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EFFECTS OF FOLIAR FERTILISATION IN THE PRODUCTION OF HYBRID SEED MAIZE

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Abstract

Maize is one of the most widely cultivated crops across the world due to its high importance in animal feeding, human nutrition, and many industrial processes. Fertilization is a key component of any crop production system and it is one of the technological elements where improvement is always searched. Foliar fertilization is an effective way to treat nutrient deficiency, to improve plant nutrition status and to help plants surpass stress periods. Foliar biostimulators are important for giving the possibility to stimulate plant metabolism and enhance plant protection mechanisms. Starting from these ideas, the aim of this paper is to present the results of the research focused on studying the effect of different combinations of classic macro & micro nutrient foliar fertilizers (Basfoliar 36 Extra, Foliar Extra, Vertex Hi-N 34, Maize Extra, Manzinc SC), or of one classic foliar fertilizer combined with one algae based biostimulator (Seamaxx SL) under different base fertilization conditions in irrigated hybrid seed maize production. The research has been conducted for 3 years in irrigated field plots in the pedo-climatic conditions of NE Romania. The obtained results brought to attention the positive effects of foliar fertilizers in hybrid seed production: increased plant height, better foliage development, better tassel development in terms of size and longer pollen shedding time, and finally a yield enhancement.

***Key words**: maize, hybrid seed, nutrients, foliar fertilizer, biostimulator.*

INTRODUCTION

Maize is the second most cultivated crop across the world since 2007, when for the first time it exceeded rice. FAO data shows that global maize area exceeded for the first time 200 M ha in 2021 (it being of 205.87 M ha), approaching wheat, which was cultivated on 220.75 M ha (FAOSTAT). Its ecological plasticity and high investment in research makes it a crop which is increasingly important.

To sustain such a wide cultivated area of maize, it is necessary a wide range of seed, especially hybrid seed. The seed quality is the most important and primary factor that impacts the success of maize growth (Bahtiar et al., 2022). Technologically hybrid seed maize production is a challenge for many farmers and only the most experienced and well prepared ones are able to multiply it. Hybrid seed maize field are often at the peak of technological and financial investment and such there is a continuous battle in order to increase yield by any possible means.

Better management practices and seed development programs together have significantly improved maize grain yield during the last century (Ray et al., 2020). High maize yield is possible by providing sufficient water and nutrients during the short growing stage (Koca, 2016). Fertilization is a key component of any crop production system and it is one of the technological elements where improvement is always searched.

Excepting classical synthetic granulated fertilizers, a product increasingly pushed and recommended is foliar fertilizer. Foliar fertilizers have been used since 1980's, at the beginning in horticulture, and nowadays more and more in field crops such as maize (Floratine, 2023).

The soil and foliar application are the main methods of nutrient application but the application of macronutrients is effective only when soil application is provided, while the best method for the micronutrient application is through foliar application (Kashyap et al., 2022).

The foliar fertilization improves the amount of the yield, one being unanimously considered that it is stimulating and corrective for mineral nutrition (Jakab-Gábor, 2017). The content of macro and micronutrients in foliar fertilizers cannot become a substitute for nutrition provided through classical base fertilization, but they can be an enhancer of this fertilization or it can help plants surpass stress or blockages (Racz, 2021).

Even though they require a very small amount of micronutrients, plants cannot grow without them. When micronutrients become a limiting factor, then water, fertilizer and other high-energy production inputs may be wasted, since a plant will only grow and develop to the extent that its most limiting growth factor will allow (Mengel, n.a.).

The availability of micronutrients is limited by the characteristics of the soil, as well as the agricultural practices, therefore an additional supply for plants is required (Luță et al., 2022). Studies proved that micronutrients deficiencies can be overcome through the use of foliar fertilizers (Oldham, 2019). In some situations, foliar-applied micronutrients are more readily available to the plant than soil-applied micronutrients, but foliar applications do not provide continuous nutrition as do soil applications (Vitosh et al., 2006).

