Effect of weeds on the water and nutrient cycle of soil
Final Report

1) Influence of long-term fertilization on the weediness and weed flora composition in maize

Investigations on weed diversity and weed-weed relationships in maize fields in terms of nutrient supplies could help to understand the competition processes for water, space and nutrient better, and as a result contribute to the development of a more effective weed control technology.

Materials and Methods

The effect of different nutrient supplies on weediness, weed flora composition of maize was studied in a long-term fertilization experiment set up in 2003 on a Calcaric Phaeosem soil (FAO) at Nagyhörcsök, Hungary. The investigated nutrient treatments were as follows: NPK (150 kg $N \cdot ha^{-1}$, 100 kg $P_2O_5 \cdot ha^{-1}$, 100 kg $K_2O \cdot ha^{-1}$) and control (without fertilization). The survey was carried out in three consecutive years, at the 2-4 leaf stage (BBCH 13) of maize. The maize was sown during the experimental years between 23rd of April and 4th of May.
At the time of sampling (04.06.2013, 03.06.2014, and 09.06.2015), weeds were collected from 1 m^2 of herbicide-free (weedy) plots with three replications in 2013, 2015, and with six replications in 2014, and then classified to species. The composition of weed flora was described by the density, frequency, and the order of dominance of species. The dominance was determined by the Berger-Parker index. The temperature and precipitation values of the interval between sowing and sampling times are shown in *Figure 1*. The experimental data were statistically analysed with analysis of variance by MStat software.

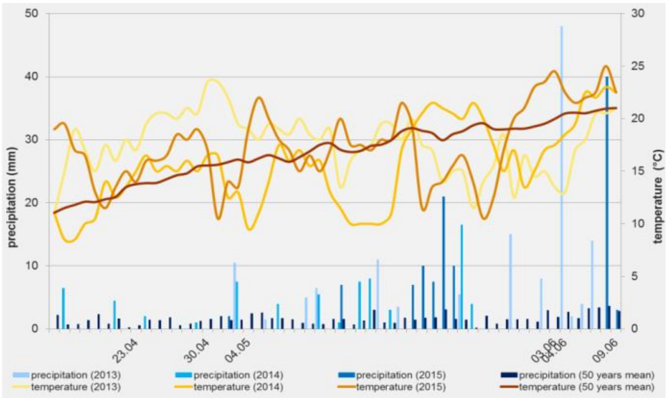

Figure 1 *Daily mean precipitation sum (mm) and daily mean temperature (°C) during the investigated period and the 50 years' average values for the same period, Nagyhörcsök*

Results

At the time of the weed surveys, altogether 17 weed species were present on the herbicide free sample areas. Two species, *Ambrosia artemisiifolia* L. and *Datura stramonium* L. occured on most plots. Remarkable differences were observed in the dominance of species depending on the treatments (*Table 1*). Based on the summarized data of the three years *A. artemisiifolia* (69.7%) and *Sorghum halepense* (L.) Pers. (17.9%) were the most dominant species in control plots. However, both species took a lower rank order under NPK treatment because nitrophilous species, such as *Chenopodium album* L. (70.0%) and *D. stramonium* (12.4%), took their place at the first two rank orders.
The total weed density was between 106.0 and 121.6 plant$\cdot m^{-2}$ in control treatment (*Photo 1*). Significant statistical difference could not be found among the three years. By contrast, the total weed density varied between 126.7 and 1044.9 plant m^{-2} in NPK treatment. In the third year the spread of the *C. album* showed a high increase, and as a result the total density grew sevenfold, it was significantly more than the previous two years (*Photo 2*).

