Bulgarian Journal of Agricultural Science, 17 (No 5) 2011, 712-720
Agricultural Academy

ENERGY EFFICIENCY OF SPRING VETCH (*Vicia sativa* L.) CULTIVATED FOR FRESH BIOMASS

N. GEORGIEVA[1], I. NIKOLOVA[1], T. ZHELYAZKOVA[2], D. PAVLOV[2] and Y. NAYDENOVA[1]
[1] *Institute of Forage Crops, BG - 5800 Pleven, Bulgaria*
[2] *Trakia University, BG - 6000 Stara Zagora, Bulgaria*

Abstract

GEORGIEVA, N., I. NIKOLOVA, T. ZHELYAZKOVA, D. PAVLOV and Y. NAYDENOVA, 2011. Energy efficiency of spring vetch (*Vicia sativa* L.) cultivated for fresh biomass.
Bulg. J. Agric. Sci., 17: 612-720

Field experiment with spring vetch, cultivated for fresh biomass was conducted for establishing productivity, composition, nutritive value and energy efficiency under the influence of different growth regulators: Atonic - 0.6 L.ha^{-1}, Masterblend - 1.6 kg.ha^{-1} and Confidor 70 VG - 0.15 kg.ha^{-1} applied in budding; budding + flowering; flowering. Energy efficiency was calculated by balance method (energy input and output) by energy equivalents for all operations and energy value of the biomass calculated by composition and digestibility. Treatment of spring vetch with Atonic, Confidor and Masterblend had a positive effect and increased the yield of biomass and had no effect on chemical composition, nutritive and energy value of the vetch biomass. Energy equivalent of the examined growth regulators is very low - 0.019 to 0.55 % from the total energy input, and has no essential effect on energy input in vetch cultivation. Treatment of spring vetch with combination Confidor + Masterblend or Confidor +Atonic increased energy output with about 28-29% and improved energy conversion, increasing the coefficient of energy efficiency with 24 to 26%.

Key words: composition, energy efficiency, regulators, spring vetch
Abbreviations: GE – gross energy; ME – metabolizable energy; NE- net energy

Introduction

Spring vetch is an important legume plant, possessing good productivity and nutritive value of the biomass and is a reliable source for resolving of protein problem in ruminant nutrition. Cultivated as early spring plant with a quick growth and short vegetation period this plant becomes more attractive recently in association with global climate changes, increasing of temperature, reducing of water supply and increasing of frost damages during winter. Productivity of vetch could be increased by treatment with growth regulators, which increases effect of cultivation. Growth regulators increased vetch grain yield (Tsibulko et al., 2000; Nikolova et al., 2010) and energy efficiency (Zhelyazkova, 2007; Zhelyazkova and Pavlov, 2008).

The problem with increasing the efficiency of energy utilisation in cultivation of different plants is actual and recently enlarged due to the economic crises, significant variation of the prices and the needs of involving of stable system for estimation

of technologies for crop production such as energy balance and efficiency, which is more stable and not affected by economic conditions. This problem is important due to the enlarging the need for reducing the energy input in crop cultivation and increasing energy output and coefficient of energy efficiency.

Establishing the effect of leaf fertilizers and combination with insecticides and growth regulators on the growth, productivity and energy efficiency of vetch whole plant biomass is important for producing of fresh forage and up to now this problem is not investigated for our circumstances.

The aim of present study was to establish energy efficiency of spring vetch cultivated for fresh biomass and possibilities for increasing by treatment with growth regulators and leaf fertilizers.

Materials and Methods

During 2007 - 2009 on the experimental base at Institute of forage plants Pleven, field experiment with spring vetch variety Obrazets 666 was conducted, in 4 repetitions by split plot method. The soil is leached chernozem, with humus content (1.0%), neutral reaction (pH_{KCl} – 5.49), low supplied with nitrogen (34.30 mg N.1000 g^{-1} soil) and phosphorus (3.72 mg P.100g^{-1} soil) and well supplied with potassium (37.50 mg K.100 g^{-1} soil).

