Breeding hexaploid triticale (x. Triticosecale Wittmack) of various varietal types with high bread making quality

[1] Shchipak G.V., [2] Tsupko Yu.V., [1] Boguslavskyi R.L., [3] Matviyets V.G.,
[4] Shchipak V.G., [5] Woś H., [5] Brzeziński W.

[1] Plant Production Institute nd. a. V. Ya. Yuryev of NAAS
[2] Department of Agriculture and Fisheries (Queensland) University of Stellenbosch
[3] Carpathian SAES of the Institute of Agriculture of the Carpathian region of NAAS
[4] Volhynia SAES of NAAS
[5] Wibex laboratory (Poland).

Results (1980 - 2017) of breeding the hexaploid triticale for increase of adaptability, productivity and grain quality are presented. By the method of intraspecific hybridization of the forms showing contrast growth habit in interzonal tests of populations, lines and cultivars, a winter and alternate triticale with high baking properties are created.

Key words: hexaploid triticale, intraspecific hybridization, multiline cultivars, bakery properties.

Breeding the hexaploid triticale is directed to increase productivity, its stability, improvement of grain quality with retention of a complex of adaptive properties. The triticale cultivars created in Poland, Russia, Romania, Belarus and other countries, successfully compete with wheat, rye, barley and exceed them by grain yield per hectare by 20 – 30% [1, 2]. In Ukraine, the triticale cultivars specialized to destination are introduced in the agrarian production differing significantly in economic valuable signs [3, 4]. Fodder triticale Amphidiploid 256, Garne, Bouquet, Shalanda which acquired spread in all agroecological zones of the country, ensure high grain yields (7,5 – 10,5 t/ha) and green crop (45 – 65 t/ha). The cultivars of food and universal appointment Amos, Nicanor, Raritet, Plastun volynskiy, Yaroslava are characterized by good and excellent indicators of quality of a gluten, dough and bread at grain productivity of 8,5 - 11,5 t/ha. These cultivar

groups belong to the semi-intensive type, are well adapted to a complex of adverse factors of wintering and vegetation. Nevertheless, they are prone to lodging in abnormally damp years what reduces yield capacity, especially, on a rich soils. For such conditions, a triticale cultivars with plant height of 85 - 100 cm are created. Triticale with high yield capacity and low stem are created in Poland, Romania, Slovakia, Russia. However, they concede to local cultivars with medium stem height by grain productivity and quality in droughty conditions of the Steppe and Forest-steppe of Ukraine.

The objective of our research was creation a gene pool of low–stem triticale with high potential productivity and improved grain quality, formation on their basis a multiline triticale cultivars with a stem length of 85–105 cm, the elastic-strong and at the same time extensible, balanced at the high level gluten that is necessary for production of high-quality bread without application of improvers.

Materials and methods

The hybrid populations were created by means of crossing the hexaploid triticale of various ecology-geographical origin and growth habit. Selection for a complex of adaptive and economic valuable traits were carried out in contrast conditions. Estimation of the populations and lines for resistance to drought, heat and germination at long dead-ripe stage, grain quality was carried out in the droughty Steppe (Seaside Experimental Breeding Station, Yalta, the South of the Donetsk Region). The hybrid and breeding material was investigated for productivity, quality, resistance to adverse factors of wintering and vegetation in the zones of western Forest (Volynskaya Experimental Station, Rokini) and eastern Forest-Steppe (Plant Production Institute nd. a. V. Ya. Yuryev. In F_3 – F_4, protein content, starch, carotenoids, sedimentation, grain hardness, falling number were defined. Since F_4, a full technological analysis was carried out. Grain and flour qualities, baking properties were determined as defined by Methodical recommendations [5], without application of improvers. Grain samples were

ground in milling apparatus MLU 202 to 67-70% flour. Recipe dough had been of the same: flour 100g at humidity 14%, yeast dry-1,3 g, sugar - 4,5 g, salt - 1,5 g, water – at absorption farinograph. The electrophoresis of glutenin was carried out in Wibex laboratory (Poland).

Results and discussion

A hexaploid triticale are unique crop whose grain is suitable for production of various foodstuff including high-quality bread. Among the European countries, Ukraine is one of those consuming the most amount of bread. About 42% of proteins in the diet of Ukrainians come from wheat bread. This kind of bread however is not sufficient in one of the most important aminoacid – lysine. Bread with increased lysine content can be produced from new cereal crop – triticale. The future of this bread depends highly on the availability of suitable cultivars with high productivity, adaptability and increased protein and lysine content in grain in combination with increased bread making quality. White and whole meal triticale bread is preferred by a large group of people who suffer from overweight, hypertension, diabetes etc. This study examine suitability of the new triticale cultivars for use as a source for production of triticale bread.

The correlation analysis of quality indexes of grain, dough and bread in 7,3 thousand samples of triticale with average and tall stem height for 1983-1995 revealed essential influence of only some of them on baking properties. Bread volume was influenced positively by porosity of a crumb (r=0,42), grain vitreousness (r=0,53) and gluten content (r=0,41). The general bakery value was in strong negative dependence on the gluten content (r =-0,71), an DIG index (r = -0,77) and respectively group of gluten quality (r =-0,66). Positive connection on the average level is shown between the general bakery value and flour strength (r=0,40), dough elasticity (r=0,51). The bread quality is determined to the greatest extent by the porosity of crumb (r=0,90).

The flour strength as the important index of flour and gluten quality makes reliable positive influence on porosity (r=0,43) and the general baking value (r=0,40). The connextion between flour strength and gluten quality (r=0,51), dough elasticity (r=0,66) and tensile properties (r=0,67) was stronger.

The winter triticale with the high gluten content is characterized by weak gluten quality, inelastic blurring dough (r =-0,42), gave bread with bad porosity (r =-0,46) and a low general bakery rating (r =-0,71). Broad search of lines of triticale with a large gluten yield which occured a long time in 70s and 80s didn't lead to creation of a forms with high baking properties. It wasn't promoted by limitation of a gene pool of the crop and the approved dogma about blocking the corresponding wheat loci by a rye genome, what theoretically prevented the possibility of synthesing of triticale with unique qualities of a gluten. During breeding the baking triticale, it should be expanded search of hybrid combinations with the minimum negative influence of rye chromosomes, and selection of posterities with complementary nature of interaction of the wheat and rye genetic systems should be carried out also among the forms with low gluten content but with high rates of elasticity and tensile properties of dough achieving balance of gluten complex at a high level. For this purpose, since 1980 to 2017, 16,3 thousand combinations including 67,9% of intraspecific crossings are carried out. Based on the hybridization of triticale 2n=42 x 2n=42 with various growth habit, there are created and transferred to state testing 26 cultivars from which two (Yunga, Stepan) weren't registered.

Crossing of a winter tall cultivar Amphidiploid 3/5 with the spring average height triticale line L-5 created earlier by selection from the combination GTA418 / Amphidiploid 206 was executed in 1980. The hybrids were tested at alternation of spring crops with autumn ones that led to creation of alternate triticale with high winter hardiness [6]. The low-stem productive line of alternate growth habit D77/75 was selected from the alternate triticale D77 and was widely used in crossings. In the F_1 population (spring triticale Kharkivskyi 41/D77/75), there was

selected in 1988 the alternate line D8-192 with easy thresh and well executed grain of wheaten morphology.

