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THE EFFECTS OF MICRO-GRANULATED FERTILIZATION ON POLLINATION AND YIELD OF HYBRID SEED CORN

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Abstract

This study is carried on to identify the effects of micro-granulated fertilization on pollination and yield of hybrid seed corn. On the trial that set up as random parcels, the inbreds of a Monsanto simple corn hybrid are used. We have control parcels without micro-granulated fertilizer and test parcels with micro-granulated fertilizer applied. The results of the study help us draw valuable conclusions regarding the efficiency of the application of micro-granulated fertilizer at planting in seed corn and its effect on pollination nicking: the time from planting to emergence was shorter on average by 2 days which helped fast development during early vegetation stages; in 4 leaf stage the root of the corn with micro-granulated fertiliser applied at planting was 20% more developed than the root of the control; at 8 leaf stage we can observe the 20% difference in root development; the plants had a faster development which helped reach flowering time 4-5 days before the control; the earlier start of flowering compared to the control resulted in a better protection from draught limiting its protandric effects thus generating a higher percentage of pollinated kernels; plant height and vigour were obviously increased compared to the control, showing better resistance to disease and flattening; we observed a superior ear development from a size standpoint and a higher Thousand Kernel Weight. Most importantly following the study we can observe that the parcel fertilized with micro-granulated fertilizer had a higher yield by 1104 kg per hectare.

Key words*: micro-granulated fertilizer, pollination, nicking, yield.*

INTRODUCTION

Attaining the full potential of hybrid corn and its productive qualities is strongly tied with the quality of the hybrid seed obtained after the multiplication process.

The process of breeding and multiplication of seeds is a long term process which need huge efforts and vast budgets for research and development.

The seed production system must be organized so it is able to allow the propagation into production in the shortest time of new valuable varieties and hybrids created in the country or registered in the EU and at the same the periodical renewal of the seeds of the varieties and hybrids already cultivated in the country.

The problem of fertilization in seed corn fields is becoming increasingly important as seed companies (Monsanto, Pioneer etc.) are facing a continuous increase in demand of high quality seed with increasingly varied traits and increased yield capability. Fertilization used for seed corn fields must take into account the newest ideas in the fields of agro-chemistry and plant growing, the grower having the duty of maintaining hybrid characteristics and technically not to influence the synchronisation at pollination of the two parental inbred lines. Any different assimilation of fertilizer might affect the synchronisation thus, increasing or decreasing the quantity of viable pollen at the time of fecundation.

For a long time, seed growers have used classic fertilization schemes which included complex fertilizer as 16:16:16, 20:20:0 or simple fertilizer as Ammonium Nitrate and even Urea despite its high volatilisation rate during summer. Nitrogen fertilisation is an expensive but necessary input in any agricultural system. Nitrogen fertilisation furthermore enables farmers to achieve high yields that drive modern agriculture (Brady & Weil, 2008).

Time of N application studies have been reported, extensively in the literature. The general conclusion among researches has been that N should be applied nearest to the time it is needed by the crop, i.e., dressed several weeks

after corn emergence (Aldrich, 1984; Fox et al., 1986; Olson & Kurtz, 1982; Russelle et al., 1981; Stanley & Rhoades, 1977; Welch et al., 1971). The context of higher importance of fertilizers costs leading farmers to "just enough" habits with more sophisticated products as well as an increased awareness of precision farming methods and micro-fertilizers agronomic benefits (Laurent Lemarchand et al., 2016).

Taking into account the increase in required yield of hybrid seed and taking into account the low vigour of inbreds, during the last few years seed growers have turned their attention to fertilisation in general, but more so on starter and precision fertilisation to ensure the inbreds have a good development even from the earliest vegetative stages. Micro-granulated fertilizers influence the vegetative development of plants, encouraging the formation of taller, vigorous plants, with large dark green leaves (Crista F et al., 2004).