The soil parent material and soil formation process over time along with the effects of soil moisture, aeration, and temperature can significantly impact the amount of plant-available micronutrients (Mallarino et al., 2014). Also, some soil conditions such as high soil pH and low organic matter may contribute to decrease the supply of micronutrients to crops (Mueller & Ruiz Diaz, 2011). The total concentration of a micronutrient in the soil is usually a poor indicator of its availability to the maize plant (Johnston & Dowbenko, 2004). Several blockages or immobilisation of these elements can occur in the soil which makes them impossible for absorption through the root system. This imposes for maize production, especially for sensitive inbred lines used in seed production, the development of a management system which needs to take into account conditions that impact microelement availability, most common of these being: soil pH, temperature, interaction between nutrients.

The aim of this paper is to present the results of the research focused on studying the effect of different combinations of classic macro&micro nutrient foliar fertilizers (Basfoliar 34 Extra, Foliar Extra, Vertex Hi-N 34, Maize Extra, Manzinc SC), or of one classic foliar fertilizer combined with one algae based biostimulator (Seamaxx SL) under different base fertilization conditions in irrigated hybrid seed maize production.

MATHERIALS AND METHODS

Field experiments were conducted in 2020, 2021 and 2022 on a chernozem soil in the north-eastern part of Romania, referenced exactly in the pedo-climatic conditions of the Moldavian Plain near the Prut River (NE Romania: 47.5188° N, 27.4490° E) in Bivolari commune, Iasi County.

The experimental variants were based on 4 different foliar fertilization programmes with different macro and micronutrient content applied on the basis of the classical fertilization scheme used by the farmer and quality checked by the parent company that created the inbred lines.

The field experiments were organised using the method of subdivided plots with 4 replications being of type 2 x 5 with the following experimental factors (Table 1):

- Factor A - base fertilization, with 2 graduations:
  - a1 = fertilization only at seedbed preparation;
  - a2 = fertilization at seedbed preparation + microgranulated starter + nitrogen application in the growth stage of the maize plants BBCH 16.
- Factor B - foliar fertilization, with 5 graduations:
  - b0 = no foliar fertilization;
  - b1 = Basfoliar 36 Extra (2 l/ha) + Basfoliar 36 Extra (2 l/ha);
  - b2 = Manzinc SC (0.7 l/ha) + Seamaxx SL (1.5 l/ha);
  - b3 = Maize Extra (1 l/ha) + Vertex Hi-N 34 (3 l/ha);
  - b4 = Foliar Extra (2 l/ha) + Seamaxx SL (1 l/ha).

The experimental variant a1 consisted of fertilization only at seedbed preparation with the following fertilizer rates: 100 kg/ha of ammonium nitrate applied in the autumn of the preceding year; 300 kg/ha of complex fertiliser 14: 14: 14 + $7SO_3$ + 4MgO applied at seedbed preparation; 150 kg/ha of complex fertiliser 20: 20: 0 + 0.5 Zn applied at seedbed preparation. These fertilisers assured the following rates of nutrients: 105.5 kg/ha N; 72 kg/ha P_2O_5; 42 kg/ha K_2O; 21 kg/ha SO_3; 12 kg/ha MgO; 0.75 kg/ha Zn.

The experimental variant a2 consisted of fertilization at seedbed preparation as in the case of variant a1, but having an extra microgranulated starter Physiostart applied in a rate of 20 kg/ha during sowing and having an application of ammonium nitrate in the growth stage BBCH 16 in a rate of 200 kg/ha. All these fertilisers assured the following rates of nutrients: 174.1 kg/ha N; 77.6 kg/ha P_2O_5; 42 kg/ha K_2O; 25.6 kg/ha SO_3; 12 kg/ha MgO; 2.8 kg CaO; 1.15 kg/ha Zn.

Physiostart is a microgranulated fertilizer used as a starter, this containing: 8% ammonium nitrogen; 28% P_2O_5; 14% CaO; 23% SO_3; 2% Zn.

