

THE CORRELATIONS BETWEEN THE DROUGHT AND CLIMATE INDEX AND MAIZE YIELD IN THE CRIȘURILOR PLAIN

Cristian DOMUȚA

University of Oradea, Faculty of Environmental Protection
26 Gen. Magheru St., 410048 Oradea, Romania
Corresponding author: cristian_domuta@yahoo.com

Abstract: The paper is based on the researches carried out in Oradea during 2006-2008 in the following variants: V_1 = Irrigated, without irrigation suspending; V_2 = Irrigated, irrigation suspending in May; V_3 = Irrigated, irrigation suspending in June; V_4 = Irrigated, irrigation suspending in July; V_5 = Irrigated, irrigation suspending in August; V_6 = Unirrigated. The hybrid used: Fundulea 376. Total nitrogen content of the maize grains was determined in the laboratory of the Agricultural and Development Research Station Oradea. In unirrigated maize, soil water reserve on 0-75 cm depth (watering depth) decreased bellow easily available water content (pedological drought) every year: 46 days in 2006; 110 days in 2007 and 76 days in 2008. In the variants with irrigation suspending in the months of the maize irrigation season the pedological drought was presented in these months and a few days in the next month. In the variant with optimum irrigation, water reserve on 0-75 cm depth was maintained between easily available water content and field capacity. Pedological

drought was determined every year and the irrigation was also needed. The irrigation determined the increase of the total water consumption and yield gain in comparison with unirrigated variant. Irrigation suspending in different months determined the yield losses very significant statistically. The biggest protein content was registered in the variant without irrigation suspending; the values registered in the variants with irrigation suspending in May, June, July and August and in the unirrigated variant are smaller, with differences statistically assured. There was a direct link between de Martonne aridity index values and water consumption, yield and protein content and an inverse link between pedological drought and yield quantity and protein content. These are the arguments for irrigation opportunity in maize from Crișurilor Plain. The researches were carried out in the project: PN-II-ID-PCE-2008; 1103/2009 "Study of the relationships in the soil-water-plant-atmosphere system on the land affected succesively by excess and deficit of moisture from North Western Romania regarding the improve of the yield quantity and quality".

Key words: maize, drought, yield, correlations, irrigation suspending

INTRODUCTION

The Crișurilor Plain occupies the central part of the Western Plain of Romania and maize and wheat are cropped on the biggest surfaces. The first researches regarding the maize irrigation were realized starting 1967 by STEPĂNESCU E. and MIHĂILESCU in Girișu de Criș and water regime of the maize using the furrow irrigation was studied: STEPĂNESCU and MATE ȘT. (1972) published the researches regarding easily available water content (50% and 70% for utile water capacity) and watering depth (0.50 m; 0.85 m; 1.2 m) in maize on the chernazem from Girișu de Criș. The researches regarding the soil management in irrigated crops were made by MATE ȘT. (1970-1987), Țucudean I. (1987-1998) in Girișu de Criș and by DOMUȚA C. in Oradea after that (STEPĂNESCU, MATE ȘT. 1972; DOMUȚA C, 1995, 1998).

During 1973-1975 in Girișu de Criș, STEPĂNESCU E. was realized researches regarding the water consumption of the unirrigated and irrigated maize, covering sources, crop coefficient for pan evaporation class A and reference evapotranspiration Thornthwaite, water consumption-yield relationship. Starting 1976 the researches were carried out in Oradea on the preluvosoil and STEPĂNESCU E. (1976-1980), BUTA MIHAELA (1981-1982), COLIBAȘ MARIA

(1983-1985) and Șandor Maria (1986), DOMUȚA C. (1987-2008) were the coordinators. The results of the researches during 1973-1985 were published by GRUMEZA N. and al. (1987) and sustained the irrigation opportunity in maize and established the parameter needed for irrigation projects and irrigation scheduling. DOMUȚA C. (2005) published the researches regarding the contribution of the subjacent layer of the watering depth in water consumption, pedological drought and their correlations with yield and yield determined by irrigation, microclimate, leaves turgescence and plant nutrition modifications under the irrigation influence, influence of the irrigation rate decrease on water consumption, yield, water use efficiency in maize, economical efficiency of the irrigation in maize. BORZA IOANA (2006, 2007) published the researches regarding the influence of the phytotechny factors – crop rotation, weeds, fertilization, water regime – on maize yield and water use efficiency in maize.