Micro-granulated fertilizers are target distributed near the seed ensuring the necessary nutritional start, especially phosphorus which has a key role in the development of the root system immediately after the water absorption by the seed and at germination, respectively at the development of the radicle. One of the unknowns that occurs when using micro-granulated fertilizer is its effect on pollination timing taking into account the fact that most hybrid seed corn is planted split in time, because of different maturities of the parental inbreds and also to ensure that most pollen is available from the male inbred at the time of the silking of female inbreds.

It is obvious that any delay determined by using this type of fertilizer, for example the early or late opening of male anthers affects the final percentage of pollinated ovules and thus the final yield. Therefore a study of the effects of micro-granulated fertilization on polination and yield in seed corn is important and valuable for seed corn production technology.

The aim of this study was to assess the behaviour of the inbred lines in terms of pollination and seed yield, mainly of a Monsanto maize hybrid, under different fertilization conditions, including fertilization at sowing with micro-granulated fertilizer.

MATERIALS AND METHODS

The field experiments were carried out during the 2017 growing season in the soil and climate conditions of the company Integrasem SRL from Bivolari Commune, Iasi County, Romania. Several variants of fertilization of parental forms with classical and micro-grained fertilizers have been tested in the field experience and the comparison of the results obtained with the control represented by the fertilization scheme established and agreed with the agronomist of Monsanto.

To start the experience, the inbred lines of a semi-early hybrid, group FAO 360, a hybrid best suited to zoning due to climate change, were chosen. This is a hybrid with good tolerance to drought, with an early flowering that protects it from the summer heat, with a deep and vigorous root system and with an excellent start into vegetation. The sowing scheme dictated the time difference between the sowing of the two parental forms to ensure the flowering coincidence of the female and male inbreds and a longer period of viable pollen to have the fullest pollination.

The classic fertilizers used in this experiment are complex fertilizers with nitrogen, phosphorus and potash of the type 16:16:16; 20:20:0 and fertilizers based on ammonium nitrate ammonium. The micro-grain fertilizer used is one with a specific formulation to ensure an optimal dose of nutrients with N, and especially with P, Ca, S, Zn, at germination and plant growth.

Physiostart is a starter product designed specifically to meet plant requirements in the first phase of vegetation. It is administered to spring crops at a dose of 20-30 kg/ha. Physiostart contains nitrogen in ammoniacal form, preferred by young plants, and does not affect germination of seeds. Phosphorus is available immediately because it has a high solubility and its effect is seen on the development of the root system. The product also contains calcium, sulfur and zinc microelements. It is a formula created specifically to ensure a good start for crops. Being a micro-granulated product, we need to know that it cannot cover all the nutrient requirements of agricultural crops and that is

why basic fertilization with chemical fertilizers should be done.

Physiostart is ideal for spring crops as it provides a strong root development, thus increasing plant resistance to drought, ensuring a faster start of culture, avoiding critical phases during strong heat, and helping to continually increase of the plant of culture.

The experience was performed on a surface of 5.47 ha organized as random blocks with 4 variants and 3 replications, each variant having 0.5 ha size. The sowing parity was "narrow rows" 6 female rows to 2 male rows with the distance of 60 cm betweeen female parental rows, 60 cm between the female and male 1, and 45 cm between the two rows of Male 1 and Male 2, with a distance of 17 cm between seeds in a row, resulting in high density crops.

Analyzes and determinations made in the field and laboratory were:

- ✓ Plant height - in the 4-leaf stage;
- ✓ Plant height - in the 8-leaf stage;
- ✓ The number of leaves per plant;
- ✓ Evolution of the root system up to the phase of 4 leaves and 8 leaves;
- ✓ Leaf -7 length;
- ✓ Duration from sowing to emergence;
- ✓ Duration from emergence to flowering;
- ✓ The flowering gap between Male inbred and the Female inbred;
- ✓ The average number of kernels on the ear;
- ✓ Grain Yield/ha.

