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MAIZE YIELD EVOLUTION IN ROMANIA AND FARMERS' INVOLVEMENT TO INCREASE IT

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Abstract

Even though pedoclimate conditions in Romania are favourable for maize production (similar with Corn Belt), yield and annual gain yield are quite low. Starting with 1961, national average was only 9 times higher than 4 t/ha. This is also because the use of research results in production is low. Individual farmers from different regions, seed companies and APPR (Romanian Maize Growers Association), have organized field trials to compare hybrids and technology items such as plant density, fertilization and irrigation. This information has a major impact on maize yield at a regional scale because it is used by the APPR members and their neighbours. Maize yield is the combined effect of high-performance genetics (50% to 75% of total gain yield in Romania, according to Sarca et al., 2007) and modern technologies. On the fertile soils (such as in Orezu), hybrid ability to use water and nitrogen efficiently varies significantly among the varieties. One of the highest difference noticed was 5.496 kg/ha. The data obtained on Maize Days in Orezu have shown that high yield could be produced only with particular technologies for every combination of parcel (pedoclimatic conditions) and hybrid (genetic resources). To harvest high yields, farmers must create themselves adapted technologies for each parcel and type of hybrid.

Key words*: maize, hybrids trials, yield, Maize Day, Romania.*

INTRODUCTION

In 2013, Romania ranked the 13th in area terms, with 2.51 million hectares, the 62nd in yield terms (4.497 tons per hectare, one ton below the world average of 5.52 tons per hectare), and the 14th in production terms (11.3 million tons)! Romanian agronomists, farmers and politicians are always thinking the same when describing the yield potential of the main crops in our country: we could easily double the yield. Is this possible in maize? How can be farmers involved in that demarche?

Maize acreage was always important in Romania: it varied from 978,800 ha (the average for 1862 - 1866 period), up to 4,324,766 ha in 1947. (Ionescu – Șișești, 1955). Unfortunately, on these large surfaces, we have harvested only small yields: 940 kg/ha up to 1335 kg/ha (averages for 10 years' periods).

Ionescu-Șișești (1955), pointed out two important facts for maize production in Romania.

First, in our country, maize finds very favourable growth conditions, similar with those of Corn Belt (region in USA with ideal conditions for raising corn).

Second, when good agronomic practices were used, satisfactory yield was obtained at county level, with more than 2 t/ha between 1906-1911 and up to 6 t/ha in collective and individual farms after 1950. We should mention that national yield in 5 years (1992, 1993, 2000, 2007 and 2012), was very similar with those obtained one hundred years ago, at county level in Ilfov, Ialomita, Vlasca, Braila and Covurlui (the county that included Galați). This happens because the drought was too severe and irrigation support was too small at country level.

Maize yield is the combined effect of high-performance genetics (50% to 75% of total gain yield in Romania, according to Sarca et al. 2007) and modern technologies. The genetic material must be used by adequate technology.

Sarca et al. 2007 noticed the fact that the research results are being materialized in practice in a proportion no higher than 28-50% (the potential of hybrids is much bigger than the results obtained in production).
We identified a major cause for that situation. It is difficult for farmers to select from the catalogues of seed companies the hybrids to plant, because they propose too many hybrids of different genetics, with a large variation in yield. A wrong choice could reduce the yield up to 4 to/ha. For this reason, individual farmers or associations must find themselves the information they need using field trials.

MATERIALS AND METHODS

In this work, we comment the information obtained from large hybrids trials conducted by farmers in field conditions, called Maize Day, organized by Nicolae Sitaru at Orezu, Ialomita County in 2014 and 2015. Some analysis was made within the project ADER 13.1.2 – Phase 5.5.
Starting with 2010, 50-120 hybrids were planted each year. They belong to the main seed companies present in Romania: KWS, Maisadour, RAGT, Euralis, Syngenta, Limagrain, Procera, Dow Seeds, INCDA Fundulea, Pioneer, Dekalb, IF Porumbeni, and Caussade Semences, in different densities: 60-65,000 and 70-75,000 plants/ha. Nitrogen rate varied from 109 kg N/ha in 2014 to 183 kg N/ha in 2015.
To produce high yields, maize plants need 200-300 mm rainfall from 10 leaves stage to 50% whole plant humidity. Rainfall was 186.7 in 2015 and 275 mm in 2014.

