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Productivity and economic effect for cotton cultivated under different inter - row space and irrigation rate

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Abstract

Field trial on cotton (Vega cultivar) was carried out during 2007-2012 on leached vertisols under irrigation regime of sprinkling – 75 % of the field moisture capacity (FMC) for the soil layer of 0 – 40 cm. The trial included the following variants: **Factor A) Irrigation with lower rates:** 1). Non-irrigated variant – for standard. 2). Two irrigations of 600 mm/ha at 75 % FMC in soil layer 0-40 cm – the first one at the blooming period and the second – at the boll formations period; 3). Two irrigations of 450 mm/ha at 75 % FMC in soil layer 0-40 cm – the first one at the blooming stage and the second – at the boll formations period; 4). Single irrigation of 600 mm/ha at 75 % FMC in soil layer 0-40 cm in the interphase period blooming - boll formations. **Factor B) Width of inter-row space:** 1). Inter-row space 60 cm - standard. 2). Inter-row space 80 cm. It was established that the best results were obtained at the variant where cotton cultivated of 80 cm inter-row space and with second time irrigation with 600mm - with 939 kg/ha more that non-irrigated control and with 11.9 % more then variant with irrigated norm 600 mm/ha. In reference of net profit of 1000 m^3 irrigated water the best results were realized after single irrigation norm of 600 mm/ha. In respect of width of inter-row space the yield from a unit of area with inter-row space 80 cm we receive with 4.6 % more then sowing of 60 cm inter-row space.

Key words: cotton, irrigation rate, inter-row space, water deficit, cotton yield

For Bulgarian cotton wore defined optimal and rational irrigation regimes, pre irrigation soil humidity, the soil depth humidity and period of watering. It was found out that a single irrigation quantity and irrigation rate during the years with different rainfall provision for the main soil type – Pelic vertisols and Chromic cambiosols (by FAO).

During in the last 20 years the deficit of irrigation water and grow of the value of irrigated water was increased the deficit of irrigation. This situation is necessary that steps should be taken to reduce of cotton irrigation depth, with a view to receiving to a high effect from unit of irrigated water and unit of area. The studies to this effect were carried out in USA (McMichael Hesketh 1982; Garrot, Punymeier, Husman, 1988; Gerik et all 1996); Gruce (Danalotos et al 1998; Paschalidis Stavrikos, 2006); Uzbekistan (Bezborodov, 1995), Bulgaria (Nikolov, 1994) and others authors (Spenser, 1998).

Standard inter-row space for cotton of Bulgaria is 60 cm, because of let up quantity of rainfalls on the summer period (from May to September) with 8.0 – 12.0 %, in comparison with of long year period was tested to cultivate cotton on inter-row space of 80 cm.

Herewith investigation sets the task of ascertaining of rational irrigation regime under conditions of regulated water deficit for cotton. It was tested sown fields of cotton under irrigation and non irrigation regime at width of inter-row spaces respectively of 60 and 80 cm.

Material and Methods

During the period 2007-2012 a field trial was set by the standard method in 4 replications with size of the plots - 20 m^2. The following variants were tested:

Factor A: Irrigation with lower rates:

1). Non-irrigated variant – for standard.

2). Two irrigations of 600 mm/ha at 75 % FMC in soil layer 0-40 cm – the first one at the blooming period and the second – at the boll formations period;

3). Two irrigations of 450 mm/ha at 75 % FMC in soil layer 0-40 cm – the first one at the blooming stage and the second – at the boll formations period;

4). Single irrigation of 600 mm/ha at 75 % FMC in soil layer 0-40 cm in the interphase period blooming-boll formations.

Factor B: Width of inter-row space:

1). Inter-row space 60 cm - standard.

2). Inter-row space 80 cm.

The tests were conducted at an irrigation regime of sprinkling on variety Vega, in two crop rotation (durum wheat - cotton), at fertilization rate of N_{180} and crops density of 170 000 plants per 1 ha.

The soil type was Pelic vertisols with humus horizon – 70 - 115 cm, with humus content of 1.8 – 3.5 % and clay minerals 60 %, wilting moisture 18-20 %. FMC for layer 0-50 cm was 34.2 %, 51-100 cm was 31.6 % and 101-200 cm – 28.7 %. The productive moisture for layer 0-60 cm was 96 mm, for layer 0-100 cm was 181 mm and from101 to 200 cm contains 99 mm.