Statistical analysis

The statistical analysis of the data was performed using ANOVA Analysis. Relationship between different traits was determined with the Linear Regression Procedure.

RESULTS AND DISCUSSIONS

The results revealed a significant correlation between all the analyzed characters and the yield per hectare. For each comparison the fertilized version of the micro-grain fertilizer, Physiostart, has outperformed the control variant. Thus, there was a production increase of 1015 kg compared to the control variant (Table 1).

A first observation is the much faster emergence of the plants at the micro-granulated applied version at sowing, i.e. about 6 days after sowing compared to the control variant at which emergence occurred 9 days after sowing. In Figure 1 is shown the effect in the linear regression between Sowing-Emergence time and Yield. Significant phosphorus intake near the first seed root accelerated the emergence of the version fertilized with micro-granulated fertilizer, the difference being visible also in later stages of development.

Table 1. The mean values of morpho-physiological and agronomic characters recorded in micro-granulated fertilization variants and maize control variants

NS	ND S-E	NR - 4 L	H-4 L	NR - 8 L	H - 8 L	LL 7	ND E-F	FG T1-M2	NK/E	PR	V
1	**8**	**7**	**23**	**10**	**48**	**30**	**70**	**3**	**417**	**4720**	**MG**
2	**7**	**8**	**25**	**11**	**51**	**32**	**67**	**2**	**427**	**4840**	
3	**7**	**8**	**24**	**11**	**50**	**31**	**68**	**2**	**420**	**4770**	
4	**6**	**9**	**26**	**12**	**52**	**33**	**66**	**2**	**431**	**4870**	
5	**7**	**8**	**24**	**11**	**49**	**30**	**70**	**3**	**419**	**4760**	
Max	**8**	**9**	**26**	**12**	**52**	**33**	**70**	**3**	**431**	**4870**	
Min	**6**	**7**	**23**	**10**	**48**	**30**	**66**	**2**	**417**	**4720**	
Average	**7**	**8**	**24.4**	**11**	**50**	**31.2**	**68.2**	**2.4**	**422.8**	**4783**	
1	9	4	15	7	33	16	74	4	406	3730	**M**
2	10	3	13	6	31	14	75	5	395	3760	
3	9	4	14	7	32	15	74	5	398	3710	
4	9	4	16	7	34	16	73	4	410	3780	
5	8	5	17	8	35	17	72	4	412	3860	
Min	8	3	13	6	31	14	72	4	395	3710	
Max	10	5	17	8	35	17	75	5	412	3860	
Average	**9**	**4**	**15**	**7**	**33**	**15.6**	**73.6**	**4.4**	**404.2**	**3768**	

NS - sample number; ND S-E - number of days from sowing to emergenece; NR-4 L - roots number - 4 leaves; H-4L - height - 4 leaves; NR-8 L - roots number - 8 leaves; H-8L - height - 8 leaves; LL-7 - leaf length 7 (cm); ND E-F - number of days emergence-flowering; FG T1-M - Flowering gap between male inbred T1 and female inbred M (days); NK/E - number of kernels on ear; PR - seed production/ha (kg); V - variant; MG - micro-granulated fertilizer; M - control

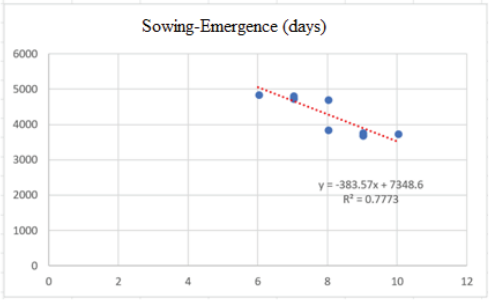

Figure 1. Linear regression between Sowing-Emergence Time and Grain Yield (kg/ha)

Significant phosphorus intake near the first seed root accelerated the emergence of the version fertilized with micro-granulated fertilizer, the difference being visible also in

later stages of development. In the four leaf stage of the two variants, the number of roots and the height of the plants were evaluated (Figure 2). The variant tested showed a higher root development of an average of 9 roots developed versus 6 in the control variant.

