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Comparative study of a winter wheat variety and hybrid sown after different pre-crops on chernozem soil

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SUMMARY

Wheat production is a determining branch within Hungarian crop production (produced on nearly one million hectares). Weather anomalies caused by climatic change confirmed the importance of the biological background (variety, hybrid) in wheat production. The adapting ability and reaction of different wheat genotypes towards nutrient supply were studied in a long-term field experiment on chernozem soil type in the case of different pre-crops (sunflower and maize). According to the experimental results of the vegetation of 2017/2018, the yield of the variety Ingenio sown after the sunflower as previous crop ranged between 4168 and 8734 kg ha^{-1}, while in the case of maize as previous crop, this value ranged between 2084 and 7782kg ha^{-1}, depending on the applied nutrient supply level. The studied genotypes produced rather significant yield surplus as a response to the application of mineral fertilization (4.6–5.1 t ha^{-1} after sunflower and 5.7–6.3 t ha^{-1} after maize). Optimal mineral fertilizer dosage was determined by both the genotype and the pre-crop. N-optimum values of wheat genotypes was determined using regression analysis. In the case of the variety Ingenio sown after sunflower, the optimum range was $N_{144-150}$+PK, while after maize, it was $N_{123-150}$+PK, respectively. For the hybrid Hyland, these optimum ranges were $N_{114-120}$+PK, just as $N_{150-153}$+PK, resp. The application of optimal mineral fertilizer dosages improved water utilization of the studied wheat genotypes to a significant extent. WUE values of the control, unfertilized treatments ranged between 4.1–8.3 kg mm^{-1}, while in optimal fertilizer treatment, it ranged between 15.5 and 17.4 kg mm^{-1}.

Keywords: *wheat, variety, hybrid, pre-crops, fertilizer responses, WUE*

INTRODUCTION

The improvement of the genetic potential of winter wheat depends basically on the given genotype and the applied agronomic treatment (Threthowan et al., 2012). According to Lásztity et al. (1994) yield may be affected – in addition to the genetic properties of the crop – mainly by the nutrient and water supply level of the soil.

Variety, sowing area properties, cropping standards and technology are the main determining factors of nutrient requirement. Adequate nutrient supply and other production factors enable the production of potential yield of a given variety in a strong relationship (Koltay et al., 1982). Mengistu et al. (2010) found close correlation between genotype, environment and yield. Various winter wheat varieties showed different reactions towards different environmental conditions in their yield. Pepó and Csajbók (2014) studied the effect of different agrotechnical measurements on the yield of winter wheat on chernozem soil. In their study, it has been revealed that fertilization affected winter wheat yield increment by 50%, while crop rotation by 28%, plant protection by 16% and irrigation by 2%. According to Pepó (2002), winter wheat is one of the field crops with the highest nutrient demand and best nutrient reaction. Nitrogen nutrition is a limiting factor in winter wheat production and it greatly influences the available yield (Fodor et al., 2011). Pre-crops prove to be a significant yield determining factor of winter wheat. The nutrient and water use of the pre-crop, as well as the amount of nutrients mobilized or temporarily immobilized after the decomposition of pre-crop residues affect the utilization of applied mineral fertilizers to a significant extent. Soil nutrient supply level after pre-crops that are harvested late in the autumn, and that use high amount of water (such as maize or sugar-beet) is far lower than in the case of pre-crops harvested earlier. Furthermore, late pre-crops make the adequate execution of soil preparation management more difficult. The closer the harvest of the pre-crop is to the sowing time of the main crop, the more expressed the effect of the pre-crop is. According to Barabás (1987), the effect of the pre-crop is not that expressed in the case of crops sown in the spring period. Main pre-crops of winter wheat in Hungary are winter wheat and maize.

Wheat hybrids show better vitality, physiological activity and stress resistance in contrast to traditional varieties. As a result of the heterosis effect, wheat hybrids show higher yield potential. Furthermore, on fields with less favourable soil conditions that are prone to drought, the tolerance of hybrid wheat towards stress, as well as its yield stability is higher than in the case of traditional varieties. According to the results of experimental work executed in India, the production of wheat hybrids does not have any demand on higher production intensity than any other widespread wheat varieties – in contrast to the misconceptions (Matuschke et al., 2007). Some further results confirm that winter wheat hybrids show higher yield potential, however, their alfa-, beta and gamma gliadin content proved to be significantly lower (Buczek et al., 2016).

