area per plant of the historical variety Nürnberg at sowing rate of 300 grains per 1 m^2
Abbildung 4: Durchschnittliche Assimilationsfläche pro Pflanze bei der historischen Sorte Nürnberger bei Saatdichte 300 Körner pro 1 qm

than the other varieties. This also means that assimilating area withered earlier, and production of assimilates in the generative period diminished (Table 4).

Based on our previous studies and results of other authors (PETR, 1971; THORNE, 1973), the increment of dry matter in the generative period seems to be important, which can again manifest itself in a higher 1000-kernel weight (TKW). Figure 5 shows this relation. Modern varieties Dvoran, Denár, Jantar and Diamant have higher increments than the historical variety Nürnberg.

However, we did not prove the relation between the total production of dry matter of above-ground biomass and the grain yield. Therefore, we concentrated ourselves on a study of proportions of dry matter of different parts of plants, which can manifest a distribution of dry matter in organs, as well as dry matter proportions of economically significant or harvest organs. Table 5 shows remarkable results in this direction.

Table 4: Maximum values reached for above-ground biomass dry matter in g.m^{-2}
Tabelle 4: Höchstwerte, die für die Trockensubstanz der oberirdischen Biomasse erreicht wurden, in g.m^{-2}

Variety	Day 1970	g.m^{-2}	Day 1971	g.m^{-2}	Day 1972	g.m^{-2}
Diamant	3.8.	1041	15.7.	1004	10.8.	1378
Dvoran	8.8.	1071	30.7.	1150	10.8.	1527
Nürnberg	23.7.	1013	5.7.	835	10.8.	1251
Jantar	3.8.	1124	30.7.	1010	–	–

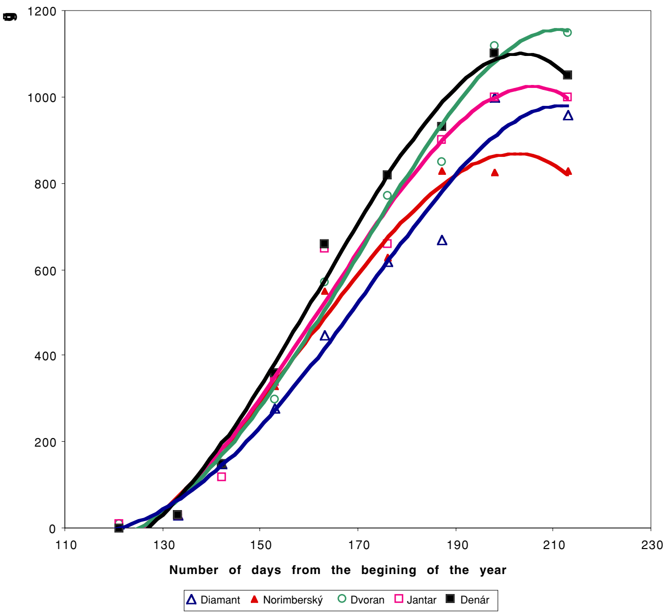

Figure 5: Above-ground dry matter per 1 m^2 (g) – varieties Diamant, Jantar, Nürnberg, Dvoran, Denár

Abbildung 5: Oberirdische Trockensubstanz pro 1 qm (g) – Sorten Diamant, Jantar, Nürnberger, Dvoran, Denár

It can be deduced from the proportion of dry matter of different parts of plants that the historical variety Nürnberg utilises greater part of the total amount of dry matter, which is almost identical as in the case of modern varieties, for vegetative organs – leaves, stems, and less for generative organs – spike and particularly grain. This fact is expressed in the best way by the harvest index (HI), which is a ratio of dry matter of economically important organs, in our case of grains, to the total dry matter of above-ground biomass. In a 3-year average, HI of Diamant was 0.44, of Dvoran 0.42, of Denár 0.40, and of Nürnberg 0.32. If we express this technically as a ratio of grain to straw, then we have the following results: Diamant 1 : 0.85-1.56, and Nürnberg 1 : 2.11–2.31. This can be the reason for a low grain yield of this variety, which averaged at 2.90 tonnes per 1 hectare from 3-year trials, as compared with Diamant with the yield of 4.84, Dvoran with 4.92, and Jantar with 4.74 $t.ha^{-1}$. The main progress in breeding during the past 150 years can be seen particularly here.

