ENERGY EFFECTIVENESS OF THE PRODUCTION OF WINTER BROAD BEANS, RAISED AT A DIFFERENT DEGREE OF MOISTURE SUPPORT

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Abstract

The influence of the irrigation over the energy effectiveness of the production of winter fodder broad beans of "Merris Binna" kind has been studied. The experiment was conducted in Agricultural Institute – Stara Zagora, Bulgaria. The following variants were tested: 1.Without irrigation-control ; 2.Optimally irrigated (3 times of watering); 3. Without irrigation in the stage "bloom"; 4. Without irrigation in the stage"pod forming"; 5. Without irrigation in the stage "grain forming".

It was established that the irrigation has a positive influence over the received energy from the biomass of winter fodder broad beans and the energy effectiveness of its production.

The highest energy efficiency ratio is obtained from variants without irrigation in the stage "grain forming": Gross Energy (GE) = 8.78 MJ, metabolizable energy (ME) = 4.71 MJ and Net Energy (NE) = 2.77 MJ

Key words: winter broad beans, irrigation, energy effectiveness

INTRODUCTION

Because of the increasing amount of agricultural produce the current agriculture is accompanied by the increasing growth of the common energy consumptions. However, parallel with that, the insufficiency of natural energy resources also rises and thus makes the traditional economic assessment not objective enough. One of the criteria for the accession of Bulgaria to the European Union (EU) is the increase of the energy effectiveness in all spheres of life. This imposes the use of the energy approach for assessment which allows comparing different production technologies in time and space, reducing the influence of the market price situation and allows choosing the most effective and energy-saving technology for the cultivation of agricultural cultures [1]; [2]; [8]; [9]; [11]; [12]; [14]

The annually increasing insufficiency of protein needed for the feeding of people and animals worldwide requires from the scientists and specialists to find sources for the production of more and cheaper albumen from unit of area. Grain-bean's forage plants, including broad beans, has the greatest importance from all field cultures. From the studied factors of agricultural complex irrigation has the highest statistical significance, but studies regarding its impact on the energy efficiency of its production are missing [4]; [10]; [15].

The purpose of this study is to establish the energy effectiveness in the production of winter broad beans depending on the degree of moisture support during its cultivation.

MATERIAL AND METHOD

The results of a field experiment carried out at the experimental field of the Agricultural Institute - Stara Zagora, Bulgaria the introductive forage broad beans of "Merris Binna" kind (Faba vulgaris var. equina) was conducted under the conditions of irrigation. The experiment was brought out by means of the block method after predecessor of winter wheat, with crops area of 19, 6 sq.m, 4 repetitions. The following variants were studied: 1.Without irrigation-control ; 2.Optimally irrigated (3 times of watering); 3. Without irrigation in the stage "bloom"; 4. Without irrigation in the stage"pod forming"; 5. Without irrigation in the stage" grain forming".

The common technology for the cultivation of broad beans was applied. For the establishment of the energy effectiveness from the cultivation of the winter broad beans was used the energy approach for analysis of the agricultural produce [2]; [6]; [7]; [8]; [14]; [17]

All expenses for the different technological practices as well as all bought materials were calculated on the basis of the developed technological maps according to the variant and the years of the study by using zonal changes norms turned into energy value by means of the relevant energy equivalents: for fertilizing – 60, 6 MJ/kg N; 11, 10 MJ/kg P_2O_5 [3]; diesel fuel – 56, 31 MJ/l [11]; for mechanization – 64, 80 MJ/h [11]; for seeds – evaluated energy equivalent - 19,12 MJ/kg [13]; for herbicides – 238,0 MJ/l; for insecticides – 199,0 MJ/l; for fungicides – 92,0 MJ/l [8]; for electric power – 3,60 MJ/kWh [12]; for water – 0,63 MJ/m^3 [18]; for the labor – 2,30 MJ/h [18].

The energy received from the biomass of the winter broad beans was calculated on the basis of the obtained production of dry substance (DS) from grain and straw and the contents of Gross energy (GE), Metabolizable energy (ME) and Net energy (NE) in kg GE from grain [13] and straw [16].

The coefficient of energy effectiveness R was established as ratio of the received from the final product energy "P" (MJ/ha) to the energy used for its production „E" (MJ/ha), i.e. (R) = (Π / E). [8].

RESULTS AND DISCUSSIONS

The energy consumption in the cultivation of winter forage broad beans under conditions of irrigation average for the period is 18 607,73 MJ/ha (table 1). During the years the values of the used energy are different. The lowest ones can be seen in the first year of the study. The greatest energy consumptions can be seen during the third year of the study because of the increasing amount of the energy consumption needed for the harvesting and conservation of the received bigger production. By variants, the lowest ones are the energy consumptions in the non-irrigated control, and the highest ones are in the variant with the optimally irrigated (3 times of watering) because of the additional energy consumptions for irrigation and additionally received bigger production. The differences between the other variants are very small. This tendency is typical for the three years of the study.