One of the most valuable hybrid combinations F_1 (Amphidiploid 547/D8-192) / spring triticale Aist Kharkivskyi) was carried out in 1989. From it, by means of repeated selections in the contrast conditions of Forest Steppe and sharply arid Steppe, the comprehensively valuable lines were obtained which have the various on quality gluten – from weak to very strong: GDI 45 … 120 units, number of falling of 236 - 394 sec., dough elasticity 40… 95 mm, tensile strength 30… 110 mm. Stabilization of quality of a gluten complex at the high level was reached in the created cultivar by association of a respective complementary lines. The mixing effect was intensified due to the increased elasticity of dough of some lines and unique tensile ability of other lines [7]. The genetic basis of the cultivar Raritet was made by the lines with contrast indexes of dough quality: tensile strength to 86 mm, elasticity 79 mm, what promoted formation of the gluten complex balanced at the high level (P/L=82/77), increase of flour strength (to 222 a.u.) and obtaining high-quality bread without improvers (550 – 600 ml.). The cultivar was transferred to state test in 2004, registered in 2008.

The new cultivar distinguished by an increased productivity in all zones, immunity to diseases, steadily high baking properties [8]. Wide use of the Raritet in intraspecific crossings revealed its extraordinary combination ability including quality of gluten, dough and bread. There were open a new opportunities to increase baking properties of triticale that was limited by very strong but insufficiently gluten tensile strength of the cultivar Raritet. For improvement of the cultivar type of bread making destination, a numerous crossings were carried out. As the most valuable combinations are recognized the options with participation of the forms with weak but viscous, excessively extensible gluten: Amphidiploid 206 / Raritet, Raritet/Valentin 90 and Raritet/HAD 7 from which the lines with more elastic-strong and at the same time tensile strength gluten are selected. On their basis, new multiline cultivars of baking and universal types are created: Amos (it is registered since 2014), Markiyan (since 2015), Nicanor (since 2016). Creation of

these cultivars increased significantly quality of triticale bread: the volume increased to 650 ml at the general baking value of 9,0 points.

Improvenent of triticale competitiveness requires combination in one cultivar of increased grain yield with short stem and high baking quality while maintaining complex resistance to unfavorable factors. A such forms were absent in the available assortment. Undersized cultivars from Poland, Romania, Slovakia, Russia possess high potential productivity but a weak gluten and are used mainly for the fodder and technical purposes. While perennial tests of the population Raritet/HAD 7 in contrast conditions, we are selected constant highly productive triticale with plant height of 40 – 105 cm. Obtaining of low-stem forms when crossing tall components isn't the unique phenomenon, as a genealogy of the Raritet includes forms of triticale and wheat with a short stem. The complementarity of initial genotypes by technological qualities, high rates of dough tensile strength of HAD 7 and elasticticy of a gluten complex in the Raritet increased probability of selection, at rather large sample size, the low-stem lines with the excellent baking qualities, best than in the parental forms.

In the conditions of 2014 – 2017, the low-stem lines of triticale (2,8 thousand samples) allocated from a combination Raritet / HAD 7 differed by good and excellent winter hardiness (8,2 – 9,0 points), had 530 – 640 ears on 1 m^2 with a plant height of 62 - 98 cm that is equal to the level of a low-stem Polish cultivar Baltiko. In comparison with the Raritet, plant height is reduced by 30 – 50% by shortening of all internodes, mostly due the middle (l_4) and lower (l_5, l_6) that increased the lodging resistance to 9 points. Duration of the vegetation period of the low-stem lines corresponds to initial forms (275 – 278 days). The new triticale inherited mainly high resistance to smut and foliar–stem diseases. These lines passed through selections in the acute arid steppe show high resistance to heat and form well filled grain with 1000 kernel weight of 44,3 – 62,5 g. In droughty conditions of 2014 – 2017, the grain productivity of the best low-stem cultivars Timofey, Pudik and Yelan varied from 8,82 to 10,77 t/ha and averaged 9,94 –

10,36 t/ha that exceeds the standard cultivars Raritet by 3,07 – 3,49 t/ha, Baltiko – by 1,81 – 2,23 t/ha, the wheat Podolyanka by 3,69 – 4,11 t/ha.

The analysis of interrelations of thirty morphobiological and technological traits in the low-stem cultivars and lines of triticale testifies that all studied traits influence on formation of grain quality but make in these processes significantly different contribution. The high volume of bread (650 – 880 ml) depended reliable on 15 traits including stability of dough (r=0,58), its resilience to mixing (r=0,63) and the overall valorimetric estimate (r=0,71). The volume of bread had a negative close connections with protein content (r =-0,53), dough softening (r =-0,54), GDI (r =-0,63) and plant height (r =-0,72).

There was reliable impact of 18 traits on the general baking rating, the most effective of them are: stability and resilience of dough (r=0,69; 0,70), general valorimetric value (r=0,76), bread volume (r=0,76) and especially crumb elasticity (r=0,82) and bread porosity (r=0,87). No significant influence of falling number on the bread volume and the general bakery rating was observed. The greatest number of reliable correlations is recorded with the general bakery rating (18), dough softening (20) and bread porosity (21). Possibility of high-reliable prediction of bakery qualities of the low–stem triticale depending on a complex the morphobiological and technological traits is confirmed by the regression analysis and makes 93%. The investigated tendencies of interdependence of bakery qualities formed the basis of creation of genotypes with specific qualities of protein–gluten complex which were used further when forming multiline cultivars.

The physical grain properties of low–stem triticale are good and excellent. The test weight varied in the range of 662 – 804 g/l, a grain vitreousity – of 17 - 52%, a grain hardness – of 76,4 – 123,0 N. The sedimentation indexes (33 – 40 ml.) in new lines are higher in comparison with fodder triticale Amphidiploid 256 and Pawo (27 – 31 ml). The observed variability of falling number (73 – 230 sec.), had no essential impact on quality. The low–stem triticale characterized by low grain protein content (9,8 – 11,9%) what is at the level of the parental Raritet.

Quantity of a gluten in flour of low–stem amphidiploids is various: 10,0 – 22,0%. The Raritet had a gluten output of 16,0 – 19,3%, the wheat – 20,0 – 27,9%.

The low–stem triticale form exclusively elastic and strong gluten: the GDI index varied from 30 to 55 u., many lines surpassed both bread wheat (63 u.) and the best cultivar on this trait Raritet (55 u.).

The cultivar types of triticale differ significantly on flour strength. In winter triticale of fodder type it makes 55 – 98 u.a., spring triticale – 109 – 131 u.a. In comparison with spring amphidiploids, triticale of alternate growth habit Yaroslava and Alesandra formed stronger flour especially at autumn sowing (157 – 196 u.a.). According to V. E. Shevchenko, A. E. Pshenichny [9], in the first in the former USSR cultivar of grain triticale Amphidiploid 206 flour strength fluctuated depending on year conditions, forecrops (57 – 95 u.a.) and averaged 72 u.a., in wheat Mironovskaya 808 what is 4 times more, 288 u.a. Steadily high value of flour strength was ascertained first in the Raritet. On average in 10 years (2001 - 2011), this index reached in this cultivar 193 u.a., at the spring cultivar Aist – 121 u.a., spring wheat Kharkivska 26 – 200 u.a., winter wheat Odesskaya 267 – 319 u.a. [8]. The similar ratio of flour strength in various cultivars was observed also in 2014 – 2017 (tab. 1, 2).

