NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro

ROMANIAN AGRICULTURAL RESEARCH, NO. 32, 2015
Print ISSN 1222-4227; Online ISSN 2067-5720

RESPONSE OF NINE MAIZE (*ZEA MAYS* L.) HYBRIDS DEVELOPED AT NARDI FUNDULEA, TO BASIC CONSERVATION AGRICULTURE PRACTICES

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ABSTRACT

The purpose of this study was to find out how genotype x tillage (G x T) and genotype x rotation and residue management (G x RRM) interactions influence the maize (*Zea mays* L.) grain yield, fat content, protein content and starch content in wheat-maize-soybean and wheat-soybean-maize rotations. The hybrids Milcov, F475M, Mostiştea, Crişana, Generos, F376, Rapsodia, Iezer and Olt, developed at NARDI Fundulea, were planted in chisel-till (CT) and no-till (NT) systems, with wheat and soybean residues maintained on soil surface, in a randomized complete block with a split split-plot design, at NARDI Fundulea, during the period of 2012-2014. G x T significant interaction did occur only for starch content and G x RRM interaction for protein content and starch content. Grain yield and fat content were unaffected by rotation and residue management. Among the nine hybrids, grain yield varied from 7.968 t ha^{-1} to 10.036 t ha^{-1} under CT system and from 8.018 t ha^{-1} under wheat residues to 10.224 t ha^{-1} under soybean residues. Fat content increased from 3.98% to 4.95% under CT system and from 4.02% under wheat and soybean residues to 4.95% under soybean residues. Protein content decreased from 10.82% under CT system to 9.25% under NT system, and from 10.97% under soybean residues to 9.27% under maize residues. Starch content varied from 70.82% under CT system to 75.57% under NT system, and from 70.88% under soybean residues to 72.73% under wheat residues. The main conclusion of this research is that the maize hybrids developed and recommended for traditional agriculture (chisel-till) can be successfully extended, with almost similar results regarding grain yield, protein and oil contents, to conservative agriculture (no-till), in wheat-maize-soybean and wheat-soybean-maize rotations, with previous crop residue retention. When high starch content is of interest, the results of this experiment suggest the necessity of developing maize hybrids in the specific conditions of conservative agriculture, with certain crop rotations and the retention of vegetal residue on ground surface.

Key words: maize, grain yield and quality, conservation agriculture, genotype x tillage system interaction, genotype x rotation and residue management interaction.

INTRODUCTION

Knowledge of specific crop responses to tillage and surface crop residues as affected by soils, climate and N fertilization is necessary in the selection of appropriate tillage and crop residue management strategies for improved crop production (Aina et al., 1991). Agriculture in Romania is mostly based on mouldboard plough and combined mechanical and hand weeding, and this system is often thought to lead to land degradation and excessive nutrient losses (Knowler and Bradshaw, 2007). In order to combat this scourge, conservation agriculture (CA) has been promoted through continuous zero-tillage or strip tillage, permanent soil cover and crop rotations (FAO, 2008). The effectiveness of CA for controlling excessive water runoff and soil erosion is well documented (Scopel et al., 2004), and it is expected that this contribution can be measured in terms of crop yield. Other benefits associated with CA include decreased energy and labour costs which lead to higher income and so a better standard of living for the farmers (Ribeiro et al., 2007; Lahmar, 2010).

Maize is one of the most important grain crops in Romania, with over 2 million hectares of production. Evaluation of maize quality traits across several genotypes is essential to determine the potential of this crop for value-added products (Haş et al., 2010). The major chemical component of the maize grain is starch, which usually provides

Received 25 May 2015; accepted 29 June 2015. First Online: July 2015. DII 2067-5720 RAR 2015-83

up to 72 to 73 percent of the grain weight in the commercial hybrids (Boyer and Shannon, 1987). After starch, the next largest chemical component of maize grain is the protein. Protein content varies in common cultivars from about 8 to 11 percent of the grain weight. Most of it is found in the endosperm. Another important chemical component of maize grain is oil, which comes mainly from the germ (Lunven, 1992).

