

Chețan, Felicia

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THE PROMOTION OF AN AGRICULTURAL SYSTEM WITH SUSTAINABLE TECHNOLOGY ELEMENTS, THE USE OF VEGETABLE RESIDUES AND GREEN FERTILIZERS FOR MAIZE CULTIVATION IN THE TRANSYLVANIA HILLS

FELICIA CHEȚAN¹

Abstract

The paper presents the results of research conducted under the conditions of Turda Agricultural Research and Development Station (ARDS Turda) located in the hill area of Transylvania, regarding the influence of the soil tillage system (CS - plow, MC - minimum chisel, MD - minimum disk and NT - direct sowing), the vegetable residues and the fertilization system on maize yield, in the period 2019, 2020. The systems MD (6430 kg/ha) and NT (5421 kg/ha) negatively influence the yield of maize, the differences from the control (SC 8779 kg/ha) being between 2260 kg/ha - 3239 kg/ha. The yield average achieved in MC (8653 kg/ha) with a difference of 126 kg/ha, does not present statistical assurance. The technological variant with 2.5 t/ha vegetable residues + 350 kg/ha NPK proved to be more efficient in obtained the yield, compared to the variants without mineral fertilizers (vegetable residues + mustard green fertilizer; vegetable residues + gulle).

Keywords: vegetable residues, tillage systems, fertilization, yield, maize

JEL classification: Q01, Q15, Q16

INTRODUCTION

To reduce soil and environmental degradation, due to conventional agriculture and improperly applied technologies that have contributed to lower fertility of agricultural land, numerous studies and research have been conducted to implement new, conservative agricultural technologies, whose main component is the way of cultivating the land for sowing (Yule, 1984; Ungher & Cassel, 1991; Horn et al., 2000; Ibanez et al., 2008; Ulrich et al., 2006; Guş & Rusu, 2011; Wozniak et al., 2014).

The system with minimal works involves the basic work without turning the furrow using several variants: disc harrow, chisel, rotary harrow and preservation of plant debris (in proportion of over 30%) on to the soil surface or superficially incorporated by the works performed, fulfilling the role of mulch. The disc penetrates into the soil up to 15 cm, cuts and grinds it, partially turning it, but its excessive use leads to the deterioration of the soil structure for the most part. The chisel swells the soil, loosening it, and the work is of better quality if performed when the soil is relatively dry. The data published by Behrens (1979) show that in 1973 of the total area cultivated with corn in the USA, the minimum tillage technology was practiced on approximately 12% and no tillage on 23%. Argentina, Brazil, Paraguay and Uruguay use the system for more than 70% of the total cultivated area.

Of the total global area occupied by conservation systems, about 42% is in South America, 34% in the US and Canada, about 11% in Australia and New Zealand, approximate 7% is in Asia and the remaining 5% is in the rest of the world, comprising 3% Europe and Africa 1%. Since the 2000s, the areas occupied by conservative agriculture have expanded in Europe as a result of promotion by the European Federation for Conservative Agriculture (ECAFA), according to data presented by the Food and Agriculture Organization of the United Nations (<https://journals.openedition.org/factsreports/3966>). The same source mentions that in 2013, of the total area of cultivated land on all continents, conservative agriculture occupied about 11%.

According to National Research and Development Institute for Soil Science, Agrochemistry and Environment - ICPA Bucharest, approximately 49.6% of the arable area (4,984 million ha) is

¹ Dr. ing. Chețan Felicia, CS III, STAȚIUNEA DE CERCETARE DEZVOLTARE AGRICOLĂ TURDA, e-mail: felice_fely@yahoo.com

