Scientific Papers. Series A. Agronomy, Vol. LXIII, No. 1, 2020
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

GREEN FORAGE PRODUCTIVITY AND YIELD COMPONENTS OF TRITICALE VARIETIES (×*Triticosecale* Wittm.) UNDER THE INFLUENCE OF DIFFERENT NITROGEN FERTILIZATION LEVELS

Hristofor KIRCHEV

Agricultural University of Plovdiv, 12 Mendeleev Blvd, Plovdiv, Bulgaria

Corresponding author email: hristofor_kirchev@abv.bg

Abstract

A three-year field experiment for determination of the green fodder yield of triticale varieties has been carried out on the experimental field of the Crop Science Department at the Agricultural University of Plovdiv. The experiment has been conducted in block method in 4 replications after predecessor sunflower. The study used the varieties Lasko - standard, Boomerang, Respect and Attila, created in the breeding center of triticale in Bulgaria - Dobruja Agricultural Institute, Gen. Toshevo. Triticale is grown under two levels of nitrogen fertilization - 60 and 180 kg ha^{-1} nitrogen. As a result of the experiment, the main structural elements of the yield and some quality parameters of the plants have been established, depending on the variety and the nitrogen fertiliszation level. For the three years of the study, the average yield of green mass of all triticale varieties, fertilized with 180 t ha^{-1} nitrogen is higher than the lower fertilizer rate. Under the influence of both fertilization rates, the variety Lasko has proven as less productive than all other varieties created in the Dobruja Agricultural Institute, Gen. Toshevo, Bulgaria.

Key words*: triticale, nitrogen fertilization, fodder yield.*

INTRODUCTION

Triticale is a grain crop, artificially created from a cross between wheat and rye. Apart from grain, rye genome involvement in its creation, makes triticale crop suitable for use in various feed derived from the green mass. Harvested after full spike formation, the crop is suitable for silage and production of various feed hay. Several studies identify the triticale crop as appropriate for participation in grass-forage mixtures with legumes or self (Aguilar-López et al., 2013; Bilgili et al., 2009; Jacobs and Ward, 2012; Zannat et al., 2012; Demidova et al., 2015; Liu et al., 2017; Maisak, 2017; Ostos Garrido et al., 2018).

An important point in the production of green forage of triticale is the choice of the variety. In a world selection of triticale varieties, designed specifically for green mass are created (Kina et al., 2009; Li et al., 2012; Royo and Blanco, 1999). Bulgaria is one of the first countries in the world that creates its own varieties of triticale. Almost all Bulgarian varieties, however, are designed for grain. The only one official recognized Bulgarian triticale variety of green mass is Belitsa1, created in the early '80s of the 20th Century (Tzvetkov, 1989; Giurova et al., 1993). However, variety Belitsa1 has been long unsupported and no seeds are produced from it. This requires the production of green forage from triticale to use modern varieties, intended mainly for grain.

Besides choosing the variety, obtaining maximum biological yield is greatly influenced by the nitrogen fertilization, which is a powerful factor in the growth of vegetative organs of the plants (Cazzato et al., 2012; Nogalska et al., 2012; Georgieva, 2019).

According to Wysokinski and Kuziemska, (2019) following the application of a single nitrogen dose, spring triticale took up 65.05 kg N ha^{-1} from the fertilizer, and the utilization coefficient of N amounted to 54.3%. The split application of the total amount of fertilizer divided into two and three doses increased the amount of nitrogen taken up from the fertilizer by 7.31 and 14.90 kg N ha^{-1}, respectively, and the value of the coefficient of its utilization rose by 6.0 and 12.4%, respectively. The amount of this element taken up from the soil reserves was not dependent on the test variants of nitrogen fertilization. A significant increase in the uptake and utilization of nitrogen from the fertilizer by triticale was obtained from BBCH stage 22 to stage 65. From BBCH stage

65 to stage 92, no significant increase in the amount of nitrogen taken up from these sources or in the value of the coefficient of utilization was noted.

At the experimental base of the Department of Plant production at Trakia University, Stara Zagora, nitrogen assimilation from fertilization increases with the increase of the nitrogen fertilizer rates. With the obtained yield from triticale an average of 96.53 kg ha^{-1} N is extracted from the soil with the grain, 18.97 kg ha^{-1} N with the straw or a total of 115.50 kg ha^{-1} N. When growing triticale after leguminous predecessors the utilization of nitrogen is 35.39% and after predecessors sunflower, wheat and triticale - 28.76%. Nitrogen required for 100 kg yield of the grain of triticale is 1.9 kg of nitrogen when growing after legume predecessors and 2.8 kg of nitrogen after the other predecessors (Gerdzhikova et al., 2017).

