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EFFECTIVE CULTIVATION OF EXTRA-EARLY SOYBEAN CULTIVAR CV. 'VNIIOZ 86' UNDER IRRIGATION

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Abstract. The influence of sowing methods and irrigation regimes on productivity of extra-early soybean cultivar VNIIOZ 86 has been studied at Russian Research Institute of Irrigated Agriculture.

The use of differential irrigation regimes (70—80—70% and 80—80—70% of FMC) resulted in 2.42 ... 2.51 t/ha yield and mid-level profitability of grain production (80.6%), which was 0.25 ... 0.34 t/ha more compared to the control (80—80—80% of FMC), as synchronization of vegetative growth and reproductive development increased grain amount in total biomass up to 36.2%. Differential irrigation regimes restrained an increase in crude protein level in the seeds (at the level of 35.4 ... 41.2%) compared with the control (36.5 ... 41%). However, they increased fat content in the seeds (18.1 ... 21.4%) compared to the control variant (16.1 ... 18.6%). Optimization of irrigation regime increased protein (up to 0.68 ... 0.94 t/ha) and fat (0.37 ... 0.46 t/ha) compared to the control (0.64 ... 0.83 t/ha and 0.29 ... 0.35 t/ha, respectively). The smallest water consumption coefficient was observed in sites with differential irrigation regimes — 1,174 ... 1,524 m^3/t, when in the control site it was 1,651 ... 1,977 m^3/t.

Extra-early VNIIOZ 86 plants require 8 ... 14 irrigations at a rate of 190 ... 230 m^3/ha. It is enough to perform 8 irrigations in relatively favorable years (2013), and up to 14 irrigations in dry years (2014—2015). To maintain a differential irrigation regime, it is necessary to perform 8 ... 10 irrigations in wet and up to 10 ... 13 irrigations in dry years.

The highly profitable cultivation of early soybeans (107.9%) was achieved using drilled sowing (0.30 × 0.042 m) that resulted in significant yield increase (up to 3.02 t/ha) which was 0.41 t/ha higher compared to wide-space sowing technique (0.70 × 0.024 m).

Key words: soybeans, cultivars, irrigation regimes, yield, growth stages, protein and fat content in seeds

INTRODUCTION

Increase in protein and vegetable oil consumption, as well as produce of pharmaceutical and other industries, defines the relevance of the research aimed at optimizing reclamation and other agricultural methods of soybean cultivation, ensuring stable grain yields under limited resource consumption conditions.

Soybean is a light requiring crop with a positive response to irrigation. Its world cultivation is concentrated in southern countries such as the USA, Brazil, Argentina, China, and India. Here, natural soil moisture reaches up to 400 mm and growing season is long enough (up to 180 days) which make it possible to cultivate medium-late maturing high-yielding cultivars (up to 3.0 ... 3.5 t/ha) while world yield level averages 2.6 t/ha.

Despite the rapid increase in soybean plantings (2.6 million hectares) in the Russian Federation, average soybean yields remain low (1.5 t/ha). The insufficiently favorable natural hydro-thermal conditions for highly profitable soybean cultivation in the main agricultural regions of Russia impel to use early soybean cultivars characterized by low yield level (on average 2 t/ha) without irrigation. Hard weather events that periodically occur during growing season do not contribute to increasing in the seed protein content, which reaches 30 ... 35% of dry matter while US standard is over 35%).

Soybean has a high positive response to irrigation, resulting in yield increase from 2.5 to 4.5 t/ha and increase in crude protein content up to 35 ... 45% in seeds depending on the cultivar, agricultural practices [1—3]. However, cultivation process of early soybean cultivars under various sprinkling irrigation regimes and sowing methods is not described enough [4—6].

MATERIALS AND METHODS

The experiments were conducted in Russian Research Institute of Irrigated Agriculture in 2013—2017. Seeds of early soybean cultivar VNIIOZ 86 (Volgograd selection) included in State Register of breeding achievements approved for cultivating in the Lower Volga region were used [7]. Irrigation regimes (2013—2015) applied were a permanent one with 80—80—80% of FMC (control) and changing regimes depending on basic soybean growth stages: 70—80—70% of FMC (emergence — flowering at 70%, flowering — seed formation at 80%, maturity at 70% of FMC), and 80—80—70% of FMC (emergence — flowering at 80%, flowering — seed formation at 80%, maturity at 70% of FMC). We used two sowing methods: wide-space (0.30 × 0.024 m) as a control and drilled sowing (0.30 × 0.042 m).

RESULTS AND DISCUSSION

The experiments showed that extra-early soybean cv. VNIIOZ 86 requires 2,135 ^{o}C of active temperatures during emergence-maturity (92 days) under irrigation to form yield. Soybean plants need most heat (26.1%) during seed formation-maturity, and the smallest heat (9.4%) is required at emergence. In emergence-flowering period the mean temperature is 22.1 °C, and in flowering — beginning maturity period the mean temperature approaches 24 °C, therefore, it is important to coordinate improvement of irrigation regimes with heat availability in crops during different growth and development stages of particular cultivar, smoothing out temperature extremes.