MATERIALS AND METHODS

Experimental setup parameters

The pre-crops studied in the experiment were sunflower and maize. The winter wheat variety Ingenio – which is an early variety with high milling quality –

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and the hybrid Hyland – a late-ripening hybrid with extraordinary vitality and highly standard yields over the different crop years – were involved in the experiment. On the 4th October 2017, winter wheat was sown using a Sulky sowing machine, applying the optimal plant number of the given variety and hybrid respectively.

Location and soil characteristics of the experimental site

The Látókép Experimetnal Site of the University of Debrecen, Research Institutes and Educational Farm is located on the loess plateau of the Hajdúság region, about 15 km far from the city of Debrecen along the main traffic road Nr. 33. The experimental land is flat. According to the soil's genetic properties, it can be classified as calcareous chernozem.

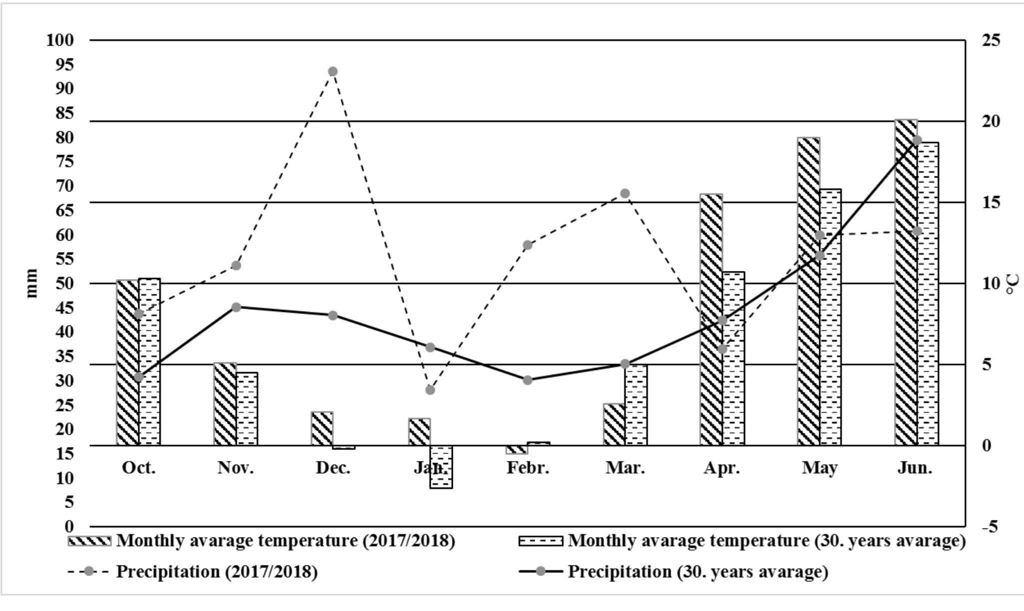
Regarding the soil's physical characters, it can be classified as a loamy soil, soil pH is close to neutral. Its phosphorous supply is medium, while its potassium supply is rather medium-good. Soil humus content is medium, the humus layer is about 80 cm.

Regarding soil water management characters and the data published by Várallyay, the experimental soil can be classified into the 4th water management group, which means medium water infiltration rate. Disponible water rate is 50% of the soil water capacity. Soil water level is at 3–5 m depth and it does not rise above 2 m even in wet crop years.

Weather conditions of the experimental crop year

Generative and vegetative development of winter wheat is basically determined by the amount and distribution of natural precipitation. In general, weather conditions of the crop year 2017/2018 can be considered as unfavorable (*Figure 1*). Mild autumn days and continuously chilling wet weather affected the emerging and early development of wither wheat positively. February and March were colder than the average, these months affected plant development in a negative way. In the vegetative development phase of wheat, warm April and May were unfavorable as well and decreased the length of each phenological phase. The ripening phase occurred 1.5–2 weeks earlier than expected usually.

