INFLUENCE OF IRRIGATION ON PRODUCTIVITY AND EVAPOTRANSPIRATION OF BEANS

Gergana Ilcheva
LTU – Sofia

INTRODUCTION

Research related to irrigation of beans in Bulgaria lead the begining through the 70's and 80's of last century. The results regarding the reaction of the culture at different intensification factors of irrigation show that for the conditions of our country it increases yields by 30-50% depending on the year. The necessity of the beans of the water increases from budding phase to form beans Vitkov, M. (1974), as Giralt Perez, E. (1979) suggested pre-irrigation soil moisture to 80% by FC (field capacity). Erdem, Y., et al. (2006) state that the same should apply to the layer 0-60 cm. Optimal irrigated plants are considerably higher and with a much greater leaf area (Sadek, I.U., et al., 2002). Irrigation increases the number of beans and their particle sizes and the number of grains in a bean (Mehta, O.P., et al., 1987; Stone, L.F., et al. 1988). Significantly increased the proportion of fully developed pods, compared with underdeveloped (Pascale, S. De & M.I. Sifola, 1995).

Irrigation regime depends largely on the intensity of evapotranspiration (ET), becouse it directly affects the length of the period between irrigations and from there the number of irrigations and the size of the irrigation norm. For the conditions of our country, ET at field beans was studied for the regions of Ruse and Pazardzhik. According to the Vitkov, M. (1972, 1973, 1975), the optimum irrigation depth value for layer 0-60 cm is in the range 263-346 mm. From sowing to budding stage (about 30 days), the bean consumes 1,6 - 2,9 mm water per day. The maximum is focused mainly during budding - mass flowering when 10 day period values reach 4,6 - 5,9 mm. During the formation of beans and pouring the seeds ET decreased to 2,2 - 4,0 mm. For cinnamon forest soils (typical of the region of Pazardzhik) research related to study of the bean's evapotranspiration is conducted by Delibaltov, J. and M. Sarkizov (1974). According to these authors, the value of total ET for no irrigated bean ranged in 236-354 mm. From planting to mass germination daily ET average is 1,4 mm, when to the beginning of flowering up to 2,6 mm. And here the period start flowering - a mass flowering is characterized by very intense ET, which amounts to 40-50% of the total for the entire growing season. Non-irrigated beans during this period consumes an average of 134,9 mm of water (3,2 mm a day), and then consumption decreases considerably and during the formation of beans period and pouring grain ET is only 24 mm (1,6 mm per day). According to C.Săicu (1987, 1988) the main part of the ET (82%) is formed by vegetation rainfall, 11% - of the amount of irrigation norm and 7% - of the initial water supply.

The aim of the study is to determine the influence of optimum irrigation regime on productivity and evapotranspiration of beans grown in the region of Plovdiv.

MATERIAL AND METHODS

Used data from field experiment to establish the effect of different water availability to plants on yield and ET of beans. The experiment was conducted during the period 2014 - 2015 year in experimental field of Agricultural University – Plovdiv on alluvial soil, with common bean – variety "Dobrudjanski 7", which is standard for the country. The experiment was conducted on the block method in four repetitions. For the purpose of this work used data of the following two variants: 1) without irrigation; 2) irrigation at 80% of FC for the layer of 0-40 cm. Irrigation rate for variant 2 is calculated to moisten the layer 0-60cm up to FC. Irrigation is done

by gravity in short closed furrows. ET was established through the balance metod for one-meter soil layer, at intervals of 20 cm. The dynamics of soil moisture is periodically laid down in 7-10 days weighting method by soil sampling to a depth of 1 m during interval of 10 cm. In order to obtain reliable results in the area of the test area are respected all agricultural activities related to the cultivation of the crop. Yield data were statistically processed by specialized computer program BIOSTAT (E.Penchev, 1988), as established warranted, the differences between the two versions.

RESULTS

The influence of irrigation on the yield depends largely on the nature of the year and especially on the amount and distribution of rainfall during the growing period (Figure 1). For the period from May to August, the first experimental year was characterized by humid with average rainfall 289 mm and security 20%. They provide the plants with water until flowering. During the reproductive period fell less than 120 mm or 43% of the vegetation rainfall, but due to significantly higher water consumption, they fail to maintain a constant soil moisture in the optimal range. The second experimental year was characterized by humid with rainfall of 302mm and security 13%. A significant part of them, however, fell in the third decade of August (136mm), while during the flowering period and forming the beans their quantity is only 20mm. Temperature sum first attempt in 2014 was an average of 46% and security ΣT ° = 2631 ° C. The second year of experience 2015 is warm with security 18% and ΣT ° = 2748 ° C. The data in ten-day periods are presented in Figure 2.