Implementation of CA practices for maize production in Romania could result in a valuable improvement of this crop, especially in the southern semiarid regions, but it may present different challenges from where CA was originated and was successful. In semiarid regions (300-500 mm annual rainfall), the superiority of CA depends on the ability of farmers to retain crop residues and ensure adequate weed control (Giller et al., 2009). Additional improvements in grain yield and quality can be attainable if genotypes better adapted to CA and the respective soil and environmental conditions can be developed. Most published studies, ranging from genotype evaluation to impacts of tillage management or rotation and residue management on grain yield, used genotypes developed under conventional tillage (Herrera et al., 2013).

Cooper et al. (2001) examined the magnitude of wheat genotype (G) x management x environment interaction for grain yield and grain protein concentration in multi-environment trials. They reported that the G x management component of the three-way interaction (G x management x environment) was the largest source of variation for both grain yield and grain protein concentration. These findings indicate not only the importance of each component of the interaction for achieving high yields and high grain quality, but also the potential to exploit such interactions to maximize these traits when CA is applied. From the potential interactions of genotypes with components of farming system, the type of interaction most extensively studied for maize is G x T (tillage practice). Rotation and residue management (RRM) are not explained in all cases, but it is well known that rotation and maintenance of residues on the soil surface under no-tillage is fundamental (Verhulst et al., 2011). The identification and exploitation of G x T and G x RRM are expected to improve the grain yield and its quality by accelerated adoption of CA practices. In this sense, a large G x T or G x RRM interaction would indicate that specific genotypes have to be developed for specific tillage, rotation and residue management.

The main objective of this research was to investigate the occurrence of the G x T and a G x RRM interactions, by testing a set of diverse maize hybrids developed by NARDI Fundulea and evaluating their yield and grain quality under two contrasting T and RRM regimes: no-till/chisel till and respectively soybean/wheat.

MATERIAL AND METHODS

The maize hybrids under study were as follows: Milcov, F475M, Mostiştea, Crişana, Generos, F376, Rapsodia, Iezer and Olt. These were tested at NARDI Fundulea, in 2012, 2013 and 2014 growing seasons. The experimental plot was located at 44°27'45" latitude and 26°31'35" longitude, in Eastern part of Romanian Danube Plain, and East of Fundulea town.

Soil and Climatic Description

Soil on which this experimentation was carried out is a cambic cernozem formed on loessoide deposits, which is typical for a large area of this plain. Its surface is flat, at 68 m altitude, and with the underground water at 10-12 m depth. Morphologically, the soil presents an Ap 0-27 cm horizon, dusty-argillaceous, with 36.5% clay, 49.2 mm ha^{-1} permeability and with a compaction of 1.41 g cm^{-3}.

It contains high-very high levels of: potassium (soluble K=175 ppm), phosphorus (70 ppm), and humus (2.2%). The total nitrogen content is around 0.157, C/N=15.9 and pH = 6.7. Climate is of temperate continental type, with a 50 year multiannual mean temperature of 10.7°C and 580 mm precipitations per year.

The total rainfall during 2012 growing season (April - September) was 315 mm, lower than the long-term average which was of 352 mm. Precipitation distribution was very different from the normal (Table 1). In June and July of 2012 there was an extended severe dry period, with rainfalls of 21 mm and 2 mm, much lower than the long-term averages. The potential evapotranspiration's (calculated by the method of Thornthwaite, 1948) were of 112 and 141 mm. In 2013 and 2014 the rainfall totalled 472 mm and 436 mm, respectively, which were considerably higher than the long-term average, of 352 mm. Their distribution was also more favorable to the crop. While in 2013 the only drier month was August, in 2014 the drought installed in July and lasted up to the end of the vegetation season.

