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Characteristics of wheat-barley hybrids (X *Tritordeum* Ascherson et Graebner) under Central-European climatic conditions

Charakterystyka mieszańców pszenicy z jęczmieniem (X *Tritordeum* Ascherson et Graebner) w warunkach klimatycznych Europy Środkowej

Thirteen genotypes of hexaploid (2n = 6x = 42; $AABBH^{ch}H^{ch}$) tritordeum and two genotypes of octoploid (2n = 8x = 56; $AABBDDH^{ch}H^{ch}$) tritordeum were analysed. These genotypes were sown in 1999, 2000 and 2001 in spring with check varieties of spring wheat Sandra and Saxana. They were sown also as winter forms in 1999/00 and 2001/02 with check varieties of winter wheat Astella and Brea, and winter donors of high protein content, Nap Hal, Atlas 66 and Lancota. Tritordeum stands were not damaged due to mild winter. Spring crops produced average yields as follows: 6x tritordeum 1.99 $t \cdot ha^{-1}$, 8x tritordeum 0.98 $t \cdot ha^{-1}$, Sandra 6.75 $t \cdot ha^{-1}$, and Saxana 6.85 $t \cdot ha^{-1}$. Tritordeum sown in spring matured late and non-uniformly because of a perennial character of original *H. chilense*. There was a natural occurrence of ergot (*Claviceps purpurea*) in most tested genotypes of tritordeum sown in spring, which evidences a higher percentage of open flowering. Winter crops produced average yields as follows: 6x tritordeum 2.97 $t \cdot ha^{-1}$, 8x tritordeum 1.88 $t \cdot ha^{-1}$, Astella 8.78 $t \cdot ha^{-1}$, and Brea 7.45 $t \cdot ha^{-1}$. A mild course of the winter did not damage tritordeum stands sown in autumn, vernalisation effect limited problems with late maturing. Higher yields produced by tritordeum sown in autumn suggest that it would be useful to develop winter forms for Central-European conditions. Higher field resistance to leaf rust and leaf blotches was found in tritordeum vs. check varieties. Protein content in tritordeum sown in spring was on average in 6x forms 19.6%, in 8x 19.0%, in the varieties Sandra and Saxana 14.1%; in tritordeum sown in autumn in 6x forms 19.2%, 8x forms 18.9%, in the wheat varieties Astella 10.2% and Brea 11.9%. It was also higher than in known donors of high protein content (Nap Hal — 17.5%, Atlas 66 — 17.0%, Lancota — 16.3%). A slightly higher content of essential amino acids (Lys, Phe, Val, Leu, Ile, Met and Thr) was assessed in grain dry weight of tritordeum. It is interesting that highly significantly higher content of cystine (Cys-Cys) amino acid was found in both spring and autumn sown crops. A lower loaf volume in hexaploid tritordeum in comparison with bread wheat suggests that this crop will be used rather for feeding purposes. A high content of carotenoides in tritordeum caused yellow coloration of flour and bread-crumb. Wider use of winter forms of tritordeum, if they were developed, is assumed. Potential use of tritordeum under conditions of Central Europe is discussed.