Effect of different chemical compounds: Atonic - 0.6 L.ha^{-1}. Masterblend - 1.6 kg.ha^{-1} and Confidor 70 VG - 0.15 kg.ha^{-1} was examined. Atonic – growth stimulator, containing - 0.2% sodium orthonitrophenolat; 0.3% sodium paranitrophenolat and 0.1% sodium -5-nitrogvaicol. Developed from Azahi Chemical. Japan for growth stimulation and for increasing amount and quality of plant production recommended for combined treatment with leaf fertilizers and pesticides for synergetic effect. Masterblend – crystal leaf fertilizer of Masterblend Fertilizer (USA), containing 20% N (6.22% nitrate+3.88% ammonium+9.90% urea), 20% soluble phosphorus (P_2O_5), 20% soluble potassium (K_2O) and trace elements (B, Cu, Fe, Mn, Mo, Zn, Mg). Confidor 70 VG (700 g.kg^{-1} imidacloprid), from Bayer, affiliated to the group of chlornicotineline insecticides, with growth stimulation effect, increasing of total plant biomass, the index of generative organs and the crop yield (Thielert 2006).

The experiment includes next variants:

1. Control (treatment with distillated water);
2. Atonic;
3. Masterblend;
4. Atonic+Masterblend;
5. Confidor;
6. Confidor+Atonic;
7. Confidor+Atonic+Masterblend;
8. Confidor+Masterblend.

Treatment was performed in the stages budding, budding+flowering, flowering, with above mentioned concentrations.

The spring vetch was cultivated after predecessor oats, after soil preparation including tillage at 25 cm and disc harrowing at 15 cm. Sowing was performed early spring (March), in 12 cm row space, on a depth 4-6 cm. with seeding rate 220 germination seeds m^{-2} (150 kg.ha^{-1}).

The survey was performed in non irrigation conditions. The sum of annual rains for the experimental period was 555.8 mm average. With the highest amount of vegetation rainfall 176.3 mm was 2008 and with the minimal (98.4 mm) – 2007. Average annual temperature was 12.9^0C.

Vetch biomass was cut in milk-dough stage of pods and was transported to the farm for feeding as fresh forage.

Chemical composition of the biomass was established by Weende (AOAC 1984). Energy value – gross energy (GE); metabolizable energy (ME) and net energy (NE) in MJ kg^{-1} DM was calculated on the base of composition and coefficient of digestibility by Todorov et al. (2007).

Energy efficiency was calculated on the base of balance method (energy input and output) by (Pimentel et al., 1973, 1983; Hülsbergen et al., 2001; Ivanov, 1998, 1999a. 1999b; Tokarev et al., 1989;

Tyulin et al., 1999). Energy input for mechanization and human labor was calculated by Ozkan et al. (2004) and Yaldiz et al. (1993) respectively. Energy for diesel fuel was calculated based on the local standards and by coefficient of Ozkan et al (2004). Energy equivalent for Masterblend was established by coefficient of Bhat et al (1994); for Confidor 70 VG by Tzilivakis et al. (2005); Green (1987); and for Atonic by Yaldiz et al (1993). Energy equivalent of seeds for sowing was calculated by coefficient of Zhelyazkova (2007).

Energy efficiency was established by coefficient (R), defined by Pimentel (Pimentel et al., 1973, 1983) as a ratio among the energy P (MJ. ha^{-1}), obtained from the total crop biomass yield of the agricultural product to E ($MJ.ha^{-1}$), energy input for production: (R = P / E). All data obtained were statistically analysed for significance of differences with ANOVA by StatSoft, STATISTICA for Windows.

Results

The yield of dry matter of spring vetch, cultivated on leached chernozem in the area of Pleven varies from 2088.9 to 4485.9 $kg.ha^{-1}$ depending on the influence of the moisture and water supply during the different years of cultivation (Table 1). The factors needed for plant development had been in the highest favorable combination for spring vetch growth and as a result the yield obtained is the highest during 2008. Productivity was significantly lower in 2007 (almost twice) due to unfavorable distribution of moisture during the vegetation period.