Table 1. Yearly weather data of 2012-2014 crop cycles and the average of 1960-2014 at NARDI Fundulea zone

Month	Rainfall (mm)				Potential evapotranspiration (mm)			
	2012	2013	2014	1960-2014	2012	2013	2014	1960-2014
April	35	39	83	45	54	49	40	39
May	160	97	101	62	77	83	68	71
June	21	127	136	75	112	101	88	95
July	2	96	52	71	141	111	110	108
August	48	22	27	49	124	115	116	104
September	49	91	37	50	86	70	78	73
Rainfall mean April-September	315	472	436	352				

Field management

The experiment was implemented in 2011 within a long-term multidisciplinary research platform based on CA, initiated in 2010. The experiment was executed in a Randomized Complete Block Design with split-split plot arrangement, in three replications. Tillage systems were main plots, crop residue type soil cover represented subplots and maize hybrids were sub-sub plots. Net sub-sub plot size was of 2.8 m wide by 10 m long. The tillage plots were maintained in the same placement each year, but the subplots for crop residue type and sub-sub plots for maize hybrids were re-randomized within each tillage plot every year.

The tillage treatments were as follows: (i) no-tillage (NT) - no soil disturbance was done except for planting; (ii) chisel ploughing and disking or conventional tillage (CT) - the soil was tilled to a depth of 15 cm with a chisel plough mounted with twisted shanks SG-M 730 (Knoche Maschinenbau GmbH, Bad Nenndorf, Germany), and one pass was made with a CultiPack (Noka-Tume Oy, Turenky, Finland), combination tool consisting of two gangs of offset disks working the soil to approximately 10 cm depth. All tillage operations were done in the autumn, at near-optimal soil moisture conditions. The crop residue soil cover was as follows: (i) soybean (S) and (ii) wheat (W). Residues were chopped and uniform spread on soil surface.

All 120 plots were seeded in the same day, on April 20 in 2012, April 25 in 2013 and April 29 in 2014. Seeding rate for all plots was 60,000 live kernels ha^{-1}. The combined planter used for seeding and fertilizing was of the type of Regina (Gaspardo Seminatrici S.p.A., Morsano al Tagliamento, PN, Italy). This planter can be adjusted for seeding in prepared soil or directly in no tilled land. It is provided with wheals to control precisely the depth of seeding, which in this case was of 5-6 cm.

The doses of nitrogen and phosphorus fertilizers were of 30 kg a.i. ha^{-1} and 80 kg a.i. ha^{-1}, respectively. Their application was simultaneous with seeding. Additionally, a dose of 90 kg a.i. ha^{-1} nitrogen fertilizer was added by surface-banding at the 5-6 leaf stage.

Appropriate herbicides were used to control weeds as needed. No diseases or insect pest controls were applied. Harvest was performed each year in September. Ears were hand harvested off the two central rows of each plot, and then dried and shelled.

Sampling and methods

The grain yield and quality characteristics are reported at 15.5% standard moisture. Grain chemical traits were evaluated based on the data obtained using the Foss Infratec 1241 Grain Analyzer (Foss Tecator AB, Hóganas, Sweden), which was calibrated based on the results recorded using direct methods, as follows: a) the protein content was determined by Kjeldhal method, which is based on vegetal material mineralization with concentrated sulphuric acid in the presence of catalysers for lifting the boiling point and speeding the mineralization process. The amount of sulphuric acid (N/10) cm^3 consumed is equivalent to the ammonia quantity in the analyzed probe. The meal raw (crude, total) protein content (%) was calculated by multiplying the nitrogen percentage of the analyzed probe with 6.25; b) the total fat was determined by classical Soxhlet method (fat petrol ether extraction) and reported to dry matter; c) the starch content was estimated following the Ewers-Grossfeld procedure: by hydrolysis under hydrochloric acid influence, a glucose solution is obtained which shows a concentration closely related to the starch content of the probe. As glucose is optically active, its concentration was measured with a refractometer (polarimeter). All these results were reported as percentages.