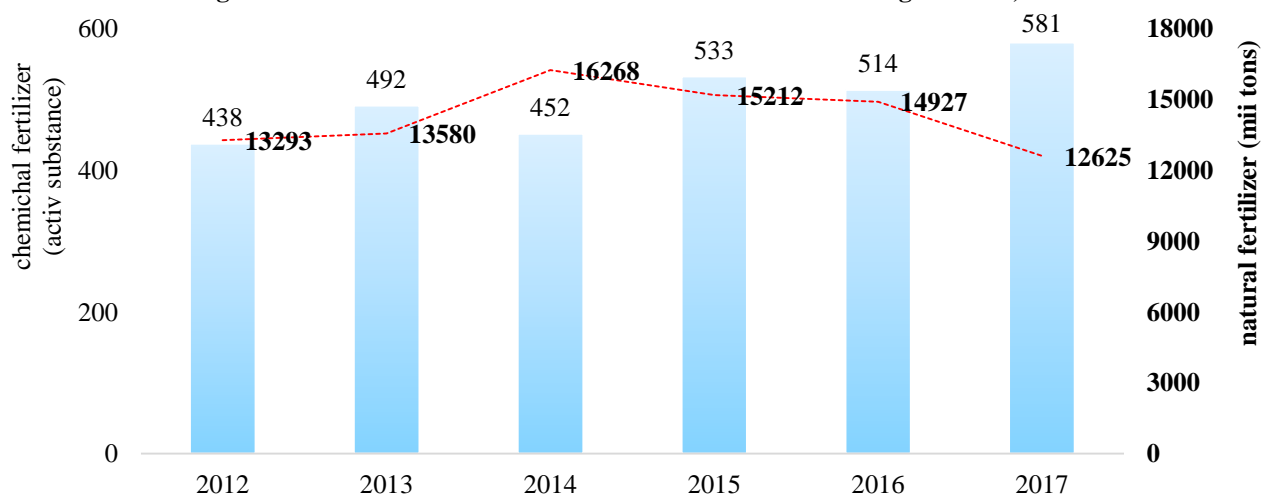
suitable for conservative systems, 15% being represented by flat lands with low slopes and approximately 35% are lands with higher slopes on which there need to be combined conservative variants with anti-erosion works performed on contour lines. The largest land areas suitable for unconventional technology are in the Moldova and Dobrogea.

(www.icpa.ro/documente/coduri/Aplicarea_lucrarilor_conservative_ale_solului.pdf).

The new soil tillage systems depend on the local pedo-climatic conditions, therefore when choosing the tillage variant, the technological properties of the soil have to be taken into account: humidity, soil exposure, macro and microclimate, humus content, etc. (Malschi, 2007; Chețan et al., 2018; Chețan & Chețan, 2020). Optimal climatic conditions, humidity in particular, loamy, loamy-clay soils with a high humus content contribute to the success of maize cultivation obtained in a minimal system (Hulpoi, 1970). The failure of the extension in practice of some alternative land cultivation variants were related to cultural deficiencies and lower yields in the first years of application, requiring a period of at least 10 years for the system of conservative agriculture to balance (Chețan, 2020 a).

The application of unconventional mulching systems, green manures, as well as crop rotation are practices that contribute to maintaining and improving the soil quality. As green manure, there can be sown mustard, a crop that is not expensive, grows quickly, which by shading protects the soil from high temperatures that occur in late summer-early autumn and loosens it due to the well-developed root system (pivoting) that explores in depth the ground. After harvesting the wheat, it can be immediately sown in stubble and in late autumn, when the mustard is in bloom, the crop is abolished at the time of the autumn technological works (plowing, chisel, disk), because the plants are not resistant to low temperatures and are destroyed by frost. In the no tillage system, the crop is not mechanically destroyed. It is preserved, but the plants rot completely until spring, without preventing the sowing of corn (Chețan, 2020 b).