The aim of this study is to identify the genotypic specifics of triticale varieties in terms of feedstock productivity at two rates of nitrogen fertilization.

MATERIALS AND METHODS

The experiment has been carried out during the 2017-2019 years in the experimental field of the Crop Science Department, Agricultural University of Plovdiv. Four varieties of triticale - Lasko (international triticale standard) the first Polish hexaploid triticale variety, obtained at the Laski Breeding Station from the cross Triticale 57 - winter wheat C 1218/67 x 6TA 206 (Wolski and Tymieniecka, 1983), Boomerang, Respect and Attila, created in the Dobruja Agricultural Institute, Gen. Toshevo, Bulgaria have been tested. Varieties have been grown at two levels of nitrogen fertilization - 60 and 180 kg ha^{-1} nitrogen, introduced in early spring. The experiment was conducted after the predecessor sunflower and arranged according to the split-plot method in four replications.

The yield of green mass (t ha^{-1}) has been recorded at the end of the heading stage (BBCH 59) of the harvest plots with a size of 10 m^2. The following structural elements of the plants have been determined: plant height (cm); the number of spikes per plant, length of spikes (cm). Depending on the amount of the accumulated biomass, the share of the main three organs (stems, leaves, and spikes) in the formation of the green mass is calculated.

Statistical analyses of individual factors were performed with a software package SPSS 16.0.

RESULTS AND DISCUSSIONS

Weather conditions during the vegetation are one of the factors that strongly influence the productivity of the tested varieties (Figure 1).

Although the sowing during the first year of the study has been carried out at the optimum crop time (11.10), the autumn drought delayed the onset of the crop and emergence phases was observed on 10.11 (one month later after sowing). The autumn of 2016 has indicators close to the minimum temperatures for the growth and development of the crop. During the sharp cold of the weather at the end of November, the growing season ended and the crops came to rest in the third leaf phase. December is warm with average monthly temperatures of 2.2˚C. January is characterized as cold as the average monthly temperature (-3.9˚C) is lower than the long-time average. The months were characterized by sharp and short-term decreases in temperatures up to –10.3˚C and the lack of snow cover, which represented a real threat to sowing, but despite the low temperatures, no frost was observed. The onset of permanent spring vegetation is recorded under the conditions of the third ten days of March with values of average daily temperatures of the order of 9.7˚C. The period of filling and ripening of the grain - May and June is characterized by values of temperatures close to the optimum. The amounts of winter rainfall were less than typical for the Plovdiv area, except for January, with a minimum of 2.4 mm recorded in December. In March, the amount of rainfall is 47.9 mm, while in May and June, when the maximum rainfall occurs, the amount of rainfall is respectively 87.3 mm and 124.6 mm below the normal. The total rainfall during the triticale vegetation is 288.4 mm, which is 271.6 mm below the climatic norm of the investigated area.

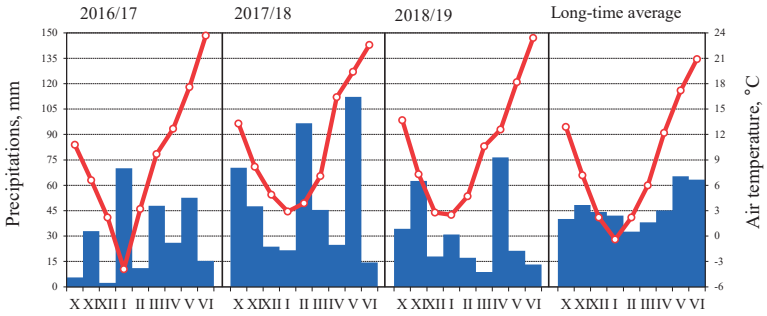

Figure 1. Meteorological conditions (climatogramme) during the years of the investigation

During the second year of the study, the temperatures during the growing season of triticale not only were higher than the previous year but also exceeded the climatic norm of the area, with the sum of average monthly temperatures of 11˚C, which is 2.1˚C above the long-term average. Unlike the 2016/2017 drought, the second harvest year is characterized by sufficient rainfall, which contributes to better soil moisture conservation and optimum crop development. Positive monthly average temperatures in November (8.2˚C), as well as low rainfall (47.6 mm) close to the climatic conditions, create the conditions for the beginning of the tillering in the first ten days of December. The total rainfall in the second year exceeds the area's climate norm (417.0 mm) by 40 mm. Heavy rainfall in March (112.3 mm) prolongs the period of pouring and ripening of the grain.