Analysis of the photosynthetic activity of VNIIOZ 86 plants showed low formation level of the maximum leaf surface area (25.7 ... 31.3 thousand m^2/ha), which is characteristic of early cultivars. The photosynthetic potential (FP) was 1,480 ... 1,880 thousand m^2 days/ha, the average daily increase in organic matter was 84.6 ... 95.5 kg/ha, dry biomass was 6.92 ... 7.83 t/ha, and yield was 2.17 ... 2.51 t/ha.

The use of differential irrigation regimes resulted in significant increase in VNIIOZ 86 grain productivity (Table 1).

Table 1

Influence of irrigation regime on cv. VNIIOZ 86 productivity

Irrigation regime, % of FMC	Yield, t/ha				Deviation from the control	
	2013	2014	2015	average	t/ha	%
70—80—70	2.74	2.5	2.25	2.51	0.34	15.7
80—80—70	2.61	2.46	2.19	2.42	0.25	11.5
80—80—80	2.35	2.13	2.04	2.17	—	—
LSD_{05} (factor A)	0.16	0.03	0.05	0.05		
LSD_{05} (factor B)	0.16	0.04	0.06	0.06		
LSD_{05} (factor AB)	0.23	0.04	0.06	0.06		

The yield increase reached 0.25 ... 0.34 t/ha or 11.5 ... 15.7% compared to the control irrigation regime (80—80—80% of FMC). High VNIIOZ 86 yields under changing irrigation regimes were formed in 2013 and amounted 2.61 ... 2.74 t/ha, which was significantly higher than in the control variant (2.35 t/ha).

Analysis of the plant productivity structure showed that irrigation regimes coordinated with the main stages of organogenesis led to increase in plant number — up to 27 plants/m^2, grain mass — up to 9.6 g/plant, grain size — up to 149.8 g/1000 seeds and grain part in the total biomass — up to 36.2% which contributed to yield increase.

Differential irrigation did not increased protein content in seeds (35.4 ... 41.2%) compared to permanent irrigation (36.5 ... 41%), since process of crude protein accumulation in seeds is negatively correlated with crop yield, even under irrigation conditions ($r = -0.7$) [8]. Considering the negative correlation between protein and fat content in seeds ($r = -0.5$), we established that the differential irrigation regime increased fat concentration in the seeds (18.1 ... 21.4%) compared to the permanent one (16.1 ... 18.6%).

Analysis of grain quality characteristics in irrigated soybean showed that it is important to count protein and fat amount per unit of area harvested. Optimization of irrigation regime led to increase in gross yield of crude protein up to 0.68 ... 0.94 t/ha compared to the control (0.64 ... 0.83 t/ha); and fat (0.37 ... 0.46 t/ha) compared to the permanent irrigation regime (0.29 ... 0.35 t/ha). Therefore, it is important to apply differential irrigation regimes concerning growth stages of certain cultivar in order to obtain significant protein and fat levels.

The water balance of VNIIOZ 86 soybean plants is composed of irrigation rate (62.9 ... 68.2%), precipitation (24.5 ... 29.2%) and soil moisture (7.2 ... 7.9%). When analyzing dependence of number of irrigations on irrigation regime, weather conditions and water consumption at different VNIIOZ 86 growth stages, it was established (Table 2) that soybean plants required 8 ... 14 irrigations with rates 190 ... 230 m^3/ha. In 2013, which was more favorable, plants required 8 irrigations with rate of almost 190 m^3/ha. To ensure differential irrigation regimes with irrigation water, it is necessary to perform 8 ... 10 irrigations in wet years (2013) and up to 10 ... 13 irrigations in dry years (2014, 2015).

Table 2

Dependence of irrigation regime on weather conditions and growth stages of soybean cv. VNIIOZ 86

Growth stage	Irrigation regime % of FMC	Year					
		2013		2014		2015	
		1	2	1	2	1	2
Emergence — shoot development	70—80—70	20.7	0	26.6	1	21.8	1
	80—80—70	32.3	1	35.6	2	30.9	2
	80—80—80	30.5	1	35.6	2	31.1	2
Shoot development — flowering	70—80—70	27.8	0	33.1	1	29.1	0
	80—80—70	40.4	1	43.8	2	40.6	1
	80—80—80	40.7	1	47.8	2	40.4	1
Flowering — pod formation	70—80—70	46.5	2	48.9	2	42.1	2
	80—80—70	46.4	2	45.4	2	41.9	2
	80—80—80	46.8	2	48.8	2	42.0	2
Pod formation — seed formation	70—80—70	48.5	2	54.1	3	64.2	3
	80—80—70	48.8	2	54.3	3	64.4	3
	80—80—80	48.9	2	59.2	3	64.0	3
Seed formation — beginning maturity	70—80—70	33.2	3	34.8	3	40.0	3
	80—80—70	33.3	3	36.3	3	42.6	3
	80—80—80	35.6	3	38.3	3	44.0	3
Beginning maturity — full maturity	70—80—70	19.5	1	17.5	1	16.8	1
	80—80—70	19.7	1	18.2	1	16.5	1
	80—80—80	34.5	2	34.2	2	33.8	2
Total (emergence — full maturity)	70—80—70	196.2	8	215.0	11	214.0	9
	80—80—70	220.9	10	233.0	13	236.9	12
	80—80—80	237.0	11	263.9	14	255.3	13

1 — average daily water consumption, m^3/ha; 2 — number of irrigations.