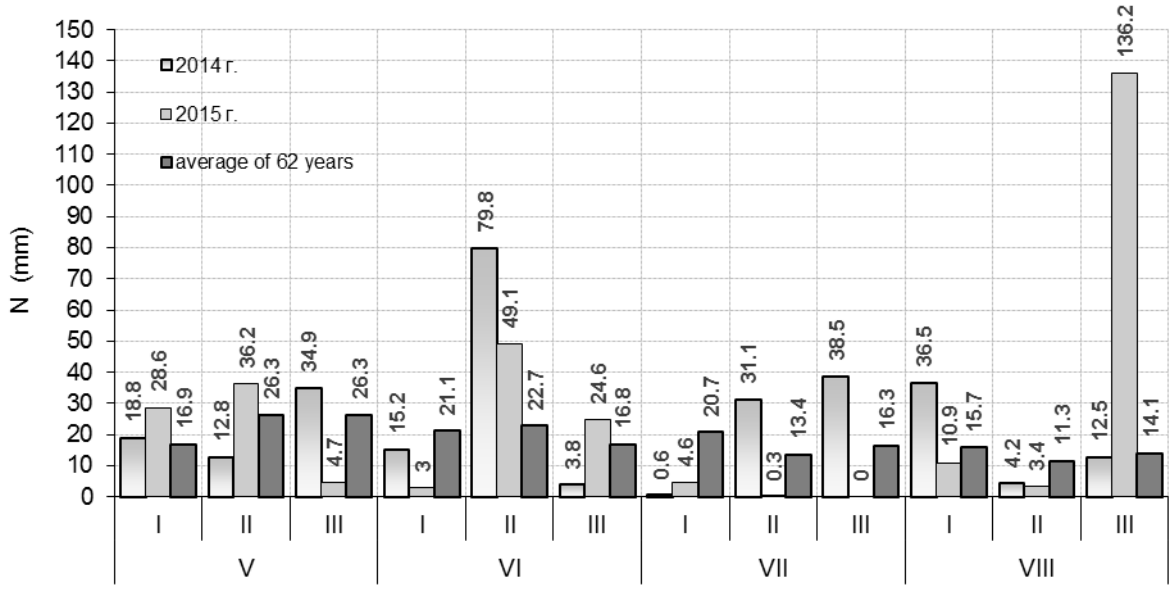


Fig.1. Precipitations for vegetation period

The elements of the irrigation system in accordance with the weather conditions experienced two years, in 2014 were filed two irrigations with irrigation rate 50 mm (to one respectively during flowering and forming the beans), 7 days period between irrigations and 100 mm irrigation depth. In 2015 irrigations are 4 evenly distributed through the same two stages (flowering and forming the beans). Irrigation rate for each of irrigation is 50 mm, and irrigation depth - 200 mm.