Treatment of vetch biomass with different growth regulators had a positive effect on productivity. Dry matter yield increased average with 27.2%. The separate growth regulators applied had different effect on the growth and productivity. The highest effect was obtained from the combination

Table 1

Yield of Vetch dry matter, $kg.ha^{-1}$

Variants	2007	2008	2009	Average	%
For variants average from the stages					
Control	2088.9a	3450.7	2652.2a	2730.6a	100
Atonic	2184.8ab	3847.5	2884.9a	2972.4a	108.9
Masterblend	2440.6b	4218.4a	3192.3b	3283.8b	120.3
Atonic+Masterblend	2483.3b	4278.8a	3223.1b	3328.4b	121.9
Confidor	2515.2b	4270.2a	3271.4b	3352.3b	122.8
Confidor+Atonic	2568.5b	4485.9a	3367.9b	3474.1b	127.2
Confidor+ Atonic+ Masterblend	2504.6b	4365.1a	3297.7b	3389.1b	124.1
Confidor + Masterblend	2536.6b	4425.5a	3337.2b	3433.1b	125.7
For stages average from all variants					
budding	2402.0A	4150.5	3067.7A	3206.8A	118.5
budding+flowering	2557,9A	4503.1	3523.9	3528.3	123.1
flowering	2286.1A	3849.7	2868.5A	3001.4A	114.5
average	2415.3	4167.8	3153.4	3245.5	118.9
$LSD_{0.05\%}$	272.6	279.2	300.9	290.1	

*Differences among the variants are statistically signifficant at $P<0.05$ if have not equal letters (small letters for mean values of variants and capital letters for mean values for stages)

Table 2

Chemical composition, g.kg^{-1} and energy value, MJ.kg^{-1} of Vetch dry matter average for 2008 - 2009

Variants	Crude protein	Crude fat	Crude fibre	Ash	NFE	Gross energy (GE)	Metabo-lyzable energy (ME)	Net energy (NE)
	For variants average from the stages							
Control	182.6	19.9	227.7	117.1	452.8	17.6	9.3	5.3
Atonic	176.6	21.8	236.3	102	463.3	17.9	9.4	5.4
Masterblend	174.6	19.8	241.5	100.8	463.2	17.9	9.4	5.4
Atonic+Masterblend	169.6	22.6	239.2	105.5	463.1	17.8	9.4	5.4
Confidor	168.5	19	241.8	97.7	473	17.9	9.5	5.4
Confidor+Atonic	167.9	22.2	247.1	98.8	464.1	17.9	9.4	5.4
Confidor+Atonic+Masterblend	164.8	21.8	251.9	98.8	462.7	17.9	9.4	5.4
Confidor + Masterblend	159.3	20.3	244.2	89.8	486.4	18	9.6	5.5
For stages average from all variants								
budding	165.7	20.1	245.5	102.5	466.2	17.8	9.4	5.4
budding+flowering	168.8	20.7	244.2	97.8	468.6	17.9	9.4	5.4
flowering	177	22	234	103.6	463.5	17.9	9.4	5.4
average	170.5	20.9	241.2	101.3	466.1	17.9	9.4	5.4

Table 3

Energy input in spring vetch cultivation, MJ.ha^{-1}

Variants	Year			Average	
	2007	2008	2009	MJ.ha^{-1}	%
	For variants average from the stages				
Control	7000.8	7500.9	7102.2	7201.3	100
Atonic	7103.6	7690	7231.5	7341.7	102
Masterblend	7076.8	7711.7	7214.7	7334.4	101.9
Atonic+Masterblend	7167.8	7809.4	7300.7	7426	103.1
Confidor	7133.6	7747.8	7269.8	7383.7	102.5
Confidor+Atonic	7226	7905.7	7370.8	7500.8	104.2
Confidor+Atonic+ Masterblend	7215.8	7877.1	7360.1	7484.3	103.9
Confidor + Masterblend	7139.5	7773.3	7268.6	7393.8	102.7
For stages average from all variants					
budding	7088.1	7691.2	7207.7	7329	102.2
budding+flowering	7247.1	7933.8	7419.3	7533.4	103.4
flowering	7063.7	7630.9	7167.3	7287.3	101.9
average	7133	7752	7264.8	7383.2	

Confidor+Atonic. The maximal productivity was developed from this combination during 2008. Second place occupy the combination among Confidor+Masterblend. Separate application of investigated growth regulators had a less effect compared to treatment in combination. Confidor and Masterblend have a higher effect on DM yield when applied alone compared to Atonic.