Figure 1: **Meteorological data of the vegetation period (Debrecen-Látókép, 2018)**



The long-term experiment was set up in the autumn of 1983. The field experiment was set up in four replications in a split row design. The applied mineral fertilizer dosages are shown in the Table below (*Table 1).*

Experimental studies were carried out on plots with average plant protection management treatments, as shown in the Table below (*Table 2).*

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Table 1

Mineral fertilizer treatments applied in the experiment (Debrecen-Látókép, 2018)

Treatment	N	P_2O_5	K_2O
	kg ha^{-1}		
0	0	0	0
1	30	22.5	26.5
2	60	45	53
3	90	67.5	79.5
4	120	90	106
5	150	112.5	132.5

Table 2

The average plant protection management technology applied in the experiment (Debrecen-Látókép, 2018)

Plant protection measurements	Time of application	Amount and denomination of applied pesticides
Fungicide treatments	27th April 2018.	Falcon Pro 0.8 l/ha
	11th May 2018.	Falcon Pro 1.0 l/ha
Herbicide treatment	14th April 2018.	Sekator OD 0.15 l/ha
Insecticide treatment	11th May 2018.	Biscaya 0.3 l/ha

RESULTS AND DISCUSSION

When evaluating the results of the crop year 2017/2018 (*Table 3*), it can be stated that the lowest yield was obtained in the control treatment plots of the Ingenio wheat variety with maize as pre-crop. The hybrid wheat Hyland produced 18% higher yield regarding the yield results of the control treatments. The studied variety and hybrid produced almost the same yields after the pre-crop maize which refers to the fact that soil natural nutrient content is lower and can be utilized harder. Highest yield in the case of the control treatment combinations (1097 kg ha^{-1}) was measured in the case of the Ingenio variety sown after the pre-crop sunflower, which was 35% higher than the yield of the hybrid Hyland.

According to our results of the crop year 2018, the highest yield was produced in the case of the treatment combination of the variety Ingenio, at a nutrient supply level of N_{150}+PK, which showed a yield surplus of 4566 kg ha^{-1} in contrast to the untreated control plots. However, the hybrid Hyland produced maximum yield in the case of the – less favorable – pre-crop maize and at a nutrient supply level of N_{150}+PK, resulting in 6302 kg ha^{-1} yield surplus above the yield of untreated control plots. This genotype produced maximum yield (8658 kg ha^{-1}) after the pre-crop sunflower at a nutrient supply level of N_{120}+ PK regarding all studied genotypes.

Significant differences were found in the case of the variety Ingenio between the yield results of the control treatment and the N_{60}+PK, N_{90}+PK, N_{120}+PK, similarly to the N_{150}+PK nutrient supply treatments. This finding confirms that increasing nutrient dosages result in significant yield increment. Studying the variety Ingenio after the pre-crop maize, significant yield increment was measured as response to increasing nutrient amount application in contrast to the control treatment result.

According to the results of our study, it can be stated that significant difference was found in the case of the hybrid Hyland and the pre-crop sunflower between the yield results treated with increasing nutrient levels and the untreated control plot yield results. After the pre-crop maize, the yield result of the control plot showed also significant differences – except for the nutrient supply level N_{30}+PK.

Analyzing the yield result of both unfavorable pre-crops, significant difference was found between the average yields of the variety Ingenio and hybrid Hyland. In both cases, sunflower proved to be a more favorable pre-crop.

Analyzing the nutrient optimum of the variety and the hybrid using regression analysis (*Figure 2*), it can be stated that, on the studied experimental soil type, the optimum NPK level of the variety Ingenio after the pre-crop sunflower was N_{177}+PK nutrient supply level, while in the case of maize as previous crop, this value was N_{195}+PK nutrient supply level respectively. In the case of the hybrid Hyland and the pre-crop sunflower, the highest yield was produced in the case of the application of the lower nutrient supply level of N_{153}+PK. In the case of maize as pre-crop which is considered to be unfavorable, the hybrid wheat produced its maximum yield (8660 kg ha^{-1}) at a nutrient supply level of N_{150}+PK.