If the experimental variant a1 assures good nutritional conditions for maize plants, then the variant a2 was intended to assure very good nutritional conditions especially concerning the nitrogen nutrition, the aim being to see the effect of different foliar fertilizers under different combinations under these good and very good base fertilisation conditions.

The foliar fertilizers combinations used in the field experiments were applied separately in a 2 pass program: one at the critical phase of 3 fully unfolded leaves (BBCH 13) where ear initiation starts and any deficiency can lead to limited production potential (Nielsen, 2007) and one pass before flowering (before detasseling), the intention being to obtain better development of the tassel of the male maize plants to ensure better pollination of the female plants. Each foliar fertilizer combination used contains macro and microelements in order to ensure a balanced fertilization.

Table 1. Presentation of the experimental factors

Experimental variants	Fertilizer products	Fertilizer application period	Fertilizer rate (kg or l/ha)	Nutrient rate (kg/ha)						
				N	P_2O_5	K_2O	SO_3	MgO	CaO	Zn
a1b0 Control 1 (C1)	Ammonium nitrate	Autumn (preceding year)	100	33.5	0	0	0	0	0	0
	14:14:14+7SO_3+4MgO	Seedbed preparation	300	42	42	42	21	12	0	0
	20:20:0+0.5Zn	Seedbed preparation	150	30	30	0	0	0	0	0.75
	Total Control 1			*105.5*	*72*	*42*	*21*	*12*	*0*	*0.75*
a1b1	C1 + Basfoliar + Basfoliar	BBCH-13 & BBCH-51	2+2	1.08	0	0	0	0.12	0	0.0004
	Total C1 + Basfoliar + Basfoliar			*106.9*	*72*	*42*	*21*	*12.12*	*0*	*0.7504*
a1b2	C1 + Manzinc + Seamaxx	BBCH-13 & BBCH-51	0.7+1.5	0.06	0.03	0.05	0	0	0	0.25
	Total C1 + Manzinc + Seamaxx			*105.56*	*72.03*	*42.05*	*21*	*12*	*0*	*1.0*
a1b3	C1 + Maize Extra + Vertex	BBCH-13 & BBCH-51	1+3	0.98	0.35	0.05	0	0.11	0	0.09
	Total C1 + Maize Extra + Vertex			*106.48*	*72.35*	*42.05*	*21*	*12.11*	*0*	*0.84*
a1b4	C1 + Foliar Extra + Seamaxx	BBCH-13 & BBCH-51	2+1	0.28	0.18	0.10	0	0.04	0	0.00
	Total C1+Foliar Extra+Seamaxx			*105.78*	*72.18*	*42.10*	*21*	*12.04*	*0*	*0.75*
a2b0 Control 2 (C2)	Ammonium nitrate	Autumn (preceding year)	100	33.5	0	0	0	0	0	0
	14:14:14+7SO_3+4MgO	Seedbed preparation	300	42	42	42	21	12	0	0
	20:20:0+0.5Zn	Seedbed preparation	150	30	30	0	0	0	0	0.75
	Physiostart	Sowing	20	1.6	5.6	0	4.6	0	2.8	0.4
	Ammonium nitrate	BBCH 16	200	67	0	0	0	0	0	0
	Total Control 2			*174.1*	*77.6*	*42*	*25.6*	*12*	*2.8*	*1.15*
a2b1	C2 + Basfoliar + Basfoliar	BBCH-13 & BBCH-51	2+2	1.08	0	0	0	0.12	0	0.0004
	Total C2 + Basfoliar +Basfoliar			*175.18*	*77.6*	*42.0*	*25.6*	*12.12*	*2.8*	*1.1504*
a2b2	C2 + Manzinc + Seamaxx	BBCH-13 & BBCH-51	0.7+1.5	0.06	0.03	0.05	0	0	0	0.25
	Total C2+ Manzinc + Seamaxx			*174.16*	*77.63*	*42.05*	*25.6*	*12*	*2.8*	*1.40*
a2b3	C2 + Maize Extra + Vertex	BBCH-13 & BBCH-51	1+3	0.98	0.35	0.05	0	0.11	0	0.09
	Total C2+ Maize Extra + Vertex			*175.08*	*77.95*	*42.05*	*25.6*	*12.11*	*2.8*	*1.24*
a2b4	C2 + Foliar Extra + Seamaxx	BBCH-13 & BBCH-51	2+1	0.28	0.18	0.10	0	0.04	0	0
	Total C2+ Foliar Extra + Seamaxx			*174.38*	*77.78*	*42.10*	*25.6*	*12.04*	*2.8*	*1.15*

