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# Relation Between Areas of Maize Tillage for Grain and Infection-pressure Zones of Potato Tillage with PVY and PLRV in Poland[1]

*Leszek Styszko, Diana Fijałkowska*
*Koszalin University of Technology*

*Adam Majewski*
*Koppert Polska Ltd., Duchnice-Ożarów Mazowiecki*

## 1. Introduction

The climate warming in Poland caused, that in years 1990-2007 area of maize tillage for grain started to grow with decreasing acreage of potato tillage, also in northern Poland (table 1). This region has been recognised earlier as unfavourable (III) for maize tillage for grain. Maize is the plant which has very wide possibility of usage: as fodder, for consumption and for energetic purposes (biogas and bioethanol). The region of Pomerania is variable when considering climate conditions. Western Pomerania has better conditions for maize tillage, than Middle and Eastern Pomerania. The least favourable conditions for maize tillage are in northern and central part of Pomorskie province. When comparing the maps of maize tillage regions in Poland (Fig. 1) it seems that they may be negatively correlated with infection-pressure-zones of potato tillage with potato leaf roll virus (PLRV) (Fig. 2) and potato virus Y (PVY) (Fig. 3). Those zones were established earlier on the base of accumulated sum of positive temperatures in the period 1.01-30.04 for PLRV and 1.01-10.07 for PVY in the years 1948-1962 (Gabriel 1965). Analysis of those zones leads to conclusion, that macroregion Pomerania cannot be uniformly included in region III of maize tillage, as it is done in many publications (**Dubas** 1999, **Sulewska 1997**).

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**Table 1.** Area of potato and maize tillage in Poland in the years 1990-2007 according to **Central Statistical Office**

**Tabela 1.** Powierzchnia uprawy ziemniaków i kukurydzy w Polsce w latach 1990-2007 według **GUS**

| Year | Potatoes, thousands of ha | Maize, thousands of ha | In this directions of maize usage: | | | |
|---|---|---|---|---|---|---|
| | | | Grain | | Silage | |
| | | | Acreage, thou. ha | percent | Acreage, thou. ha | percent |
| 1990 | 1835 | 384 | 59 | 15.4 | 325 | 84.6 |
| 1995 | 1522 | 181 | **48** | 26.5 | 133 | 73.5 |
| 1996 | 1342 | 223 | **69** | 30.9 | 154 | 69.1 |
| 1997 | 1306 | 225 | **77** | 34.2 | 148 | 65.8 |
| 1998 | 1295 | 230 | **85** | 37.0 | 145 | 63.0 |
| 1999 | 1268 | 250 | **104** | 41.6 | 146 | 58.4 |
| 2000 | 1251 | 314 | **152** | 48.4 | 162 | 51.6 |
| 2001 | 1194 | 404 | **224** | 55.4 | 180 | 44.6 |
| 2002 | 803 | 515 | **319** | 61.9 | 196 | 38.1 |
| 2003 | 766 | 595 | **356** | 59.8 | 239 | 40.2 |
| 2004 | 713 | 702 | **412** | 58.7 | 290 | 41.3 |
| 2005 | 588 | 665 | **339** | 50.9 | 326 | 49.0 |
| 2006 | 597 | 659 | **310** | 47.0 | 349 | 53.0 |
| 2007 | 570 | 629 | **262** | 41.7 | 367 | 58.3 |

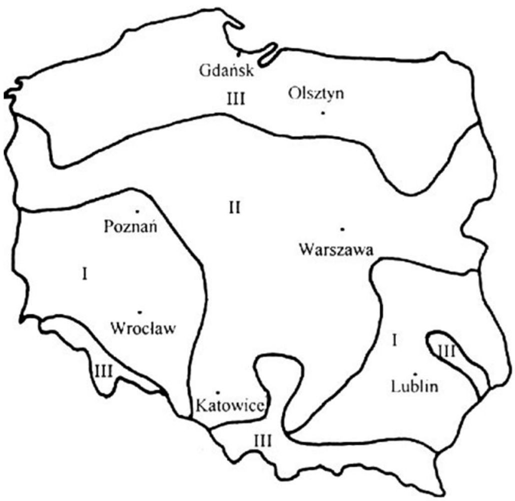


**Fig. 1.** Regions of maize tillage in Poland (**Dubas 1999**); region I – the best climate conditions for maize tillage, region III – the worst