In the experiments carried out in the years 1990–1992, almost identical maximum values of dry matter of above-ground biomass were found in comparison with the previous years. Fast growth of dry matter manifested itself again in the starting period of vegetation, while lesser increments of dry matter were observed in the generative period. The dry matter increments between 9 July and 24 July were as follows: Nürnberg only 108 g per 1 m^2, Rubín 204.9 g, Malvaz even 487.2 g, and Perun 157.1 g per 1 m^2 (Table 6).

The variety Diamant contributed considerably to breeding; it laid the foundation for 173 varieties in Czechoslovakia and abroad. This variety and the varieties developed from it possess new valuable features and characteristics as compared with older varieties, above all with the historical variety Nürnberg. The production of total dry matter from an area unit did not rise, nevertheless, the distribution of dry matter improved in favour of generative organs. Thus, the harvest index (HI) could be successfully increased to more than 0.44. This was identified also by BULMAN et al. (1993) and AUSTIN et al. (1980), who also see improvement of HI as a source for future progress in cereals breeding. Next to it, they expect also some increase in production of total dry matter per area unit.

Table 5: Percentage of dry matter of different parts of plants in % – a 3-year average (measured on 6 July-15 July, and on 3 August)

Tabelle 5: Prozentzahl der Trockensubstanz in verschiedenen Pflanzenteilen – dreijähriger Durchschnitt (vom 6. Juli – 15. Juli und am 3. August gemessen)

Variety	leaves	stems and sheats	two upper leaves	spike	grains	two upper leaves	stems	spike and grains
	Measured on 6.7. 13.7. and 15.7.					measured on 3.8.		
Diamant	8.6	39.0	4.8	15.6	44.2	9.1	31.6	56.7
Jantar and Dvoran	8.7	43.2	3.0	16.5	41.8	8.5	36.9	54.6
Nürnberg	9.5	50.5	5.4	12.7	32.5	12.1	46.1	49.1

Table 6: Dry matter production in spring barley varieties in 1992 in $g.m^{-2}$

Tabelle 6: Trockensubstanz-Produktion bei Sommergerstesorten 1992 (in $g.m^{-2}$)

Variety Date of measuring	7.5.	26.5.	9.6.	23.6.	9.7.	24.7.
Nürnberg	37.6	114.8	445.5	769.2	1092.0	1200.4
Rubín	2.8	56.5	196.4	748.8	888.0	1092.9
Malvaz	3.2	57.9	239.9	584.3	692.9	1180.1
Perun	5.2	70.8	228.1	791.3	948.5	1105.6

Table 7: Progress in breeding brought about in quality of malting barley
Tabelle 7: Züchtungsfortschritte in der Qualität der Malzgerste

Variety	GP (%Nx6.25)	E (%)	RE 45 (%)	K (index)	DP (WK)	AFA (%)
19th century Nürnberg	13.1	77.0	32.9	31.5	285	79.0
1950s Valtický	12.3	80.5	40.1	39.1	384	79,1
1970s Diamant	12.7	81.2	38.0	40.3	305	78,3
1980s Rubín	11.4	81.6	45.6	48.5	325	82.0
1990s Akcent	11.2	81.8	45.2	45.2	333	82.3
End of 20th century Tolar	10.7	82.1	38.2	44.5	403	82.6

Analyses carried out in line with the international methodology EBC (1987) and MEBAK (1979) in the Brewery and Malting Research Institute Brno
GP-grain protein, E-extract, RE-relative extract at 45°C, K-Kolbach number, DP-diastatic power (WK), AFA-apparent final attenuation

Diamant excelled also due to a longer period of an active function of leaf area after earing, which positively affected weight of 1000 grains (TGW). Diamant provided its offspring with a short straw and a considerably higher tillering – a higher number of fertile tillers. Thus, number of ears per 1 m^2 exceeded 1000. Number of grains in an ear kept up at the same level as in older varieties, so the total number of grains per 1 m^2 raised significantly. Thus, the sink capacity increased; however, photosynthetic production of the original variety Diamant failed to saturate it with the level of assimilate sources. Nonetheless, this was successfully overcome with new varieties bred from Diamant. As compared with original varieties, the character of creation of yield changed, when the yield is formed by yield of tillers, while it was above all the yield of the main stem in older varieties.

The quality of barley has also changed towards requirements for its utilization in malt production. Content of nitrogen substances decreased, extract increased, the relative extract attained optimum values (it was Diamant, Valtický and Nürnberg that were closer optimum values of the Kolbach number), values of diastatic power and the apparent final attenuation were favourable – see Table 7.

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Eingelangt am 27. März 2001
Angenommen am 13. Dezember 2001