BREEDING PROGRAM RESULTS AND DEVELOPMENT PATTERN OF DIFFERENT TYPES OF *LUPINUSALBUS* CULTIVARS

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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 have been conducted in Central-Chemozem zone (500 km south of Moscow). We were successful in breeding early maturing spring cultivars with reduced branching. These cultivars with different plant architecture were studied to determine their development pattern.

Key words: *Lupinus albus,* breeding, early maturity, development pattern, seed yield.

Introduction

White lupin cultivation in Russia is important due to its high potential seed and protein yield. Protein content in seed are 36-40% as in soya been. Besides it does not require mineral nitrogen application. White lupin is a relatively new crop for the Central-Chemozem region of Russia. The climate of the region is moderate. The sum of temperature during vegetation period (>5° C) is 2000-2200° C. Precipitation during vegetative period (April — September) is 280-300 mm. Period of vegetation to full maturity must not exceed 130 days. The earliest forms of white lupin collection matured in the region only on dry year. So, the first objective was to breed new forms of *Lupinus albus* with stable maturity under the given climate conditions and obtain the productive and Fusarium resistant cultivars. Then these cultivars with different plant architecture were studied to determine their development pattern.

Material and Methods

Breeding program of white lupin *(Lupinus albus L.)* began in 1980. Comparative study of cultivars obtained under breeding program has been conducted at Experimental Field of Moscow Agricultural Timiryazev Academy in Tambov region in 2007-2009. Plot size was 25 m^2. Field experiment was carried out in 4 replications. The soil was leached chernozem (pH 6,2). Early maturing cultivars of white lupin were studied. Among them were Start, Gamma, Manovitskiy, Delta, Dega and Deter 1 cultivars of our selection. The cultivars were obtained using induced mutants (Gataulina 1987, 1994). Then crossing was applied to obtain cultivars with required features. The sowing was performed by the end of April. The density before harvesting was 35-40 plants/m^2. Wet and dry matter accumulation were determined by sampling 15 plants from every plot at 15 days interval. Yield components were determined by studying 25 plants from every plot.

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Results and Discussion

Five white lupin cultivars of our selection - Start, Manovitskiy, Gamma, Delta and Dega—were officially certified and registered in Russia after the State testing. Start was the first early matured cultivar registered in 1984 followed by cv. Manovitskiy (1993), Gamma (1998), Delta (2000), Dega (2004). Cv. Deter 1 is in process of testing. Cv. Desnyansky was bred in Russian Lupin Research Institute (Bryansk).

Types of determination. These cultivars have a different plant architecture. Type 1 is presented by cv. Deter 1. The plants are without any branches and pods set only on main stem (table 1). Start and Gamma (type 2) are characterized by a low plant height, small seeds and reduced branching. The pods are formed only on the main stem and the short branches of the first level. The pods of the main stem and lateral branches are arranged almost on the same level. Periods of flowering, pod filling and maturing are shortened due to limited branching and compact architecture of the plants. As to the characteristics of the cultivars, Fusarium resistant Gamma matures 4-5 days earlier than Start. Cv. Delta (type 3) and Manovitskiy (type 4) have branches of the 2-d and 3-d order (Manovitskiy) with pods on them.

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, t ha^{-1}	44	52	57	65
Dry matter accumulation, t ha^{-1}	5.6	6.5	6.8	7.8
Seed yield, t ha^{-1}	3.10	3.25	3.45	3.55

Period of vegetation and plant height. As follows from Table 1, branchless cv. Deter 1 (type 1) simultaneously matured 15 and 30 days earlier than Start or Gamma (type 2) and Manovitskiy (type 4) respectively. Under conditions of Tambov region which is frequently subject to lack of moisture during growing season, plants were not high. Even plant height of type 4 was 73 cm in average. As regard to other cultivars, the earlier they matured, the lower was their plant height. The determinate cv. Deter 1 had the lowest plant height as it didn't form lateral branches at all.

The dates of table 1 characterize white lupin cultivars in average when the weather conditions were about the normal and they were rather favorable for plant growth and development. Unfortunately, the weather is variable, it differs very much depending the year.

Weather conditions during vegetation strongly effect plant growth and vegetation period (table 2).

Table 2

Effect of weather conditions on plant height and period between emergence and maturity of *Lupinus albus* cultivars (2009 — humid with high temperature, 2008 — near normal, 2007 — drought during vegetative growth, high temperature)

Cultivar	Plant height, cm				Period from emergence till maturity, days			
	2007	2008	2009	Min-max	2007	2008	2009	Min-max
Deter 1	35	59	93	35-93	90	105	97	90-105
Gamma	37	70	93	37-93	94	114	102	94-114
Delta	35	71	93	35-93	94	115	105	94-115
Dega	37	70	92	37-92	94	114	102	94-114
Desnyansky	35	74	105	35-105	98	124	110	98-124

In 2008 the weather was near the normal and favorable for vegetative growth and pod setting. In 2009 precipitation on June and July was 1.5 times more than normal. It was favorable for plant growth and pod set. On this condition the plant height was the highest. In this year the temperature was higher than usual, so vegetation period was reduced comparing 2008. In 2007 there was a drought during vegetative period, the temperature level was 4-5° higher than normal. In this condition the plant height was very low and vegetation period was the shortest. Min and max plant height of cultivars differed 3 times and vegetation period 15-26 days. Differences between types were minimal in drought conditions.