The effect of treatment with growth regulators depend also from the stage of development of plants and the time of application. The highest yield was obtained when treatment twice was applied in stage of budding and flowering. The effect was lower when treatment was performed in flowering. This demonstrates that treatment with growth regulators or leaf fertilizers has a higher positive effect when performed in earlier stages of plant development.

Treatment of vetch with different growth regulators and leaf fertilizers had not significant effect on the chemical composition of the biomass obtained when cutting was performed in milk-dough stage of pods. There is tendency for decreasing of protein content under treatment with the regulators (Table 2). Crude fibre oppositely increased. Average for all stimulators the content of crude protein was higher and the fibre was lower when treatment was applied in flowering stage. Variations in the chemical compounds of the vetch DM biomass were not significant and had not changed essentially the energy value. Nutritive value of the vetch biomass had not been affected by treatment with the applied growth regulators and leaf fertilizer.

Treatment with growth regulators increased the energy input only with 1.9 to 4.2% compared to the control (Table 3). The higher value was obtained with application of Confidor +Atonic. Energy input was higher during 2008 due to the higher amount of the biomass and energy needed for cutting and transport. On the same base the energy input was higher when treatment was applied in budding and

Table 4

Structure of energy input in spring vetch cultivation average for 2007 - 2009, MJ.ha^{-1}

Variants	Diesel fuel	Machinery	Human labour	Atonic	Confidor	Masterblend	Electricity	Water	Seeds	Total, MJ.ha^{-1}
	For variants average from the stages									
Control	3802.4	482.5	18.4	0	0	0	1.2	0.3	2896.5	7201.3
Atonic	3851.4	492.7	18.7	81	0	0	1.2	0.3	2896.5	7341.7
Masterblend	3909.8	504.7	19.1	0	0	2.7	1.2	0.3	2896.5	7334.4
Atonic+Masterblend	3918.5	506.6	19.2	81	0	2.7	1.2	0.3	2896.5	7425.9
Confidor	3916.4	507.4	19.2	0	42.8	0	1.2	0.3	2896.5	7383.7
Confidor+Atonic	3947.2	512.5	19.4	81	42.8	0	1.2	0.3	2896.5	7500.8
Confidor+Atonic +Masterblend	3931.3	509.3	19.3	81	42.8	2.7	1.2	0.3	2896.5	7484.3
Confidor +Masterblend	3926.1	504.9	19.4	0	42.8	2.7	1.2	0.3	2896.5	7393.8
For stages average from all variants										
budding	3866.7	498.3	18.9	30.4	16.1	1	0.9	0.2	2896.5	7329
budding+flowering	4000.9	519.3	19.7	60.7	32.1	2.1	1.7	0.4	2896.5	7533.4
flowering	3833.5	490.1	18.6	30.4	16.1	1	0.9	0.2	2896.5	7287.3
average	3900.4	502.6	19.1	40.5	21.4	1.4	1.2	0.3	2896.5	7383.2
%	52.83	6.81	0.26	0.55	0.29	0.019	0.016	0.003	39.2	100

Table 5

Energy output from the whole biologic mass (MJ.ha^{-1}) and coefficient of energy efficiency of the spring vetch average for the period 2007 – 2009