The best low–stem lines of winter triticale have advantage in flour strength in comparison with the fodder and earlier created cultivars of baking destination. In 2014 – 2017, flour strength in the low–stem triticale was 190 – 353 u.a., Amphidiploid 256 – 57 u.a., Raritet – 194 u.a., winter wheat Podolyanka – 157 – 262 u.a.

At a present stage of breeding, an important index of bakery qualities of triticale is balance of dough properties at high level. In the triticale with a weak gluten, elasticity of dough is very low: 39 – 52 mm. The fodder triticale are more various by dough tensile strength: 37 – 82 mm. Unlike the feed cultivars, Raritet has the dough balanced at the high level on elasticity and tensile strength. On average for 2001 - 2011, these indexes were 71 and 74 mm and P/L equaled one. In 2014 – 2017, the cultivar Raritet formed the same elastic and tensile dough that

provided obtaining bread without improvers with the volume of 627 ml with the general bread making rating of 9 points. The HAD 7 line had unbalanced dough with elasticity 50 and tensile strength of 88 mm. The low–stem triticale lines allocated from the combination Raritet/HAD 7 give dough with elasticity 72 - 96 and tensile strength of 68 - 89 mm. The cultivars Timofey, Pudik and Yelan created with involvement of the best low–stem lines the elasticity – tensile strength was steadily high and averaged for 2014 - 2017 84 – 81 mm, 81 – 77 mm and 72 – 77 mm respectively. In the same years, the P-L in Raritet was 71 – 74, in winter wheat Podolyanka – 72 – 69 mm.

In triticale of fodder type (Amphidiploid 256, Pawo, Baltiko, Titan, etc.), the physical properties of dough are low: time of formations 1,30 … 2,10 min., resilience 0,50 … 3,00 min., resistance 2,00 … 4,24 min., stability 3,00 … 5,40 min. and softening varied from 156 to 220 u.f. The dough in such triticale is forming quickly but its stability is five times less and the valorimetric value is twice less in comparison with strong wheat and triticale of a baking type (fig. 1 - 3). Thus, farinogram testify that triticale of fodder type form weak dough which is intensively diluted. It is at them less elastic, excessively plastic, very sticky, more resembles on rye or dough from weak wheat flour, or the sprouted, damaged by a wheat byg, defective grain. Bread from the flour of similar triticale producted without improvers using wheat technology turns out to be of small volume (360 … 490 ml) with condensed crushed crumb. As a result, the general bread making rating doesn't exceeds 5,5 – 7,5 points.

The best low–stem lines and cultivars of triticale give the dough elastic, steady against a batch and softening**,** tensile, with high gas-retaining ability which isn't inferior to the farinograms of valuable and strong wheats (fig. 4 – 7). So in the lines HAD 69 … 189, the cultivars Timofey, Pudik and Yelan, time of dough formation is of 2,8 – 3,5 min., resilience – of 10,5 - 12,5 min., resistance to a batch – of 13,4 – 15,7 min., stability – 10,5 – 17,2 min., dough liquefaction – 55 – 98 u.f., valorimetric value 84 – 90 e.v. The loaf volume at its production by wheat technology without improvers is at them of 610 – 880 ml. with the general bread

making rating of 8,6 - 9,0 points (fig. 8). By color and appearance, bread from flour of triticale of baking type is similar to one from wheat but with better nutritious, flavouring and aromatic qualities.

During the analysis of glutenin of low–stem cultivars Timofey and Pudik in comparison with the standard of a fodder type Amphidiploid 256, the parental forms Raritet and HAD 7 (Plastun), are revealed following subunit composition. The Amphidiploid 256 has subunits 2*-7+9 (75%) and 1-7+9 (25%). The maternal form with the high bakery quality Raritet is presented also by the spectrum of two types: 2*-7+8 (75%) and 2*-7+9 (25%). The fatherly cultivar HAD 7 which is characterized by medium baking properties have the subunit of 2*-7+8 (fig. 9). In the spectrum of Timofey created by combination of two low–stem lines selected from the hybrid Raritet/HAD 7, there are presented two high-molecular subunits: 2*-7+9 (80%) and 2*-7+8 (20%). The highest quality of a gluten, dough and bread is revealed in the cultivars Pudik and Yelan having a subunit 2*-7+8. The received morfo-biochemical index's need to be added with the complex molecular and genetic analysis of pecularities of an expression of the genes defining grain quality of the new triticale cultivars capable to form steadily a superfast elastic gluten, to produce high-quality bread of volume over 700 ml without improvers. For further researches of the nature of quality of strongly connected wheat – rye gluten complex with use of the new approaches, seeds of the best low–stem cultivars are sent to the USA (J. Dubcovsky, UC Davis), Australia (R. Trethowan, The University of Sydney), Poland (H. Woś), Russia (A.I. Grabovets, the Don ZNIISH), Mexico (H. J. Braun, CIMMYT).

Conclusions

Thus, as a result of purposeful researches 1980 – 2017 for improvement the hexaploid triticale, there are created medium–stem (the Raritet, Amos, Nicanor) and low–stem (Timofey, Pudik, Yelan) cultivars with yield capacity of 9,5 - 12,5 t/ha, complex immunity to the main diseases, bread volume without improvers of

650 - 800 ml at the general bakery value of 9,0 points that meet requirements to valuable and strong wheats.

Table 1 Morphological and technological traits of hexaploid triticale and wheat (2014 - 2017 $\overline{X}$)

Cultivar	Plant height, cm	Yield capacity, t/ha	Protein in grain, %	Gluten in flour, %	GDI, units	Falling number, sec.	Elasticity of dough, mm	Tensile strength of dough, mm	Flour strength u.a.	Loaf volume, ml	General bread making rating, point
Triticale winter											
Amphidiploid 256, St	136	5,61	12,30	16,7	82	206	39	37	57	473	6,6
Raritet, St	125	6,87	11,52	17,4	55	254	71	74	194	627	9,0
Shalanda	138	7,64	12,27	14,8	117	156	46	51	55	465	6,5
Bouquet	139	7,95	11,85	16,9	75	208	48	62	98	486	8,1
Nikanor	127	8,02	11,62	18,5	55	195	69	78	180	590	8,5
Amos	123	7,33	11,48	16,9	58	246	75	79	203	640	9,0
Timofey	92	9,94	11,67	17,0	54	152	84	81	210	698	8,7
Pudik	90	10,14	11,39	20,3	45	226	81	77	226	727	9,0
Yelan	94	10,36	11,87	19,0	50	199	72	77	229	800	9,0
Triticale alternate											
Yaroslava*	98	3,72	12,80	22,0	68	180	58	65	132	498	8,3
Yaroslava**	125	8,68	12,18	20,4	63	203	65	77	157	617	8,7
Aleksandra*	102	4,10	12,69	21,8	65	178	84	62	156	600	8,5
Aleksandra**	128	8,56	12,06	18,6	50	206	88	57	196	640	8,6
Triticale spring											
Aist x.*	102	3,01	12,96	21,5	70	231	57	64	124	417	6,6
Aist x.**	135	6,14	12,34	19,0	70	207	71	50	131	440	7,1
Hlibodar*	112	3,32	12,04	23,4	70	197	57	66	129	426	7,4
Darhliba*	116	3,51	12,02	17,0	63	183	56	55	109	490	7,6
Wheat winter											
Podolyanka, st	102	6,25	12,44	27,0	63	263	72	69	207	657	8,8
HIP_{05}		0.43									