MATERIAL AND METHODS

The researches were carried out in Agricultural Research and Development Station Oradea on the preluvosoil with the following soil profile: Ap = 0-24 cm; El = 24-34 cm; Bt₁=34-54 cm; Bt = 54-78 cm; Bt/c =78-95 cm; C = 95-145 cm. There are a big hydro stability (47.5%) of the aggregates ($\square = 0.25$ mm) on ploughingland and bulk density (1.41 g/cm³) indicates a low settling and total porosity is median. On the subjacent depth of the ploughing layer bulk density characterizes the soil like moderate and very settled and total porosity is small and very small. Hydraulic conductivity is big (21.0 mm/h) on 0-20 cm; median (10.5 mm/h; 4.4 mm/h) on 20 – 40 cm and 40 – 60 cm and very small (1.0 mm/h) on 60 – 80 cm.

The watering depth (0-75 cm) was a fixed one (GRUMEZA N. et al., 1989) and field capacity (FC = 24.2% = 2782 m³/ha) and wilting point (WP = 10.1 = 1158 m³/ha) have median values. Easily available water content (Wea) was established in function of texture: Wea = WP + 2/3 (FC – WP); (CANARACHE A., 1990); their values for 0-75 cm are 19.5% and 2240 m³/ha.

All the soil profile are low acid (6.11 – 6.8), humus content (1.44 – 1.75%) is small and total nitrogen is low median (0.127 – 0.157). After 30 years of good soil management, good practices the soil phosphorus content became very good (from 22.0 ppm to 150.8 ppm) on ploughing depth, potassium content (124.5 ppm) is median.

A drill is the water source for irrigation and their quality for irrigation is very good: pH = 7.2; Na⁺ = 12.9%; mineral residue = 0.5 g/l; CSR = -1.7; SAR = 0.52.

In comparison with multiannual average (1931-2005) of 621.1 mm during the studied period the annual rainfall were of 684.7 mm in 2006; of 556.1 mm in 2007 and of 585.7 mm in 2008.

The following variants were studied: V₁ = unirrigated; V₂ = Irrigated without the irrigation suspending in the maize irrigation season; V₃ = Irrigated, with irrigation suspending in May, V₄ = Irrigated, with irrigation suspending in June; V₅ = Irrigated, with irrigation suspending in July; V₆ = Irrigated, with irrigation suspending in August. The surface of the experiment plot was 50 m². Number of repetition = 4; Irrigation method used was sprinkler with modifications for rectangular plots. Cultivar used: Fundulea 376. Fertilization system: N₁₂₀P₉₀K₆₀.

Soil moisture of 0 – 75 cm depth was determined ten to ten days and monthly on 0 – 150 cm depth. In the variant without irrigation suspending the moment of the irrigation use was when the soil water reserve on 0 – 75 cm depth decreased to easily available water content. In the variant with irrigation suspending in different months didn't irrigate in these months.

RESULTS AND DISCUSSIONS

Pedological drought in maize

Pedological drought is considered when the soil moisture bellow easily available

water content on watering depth; the decrease of the soil moisture below wilting point is considered very strong pedological drought (DOMUȚA C., 2004). The determination of the number of days with drought is based on the soil moisture determination and on the soil water reserve graph realized after that (DOMUȚA C., 1995).

