DOI: 10.22620/agrisci.2022.33.003

IS THE WINTER WHEAT DEVELOPMENT AND PRODUCTIVITY INFLUENCED BY THE MONOCULTURE GROWING?

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Abstract

Information about the influence of growing winter wheat as a monoculture is limited. Therefore a study of winter wheat in five consecutive vegetation seasons (2015/2016, 2016/2017, 2017/2018, 2018/2019, and 2019/2020) was performed. The experiment was situated in the experimental field of "Agriculture and herbology" Department at the Agricultural University of Plovdiv, Bulgaria. The Bulgarian winter wheat variety "Enola" was under evaluation. All evaluated parameters of the crop such as the plant height before harvest, ear length, seed yield, absolute seed mass, as well as the hectoliter seed mass were influenced by the monoculture growing. The highest results of the studied indicators for winter wheat were recorded in the first two growing seasons. The studied parameters in the next growing periods were decreased by the monoculture, and the lowest results were recorded for the last experimental season.

Keywords: winter wheat, monoculture, development, seed yield

INTRODUCTION

Winter wheat (*Triticum aestivum* L.) is one of the widely grown and most consumed food crops all over the world. It is a major field crop in Bulgaria, where, for 2020 winter wheat was grown on an area of 1 200 580 ha with a total production of 4 714 452 tons (MZH, 2020). Crop rotation plays a major role in crop yielding (Hilton et al., 2018). The preceding crops must be carefully chosen for obtaining higher yields and seed quality. The most suitable preceding crop for winter wheat is coriander (Delibaltova, 2008; Delibaltova, et al., 2010; Delibaltova and Kirchev, 2016).

Also, including winter wheat in the rotation with maize and soybean is in favor for the crops growing and development as well as for the pest and disease management (Bezdicek and Granatstein, 1989; Raimbault and Vyn, 1991; Anderson, 2008). Past research has confirmed that the maize yield can increase by more than 40% in a winter wheat-corn-soybean rotation compared to the rotation of maize after soybean (Zhang et al., 1996; Katsvairo et al., 2002). The research conducted by Rahimizadeh et al. (2010) showed that the efficiency of nitrogen use is also influenced by the preceding crop. The highest results were obtained when wheat was grown after potatoes and the lowest when wheat was following wheat. In a trial performed by Dogan and Bilgili (2010) the seed yield of wheat grown after sunflower was lower than those of wheat grown after alfalfa. Grain yields of winter wheat following cereals were lower than those obtained for winter wheat grown after non-cereal crops (Smagacz et al., 2016; Wozniak, 2019). Higher winter wheat grain yields and dry straw biomass have been recorded by Gandia et al. (2021) when the crop was grown in rotation. In the most diverse crop rotation studied by Jalli et al. (2021), the average seed yield was 21% higher than the yield in the wheat monoculture. Berca et al. (2021) recommend avoiding of long-term winter wheat monoculture and applying a four-year crop with peas as ameliorating plant. According to Bennett et al. (2012), the causes of

yield decrease are complex and many factors have been implicated such as the alteration of soil physicochemical properties by land management practices and biotic factors as the changes in the composition of soil or rhizosphere microbial communities. Jankowski et al. (2015) also found a decline in the gluten content and a falling number of the winter wheat grains if the crop was grown as a monoculture.

The current research aims to evaluate the effect of monoculture on winter wheat development and seed yields.

MATERIALS AND METHODS

The trial was conducted in five consecutive vegetation seasons of winter wheat (2015/2016, 2016/2017, 2017/2018, 2018/2019, and 2019/2020). The research was performed on the experimental field of "Agriculture and herbology" Department at the Agricultural University of Plovdiv, Bulgaria. The experiment was conducted by the long plots method with a total size of 100 m^2 (four plots total = 400 m^2). The following parameters were under evaluation:

- Plant height before harvest (cm). Measurements were done on 4 samples of 25 plans = 100 plants in total;
- Ear length (cm). Measurements were done on 4 samples of 25 plans = 100 plants in total;
- Winter wheat seed yield (t ha^{-1}), by harvesting the four plots with experimental plot harvester of Wintersteiger Company;
- Absolute mass of 1000 seeds (g) (in four replications) (Tonev et al., 2018);
- Hectoliter seed mass (kg) (in four replications) (Tonev et al., 2018);

The soil on the experimental field is classified as Mollic Fluvisols, with an average sandy-clay mechanical composition, not high humus content, and weak-alkaline reaction. The nitrogen content is low, the content of phosphorus varies from low to average and the potassium content is high (Popova et al., 2012).