Photo 1 and 2 *Weeds in the control (left) and NPK (right) treatment*

Table 1 *Order of dominance (OD) and dominance index (DI) of the weed species in the different treatments (Ø, NPK) based on the average of three years' sampling data (n=12)*

Weed species	EPPO code	Control		NPK	
		OD	DI	OD	DI
Ambrosia artemisiifolia L.	AMBEL	1.	0.697	3.	0.041
Sorghum halepense (L.) Pers.	SORHA	2.	0.179	6.	0.018
Datura stramonium L.	DATST	3.	0.043	2.	0.124
Fallopia convolvulus (L.) A. Löve	FALCO	4.	0.022	7.	0.016
Chenopodium album L.	CHEAL	5.	0.017	1.	0.700
Helianthus annuus L.	HELAN	6.	0.008	12.	0.003
Solanum nigrum L.	SOLNI	7.	0.008	10.	0.006
Stachys annua L.	STAAN	8.	0.006	15.	0.001
Hibiscus trionum L.	HIBTR	9.	0.006	16.	0.001
Convolvulus arvensis L.	CONAR	10.	0.003	14.	0.002
Heliotropium europaeum L.	HELEU	11.	0.003	11.	0.005
Amaranthus hybridus L.	AMACH	12.	0.002	8.	0.015
Setaria pumila (Poir.) Schult.	SETPU	13.	0.002	13.	0.002
Chenopodium hybridum L.	CHEHY	14.	0.002	4.	0.036
Ajuga chamaepitys (L.) Schreb.	AJUCH	15.	0.001	17.	-
Amaranthus blitoides S. Watson	AMABL	16.	-	5.	0.024
Echinochloa crus-galli (L.) P. B.	ECHCG	17.	-	9.	0.007
Total			1.000		1.000

Figure 2-3-4 show the density of the eight most dominant species and the total density of weeds in the three studied years. Significant differences were found in density of *C. album*, *A. artemisiifolia*, *D. stramonium*, *S. halepense,* and *Chenopodium hybridum* L. between the treatments. *A. artemisiifolia* and *S. halepense* preferred the unfertilized conditions, while the other three species had higher abundance with NPK treatment. In the control, density of *A. artemisiifolia* increased significantly, while *S. halepense* decreased. The density of *Fallopia convolvulus* (L.) A. Löve has also been significantly increased. In the third year the number of *C. album* showed a sudden increase: while the number of individuals was 89.6 plant m^{-2} in the first two years (2013-2014), then it peaked at nearly 1,000 plant m^{-2} in 2015.

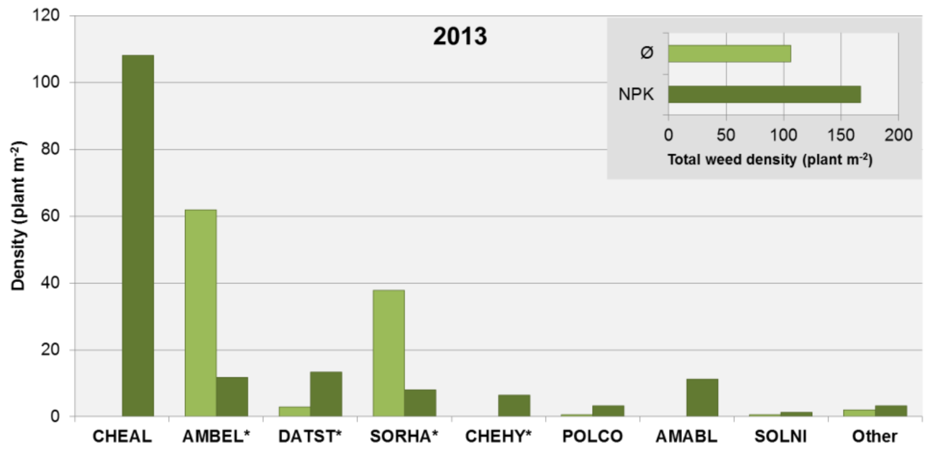

Figure 2 *Density of each weed species and total weed density (plant·m^{-2}) in different treatments (Ø, NPK) on 4th June 2013 (n=3).* Note: ** significant differences (p<0.05) between treatments.*

