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INCREASING GRAIN YIELD POTENTIAL AND STABILITY IN DURUM WINTER WHEAT IN UKRAINE

Invests into a soil and water unit will be decreasing during next century due to prognoses. Scientific investigations show that seed wheat production must grow up on 1.6 per cent a year next 20years to satisfy wheat requirement in the world. This complete task to intensify theoretical and practical breeding and secure further rise in wheat seed production [1]. Durum wheat was spread on 15.5–18.3 mln ha and annual seed production – 30–35 mln ton. Average yield of it is 2.2 t/ha, that on 0.5 t/ha more then main yield of durum wheat in 1986 year [2]. This progress was possible because of significant increase of breeding work level in the world. During 27 years (1967–1994) harvest increasing of spring durum wheat was 1.7 per cent a year, and twice times more then progress of bread whet breeding (0.9 per cent last 30 years) [3, 4]. In Ukraine we must to provide in production winter durum wheat varieties two-three times preyielded spring varieties of this culture because of more effective using of autumn-winter moisture of soil. We tested futures and peculiarities of the culture and as a result of breeding work in Plant Breeding and Genetics Institute (PBGI) the seed harvest of new varieties 3.41–4.36 t/ha more than the first var. Michurinka and Novomichurinka had.

Material end methods

The first varieties of typical winter durum wheat Michurinka and Novomichurinka were created by interspecies hybridization varieties of bread winter and durum spring wheat, following by saturated crosses with bread winter wheat. Systematic improving of durum winter wheat has been initiated on the 70^{th} of the XX century. New initial material of winter durum wheat was created on introgression of dwarf-genes and alleles with low photoperiodic sensitiveness, improving of flower fertility and resistance to biotic and a biotic stress. Dwarfness donors in hybridization were the most frost and winter resistant varieties of durum winter wheat of extensive type: Novomichurinka, Rubizch, Odeska Jubileina, Kharkivska 1 and est.

Results and discussion

As a result of these researches the initial material was created and potential of productivity raised up to 2.0–2.5 times. Development on this material of breeding program gave a possibility to breed the first varieties of shortness durum winter wheat in the Soviet Union. There were Parus and Koral Odesky registries in 1983 and 1985 years in the State varieties Register of the Ukraine and Russian Federation. Productivity of durum winter wheat have increased on 2.3 t/ha compare to Michurinka and Novomichurinka, and on 1.8 t/ha respectively to cultivated varieties [5, 6]. During this period 5 strain renovations have place in the Ukraine. Grain yields of durum winter wheat varieties increased on 4.36 t/ha, or 148.8 per cent (table 1), under comparative condition of tests. Absence of stabile yields of new varieties in years had shown low lever of their adaptive to stress factors of environment. The main a biotic factors decreased stability of yield in the Sought Ukraine was low resistance to frost, winter and drought. As far as simple interspecies and top crosses did not give adapted to local conditions varieties of durum winter wheat, then this problem was solved by polystaged hybridization with adaptive to stress conditions initial material. Long term investigation of the PBGI and other institutes had demonstrated that all relatively frost and winter resistant varieties and forms of durum winter wheat included cytoplasm of winter resistant varieties of bread winter wheat. High winter resistant varieties of bread winter wheat and well adapted to local conditions varieties and forms of durum winter wheat of our own breeding have been included to breeding work to create winter and frost resistant initial material. On plants F_1 of species hybrids have been made following crosses by winter and frost resistant varieties and forms of durum winter wheat to confirm tetraploid genome stability and it winter resistance. After some years of selection hybrid material has been crossed with winter resistant varieties of bread and durum wheat from different agro ecological zones that allowed accumulating adaptive features in initial material.

