BREEDING OF *LUPINUS ALBUS* CULTIVARS IN RUSSIA: RESULTS, PERSPECTIVES, PROBLEMS

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ABSTRACT

White lupin cultivation in Russia is important due to its high potential seed and protein yield. White lupin breeding program and studies have been conducted in Central-Chernozem zone (500 km south of Moscow, Tambov region). The main objective of white lupin breeding in Russia is to obtain early maturing cultivars. We were successful in breeding early maturing spring cultivars with reduced branching and different plant architecture (types 1-4): Type 1: cv. Deter 1 is without any branches and with pods set only on main stem; type 2: cvs Start and Gamma are characterised by a low plant height. The pods are formed on the main stem and short branches of the first level; type 3: cvs Delta and Dega have short branches of 2-d level with pods on them; 4. cvs Manovitsky and Desnyansky have branches 2-d and 3-d level. These cultivars mature in Tambov region. Their vegetative period is 100-140 days; seed yield is 2.0-4.0 t per ha depending on a cultivar and weather conditions. Results, perspectives and problems are discussed.

KEY WORDS

Lupinus albus, breeding, early maturity, seed yield

INTRODUCTION

White lupin cultivation in Russia is important due to its high potential seed and protein yield. Besides, it does not require mineral nitrogen. The seeds of this species are a good resource for protein balance in animal feeding. White lupin has perspectives for feed and food technology in Russia. *Lupinus albus* can be cultivated in the Central European part of Russia. Climate of this region is moderate. The sum of temperatures during vegetation period (> 5°C) is 2000-2200°C. Unstable maturation is a main limiting factor of white lupin production in this region. Sowing date is the end of April and maturity must be at the end of August or no later than middle of September: Cool and humid September weather is unfavourable for maturation. The famous in Australia cv. Kievsky mutant reaches maturity in the Central Chernozem zone of Russia in the middle of September only during dry years. Period from sowing till maturity should be no longer than 130 days, better if it is 110-120 days. Thus the first objective of white lupin breeding is to obtain early maturing cultivars. Lupin cultivars have to be resistant to Fusarium. The disease is dangerous for lupin production in Russia. Highly productive and Fusarium-resistant cultivars with stable maturity are the main objectives of *Lupinus albus* breeding in Russia.

MATERIALS AND METHODS

Breeding program of white lupin (*Lupinus albus L.*) started in 1980 at Experimental Field of Moscow Agricultural Timiryazev Academy in Tambov region (500 km south Moscow). The soil there is a leached chernozem (pH 6.2). Precipitation during vegetative period (April-September) is 280-300 mm. The lines with reduced branches were created by using artificial mutagenesis (Gataulina, 1987, 1994). We've used several schemes of crossing and were successful in breeding early maturing spring cultivars with required features and different plant architecture. Recently breeding program is conducted in collaboration with Russian Lupin Research Institute, Bryansk.

Comparative studies of spring cultivars growth and development were conducted at the same place. Among them were Start, Gamma, Manovitskiy, Delta, Dega, Desniansky and Deter1 cultivars of Tymiryasev Academy and Bryansk selection. The size of the field plot was 25 m^2 with 4 replicates. The sowing was performed at the end of April. The density before harvesting was 35-40 plants/m^2. Wet and dry matter accumulation and leaf area were determined by sampling 15 plants from every plot at 15 days interval. Yield components were determined by studying 25 plants from every plot.

RESULTS AND DISCUSSION

Start was the first early maturing cultivar registered in 1984 followed by cv. Manovitskiy (1993) and Gamma (1998). These cultivars were obtained by selection from induced mutants when dry seeds of sample Bely 7 were treated with gamma – rays (15-20 kr).

IN J.A. Palta and J.B. Berger (eds). 2008. 'Lupins for Health and Wealth' Proceedings of the 12th International Lupin Conference, 14-18 Sept. 2008, Fremantle, Western Australia. International Lupin Association, Canterbury, New Zealand. ISBN 0-86476-153-8.

Start and Gamma are characterised by a low plant height, small seeds and reduced branching in comparison with Bely 7. Periods of flowering, pod filling and maturing are shortened due to a limited branching and compact architecture of the plants. Fusarium-resistant Gamma matures 4-5 days earlier than Start. Manovitskiy has higher plants in comparison with Start, besides its vegetation period is 5-10 days longer depending on whether conditions. Cultivars Delta (registered in 2000) and Dega (2004) were obtained in collaboration with Russian Lupin Research Institute. They are Fuzarium-resistant and are characterised by a higher seed yield and non-lodging at humid conditions in comparison with Gamma.