	Energy output. MJ.ha^{-1}			Coefficient of energy efficiency		
	GE	ME	NE	GE	ME	NE
	For variants average from the stages					
Control	48081.2a	25368.4a	14544.6a	6.6a	3.5a	2.0a
%	100.0	100.0	100.0	100.0	100.0	100.0
Atonic	53172.4ab	28072.8ab	16103.9ab	7.1ab	3.7ab	2.1ab
%	110.6	110.7	110.7	108.3	108.1	108.2
Masterblend	58693.9bc	30883.5bc	17701.3bc	7.9bc	4.1bc	2.3bc
%	122.1	121.7	121.7	119.6	119.1	119.0
Atonic+Masterblend	59254.6bc	31247.7bc	17915.8bc	7.9bc	4.1bc	2.3bc
%	123.2	123.2	123.2	119.2	119.0	119.0
Confidor	59905.5bc	31682.9bc	18177.3bc	8.0bc	4.2bc	2.4c
%	124.6	124.9	125.0	121.3	121.4	121.5
Confidor+Atonic	62285.4c	32734.7c	18763.6c	8.2c	4.3c	2.4c
%	129.5	129.0	129.0	124.0	123.3	123.3
Confidor+Atonic+Masterblend	60702.6bc	31834.9bc	18232.9bc	8.0bc	4.2bc	2.4bc
%	126.3	125.5	125.4	121.2	120.3	120.1
Confidor +Masterblend	61691.5bc	32835.8c	18866.7c	8.2c	4.4c	2.5c
%	128.3	129.4	129.7	124.7	125.6	125.8
For stages average from all variants						
budding	57085.4A	30076.0A	17244.0A	7.7A	4.0A	2.3A
budding+flowering	63202.5	33327.2	19110.4	8.3AB	4.4	2.5AB
flowering	53632.2A	28344.7A	16260.4A	7.3AC	3.8A	2.2AC
average	57973.4	30582.7	17538.3	7.8	4.1	2.4

*Differences among the variants are statistically signifficant at $P<0.05$ if have not equal letters (small letters for mean values of variants and capital letters for mean values for stages)

flowering due to accumulation of higher volume of biomass.

The main part in the total amount of energy invested in cultivation of vetch occupies the energy for Diesel fuel (Table 4). Energy input for application of growth regulators is not significant. A little higher is the energy input for Atonic while for Masterblend was the lowest. This is too small and had not essential effect on energy investment for vetch cultivation. The higher energy input was observed when treatment twice was applied in budding and flowering.

Applied growth regulators have led to increasing the amount of energy obtained with about 11 to 30 % (Table 5). The highest effect was obtained with application of combination Confidor +Atonic. The difference is statistically significant at $P<0.05$ with control and Atonic. Second place occupy application of Confidor +Masterblend. The lowest effect was obtained from Atonic. Treatment with

Table 6

Degree of Influence of factors on the vetch productivity and energy efficiency (ANOVA)

Parameters	SS	DF	F	P<	%
Yield of Dry matter					
Regulators	4207579	7	36.44	0.0000	9
Stage	3385142	2	102.60	0.0000	7.24
Year	37158174	2	1126.21	0.0000	79.52
Regulators*Stage	191504	14			0.41
Regulators*Year	334328	14			0.72
Stage*Year	430139	4			0.92
Regulators*Stage*Year	33845	28			0.07
Error	989816	60			
Output of Gross energy					
Regulators	1499985782	7	40.97	0.0000	9.92
Stage	1127457574	2	107.78	0.0000	7.46
Year	11859737964	2	1133.74	0.0000	78.46
Regulators*Stage	47508644	14			0.31
Regulators*Year	116765561	14			0.77
Stage*Year	139430226	4			0.92
Regulators*Stage*Year	10116652	28			0.07
Error	313821084	60			
Coefficient of Gross energy utilization					
Regulators	20.71	7	2.96	0.0000	10.85
Stage	12.41	2	6.21	0.0000	6.51
Year	150.85	2	75.43	0.0000	79.06
Regulators*Stage	0.58				0.3
Regulators*Year	1.03				0.54
Stage*Year	1.67				0.87
Regulators*Stage*Year	0.14				0.07
Error	3.41	60			

growth regulators in the two stages – budding and flowering led to increasing the energy output with about 10 to 15%. Differences with treatment in budding and flowering are statistically significant at $P<0.05$.