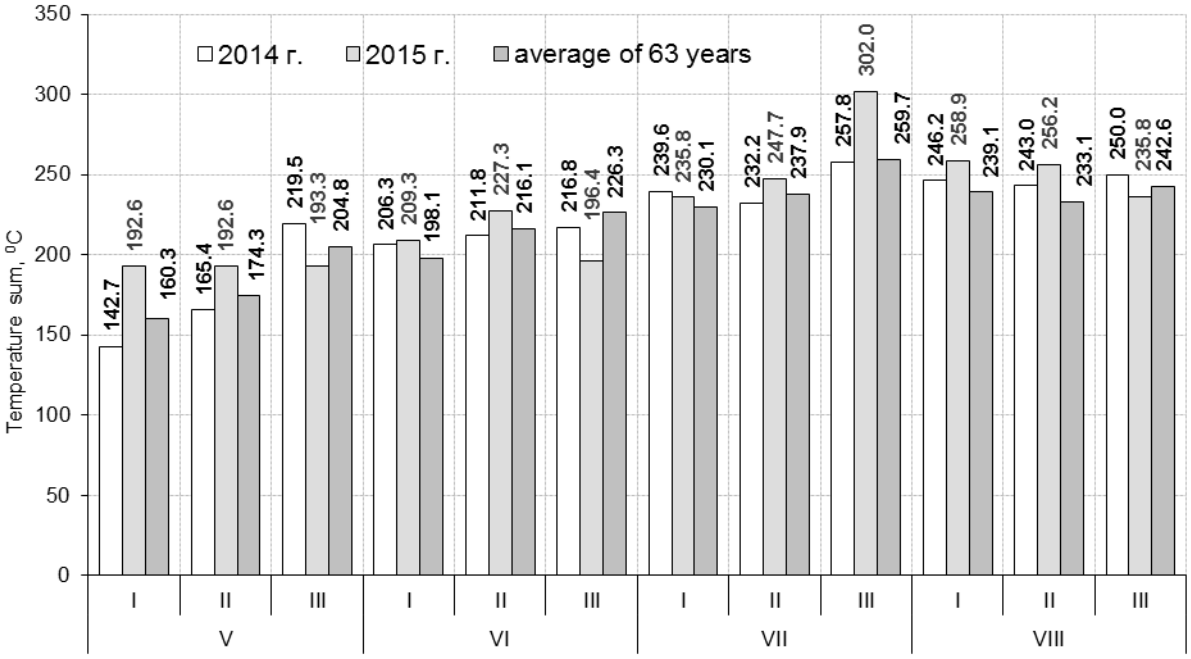


Fig.2 Temperature amount of ten-day periods

Optimizing soil moisture leads to a substantial and statistically proven to increase the yield of grains, as for the conditions of the experiment, the increase was from 56% to over 70% (Table 2). Statistically proven are differences in the absolute weight of the seed as a result of irrigation, the same was increased on average by 16% (Table 3). Irrigation has no statistically proven influence on the specific weight of the seeds (Table 4).

Table 1. Parameters of irrigation regime

Year	Date	Norm (mm)	period between irrigations	phase
2014	06 VII	50	7 days	flowering
	13 VII	50		fructification
2015	15 VI	50	21 days	flowering
	06 VII	50		
	13 VII	50	8 days	fructification
	21 VII	50		

7 days

Without irrigation ET total range is 290 - 300mm (for layer 0-60 cm). Irrigation increases consumption by 33-44%, is same reach or exceed 400 mm (Table 5). The maximum average daily ET under irrigated conditions in the first or second decade of July and in the range 3.9 - 4.3 mm. Optimizing soil moisture shifting time occurrence the maximum one decade later, with values reaching even than 6 mm per day (Fig. 3).

Table 2. Effect of irrigation on yield

Year	Version	Yield (kg/da)	according to dry		according to irrigated	
			±Y (kg/da)	%	±Y (kg/da)	%
2014	Without irrigation	153.0	St.	100.0	-86.2	64.0
	Irrigated	239.2	86.2	156.3	St.	100.0
	GD: 5%=33.3 kg/da, 1%=61.2 kg/da, 0.1%=135.6 kg/da					
2015	Without irrigation	146.9	St.	100.0	-104.7	58.4
	Irrigated	251.6	104.7	171.3	St.	100.0
	GD: 5%=23.9 kg/da, 1%=43.9 kg/da, 0.1%=97.3 kg/da					
Average	Without irrigation	150.0	St.	100.0	-95.4	61.1
	Irrigated	245.4	95.4	163.6	St.	100.0
	GD: 5%=21.8 kg/da, 1%=40.0 kg/da, 0.1%=88.5 kg/da					

Table 3. Effect of irrigation on the weight of 1000 seeds

Year	Version	weight (g)	according to dry		according to irrigated	
			±Y (g)	%	±Y (g)	%
2014	Without irrigation	362.4	St.	100.0	-71.1	83.6
	Irrigated	433.5	71.1	119.6	St.	100.0
	GD: 5%=50.3 g, 1%=92.4 g, 0.1%=204.7 g					
2015	Without irrigation	356.3	St.	100.0	-46.4	88.5
	Irrigated	402.7	46.4	113.0	St.	100.0
	GD: 5%=31.6 g, 1%=58.1 g, 0.1%=128.7 g					
Average	Without irrigation	359.4	St.	100.0	-58.7	86.0
	Irrigated	418.1	58.7	116.3	St.	100.0
	GD: 5%=38.0 g, 1%=69.7 g, 0.1%=154.5 g					

Table 4. Hectoliter weight of seeds

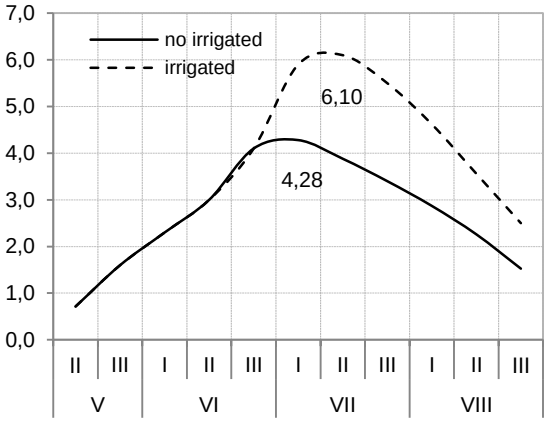
Year	Version	Weight (kg)	according to dry		according to irrigated	
			±Y (kg)	%	±Y (kg)	%
2014	Without irrigation	151.9	St.	100.0	-3.8	97.6
	Irrigated	155.7	3.8	102.5	St.	100.0
	GD: 5%=7.1 kg, 1%=13.1 kg, 0.1%=28.9 kg					
2015	Without irrigation	152.2	St.	100.0	6.8	104.7
	Irrigated	145.4	-6.8	95.5	St.	100.0
	GD: 5%=7.3 kg, 1%=13.4 kg, 0.1%=29.6kg					
Average	Without irrigation	152.1	St.	100.0	1.6	101.1
	Irrigated	150.5	-1.6	98.9	St.	100.0
	GD: 5%=4.7 kg, 1%=8.7 kg, 0.1%=19.3 kg					