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Table 3

The effect of mineral fertilization on the yield of the variety Ingenio and the hybrid Hyland (kg ha^{-1}) in the case of different pre-crops (Debrecen, 2018)

Genotype	Sunflower	Ingenio		Maize	Ingenio		Sunflower	Hyland		Maize	Hyland	
Nutrient supply	Yield kg ha^{-1}	Yield kg	%	Yield kg ha^{-1}	Yield difference kg ha^{-1}	%	Yield kg ha^{-1}	Yield difference kg ha^{-1}	%	Yield kg ha^{-1}	Yield difference kg ha^{-1}	%
Control	4168	0	100	2084	0	100	3071	0	100	2458	0	100
N_{30}+PK	5158	990	123	4226	2142	203	5470	2399	78	3743	1285	152
N_{60}+PK	6407	2239	153	5467	3383	262	6972	3901	227	4896	2438	199
N_{90}+PK	7448	3280	178	7203	5119	346	8017	4946	261	6650	4192	271
N_{120}+PK	8207	4039	196	7690	5606	369	8658	5587	282	8644	6186	352
N_{150}+PK	8734	4566	209	7782	5698	373	8206	5135	267	8760	6302	356
Average	6687	-		5742	-		6732	-		5859	-	
$LSD_{5\%}$ Variety	883											
$LSD_{5\%}$ Nutrient-supply	1391											
$LSD_{5\%}$ Pre-crop	883											

Figure 2: **Analysis of the reaction of the studied winter wheat variety towards nutrient supply (Debrecen, 2017/2018)**