Key words: amino acid, quality, tritordeum, yield

Analizowano trzynaście genotypów tritordeum heksaploidalnego (2n = 4x = 42; $AABBH^{ch}H^{ch}$) i dwa genotypy oktoploidalnego (2n = 4x = 56; $AABBDDH^{ch}H^{ch}$). Genotypy te wysiewano wiosną w latach 1999–2001 razem z wzorcowymi odmianami pszenicy jarej Sandra i Saxana. W latach 1999 i 2000 wysiano je również jako zboże ozime wraz ze wzorcami pszenicy ozimej Astella i Brea oraz źródłami wysokiej zawartości białka — pszenicami Nap Hal, Atlas 66 i Lancota. Średnie plony z upraw jarych wyniosły: 1,99 $t{\cdot}ha^{-1}$ dla tritiordeum 6x, 0,98 t/ha dla tritordeum 8x oraz 6,75 $t{\cdot}ha^{-1}$ i 6,85 $t{\cdot}ha^{-1}$ dla pszenic Sandra i Saxana. Tritordeum w siewie jarym dojrzewało późno i nierównomiernie ze względu na bylinowy charakter *Hordeum chiloense*, z którego udziałem powstało. Większość badanych genotypów uległo też naturalnej infekcji sporyszem (*Claviceps purpurea*), co wskazuje na wyższy procent otwartego kwitnienia. Łagodne zimy 1999/2000 i 2000/2001 nie uszkodziły zasiewów tritordeum. Uprawy ozime plonowały następująco: tritordeum 6x — 2,97 $t{\cdot}ha^{-1}$, tritordeum 8x — 1,88 $t{\cdot}ha^{-1}$, Astella — 8,78 t/ha, Brea — 7,45 $t{\cdot}ha^{-1}$. Jaryzacja ozimin ograniczyła znaczenie opóźnionego dojrzewania. Wyższe plony tritordeum z siewu jesiennego sugerują możliwość wytworzenia form ozimych dla warunków Europy Środkowej. U mieszańców tych stwierdzono również, w warunkach polowych, wyższą odporność na rdzę liściową i septoriozę niż u wzorcowych odmian pszenicy. Zawartość białka u tritordeum z upraw jarych wyniosła średnio 19,6% u form 6x, 19,0% u form 8x, a u pszenic Sandra i Saxana po 14,1%. W ziarnie zebranym z upraw ozimych wartości te wyniosły odpowiednio dla form 6x i 8x 19,2% i 18,8%, a dla wzorcowych pszenic Astella i Brea 10,2% i 11,9%. Było to również więcej, niż w pszenicach Nap Hal, Atlas 66 i Lancota (odpowiednio 17,5%, 17,0% i 16,3%) uznanych za źródła wysokiej zawartości białka. Zawartość niezbędnych aminokwasów (Liz, Fen, Wal, Leu, Ileu, Met, i Tre) w ziarnie tritordeum też była nieco wyższa. Interesująca była wysoce istotna zwyżka zawartości cystyny (Cys-S-S-Cys) w plonach z zasiewów zarówno jarych jak i ozimych. Mniejsza objętość bochenków chleba z tritordeum (heksaploidalnego) w porównaniu do uzyskanych z mąki pszennej sugeruje, że roślina ta będzie nadawała się raczej do wykorzystania na pasze. Wysoka zawartość karotenoidów u tritordeum powoduje żółte zabarwienie mąki i miąższu chleba. Dyskutowana jest możliwość wytworzenia i szerszego wykorzystania form ozimych tritordeum w Europie Środkowej.

Słowa kluczowe: jakość, aminokwas, tritordeum, plon

INTRODUCTION

Tritordeum (X *Tritordeum* Ascherson et Graebner) is an amphiploid species derived from crosses of wheat (*Triticum* spp.) and wild perennial barley (*Hordeum chilense* Roemer et Schultese; 2n = 2x = 14, HchHch) that was developed in Spain (Cubero *et al.*, 1986; Martin *et al.*, 1999). Some hexaploid (2n = 6x = 42; AABBHchHch) and octoploid (2n = 8x = 56; AABBDDHchHch) forms have been obtained for research purposes in the Czech Republic (CR). Since tritordeum was derived from crosses of perennial form *H. chilense* and spring forms of wheat, the resulting lines are considered as spring forms. This paper presents mostly results of field experiments and data on grain quality.

MATERIAL AND METHODS

Thirteen genotypes of hexaploid (6x) tritordeum (HT31-1, HT31-2, HT31-3, HT31-4, HT31-5 /= lines derived from HT31/, HT115, HT119, HT129, HT135, HTC1323, HTC1324, HTC1331, HTC1380) and two genotypes of octoploid (8x) tritordeum (HT108 and HT219) were analysed at the Agricultural Research Institute Kroměříž, Ltd. Depending on a sowing date, they were compared with spring wheat varieties: Sandra (bread quality — B), Saxana (baking quality — A) and winter wheat varieties: Astella (bread quality — B), Brea (elite baking quality — E) registered in the Czech Republic and winter wheat donors of high protein content - Nap Hal, Atlas 66 and Lancota. Hexaploid and octoploid tritordeum was sown a) in spring and b) in autumn.