* - spring crops

** - autumn crops

Table 2 Physical properties of dough and bread volume of triticale and wheat (2014 - 2017, $\overline{X}$)

Cultivar	Country	Flour strength, a.u.	Water absorption, %	Dough					General valorimetric value, u.v.	Loaf volume, ml
				time of formation, min.	resilience, min.	resistance, min.	stability, min.	softening, u.f.		
Amphidiploid 256, St	Ukraine	57	56,0	1,95	2,29	4,24	4,03	156	48	473
Raritet, St	Ukraine	194	55,1	2,65	6,46	9,17	9,10	87	74	627
Markiyan	Ukraine	180	57,0	2,45	4,23	6,44	7,73	99	71	610
Nikanor	Ukraine	180	57,6	2,98	3,50	5,98	7,15	105	69	590
Amos	Ukraine	203	54,1	2,50	6,50	9,00	9,15	82	78	640
Yaroslava	Ukraine	157	59,0	2,50	4,00	5,62	6,45	140	61	617
Timofey	Ukraine	210	53,4	2,85	10,75	13,60	15,15	81	84	698
Pudik	Ukraine	226	55,5	3,20	12,50	15,70	17,20	62	90	727
Yelan	Ukraine	229	54,8	2,90	10,50	13,40	13,85	75	86	800
Valentin 90	Russia	140	57,8	1,99	3,00	5,45	4,66	140	57	490
Hermes	Russia	59	48,0	1,80	0,50	2,30	3,00	140	34	420
Kapriz	Russia	93	58,3	2,33	2,75	5,08	5,00	169	55	465
Kroha	Russia	20	49,8	2,00	1,00	3,00	4,00	210	25	390
Lamberto	Poland	102	57,9	1,30	3,00	4,30	5,00	220	49	420
Pawo	Poland	65	55,6	2,10	2,03	4,27	3,47	180	48	390
Domital	Poland	39	49,8	2,20	2,00	4,20	4,80	160	34	430
Baltiko	Poland	39	54,0	1,80	1,50	3,30	5,40	170	32	360
Titan	Romania	26	49,2	1,90	1,30	3,20	3,20	190	39	390
Gorun	Romania	52	50,0	1,50	0,50	2,00	3,70	185	30	420
Stil	Romania	39	53,0	2,00	1,20	3,20	4,00	200	39	400
Kandur	Slovakia	26	51,6	1,90	1,10	2,90	4,00	170	29	390
Amphidiploid 206	USSR	103	55,1	2,10	0,50	2,60	1,50	220	34	467
Podolyanka, wheat soft	Ukraine	207	59,7	2,82	10,20	13,07	15,47	73	85	657

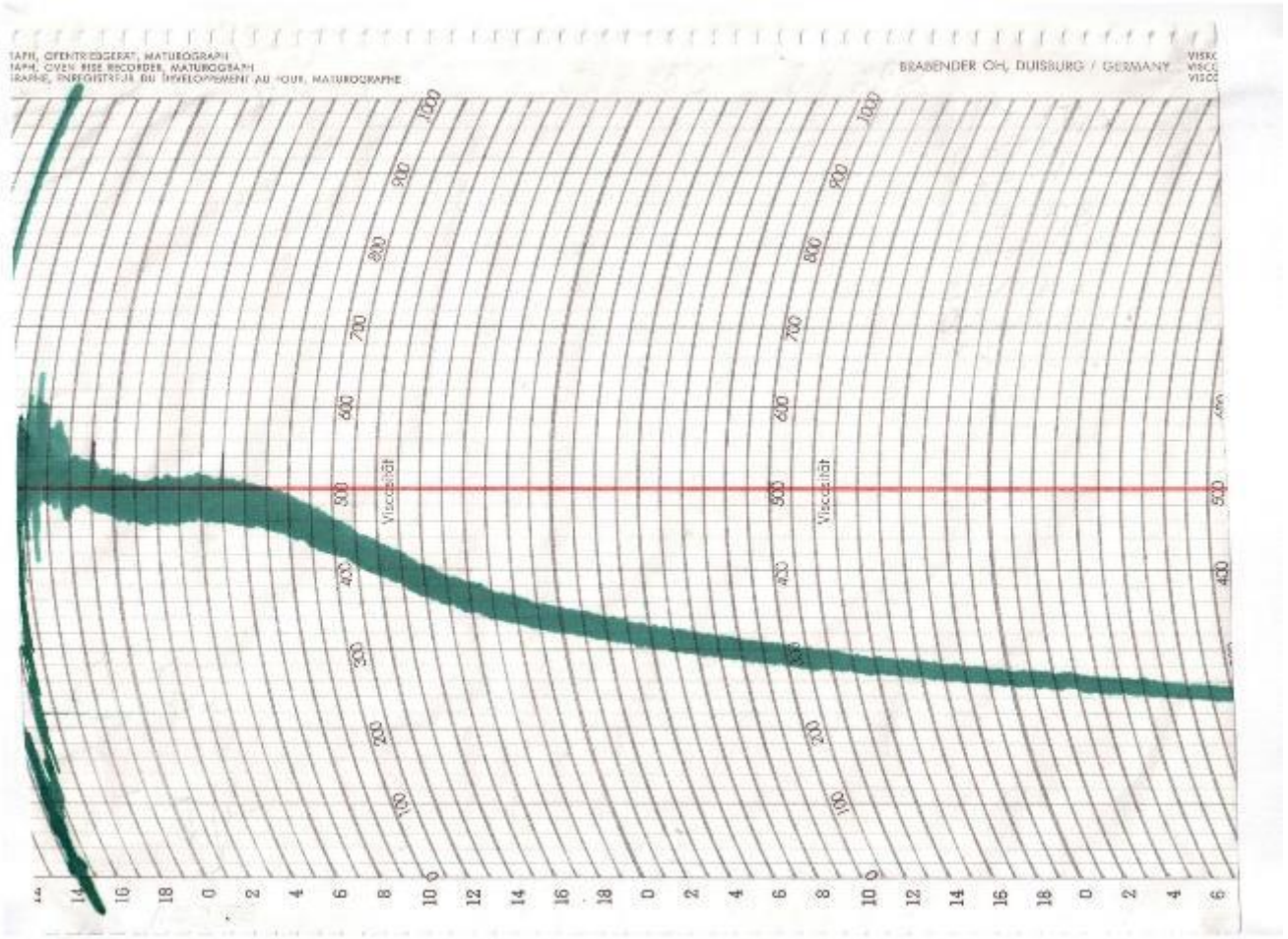

Fig. 1. Farinogram of the triticale cultivar Amphidiploid 256 (2016)