Application of growth regulators had a positive effect on the degree of energy utilization and increases the coefficient of energy conversion with about 8 of 26 %. The highest coefficient of energy conversion was obtained from application of combination Confidor +Masterblend and combination Confidor +Atonic, which led to increasing the efficiency with about 26 %. Treatment in the stages budding and flowering increases the coefficient of energy efficiency and is more effective compared to treatment alone in budding or flowering.

Discussion

Examined growth regulators applied in different stages have positive effect on the vetch growth, productivity and energy efficiency. For the condition of Pleven on the soil type leached chernozem vetch productivity was significantly affected by the climate conditions depending on the water supply in the separate years. Productivity in 2008 exceeded with 72.5% the yield obtained during 2007 and with 32,2% during 2009. The difference in amount of energy input in the separate years is not significant (8.7 and 6.7% for the same years compared to 2008). As a final effect the energy output and the coefficient of energy efficiency has been determined mainly from the climate conditions for the years defined with the yield of dry matter obtained compared to other factors. ANOVA test for the effect of factors influencing on the energy conversion confirms that climate conditions during the years have the main effect with 78 to 79 % impact (Table 6). The effect of growth regulators varies from 9 to 10% for the main observed parameters – yield, GE output and GE coefficient of utilization. The lowest effect was obtained from stage of application with variation from 6 to 7%. Interaction among the investigated factors – year, regulators and stages had no essential effect.

Comparison of different technologies for utilization of the vetch biomass – cutting as green forage or separately for grain and straw demonstrated that energy input is lower (7383.2 $MJ.ha^{-1}$) when the crop was used as green forage compared to utilization for grain and straw (17314.6 $MJ.ha^{-1}$ Zhelyazkova and Pavlov (2008)). Energy output of vetch cultivated for grain and straw was almost twice higher (142241.4 $MJ.ha^{-1}$ in comparison with utilization as green forage (57973.4 $MJ.ha^{-1}$. Though the big differences among energy input and energy output in the two technologies of vetch biomass utilization there are not significant differences in coefficient of energy efficiency – average 7.8 for utilization as green biomass and 8.2 for grain production.

Conclusion

Energy efficiency of spring vetch, cultivated on leached chernozem for fresh biomass was average 6.6 for GE; 3.5 for ME and 2.0 for NE.

Treatment of spring vetch cultivated for fresh biomass with Atonic, Confidor and Masterblend has a positive effect and increased the yield of biomass. The highest effect was obtained with treatment with combination Confidor +Atonic.

Applied growth regulators have not significant effect on chemical composition and energy value and do not affect nutritive value of the vetch biomass.

Energy equivalent of the examined growth regulators is very low – 0.019 to 0.55 % from total energy input and has no essential effect on energy input in vetch cultivation.

Treatment of spring vetch with combination Confidor + Masterblend or Confidor +Atonic increased energy output with about 28-29% and improve energy conversion, increasing the coefficient of energy efficiency with about 24 to 26%.

References

AOAC, 1984. Official metods of analysis (14 th. ed.). Washington. DC. p. 125

Bhat, M. G., B. C. English, A. F. Turhollow and H. O. Nyangito, 1994. Energy in synthetic fertilizers and pesticides: Revisited. Final project report Oak Ridge National Laboratory United States. Report Num. ORNL/Sub/90-99732/2. http://www.osti.gov/bridge/product.biblio.jsp?osti_id=10120269

Green, M. B., 1987. Energy in pesticide manufacture. distribution and use. In Energy in Plant Nutrition and Pest Control ed Z. R. Helsel Amsterdam. The Netherlands ISBN 0-444-42753-8: 165-177 (cited by Tzilivakis et al., 2005)

Hatirli, S. A., B. Ozkan and C. Fert, 2006. Energy inputs and crop yield relationship in greenhouse tomato production. *Renewable Energy*, **31**: 427–438.