In climatic terms, the third year is approaching the second year, with positive temperatures in the autumn and winter period exceeding the climatic norm. The period from sowing to germination is 10 days, as in the second year. Although the rainfall in October is 5.8 mm below the region's climatic norm, the average monthly temperatures (13.7˚C) exceed the 0.8˚C long-term average, which contributes to the onset of the emergence phase. Positive average monthly temperatures in November (7.3˚C) and heavy rainfall (62.5 mm), which exceed the climatic norm, contribute to the beginning of the tillering in early December. Although in 2017/18 the amount of rainfall during the same period exceeds the climatic norm, temperature plays a decisive role in the occurrence of the stem elongation phase. In 2018/19, the highest monthly average temperatures over the test period (23.4˚C) are observed in June, which contributes to the earliest entry into the ripening phase.

The yield of green mass of the studied triticale varies depends on the conditions during the years and is greatly influenced by the tested levels of nitrogen fertilization (Table 1).

Table 1. Green mass yield, t ha^{-1}

Years	2017		2018		2019		Average	
Varieties N level	N_{60}	N_{180}	N_{60}	N_{180}	N_{60}	N_{180}	N_{60}	N_{180}
Lasko	2.4 ^{a}	4.2 ^{a}	4.2 ^{a}	4.9 ^{a}	3.5 ^{a}	4.2 ^{a}	3.4 ^{a}	4.4 ^{a}
Boomerang	2.9 ^{c}	4.6 ^{b}	4.7 ^{b}	5.6 ^{b}	3.6 ^{b}	5.2 ^{b}	3.7 ^{b}	5.1 ^{c}
Respect	2.6 ^{b}	4.5 ^{b}	4.6 ^{b}	5.6 ^{b}	3.5 ^{b}	4.9 ^{b}	3.6 ^{b}	5.0 ^{b}
Attila	2.5 ^{b}	4.6 ^{b}	4.6 ^{b}	5.6 ^{b}	3.6 ^{b}	4.8 ^{b}	3.6 ^{b}	5.0 ^{b}
LSD 5%	*0.2*	*0.2*	*0.2*	*0.3*	*0.2*	*0.2*	*0.2*	*0.2*

*Values with the same letters do not differ significantly.

For the tested period, the yields of all varieties are the lowest at the first fertilization rate (N_{60}). During the three years of study, the lower yield is derived from the variety Lasko - 2.4, 4.2 and 3.5 t ha^{-1}, respectively in 2017, 2018 and 2019 years in the conditions of the fertilization rate N_{60}.

Differences between the international standard variety Lasko and varieties selected in Dobruja Agricultural Institute, Gen. Toshevo, Bulgaria

in the first year of study sets the standard in the lowest group of productivity of green mass and varieties Respect and Attila prove to be high yielding. Variety Boomerang proved as more productive than both the standard and the other varieties in the first year when fertilized with N_{60}. In 2018 and 2019 years, the differences in grain yield were demonstrated only between Lasko and the varieties created in Bulgaria. Both levels of fertilization established no differences between the three Italian varieties of triticale. This is probably due to the closest genotype origin of the varieties Boomerang, Respect and Attila. The reason for the differences proven in the first year for the lowest nitrogen rate can be attributed to poor rainfall conditions during the spring of 2017, from which it can be concluded that in terms of drought years and lower rates of fertilization, genotypic differences in triticale are more pronounced.

Average for the three years of the study, the average yield of green mass of all varieties of triticale, fertilized with 180 t kg ha^{-1} nitrogen is higher than the lower fertilizer rate by 1.33 t ha^{-1}. Under the conditions of both fertilization rates, the variety Lasko has proven as less productive than all other varieties created in the Dobruja Agricultural Institute, Gen. Toshevo, Bulgaria.

The main structural components directly influencing the formation of crop and productivity of triticale varieties can be considered independently by factors - variety, conditions of the year and nitrogen fertilization (Table 2).

Table 2. Differences between the main productivity components

Indices*	Plant height, cm	Number of spikes	Length of spike, cm
		Varieties	
LASKO	105 ^{a}	2.1 ^{a}	11.5 ^{a}
Boomerang	115 ^{b}	3.3 ^{b}	16.0 ^{c}
Respect	120 ^{c}	3.1 ^{b}	14.5 ^{b}
Attila	118 ^{b}	3.1 ^{b}	13.5 ^{b}
		Years	
2017	110 ^{a}	2.6 ^{a}	13.2 ^{a}
2018	119 ^{b}	3.2 ^{b}	14.0 ^{a}
2019	118 ^{b}	2.9 ^{b}	13.6 ^{a}
		Nitrogen fertilization	
N_{60}	110 ^{a}	2.5 ^{a}	13.8 ^{a}
N_{180}	119 ^{b}	3.2 ^{b}	14.0 ^{a}

*Values with the same letters do not differ significantly.