— a) Tritordeum genotypes were sown in spring 1999, 2000 and 2001 together with the check varieties Sandra and Saxana after the forecrop sugar beet. They were sown in plots of 2.5 m^2 in size (without replicates) in 1999, in plots of 10 m^2 (1 to 4 replicates depending on seed amount available) in 2000, and in plots of 10 m^2 in 4 replicates in 2001. The seeding rates of 5.0 and 4.5 mio germinable seeds per hectare were used for tritordeum and spring wheat (Sandra and Saxana), respectively. A total nitrogen rate of 70 $kg.ha^{-1}$ (nitrate fertiliser in split application) was applied after emergence and at tillering.

— b) In the growing seasons 1999–2000 and 2000–2001, tritordeum was sown also in autumn together with check varieties Astella and Brea and donors of high protein content (Nap Hal, Atlas 66, Lancota). In the both years, they were sown in plots of 10 m^2 in size without replicates after the forecrop oilseed rape. The seeding rates of 4.5 and 4.0 mio germinable seeds per hectare were used for tritordeum and winter wheat, respectively. Nitrogen rates of 33 $kg\cdot ha^{-1}$ were applied prior to sowing and 33 $kg\cdot ha^{-1}$ in spring in the form of nitrate fertiliser. 36 $kg\cdot ha^{-1}$ P_2O_5 and 36 $kg\cdot ha^{-1}$ K_2O were applied to both spring and autumn sown cereals. After harvest, characteristics of grain quality were evaluated. Crude protein content (Kjejdahl´s method), content of individual amino acids using an amino acid analyser AAA 331, wet gluten content using a washing instrument according to Špidla and Hýža, falling number on the Falling Number 1600 instrument, SDS-sedimentation value according to the methodology of Axford, gluten index on Glutomatic 2200, and farinographic values (water absorption, dough development, stability and softening) were analysed. Alveographic evaluation was performed for some samples only. A baking test was carried out based on 100 g flour.

RESULTS

Field experiments

In all field experiments, tritordeum was rather late in emergence (by about 5 days) in comparison with wheat. The most important results are in Table 1.

Table 1

Characters of hexaploid tritordeum and wheat sown in spring and autumn
Cechy tritordeum heksaploidalnego i pszenicy wysiewanych wiosną i jesienią