In unirrigated maize, in 2006, pedological drought affected the plants in 46 days. Irrigation suspending in July determined 23 days with pedological drought and irrigation suspending in August determined 6 days with pedological drought (table 1)

Table 1

Number of days with pedological drought in maize from different variants of water provisionment, in the conditions from Oradea 2006-2008

| Variant | Month | | | | | IV-VIII |
|----------------|-------|----|----|-----|------|---------|
| | IV | V | VI | VII | VIII | |
| 2006 | | | | | | |
| V ₁ | 0 | 0 | 0 | 0 | 0 | 0 |
| V ₂ | 0 | 0 | 0 | 0 | 0 | 0 |
| V ₃ | 0 | 0 | 0 | 0 | 0 | 0 |
| V ₄ | 0 | 0 | 0 | 20 | 3 | 23 |
| V ₅ | 0 | 0 | 0 | 0 | 6 | 6 |
| V ₆ | 0 | 0 | 5 | 31 | 10 | 46 |
| 2007 | | | | | | |
| V ₁ | 0 | 0 | 0 | 0 | 0 | 0 |
| V ₂ | 0 | 10 | 2 | 0 | 0 | 12 |
| V ₃ | 0 | 0 | 17 | 4 | 0 | 21 |
| V ₄ | 0 | 0 | 0 | 20 | 5 | 24 |
| V ₅ | 0 | 0 | 0 | 0 | 17 | 17 |
| V ₆ | 14 | 22 | 26 | 28 | 20 | 110 |
| 2008 | | | | | | |
| V ₁ | 0 | 0 | 0 | 0 | 0 | 0 |
| V ₂ | 0 | 8 | 2 | 0 | 0 | 10 |
| V ₃ | 0 | 0 | 14 | 0 | 0 | 14 |
| V ₄ | 0 | 0 | 0 | 21 | 3 | 24 |
| V ₅ | 0 | 0 | 0 | 0 | 28 | 28 |
| V ₆ | 0 | 8 | 16 | 21 | 31 | 76 |

- V₁ = Irrigated without irrigation suspending
- V₂ = Irrigated, irrigation suspending in May (4 – 9 leave)
- V₃ = Irrigated, irrigation suspending in June (10 – 18 leave)
- V₄ = Irrigated, irrigation suspending in July (panicle appearance – grains fill)
- V₅ = Irrigated, irrigation suspending in August (grains fill - milk-vax ripen)
- V₆ = Unirrigated

The biggest number with pedological drought in unirrigated maize was registered in 2007, 110 days. Irrigation suspending in every month of the maize irrigation season determined the appearance of the pedological drought, the biggest in the variant with irrigation suspending in July (24 days) and June (21 days) and the smallest in the variant with irrigation suspending in May (12 days). (table 1)

In 2008, number of days with pedological drought in unirrigated maize was of 76 In the variant with irrigation suspending in August (28 days) and July (24 days) and the smallest in the variant with irrigation suspending in May. (table 1)

Irrigation water regime in maize

Optimum irrigation water regime of the maize consists of 1160 m³/ha and 3 rated in 2006, 2950 m³/ha and 8 rates in 2007 and 3320 m³/ha and 8 rates also in 2008. Irrigation suspending determined the decrease of the irrigation rate (table 2)

Irrigation regime of the maize from different variants of water provisionment in the conditions from Oradea 2006-2008

| Variant | IV | | V | | VI | | VII | | VIII | | IV-VIII | |
|----------------|------------|---|------------|---|------------|---|------------|---|------------|---|------------|---|
| | Σm | n | Σm | n | Σm | n | Σm | n | Σm | n | Σm | N |
| 2006 | | | | | | | | | | | | |
| V ₁ | - | - | - | - | - | - | 1160 | 3 | - | - | 1160 | 3 |
| V ₂ | - | - | - | - | - | - | 1160 | 3 | - | - | 1160 | 3 |
| V ₃ | - | - | - | - | - | - | 1160 | 3 | - | - | 1160 | 3 |
| V ₄ | - | - | - | - | - | - | - | - | - | - | - | - |
| V ₅ | - | - | - | - | - | - | 1160 | 3 | - | - | 1160 | 3 |
| 2007 | | | | | | | | | | | | |
| V ₁ | 300 | 1 | 400 | 1 | 500 | 1 | 1200 | 4 | 550 | 1 | 2950 | 8 |
| V ₂ | 300 | 1 | - | - | 500 | 1 | 1200 | 4 | 550 | 1 | 2550 | 7 |
| V ₃ | 300 | 1 | 400 | 1 | - | - | 1200 | 4 | 550 | 1 | 2450 | 7 |
| V ₄ | 300 | 1 | 400 | 1 | 500 | 1 | - | - | 550 | 1 | 1750 | 4 |
| V ₅ | 300 | 1 | 400 | 1 | 500 | 1 | 1200 | 4 | - | - | 2400 | 7 |
| 2008 | | | | | | | | | | | | |
| V ₁ | - | - | 500 | 1 | 1020 | 2 | 1100 | 3 | 700 | 2 | 3320 | 8 |
| V ₂ | - | - | - | - | 1020 | 2 | 1100 | 2 | 700 | 2 | 2820 | 6 |
| V ₃ | - | - | 500 | 1 | - | - | 1100 | 2 | 70 | 2 | 2300 | 5 |
| V ₄ | - | - | 500 | 1 | 1020 | 2 | - | - | 700 | 2 | 2220 | 5 |
| V ₅ | - | - | 500 | 1 | 1020 | 2 | 1100 | 2 | - | - | 2620 | 5 |