Analyzing the structure of the used energy in the cultivation of winter forage broad beans average for the period of the cultivation (table 2), it can be established that the biggest share belongs to the diesel fuel and mechanization (total 42,94%) and fertilizers (26,69%) from the total energy consumptions. Quite big is the share of the energy consumptions used for seeds (19,37%). The smallest share is that of the energy consumptions used for electric power and human labor (0, 01% and 0, 51%). The share of the energy for the pesticides is 7,22%.

Table 1. Energy input in faba bean cultivation for years and average for the period, MJ/ha

Варианти / Variants	Year			Average	
	I	II	III	MJ/ha	%
Without irrigation	11 390.50	18 757.75	18 805.87	16 318.04	100.0
Optimal irrigation	18 039.69	25 048.74	27 000.60	23 363.01	143.17
Without irrigation in the stage "bloom"	12 447.09	19 588.05	21 870.36	17 968.50	110.11
Without irrigation in the stage "pod forming"	12 049.98	19 574.64	21 359.04	17 661.22	108.23
Without irrigation in the stage "grain forming"	12 191.13	19 204.56	21 788.07	17 727.92	108.64
Average	13 223.67	20 434.74	22 164.78	18 607.73	

Table 2. Structure of energy input in faba bean cultivation average for the 3 years period, MJ/ha

The bearer of the energy	Variants					Average	
	Without irrigation	Optimal irrigation	Without irrigation in the stage "bloom"	Without irrigation in the stage "pod forming"	Without irrigation in the stage "grain forming"	MJ/ha	%
Diesei-oil	5 409.76	11 002.57	6 169.02	6 013.18	6 075.74	6 934.05	37.26
Fertilizers total	4 968.00	4 968.00	4 968.00	4 968.00	4 968.00	4 968.00	26.69
Nitrogen	3 636.00	3 636.00	3 636.00	3 636.00	3 636.00	3 636.00	19.54
Phosphorus	1 332.00	1 332.00	1 332.00	1 332.00	1 332.00	1 332.00	7.15
Pesticides Total	1 343.90	1 343.90	1 343.90	1 343.90	1 343.90	1 343.90	7.22
Herbicides	714.00	714.00	714.00	714.00	714.00	714.00	3.83
Insecticides	179.00	179.00	179.00	179.00	179.00	179.00	0.96
Fungicides	450.90	450.90	450.90	450.90	450.90	450.90	2.43
Human labour	83.22	119.10	91.63	90.07	90.41	94.88	0.51
Electricity	1.63	2.30	1.80	1.77	1.77	1.85	0.01
Machinery	926.71	1 326.80	1 020.43	1 002.98	1 006.77	1 056.73	5.68
Water	0.81	1 006.68	756.90	628.36	628.37	604.22	3.26
Seeds	3 584.01	3 593.66	3 616.82	3 612.96	3 612.96	3 604.08	19.37
Total, MJ/ha	16 318.04	23 363.01	17 968.50	17 661.22	17 727.92	18 607.73	100.00

From all expenses epending on the purpose of the biomass received at the conversion of the energy from forage cultures the obtained physiologically useful for the animals ME is used and for the conditions of the experiment it is average 79659,84 MJ/ha and the productive energy NE – is average 46679,16 MJ/ha (table 3). The received Metabolizable energy represents 53, 6 % from the GE. The lowest values of Gross and Metabolizable energy were accounted during the first year of the study when the lowest production of dry substance of grain and straw was obtained. The highest values of GE, ME and NE were received from the variant with the Optimal irrigation is like the exceeding towards the non-irrigated control and is with 23,6% for GE; 25,75% for ME; 27,22% for NE. The lowest energy incomes are received from the variant without any watering in beans formation phase, which fact shows its great importance for the quantity of the productions. The differences in the energy incomes are statistically proved ($p < 0,05$).

The positive balance between the used and the received energy from basic and additional production is a prerequisite for high energy effectiveness of the production of winter fodder broad beans expressed by the coefficient of energy effectiveness (table 4). Average for the period of the study the values of this coefficient are 8,05 for GE; 4,31 for ME; 2,52 for NE.