The winter wheat (*Triticum aestivum* L.) variety grown in the study was "Enola" (Kostov et al. 1999). The predecessor of the winter wheat before the first year of research was maize.

The performed growing technology was the same in the five experimental years including combined fertilization with 250 kg ha^{-1} with N:P:K (15:15:15), followed by deep plowing. Before sowing the crops, disking on the depth of 15 cm and two harrowing operations on 8 cm of depth were done. The sowing density was 550.000 plants ha^{-1}. Spring dressing with 250 kg ha^{-1} NH_4NO_3 was also performed. Plant protection practices for weed, disease, and insects control were done by rotating the plant protection products, so that no resistance to some of the crop enemies emerged.

The statistical analysis of collected data was accomplished by using Duncan's multiple range test of the SPSS 19 program. Statistical differences were considered significant at $p < 0.05$.

RESULTS AND DISCUSSION

On the next three figures, the obtained results for plant biometry, productivity, and seed qualities are presented.

Figure 1 shows the results of the plant height and winter wheat ear length. According to many authors, the plant growth and development is influenced by the preceding crop (Christen et al., 1992; Kalburtji and Gagianas, 1997; Arihara and Karasawa, 2000; Krupinsky et al., 2006; Haase et al., 2007; Friberg et al., 2019). In the monoculture system, the winter wheat growth is diminished (Debaeke et al., 1996; Sieling et al. 2005; Soane et al., 2012; Schlegel et al., 2018; Wozniak, 2019). These findings correspond to the obtained data from the current study. The highest plants were measured in the first year of the study – 103.91 cm, and in the second year, the height was 103.33 cm. There were no statistical differences for the first two years of the trial. After the second research year severe and statistically

proven differences were recorded for the plant height after growing the plants as a mono-cropping system– 97.46, 91.76, and 90.36 cm for 2018, 2019, and 2020 respectively.

The ear length was also influenced by the mono-cropping of the winter wheat. The results followed the same tendencies as the plant height. The indicator was severely diminished after the first and second years of the experiment. No statistical differences were recorded for the ear length in 2016 (11.14 cm) and 2017 (10.95 cm), but in the next research years, the indicator statistically decreased – 9.94, 8.86, and 8.01 cm for 2018, 2019, and 2020 respectively.