V₁ = Irrigated without irrigation suspending

V₂ = Irrigated, irrigation suspending in May (4 – 9 leave)

V₃ = Irrigated, irrigation suspending in June (10 – 18 leave)

V₄ = Irrigated, irrigation suspending in July (panicle appearance – grains fill)

V₅ = Irrigated, irrigation suspending in August (grains fill - milk-wax ripen)

Σm = irrigation rate

n = number of rate

Irrigation influence in maize yield

The yield obtained in 2006 in the variant without irrigation suspending in the maize irrigation season was bigger than the yield from unirrigated variant with 42.9%. The irrigation was needed in August, only and their suspending determined an yield losses of 3870 kg/ha (29.4%) in comparison with the optimum irrigated variant (table 3)

In 2007, the yield gain obtained in the variant with optimum irrigation in comparison with unirrigated variant was 6650 kg/ha (102.8%). Irrigation was needed every month of the irrigation season and their suspending determined the yield losses very significant statistically; the biggest yield losses (5220 kg/ha, 39.8%) was determined in the variant with irrigation suspending in June.

Yield obtained in 2008 in the variant without irrigation suspending (14200 kg/ha) was bigger than the yield from unirrigated variant with 86.5%. Irrigation suspending determined the yield losses, very significant statistically in all the cases; the biggest was determined by irrigation suspending in August, 3860 kg/ha (27.2%). (table 3)

The correlations between de Martonne aridity index and water consumption and pedological drought and yield

Five types of function – linear, logarithmic, polynomial, power, exponential – were used for quantification of the correlations. Between de Martonne aridity index and maize water consumption was quantified a direct link, very significant (power function); there were an inverse correlations (polynomial function had the biggest correlation coefficient) very

significant statistically, between number of days with pedological drought and yield obtained in the studied variant. (Fig. 2)

Table 3

Influence on yield of the irrigation suspending in different months of the maize irrigation season in the conditions from Oradea, 2006-2008

| Variant | Yield | | Difference | | Statistically significant |
|----------------|-------|--------------|------------|----------------|---------------------------|
| | Kg/ha | % | Kg/ha | % | |
| 2006 | | | | | |
| V ₁ | 13200 | 100 | - | - | Mt |
| V ₂ | 13110 | 99.3 | -90 | -0.7 | - |
| V ₃ | 13410 | 101.6 | +210 | +1.6 | - |
| V ₄ | 9330 | 70.6 | 3870 | -29.4 | ooo |
| V ₅ | 13340 | 101.1 | 140 | 1.1 | - |
| V ₆ | 9240 | 70.0 | 3960 | -30.0 | ooo |
| LSD 5% = 230 | | LSD 1% = 410 | | LSD 0.1% = 670 | |
| 2007 | | | | | |
| V ₁ | 13120 | 100 | - | - | Mt |
| V ₂ | 12100 | 92.2 | -1020 | -7.8 | ooo |
| V ₃ | 7900 | 60.2 | -5220 | -39.8 | ooo |
| V ₄ | 8300 | 63.6 | -4820 | -36.4 | ooo |
| V ₅ | 10490 | 79.9 | -2630 | -20.1 | ooo |
| V ₆ | 6470 | 49.3 | -6650 | -50.7 | ooo |
| LSD 5% = 240 | | LSD 1% = 410 | | LSD 0.1% = 790 | |
| 2008 | | | | | |
| V ₁ | 14200 | 100 | - | - | Mt |
| V ₂ | 13180 | 92.8 | -1020 | -7.2 | ooo |
| V ₃ | 11620 | 81.8 | -2580 | -18.2 | ooo |
| V ₄ | 11540 | 81.3 | -2660 | -18.7 | ooo |
| V ₅ | 10340 | 72.8 | -3860 | -27.2 | ooo |
| V ₆ | 7610 | 51.5 | -6590 | -48.5 | ooo |
| LSD 5% = 190 | | LSD 1% = 310 | | LSD 0.1% = 680 | |

