Journal of Agricultural, Food and Environmental Sciences Vol 76 No 5 (2022) 21-27
DOI: https://doi.org/10.55302/JAFES22765021i

EFFECT OF N, S AND B APPLICATION OF BIOMASS YIELD AND HARVEST INDEX FOR TWO OILSEED RAPE GENOTYPES

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ABSTRACT

The agro biomass as a renewable energy gradually substituting other sources of biomass. Rapeseed was optimally included in the agro-energy complex as edible oil, as fodder, biofuel and biomass for bioenergy and thermal energy. The main goal of this research was to improve the production potential of winter oilseed rape by using different amounts of N, S and B. The specific objectives were to examine the effect of nitrogen (100 and 150 kg ha^{-1}) applying individually and in combination with sulfur (30 kg ha^{-1} and 70 kg ha^{-1}) and boron (1 and 2 kg ha^{-1}). The experiment was setup in Skopje region, in three vegetation years 2016 - 2018, with two genotypes: (variety and hybrid), in 15 variants and 4 replications: 1: control Ø; 2: N100; 3: N150; 4: N100+S30; 5: N100+ S70; 6: N150+S30; 7: N150+S70; 8: N100+S30+B1; 9: N100+S30+B2; 10: N100+ S70+B1; 11: N100+S70+B2; 12: N150+S30+B1; 13: N150+S30+B2; 14: N150+S70+B1 и 15: N150+S70+B2. To prove the effects of the applied elements, the following characteristics of production properties were analyzed: above ground biomass yield and harvest index. The above ground biomass yield from the average results obtained from the elements used in three years of research showed, a variety ranging from 11.5 t ha^{-1} to 13.4 t ha^{-1}, and for the hybrid from 12.2 t ha^{-1} raise to 14.6 t ha^{-1}. The harvest index for the variety varied from 0.27 to 0.35 Hi, and for the hybrid, the mean values for the experimental period varied from 0.31 to 0.38 Hi.

Key words: oilseed rape, N, S, B, biomass yield, harvest index.

INTRODUCTION

Measurement of aboveground biomass, a key production parameter, is required to calculate the harvest index. The harvest index measures the ratio of seed yield in the crop's overall aboveground biomass per unit area (Donald and Hamblin, 1976). In oilseed rape, it is typically between 0.20 and 0.27, or between 0.15 and 0.36 on average, and is strongly influenced by the genotype and climatic factors (Luo et al. 2015). The value of the harvest index might vary within a single production year depending on the location, i.e., the kind of soil, the amount of rainfall during the vegetation, and, to a lesser extent, the agro technical practices used during its cultivation (www.canr.msu.edu). The analysis of the results in this research largely confirmed the influence of the environmental conditions in which the oilseed rape was grown.

MATERIALS AND METHODS

Aim of the research is to compare two parameters biomass and harvest index determinate from combinations of N, S and B in the production of oil seed rape. The setup was conducted in three vegetation years 2016 - 2018, with two genotypes of oilseed rape: variety (zorica) and hybrid (rohan), distributed in 15 variants and 4 replications. From the fertilizers in the study, ammonium nitrate (NH_4NO_3) (34.4% N), ammonium sulfate ((NH_4) $2SO_4$) (21% N; 24% S), boron (8% liquid mineral fertilizer) and NPK 5: 15: 30 complex mineral fertilizer were used. For all variants, ANOVA and the least significant difference (LSD) test at the p0.05 and 0,01 level were used to determine whether there was a significant difference between mean values, and harvest index (Hi) – what represents a ratio between seed yield and aboveground dry biomass yield, was calculated using the formula Hi=seed yield/aboveground biomass yield (Donald & Hamblin, 1976 To determine the linear relationship between Hi yield and aboveground biomass, the overall correlation between Hi yield and aboveground biomass of all variants was first observed and then multiplied correlation coefficient r to determine coefficient of determination R^2 and regression level. Excel (M.Office) and PSAW 17 program are used for the statistical evaluation of the partial flows.