Table 1. Type of *Lupinus albus* cultivars adapted to Central Chernozem region of Russia. Numbers are averages for years with normal precipitation at a plant density of 40 plants m^{-2}.

Characters	Type of architecture, cultivar			
	1	2	3	4
	Deter 1	Start, Gamma	Delta, Dega	Manovitsky, Desnyansky
Lateral branches, order	0	1-2	2-3	2-4
Growth period (sowing-maturity), days	106	115	120	130
Plant height, cm	55	60	65	73
First pod height, cm	42	43	45	50
Wet matter accumulation, mg ha^{-1}	44	52	57	65
Dry matter accumulation, mg ha-	5.6	6.5	6.8	7.8
Seed yield, mg ha^{-1}	3.10	3.25	3.45	3.55

Table 2. Effect of weather conditions (water supply) on plant height and period between sowing and maturity of *Lupinus albus* cultivars (2003 – humid, 2006 – middle, 2007 – drought during vegetative growth).

Type	Cultivar	Plant height, cm			Sowing – maturity, days		
		2003	2006	2007	2003	2006	2007
2	Start	67	60	37	138	110	106
	Gamma	60	60	36	137	109	106
3	Delta	69	64	36	143	111	106
	Dega	65	62	35	143	111	106
4	Manovitsky	73	67	35	155	118	109
	Desnyansky	78	68	37	155	120	110
1	Deter 1	60	56	35	125	100	102

Table 3. Effect of annual weather conditions on seed yield of *Lupinus albus* cultivars.

Cultivar, line	Seed yield, t ha^{-1}				% from main stem			
	2004	2005	2006	2007	2004	2005	2006	2007
Gamma	2.85	1.80	3.23	2.38	80	90	92	95
Delta	2.70	2.07	3.43	2.67	79	88	91	97
Desnyansky	3.86	2.40	3.55	3.09	56	65	80	88
Dega	2.70	2.02	3.23	2.34	78	88	91	97
Deter 1	2.70	1.80	3.26	2.26	100	100	100	100
22M(NxD)17	3.60	2.06	4.05	3.23	78	87	90	95
9M(ZxD)	2.45	2.38	3.23	3.26	83	73	90	93
LSD_{05}	0.27	0.27	0.36	0.30				

Table 4. Dry matter accumulation (stage of filling pods) and weight of 1000 seeds.

Cultivar, line	Dry matter accumulation, t ha^{-1}				Weight of 1000 seeds, g			
	2004	2005	2006	2007	2004	2005	2006	2007
Gamma	52.0	50.0	48.7	46.1	340	300	430	320
Delta	52.7	57.4	53.7	44.5	380	305	440	340
Desniansky	70.2	69.7	64.5	46.8	420	335	470	350
Dega	53.2	50.0	54.2	46.2	370	310	415	335
Deter 1	56.5	51.8	40.2	48.5	380	280	440	340
22M(NxD)17	60.5	71.2	60.6	52.9	390	320	440	350
9M(ZxD)	52.7	57.0	50.7	54.6	360	345	510	420
LSD_{05}	5.3	5.1	4.7	4.2				

Table 5. Protein content and protein yield.

Cultivar, line	Protein content, %				Protein yield, kg ha^{-1}			
	2004	2005	2006	2007	2004	2005	2006	2007
Gamma	36.4	36,8	35,5	35,1	1035	660	1150	835
Delta	**37.0**	**37,9**	**39,0**	**36,6**	1000	785	1340	980
Desnyansky	35.0	3,34	32,8	32,1	1350	800	1165	990
Dega78	35.7	34,4	34,9	33,5	965	695	1130	785
Deter 1	**39.1**	**38,5**	**38,4**	**37,0**	1055	695	1250	835
22M(NxD)17	35.6	34,7	35,0	33,3	1280	715	1420	1075
9M(ZxD)	36,6	34,4	35,3	33,8	900	820	1170	1100

TYPES OF DETERMINATION

These cultivars have a different plant architecture and vegetative period from sowing till maturity, though all of them matured in the conditions of Tambov region and even in a more humid Bryansk region. Type 1 is presented by cv. Deter 1 which plants are without any branches and pods are set only on a main stem (Table 1). Start and Gamma (type 2) are characterised by a low plant height. The pods are formed only on the main stem and the short branches of the first level. Periods of flowering, pod filling and maturing are shortened due to a limited branching and compact architecture of the plants. Cv. Gamma is resistant to Fuzarium. It matures 3-4 days earlier than Start. Cvs Delta and Dega (type3) have short branches of second level with pods on them. Manovitskiy and Desniansky (type 4) have branches of the second and third order. Branches of type 4 are longer, than of type 3. Gamma, Delta, Dega and Desnyansky are Fuzarium-resistant.