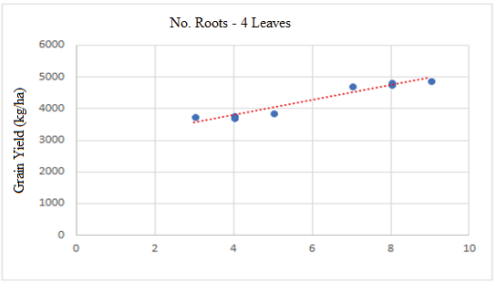

Figure 2. Linear regression between No. Roots - 4 leaves and Grain Yield (kg/ha)

Regression Statistics	
Multiple R	0.971462885
R Square	0.943740137
Adjusted R Square	0.936707654
Standard Error	136.5140269
Observations	10

ANOVA

	df	SS	MS	F	Significance F
Regression	1	2500911.364	2500911.364	134.1972896	2.80329E-06
Residual	8	149088.6364	18636.07955		
Total	9	2650000			

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	2849.545455	130.8102037	21.78381635	2.07972E-08	2547.896584	3151.194325	2547.896584	3151.194325
Numar Radacini 4 Frunze	238.4090909	20.5802639	11.58435538	2.80329E-06	190.9509172	285.8672646	190.9509172	285.8672646

Figure 3. Regression Analysis of No. Roots - 4 leaves and Grain Yield (kg/ha)

The independent variable (x-root number) was tested with the dependent variable (y-grain yield/hectare), the yield obtained extrapolated per hectare to assess the existence of a correlation relationship between the two. The statistical result $P<0.05$ denied the statistical independence hypothesis between the two factors and demonstrated a significant positive correlation between the number of roots developed in the 4 leaf stage and the yield obtained. The high R2 value shows that our linear regression very well explains the variability and relationship of the variables (Figure 3).

The plants height of 4-leaves is higher in the micro-granulate fertilized variant, with a 9 cm on average larger height, the increase from the fertilizer ensures a harmonious development above the ground, stimulating the growth of the foliar mass (Figure 4).

The statistical test shows a positive correlation between this variable and the yield obtained, and thus the plants with a larger size at this stage of development have a higher production.

In the 8-leaves stage, before hoeing and before the explosive maize growing period following assimilation of the extra nitrogen applied at hoeing, was determined the plant size, the number of roots, the length of the 7th most developed leaf at that moment.

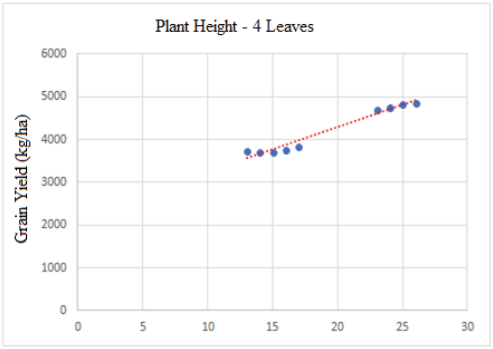

Figure 4. Linear regression between Plant Height-4 leaves and Grain Yield (kg/ha)

The radicular system of the test variant proves a much higher vitality with a higher number of roots, 11 compared to 7 in the control variant, with a longer root length and much more root hairs (Figure 5). This superior development of the radicular system correlates positively with seed production following statistical tests proving a direct proportional undeniable relationship between the number of roots and the final production.

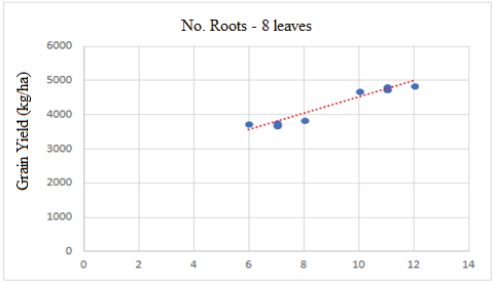

Figure 5. Linear regression between No. Roots - 8 leaves and Grain Yield (kg / ha)

The difference in the height of the plants in the 8-leaves stage further confirms the positive relationship between superior foliage development and higher yield. This superior development provides increased photosynthetic activity, resulting in an increase in the development gap between the plants included in the two experimental variants (Figure 6).