RESULTS AND DISCUSSION

Aboveground biomass yield

To determine the harvest index, aboveground biomass was first measured together with the seeds, from each variant for both genotypes. The obtained results are presented in table 1.

The analysis of the yield of aboveground biomass from the obtained average results of the elements used in the years of research showed that for the variety range from 11.5 t ha^{-1} to 13.4 t ha^{-1} (variant 15). The analysis of variance and the LSD test showed significance at the 0.05 level only between the value determined in variant 15 which was higher compared to the control and variants 6, and 14 in which the values of this property were lower. In the first year, statistically significant differences at the 0,01 level were confirmed between variant 15 (16.6 t ha^{-1}) compared to the control (13.3 t ha^{-1}) and all others, with the exception of variants 3 and 13, while in the third year high significance was confirmed between variants 3, 5, 7 and 12 (17.3 – 17.5 t ha^{-1}) compared to the control (15.3 t ha^{-1}) and variants 2, 6, 13 and 14. The average values for the aboveground biomass yield in the hybrid by variants compared to the variety were higher and ranged from 12.2 t ha^{-1} to 14.6 t ha^{-1} (variant 5 & 15). As with the dawn cultivar, the analysis of variance and LSD test confirmed statistical significance only at the 0,05 level between variant 15 compared to the control and variants 2, 4, 5 and 7. And with this genotype, obtained values by year, in the second vegetation year, statistical justification was not confirmed, and it can be stated that none of the elements in the quantities that were used in the conditions (temperature and precipitation) in the second year had any influence.

Table 1. Aboveground biomass yield (t ha^{-1}), variety (Zorica G1), hybrid (Rohan G2)

Treatments	Years						x var.*years	
	2016		2017		2018			
Variants	G1	G2	G1	G2	G1	G2	G1	G2
1 ø контрола	13,3	13,7	6,9	7,2	15,3	16,0	11,8	12,3
2 N_1	14,4	15,2	7,1	7,3	14,8	14,3	12,1	12,3
3 N_2	15,0	14,3	6,9	7,6	17,5	17,0	13,1	13,0
4 N_1+S_1	14,3	15,8	7,6	8,6	16,0	13,5	12,6	12,6
5 N_1+S_2	13,6	14,8	7,8	7,4	17,0	14,5	12,8	12,2
6 N_2+S_1	12,5	15,3	7,3	8,0	14,8	15,8	11,5	13,0
7 N_2+S_2	14,3	15,1	7,4	6,8	17,3	16,3	13,0	12,7
8 N_1+S_1+B_1	13,9	16,8	7,5	7,5	16,0	16,3	12,5	13,5
9 N_1+S_1+B_2	13,4	14,3	7,9	7,4	16,0	15,3	12,4	12,3
10 N_1+S_2+B_1	13,4	16,0	8,0	7,3	16,3	16,5	12,6	13,3
11 N_1+S_2+B_2	14,5	17,2	7,3	7,6	16,3	15,3	12,7	13,4
12 N_2+S_1+B_1	12,8	15,8	7,3	8,1	17,5	19,0	12,5	14,3
13 N_2+S_1+B_2	14,9	17,7	7,8	7,6	14,0	14,5	12,2	13,3
14 N_2+S_2+B_1	12,9	17,5	7,2	7,4	15,0	15,8	11,7	13,6
15 N_2+S_2+B_2	16,6	16,7	7,6	8,7	16,0	18,5	13,4*	14,6*
x genotype * years	14,0	15,7	7,4	7,6	16,0	15,9		
LSD var.*yer. 0,05	1,45	1,90						
LSD genotype*year 0,05	1,46	1,85						