Table 3. Energy output from the whole biologic mass of the faba bean for years and average for the 3 years period, MJ/ha

Variants	Year			Average	
	I	II	III	MJ/ha	%
Gross energy - MJ / ha					
Without irrigation	92793,20	145503,80	159973,00	132756,66	100,00
Optimal irrigation	126916,30	171521,70	193805,50	164081,16	123,60
Without irrigation in the stage "bloom"	107324,90	156756,00	183740,90	149273,93	112,40
Without irrigation in the stage "pod forming"	101672,30	151116.22	171721,20	141503.24	106,60
Without irrigation in the stage "grain forming"	109462,50	166263,50	191203,00	155643,00	117,23
Average	107633,84	158232.24	180088,72	148651.59	
LSD P<0,05 = 8447 P<0,01 = 11635 P<0,001 = 16018					

Metabolizable energy - MJ / ha					
Without irrigation	49251,60	78191,80	84020,00	70487,80	100,00
Optimal irrigation	68534,20	93284,80	104113,00	88644,00	125,75
Without irrigation in the stage ”bloom”	56981,20	84828,00	98189,20	79999,46	113,49
Without irrigation in the stage ”pod forming”	53617,30	81552,40	91654,20	75607,96	107,26
Without irrigation in the stage ”grain forming”	58430,40	89582,80	102666,80	83560,00	118,54
Average	57362,94	85487,96	96128,64	79659,84	
LSD P<0,05 = 3588 P<0,01 = 4944 P<0,001 = 6806					
Net energy - MJ / ha					
Without irrigation	28687,20	45847,20	48658,80	41064,40	100,00
Optimal irrigation	40380,60	55171,80	61174,20	52242,20	127,22
Without irrigation in the stage ”bloom”	33191,40	49916,40	57395,40	46834,40	114,05
Without irrigation in the stage ”pod forming”	31144,80	47940,00	53588,40	44224,40	107,69
Without irrigation in the stage ”grain forming”	34179,60	52665,00	60246,60	49030,40	119,39
Average	33516,72	50308,08	56212,68	46679,16	
LSD P<0,05 = 1851 P<0,01 = 2549 P<0,001 = 3509					

Table 4. Coefficient of the energy efficiency from the whole biologic mass of the faba bean for years and average for the 3 years period

Variants	Year			Average	
	I	II	III	MJ/ha	%
Gross energy - MJ / ha					
Without irrigation	8.14	7.75	8.51	8.13	100.00
Optimal irrigation	7.04	6.84	7.18	7.02	86.34
Without irrigation in the stage ”bloom”	8.62	8.00	8.28	8.30	102.09
Without irrigation in the stage ”pod forming”	8.43	7.72	8.03	8.01	99.13
Without irrigation in the stage ”grain forming”	8.97	8.65	8.72	8.78	107.99
Average	8.24	7.79	8.14	8.05	
LSD P<0,05 = 0.45 P<0,01 = 0.63 P<0,001 = 0.87					
Metabolizable energy - MJ / ha					
Without irrigation	4.32	4.17	4.47	4.32	100.00
Optimal irrigation	3.79	3.72	3.86	3.79	87.73
Without irrigation in the stage ”bloom”	4.58	4.33	4.44	4.45	103.00
Without irrigation in the stage ”pod forming”	4.45	4.17	4.22	4.28	99.07
Without irrigation in the stage ”grain forming”	4.79	4.66	4.68	4.71	109.02
Average	4.38	4.21	4.33	4.31	
LSD P<0,05 = 0.19 P<0,01 = 0.27 P<0,001 = 0.38					
Net energy - MJ / ha					
Without irrigation	2.52	2.44	2.57	2.51	100.00
Optimal irrigation	2.24	2.20	2.25	2.23	88.84
Without irrigation in the stage ”bloom”	2.66	2.55	2.62	2.61	103.98
Without irrigation in the stage ”pod forming”	2.58	2.45	2.47	2.50	99.60
Without irrigation in the stage ”grain forming”	2.80	2.75	2.76	2.77	110.35
Average	2.56	2.47	2.53	2.52	
LSD P<0,05 = 0.10 P<0,01 = 0.13 P<0,001 = 0.19					

The highest energy efficiency ratio is obtained from variants without irrigation in the stage "grain forming": Gross Energy (GE) = 8.78, metabolizable energy (ME) = 4.71 and Net Energy (NE) = 2.77,which is 25,07% for GE; 24,27% for ME and 24,21% for NE compared to the optimally irrigated and 7,9%; 9,02%; 10,35% compared to the control (without irrigation).

DEDUCTIONS

* The invested in the production of the winter broad beans energy consumptions under the influence of irrigation average for the period are 18 607,73 MJ/ha.

* The attached degrees of moisture support exert positive influence over the received energy from the biomass of the winter broad beans and the energy effectiveness of its production.

* The highest energy efficiency ratio is obtained from variants without irrigation in the stage "grain forming": Gross Energy (GE) = 8.78, metabolizable energy (ME) = 4.71 and Net Energy (NE) = 2.77

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