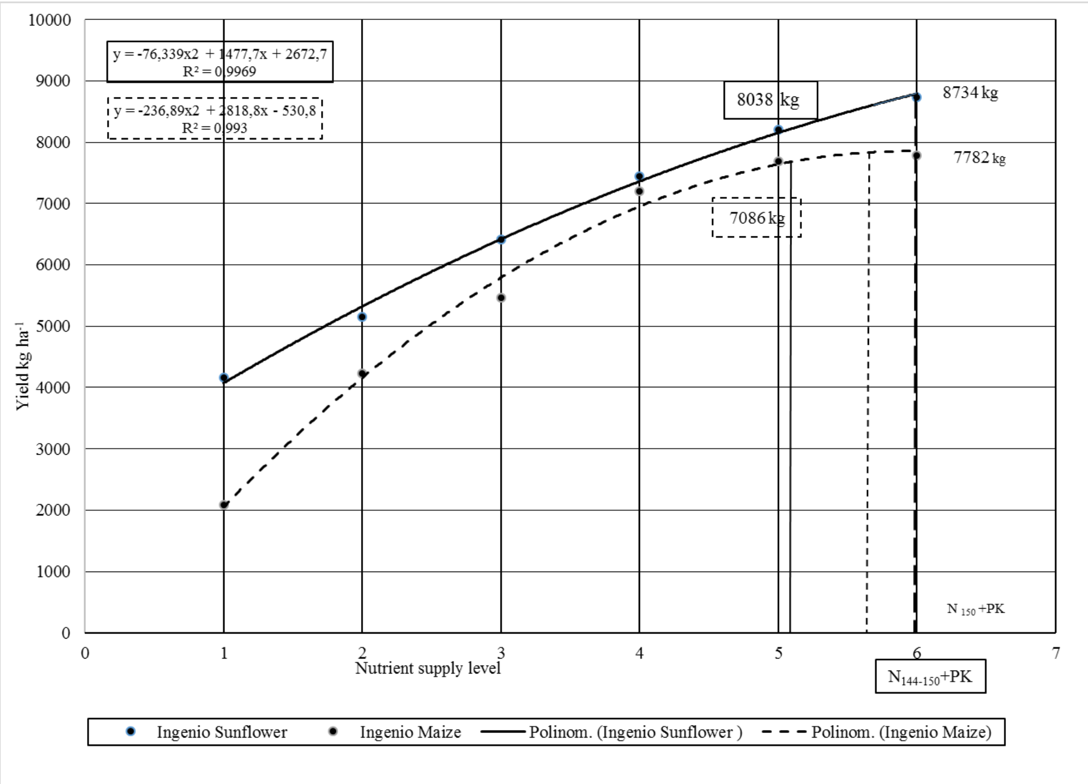

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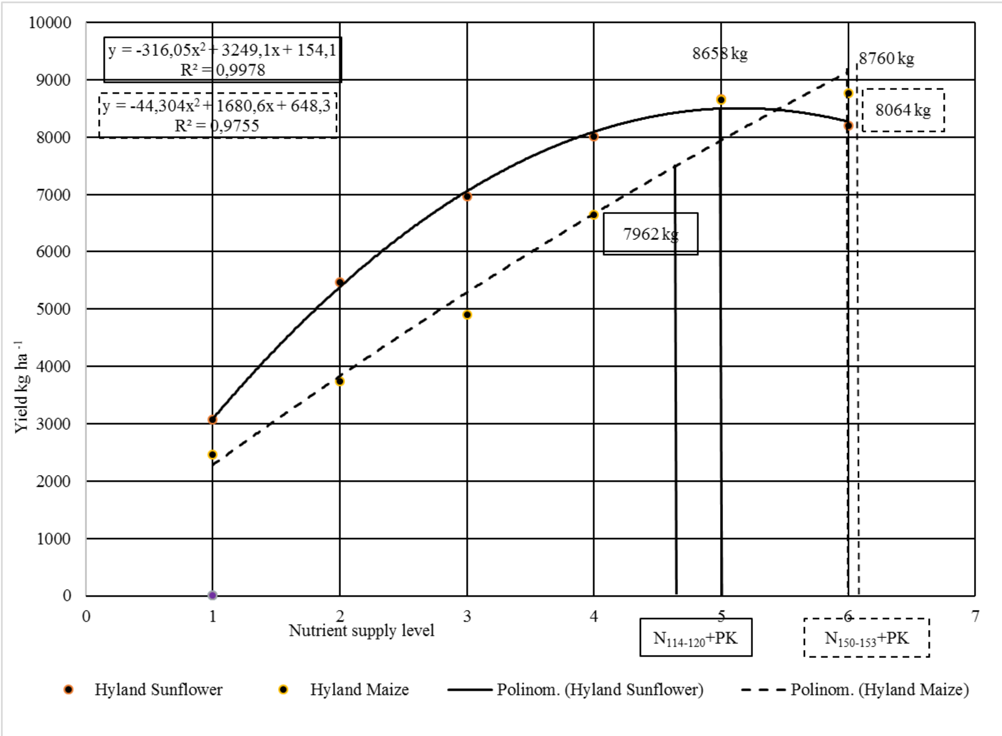
Figure 3: **Analysis of the reaction of the studied winter wheat hybrid towards nutrient supply (Debrecen-Látókép, 2018)**



The optimum interval of mineral fertilizer dosage was determined by deducing half of the $LSD_{5\%}$ nutrient value from the maximum yield. Optimum mineral fertilizer dosages proved to be different in the case of the two studied genotypes. According to these results, it has been stated that, in the case of the variety Ingenio sown after the pre-crop sunflower, the optimal mineral fertilizer interval was $N_{144-150}$+PK, while in the case of maize as a pre-crop, the optimum interval was $N_{123-150}$+PK, respectively.

In the case of the winter wheat Hyland, the optimal mineral fertilizer dosage interval was $N_{114-120}$+PK for the pre-crop sunflower, while for the pre-crop maize it was $N_{150-153}$+PK (*Figures 2 and 3*).