The most intensively used water from the topsoil (0 - 20cm). At the same irrigation contributes 55-58% in the formation of ET for one-meter layer. Under optimal irrigation this share is 48-49%. For the layer 0 - 60cm values are respectively 88-94%, and 85-97%. Details for layer formation ET bean under irrigated conditions and optimum irrigation are presented in Table 6.

Table 5. Summary ET beans on options for layer 0 - 60 cm.

Version	mm	% to dry	% to irrigated
2014			
no irrigated	299.1	100.0	75.0
irrigated	398.9	133.4	100.0
2015			
no irrigated	289.4	100.0	69.6
irrigated	415.8	143.7	100.0

in 2014 year



in 2015 year

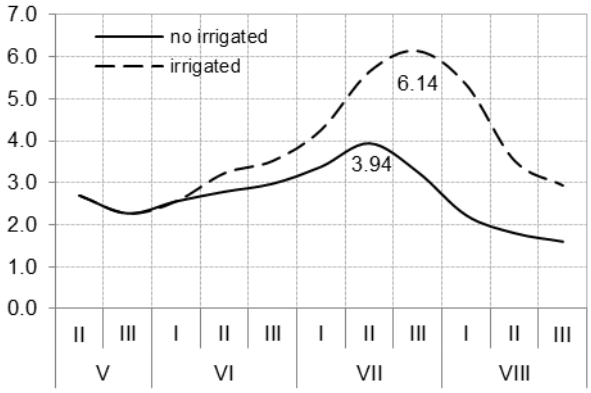


Figure 3. Average daily flow of beans ET

Table 6. ET formation in different soil layers

Soil layer	ET	2014		2015	
		No irrigated	Irrigated	No irrigated	Irrigated
0-20	mm	197.3	202.2	174.0	252.4
	%	58.1	49.0	55.4	47.6
20-40	mm	69.2	146.1	73.5	156.3
	%	20.4	35.4	23.4	29.5
40-60	mm	32.6	50.6	46.1	43.7
	%	9.6	12.3	14.7	8.2
60-80	mm	24.6	9.2	9.5	23.9
	%	7.2	2.2	3.0	4.5
80-100	mm	16.1	4.9	10.8	53.4
	%	4.7	1.2	3.4	10.1
0-60	mm	299.1	398.9	293.6	452.4
	%	88.0	96.6	93.5	85.4
0-100	mm	339.8	413.0	313.9	529.7
	%	100.0	100.0	100.0	100.0

Table 7. Participation of rainfall, irrigation depth and initial water reserve in forming ET

indicator	No irrigated		irrigated	
	mm	%	mm	%
2014				
ΣET	299.1	100.0	398.9	100.0
W	34.5	11.5	34.3	8.6
N	264.6	88.5	264.6	66.3
M	–	0.0	100.0	25.1
2015				
ΣET	293.6	100.0	452.4	100.0
W	30.0	10.2	7.1	1.6
N	263.7	89.8	247.5	54.7
M	–	0.0	197.8	43.7
ET – Evapotranspiration; W – Initial water reserve; N – Vegetation rainfall; M – Irrigation rate				

The irrigation depth under irrigation formed between 25 and 44% of water consumption. The part of rainfalls is between 55 and 66% and they are the main item in the formation of ET in beans. Without irrigation their relative participation is even higher (88-94%). The data are plotted in Table 7.

CONCLUSIONS

To maintain 80% of FC pre-irrigation soil moisture for the layer 0-40 cm, the number of irrigations for common bean in the region of Plovdiv is 2-4, depending on the amount and distribution of rainfall. The amount of irrigation rate is 50mm.

Irrigation increases the yield by 56-71% and the absolute mass of seeds growing on average by 16%. The hectoliter weight of the seed does not change the result of maintaining a higher soil moisture.

Irrigation increases ET by 33-44%, the same reach or exceeds 400 mm. The maximum average daily ET under irrigated conditions in the first or second decade of July and in the range 3.9 - 4.3 mm. Irrigation shifting time occurrence the maximum one decade later and the same reach and even exceed 6 mm per day.

The most intensively used water from the topsoil (0 - 20cm). At the same irrigation contributes 55-58% to the formation of ET for one-meter layer. Under optimal irrigation this share is 48-49%. For layer 0 - 60cm values around and above 90%.

The irrigation norm under irrigation formed between 25 and 44% of the ET culture and rainfall - between 55 and 66%.

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