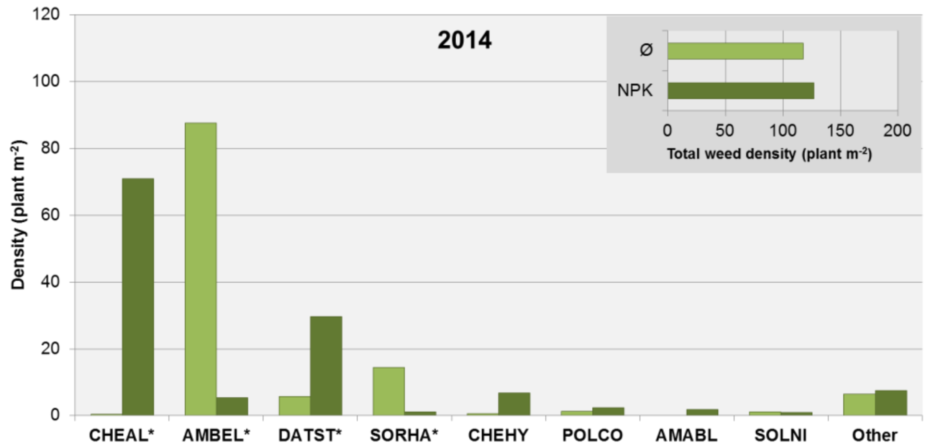

Figure 3 *Density of each weed species and total weed density (plant·m^{-2}) in different treatments (Ø, NPK) on 3rd June 2014 (n=6).* Note: ** significant differences (p<0.05) between treatments.*

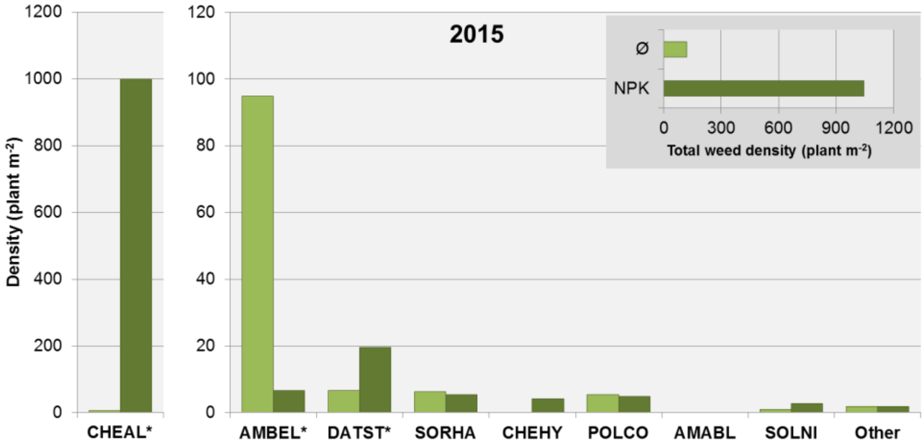

Figure 4 *Density of each weed species and total weed density (plant·m^{-2}) in different treatments (Ø, NPK) on 9th June 2015 (n=3).* Note*: * significant differences (p<0.05) between treatments.*

Conclusions

According to the results of the weed surveys following can be concluded:

In the 2014 experimental year, the number of species occurred both in control and NPK was greater than in the other two years (2013, 2015).

The similar order of dominance between weeds in either control or NPK treatment indicates different nutritional demands of the weed species. The most dominant weed species of the control were *Ambrosia artemisiifolia* and *Sorghum halepense,* and of the NPK treatment were *Chenopodium album* and *Datura stramonium*.

In all three experimental years the effect of treatments on the density of *A. artemisiifolia, C. album,* and *D. stramonium* was clearly manifested. Due to the good nutrient supply there was a significant increase in the density of *C. album* and *D. stramonium,* and an opposite tendency was found for *A. artemisiifolia*.

Outstanding seed production of *C. album* can provide an advantage for competition with other species. It seems to be justified by the high increase of its density in 2015.

Our results of density of weeds demonstrate that the competitiveness of *A. artemisiifolia* is very good under limited nutrient resources, however, in the NPK treatment, *A. artemisiifolia* was a weak competitor, and *C. album* and *D. stramonium* were stronger. The dominance of *A. artemisiifolia* in the control is almost the same as it of *C. album* in the NPK treatment.