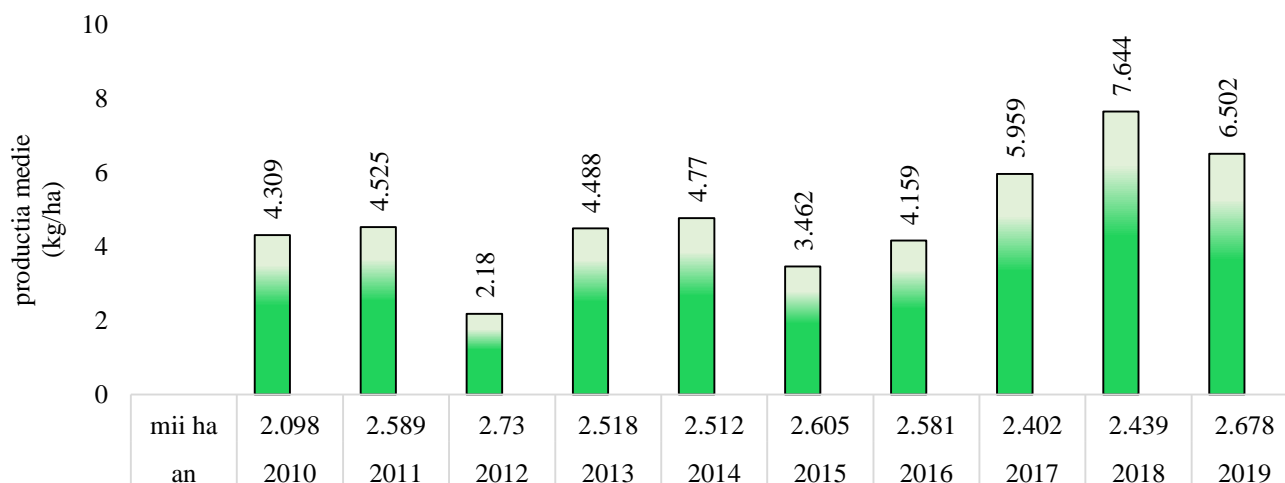
Figure 1. Chemical and natural fertilizers used in Romanian agriculture, 2012-2017



Source: <https://www.madr.ro/>

In recent years, there has been an increase in the sum of useful temperatures during the vegetation period of the maize crop, to which has been added the poor, uneven distribution of rainfall (during the critical periods of June and July), which led to the promotion of hybrids with a longer vegetation period (from the FAO group 300-400) that have better resistance to low temperatures (from the first part of the vegetation period), to drought but also to heat (Has and et al., 2010; Grecu et al., 2011). It is known that the hybrid alone, without proper technology, cannot ensure high performance, and if there are no valuable hybrids, much of the investment expenditure, primarily machinery and equipment needed to practice unconventional agriculture, is lost.

Figure 2. The maize cultivation in Romania, 2010-2019



Source: <http://faostat3.fao.org>

The paper presents the results of research conducted in 2019 and 2020 on the influence of soil tillage, fertilization and mulch on corn production, in the soil and climatic conditions at the Turda Agricultural Research and Development Station (ARDS Turda).

MATERIAL AND METHODS

In 2018 (after the wheat harvest), an experimental field was set up with four tillage systems, to test their influence on the production of two maize hybrids. It should be noted that the land was not cleared of plant debris and was completely preserved (2.5 t/ha). The multifactorial type experiment (subdivided plots method) was located on a vertical clay-iluvial chernozem type soil (SRTS 2012), with pH 6.9; humus 2.95%; total nitrogen 0.211%; phosphorus 23 ppm; potassium 283 ppm, values determined on 0-30 cm depth.

The sowing was carried out with the MT-6 machine at a density of 65,000 plants/ha, the seed treated with 1.0 l/to fungicide based on 25 g/lfludioxonil 9.7 g/lmetalaxyl-M (mefenoxam).

Regardless of the cultivation system practiced, in order to obtain superior productions from a quantitative and qualitative point of view, an important role, aside from all the other technological links, plays is the weed control. In general, pre-emergence and supplementation with post-emergence herbicide ensures a weed-free cultivation, the condition being the knowing of the spectrum of weeds in order to take effective control measures.

In preemergence was applied 0.4 l/ha product based on isoxaflutole 240 g/l and cyprosulfamide (safener) 240 g/l) + 1.4 l/ha based on dimethenamid-P (optically active 720 g/l) and in postemergence 1.0 l/ha product based on fluroxypir 250 g/l to control dicotyledonous weeds (especially *Convolvulus arvensis*, *Rubus caesius*) + 1.5 l/ha based on 40 g/l nicosulfuron to control annual monocotyledonous weeds and perennials (*Agropyron repens*, *Sorghum halpense*, *Setaria* sp., *Cynodon dactylon*, etc.). Against pests (*Tanymecus dilaticollis*, *Diabrotica* v. *Virgifera*) 0.15 l/ha of thiacloprid product 480 g/l was applied.