Basfoliar 36 Extra is a complex foliar fertilizer which contains: 27.0% nitrogen of which: 3.6% ammonium nitrogen, 4.7% nitric nitrogen, and 18.7% ureic nitrogen; 3.0% MgO; 0.02% B; 0.2% Cu; 0.02% Fe; 1.0% Mn; 0.005% Mo, 0.01% Zn.

Seamaxx SL is a foliar fertilizer enhanced with a biostimulating extract from algae *Ascophyllum nodosum* (200 g/l) which contains: 38 g/l N; 17.5 g/l P_2O_5; 30 g/l K_2O; 0.2 g/l Mn; 0.1 g/l Fe; 0.1 g/l Zn; 36.4 mg/l Cu; 142 mg/l B; 8.7 mg/l Mo.

Manzinc SC is a dedicated foliar fertilizer targeted on Manganese and Zinc deficiencies which are most common in maize crop production, this containing 250 g/l Mn and 352 g/l Zn.

Maize Extra is a foliar fertilizer which contains: 35% P_2O_5; 5% K_20; 8.6% Zn.

Vertex Hi-N 34 is a high nitrogen content foliar fertilizer designed to be a booster especially during intense growth period starting from 8 leaves to tasselling (BBCH-18 onwards), this containing: 328 g/l nitrogen out of which 68 g/l ammonium nitrogen, 99 g/l nitric nitrogen, and 161 g/l ureic nitrogen; 35 g/l MgO; 9 g/l Mn; 5 g/l Cu.

Foliar Extra is a foliar fertilizer which can be used on most types of crops, this containing: 120 g/l nitrogen, out of which 17 g/l nitric nitrogen and 103 g/l ureic nitrogen; 80 g/l P_2O_5; 36 g/l K_2O; 22 g/l MgO; 2.1 g/l Mn.

The field experiments were performed each year under irrigation conditions aiming to assure optimum water supply of maize plants of the inbred lines of hybrid P9889, a FAO 350 hybrid with stay green technology which is well adapted for the climate and soil conditions found in the Moldavian plain. In each experimental year there were applied 5 irrigation passes of 30 mm at the following growth stages: 3-4 leaves, 8 leaves, 12 leaves, after detasselling and at grain fill.

The planting instructions were provided by the parent seed company, respectively a parity of female and male rows of 6:2 with 60 cm between rows. The sowing was performed firstly for the 6 female rows and one row of male (male 1) and then for the second male row (male 2) after 33 GDD (Growing Degree Days) in order to ensure a better flowering time nicking and a longer pollen coverage time. The 6: 2 ratios of female to male rows are less complicated and less costly to handle with conventional planters and harvesters (Wright, 1980).

Each experimental variant had 192 m^2 in size which consisted of 8 rows of plants (6 female rows and 2 male rows) with 60 cm between rows resulting in a width of 4.8 m and 40 m of length.

The sowing distance between seeds per row was of 18.3 cm, which helps ensure high female crop density characteristic of seed production fields.

From a climatic point of view, 2020 has been a warm and dry year, with an average temperature of 12.5ºC which was one of the highest registered ever for the area where the experiments were located, and with 479.9 mm of total rainfall unevenly distributed: 1.8 mm in April and 5.8 mm in August, but an impressive 132 mm in May and 90.4 mm in June which helped in the initial phases of vegetation but late drought seriously impacted yields.