Related publications

Lehoczky É, Kamuti M, Mazsu N, Radimszky L, Sándor R: Composition, density and dominance of weeds in maize at different nutrient supply levels. *Növénytermelés* 63: (Suppl.) 287-290, 2014

Lehoczky É, Kamuti M, Mazsu N, Tamás J, Sáringer-Kenyeres D, Gólya G: Influence of NPK fertilization on weed flora in maize filed, *Agrokémia és Talajtan* 63: (1) 139-148, 2014

Lehoczky É., Gólya G., Tamás J., Németh T.: Biodiversity and biomass production of weeds in a long-term fertilization experiment, *Communications in Soil Science and Plant Analysis* 46:(1) pp. 390-398., 2015

Riczu P, Nagy A, Lehoczky É, Tamás J: Precision Weed Detection Using Terrestrial Laser Scanning Techniques, *Communications in Soil Science and Plant Analysis* 46:(1) pp. 309-316., 2015

Lehoczky É., Kamuti M., Mazsu N., Csathó P.: Gyomosodás és gyomflóra összetétel vizsgálatok mezőföldi trágyázási tartamkísérletben. *Növénytermelés* 65 (3): 19-30. 2016

Mazsu N., Kamuti M., Sándor R., Szentes D., Lehoczky É.: Gyomflóra és biomassza produkció vizsgálatok trágyázási tartamkísérletben a kukorica korai fenológiai stádiumában*. Agrokémia és Talajtan* 66 (1): 131-148., 2017

Mazsu N., Kamuti M., Sándor R., Csathó P., Lehoczky É.: Gyomflóra és biomassza produkció vizsgálatok a kukorica korai fenológiai stádiumában trágyázási tartamkísérletben. In: Kátai J. és Sándor Zs. (szerk.) *Talajvédelem Különszám*, Okszerű talajhasználat – Talajvédelem, Talajvédelmi Alapítvány, Debrecen. pp. 421-430., 2017

Mazsu, N.,Szentes, D., Szabó, A., Gedeon, Cs., Lehoczky, É.: Influence of long-term fertilization on weed flora diversity in maize cultivation. *International Conference on Long-Term Field Experiments,* 27-28. September 2017. Nyíregyháza, Hungary. Proceedings of Abstracts, p. 29.

2) Soil moisture changes in maize - weed vegetation, in a long-term fertilization experiment

Soil moisture is often used as an indicator of water limitation in dryland agro-ecosystems, as it controls several important chemical and biological processes. Therefore, the questions of water availability and weed-crop interactions were addressed to the field experiment for predicting the impacts of changes in soil moisture and nutrient supply.

Materials and methods

Investigations were carried out in a long-term (launched in 2003) fertilization field experiment with maize monoculture on a calcareous loamy chernozem soil at Nagyhörcsök between 2013 and 2015. Two different treatments were examined: Control and NPK (N:150 kg N $\cdot ha^{-1} \cdot yr^{-1}$; P:100 kg $P_2O_5 \cdot ha^{-1} \cdot yr^{-1}$; K:100 kg $K_2O \cdot ha^{-1} \cdot yr^{-1}$) (*Fig. 5*).

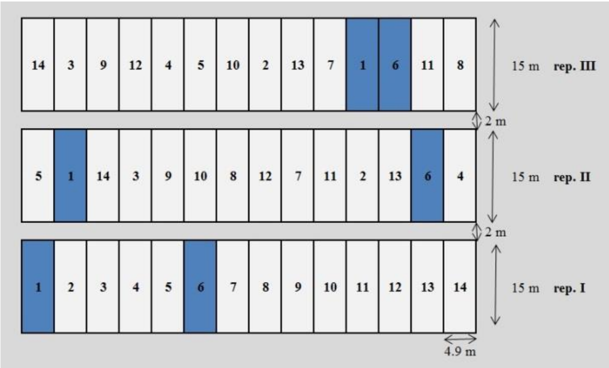

Photo 1
IMKO TRIME-FM3 soil moisture measuring device

Figure 5 Experimental design and investigated treatments: control (No. 1) and NPK (No. 6)

Photo 2 and 3
Weeds in control (above) and NPK (below) treatments at 6-8 leaf stage of maize

Volumetric soil water content (SWC) was measured under weed-free maize monoculture in three replications and weed-maize combined cells in six replications using an IMKO TRIME-3FM device (*Photo 1*) which is a time domain reflectometry (TDR) based system. The SWC of the 0-80 cm soil profile was recorded with 10 cm resolution, in every second week between sowing and harvesting. Simultaneously, weed, weedy and weed-free maize samples were taken at four different phenological stages of maize: BBCH 13, 17, 63 and 89 (*Photo 2 and 3*). The harvested aboveground biomass values (each from a 1 m^2 area) were measured (fresh and dry weight). Meteorological conditions also were recorded during the period of investigation. The Pálfai aridity index was calculated (*Fig. 6*) using the measured long-term (1967–2016) daily meteorological database.