Respect to temperature sums (Table 1) years 2007, 2011 and 2012 were warm, and 2008, 2009 and 2010 – moderate warm years. In respect of the rainfall sum for the period June – August was characterized years 2007, 2011 and 2012 as dry, 2008 and 2009 as moderate, and 2010 as humid year.

Making production expenses under non-irrigation conditions was in amount of BGN 1857.50/ha or € 928.75 per ha. The buy up cost of seed cotton was 1300 BGN/t (0.40 BGN/kg subsidy + 0.80 BGN/kg redeem price). Middle price of stick up by pomp irrigation water was 0.30 BGN per 1 m^2 and 200 BGN/ha for expenses service. In production expenses not-include income, interests of credits and amortizes assign-ments.

Results and Discussions

September yield which expressed cotton earliness for the irrigated variants during the dry years (2007,2011 and 2012) was significantly higher than the non irrigated control – with 17.3-19.5 %. For the moderately humid years (2008 and 2009) the yields of the irrigated variants were 7.1 – 13.8 % higher than the non-irrigated cotton. During the humid years (2010) the average results showed that the irrigated variant exceeded the non-irrigated variants with 118.0 kg/ha and by total yields outweigh with 48 – 358 kg/ha more.

Decrease of irrigation norm from 1200 m^3/ha with 25 % and 50 % at cotton field not bring about to adequate change in yields – the drop in this case is with 319 kg/ha (89.4%) and 163 kg/ha (94.6). With reduce irrigation norm from 1200 m^3/ha to 600 mm/ha expenses for irrigation reduce with 33.0 %, net income from 1000 m^3 irrigation water norm is the highest (Table 2).

Table 1. Climatic conditions for the 2007 – 2012 period.

Years	Mounts						Σ IV-IX	Σ VI-VIII	Σ V-IX
	IV	V	VI	VII	VIII	IX			
Sum of temperature Σ t ^{0}C									
1928 – 07	343	519	622	720	711	561	3476	2053	3133
2007	351	579	693	825	753	527	3728	2271	3377
2008	386	522	636	717	792	555	3608	2145	3222
2009	357	569	648	751	725	571	3621	2124	3264
2010	364	554	624	706	798	582	3628	2128	3264
2011	535	538	645	772	743	558	3791	2160	3256
2012	412	519	688	830	787	623	3859	2305	3447
Rainfalls - mm									
1928 - 07	45	63	65	52	41	34	300	158	255
2007	19	53	39	0	62	128	301	101	282
2008	66	36	95	36	3	91	327	134	261
2009	17	16	14	89	35	58	229	138	212
2010	63	27	82	114	22	48	356	218	293
2011	46	46	31	24	56	51	255	113	209
2012	40	128	16	7	10	10	211	33	171

During the dry years the earliness of the irrigated variants was within the limits of 79.3 – 84.9 % of the total yield amount. For moderate years this percentage was within 72.7 – 82.7 %, and for humid – 50-59.1 %. For the non-irrigated controls this ratio was respectively 91.2 %, 85.1 % and 74.7 %. Average for the period 2001-2007 the earliness of the irrigated variants was within the limits of 72.6 – 74 % and 83.7 % for non-irrigated control. The highest September yield was realized by variant 1 – average of 2042 kg/ha (99.1 %), 361 kg more than the non-irrigated cotton and 112-259 kg more than the other variants (Table 2).

The irrigation effect expressed in increase of total seed-cotton yield was strongly dependant on the rainfall and temperature during the cotton vegetation period. During the dry years the yield increase was an average of 51.2-53.9 % for variants with two irrigations, while for single irrigation in the period of mass blooming was from 21.1 to 30.4 % - Tables 3 and 4.

During the moderately humid years the yield increase was with an average of 34.5 % or 930 kg/ha more than the variant with two irrigations of 400 m^3/ ha performed at the cotton bud formation and blooming stages. From the other variants was obtained 21.7 – 25.0 % higher yield as compared to the non-irrigated control. The irrigation effect was smallest in the humid years – 2004 and 2005. Given in percentage of the non-irrigated control, the increase was from 9.0 to 27.9 % - Table 4.Average for the period the total seed-cotton yield of single irrigation was 21 % higher than the standard. With two irrigations the yield increase was 29.7-36.9 % or 601-747 kg/ha higher - Table 4.