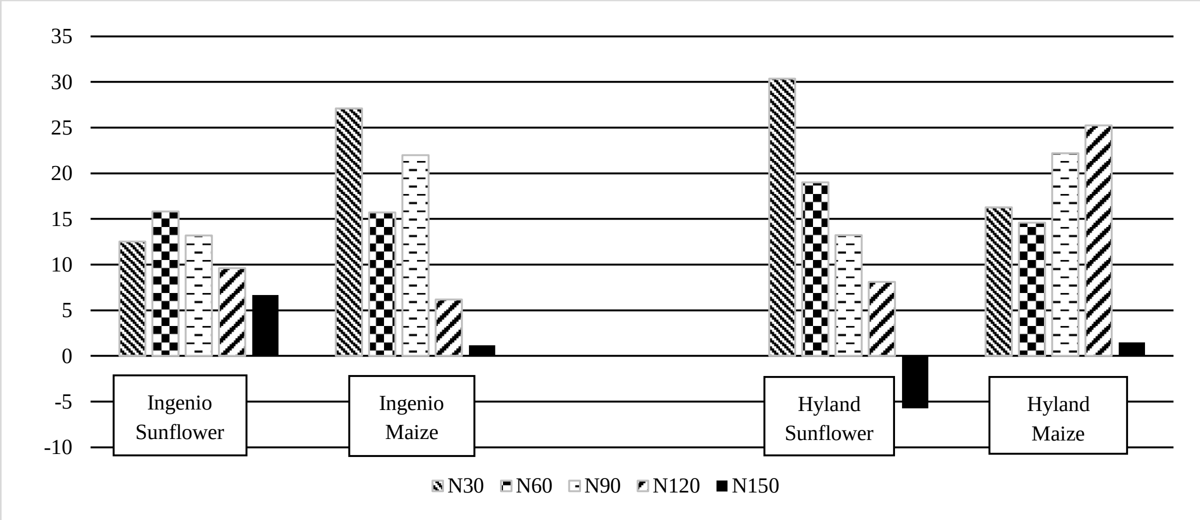
In the crop year 2018, the nutrient reaction of genotypes was analyzed also from the aspect of yield increment by means of each supplied kg of NPK mineral fertilizer active substance (*Figure 4*). It can be stated that, in the case of the studied variety sown after the pre-crop maize, the highest yield increment was observed in the case of the application of the nutrient level N_{30}+PK (27.11 kg ha^{-1}). When applying higher nutrient dosages, high yield increment was observed in the case of the application of the nutrient supply level N_{90}+PK as well. By increasing the applied mineral fertilizer amount, the yield surplus per 1 kg NPK fertilizer active substance showed significant decrease (1.16 kg ha^{-1}).

The winter wheat variety Ingenio sown after the pre-crop sunflower showed the highest yield increment – in contrast to the pre-crop maize – to a lower extent at a nutrient supply level of N_{60}+PK. Increasing the applied nutrient dosages resulted in the continuous decrement of yield surplus.

The winter wheat hybrid in the case of sunflower as a pre-crop produced extreme yield increment maximum (30.37 kg ha^{-1}) in the case of the application of the nutrient dosage N_{30}+PK. Any higher nutrient supply level applied resulted in strong decrement. In the case of the application of the nutrient supply level N_{150}+PK, even yield depression could be observed. In contrast, in the case of the hybrid sown after the pre-crop maize, nutrient supply was optimal until the application of the supply level of N_{120}+PK, the hybrid showed better nutrient utilization that the variety. Increasing the applied nutrient supply level with further 30 kg ha^{-1} resulted in drastic, 95% yield decrement rate.

https://doi.org/10.34101/actaagrar/1/2373

Figure 4: **Relative yield surplus resulted by mineral fertilization (kg/1kg NPK) in case of different wheat genotypes and pre-crops (Debrecen-Látókép, 2018)**



From the aspect of water utilization, yields per 1 mm precipitation were analyzed in the case of the control and optimum nutrient supply levels (*Table 4*).

In the case of the untreated plots, the lowest values were calculated for both the studied hybrid and the variety for the pre-crop maize: calculated values ranged between 4.1 and 4.9 kg mm^{-1} in the case of the pre-crop sunflower, the yield per 1 mm precipitation on the control treatment was 8.3 kg ha^{-1} for the variety Ingenio and 6.1 kg ha^{-1} for the hybrid Hyland.