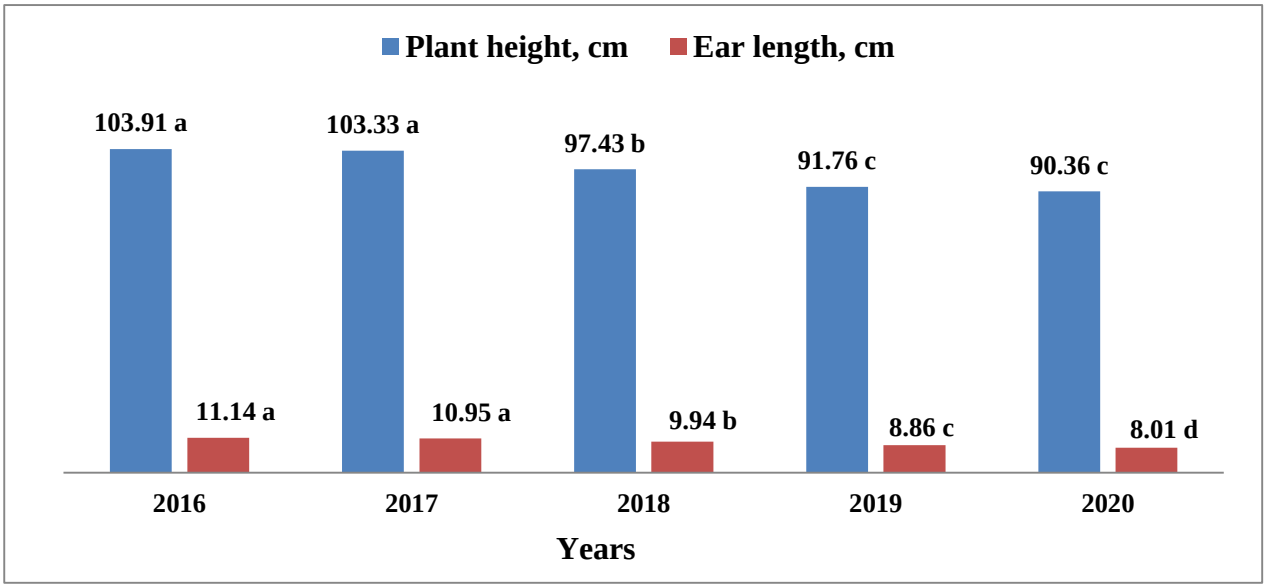

Figure 1. Winter wheat plant height before harvest (cm) and central ear length (cm)
Values with different letters are with proved differences according to Duncan's Multiple Range test ($p < 0.05$)

The yield of winter wheat grown as a monoculture was significantly lower compared to the winter wheat grown in a crop rotation (Panchenko et al., 2019; Wozniak, 2019). In long-term winter wheat monoculture the yield was decreased by 37% on average (Adamiak et al., 2018). Budzynski (2012) reported that the seed yield of 6-8 year monocultures of winter wheat was decreased by 22% when compared to the yield of the plants grown in a crop rotation with other crops. In the current trial, the seed yield of the winter wheat as a five-year monoculture was decreased from 2.50% (6.25 t ha^{-1}) in the second year (2017) to 39.31% (3.89 t ha^{-1}) in the last year (2020) (Table 1). Here also, statistical differences of the yields obtained in the first and the second year were not found, but after the third year of the study, the diminished seed yields were with statistically proven differences according to Duncan's Multiple Range test ($p < 0.05$) (Figure 2).

The indicator absolute seed mass is crucial for the yield's formation (Georgiev et al., 2014). The winter wheat grown in monoculture led to a decrease of the 1000 grains weight of the crop (Sieling and Hanus, 1990; Adamiak et al., 2018).

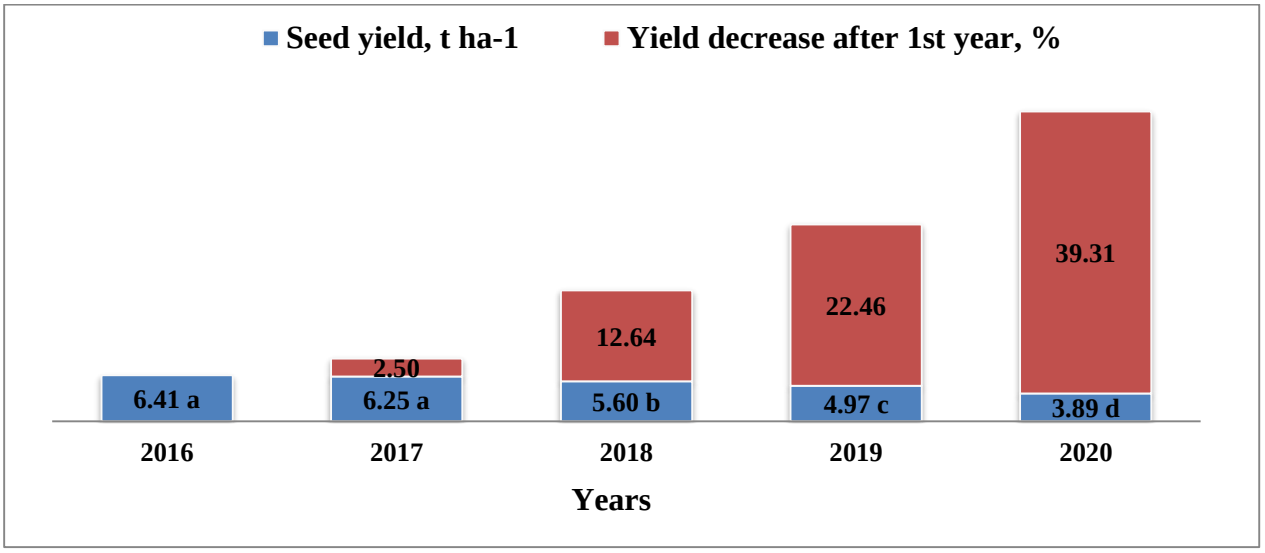

Figure 2. Winter wheat seed yield (t ha^{-1})
Values with different letters are with proved differences according to Duncan's Multiple Range test ($p < 0.05$)