Permanent water regime was maintained by conducting 11 irrigations in wet and 14 irrigations in dry years.

An important characteristic of cultivar in agricultural production is ability to use moisture sparingly when forming yield. Studies have shown that the lowest water consumption — 1,174 ... 1,524 m^3/t — was observed in crops grown under differential irrigation regimes, while under permanent irrigation regime it was 1,651 ... 1,977 m^3/t.

Irrigation is a fairly expensive item in calculation of all production costs (27.8 ... 29.7 thousand rub./ha), which is 29.9 ... 33.3%. Hence, cultivars forming yields at the level of 2.5 t/ha are characterized by medium profitability (80.6%) and cost value (11.1 thousand rub./t) ensuring low margins. Therefore, it is also important to optimize agricultural practices for early cultivars. For light requiring soybeans these are sowing methods.

Cultivar is an important factor in the discussed question about advantages of drilled sowing compared to wide-space sowing under irrigation [8—10]. The early soybean cv. VNIIOZ 86 is characterized by low branchiness and low leaf formation. When crop density is higher (up to 500 thousand plants/ha) beans are formed higher on plants (0.16 m), grain losses during harvesting are smaller (by 0.25 ... 0.45 t/ha as compared to low crop density in wide-space plantings (to 400 thousand plants/ha). Therefore, the research showed that drilled sowing with more uniform placement of plants in rows (0.30 × 0.042 m) resulted in 3.02 t/ha, exceeding the yield of wide-space sowed crops (0.70 × 0.024 m) by 0.41 t/ha. Cost value of grain produced amounted to 10 thousand rub./t, profitability was 107.9%.

CONCLUSIONS

Under irrigation conditions efficiency of cultivation of early soybean cultivars (VNIIOZ 86) is enhanced by optimizing the irrigation regime and plant growing space. Differential irrigation regimes (70—80—70% of FMC and 80—80—70% of FMC) resulted in yield increase up to 2.51 t/ha, protein and fat content increased up to 0.94 t/ha and 0.46 t/ha, respectively. Drilled sowing of early soybean cultivars led to significant yield increase — up to 3.02 t/ha and profitability of grain production rose up to 107.9%.

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АГРОМЕЛИОРАТИВНЫЕ ПРИЕМЫ РЕНТАБЕЛЬНОГО ВОЗДЕЛЫВАНИЯ РАННЕГО СОРТА СОИ ВНИИОЗ 86 В УСЛОВИЯХ ОРОШЕНИЯ

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Во Всероссийском научно-исследовательском институте орошаемого земледелия изучено влияние режимов орошения и способов посева на продукционный процесс ультраскороспелого сорта сои ВНИИОЗ 86.

Применение дифференцированных режимов орошения (70—80—70% НВ и 80—80—70% НВ) способствовало формированию 2,42—2,51 т/га и достижению среднего уровня рентабельности (80,6%) производства зерна, что существенно (на 0,25—0,34 т/га) превысило урожайность на контроле. (80—80—80% НВ) за счет достижения синхронности вегетативного роста и репродуктивного развития и таким образом — повышения доли зерна в общей биомассе — до 36,2%. Дробные режимы орошения сдерживали рост содержания сырого протеина в семенах (на уровне 35,4—41,2%) по сравнению с контролем (36,5—41%), однако приводили к большему увеличению концентрации жира в семенах (18,1—21,4%), чем на контрольном варианте (16,1—18,6%), Оптимизация режима орошения увеличивала выход белка (до 0,68—0,94 т/га) и жира (0,37—0,46 т/га) относительно контроля (соответственно 0,64—0,83 т/га и 0,29—0,35 т/га). Наименьшим коэффициентом водопотребления характеризовались посевы с дифференцированными режимами орошения — 1174—1524 м^3/т, по сравнению с контролем — 1651—1977 м^3/т.

Посевы очень скороспелого сорта ВНИИОЗ 86 нуждаются в проведении 8—14 поливов нормами 190—230 м^3/га. В относительно благоприятные годы (2013) достаточно осуществить 8 поливов, в засушливые (2014—2015) — до 14. Для поддержания дифференцированного режима орошения необходимо дать 8—10 поливов во влажные и до 10—13 — в засушливые годы.

Высокорентабельное возделывание ранней сои (107,9%) достигалось применением рядового посева (0,30 × 0,042 м), способствующего значительному росту (до 3,02 т/га) урожайности (на 0,41 т/га) относительно широкорядного агроценоза (0,70 × 0,024 м).

Ключевые слова: соя, сорта, режимы орошения, урожайность, фазы роста и развития, содержание и сбор белка и жира в семенах

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