Regarding the optimal nutrient supply levels, no significant difference was found between the yield maximum values per 1 mm precipitation. In the case of the sunflower and maize pre-crops, the variety Ingenio produced maximum yield at a nutrient supply level of N_{150}+PK. In contrast, the hybrid Hyland produced the highest yield per 1 mm precipitation at a nutrient supply level of N_{120}+PK for the pre-crop sunflower, while for the pre-crop maize, the maximum value was observed in the case of the nutrient supply level N_{150}+PK.

Table 4

Water use efficiency of winter wheat genotypes (WUE=kg yield /1mm precipitation) (Debrecen, 2018)

Nutrient supply level	Ingenio	Ingenio	Hyland	Hyland
Control	8.3	4.1	6.1	4.9
NPK	Sunflower	Maize	Sunflower	Maize
Optimum	17.4	15.5	17.2	17.4

CONCLUSION

Based on the evaluation of our experimental results, it can be stated that, in the case of the control treatment and the pre-crop maize, both the studied variety and the hybrid produced lower yields. However, in contrast to the variety, the hybrid showed 0.374 kg ha^{-1} higher yields under similar experimental conditions. According to our results, it can be stated that the pre-crop maize is less favorable as it uses the natural soil nutrient stock to a higher extent.

In the case of the pre-crop sunflower, no significant difference was revealed between the yield results of the studied winter wheat variety and hybrid resp. Ingenio winter wheat variety produced higher yields in the control treatment due to its better nutrient utilization ability. The winter wheat hybrid Hyland sown after the pre-crop maize and sunflower produced higher yields on plots with different nitrogen fertilizer treatments due to its vitality and stronger, more viable root system. In the case of sunflower as pre-crop, the hybrid produced maximum yield surplus in the case of the application of lower nutrient supply level (N_{120}+PK) – in contrast to the variety Ingenio. Under less favorable circumstances – in contrast to the expectations – the wheat hybrid sown after maize as pre-crop produced maximum yield surplus (6302 kg ha^{-1}) at the nutrient supply level of N_{150}+PK compared to the control treatment.

When evaluating the results of the vegetation 2017/2018, it has been stated that, in the case of sunflower as pre-crop and the control treatment, both wheat genotypes produced higher yields using lower

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amount of precipitation. Furthermore, no significant difference could be revealed between the studied pre-crops regarding the yield produced per 1 mm precipitation.

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REFERENCES

Barabás, Z. (1987): A búzatermesztés kézikönyve. Mezőgazdasági Kiadó. Budapest.

Buczek, J.–Jarecki, W.–Bobrecka-Jamro, D. (2016): The response of population and hybrid wheat to selected agro-environmental

Koltay, Á.–Balla L. (1982): Búzatermesztés és- nemesítés. Mezőgazdasági Kiadó. Budapest. 349-350.

Fodor, L.–Bélteki, I.–Szegedi, L. (2011): Nitrogen uptake and nitrogen content of winter wheat grown on heavy metal amended soil. Crop Production. 60.Supp. 231-249.

Lásztity, B.–Csathó P. (1994): A tartós NPK műtrágyázás hatásának vizsgálata búza kukorica dikultúrában. Növénytermelés. 43. 2. 157-167.

Matuschke, I.–Ritesh, R. M.–Qaim, M. (2007): Adaption and impact of winter what in India. World Development. 35. 8. 1422-1435.

Mengistu, N.–Baenziger, S.–Nelson, L. A.–Eskridge, K. M.–Klein, R. N.–Baltensperger, D. D.–Elmore, R. W. (2010): Grain yield performance and stability of cultivar blends vs. component cultivars of hard winter wheat in Nebraska. Crop Science. 50. 2. 617-623.

Pepó, P.–Csajbók, J. (2014): Az agrotechnikai elemek szerepe az őszi búza (Triticum aestivum L.) termesztésében. Növénytermelés. 63. 3. 73-94.

Pepó, P. (2002): Őszibúza-fajták trágyareakciója eltérő évjáratokban. Növénytermelés. 51. 2. 189-198.

Threthowan, R.–Mahmood, T.–Zulfiqar, A.–Oldach, H. K. (2012): Breeding wheat cultivars better adapted to conservation agriculture. Field Crops Research.132.76-83.

http://www.ksh.hu/docs/hun/xstadat/xstadat_eves/i_omn001b.html