Hülsbergen, K. J., B. Feil, S. Biermann, G. W.

Rathke, W. D. Kalk and W. Diepenbrock, 2001. A method of energy balancing in crop production and its application in a long-term fertilizer trial. *Agric. Ecosys. and Environ*., **86** (3): 303-321 .

Ivanov, D., 1998. A general methodical approach to the power consumption analysis of the grain and forage production. *Agric. Engin*. Sofia 35. **5**: 26-29 (Bg).

Ivanov, D., 1999a. Energy efficiency of the grain and forage production by regions in the Republic of Bulgaria. *Agric Sci*., **37** (2): 30-34 (Bg).

Ivanov, D., 1999b. A structural analysis of the energy consumption in the Bulgarian grain production. *Agric. Econ Manag.,* **44** (4): 13-20 (Bg).

Nikolova, I., N. Georgieva and V. Sabev, 2010. Comperative economic analysis of the influence of preparations with different biological effect in spring vetch. Proceedings of Scientific Conference "Present and future of aeronautical education in Balkan-Black Sea region of Europe". USB-Pleven. Pp. 243-245.

Ozkan, B., A. Kurklu and H. Akcaoz, 2004. An input–output energy analysis in greenhouse vegetable production:a case study for Antalya region of Turkey. *Biomass and Bioenergy,*. **26:** 89–95.

Pimentel, D., L. E. Hurd, A. C. Belloti, M. J. Forster, J. N. Oka, O. D. Sholes and R. J. Whitman, 1973. Food production and the energy crisis. *Sci*., **182:** 443-449.

Pimentel, D., G. Berardi and S. Fast, 1983. Energy efficiency of farming systems: organic and conventional agriculture. *Agric. Ecosys. Envi*., **9**: 359-372.

StatSoft Inc STATISTICA for Windows, 2000. (Computer program manual). http://www.statsoft.com

Thielert, W., 2006. A unique product: The story of the imidacloprid stress shield. In: *Pflanzenschutz-Nachrichten Bayer,* **59** (1): 73-86.

Todorov, N., I. Krachunov, D. Djouvinov and A. Alexandrov, 2007. Handbook of animal feeding. Sofia. *Matcom.* 399 pp. (Bg).

Tokarev, V., V. Bratushkin and A. Nikiforov, 1989. Methodical recommendations by a fuel and energy estimation of agricultural machinery. technological processes and technologies in plant growing. Moscow *VIM*. p. 59 (Ru).

Tsibulko, V. S., I. Yu, S. Buryak, I. Popov and O. V. Chornobab, 2000. Pea, winter vetch, lucerne. Novelties in the technology of cultivation for seed. Kharkov Ukraine.

Tyulin, V., L. Petrova, P. Salihov and D. Ivanov, 1999. Biopower estimation of cultivation of forage crops in agrolandscapes. *Forage Production,* **11**: 4-7 (Ru).

Tzilivakis, J., D. J. Warner, M. May, K. A. Lewis and K. Jaggard, 2005. An assessment of the energy inputs and greenhouse gas emissions in sugar beet (*Beta vulgaris* L.) production in UK. *Agric Sys*., **85:** 101–119.

Yaldiz, O., H. Ozturk, Y. Zeren and A. Bascetincelik, 1993. Energy usage in production of field crops in Turkey 5th Int Cong on Mechanization and Energy Use in Agriculture. 11-14-Oct. Kusadasi. Turkey (cited by Hatirli et al., 2006).

Zhelyazkova, Ts., 2007. Investigation influence of some growth regulators on the productivity, chemical composition and nutritive value of spring pea (*Pisum sativum* L.) and spring vetch (*Vicia sativa* L.). Dissertation (PhD). Trakia University. St. Zagora. p.199 (Bg).

Zhelyazkova, Ts. And D. Pavlov, 2008. Influence of tretment with plant growth regulators on energy efficiency of spring vetch production. *Journ Mount Agric Balkans*, **11** (5): 815-828.

Received September, 1, 2010; accepted for printing May, 23, 2011.