Character Cechy	Harvest Zbiór	Sown in spring — Siew jary			Sown in autumn — siew ozimy		
		tritordeum	wheat — pszenica		tritordeum	wheat — pszenica	
			Sandra	Saxana		Astella	Brea
Powdery mildew (9-1) Mączniak (9-1)	1999	6.7±0.9	6	8		6	7
	2000	7.9±1.0	8	8	7.6±1.3	6	7
	2001	6.8±0.9	7	8	8.1±0.5	6	7
Leaf rust (9-1) Rdza liściowa (9-1)	1999	9	7	6		8	9
	2000	9	7	6	7.9±0.4	7	7
	2001	8 (7 - 9)	7	6	7.6±0.6	5	5
Septoria — spike (9-1) Septoria klosa (9-1)	1999	5.1±1.2	7	7		8	7
	2000	7.2±1.0	7	7	7.2±0.4	7	8
Septoria — leaf (9-1) septoria liści (9-1)	1999	6.4±0.8	6	7		6	7
	2000	6.8±1.2	7	7	6.8±0.3	7	6
	2001	7.2±0.4	7	7	6.2±0.4	6	7
Stem length (m) Wysokość (m)	1999	0.95±0.14	0.94	0.90		0.83	0.89
	2000	0.73±0.11	0.70	0.68	0.82±0.04	0.84	0.92
	2001	0.71±0.06	0.86	0.75	1.05±0.07	0.80	0.85
Date of heading Data kłoszenia	1999	03.-07.06.	03.06.	02.06.		24.05.	26.05.
	2000	05.-11.06.	02.06.	01.06.	08.-10.05.	11.05.	15.05.
	2001	11.-18.06.	12.06.	12.06.	21.-25.05.	21.05.	27.05.
Date of maturing Data dojrzewania	1999	?	24.07.	24.07.		18.07.	20.07.
	2000	(very late)	16.07.	16.07.	10.-16.07.	13.07.	15.07.
	2001	(very late)			13.-18.07.	16.07.	20.07.
1000-kernel weight (g) Masa 1000 nasion	1999	37.6±2.1	43.2	42.7		45.1	43.0
	2000	28.7±2.6	30.7	32.7	33.1±5.0	40.1	43.4
	2001	38.8±3.8	45.7	44.8	40.3±4.3	41.4	44.6
Yield ($t.ha^{-1}$) Plon	2000	1.48±0.31	6.25	6.41	2.04±0.46	9.27	7.45
	2001	2.44±0.33	6.89	7.02	3.92±0.84	8.26	6.74
Protein content (%) Zawartość białka	1999	17.6±0.7	13.4	13.8		9.5	12.5
	2000	21.2±1.8	15.7	14.6	19.8±1.8	10.8	12.0
	2001	17.7±1.1	13.2	13.0	18.6±1.5	9.7	11.8
Lysine content in grain DM ($mg.g^{-1}$) Zawartość lizyny w suchej masie ziarna	1999	5.4±0.8	6.0	6.2		5,47	5.64
	2000	5.7±0.5	4.0	3.9		3.71	3.68
Cystine content in grain DM ($mg \cdot g^{-1}$) Zawartość cysteiny w suchej masie ziarna	1999	5.8±0.9	2.3	2.3	6.2±0.5	3.27	1.54
	2000	6.8±0.7	3.4	3.3	5.4±0.5	3.31	3.22
Falling number (sec) Liczba opadania (sek.)	2000	118±61	88	122	214±26	166	148
	2001	185±82	192	215	225±32	245	261
SDS — sedimentation value (ml) Liczba sedymantacji — SDS (ml)	2000	54.5±6.7	82	87	57.3±8.8	42	61
	2001	44.3±5.5	55	64	55.2±7.2	40	57
Wet gluten content (%) Zawartośc glutenu mokrego (%)	2000	43±4	31	27	41.5±1.6	23.6	28.0
	2001	38±6	25	24	37.3±1.4	21.2	24.2
Gluten index Indeks glutenu	2000	46±29	96	99	46±24	86	90
Water absorption (ml) Wodochłonność (ml)	2000	56.8±1.1	56.2	59	57.7±2.2	50.6	56.0
Peak of development time (min) Szczyt czasu rozwoju (min)	2000	2.3±0.8	2.5	2.0	2.7±0.2	1.0	1.0
Dough stability (min) Stabilność ciasta (min)	2000	2.7±1.3	9.6	9.0	1.7±0.2	1.5	4.5
Degrees of softening (BU) Rozmiękczenie (BU)	2000	107±30	60	50	103±21	100	90
Loaf volume (cm^3) Objętość chleba (cm^3)	2000	260±60	350	443			

Spring sowing (1999–2001)

In 1999–2001, yields of hexaploid (1.99 t·ha^{-1}) and octoploid (0.98 t·ha^{-1}) tritordeum were on average much lower than those of check varieties of spring wheat, Sandra (6.75 t·ha^{-1}) and Saxana (6.85 t·ha^{-1}). Yields of tritordeum were significantly lower than those of wheat at P ≥ 1%. Severe drought during the second half of April and early May in 2000 resulted in considerable yield loss, decrease in stem length, reduction of average grain weight and increase in grain protein content. That year, yields of tritordeum ranged from 0.64 to 2.20 t·ha^{-1}, which was about a quarter of yields produced by the check varieties (Sandra 6.25 t.ha^{-1}, Saxana 6.41 t·ha^{-1}). Yields of hexaploid tritordeum from 2.05 t·ha^{-1} (HT119) to 3.12 t·ha^{-1} (HTC1380) were obtained in 2001 when weather conditions were more favourable. A disadvantage of tritordeum sown in spring was its lateness in comparison with spring wheat. It was hardly possible to predict a date of maturation because of continuous growth of late tillers. So, besides mature spikes there was about a third of immature spikes at the milk to waxy stage during the harvest. The harvested grain was necessary to dry. The spring sown tritordeum had a date of heading approximately comparable with check varieties of spring wheat but markedly late maturation. It is probably caused by effects of the genome of wild perennial species *H. chilense.* It also induces a high level of rejuvenation of tillers in tritordeum, which results in large non-uniformity in spike maturation on different stems of one plant. Considerably late maturation of tritordeum probably led to delayed incidence of fungal diseases in comparison with wheat. All genotypes of hexaploid tritordeum in both spring plantings demonstrated high field resistance to leaf rust (*Puccinia recondita* f. sp. *tritici*) (9) vs. varieties Sandra (7) and Saxana (6). Resistance to powdery mildew (*Blumeria graminis*) in tritordeum ranged on the level of checks from 6 to 8 in 1999. Infection pressure of powdery mildew in 2000 was lower than in 1999 and 2001. Field resistance to Septoria leaf blotch (*Septoria tritici*) was somewhat higher than in check wheat varieties. There were big differences in resistance to Septoria glume blotch (*St. nodorum*) in 1999 and 2000 among individual genotypes. More susceptible genotypes were HTC1323 and HTC1324 (3) and more resistant HTC1331 (7); check varieties Saxana and Sandra were scored with 7. This disease did not occur in 2001. It is interesting that most tested genotypes of tritordeum were naturally infected by ergot (*Claviceps purpurea*). In both years, extreme infection was found in HT135 and increased infection in HT119.