Table 1. Grain yields of durum winter wheat in different strain renovation in comparison varieties test of PBGI in 2007–2010 years (background-black fallow)

Strain renovation	Variety	Years of cultivation	Average grain yield, t/ha	Over yield on strain renovation, t/ha	
				The first	The previous
I	Michurinka Novomichurinka	1960–1968 1963–1970	2.93	-	- 0.28
II	Rubizch Odeska Jubileina	1969–1975 1972–1980	3.43	0.50	0.50
III	Parus Koral Odesky	1983–2000 1985–2002	5.23	2.30	1.80
IV	Iceberg Odesky Aliy Parus Delpfin Argonavt Perlina Odeska Zolote Runo Laguna	1990 1993 1999 2001 2001 2004 2005	6.34	3.42	1.11
V	Gardemarine Burshtyn Kontinent Tavrida Kreiser Lincor Bosfor Gavan	2006 2007 2008 2009 2010 2010 2011 2011	7.29	4.36	0.95

Breeding of durum winter wheat in the PBGI had carried from long straw extensive varieties with a number of negative features and indexes to semi dwarf and dwarf varieties with increasing productivity and improving their economic characteristics. Yield of modern varieties of durum winter wheat compare to the first of them – Michurinka and Novomichurinka increased on 2.5 times in steppe zone and on 2.8–3.0 times in forest-steppe zone. Plants height had decreased from the third to the fifth varieties exchange on 45.1; 36.0; 33.3 cm compared to the first one. Yield has in that groups gradually increased on 2.3; 3.4; 4.4 t/ha. At that time frost resistance had increased too. That is why frost resistance collection and breeding material were tested by freezing in climatizer at 17–19 °C of frost. Varieties Aliy Parus, Perlina Odeska, Gardemarine, Burshtyn, Tavrida and Bosfor had higher frost resistance compare to standard Iceberg Odesky, and Laguna and Kontinent had the same.

Level of frost resistance of durum winter wheat given on figure 1 was confirmed by unprecedented freezing under field conditions from 29 January to 15 February 2012 when temperature in tillering node was -8.5 – -11.3 °C without of any snow cover. Living plants were counted per $1m^2$ before harvest (table 2). Under hard winter conditions the next varieties: Iceberg Odesky, Aliy Parus, Perlina Odeska, Gardemarine, Burstyn, Tavride, Kontinent and Bosfor were characterized by high frost resistance. The best frost and winter resistance had demonstrated varieties which had necessity in long time vernalization and strong photoperiodic sensitivity. But more sustained yield of grain in the South of Ukraine gave varieties of durum winter wheat with long term vernalization necessity (30–35 days) and semi strong photoperiodic sensitivity. They earlier begin to vegetate and better used soil moisture in spring. Iceberg Odesky is one of such a variety; it occupies the main areal in the south part of winter wheat zone of SNG countries (28 regions and districts). Varieties Argonavt, Laguna, Gardemarine, Tavrida and Gavan are the same rate. Varieties characterized by middle necessity in vernalization and neutral reaction on photoperiodic sensitivity (Perlina Odeska, Burshtun, Kontinent) better then others used soil moisture after winter to form high productivity.

Table 2. Frost resistance of durum winter wheat varieties in the ecological varieties test 2011–2012 years (black fallow, planting rate 5 mln germinating seeds on hectare, date of sowing 7.10.2011)

NN	Variety	Frost resistance		NN	Variety	Frost resistance	
		plants	per sent			plants	per sent
1	Novomichurinka	194	38.8	12	Zolote Runo	186	37.2
2	Odeska Yantarna	166	33.2	13	Laguna	254	50.8
3	Rubizch	190	38.0	14	Gardemarine	258	51.6
4	Odeska Jubileina	189	37.8	15	Burshtyn	268	53.6
5	Parus	142	28.4	16	Kontinent	256	51.2
6	Koral Odesky	199	39.8	17	Tavrida	255	51.0
7	Iceberg Odesky	276	55.2	18	Kreiser	218	43.6
8	Aliy Parus	282	56.4	19	Lincor	193	38.6
9	Delfin	214	42.8	20	Bosfor	288	57.6
10	Argonavt	251	50.2	21	Gavan	229	45.8
11	Perlina Odeska	257	51.4	22	Kassiopeya	225	45.0

Microevolution of durum winter wheat breeding in Ukraine directed to decreasing straw height for improving varieties resistance to lodging and increasing of yield index (table 3). Reducing of straw height due to change of plant architectonics and different elements of yield structure. On the first stage of straw height reducing (var. Parus and Koral Odesky – the third renovation) significant yield increase was achieved by rise of grain mass in kernel on 0.35, grain mass from plant – 0.7, and seed size – 14.9 g. Productive tillering of the varieties increased on 0.15 pieces. Redistribution of plastic matters during ontogenesis for grain part of plant from common biological yield was confirmed by yield index.