The height of the stems varies depending on the variety from 105 cm in cultivar Lasko to 120 cm in Respect variety. Differences between varieties were statistically significant, except by Boomerang and Attila, where the difference in height of the stem is not proven. The influence of the conditions of the year is shown only between the first and the remaining two years of the study. The higher rate of nitrogen fertilization has been proven to increase the height of the crop by 9 cm.

The formation of productive tillers (number of spikes) is one of the main factors influencing directly the crop productivity. The amount of spikes per plant varieties varies between 2.1 and 3.3 per plant. These differences, however, are only proven compared with Lasko, and the remaining three varieties can be grouped together in terms of their productive tillering. In the second and third year, an equal number of productive tillers (spikes) are formed and in 2017 when are observed the lowest yields of green mass, the tillering is lowest. The higher nitrogen rate leads to an increase in productive tillering with 0.7 spikes per plant compared to the fertilization with 60 kg ha^{-1} N and the differences between both fertilization rates are statistically proven.

According to the spike length, there is a statistically proven difference between Lasko and all tested varieties, only between the varieties Respect and Attila, the difference remains unproven, which set them in the same statistical group. Longest spike gives the variety with the highest average yield - Boomerang. Weather conditions during the three years of study do not lead to statistically proven differences in the length of the spikes.

Because of the genetic determination of the length of the spike, the increasing nitrogen fertilization has no proven positive impact on the indicator.

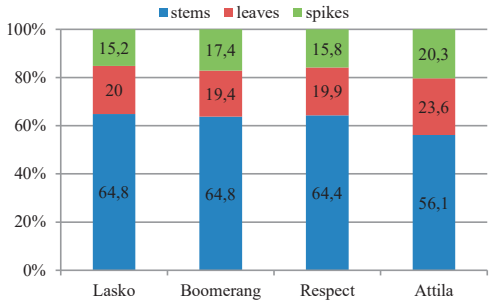

Figure 2. Part of the organs of the plant in the formation of the yield

The organs of the plants that form the total biomass of triticale in the medium milk stage are the stems, leaves, and spikes (Figure 2). The highest proportion of plants in all triticale varieties occupy the stems (62.5% of the plant mass on average for all triticale varieties). The lowest is the proportion of stems in the Attila variety - 56.1% and the largest in the varieties Lasko and Boomerang - 64.8%. The leaves occupy an average of 20.7% of the mass of the plants. The highest proportion of leaves is in the Attila variety - 23.6%, followed by the Lasko (20%) Respect (19.9%) and the lowest in the Boomerang variety - 19.4%. The share of spikes by all varieties of triticale occupies 17.2% of the mass of the whole plant. The highest share of the spikes is in the Attila variety - 20.3% and the smallest in the Lasko variety - 15.2%.

Relations between yield and the various structural elements, expressed by the correlation coefficient indicates that an increase in each of the three indicators influences positively the yield of green mass of triticale (Table 3). In most influence on the yield of a crop has a density, expressed as the number of spikes (r = 0.648), followed by plant height (r = 0.620) and the length of the spike (r = 0.592).

CONCLUSIONS

Average for the three years of the study, the yield of green mass of all triticale varieties, fertilized with 180 t ha^{-1} nitrogen is higher than the lower fertilizer rate. Under the conditions of both fertilization rates, variety Lasko has proven as less productive than all other varieties created in the Dobruja Agricultural Institute, Gen. Toshevo, Bulgaria.

The largest share of the plants of all triticale varieties is occupied by the stems (62.5%) followed by the leaves (20.7%) and the share of the spikes occupies 17.2% of the mass of the whole plant.

Relations between yield and the various structural elements expressed by the correlation coefficient indicates that an increase in each of the three indicators influences the yield of green mass of triticale. The productive tillering influences the yield of a crop to the largest extent, followed by plant height and length of the spike.

Table 3. Correlation analysis

Signs	1. Green mass yield	2. Plant height	3. Number of spikes	4. Length of spike
1	1			
2	0.620*	1		
3	0.648*	-0.112	1	
4	0.592*	0.957*	-0.016	1

Correlation is significant at the p = 0.05 level.