Statistical analysis

Analysis of variance (ANOVA) was performed using the MSTAT-C statistical package to determine the significance of differences calculated for grain yields and chemical traits, with hybrids, tillage system and crop residue type soil cover as main factors, for all three growing seasons. „Duncan's New Multiple Range Test”, at 0.05 probability level, was used to compare the mean differences. Correlation analysis (Steel and Torrie, 1980) was also run on grain yield and chemical traits for each tillage system and crop residue type soil cover. We hypothesized that a lack of relationship or a nonlinear relationship between the grain yields and chemical traits of the same hybrids grown under NT and CT or under S and W would exist if the grain yield and its quality traits were broadly modified by the G x T or respectively by G x RRM interactions.

RESULTS AND DISCUSSION

Data presented in Table 2 reveal that the two tillage systems did not affect significantly the maize grain yield per hectare ($P>0.05$). The average value calculated for NT system, over the three experimental growing seasons, was higher with only 1.5% than that for CT system. In exchange, the hybrids under study had a very significant influence on this trait ($P<0.001$), therefore it is suggested that they represent a large genetic diversity. The highest grain yield was registered for hybrid Olt (9.934 t ha^{-1}) and the most reduced one for Generos (8.543 t ha^{-1}).

Tillage system x hybrid interaction makes evident that the influence of the two tillage systems on average yield performance of all genotypes was very significant ($P<0.001$).

Maize hybrids reacted differently to the respective tillage systems. Some of them, such as Olt, Mostiştea, Crişana, Rapsodia and F475M had a slightly higher yield in CT system, in comparison with NT system. The others, such as F376, Generos, Iezer and Milcov performed better in NT system, with yield differences raging between 0.112 t ha^{-1} and 1.164 t ha^{-1}.

The grain yield was significantly ($P<0.05$) influenced by the crop residue type (data presented in Table 2). The average value calculated for S crop residues, over the three experimental growing seasons, was higher with only 2.2% than that for W crop residues. Crop residue type x hybrid interaction was very significant ($P<0.001$). Maize genotypes reacted differently to the respective crop residues type. Some of them, such as Olt, Crişana and Generos had a slightly higher yield in W crop residues, when compared to S crop residues. The others, as F376, F475M, Iezer, Mostiştea, Rapsodia and Milcov performed better in S crop residues, with yield differences raging between 0.080 t ha^{-1} and 1.064 t ha^{-1}.

Table 2. Influence of planting methods, within two tillage systems and two crop residue type soil cover, on grain yield of nine maize hybrids, Fundulea (2012, 2013 and 2014 season means)

Hybrid	Grain yield, t ha^{-1}				
	Tillage system		Mean	Crop residue type	
	NT	CT		S	W
Milcov	9.132cd	7.968f	8.550D	9.082defg	8.018i
F475M	8.531e	9.042cde	8.786CD	8.871defgh	8.702fgh
Mostiştea	8.563de	8.611de	8.587D	8.763efgh	8.411ghi
Crişana	9.087cde	9.151cd	9.119BC	9.071defg	9.167cdefg
Generos	8.611de	8.476e	8.543D	8.219hi	8.867defgh
F376	9.354bc	9.242c	9.298B	9.338cdefg	9.258cdefg
Rapsodia	9.796abc	10.036a	9.916A	10.224a	9.607abcde
Iezer	9.978a	9.239c	9.609AB	9.765abcd	9.452bcdef
Olt	9.913ab	9.954ab	9.934A	9.902abc	9.966ab
Mean	9.218A	9.080A		9.248A	9.050B

Means within the same row, followed by the same letter are not significantly different at the 5% level.

The variability of maize grain yields obtained in CT corresponds to around 45% of the variability which took place in NT (Figure 1), indicating thus the existence of a strong linear relationship between them.

On average over the three experimental years (2012-2014), the grain yield was not statistically influenced by the G x T interaction.