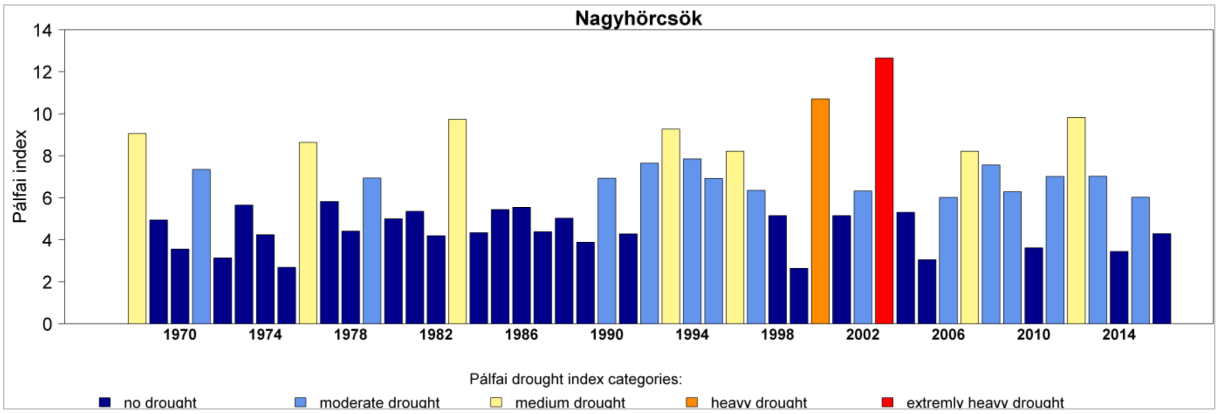

Figure 6 Temporal changes of Pálfai drought index at Nagyhörcsök (Hungary) between 1968 and 2016.

Results

Figure 7 illustrates the vertical change of SWC during the vegetation period, which varied most in the 0-50 cm depth layer.

The progress of the phenological phases increase the differences in SWC changes under weedy and weed-free plots at both control and NPK treatments.

SWC were significantly lower under weedy maize plots than under weed-free maize parcels at control and NPK treatments either.

The highest difference was observed in 2015, whilst the lowest in 2014 due to the inter-annual heterogeneity of meteorological conditions. 2014 was a rainy year without drought and heat wave periods, whereas 2015 was an arid year, similar to 2013 (see in *Fig. 6*).

Arid conditions reflected on the amount of precipitation and the length of the heat wave periods during the vegetation season. The amount of harvested aboveground biomass and the degree of plant cover were influenced by nutrition treatments, which had an effect on the vertical distribution of SWC (*Fig. 8*).