When analyzing the average values of all varieties of both genotypes by year, for the variety they amount to 14.0 t ha^{-1} (I), 7.4 t ha^{-1} (II), and 16 t ha^{-1} (III), with high significance determined at the level of 0,01 between the third year where the achieved biomass was higher compared to the first and second year. Identity was also found in the hybrid where the values were 15.7 t ha^{-1}, 7.6 t ha^{-1} and 15.9 t ha^{-1} (years I-III respectively), with proven highly significant statistical differences at the level of p 0.01 between the values of the first and the third which were higher compared to the second year of the trials. If the average values by variants are analyzed, it can be concluded that the single use of N in the amount of 100 and 150 kg ha^{-1} (variants 2 and 3), as well as the combined use of N and S (variants 4, 5 and 6) do not showed a positive effect, that is, significance on the values of this property compared to the control variant. The analysis of the values obtained during the experimental period, for the variety with the use of 150 kg N ha^{-1} (variant 3) in the first and third year as well as the combined use of 100 kg N ha^{-1}+70 kg S ha^{-1} (variant 5) in the third year, shows high obtained biomass. From variant 3 and for the hybrid in the third vegetation year. Cultivation conditions and the use of N and S in larger amounts, can influence the realization of higher values. Significant biomass yield (15.77 t ha^{-1}) with the application of 120 kg N was established by Žák et al. (2012), as well as Singh (2019) achieved the highest biomass yield from oilseed rape using the highest amounts of N (specifically 130 kg N ha^{-1}). Khalid (2009) obtained a maximum biomass yield of 9 058 kg ha^{-1} when 40 kg S ha^{-1} was used. Poisson et al. (2019) examined the influence and interaction of S and N during fertilization of oilseed rape that the treatment with the highest amounts of sulfur (S30) and nitrogen (N97.2) (in kg ha^{-1}) results in obtaining the highest biomass, on average by + 22 % compared to the treatments S0 + N97.2 and S30 + N28.4, in S0 + N97.2 the stem participates with 61 %, while the seed with 9%, in contrast to S30 + N97.2 where the participation of the stem is 41 % and the seed 27%, which only confirms the importance of sulfur in formation of higher seed oilseed rape yield.

Harvest index

From the average values obtained, depending on the elements used, it can be concluded that the values of the harvest index for the variety were between 0.27 (control) and 0.35 (variants 11 and 13). The analysis of variance and the LSD test revealed highly significant statistical differences at the 0,01 probability level between the values of variants 11, 12 and 13, which were higher compared to the control (Table 2). A significance of 0.05 was also demonstrated between variants 11 and 13, where a higher harvest index was determined compared to variants 2, 4, 9 and 10. The evaluation according to years showed the same value differences in the first year of the test without statistics. The harvest index in the second and third year shows lower values in the control variant, while in the second year a statistical significance (p>0.01) was found between variant 11 (0.47) versus the control (0.37) and variants 2, 4, 5, 6, 7, 8, 10 and 14 (0.35–0.39), while in the third between variant 13 (0.31) compared to control (0.2) and variants 3, 4, 5, 7, 9 and 14 (0.22-0.24). In the case of the hybrid, the mean values for this property according to variants in the test period were between 0.31 (variant 3) and 0.38 (variants 8 and 13).

Table 2. Harvest index (Hi)