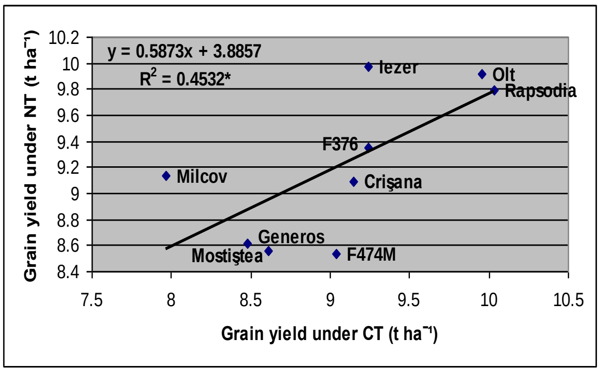

Figure 1. Relationship of grain yield under no tillage (NT) and chisel tillage (CT) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

The variability of maize grain yield from plots with wheat residue (W) explains around 49% from the variability recorded for the plots with soybean (S) crop residues (Figure 2), revealing also in this case a strong linear relationship between the two instances. Considering the means over the three experimental years grain yield was not statistically influenced by the G x RRM interaction.

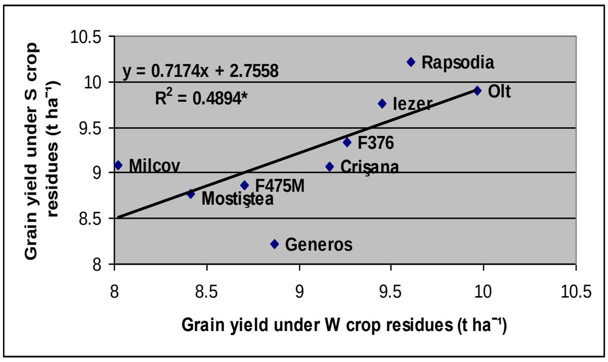

Figure 2. Relationship of grain yield under soybean crop residues (S) and wheat crop residues (W) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

Almost all studies that examined G x T effects on grain yield of maize have been conducted in North America. Most of these studies (82%) surveyed did not report significant G x T interactions (Herrera et al., 2013). Genotypes x tillage interactions were significant in Manitoba - Canada (Wall and Stobbe, 1983) and in Wisconsin (Carter and Barnett, 1987).

Fat content, which may be considered an important quality characteristic of maize grains, was not influenced by tillage system (P>0.05), but varied very significantly (P<0.001) among hybrids (Table 3). The interaction between the two factors was not significant. The highest value was recorded for hybrid Mostiştea (4.95%) and the lowest for F475M (3.98%), both in CT system.

Fat content was also not significantly (P>0.05) influenced by the crop residue type (Table 3). The average value calculated for S crop residues variants, over the three experimental growing seasons, was higher with only 0.7% than that under W crop residues. Crop residue type x hybrid interaction was not significant (P>0.05) too. The highest value (4.95%) was recorded in hybrid Mostiştea under S crop residue, and the lowest value in hybrid F475M (4.02%), in both crop residue types.

Table 3. Influence of planting methods, within two tillage systems and two crop residue type soil cover, on fat content of nine maize hybrids, Fundulea (2012, 2013 and 2014 season means)

Hybrid	Fat content, %				
	Tillage system		Mean	Crop residue type	
	NT	CT		S	W
Milcov	4.20bc	4.18bc	4.19C	4.22cd	4.17cd
F475M	4.05c	3.98c	4.02C	4.02d	4.02d
Mostiştea	4.93a	4.95a	4.94A	4.95a	4.93a
Crişana	4.55ab	4.57ab	4.56B	4.57abc	4.55abc
Generos	4.15bc	4.27bc	4.21C	4.22cd	4.20cd
F376	4.28bc	4.85a	4.57B	4.77ab	4.37bcd
Rapsodia	4.17bc	4.37bc	4.27BC	4.25cd	4.28cd
Iezer	4.60ab	4.52ab	4.56B	4.50abc	4.62abc
Olt	4.25bc	4.37bc	4.31BC	4.28cd	4.33bcd
Mean	4.35A	4.45A		4.42A	4.39A

Means within the same row, followed by the same letter are not significantly different at the 5% level.