Ratio of common plants biomass and grain part before harvest for taller varieties was 0.19–0.27, and for Parus and Koral Odesky 0.60 and 0.59, relatively Grain part increased in common biological yield on 2.2–3.1 times. The first semi dwarf varieties Parus and Koral Odesky had significantly increased productive potential of durum winter wheat, but they were quit sensibly to uncomfortable environments which were very typical for the North Black sea region. It was necessary to improve adaptive features of new varieties by breeding polystaged hybridization was used – created semi dwarf forms were crossed with adapted to local conditions varieties and forms of durum winter wheat. Var. Iceberg Odesky (1985) and Aliy Parus (1990) were the result of this breeding work.

The varieties were cultivated in the Steppe and Forest steppe zone of Ukraine and in the other countries more then 20 years. Into the Register were introduced var. Delpfin, Argonavt, Perlina Odeska, Zolote Runo, Laguna, which were characterized by higher yield and grain quality, good reaction on high fertilizing and complex resistance to spreaded diseases. Different elements of yield structure ensured rise of their productivity. Risen grain yield of these varieties was the result of growing biomass (+0.62 kg/m2). Decreasing of yield index (-13.9) did not affected their productivity because of increasing grain number in main spike (+6.2) and other productive spires of plant (+0.09 g). Although rate of grain fulling became better (varieties headed and matured later), raised seed volume weigh due to its uniform. In fact the yield of these varieties raised on 0.06 kg/m^2 compare to Parus and Koral Odesky. Varieties of durum winter wheat had included to the Register of plants (2006–2011), Gardemarine, Burshtyn, Kontinent, Tavrida, Kreiser, Lincor, Bosfor and Gavan, increased their yield by rising of biomass (+0.12 kg/m^2) and number of grains in a spike (+0.05 kg/m^2). Main spike had on 3.2 grain more (in average) and it's weight became more on 0.07g for this pike and 0.22g from other one. Yield index increased (+1.2) too, but 1000 grain weight had decreased (-2.8 g).

Conclusions

Introgression into genotype of extensive varieties of durum winter wheat genes of dwarfness and alleles of low photoperiodic sensitivity resulted by grain yield rising on 18.0 c/ha compare to previous varieties exchange. These modifications become possible because of redistribution of plastic matters during ontogenesis to grain part, as yield index showed. Yield index of extensive varieties was 0.19–0.27, varieties Parus and Koral Odesky had yield indexes – 0.60 and 0.59, respectively. Grain part had increased in total biological yield on 2.2–3.1 times. Productivity increasing of varieties of durum winter wheat was dependent on rising of biomass (+0,62 kg/m^2), at first. Although yield index had decreased (-13.9), new varieties had more

grains in a main spike (+6.2) and in other productive spikes (+0.09 g) and total on one square meter.

Varieties of the last germination had yield increasing due to rising of biomass (+0.12 kg/m^2), grain number in a spike on 1m^2 (+0.05 kg/m^2). Grain number in a spike increased on 3.2 grains, and their weight from a spike – on 0.07 g, and from regrowthes – 0.22 g yield index had demonstrated some increasing (+1.2) and decreasing of 1000 grain mass (-2.8 g). Modern varieties of durum winter wheat had more prolonged period of vegetation on 2–3 days.

Increasing of potential productivity and stability of grain yield of durum winter wheat can't be achieved without high adaptability to a biotical and biotical factors of stress environment.

Table 3. Index of yield structure of durum winter wheat varieties of PBGI, breeding which were introduce to the Register of plant varieties of Ukraine (average for 2008–2011 years)