Wet and dry matter accumulation. In 2007 all types of cultivars showed almost the same wet and dry matter accumulation (table 3). The more lateral branches are the higher these characters when water supply is enough (2008, 2009). Wet and dry matter accumulations are 15-20% less for the branchless Deter 1, than for Gamma, when the plant density is equal. They are 10-15% more for Delta and Dega (Type 3), than for Gamma (Type 2).

Table 3

Wet and dry matter accumulation (stage of filling pods)

Cultivar	Wet matter accumulation, t ha^{-1}				Dry matter accumulation, t ha^{-1}			
	2007	2008	2009	average	2007	2008	2009	average
Deter 1	37.6	45.6	48.4	43.9	4.85	8.55	6.58	6.66
Gamma	35.5	47.5	63.2	48.7	4.61	9.50	8.60	7.57
Delta	34.2	49.0	73.6	52.2	4.45	9.80	1.,01	8.09
Dega	35.5	52.2	62.4	50.0	4.62	11.16	9.79	8.52
Desnyansky	36.0	55.8	51.6	47.8	4.68	9.85	9.19	7.91

Type 2 (Gamma) demonstrates good possibilities to form a rather high yield of wet and dry matter. Cv. Desnyansky (Type 4) was not higher than type 3.

Seed yield. Number of pods and seeds per plant and seed yield depend on genotype and weather conditions, especially during flowering and pod formation period (table 4, 5).

Table 4

Yield components

Cultivar	Number per plant		1000 seeds weight, g	Seed weight per plant, g
	pods	seeds		
2007				
Deter 1	6.2	18	340	6.0
Gamma	6.7	21	327	6.9
Delta	6.3	22	340	7.6
Dega	5.9	19	335	6.5
Desnyansky	8.2	24	350	8.2
2008				
Deter 1	11.6	38	322	12.2
Gamma	10.8	43	307	13.3
Delta	11.2	43	340	14.3
Dega	10.8	42	325	13.3
Desnyansky	11.1	40	370	14.8
2009				
Deter 1	11.3	35	288	10.9
Gamma	12.2	44	248	7.9
Delta	16.8	59	256	13.3
Dega	12.5	47	270	12.0
Desnyansky	10.5	35	287	10.2

Table 5

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

Cultivar	Seed yield, t ha^{-1}				% from main stem			
	2007	2008	2009	average	2007	2008	2009	average
Deter 1	2.26	4.05	3.19	3.17	100	100	100	100
Gamma	2.38	4.20	3.43	3.34	96	79	72	82
Delta	2.67	4.50	4.16	3.78	97	75	62	78
Dega	2.34	4.25	3.78	3.46	97	75	72	81
Desnyansky	3.09	4.49	3.21	3.60	88	64	69	74
LSD_{05}	0.30	0.41	0.37					

In 2007 number of pods and seeds per plant was twice less than for other years. Almost all of them formed on main stem. Number of pods and seeds on the main stem of cultivars didn't differ very much. Lateral branches are responsible for differences in number pods and seeds per plant between cultivars. Under the given density 700-1000 seeds per m^2 were formed on the main stems depending on the year. The seed yield of Gamma and determinate forms originated from the main stem was 2.1-3.5 t/ha depending on genotype and weather conditions. In dry 2007 the seed yield was 1.5-1.7 times lower than for other years. Despite the 2007 drought seed yield was better than expected: the weather was favorable for seed filling this time. Weight of 1000 seeds this year was good. The other way round in 2009 the possible seed yield in 2009 was less than expected due the low weight of 1000 seeds.

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 vegetative growth through the reduction of the upper branches decreased the vegetation period without the great reduction of seed yield due to limitation of competition between vegetative and reproductive organs.

Conclusion

Early matured cultivars with strong concentration of pods on the main stem and short branches of the first level stably matured with seed yield of 3-3.5 t/ha under conditions of Central-Chemozem region of Russia. Determinate cultivar without lateral branches (topless) are promising for moderate climate zone to the North of Tambov region if compared with previously bred Start and Gamma. The weather conditions strongly effect growth and development of *Lupinus albus* cultivars, when seed yield may differ twice. Even in drought conditions the seed yield was not less than 21 ha'[1] and more than 41 ha^{-1} when the weather was about normal for this region.

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Аннотация. Селекционная работа по созданию скороспелых, с ограниченным ветвлением, сортов белого люпина и изучение особенностей их развития проводились на экспериментальной базе учхоза имени Калинина РГАУ - МСХА (Тамбовская обл.). Созданные сорта (Старт, Мановицкий, Гамма, Дельта, Дега) детерминантного типа с ограничением образования боковых побегов разного уровня. Эти сорта, включенные в Государственный реестр селекционных достижений, характеризуются высокой урожайностью семян 3-4 т/га при содержании белка 35-40%. Сорта различаются по архитектонике растений и относятся к разным группам спелости. Обсуждаются результаты изучения роста, развития, формирования урожая биомассы, семян и элементов структуры урожая у разнотипных сортов, а также влияние метеорологических условий на эти процессы и показатели.