PERIOD OF VEGETATION AND PLANT HEIGHT

According to the main aim of breeding early maturing spring cultivars have been obtained. Type 2 and 3 cultivars are characterised by a stable maturity at Central Chernozem zone of Russia. Under very humid weather conditions (year 2003) period of vegetation is the longest (Table 2). Their period of sowing to maturity was 137-143 days and emergence to maturity 122-128 days. Middle of September is a limit of maturation because the weather is not very cool and humid yet. There is a problem of maturing and harvesting for type 4 cultivars. The seasons with similar weather are rather seldom at Central Chernozem zone, but they are usual at Bryansk region. Usually Anthracnose is spreading very fast under similar weather conditions.

Under conditions of Tambov region (the place of breeding) which is frequently subject to a lack of moisture during growing season Anthracnose is not developed. This is a reason why Timiryazev Agricultural University (Academy) and Research Lupin Institute joint breeding program is conducted now at Tambov region (Central chernozem zone).

During normal (average) years (Table 2) period of vegetation for cultivars and perspective lines was not long. Under normal weather conditions the vegetative period of type 2 cvs is 106-110 days, type 3 is 110–116, type 4 is 118–125 days. Determinate cv. Deter 1 matured 10-12 days earlier than Gamma. At this region plants were not high. Even plant height of type 4 cultivars didn't exceed 75-78 cm. For Russian cultivars, the earlier they mature, the lower is their plant height. The determinate forms had the lowest plant height as they didn't form lateral branches at all.

SEED AND PROTEIN YIELD

The seed yield of cultivars was rather stable under given conditions (Table 3). Cultivars didn't differ very much because their potential had not been revealed to

full extent due to a period of drought during every growing season. Dry matter accumulation was the higher the longer growth period of cultivar (Table 4).

Number of pods and seeds per plant as well as their distribution on the main stem and lateral branches depend on a genotype and weather conditions. In the same year number of pods and seeds on the main stem of cultivars didn't differ very much. There were 6-7 pods and 20-25 seeds when the density was 35-40 plants m^{-2}. The share of lateral branches in the seed yield varied depending of genotype and weather conditions: 10-20% for type 2-3 and 20-44% for type 4. In 2007 (drought) plant height of all type cultivars was very low – 35-37 cm, practically all seed yield was obtained from the main stem. There were no differences between most cultivars during drought conditions in 2007. The perspective lines 22M and 9M exceeded the standard (Gamma) in seed yield by 35%. The seed yield originated from the main stem was 2.1-3.5 t/ha depending on genotype and weather conditions.

Weight of 1000 seed is important component in seed yield formation. It differs depending of cultivar and weather conditions, especially during period of seed filling (Table 4). In cultivars with reduced branching seed size is correlated with seed yield. Deter 1, without lateral branches, has almost the same seed yield as Gamma because of the higher weight of 1000 seed.

Most cultivars did not differ significantly in protein content except cvs Delta and Deter1: their protein content was 2-3% higher in comparison with the others (Table 5). Deter 1 exceeded Gamma (standard) in protein yield due to higher protein content, though the main advantage of Deter 1 is the shortest period of vegetation.

Thus, if selection was targeted to obtain the yield from the main stem, the achieved results can be considered satisfactory for this region. It should be taken into consideration that stable seed yield and maturity were obtained in this case. Huyghe *et al.* (1994) showed that the indeterminate architecture was responsible for the variability of the yield and yield components of white lupin. So, the control of a vegetative growth through the reduction of the upper branches decreased the vegetation period without the great reduction of a seed yield due to a limited competition between vegetative and reproductive organs.

PROBLEMS

Resistance to Anthracnose remains the main problem. Though there was no Anthracnose at the place of breeding for 40 years of *Lupinus albus* cultivation however we need Anthracnose resistant cultivars because the future of white lupin depends of this.

The seed production system in Russia was destroyed with the demise of the Soviet Union. Scarce finance and poor management are the main problems in seed production process in Russia now.

PERSPECTIVES

The demand for white lupin seeds is rising now in Russia especially in feed industry. So the new perspective cultivars will be in great demand.

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