Autumn sowing (2000–2001)

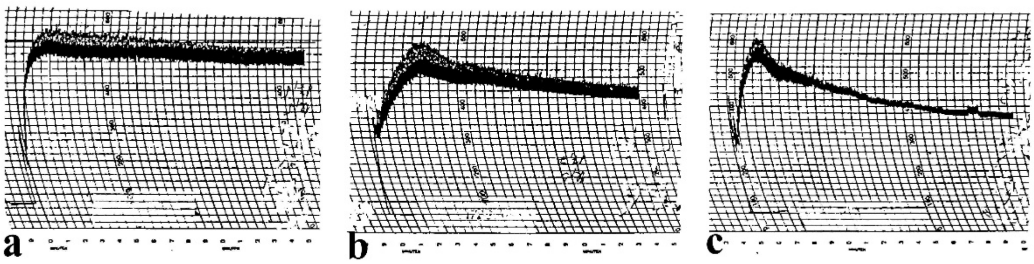
Considering this fact, we tested a possibility of eliminating the late maturation by autumn sowing and vernalisation during winter. Tritordeum was sown in autumn 1999 and 2000. In the both years, yields of hexaploid tritordeum averaged 2.98 t.ha^{-1}, octoploid tritordeum 1.88 t.ha^{-1} and check varieties Astella 8.77 t.ha^{-1}, Brea 7.10 t.ha^{-1}, Nap Hal 4.53 t.ha^{-1}, Atlas 66 4.33 t.ha^{-1}, and Lancota 5.61 t.ha^{-1}. Yields of tritordeum were significantly lower than those of wheat at P ≥ 1%.

In 2000, yields of tritordeum were very low and ranged from 1.62 t.ha^{-1} (HT119) to 2.98 t.ha^{-1} (HTC1380), whereas yields of check varieties Astella and Brea were 9.27 and 7.45 t.ha^{-1}, respectively. Higher yields were obtained in 2001 ranging from 3.86 t.ha^{-1} (HT31-1) to 5.01 $t.ha^{-1}$ (HTC1380); yields of check varieties Astella and Brea were 8.26 and 6.74 $t.ha^{-1}$, respectively.

The stands were not damaged by frost during the mild winter in 1999/00 and 2000/01. There was a very similar course of growth and development in tritordeum and wheat plants. This is confirmed by the approximately identical date of heading and maturing. Occurrence of powdery mildew found on tritordeum sown in autumn was comparable with check wheat varieties Astella and Brea. In both years, infection of wheat by leaf rust was scored with 7–9 in tritordeum and 6–7 in wheat. So, absolute resistance of tritordeum sown in autumn to this pathogen was not confirmed as it was assessed in tritordeum sown in spring.