REFERENCES

Aguilar-López, E.Y., Bórquez, J.L., Domínguez, I.A., Morales-Osorio, A., Gutiérrez-Martínez, M., Ronquillo, M. (2013). Forage Yield, Chemical Composition and In Vitro Gas Production of Triticale (× *Triticosecale* Wittmack) and Barley (*Hordeum vulgare*) associated with Common Vetch (*Vicia sativa*) Preserved as Hay or Silage. *Journal of Agricultural Science*, *5*(2), 227–238.

Bilgili, U., Cifci, E.A., Hanoglu, H., Yagdi, K., Acikgoz, E. (2009). Yield and quality of triticale forage. 2009. *Journal of Food, Agriculture and Environment*, *7*(3-4), 556–560.

Cazzato, E.E., Laudadio, V.V., Tufarelli, V.V. (2012). Effects of harvest period, nitrogen fertilization and mycorrhizal fungus inoculation on triticale (x *Triticosecale* Wittmack) forage yield and quality. *Renewable Agriculture & Food Systems*, *27*(4), 278–286.

Demidova, A.G., Kuleshova, I.V., & Gubina, T.G. (2015). Forage productivity of spring triticale in pure and mixed sowings as green feed in the conditions of Belgorod region. *Vestnik OrelGAU*, *1*, 67–74.

Gerdzhikova, M., Grozeva, N., Pavlov, D., & Tzanova, M. (2017). Effect of nitrogen fertilization in Triticale (× *Triticosecale* Wittm.), cultivated after different predecessors. Nitrogen uptake and efficiency. *AGROFOR International Journal*, *2*(3), 147–56.

Georgieva, R. (2019). Alteration of yield components of triticale depending on treatment with plant stimulants in the condition of different soil nutrition regime. *Journal of Mountain Agriculture on the Balkans*, *22* (1),130–138.

Giurova, M., Georgiev, S., Ivanova, V., Dimitrov, L. (1993). Agroclimatic zoning of rye and triticale for green mass. *Rastenievadni nauki*, 5-6, 80–83 (Bg).

Jacobs, J.L., Ward, G. N. (2012). Effect of intercropping forage peas (*Pisum sativum* L.) with winter wheat (*Tritium vulgare* L.) or triticale (*Triticale hexaploide* Lart.) on DM yield, nutritive characteristics when harvested at different stages of growth. *Animal Production Science*, *52*(10), 949–958.

Kina, B.B., Ayhan, V.V., Akman, Z.Z., Adiyaman, E.E. (2009). Determination of silage quality, herbage and hay yield of different triticale cultivars. *Asian Journal of Animal & Veterinary Advances*, *4*(3), 167–171.

Li, H., Lin, C., Li, C., Kong, G., Wang, Y., Wu, Q., Cao, L. (2012). Analysis of stability of forage triticale varieties with AMMI model. *Xinjiang Agricultural Sciences*, *49*(5), 802–807.

Liu, W., Maurer, H., Leiser, W., Tucker, M., Weissmann, S., Hahn, V., & Würschum, T. (2017). Potential for marker-assisted simultaneous improvement of grain and biomass yield in triticale. *BioEnergy Research*, *10*(2), 449–455.

Maisak, G.P. (2017). Winter crops ensilage in Permskii Krai. *Perm Agrarian Journal*, *20*(4), 91–96.

Nogalska, A.A., Czapla, J.J., & Skwierawska, M.M. (2012). The effect of multi-component fertilizers on spring triticale yield, the content and uptake of macronutrients. *Journal of Elementology*, *17*(1), 95–104.

Ostos Garrido, F.J., Pistón, F., Gómez, L.D., & McQueen-Mason, S.J. (2018). Biomass recalcitrance in barley, wheat and triticale straw: Correlation of biomass quality with classic agronomical traits. *PLoS ONE*, *13*(11), 1–14.

Royo, C., Blanco, R. (1999). Growth analysis of five spring and five winter triticale genotypes. *Agronomy Journal, 91*(2), 305–311.

Tzvetkov, S. (1989). Triticale. *Zemizdat*, Sofia (Bg).

Wolski, T., Tymieniecka, E. (1983). The first Polish triticale variety. *Cereal Research Communications*, *11*(2), 139–141.

Wysokinski, A., & Kuziemska, B. (2019). The dynamics of uptake and utilization of nitrogen from mineral fertilizer by spring triticale calculated by isotopic dilution method. *Journal of Elementology*, *24*(1), 7–18.

Zannat, M.K., Alam, M.R., Sarker, N.R., Huque, K.S., Khan, M.I., & Islam, M.A. (2012). Comparative study on the biomass yield, chemical composition and in-sacco dry matter degradability of different cultivars of triticale fodder. *Bangladesh Journal of Animal Science*, *41*(1), 24–28.