The size of the most developed leaf in this leaf-7th phase is a good example to illustrate the massive difference from the foliar canopy development, so for the fertilized micro-granulate variant we observe a leaf length of 7 inches of 31 cm on average compared to 16 cm in the case of the control variant (Figure 7). This superior development illustrates the advantage of early emergence due to microganized fertilization.

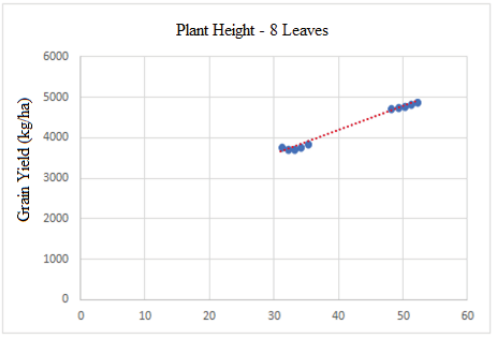

Figure 6. Linear regression between Plant height-8 leaves and Grain Yield (kg/ha)

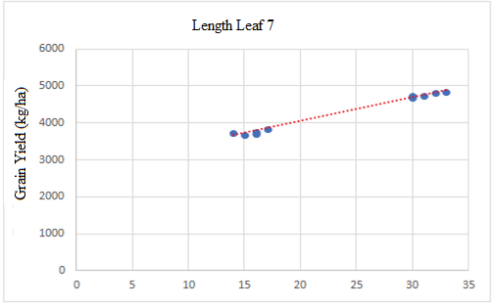

Figure 7. Linear regression between the length of leaf 7 and Grain Yield (kg/ha)

Two determinations were carried out to check the duration from emergence to blooming and the gap between the flowering of Male Inbred 1 and Female Inbred 2. The corn flowering studies show that the anthers of the masculine part, the tassel, open 5-7 days before the silks of the female, but the maximum amount of pollen is released after 2-3 days of flowering. This characteristic of corn makes it very important in the technology of producing maize to obtain a best nicking in the flowering of the two inflorescences so that the quantity of pollen is maximized (Figure 8).

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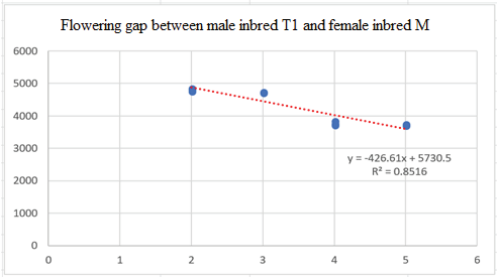

Figure 8. Linear regression between T1-M Flowering gap and Grain Yield (kg/ha)

Field determinations showed that for the tested variant the flowering gap between Male and Female was almost ideal at 2-3 days, providing a better supply of pollen and implicitly a higher percentage of pollination. In the case of the control variant, the gap between the two was 4-5 days due to longer exposure to drought conditions, which accentuated the protandric character of the masculine inflorescence.

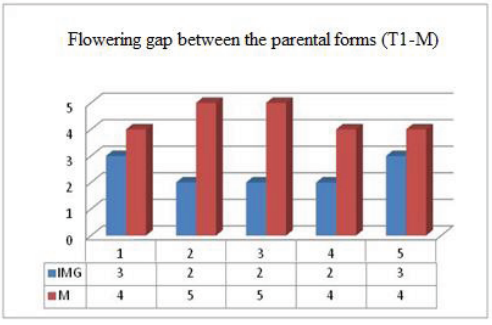

Figure 9. The graphical representation of the size of the gap in time of flowering between the parental forms

The statistical test shows a negative correlation between the delay at flowering of the two inbreds and production, the smaller delay between the two parent forms providing a

better supply of pollen and a larger number of kernels on the ears.
Very important is the time from emergence to flowering, a shorter period being desirable to avoid the intense drought since mid-July and avoiding the increase of protandria. The positive effect of this variable being statistically proven, the correlation being inversely proportional to the lower the number of days between emergence and flowering, resulting in a higher yield (Figures 10, 11).