Quality tests

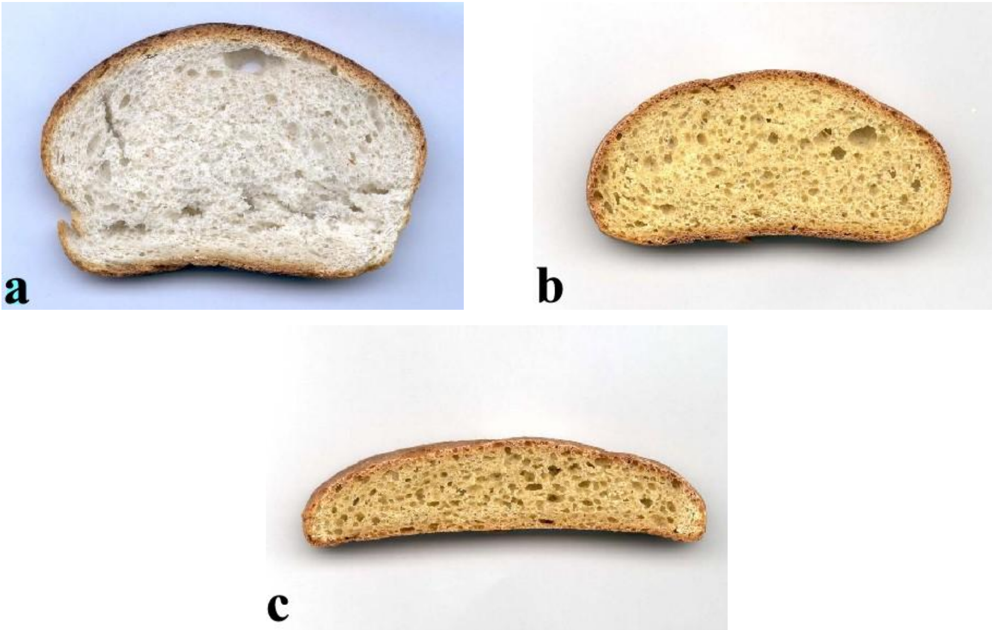
All genotypes of tritordeum were characteristic of very high crude protein content (spring sowing (1999-2001) — tritordeum: 6x — 19.6%; 8x — 19.0%; Sandra — 14.1%; Saxana — 14.1%. Autumn sowing (2000–2001) — tritordeum: 6x — 19.2%; 8x — 18.9%; Astella — 10.2%; Brea — 11.9%; Nap Hal — 17.5%; Atlas 66 — 17.0%; Lancota — 16.3%). In hexaploid tritordeum sown in spring 1999, protein content ranged from 16.3% (HTC1331) to 18.7% (HT31-3), in 2000 from 18.8% (HTC1331) to 23.8% (HT129) and in 2001 from 16.1% (HTC1380) to 18.5% (HT31-1). These results are in contrast to protein content assessed in check wheat varieties that is considerably lower. Hexaploid tritordeum exceeds well-known wheat donors Atlas 66 (17.1%), Nap Hal (16.7%) and Lancota (15.7%) that were evaluated in 2000. High protein content in tritordeum also expressed in very high values of wet gluten.



a — Saxana (50 BU— degrees of softening); b — HT31-2 (80 BU); c — HTC1380 (190 BU)
a — Saxana (50 BU — stopni rozmiękczenia; b — HT31-2 (80 BU); c — HTC1380 (190 BU

Fig. 1. Farinograms
Rys. 1. Farinogramy

Results of technological analyses suggest that tritordeum grain is less acceptable for baking as compared with wheat (Table 1). In the experiment with tritordeum sown in spring 2000, a SDS-sedimentation value ranged from 40 ml (HT135) to 63 ml (HT31-4) and on average it was lower vs. checks (Saxana 82 ml and Sandra 87 ml). In addition, values of gluten index indicate worse breadmaking properties of gluten protein of tritordeum vs. wheat. It was confirmed by dough evaluation using a farinograph. Alveograms show relatively low values of energy W and relatively low values of P. The dough of tritordeum was mostly very extensible (Figure 1). Some samples could not be evaluated by alveograph due to extreme dough extensibility and stickiness. Results of the baking test also confirmed unsuitability of tritordeum for breadmaking purposes even though there were considerable differences in loaf volume among individual tritordeum samples (Figure 2). It documents lower loaf volume vs. check varieties. Tritordeum is characteristic of carotenoides in grain endosperm, which results in yellowish colour of flour and bread-crumb. The obtained results show that tritordeum is less suitable for baking purposes, however the extremely high protein content could be useful for feeding.



a — Saxana (14.6% protein); b — HT31-2 (21.6% protein); c — HTC1380 (19.9% protein)
a — Saxana (14,6% białka); b — HT31-2 (21,6% białka); c — HTC1380 (19,.9% białka)