The experimental factors:

A - tillage system: classic a₁ (CS), plowing with Kuhn Huard Multi Master 125T cormorant plow + germination bed preparation (spring) with rotary harrow HRB 403 D + sowing + fertilizing with MT-6 seed drill + crop maintenance + harvesting; a₂ minimum tillage (MC), land prepared with Gaspardo Pinochio 2,5 chisel (autumn) + germination bed preparation (spring) with rotary harrow HRB 403 D + sown + fertilized with MT-6 seed drill + crop maintenance + harvesting; a₃ minimum tillage (MD), prepared ground Hard Disc Discovery 4 (autumn) + germination bed preparation (spring) with rotary harrow HRB 403 D + sown + fertilized with MT-6 seed drill + crop maintenance

+ harvesting; a₄ no tillage (NT), directly sown + fertilized with MT-6 seed drill + crop maintenance + harvesting.

B - cultivar: b₁ Turda 332; b₂ Turda 344.

C - fertilization: c₁ vegetable residues 2.5 t/ha + 350 kg/ha NPK (16:16:16); c₂ vegetable residues 2.5 t/ha + green mustard fertilizer, using 10 kg/ha of mustard seed for sowing; c₃ vegetable residues 2.5 t/ha + gulle 10 t/ha.

D-year (climatic conditions): d₁ 2019; d₂ 2020.

The maize production obtained on each experimental plot was weighed and transformed at STAS humidity (14%). The experimental data was processed by analyzing the variance and establishing the limit differences (LSD 5%, 1%, 0.1%), ANOVA 2015.

The meteorological conditions from April to September in the two years of experimentation (Turda Meteorological Station, longitude: 23°47 ' ; latitude 46°35'; altitude 427 m) are presented in Table 1.

Table 1. The thermal and pluviometric regime from April-September 2019, 2020at the ARDS Turda

Average monthly temperature (°C)						
Year/month	IV	V	VI	VII	VIII	IX
2019	11.3	13.6	21.8	20.4	22.1	17.1
2020	10.3	13.7	19.1	20.2	21.5	17.8
Average 63 years	9.9	15.0	17.9	19.7	19.3	15.1
Precipitation monthly amount (mm)						
2019	62.6	152.4	68.8	35.0	63.8	19.4
2020	17.8	44.4	166.6	86.8	58	57.4
Average 63 years	45.9	68.7	84.8	77.1	56.5	42.5

RESULTS AND DISCUSSION

In 2019 the average temperature recorded in April (11.3°C) was close to the multiannual average for 63 years (9.9°C). In May there were lower temperatures than normal (13.6°C) the month being characterized as a cool month, after which the temperatures increased generating a warm month (June 21.8°C). The average monthly temperature of 20.4°C recorded in July exceeded the multiannual average by 0.7°C, and, by the end of the year, the temperatures remained high, generating two warm months (August 22.1°C; September 17.1°C). From the point of view of the pluviometric regime, April was very rainy (62.6 mm), the most excessively rainy month (152.4 mm), followed by a reduction of the precipitation amounts in June (68.8 mm). The lack of precipitation was felt in July (35 mm) and September (19.4 mm), but not in August, when the precipitation amounted to 63.8 mm. The months April (10.3°C) and May (13.7°C) of 2020 were hot and dry, the pedological drought continuing until mid-June, after which the rainfall totaled 166.6 mm/month, the rains being accompanied by strong winds. In July (20.2°C) the temperatures were above the multiannual average for this period by 0.5°C and the precipitations exceeded the multiannual average by 9.7 mm, being considered a slightly rainy month. August and September were two warm months, with higher than normal thermal values. The precipitation recorded in August was close to the value of the multiannual average for this month (58 mm), but almost all the precipitation was recorded after the first decade of the month. September is characterized by a total rainfall, although almost all the precipitation was recorded in the last decade of the month (57.4 mm). Unfavorable conditions from the end of September to the beginning of October (rain and fog) maintained a high humidity of the cobs and the harvest took place after October 12.

The analysis of variance (Table 2) indicates that the maize production was affected by the working system, the difference between the control (8779 kg/ha) and the MC system (8653 kg/ha) not being very large (126 kg/ha). It seems that the MD and NT systems have a very significant

negative influence compared to Cs, the production differences being of 2348 and 3358 kg/ha respectively.

On the contrary, the results of the study conducted by Cociu et al. (2017) at Fundulea, indicates that the average production for 8 years for maize was significantly lower in the conditions of tillage with plow (8.82 t/ha) than in the chisel processing (9.05 t/ha).