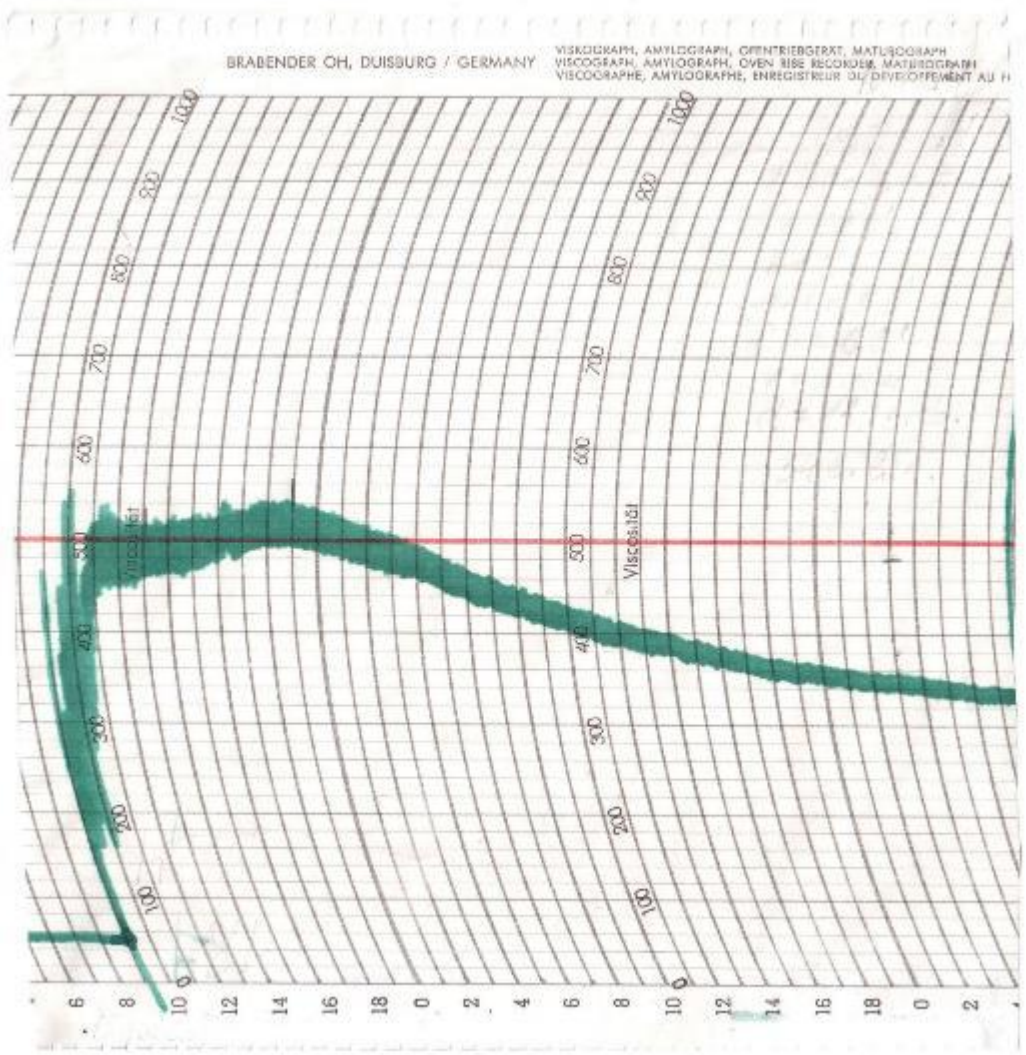

Fig. 2. Farinogram of the triticale cultivar Bouquet (2016)

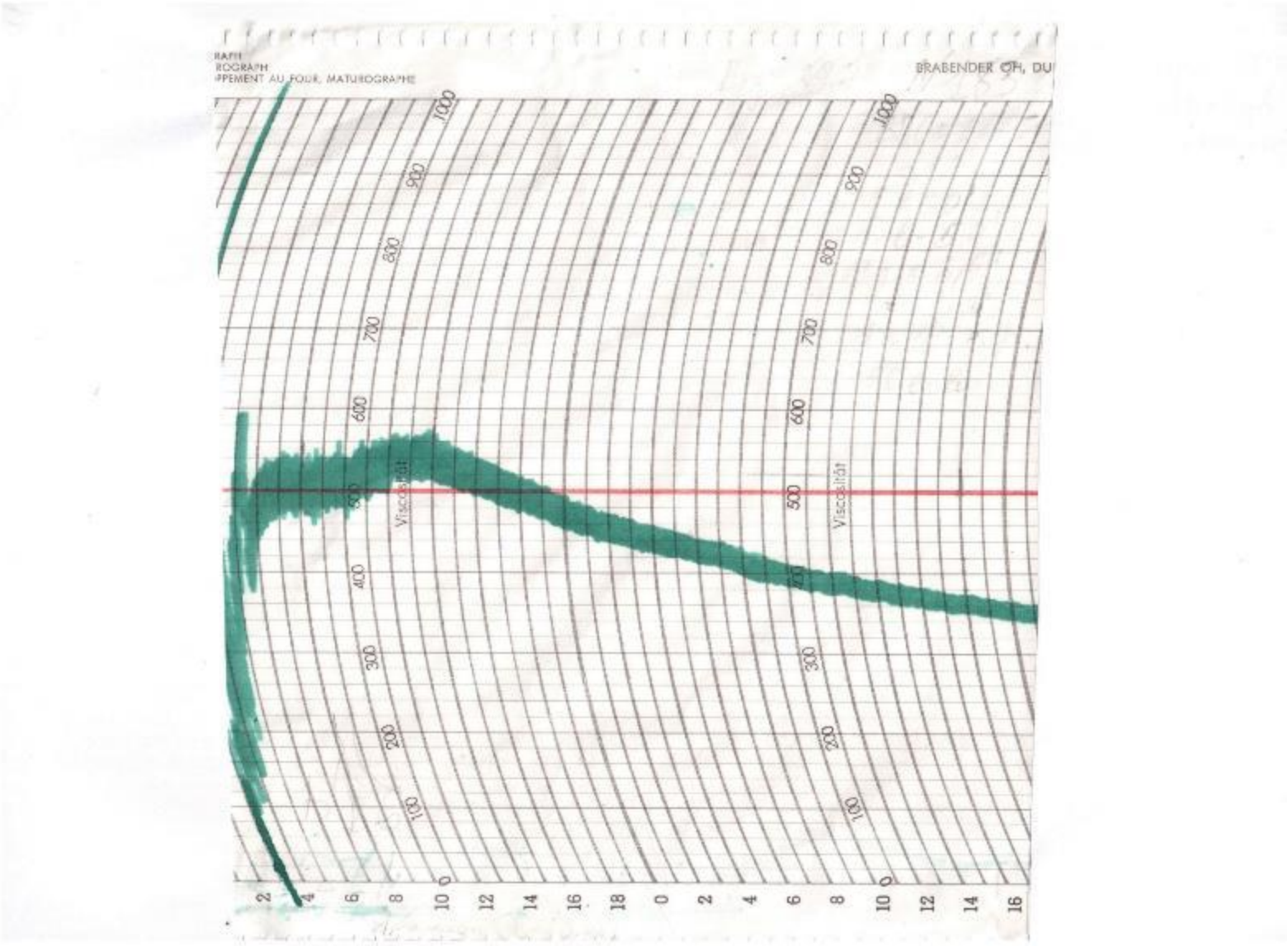

Fig. 3. Farinogram of the triticale cultivar Valentin 90 (2016)