Variability of the fat content of maize grains registered for CT plots explains around 60% from the variability recorded for NT plots (Figure 3), thus proving the existence of a very close linear relationship between the fat percentages obtained in NT and CT.

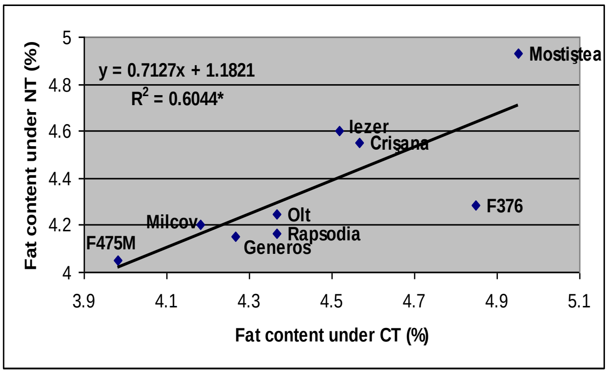

Figure 3. Relationship of fat content under no tillage (NT) and chisel tillage (CT) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

On average over the three experimental years (2012-2014), fat content of maize grains was not significantly influenced by the G x T interaction.

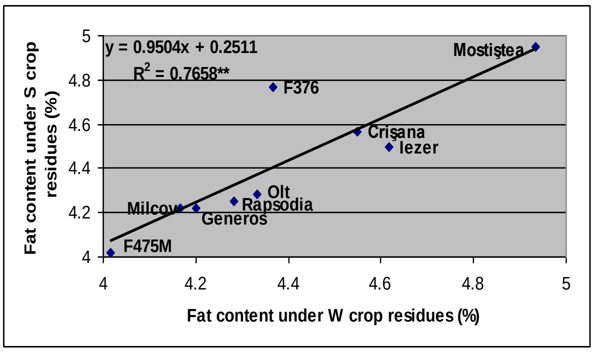

Figure 4. Relationship of fat content under soybean crop residues (S) and wheat crop residues (W) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

Variability of fat content of maize grains calculated for the plots with wheat crop residues (W) corresponds around 77% to the variability which was calculated for the plots with soybean residues (S), putting thus in evidence a very strong linear relationship between the fat percentages obtained under S crop residues and W crop residues (Figure 4).

On average over the three experimental years (2012-2014), fat content of maize grains was not significantly influenced also by the G x RRM interaction.

Another grain quality characteristic of maize is protein content. The results presented in Table 4 show that this trait was not influenced significantly, by the tillage system (P>0.05), but it was affected very significantly by the hybrid (P<0.001). The interaction between the two factors was not significant. The highest value was recorded for hybrid Milcov (10.82%) in CT system and the lowest for Rapsodia (9.25%) in NT system.

Protein content was significantly influenced (P<0.05) by the crop residue type (data presented in Table 4). The mean value calculated for this trait under S crop residues, over the three experimental growing seasons, was 3.6% higher than that registered for W crop residues. Crop residue type x hybrid interaction was not significant (P>0.05). The highest value was recorded for hybrid Milcov (10.97%) in S crop residue and the lowest for Rapsodia (9.30%), in W crop residue.

Table 4. Influence of planting methods, within two tillage systems and two crop residue type soil cover, on protein content of nine maize hybrids, Fundulea (2012, 2013 and 2014 season means)

Hybrid	Protein content, %				
	Tillage system		Mean	Crop residue type	
	NT	CT		S	W
Milcov	10.67ab	10.82a	10.74A	10.97a	10.52ab
F475M	9.35defg	9.75cdefg	9.55BC	9.83cde	9.27e
Mostiştea	9.50cdefg	9.80cdefg	9.65BC	9.82cde	9.48de
Crişana	10.02bcd	10.10bc	10.06B	10.23bc	9.88bcde
Generos	9.73cdefg	9.95cdef	9.84BC	10.28abc	9.40de
F376	9.30efg	9.98cde	9.64BC	9.95bcd	9.33de
Rapsodia	9.25g	9.65cdefg	9.45C	9.60cde	9.30de
Iezer	9.33efg	9.98cdefg	9.58BC	9.63cde	9.53de
Olt	9.27fg	9.93cdef	9.60BC	9.37de	9.83cde
Mean	9.60A	9.98A		9.97A	9.62B

Means within the same row, followed by the same letter are not significantly different at the 5% level.