Fig. 2. Baking test
Rys. 2. Test wypieku

Interesting results were obtained by comparing the content of individual amino acids in tritordeum and wheat assessed from the harvest of spring planting in 1999 and 2000. There was no considerable difference in content of amino acid lysine in wholemeal DM in tritordeum vs. check wheat varieties. In the content of some other amino acids there were differences in their proportions in sample DM. Slightly higher content of essential amino acids (lysine, phenylalanine, valine, leucine, isoleucine, methionine and threonine) was found in grain dry weight. Statistical assessment for spring sowing showed effects of the genotype in the amino acids such as phenylalanine, valine and cysteine. The most marked difference was assessed in cystine (Cys-Cys) that contains sulphur. In 1999, average content of cystine in hexaploid tritordeum was 5.8 $mg.g^{-1}$ and in 2000 6.8 $mg.g^{-1}$, whereas in check wheat it was 2.3 and 3.3 $mg.g^{-1}$, respectively. However, these differences must be confirmed by further analyses.

DISCUSSION

The tested genotypes of hexaploid and octoploid tritordeum are considered as spring forms. It is due to the fact that they were developed from Spain spring forms of wheat (*Triticum* spp.) that were used for crosses with perennial *Hordeum chilense*. Though a spring character of hexaploid tritordeum is apparent, the presence of a perennial character transferred from *H. chilense* causes considerable lateness and problems with non-uniform maturation during the harvest. These problems were successfully avoided by autumn sowing. Tritordeum sown in autumn demonstrated higher yields than tritordeum sown in spring. These results show that a period of vernalisation and probably better use of soil sources positively affect yields. This fact indicates that winter forms of tritordeum would be more suitable for conditions of Central Europe, however, they would have to be derived from winter forms of wheat. Present forms of tritordeum cannot be used as winter cereals due to their low freezing tolerance. In the growing season 2002/03, they were entirely damaged by black frost.

Among individual tritordeum genotypes, forms with increased resistance to powdery mildew and leaf rust can be found. Even though *Hordeum chilense* is considered to be a potential source of non-host resistance to a number of fungal diseases (Rubiales *et al.*, 1991), this type of absolute resistance does not express in tritordeum. In addition, results of laboratory tests of tritordeum samples to selected isolates of leaf rust that are not presented here did not indicate complex resistance to this disease in evaluated samples.

The data on grain quality correspond with published data and confirm that tritordeum can be an important source of protein (Alvarez *et al.*, 1995; Alvarez and Martin, 1996). It will be useful to study the importance of high cystine content in relation to grain breadmaking quality. This sulfur-containing amino acid is of critical significance for formation of intra- and inter-disulfide S-S bonds among individual groups of prolamin polypeptides (HMW and LMW subunits). Thus, it participates in the synthesis of HMW protein aggregates (of tertiary and quarternary structure) that condition a final structure and behaviour of gluten viscoelastic complex. Therefore, a higher amount of this amino acid should positively affect breadmaking characteristics (elasticity and extensibility). However, tritordeum features worse breadmaking characteristics of dough than wheat. It can be assumed that higher cystine content could be present rather in proteins that do not participate in high-polymer protein structures. In addition, worse breadmaking quality of tritordeum could be influenced by a high alpha-amylase activity, which can be concluded from low values of falling number.

Future research would be useful to focus on testing potential use of tritordeum for feeding purposes and specific food technologies.

CONCLUSIONS

1. Due to low yields and problems with late maturing, it is not supposed to use tritordeum spring forms in agriculture under Central-European conditions,
2. Based on higher yields in tritordeum sown in autumn, winter forms are more promising for their practical use; there are no problems with late and non-uniform maturing. Under Central-European conditions, tritordeum appears to be an intermediate form. It would be useful to select or develop new perspective amphiploid forms with good winter-hardiness. It would be also possible to develop winter amphiploid forms of tritordeum with good frost-hardiness using crosses of winter hexaploid and tetraploid wheat varieties with *Hordeum chilense*,
3. Extremely high protein content suggests potential use of tritordeum for feeding. Its breadmaking quality is lower in comparison with wheat — possibilities of alternative use of tritordeum for human nutrition cannot be excluded either.

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