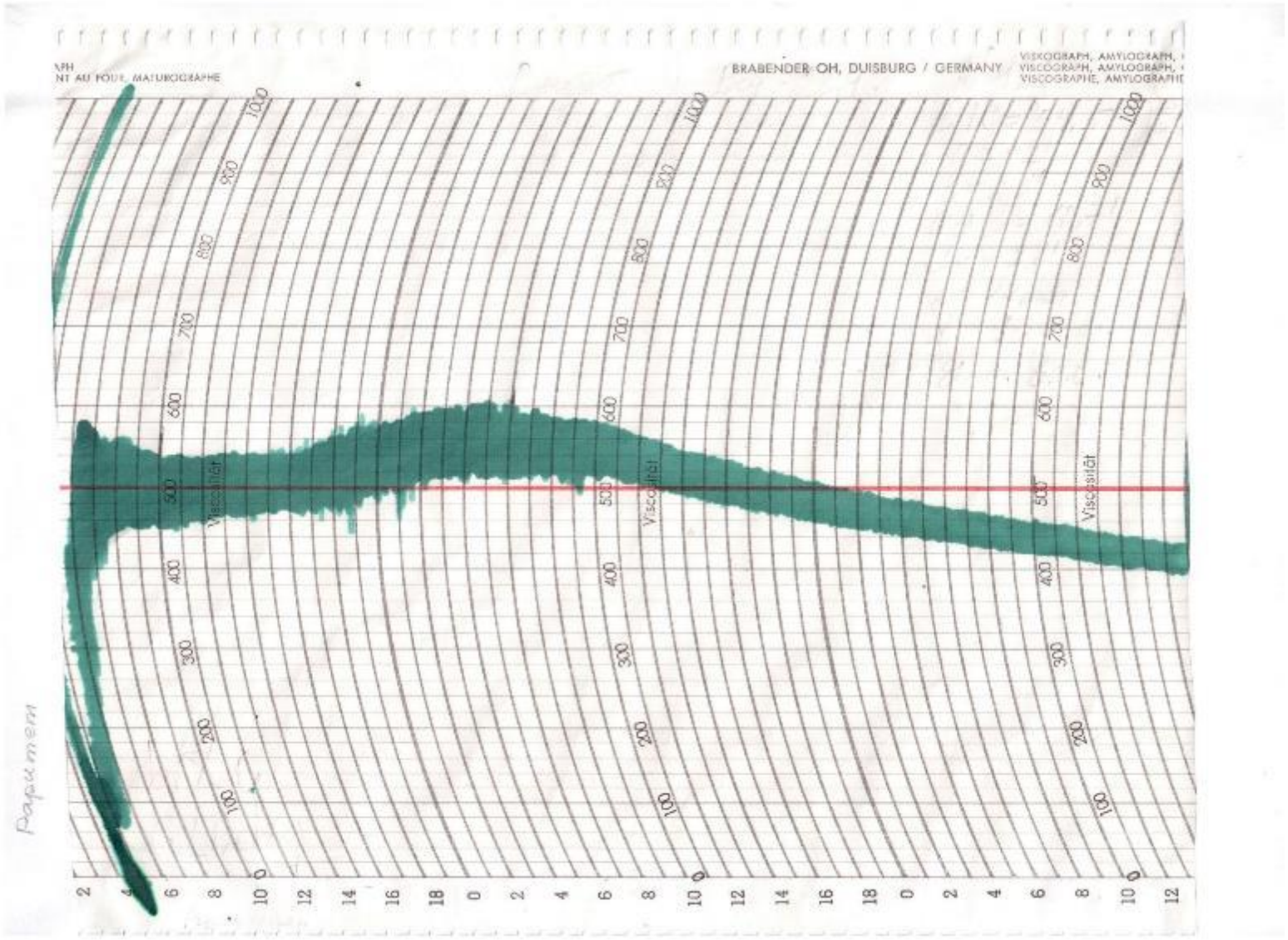

Fig. 4. Farinogram of the triticale cultivar Raritet (2016)