Variability of protein content of maize grains in CT corresponds around 65% to the variability which was calculated for the plots in NT, suggesting a strong linear relationship between the protein percentages obtained in CT and NT (Figure 5).

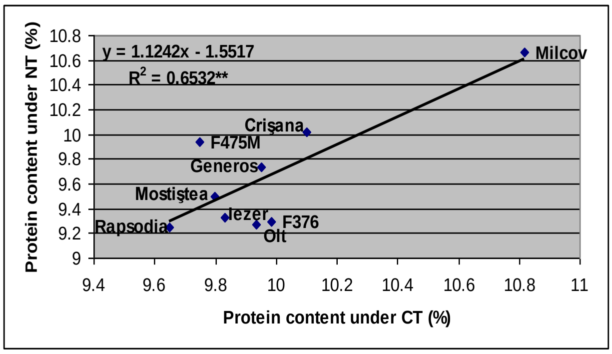

Figure 5. Relationship of protein content under no tillage (NT) and chisel tillage (CT) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

On average over the three experimental years (2012-2014), protein content of maize grains was not significantly influenced also by the G x T interaction.

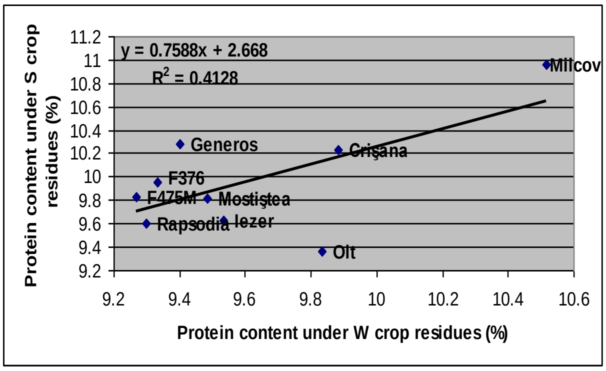

Figure 6. Relationship of protein content under soybean crop residues (S) and wheat crop residues (W) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

Variability of protein content of maize grains calculated for the plots with wheat crop residues (W) explains around 41% of the variability which was calculated for the plots with soybean residues (S), suggesting a lower linear relationship between the protein percentages obtained under S crop residues and W crop residues (Figure 6).

On average over the three experimental years (2012-2014), protein content of maize grains was significantly influenced by the G x RRM interaction.

Another major quality characteristic of maize grains is starch content. Our study shows that this trait was not significantly influenced by tillage systems (P>0.05), but varied very significantly among hybrids (P<0.001), as an expression of their genetic diversity (Table 5).

The interaction between the two factors was non-significant. The highest value of starch content was recorded in NT system, for hybrid F475M (72.43%) and the lowest for hybrid F376 in CT system (70.82%).

The starch content was not significantly (P>0.05) influenced by the crop residue type (data presented in Table 5). Crop residue type x hybrid interaction was not significant (P>0.05). The highest starch percentage was registered for hybrid Generos (72.73%) in W crop residue and the lowest for F376 (70.88%) in S crop residue.