- V₁ = Irrigated without irrigation suspending
- V₂ = Irrigated, irrigation suspending in May (4 – 9 leave)
- V₃ = Irrigated, irrigation suspending in June (10 – 18 leave)
- V₄ = Irrigated, irrigation suspending in July (panicle appearance – grains fill)
- V₅ = Irrigated, irrigation suspending in August (grains fill - milk-vax ripen)
- V₆ = Unirrigated

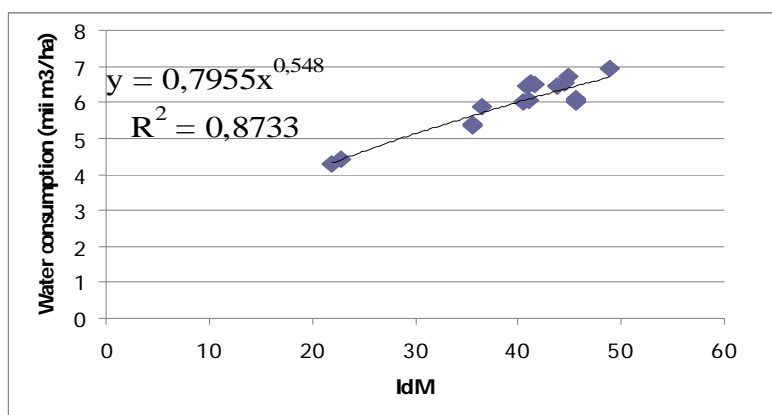


Fig. 1. Correlation between de Martonne aridity index and yield in maize, Oradea 2006-2008

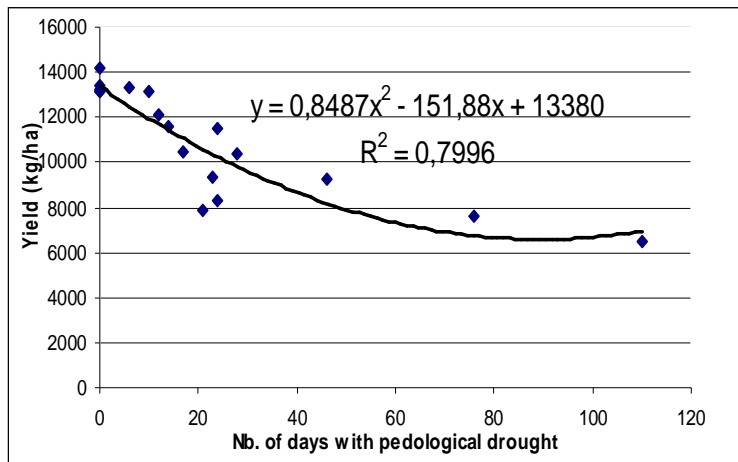


Fig. 2. Correlation between number of days with pedological drought and yield in maize, Oradea 2006-2008

The researches results sustain the needed of the optimum irrigation in maize from Crişurilor Plain because the level of the yield is very significant influenced.

CONCLUSIONS

The paper is based on the researches carried out during 2006-2008 on the preluvosoil from Agricultural Research and Development Station Oradea in 6 variants regarding the maize water regime and the following conclusions are emphasized.