RESULTS AND DISCUSSIONS

All agronomists agree that the most important factors affecting maize yield are hybrid and crop management (especially water and nitrogen). Those factors have different influence on yield, according to large scale economic development of the country. For example, reduced nitrogen rate on the national scale is a weakness of Romanian conventional agriculture, which negatively influences maize yield. But some people consider it as a benefit for those farmers who are interested in conversion to ecological agriculture. In table 1, the data show the slow increase in national yield, measured as an average for 5 years.

Table 1. The evolution of the maize yield (5 years average), from 1961-1965 to 2011- 2015 (data from www.fao.org)

Years	1961-1965	1981-1985	1986-1990	2006-2010	2011-2015
Average yield (to/ha)	1.8	3.4	2.9	3.2	3.9

In the ’50s, Romanian maize growers used local plant populations, local varieties, bred varieties, and two types of hybrids: variety-cross hybrids and – the much more productive – double-cross hybrids, the result of inbred lines of foreign origin. They were followed by Romanian simple and three-way cross hybrids, better adapted to the local conditions (Sarca et al., 2007). Foreign hybrids were also used. Until 1985, maize production recorded annual yield gain of 82 kg/ha/year (Table 2).
Between 1955 and 1985, remarkable increase in technology was noticed, both in mechanical sector (tractors, planters, combines), or crop production (plant density, sowing date, fertilization, plant protection etc.), which had a major contribution to the gain yield.
No significant yield increase was noticed during 1986-2010. In this period, total and annual yield gain have dramatically decreased (Table 2).

Table 2. Total and annual maize yield gain between 1961 and 2015 in Romania (5 years average)

5 years average	Yield gain	kg/ha
(1961-1964) - (1981-1985)	Total yield gain (kg)	1649
	Annual yield gain (kg)	82
(1986-1990) – (2006-2010)	Total yield gain (kg)	341
	Annual yield gain (kg)	17
(2006-2010) - (2011-2015)	Total yield gain (kg)	700
	Annual yield gain (kg)	140

A possible explanation is the significant decrease of the use of nitrogenous fertilizers. The nitrogen is considered a second or a third factor (after weather and hybrid) that influences maize yield. As regards weather, the nitrogen impact on maize yield could be noticed on national scale. For that reason, it makes sense to compare nitrogenous fertilizers used and

maize yield evolution. Starting with 1985, in Romania, the rates of NPK fertilizers were significantly reduced, due to political reasons and, after 1990, due to economic (transition) reasons. In the 80's, the total fertilizer rate in Romania was of approx. 150 kg NPK active substances (Popa, 2003).

According to the data from www.fao.org (Table 3, data from 1982 to 2002), the highest amount of nitrogenous fertilizers was used in 1982, 884.000 tons (100%), while the lowest quantity was used in 1999, 182,000 tons (21%). In 2010, the total quantity of fertilizers used in Romania was of 490.8 thousand tons, which means that one hectare of arable land (we assume that 9 million hectares should be fertilized), received 54.5 kg of NPK/ha, 34.6 kg of N/ha, 13.9 kg of P_2O_5/ha, and 5.9 kg of K_2O/ha (NIS).

The significant decrease of nitrogenous fertilizers used, from 100% to 27%, did not affect the yield in the same manner. Only between 1986-1989, nitrogenous fertilizer and the yield had a similar trend, 16% reduction for nitrogenous fertilizer, and 18% for the national yield. During that period, almost all use of inputs was reduced, so maize yield was also probably affected by other inputs that were restricted for homeland use, such as fuel, pesticides etc.

Table 3. Nitrogenous fertilizers and maize yield evolution (data from www.fao.org)

Years	Nitrogenous fertilizers		Maize yield	
	t	%	t/ha	%
1982-1885	874750	100	3.6	100
1986-1989	733500	84	2.9	82
1990-1993	453350	52	2.9	80
1994-1997	236650	27	3.4	93
1099-2002	232205	27	2.8	77

For the period 1994-1997, an unexpected trend was noticed. Nitrogen use decreased from 52% to 27%, while yield increased from 82% to 93%.