Treatments	2016		2017		2018		x var.*year.	
Variants	G1	G2	G1	G2	G1	G2	G1	G2
1 ø control	0,25	0,33	0,37	0,43	0,20	0,25	0,27	0,34
2 N_1	0,27	0,31	0,37	0,44	0,26	0,26	0,30	0,34
3 N_2	0,32	0,31	0,41	0,40	0,22	0,23	0,32	0,31
4 N_1+S_1	0,28	0,32	0,38	0,36	0,23	0,28	0,29	0,32
5 N_1+S_2	0,36	0,35	0,36	0,43	0,22	0,27	0,32	0,35
6 N_2+S_1	0,27	0,35	0,38	0,39	0,26	0,24	0,31	0,33
7 N_2+S_2	0,31	0,32	0,39	0,50	0,22	0,24	0,31	0,35
8 N_1+S_1+B_1	0,32	0,36	0,40	0,51	0,26	0,26	0,33*	0,38
9 N_1+S_1+B_2	0,27	0,33	0,39	0,46	0,24	0,27	0,30	0,35
10 N_1+S_2+B_1	0,31	0,30	0,35	0,48	0,24	0,26	0,30	0,35
11 N_1+S_2+B_2	0,33	0,34	0,47	0,49	0,27	0,28	0,35**	0,37
12 N_2+S_1+B_1	0,36	0,33	0,44	0,47	0,23	0,22	0,34**	0,34
13 N_2+S_1+B_2	0,32	0,35	0,42	0,47	0,31	0,32	0,35**	0,38
14 N_2+S_2+B_1	0,30	0,30	0,39	0,52	0,29	0,28	0,33*	0,36
15 N_2+S_2+B_2	0,30	0,31	0,44	0,42	0,26	0,24	0,33*	0,33
x genotype*year	0,31	0,33	0,40	0,45	0,25	0,26		
LSD var.*year 0,05	0,05	0,05						
0,01	0,07	0,07						
LSD genotype *year 0,05	0,05	0,05						
0,01	0,06	0,07						

The analysis of variance and the LSD test confirmed a high significance (p > 0.01) only between variants 8 and 13, whose harvest index values were higher than variant 3 with the lowest determined value. Statistical significance at the p 0.05 level was demonstrated between variants 8 and 13 compared to variants 4, 6 and 15. Analysis of variance and LSD test for both genotypes confirmed statistically significant differences at the 0.01 level between the second, whose values were higher compared to the first and third years. The ratio of seed yield and aboveground biomass has a positive effect on this trait, which was achieved in the variety by using 100 kg N ha^{-1}+70 kg S ha^{-1}+2 kg B ha^{-1} (variant 11) and 150 kg N ha^{-1}+30 kg S ha^{-1}+2 kg B ha^{-1} (variant 13), while in

the Rohan hybrid at 100 kg N ha^{-1}+30 kg S ha^{-1}+1 kg B ha^{-1} (variant 8) and 150 kg N ha^{-1}+30 kg S ha^{-1}+2 kg B ha^{-1} (variant 13), whereby variant 13 is distinguished as the most suitable for both genotypes. Islam et al. (2018) determine a high harvest index of 0.40 when applying 180 kg N ha^{-1}, as well as when applying 45 kg S ha^{-1} (0.38). Confirmed and in this research, high S amounts of 75 kg ha^{-1} affect the harvest index significantly (0.35) compared to 50 and 25 kg (0.34, 0.32) (Sharafi et all. 2015). When fertilizing oilseed rape grown with S and N, achieved the lowest harvest index in treatment S0 + N97.2 (Poisson et al. 2019). Veselinov et al. (2015) determined an index of 0.29 to 0.34 for winter oilseed rape genotypes, as did Habekotte (1997), who determined a mean harvest index of 0.34 at six locations under Atlantic climatic conditions. Ghassemi-Golezani et al. (2010) emphasize that winter oilseed rape varieties grown under arid conditions have a harvest index value of around 0.4, which was also confirmed in our studies, whereby the harvest index was determined in the driest vegetation year (2016/17) the harvest index for both genotypes was the highest (0.40 in the variety, 0.45 in the hybrid). On the other hand, the harvest index in spring oilseed rape in arid conditions is lower and is between 0.2-0.3 (Gunasekera et al., 2006; Kazemeini et al., 2010; Özer et al., 2003; Taheri et al., 2012).