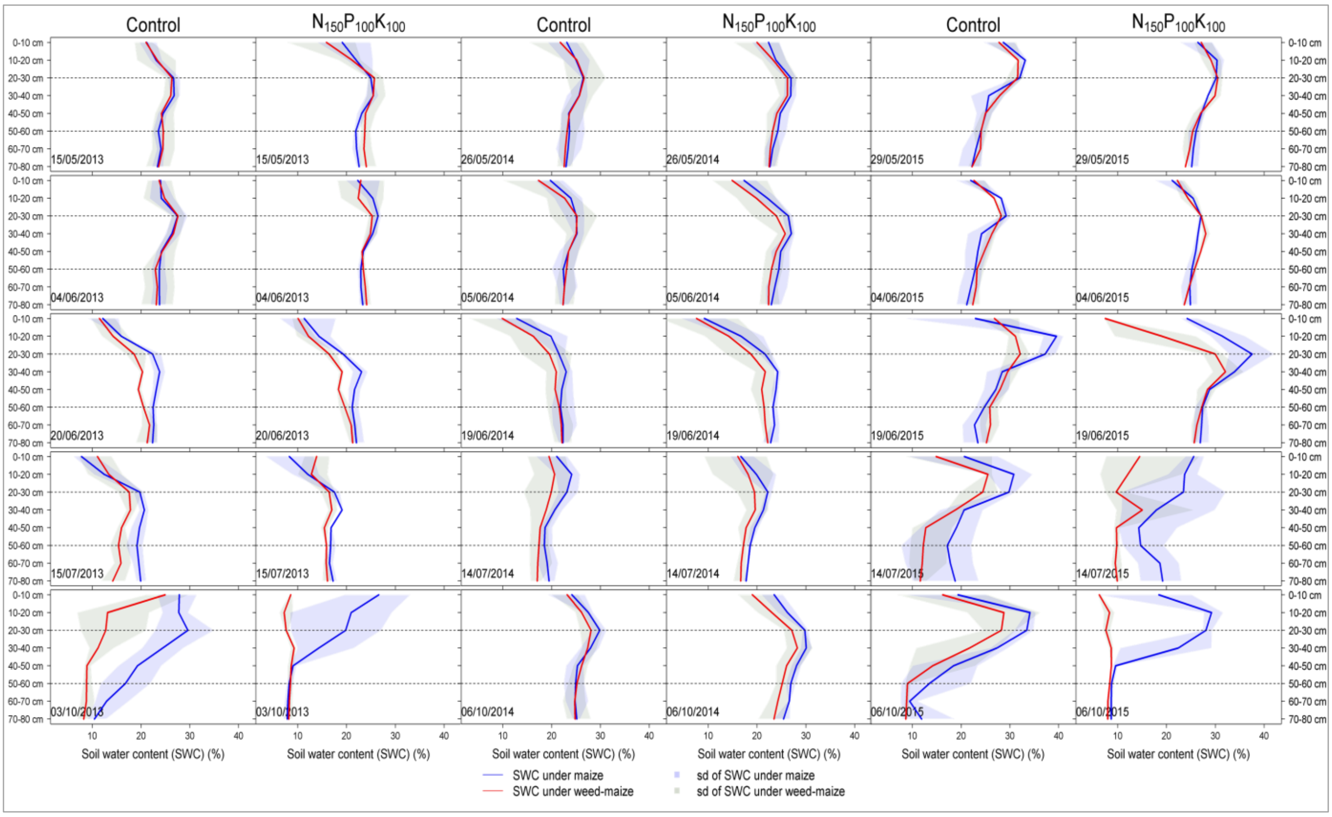

Figure 7 Volumetric soil water content (SWC, %) changes under maize and weed-maize vegetation along the soil profile (0–80 cm) with their standard deviation at the different fertilization treatments in the growing season between 2013 and 2015.