- In unirrigated variant, soil water reserve on 0-75 cm depth (watering depth) decreased bellow easily available water content (pedological drought) every year: 46 days in 2006; 110 days in 2007 and 76 days in 2008. In the variants with irrigation suspending in the months of the maize irrigation season the pedological drought was presented in these months and a few days in the next month.
- Maintaining the soil water reserve between easily available water content and field capacity determined to use an irrigation rates of 1160 m³/ha in 2006, of 2950 m³/ha in 2007 and of 3320 m³/ha in 2008. The irrigation rates were smaller in the variants with irrigation suspending in different months.
- In the all 5 variants with irrigations, the maize yields were bigger than the yields from unirrigated variant: the differences were very significant statistically. Irrigation suspending in different months of the maize irrigation season determined yield gains in comparison with the variant without irrigation suspending: in 2006 the biggest yield loss was registered in the variant with irrigation suspending in July, in 2007 in the variant with irrigation suspending in June and in 2008 in the variant with irrigation suspending in August.
- Irrigation determined the increase of the protein content in comparison with unirrigated variant. As consequence the relative difference between total protein productions increased in comparison with the relative differences between grains yields. In the variants with the irrigation suspending, protein content decreased in comparison with the variant without irrigation suspending; the differences were statistically assured.
- Between de Martonne aridity index and maize water consumption was quantified a direct link, very significant (power function $y = 0,7955x^{0,548}$, $R^2 = 0,8733$); the inverse links,

very significant statistically, were quantified between number of days with pedological drought and level of yield: $y = 0.8487x^2 - 151.88x + 13380$; $R^2 = 0.7996$). This correlations sustain the irrigation opportunity in maize from Crisurilor Plain, too.

Acknowledgments

The researches were carried out in the project: PN-II-ID-PCE-2008; 1103/2009 "Study of the relationships in the soil-water-plant-atmosphere system on the land affected succesively by excess and deficit of moisture from North Western Romania regarding the improve of the yield quantity and quality".

BIBLIOGRAPHY

1. BORZA IOANA, 2008 - Researches Regarding the Influence of the Plant Density on Yield and Water Use Efficiency in Maize Crop from Crisurilor Plain, *Analele Universității Oradea Fascicula Protecția Mediului*, vol XIII Anul 13, p.17-24
2. BORZA IOANA MARIA, 2007 - Valorificarea apei de către cultura porumbului din Câmpia Crișurilor. Editura Universității Oradea, p.195-208
3. BORZA IOANA MARIA, 2006 - Cercetări privind influența unor măsuri fitotehnice asupra valorificării apei de către cultura porumbului în condițiile Câmpiei Crișurilor. Teză de doctorat USAMV Cluj- Napoca p.189-201
4. BOTZAN M., 1966 - Culturi irigate. Ed Agrosilvică, p. 70-88
5. DOMUȚA C., 1995 - Contribuții la stabilirea consumului de apă al principalelor culturi din Câmpia Crișurilor. Teză de doctorat ASAS „Gheorghe Ionescu Șișești” București, p. 140-162
6. DOMUȚA C., 1998 - Cercetări și criterii de apreciere a oportunității irigației porumbului pentru boabe în condițiile zonei moderat subumede din centrul Câmpiei de Vest. *Analele ICCPT Fundulea* vol LXV, p. 203-222
7. DOMUȚA C., 2003 - Oportunitatea irigațiilor în Câmpia Crișurilor, Editura Universității din Oradea, p. 50-72
8. DOMUȚA C. , 2005 - Irigarea culturilor, Editura Universității din Oradea, p. 96-108
9. DOMUȚA C. 2006 - Tehnică experimentală, Editura Universității din Oradea, p.112-150
10. DOMUȚA C. , 2009 - Irigarea culturilor, Editura Universității din Oradea
11. GRUMEZA N., KLEPS CR., 2005 - Amenajările de irigații din România. Ed. Ceres București p. 151-158
12. STEPĂNESCU E., MATE ȘT., 1972 - Irigațiile – mijloc de sporire a producțiilor la principalele culturi. În vol. „Zece ani de activitate în sprijinul producției 1962-1972” Stațiunea Experimentală Agricolă Oradea, p. 63-68