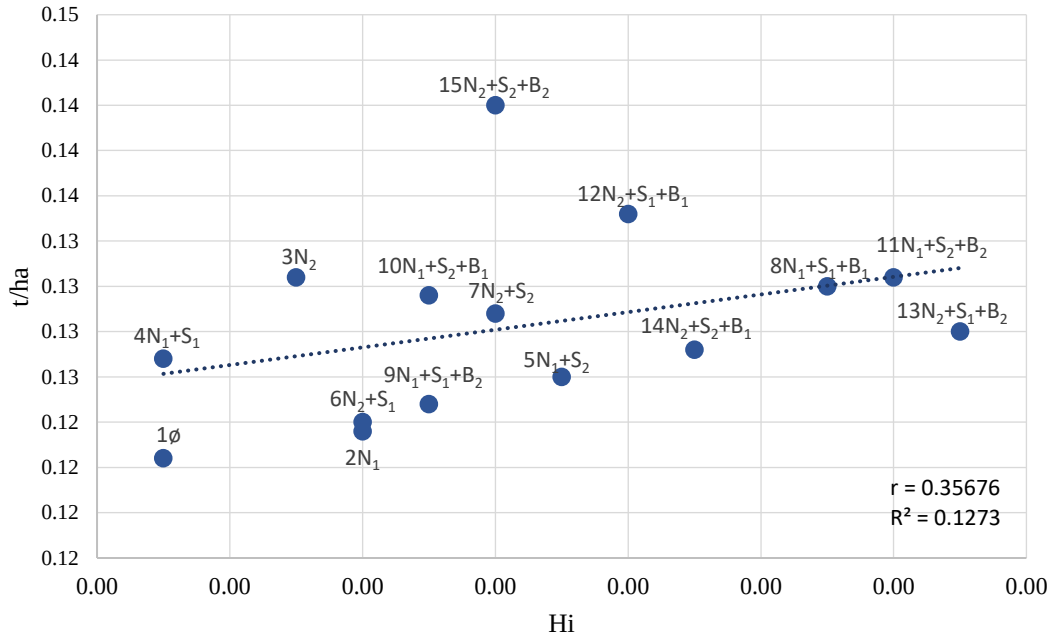

Figure 1. Regression and correlation between Hi and aboveground biomass yield (t ha^{-1}), obtained from the mean values of the two genotypes for the three-year period (2016-2018)

The used linear relationship determined a weak positive correlation and variants with Hi with different value, or those variant close to the linear trend has from low to high value of Hi (4, 7, 8, 11). The coefficient of association between the determined aboveground biomass yield and harvest index show obtained high average aboveground biomass yield of genotypes in relation to of mean value of Hi (0,33).

CONCLUSIONS

Yield of aboveground biomass from the obtained average results showed that for the variety they range from 11.5 t ha^{-1} to 13.4 t ha^{-1}. Biomass yield in the hybrid by variants were ranged from 12.2 t ha^{-1} to 14.6 t ha^{-1}. The analysis of variance showed significance only between the value determined in variant 15 (variety 13.4 t ha^{-1}, hybrid 14.6 t ha-^{1}). Harvest index for variety showed high significance in variants 11, 12 and 13 (Hi 0.35, 0.34.0.35), and not signification between variants for hybrid. Relations between aboveground biomass yield and harvest index shows a weak positive correlation coefficient, and regress on harvest index to 0.33, for accomplish higher biomass yield at both genotypes.

REFERENCES

Donald, C. M., Hamblin, J. (1976). The biological yield and harvest index of cereals as agronomic and plant breeding criteria. Advances in Agronomy, 28: 361-405

Ghassemi-Golezani, K., Khomari, S., Dalil, B., Hosseinzadeh-Mahootchy, A., Chadordooz-Jeddi, A., (2010). Effects of seed aging on field performance of winter oilseed rape. J. Food, Agric. Environ., 8(1), 175-178, www.researchgate.net/publicat ion/228083611

Gunasekera, C.P., Martin, L.D., Siddique, K.H.M., Walton, G.H., (2006). Genotype byenvironment interactions ofIndian mustard (Brassica juncea L.) and canola (B. NapusL.) in Mediterranean-type environments. European J.Agronomy, 25: 1-12.