The year 2021 can be characterised as being a favourable one for maize crop, with an average temperature of 10.6ºC and 564.6 mm rainfall among which 390.3 mm in April-August.

The year 2022 is characterised by average temperatures of 11.8°C. Precipitations were the least recorded in history for the area where the field experiments were located with 399.7 mm, the first time under 400 mm and far away from averages of 510 mm for the area. At the same time the dispersion of precipitations was the least favourable for maize production as total precipitation for the period May-July was 85 mm (Weatherspark, 2022).

The evaluation of the foliar fertilizer effects on the maize plants aimed the following:

- Plant height at detasseling (cm);
- Number of leaves per plant at detasseling;
- The flowering time gap between male inbred and the female inbred (days);
- Pollen shedding time (days);
- Tassel length (cm);
- Number of grains per cob;
- Hybrid seed yield (kg/ha).

For statistical analysis of the primary data there was used ANOVA analysis as well as linear regression in order to determine the relationships between studied traits. At the same time the specific tests such as Fisher's test, Tukey's test and Dunnett's were also used to evaluate the studied variants compared to each other and to the 2 control variants.

RESULTS AND DISCUSSIONS

The obtained results highlight that there is a low direct correlation between foliar fertilizer application and final yield as R^2 is 0.195 (Table 2).

Table 2. R squared value of regression

Goodness of fit statistics (Average yield):	
Observations	40
Sum of weights	40
DF	30
R^2	0.195

Besides this one can observe the plus of yield for foliar fertilized variants which for seed crops especially have high economic value: 564 kg/ha increase in seed yield, averaged over 3 years, for Foliar Extra + Seamaxx SL variant (Table 3). This shows us a consistent capacity even under different weather conditions for foliar fertilizers to generate superior yields. By looking at the yield distribution of the variants one can see that there are several ones that vastly outperform average yield of the control variants (Figure 1).

By testing variants between each other to see if there are significant difference regarding yield using the Tukey test one can say that using foliar fertilizers did not decrease yield, but also did not increase it significantly (Table 4). Similar formulations of the treatment plan mean that it is expected that there will not be big differences in yield between them but increases compared to control variants.

The Dunnett test confirmed that foliar fertilizer does not represent a determining factor in final yield obtained compared to the control variants, even though quantitative increases which increase profitability can be observed especially for variants with higher manganese content combined with biostimulator such as Foliar Extra + Seamaxx SL (Table 5).

Observations made at key phases of phenotypical development have shown that there is a consistent increase in plant height for variants with foliar fertilization compared to control by 1 to 20 cm in difference (Table 6). Application of biostimulators before tassel aparition (BBCH-51) stage such as *Ascophyllum nodosum* from Seamaxx has determined the highest difference in plant height at detasseling (20 cm).

Regarding the foliar development, one can observe that foliar fertilizer treatments have supported a better development of the foliar apparatus with peak performance identified for variants Maize Extra + Vertex and Foliar Extra + Seamaxx SL which on average they had one extra leaf at detaselling time (Table 6).

Table 3. Hybrid seed yield results

Experimental variants	**Fertilizer products**	**Hybrid seed yield (kg/ha)**				**Difference to Control 1**	**Difference to Control 2**
		2020	**2021**	**2022**	**Average**		
Control 1 (C1)	Fertilization at seedbed preparation	8405	8745	8625	8592	Control	-
Control 2 (C2)	Fertilization at seedbed preparation + microgranulated starter + nitrogen application at BBCH 16	9163	9465	9393	9340	749	Control
a1b1	C1 + Basfoliar + Basfoliar	9013	9305	9232	9183	592	-157
a1b2	C1 + Manzinc + Seamaxx	9063	9330	9292	9228	637	-112
a1b3	C1 + Maize Extra + Vertex	8963	9204	9182	9116	525	-224
a1b4	C1 + Foliar Extra + Seamaxx	9275	9610	9505	9463	872	123
a2b1	C2 + Basfoliar + Basfoliar	9075	9280	9295	9217	625	-124
a2b2	C2 + Manzinc + Seamaxx	9463	10070	9692	9742	1150	401
a2b3	C2 + Maize Extra + Vertex	9550	10105	9770	9808	1217	468
a2b4	C2 + Foliar Extra + Seamaxx	9625	10234	9855	9905	1313	564
Average		*9159.5*	*9534.8*	*9384.1*	*9359.4*	-	-