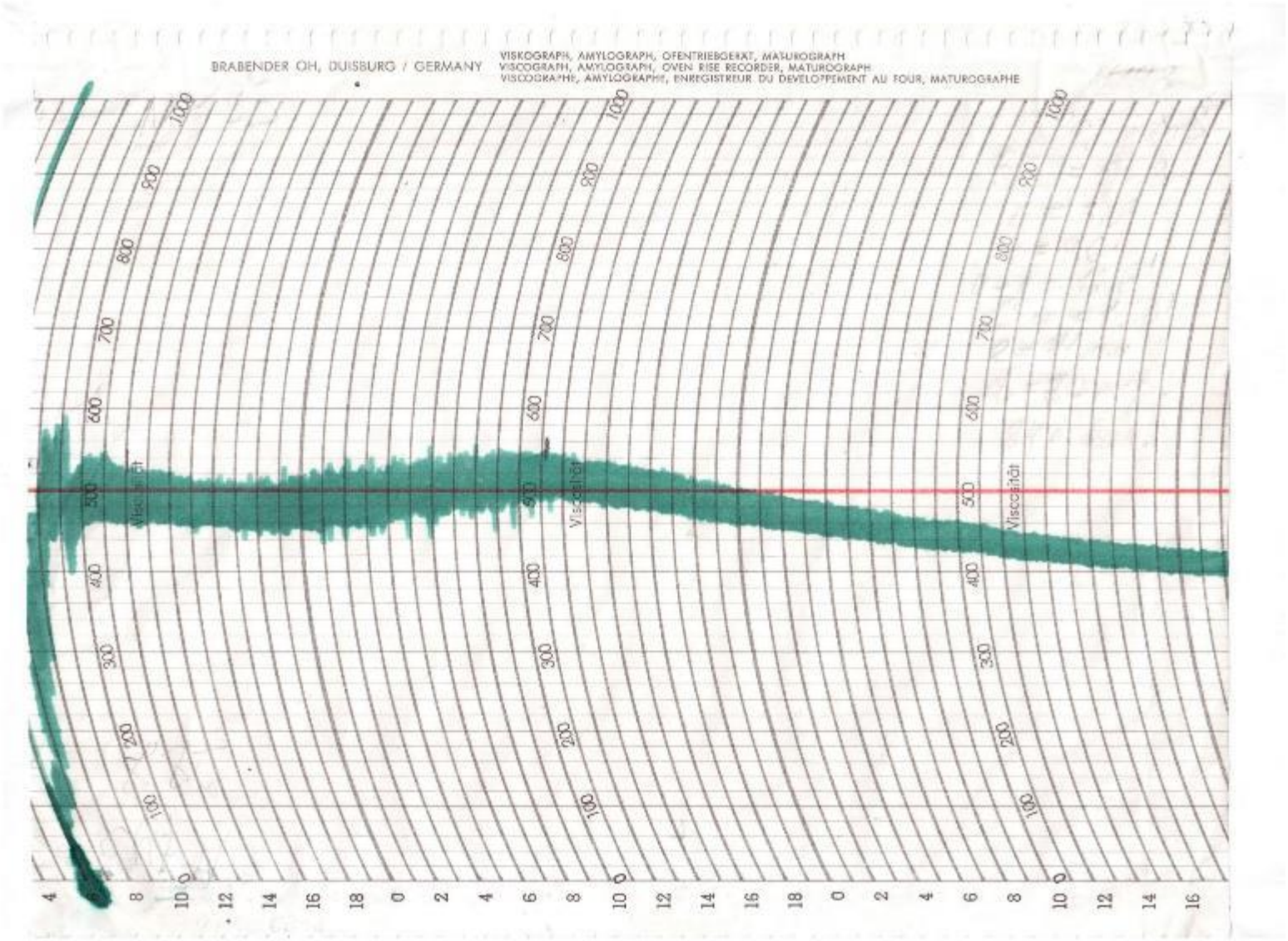

Fig. 5. Farinogram of the triticale cultivar Timofey (2016)

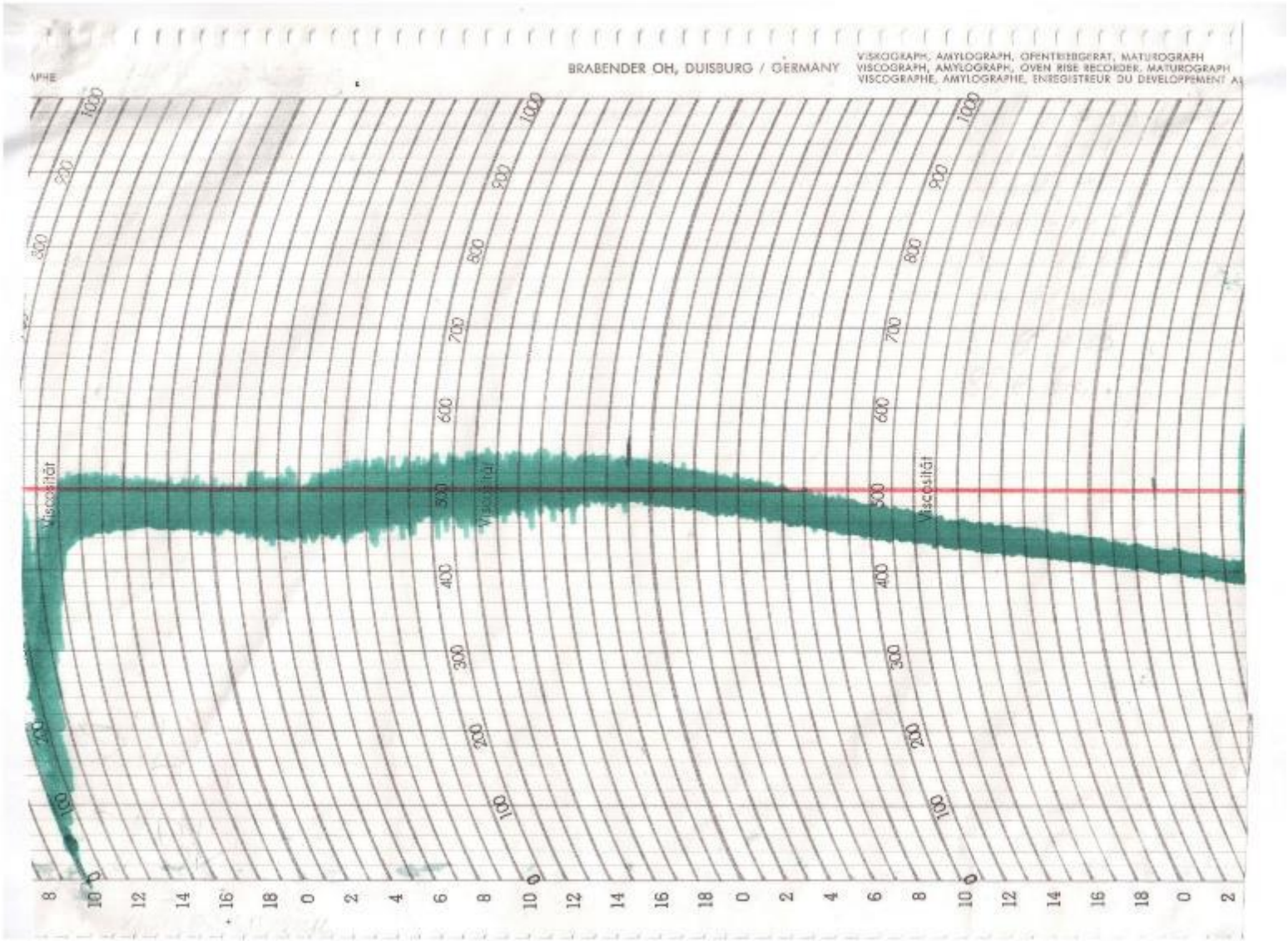

Fig. 6. Farinogram of the triticale cultivar Pudik (2016)