Habekotte, B. (1997). Options for increasing seed yield of winter oilseed rape (Brassica napus L.): a simulation study. Field Crops Research 54: 109-126, https://edepot.wur.nl/210312

Islam, R., T.Hossain, HMM T., Karim, Md F., Haque, Md N. (2018). Yield and yield components of rapeseed as influenced by nitrogen and sulphur fertilization, Journal of Oilseed Brassica, 9 (2): 84-95 July, 2018, http://srmr.org.in/ojs/in dex.php/job/article /viewFile/303/195

Kazemeini, S.A., Edalat, M., Shekoofa, A., Hamidi, R. (2010). Effects of Nitrogen and Plant Density on Rapeseed (Brassica napus L.) Yield and Yield Components in Southern Iran https://scialert.net/fulltext/? doi=jas.2010.1461.1465

Khalid R., Khan K.S., Yousaf M., Shabbir G., Subhani A. (2009). Effect of Sulfur Fertilization on Rapeseed and Plant Availabe Sulfur in Soils of Pothwar, Pakistan, Sarhad J. Agric. Vol.25, No.1, 2009, www.aup.edu.pksj_pdfeffect%20of%20sulfur%20fertilization%20on%20rapeseed%20and %20plant.pdf

Luo, X., Ma, C., Yue, Y., Hu, K., Li, Y., Duan, Z., (2015). Unravelling the complex trait of harvest index in rapeseed (Brassica napus L.) with association mapping. BMC Genomics 16:379, https://bmcgenom ics.biomedcentral.com/articles/1 0.1186/s12864-015-1607-0

Özer, H. (2003). Sowing date and nitrogen rate effects on growth, yield and yield components of two summer rapeseed cultivars. Eur J Agron.; 19 (3):453–463. http://dx.doi.org/10.1016/S1161-0301(02)00 136-3

Poisson, E., Trouverie, J., Brunel-Muguet, S., Akmouche, Y., Pontet, C., Pinochet, X., and Avice, J-Ch. (2019). Seed yield components and seed quality of oilseed rape are impacted by sulphur fertilization and its unteractions with nitrogen fertilization. Frontiers in Plant Science, Volume 10, Article 458, 1-14, https://www.frontiersin. org/articles/10.3389/fpls.2019.00458/full

Sharafi, Y., Majidi M. M., Jafarzadeh, M., Mirlohi, A. (2015). Multivariate Analysis of Genetic Variation in Winter Rapeseed (Brassica napus L.) Cultivars, J. Agr. Sci. Tech. (2015) Vol. 17: 1319-1331, http://jast.modares.ac.ir/article-23-9712-en.pdf

Singh, R., Lal, M., Singh, G., Kumar, T. (2019). Effect of nitrogen and phosphorus on growth parameter and yield of canola (Brassica napus L.), Journal of Pharmacognosy and Phytochemistry 2019; 8(1): 380-384, www.phytojournal.comarchives2019vol8 issue1PartG8-1-43-477.pdf

Taheri, E., Soleymani, A., Javanmard, H.R. (2012). Theeffect of different nitrogen levels on oil yield and harvestindex of two spring rapeseed cultivars in Isfahan region.Int. J. Agric. Crop Sci., 4(20): 1496-1498

Veselinov, B., Martinov, M., Golub, M., Višković, M., Bojić, S., Đatkov, Đ. (2015). Potencijal žetvenih ostataka uljane repice u srbiji, Naučni časopis Poljoprivredna Tehnika (Scientific Journal Agricultural Engineering), Godina XL Broj 3, 2015. 59 - 68. https://arhiva.nara.ac.rs/bit stream/handle/123456789/626/2%Marko%20Golub%20%20final.pdf?sequence=1&isAllowed=y

Žák, Š., Macák, M., Hašana, R. (2012). Influence of soil cultivation technologies and fertilisation on productivity and energy production of arable crops. Agriculture (Poľnohospodárstvo), vol. 58, no.1, pp.25–33 doi:10.2478/v10207-012-0004-9 www.canr.msu.edu/news/harvest_index_a_ pred ictor_of_corn_stover_yield