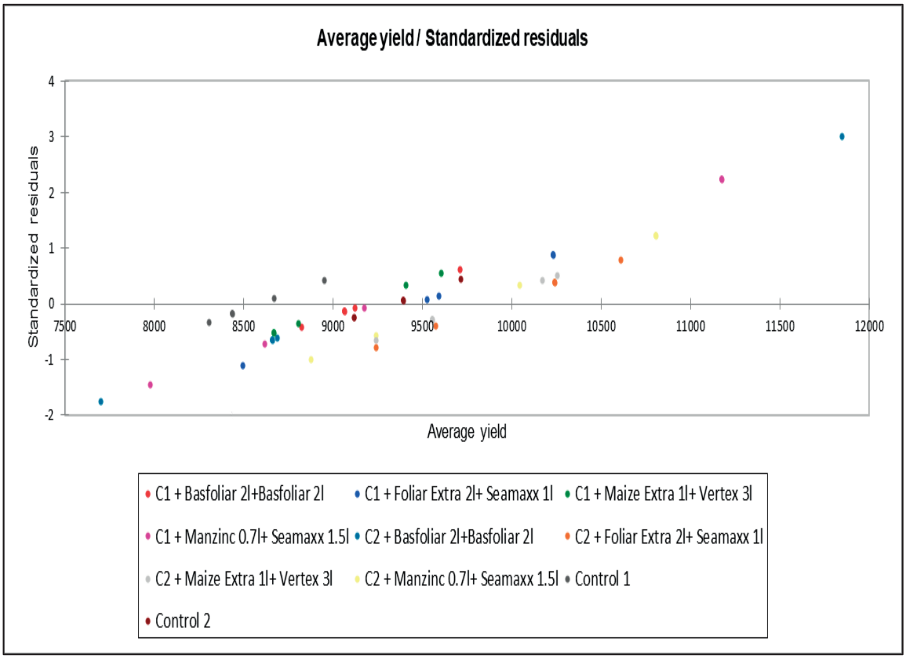

Figure 1. Hybrid seed yield distribution of variants

Table 4. Tukey Test groupings

Category	LS Means	Standard error	Lower bound (95%)	Upper bound (95%)	Groups
C2 + Foliar Extra + Seamaxx	9918.333	435.176	9028.585	10807.081	A
C2 + Maize Extra + Vertex	9806.667	435.176	8917.919	10695.415	A
C2 + Manzinc + Seamaxx	9743.333	435.176	8854.585	10632.081	A
C1 + Foliar Extra + Seamaxx	9462.500	435.176	8573.752	10351.248	A
Control 2	9336.667	435.176	8447.919	10225.415	A
C1 + Manzinc + Seamaxx	9237.500	435.176	8348.752	10126.248	A
C2 + Basfoliar + Basfoliar	9226.667	435.176	8337.919	10115.415	A
C1 + Basfoliar + Basfoliar	9182.500	435.176	8293.752	10071.248	A
C1 + Maize Extra + Vertex	9123.333	435.176	8234.585	10012.081	A
Control 1	8593.333	435.176	7704.585	9482.081	A