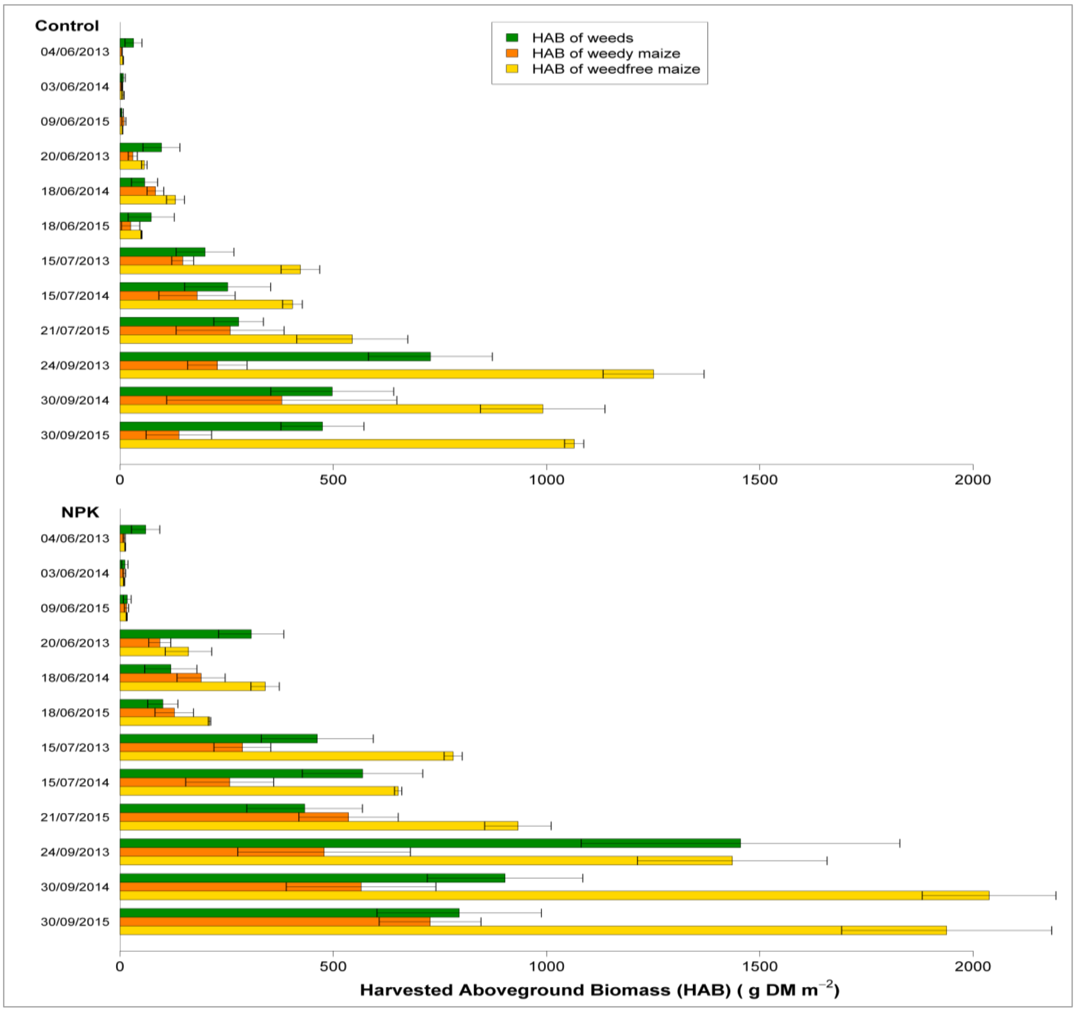

Figure 8 Harvested Aboveground Biomass (g DM·m^{-2}) of maize, weedy maize and weeds for investigated treatments in 2013-2015 (Bars are the standard deviations).

Conclusions

Competition for soil water stocks was increased in arid years (2013 and 2015) when the water stress periods reduced both crop and weed biomass production.

There was no significant difference in SWC under maize and maize-weed vegetation in a semiarid year (2014).

Control treatments showed less sensitivity to heat waves than NPK fertilized plots, owing to lower transpiration of its biomass production.

The outcome of competition for water resources depends on the relative abilities of weed and crop vegetation to tolerate soil water deficit periods.

These findings of the long-term fertilization experiment suggest the availability of water resources is the main limiting factor of plant growth. Maize production has been facing with an increasing challenge for water resources where weeds play an important role.

Related publications

Lehoczky, É., Kamuti, M., Mazsu, N., Sándor R. Changes to soil water content and biomass yield under combined maize and maize-weed vegetation with different fertilization treatments in loam soil. *Journal of Hydrology and Hydromechanics* 64:(2) 150-159., 2016

Kamuti M., Sándor R., Mazsu N., Lehoczky É.: A talajnedvesség vertikális eloszlásának vizsgálata a gyomosodással összefüggésben. In: Kátai et al. (szerk.) *Talajtani Vándorgyűlés.* Debrecen, 2016. szeptember 1-3. Összefoglalók, p. 77., 2016

Lehoczky, É., Mazsu, N., Sándor, R.: Soil moisture changes in a long-term fertilization experiment under maize and maize - weed vegetation. *International Conference on Long-Term Field Experiments,* 27-28. September 2017. Nyíregyháza, Hungary. Proceedings of Abstracts, p. 30.

3) The post effect of weediness on the following crop and soil moisture, Martonvásár 2017

Preliminary results

The study area of the project was relocated to the long-term fertilization experiment at Martonvásár in 2016. This experiment provided facilities to investigate the effect of organic manure. Twenty 7.7 × 12m (92.4 m2) randomly blocked plots were designed of which half have been herbicide-free from 2013, for the weed and crop survey. This experiment has been used for wheat and maize cultivation in rotation (2 years wheat, 2 years maize) since 1956. The dates of the weed species and maize survey were adjusted considering the four phenological stages of maize: 2-4 leaves stage (BBCH 12-14); 6-8 leaves stage (BBCH 16-18); flowering (BBCH 63); ripening (BBCH 89).