Table 5. Influence of planting methods, within two tillage systems and two crop residue type soil cover, on starch content of nine maize hybrids, Fundulea (2012, 2013 and 2014 season means)

Hybrid	Starch content, %				
	Tillage system		Mean	Crop residue type	
	NT	CT		S	W
Milcov	71.17de	71.18de	71.18DE	71.03de	71.32def
F475M	72.43a	72.38ab	72.41A	72.22abc	72.60ab
Mostiştea	71.80abcd	71.48cde	71.64CD	71.63cdef	71.65cde
Crişana	71.62abcd	71.35cde	71.48CDE	71.53cdef	71.43cdef
Generos	75.57a	71.93abcd	72.25AB	71.77cde	72.73a
F376	71.20de	70.82e	71.01E	70.88f	71.13def
Rapsodia	71.78abcd	71.58bcd	71.68BCD	71.72cde	71.65cde
Iezer	71.48cde	71.55cd	71.52CDE	71.47cdef	71.57cdef
Olt	72.10abc	71.57cd	71.83AB	71.77cde	71.90bcd
Mean	71.79A	71.54A		71.56A	71.78A

Means within the same row, followed by the same letter are not significantly different at the 5% level.

Variability of starch content of maize grains in CT explained only around 32% of the variability of this trait in NT (Figure 7), indicating that the linear relationship between the starch percentages obtained in NT and CT systems was very low.

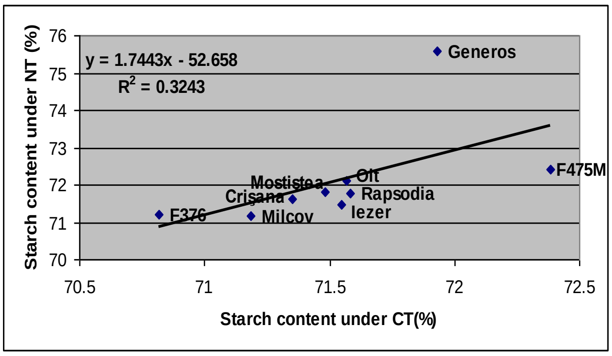

Figure 7. Relationship of starch content under no tillage (NT) and chisel tillage (CT) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

On average over the three experimental years (2012-2014), starch content of maize grains was significantly influenced by the G x T interaction.

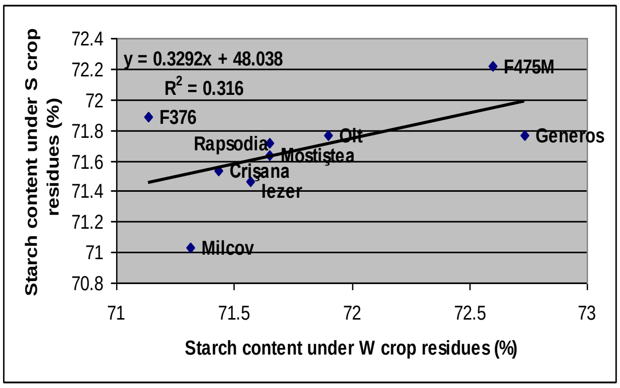

Figure 8. Relationship of starch content under soybean crop residues (S) and wheat crop residues (W) for maize hybrids, based on means of 3 years (2012, 2013 and 2014) at Fundulea

Variability of starch content of maize grains estimated for the plots with wheat crop residues (W) explained around 32% of the variability of the plots with soybean residues (S), suggesting a lack of linear relationship between the starch percentages obtained under S crop residues and W crop residues (Figure 8).

On average over the three experimental years (2012-2014), starch content of maize grains was significantly influenced by the G x RRM interaction.

CONCLUSIONS

This investigation indicates that the nine maize hybrids under study, developed at NARDI Fundulea and being recommended for traditional agriculture, can be successfully used, with almost similar results regarding grain yield, protein and oil contents, when conservation agriculture techniques are practiced, specifically in wheat – maize – soybean and wheat – soybean – maize rotations.

Regarding the starch content, the results of this research suggest the necessity of maize hybrid breeding in the specific conditions of conservative agriculture with certain crop rotations and retention of vegetal residue on soil surface, in order to develop maize hybrids with better response to this new agriculture practice for getting higher starch percentage.

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