Table 5. Dunnett Test significance results

Contrast	Difference	Standardized difference	Critical value	Critical difference	Pr > Diff	Significant
Control 2 vs C2 + Foliar Extra + Seamaxx	-581.667	-0.945	2.856	1757.447	0.925	No
Control 2 vs C2 + Maize Extra + Vertex	-470.000	-0.764	2.856	1757.447	0.977	No
Control 2 vs C2 + Manzinc + Seamaxx	-406.667	-0.661	2.856	1757.447	0.991	No
Control 2 vs C1 + Foliar Extra + Seamaxx	-125.833	-0.204	2.856	1757.447	1.000	No
Control 2 vs Control 1	743.333	1.208	2.856	1757.447	0.786	No
Control 2 vs C1 + Maize Extra + Vertex	213.333	0.347	2.856	1757.447	1.000	No
Control 2 vs C1 + Basfoliar + Basfoliar	154.167	0.251	2.856	1757.447	1.000	No
Control 2 vs C2 + Basfoliar + Basfoliar	110.000	0.179	2.856	1757.447	1.000	No
Control 2 vs C1 + Manzinc + Seamaxx	99.167	0.161	2.856	1757.447	1.000	No

Table 6. Results regarding plant height and foliar development

Experimental variants	Fertilizer products	Plant height at detasseling (cm)				Number of leaves at detasseling			
		2020	2021	2022	Average	2020	2021	2022	Average
Control 1 (C1)	Fertilization at seedbed preparation	181	188	176	182	15	16	14	15
Control 2 (C2)	Fertilization at seedbed preparation + microgranulated starter + nitrogen application at BBCH 16	182	190	177	183	15	16	14	15
a1b1	C1 + Basfoliar + Basfoliar	184	192	177	184	15	16	15	15
a1b2	C1 + Manzinc + Seamaxx	186	194	178	186	15	17	14	15
a1b3	C1 + Maize Extra + Vertex	186	195	178	186	16	17	15	16
a1b4	C1 + Foliar Extra + Seamaxx	189	197	179	188	16	17	14	16
a2b1	C2 + Basfoliar + Basfoliar	187	195	180	187	16	17	15	16
a2b2	C2 + Manzinc + Seamaxx	196	203	189	196	16	18	15	16
a2b3	C2 + Maize Extra + Vertex	198	206	190	198	17	18	16	17
a2b4	C2 + Foliar Extra + Seamaxx	203	210	192	202	17	18	16	17
Average		*189.2*	*197.0*	*181.6*	*189.2*	*15.8*	*17.0*	*14.8*	*15.8*

A parameter that is constantly monitored, this being critical for obtaining good pollination time synchronization between male and female inbreds is the flowering gap between the two. The obtained results showed that foliar fertilization had no negative impact on the flowering gap between male tassel and female stigmata appearing out of the husks. Average flowering gap remained constant, respectively 3-4 days which is consistent with maize's propensity to protandrous flowering. Moreover, one can observe a decrease of flowering gap for the variants Maize Extra + Vertex and Foliar Extra + Seamaxx SL on a better nitrogen supply through base fertilisation (Table 7).

Regarding the length of the tassel one founds that foliar fertilized variants, especially ones with biostimulants and with high nitrogen content applied at BBCH 51 show a better development in terms of length of the tassel which has a potential positive effect on pollination (Table 7).

An important parameter at flowering time is total pollen shedding time by male anthers of the tassel. One can observe that throughout the 3 years of study, foliar fertilized variants, especially ones with biostimulants (Seamaxx) on a base fertilisation at seedbed preparation and that with Basfoliar at a base fertilisation with higher nitrogen supply have led to increased pollen shedding with 1-2 extra days of pollination (Table 8). All these developments in terms of generative elements of the plant have a positive correlation with the final number of grains per cob which again is higher for variants with biostimulator and with high manganese content such as Maize Extra + Vertex and Foliar Extra + Seamaxx SL (Table 8).

Thus, even though the results of the statistical analysis performed showed weak direct correlations regarding yield for each type of foliar fertilizers, one can see that for studied elements especially regarding tassel length, pollen shedding time, number of grains per cob, variants with foliar fertilization containing manganese combined with biostimulator have better results compared to the control variants. One can say that a better development of the tassel due to application of micronutrients such as manganese combined with biostimulator has led to a better pattern of behaviour of the plant at flowering time and better pollination results.