The study distinguished five treatments: 1. control; 2. 40t·ha^{-1} farmyard manure (FYM); 3. NPK fertilization corresponding with the active substance of the 2nd treatment; 4. 80t·ha^{-1} farmyard manure (FYM); 5. NPK fertilization corresponding with the active substance of the 4th treatment, in four repetitions.

The effects of fertilization treatments on weeds and maize, maize-weed competition and soil moisture content were studied in the previous cropping year (in 2016). There was significant amount of weed biomass in the weedy areas (without herbicides) in 2016. Then, in 2017, we investigated the effect of these conditions on soil moisture content and growth parameters of maize, such as dry and fresh biomass weight of shoots, leaf area, stem length and grain yield.

The *Figure 9* and *10* show the available results of data analysis. Other important components - grain yield, nutrient uptake of maize and soil moisture content will be analysed and evaluated later.

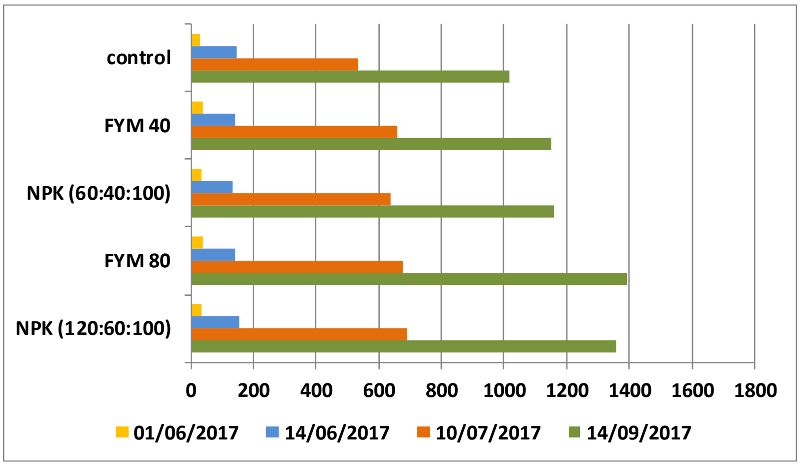

Figure 9 Dry biomass weight of maize on the previously year weedy plots

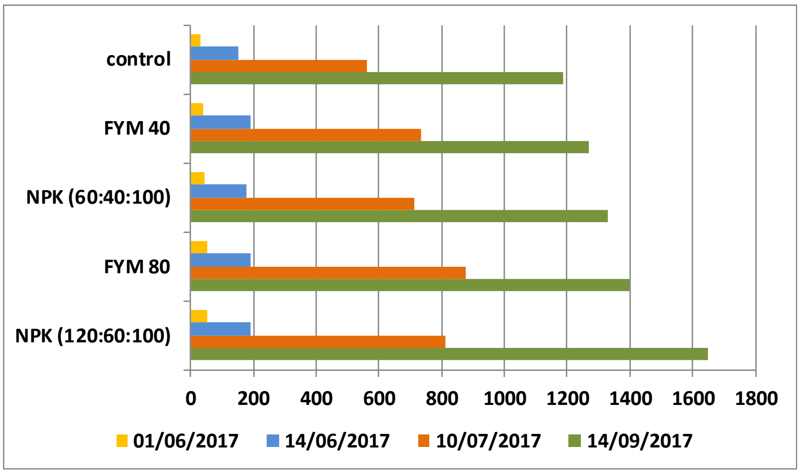

Figure 10 Dry biomass weight of maize on the previously year weed free plots

The preliminary results show that shoot biomass of maize within the average of fertilization treatments in previously weedy areas was lower than in the weed free plots. On the plots, which were weed free in previous year maize produced more shoot biomass (11-27%) than on weedy ones. The difference was higher at the beginning of the growing season (23-27%) and decreased to 11% by the end.
It can be concluded that the weediness of the precrop could have a significant effect on the growth and biomass production of maize in the next year. Detailed analysis of experimental results and main influencing factors are in process.