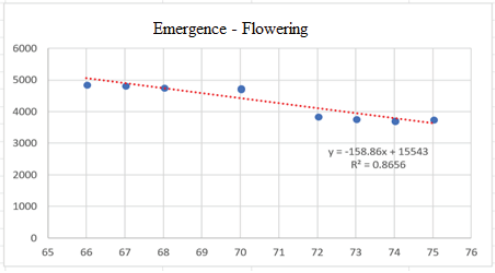

Figure 10. Linear regression between Emergence-Flowering time and Grain Yiled (kg/ha)

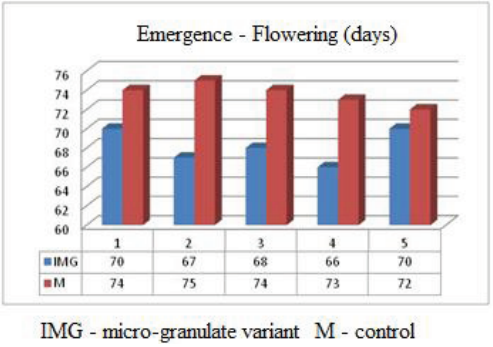

Figure 11. Graphical representation of the duration from emergence to flowering

An important determination was that of the number of kernels on the ears, which is a critical production item that plays a key role in determining production.
As a result of the analysis of the field samples, there is a higher number of grains on the ear in the case of the ears obtained in the experimental variant than in the control variant (Figure 12).
This is largely determined by the cumulative effect of faster growth of the fertilized plant with micro-granulated fertilizers and of ensuring optimal flowering nicking between parental forms.

The statistical analysis only confirms the strong correlation between the number of kernel on the ears and the final production, which is a corn production item.
In the experience we were able to highlight and demonstrate scientifically a number of quantitative and qualitative elements (number of leaves, waist, duration from emergence to flowering, the gap between parental forms, number of kernels on ear) that directly and significantly influence the production seed harvested within a hybridization parcel.

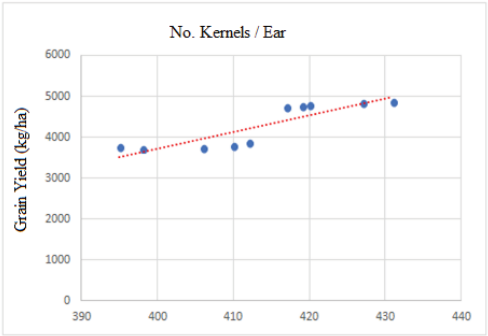

Figure 12. Linear regression between No. Kernels on ear and Grain Yield (kg/ha)

For each element, the plants fertilized with micro-granulated fertilizer at sowing proved to be clearly superior to those of the control variant, this being confirmed by the difference in production between the two variants of 1014 kg/ha in favor of the test variant.

CONCLUSIONS

The use of micro-granulated fertilizer in seed corn production brings an improvement in terms of the quality and quantity of the yield, thus giving seed growers a real help in the context of increases in required yields.
Early start of vegetation and the shortening of the planting-emergence period even with 1-2 days means a lot at flowering time and fecundation helping avoid effects of protandry and ensuring pollen viability.
The obtained results suggest that micro-granulated fertilizer applied at planting has a benefic effect on the plant with a quicker emergence, a better developed root system, shortening the time from emergence to flowering and the delay at flowering between

the 2 inbred parentals and not the least superior yield.

ACKNOWLEDGEMENTS

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