The data for the absolute and hectoliter seed mass is shown in Figure 3. As the indicators plant height before harvest, ear length, and winter wheat seed yields, the parameters absolute and hectoliter seed mass were influenced by the monoculture as well (Figure 3). In the first and the second research years, there were no statistical differences for the absolute seed mass – 41.25 g in 2016 and 40.27 g in 2017 as well as for the hectoliter seed mass – 76.29 kg in 2016 and 75.50 kg in 2017. The examined parameters statistically decreased their values after the second year of mono-cropping (Figure 3). The absolute seed mass was 38.77, 36.64, and 34.19 g in 2018, 2019, and 2020 respectively. The diminishing tendency was repeated for the hectoliter seed mass parameter where a severe decrease was recorded. The hectoliter in 2018 was 74.40 kg, and 73.04 and 71.16 kg in 2019 and 2020 respectively.

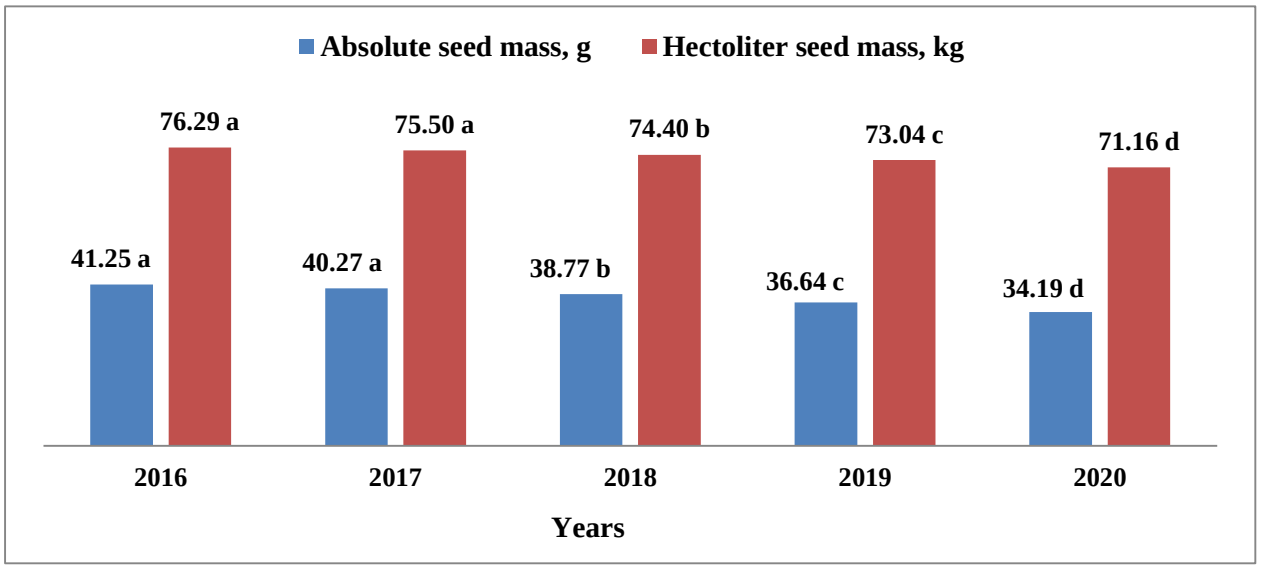

Figure 3. Absolute seed mass (g) and hectoliter seed mass (kg)
Values with different letters are with proved differences according to Duncan's Multiple Range test ($p < 0.05$)

CONCLUSION

The obtained results showed that the growing winter wheat as a monoculture influences the growth and productive abilities of the crop and it is not a good agricultural practice. If sown after itself for the second year there were no severe decreases of the vegetative, productive and qualitative parameters.

After the third year of mono-cropping the parameters evaluated as plant height before harvest, ear length, seed yield absolute, and hectoliter seed mass were severely decreased.

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