Variety	Plant height, cm	Lodging resistance points	Yield, kg/m^2			Crop yield index
			straw	grain	biomass	
Novomichurinka	132.7	4.0	1.65	0.31	1.96	0.19
Rubizch	128.5	3.0	1.78	0.45	2.23	0.25
Odeska Yubileina	143.9	3.5	1.86	0.49	2.35	0.27
Parus	86.7	5.0	1.35	0.82	2.17	0.60
Koral Odesky	88.6	5.0	1.37	0.82	2.19	0.59
Iceberg Odesky	93.6	4.5	1.80	0.87	2.67	0.48
Aliy Parus	94.6	4.5	1.79	0.94	2.73	0.52
Delpfin	99.1	4.5	1.95	0.82	2.77	0.42
Argonavt	97.7	4.5	1.98	0.93	2.91	0.47
Perlina Odeska	96.4	5.0	2.02	0.94	2.96	0.46
Zolote Runo	102.8	4.5	1.92	0.79	2.71	0.41
Laguna	93.0	5.0	2.02	0.87	2.89	0.43
Gardemarine	98.2	5.0	2.15	0.93	3.08	0.43
Burshtyn	101.6	4.5	1.96	1.03	2.99	0.52
Kontinent	94.4	5.0	1.86	0.90	2.76	0.48
Tavrida	95.1	5.0	1.90	0.93	2.83	0.49
Kreiser	101.1	4.5	2.05	0.94	2.99	0.46
Lincor	93.3	5.0	1.95	0.87	2.82	0.45
Bosfor	104.4	5.0	2.02	0.91	2.93	0.45
Gavan	106.8	4.5	2.02	0.93	2.95	0.46

References

1. Byerlee D., Traxler G. estimation of actual spillovers of national and international wheat improvement research. // In Maredia M.K. and Byerlee D. (ads) The Global Wheat Improvement System: Prospects for Enhancing Efficiency in the presence of Spillovers. CIMMIT Research Report. – CIMMYT, Mexico, 1999. – N 5. – P. 46–59.
2. World Wheat Statistics // International Wheat Council, 28 Haymarket. – London, SWLGm, 1986. – 4SS.
3. Calderini D.F., Reynolds M.P., Slafer G.A. Genetic gains in wheat yield and main physiological changes associated with them during the 20th century // In: Sattore E.H. Slafer G.A. (eds), Wheat: Ecology and Physiology of Yield Determination. Food Products Press. – New York, 1999. – P. 351–377.
4. Pfeiffer W.H. Enhancing genetic grain yield potential in durum wheat and triticale / W.H. Pfeiffer, K.D. Sayre, M. Mergoum // In Increasins Yield Potential in Wheat: Breading the Barrires, eds. M.P. Reynolds, S. Rajaram and A. McNab. – Mexico City, Mexico DF: CIMMYT, 1996. – P. 208–213.
5. Kirichenko F.G. Methods and results of breeding durum wheat in the Steppe regions of Ukranian S.S.R. // Genetics and Breeding of durum wheat: Proceedings of a Symposium organized by the Section Cereals of the European Association for Research of Plant Breeding (EUCARPIA) and by the Plant Breeding Institute of the University of Bari, eds. G.T. Scarascia Mugnozza, held in Bari, 14–18 May, 1973. – P. 305–310.
6. Palamarchuk A.I. Breeding of Intensive Type Durum Winter Wheat Varieties to Increase Adaptation Potential // In Wheat Breeding Prospects and Future Approaches: Proceedings of International Symposium by the Agricultural Academy Institute for Wheat and Sunflower "DOBRODJA", eds. I. Panayotov, S. Pavlova, June 4TH – 8TH 1990. – P. 71–75.

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Aims. To test different features of yield structure and adaptive qualities of durum winter wheat varieties this influenced on significant rise of yield potential and stability. ***Methods.*** The first varieties of typical winter durum wheat were created by interspecies hybridization varieties of bread winter and durum spring wheat, following by saturated crosses with bread winter wheat. ***Results.*** Introgression into genotype of extensive varieties of durum winter wheat genes of dwarfness and alleles of low photoperiodic sensitivity resulted by grain yield rising on 1.8 t/ha compare to previous varieties exchange. These modifications become possible because of redistribution of plastic matters during ontogenesis to grain part, as yield index showed. Productivity increasing of varieties of durum winter wheat was dependent on rising of biomass (+0.62 kg/m^2), at first. ***Conclusions.*** Increasing of potential productivity and stability of grain yield of durum winter wheat can't be achieved without high adaptability to a biotical and biotical factors of stress environment.

*Key words**:*** durum winter wheat, yield potential, varieties, adaptability.