In dry and moderately humid years, as well as in years of average temperature the irrigation effect on cotton for all irrigation regimes was statistically significant. In the humid and cool year of 2004 it was significant only for the variant with irrigation regime of two irrigations during the two stages – bud formation and flowering.

Table 2. Seed cotton yields under different inter row spaces and different irrigation regimes – by years and average. Mostly influence of factors.

Total yields by years - kg/ha		Average							Average	
		2007	2008	2009	2010	2011	2012	kg/ha	%	±D
Inter - row space - cm										
60 cm		2229	3153	2355	2660	2471	2784	2609	100	-
80 cm		2560	3220	2943	2738	2637	2965	2844	109	235^{+++}
GD	5%	90	142	30	80	94	112	87	3.3	87
	1%	124	197	41	108	130	195	160	6.1	160
	0.10%	172	274	56	146	158	215	193	7.3	193
Irrigated norms - mm										
Non irrigated		1975	1863	1989	2515	1972	2250	2094	100	-
1200 mm		2890	3780	3185	2873	2833	3609	3195	153	1101^{+++}
900 mm		2434	3633	2969	2854	2730	2931	2925	140	831^{+++}
600 mm		2205	3469	2453	2563	2633	2708	2672	128	578^{+++}
GD	5%	110	201	43	113	112	115	123	5.9	123
	1%	152	279	58	153	153	162	195	9.3	195
	0.10%	211	388	78	207	206	192	218	10.4	218

Table 3. Seed cotton yields under different conditions – by years and average. Interaction of factors.

Variants	Total yields by years - kg/ha						Average			Grade
	2007	2008	2009	2010	2011	2012	kg/ha	%	±D	
Inter-row space 60 cm										
No irrigation	1980	1949	1980	2506	1893	2000	2051	100	-	-
1200mm	2491	3755	2505	2809	2753	3567	2980	145.3	929	+++
900mm	2315	3514	2538	2805	2668	2888	2788	135.9	837	+++
600mm	2198	3392	2395	2518	2573	2680	2626	128.0	575	+++
Inter-row space 80 cm										
No irrigation	1969	1777	1998	2525	2051	2500	2137	104.1	86	-
1200mm	3289	3804	3865	2937	2913	3650	3410	166.3	1359	+++
900mm	2553	3752	3400	2903	2792	2973	3062	149.3	1011	+++
600mm	2212	3546	2510	2608	2692	2735	2717	132.5	666	+++
5 %	167	284	60	159	181	135	141	6.8	141	-
GD 1 %	230	394	82	217	250	190	153	7,5	153	-
.1 %	318	548	111	292	346	260	166	8.1	166	-

Table 4. Economic indexes on irrigated variants

Norms of irrigation	Total output BGN/ha	Costs of production BGN/ha	Net production BGN/ha	Net income BGN/ha	Effect of 1000 m^3 irrigated water kg/ha	Net profit of 1000 m^3 irrigated water BGN/ha
Inter-row space 60 cm						
Non irrigated	2681	1857,50	823,50	-	-	-
1200mm	3780	2417,50	1362,50	539	705	916,5
900mm	3596	2327,50	1268,50	445	782	1016,6
600mm	3478	2237,50	1240,50	417	1022	1328,6
Inter-row space 80 cm						
Non irrigated	2678	1857,50	820,50	-3	-	-
1200mm	4076	2417,50	1658,50	835	894	1162,2
900mm	3778	2327,50	1450,50	627	938	1219,4
600mm	3527	2237,50	1289,50	466	1085	1410,5

Average for the period the highest values were obtained by the variant with two irrigations of 400 mm done in the bud formation and flowering stages.

The effect of 1000 m^3 irrigation water per 1 ha, expressed in additional yield of kilograms of cotton, obtained with additional yield of kilograms of cotton obtained as a result of the irrigation depends on the year rainfall and temperature. This

effect was greatest for the dry and warm years and varied from 586 to 1163 kg/ha.

Conclusions

Under conditions of regulated water deficit, the highest effect was provided by irrigation regime of 75 % FMC in soil layer 0-40 cm, which was realized in two irrigations with irrigation rate of 600 mm in the phases of bud formation and blooming. Average for 6 years with this irrigation regime the total cotton yield increased with 747 kg/ha or with 36.0 %, including increase of 51.2 % in dry years.

This irrigation regime was characterized with the highest effect of 1000 m^3 irrigation water – average with 934 kg/ha.

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