The performed research resulted in un efficiently highlighting and observing all the qualitative and quantitative components that have an impact on plant development and generative growth such as plant height, foliar development, flowering gap between male and female inbreds, tassel length, pollen shedding and number of grains per cob and showing that in certain situations foliar fertilization can have a positive effect

Table 7. Results regarding flowering gap and tassel length

Experimental variants	Fertilizer products	Flowering gape (days)				Tassel length (cm)			
		2020	2021	2022	Average	2020	2021	2022	Average
Control 1 (C1)	Fertilization at seedbed preparation	4	3	4	4	20	22	20	21
Control 2 (C2)	Fertilization at seedbed preparation + microgranulated starter + nitrogen application at BBCH 16	4	4	4	4	21	22	20	21
a1b1	C1 + Basfoliar + Basfoliar	4	4	5	4	21	23	20	21
a1b2	C1 + Manzinc + Seamaxx	4	4	5	4	21	24	20	22
a1b3	C1 + Maize Extra + Vertex	4	4	5	4	21	24	20	22
a1b4	C1 + Foliar Extra + Seamaxx	4	4	5	4	21	24	20	22
a2b1	C2 + Basfoliar + Basfoliar	4	4	5	4	21	23	21	22
a2b2	C2 + Manzinc + Seamaxx	4	3	4	4	25	24	21	23
a2b3	C2 + Maize Extra + Vertex	3	3	4	3	23	25	22	23
a2b4	C2 + Foliar Extra + Seamaxx	3	3	4	3	23	25	22	23
Average		*3.8*	*3.6*	*4.5*	*3.8*	*21.7*	*23.6*	*20.6*	*22.0*

Table 8. Results regarding pollen shedding time and number of grains per cob

Experimental variants	Fertilizer products	Pollen shedding time (days)				Number of grains per cob			
		2020	2021	2022	Average	2020	2021	2022	Average
Control 1 (C1)	Fertilization at seedbed preparation	5	4	5	5	240	272	240	256
Control 2 (C2)	Fertilization at seedbed preparation + microgranulated starter + nitrogen application at BBCH 16	6	5	6	6	256	288	240	256
a1b1	C1 + Basfoliar + Basfoliar	5	5	6	5	256	288	240	224
a1b2	C1 + Manzinc + Seamaxx	7	7	6	7	256	304	240	272
a1b3	C1 + Maize Extra + Vertex	6	6	5	6	256	304	240	272
a1b4	C1 + Foliar Extra + Seamaxx	7	7	6	7	256	304	240	272
a2b1	C2 + Basfoliar + Basfoliar	7	8	6	7	256	288	256	272
a2b2	C2 + Manzinc + Seamaxx	6	5	5	5	272	304	256	272
a2b3	C2 + Maize Extra + Vertex	6	7	6	6	288	320	272	288
a2b4	C2 + Foliar Extra + Seamaxx	6	5	7	6	288	320	272	288
Average		*6.1*	*5.9*	*5.8*	*6.0*	*262.4*	*299.2*	*249*	*270.4*

CONCLUSIONS

The results of performed research show that even though foliar fertilization is not a substitute to classical soil applied fertilization there are several enhancements. Plant height at detasseling was larger for foliar fertilized variants compared to control ones and there was a better foliar development through foliar fertilisation.

Foliar fertilizers containing biostimulator (extract from algae *Ascophyllum nodosum*) and with manganese content applied before flowering resulted in better tassel development in terms of size and the same time a longer pollen shedding time due to better development of the tassel.

The obtained results showed that foliar fertilization had no negative impact on the flowering gap between male tassel and female stigmata appearing out of the husks.

The best foliar fertilizer program in terms of general plant development, generative element development and economical yield enhancement has been the one with Foliar Extra in a rate of 2 l/ha applied at 3 leaves stage (BBCH 31) and Seamaxx SL in a rate of 1 l/ha applied before flowering, respectively before detaselling (BBCH 51) under both base fertilization conditions assuring good and very good nutrition conditions for the maize plants.

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