There are some possible explanations of the fact that despite permanent and significant decrease of the nitrogenous fertilizer, maize yield was not affected in the same manner:

First, yields per-hectare did not go down too much, because, the supply of hybrids – developed by NARDI Fundulea or multinational companies – went up, offsetting the impact of the lower nitrogen rates. Maize hybrids registered by seed companies during that period were numerous and diverse, in order to best meet growers' requirements. For instance, the Olt and F376 hybrids created in Fundulea, have remained until now among the most planted hybrids in Romania, because of their drought resistance, protein content (10-12.5%) and efficient use of moderate and balanced rates of N and P fertilisers. These traits are very useful to farmers practicing a medium-input agriculture. But the development of the technical equipment is also very likely to have played a significant part, with increase with 35,951 tractors, 41,562 ploughs, and 18,075 planters (NIS). The consumption of inputs has increased too. For instance, the total quantity of herbicides increased during this period by 4,150 tons of active substance. This means that quality mechanical work, carried out on time, and increased volumes of inputs can temporarily compensate for the reduction of the nitrogen fertilizers rate. Moreover, we must not forget the fact that, in areas with (still) fertile soils, yields of 5 t/ha in monoculture or even much more in rotation systems including leguminous plants can be achieved without fertilization. Most of farmers, even the small ones, had for that moment enough knowledge and input accessibility to produce more than 3 t/ha. (Agricultura privată în România, 1997).

Lack of competition between hybrids kept gain yield smaller**.** Till recent, there hasn't been a real competition for high yield between Romanian hybrids and the foreign ones. For commercial reasons, the multinational companies have rarely submitted for registration to the State Institute for Variety Testing and Registration (ISTIS) hybrids that surpass the Romanian "witness hybrids" by more than 20%, although such hybrids have been registered in other countries. For these reasons, the output gap between the hybrids registered in different years is small, as the yearly yield gain. Many of the first Romanian hybrids (until 1970), have been created for a (semi-)extensive agriculture, without access to sufficient material resources, such as mineral fertilizers,

plant protection products, agricultural machines or equipment. For this reason, Romanian hybrids are very profitable for a large category of farmers, but are surpassed in favourable years by those foreign hybrids that have been created for "intensive conditions" (good water and nitrogen supply, higher densities than those used with the Romanian hybrids). The most cultivated Romanian hybrids, F376 and Olt, created in 1990-1993, have been evaluated within the Fundulea Institute's network between 1999–2001, the production results being 5.5 – 6 t/ha (Sarca et al., 2007).

Yield gain has increased in the last 5 years, because the farmers used more efficiently the information about yield potential of the hybrids existing on the market.

It is quite difficult to choose the right varieties, because the cultivar market is huge: almost 400 maize hybrids were registered in the 2015 Official Catalogue of the Crop Varieties Cultivated in Romania. There is only one possibility to quickly solve this problem: hybrid trials in the field made within APPR.

Farmers are looking for regional recommended hybrids, not for "universal" ones. All seed companies would like to describe their hybrids as being recommended everywhere in the area where maize is planted in Romania. Such hybrids, if they really exist, would be "rustic", with stable production in rather different pedoclimatic conditions. But the "cost" for such qualities is a medium yield level.

The selection of hybrids for high and stable production each year can be done by APPR`s field trials.

Maize days do not offer very accurate (statistical verified) results, because, usually, the replicates are not used. Instead, general trends are easier to notice. Some of them are described below:

1. In any field trial measuring hybrid potential, among winners, there are always hybrids from Monsanto and Pioneer. In real world, Pioneer hybrids are planted on 30% of the total corn surfaces. Pioneer had best average results for 6 hybrids both in 2014 (10,733 kg/ha) and 2015 (10,511 kg/ha).