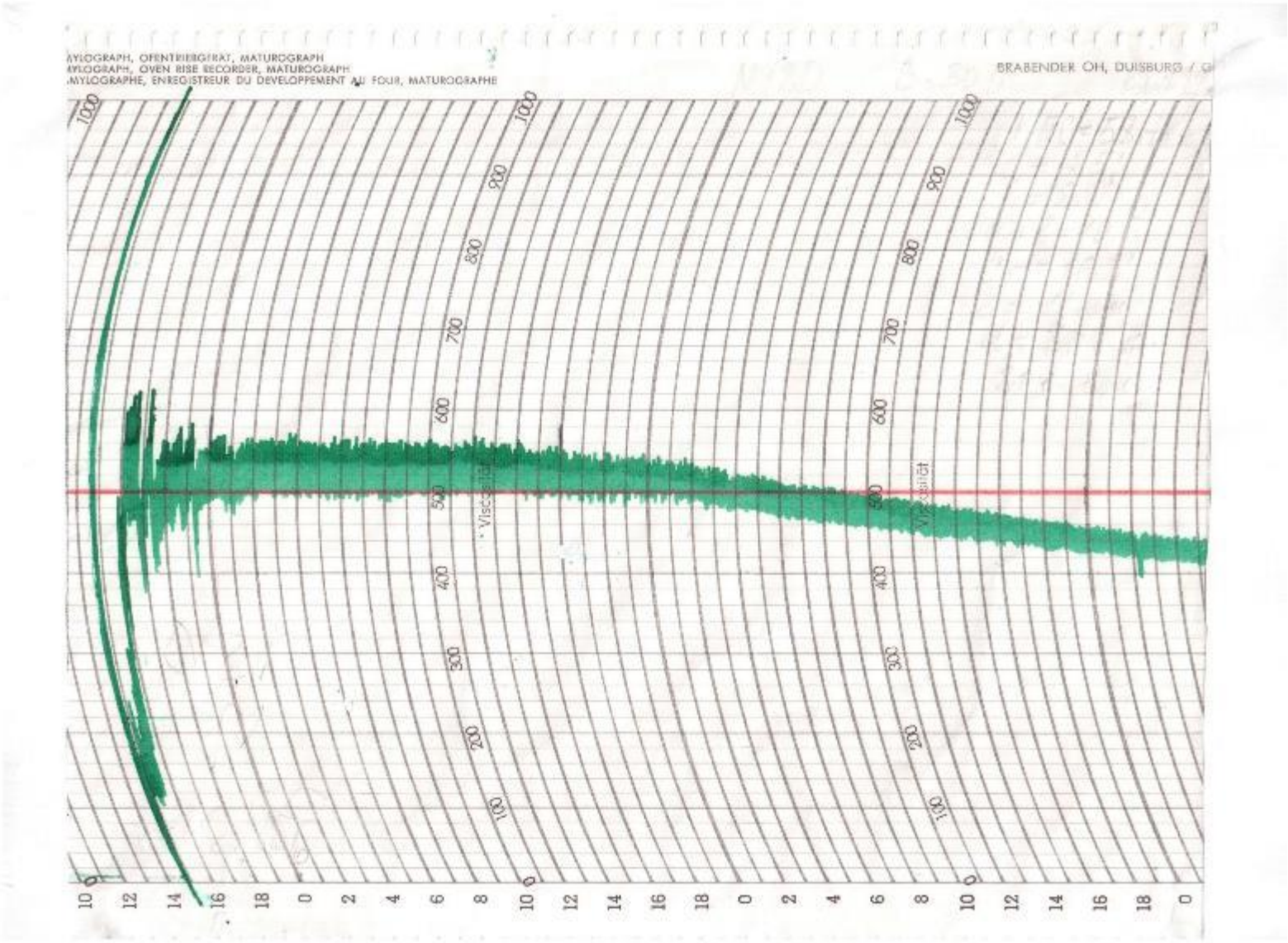

Fig. 7. Farinogram of the cultivar of bread wheat Podolyanka (2016)

Fig. 8. Bread from flour from cultivars of triticale (1 - 3) and wheat (4)
1 – Amphidiploid 256, 2 – the Raritet, 3 – Timofey, 4 – Podolyanka (2017)

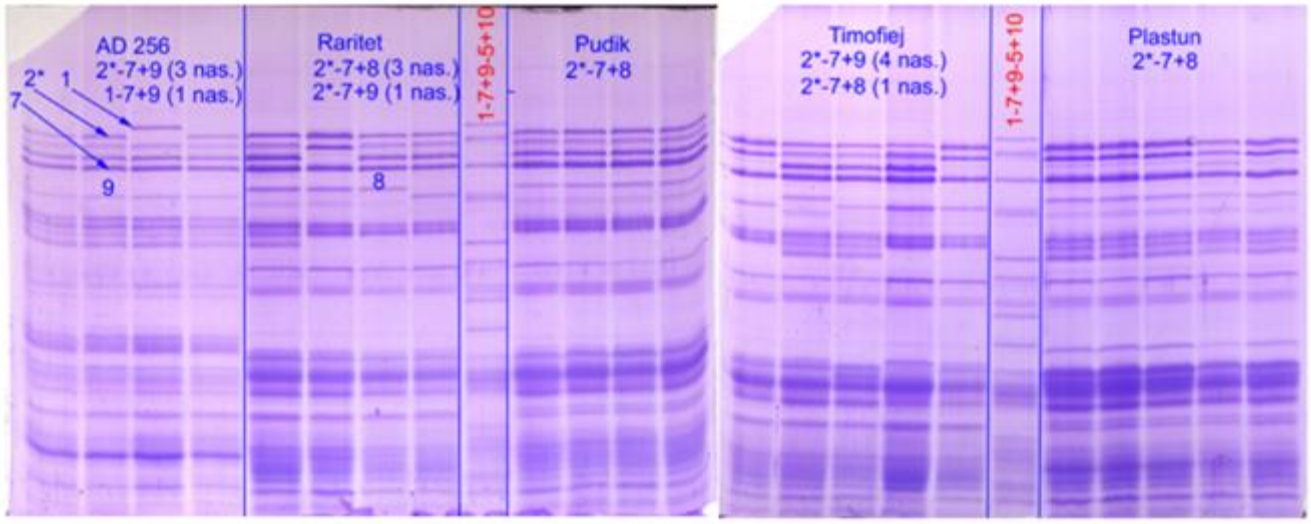

Fig. 9. Electrophoresis of glutenin of triticale cultivars Amphidiploid 256, Raritet, Pudik, Timofey and Plastun

Literature cited

1. Tritikale. – Materialyi mezhd. n.- pr. konf. «Rol tritikale v stabilizatsii i uvelichenii proizvodstva zerna i kormov»/ Otv. red Grabovets A.I. – Rostov-na-Donu, 2010. – 292 s.
2. Tritikale – kultura XXI storIchchya. – Tezi dop. mIzhn. n. – pr. konf. 4 – 6 lipnya 2017 r. – HarkIv: TOV «NIlan – LTD», 2017. – 85 s.
3. Schipak G.V. SelektsIya geksaploYidnih tritikale na pIdvischennya adaptivnih vlastivostey, urozhaynostI ta yakostI zerna/ V kn.: Osnovi upravlInnya produktsIynim protsesom polovih kultur. – HarkIv, 2016. – S. 313 – 373.
4. Schipak G.V., Chernobab R.A., Bosyuk E.A. i dr. Metodyi, napravleniya i rezultatyi selektsii ozimyih geksaploidnyih tritikale v Institute rastenievodstva im. V.Ya. Yureva NAAN / Tritikale – kultura XXI storIchchya. – Tez. dop. mIzhn. n. – pr. konf., HarkIv, 2017. – S. 57 – 59.
5. 5. MetodichnI rekomendatsIYi z otsInki yakostI zerna selektsIynogo materIalu/ Leonov O.Yu., Panchenko I.A., Sklyarevskiy K.M. ta In. – HarkIv, 2011. – 70 s.
6. 6. Schipak G.V. Rezultati selektsIYi tritikale dvoruchok// SelektsIya I nasInnitstvo. – H., 1998. – Vip. 81. – S. 38 – 45.
7. 7. SposIb stvorennya sortIv ozimogo tritikale z pIdvischenimi tehnologIchnimi pokaznikami yakostI zerna. – Patent na korisnu model No. 44901. – 2009.
8. Schipak G.V., Tsupko Yu.V., Schipak V.G. Hlebopekarnyie kachestva sortov ozimogo geksaploidnogo tritikale // Dokladyi RASHN. – 2013. - #1. – S. 3 – 7.
9. Shevchenko V.E., Pshenichnyiy A.E. Kachestvo zerna perspektivnogo tritikale Amfidiploid 206 v usloviyah Yugo-Vostoka TsChP // Tritikale. Problemyi i perspektivyi / Sb. nauch. rabot NIISH TsChP im. V.V. Dokuchaeva. – Kamennaya Step, 1976. – T. 12 – Vyip. 1. – S. 70 – 77.