Table 2. The influence of the tillage system on the maize production, ARDS Turda

The soil system factor (A)	Production (kg/ha)	(%)	Difference (kg/ha)	Significance
a ₁ classic (CS)- plow	8779	100.0	0.00	Ct.
a ₂ minimum tillage (MC) -chisel	8653	98.6	-126	0
a ₃ minimum tillage (MD) - disk	6430	73.2	-2348	000
a ₄ no tillage (NT) –direct sowing	5421	61.8	-3358	000
LSD (5%) = 113; LSD (1%) = 207; LSD (0.1%) = 460.				

The difference between the simple hybrid Turda 332 (control) and the trilinear hybrid Turda 344 is insignificant (only 74 kg/ha). The two cultivars are part of the FAO group 380 (Food and Agricultural Organization) and were distinguished by a production potential of over 7000 kg/ha of grains, which we believe is mainly due to the superior capacity to capitalize on the applied technological factors (Table 3).

Table 3. The influence of the cultivar on the maize production, ARDS Turda

The cultivar factor (B)	Production (kg/ha)	(%)	Difference (kg/ha)	Significance
b ₁ Turda 332	7358	100.0	0.00	Ct.
b ₂ Turda 344	7284	99.0	-74	-
LSD (5%) = 24; LSD (1%) = 40; LSD (0.1%) = 74.				

Compared to the production obtained in the version with fertilization with 350 kg/ha NPK (16:16:16) + 2.5 t/ha vegetable residues that determined a production of 7845 kg/ha (control), the production decreases with 881.2 kg/ha in the case of fertilization with vegetable residues 2.5 t/ha + green mustard fertilizer 10 kg/ha (6964 kg/ha) and with 691.2 kg/ha in the case of the variant with 2.5 t/ha vegetable residues + gulle 10 t/ha (7154 kg/ha), these variants very significantly negatively influencing the production of corn grains. The application of mineral fertilizers (NPK) has a beneficial effect in a better development of plants, and on the increase of production, as can be seen from the data presented in Table 4.

Table 4. The influence of the fertilization on maize production, ARDS Turda

The fertilization factor (C)	Production (kg/ha)	(%)	Difference (kg/ha)	Significance
c ₁ vegetable residues 2.5 t/ha + 350 kg/ha NPK (16:16:16)	7845	100.0	0.00	Ct.
c ₂ vegetable residues 2.5 t/ha + green mustard	6964	88.8	-881.2	000
c ₃ vegetable residues 2.5 t/ha + gulle 10 t/ha	7154	91.2	-691.2	000
LSD (5%) = 74; LSD (1%) = 102; LSD (0.1%) = 140.				

The analysis of the variance shows that the maize production was not largely influenced by climatic conditions during the experimentation period (Table 5). The maize production in the control variant (the average of the two experimental years) was 7321 kg/ha, the production differences registered in 2019 and 2020 being around 16 kg/ha, almost insignificant. In the two years, the amount of precipitation (mm) between May and August was higher than the 63-year average (287.1 mm), registering 322 mm in 2019 and 355.8 mm in 2020. As a result, the grain maize registered a high yield (7337 kg/ha in 2019 and 7305 kg/ha in 2020). In fact, J. Humlum (quoted by Salontai, 1982) established for the conditions in Romania that production increases above average when rainfall exceeds 40 mm in May, 60 mm in June, 60 mm in July and less than 80 mm in August, and that

summer rainfall has a decisive influence on maize production, its distribution being more important than the total amount of rainfall.

Table 5. The influence of the year on the maize production, ARDS Turda

The year factor (D)	Production (kg/ha)	(%)	Difference (kg/ha)	Significance
d ₀ mean	7321	100.0	0.00	Mt
d ₁ 2019	7337	100.2	16.1	-
d ₂ 2020	7305	99.8	-16.1	-
LSD (5%) = 41; LSD (1%) = 55; LSD (0.1%) = 74.				

CONCLUSIONS

In the pedoclimatic conditions in the experimental area, the level of maize production was closely related to the tillage system.

NPK type mineral fertilization applied simultaneously with sowing contributes significantly to the achievement of superior maize yields.

The minimum chisel-working system had a greater impact on maize production, showing a superiority over the straight-sowing or direct-seeding variant.

The tillage variant with the chisel could be considered as an alternative to the classic plowing system, the difference in production between the two systems not being very large (only 126 kg/ha).

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