2. All seed companies have some very good and competitive hybrids. For this reason, there is no seed monopoly and farmers can buy quality seeds at a good price. In 2014, the average for 6 hybrids was: KWS - 10,422 kg/ha, Dekalb -10,147 kg/ha, Maisadour - 10,064 kg/ha and Euralis - 10,021 kg/ha. In 2015, the differences between the best average yield were higher, the second and the third best average yield being at Euralis 9,191 kg/ha and KWS 9,050 kg/ha.

3. When selecting the hybrids, the farmers must compare their performance in APPR trials in multiple locations and over the years, in order to avoid such situation: in 2015, the difference between the highest yield (10,655 kg/ha) and the smallest (5,159 kg/ha) was 5,496 kg/ha. The small yield hybrid was tested for the first time. The company changed all the hybrids tested one year before.

4. All the companies, even the most important, propose to farmers, for different reasons, cultivars which are not adapted to the local conditions. In 2015, one of the Dekalb hybrids yielded only 5,843 kg/ha. These kinds of situations have to be avoided: very expensive seeds and poor harvest.

5. Many agronomists noticed that same yield could be obtained with different fertilization (Burlacu et al., 2007). Climatic changes strongly affected soil mineralization. Before planting maize for Golden Corn contest organized by APPR in Insula Mare a Brăilei, 150 kg N/ha was found in the soil, due to organic matter mineralization. We must mention that a general recommendation for nitrogen fertilization was a rate of 100-130 kg N/ha. This general recommendation had the effect that average farmers (50-100 ha) do not use more than 70 kg N/ha. This is one of the reasons why national yield is so small, because 70 kg N/ha could provide no more than 4 to/ha when soil mineralisation is not so active and mineral nitrogen before maize planting is only 20-40 kg N/ha.

6. Best results were obtained with 65,000 plants/ha. We must say that this density is the plant population recommended for all FAO groups at Pioneer hybrids.

Yield differences between densities could be quite large, up to 2 t/ha. This means that every hybrid must be planted at its specific density.

In the trial of 2012, the lowest variations among hybrids from the same company due to densities were of 379 kg/ha (from 8,297 kg/ha to 7,918 kg/ha), and the highest were 1,829

kg/ha (from 8,046 kg/ha to 6,217 kg/ha). Specific technologies for every type of hybrid used must be elaborated. Hybrids have to be grouped in 2-3 levels of expected yields.
Plant density varies in Romanian research and production from 30,000 plants/ha to 100,000 plants/ha in irrigated fields.
Plant density must be correlated with fertilization rates. Usually, when densities are tested, the same nitrogen rates are used. For this reason, yield was higher at lower densities, because more nitrogen was available per plant.
Nitrogen timing is also very important. As earlier in the spring is applied, the better the results are. We could ask ourselves if we could go till the autumn application of the nitrogen, because the experimental results in Fundulea have shown that the best results were obtained where most of the nitrogen was applied in the autumn. This method must be accepted by the good agriculture practice code.
7. Yield depends on the water/nitrogen interaction use efficiently by maize plants. In the trials in Orezu, with a fertile soil, water influence on yield is more important than nitrogen influence. In 2014, 109 kg N/ha and 275 mm rainfall from April to August made possible a yield of 9,572 kg/ha. Next year, a significant higher nitrogen rate, 183 kg N/ha, but only 187 mm rainfall, determined only 8,464 kg/ha.
Water stress could be diminished using conservative systems, such as strip-till.

CONCLUSIONS

Maize yield is the combined effect of high-performance genetics (50% to 75% of total gain yield in Romania, according to Sarca et al. 2007) and modern technologies.
On fertile soils (such as in Orezu), hybrid ability to use water and nitrogen efficiently varies significantly among the varieties. One of the highest difference noticed was 5,496 kg/ha.
The data obtained at Maize Days in Orezu have shown that high yield could be produced only with particular technologies for every combination of parcel (pedoclimatic conditions) and hybrid (genetic resources).
To harvest high yields, farmers must create themselves adapted technologies for each parcel and type of hybrid.
Rainfall between April – August had a higher influence on maize yield than nitrogen fertilizer.

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