**Rys. 1.** Rejony uprawy kukurydzy w Polsce (**Dubas 1999**); rejon I – najlepsze warunki klimatyczne do uprawy kukurydzy, rejon III – najgorsze

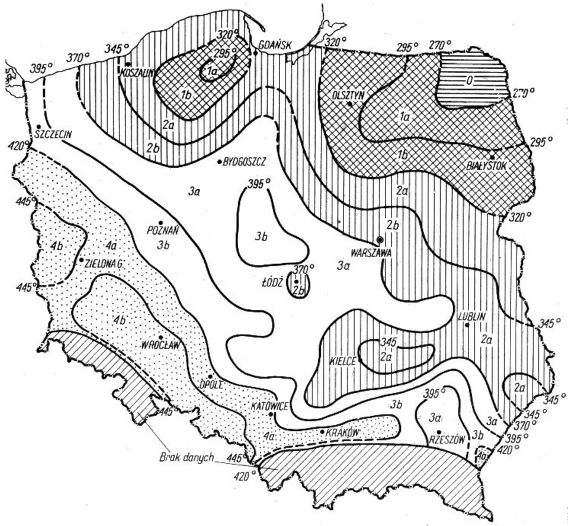


**Fig. 2.** PVY infection-pressure-zones in Poland (**Gabriel 1965**); zone 1a – the worst conditions for virus Y of potato (PVY), and zone 4b – the best

**Rys. 2.** Strefy zagrożenia PVY w Polsce (**Gabriel 1965**); strefa 1a – warunki najgorsze do szerzenia się wirusa Y ziemniaka (PVY), a strefa 4b – najlepsze.

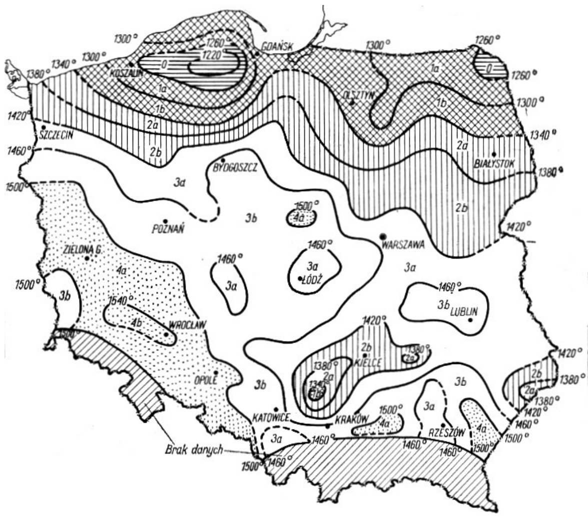


**Fig. 3.** PLRV infection-pressure-zones (**Gabriel 1965**); zone 1a – the worst conditions for leaf coil virus of potato (PLRV) spreading, and zone 4b – the best

**Rys. 3.** Strefy zagrożenia PLRV w Polsce (**Gabriel 1965**); strefa 1a – warunki najgorsze do szerzenia się wirusa liściozwoju ziemniaka (PLRV), a strefa 4b – najlepsze

The aim of the research was to determine relationship between regions of maize tillage for grain and infection-pressure-zones of leaf roll and potato Y viruses of potato tillage in Poland. Determination of this relationship may be useful when selecting areas for maize tillage for energetic purposes in northern Poland.

## 2. Materials and methods

In the years 2001-2005 one factor cornfield experiments in two repetitions in 15 localities with 12 varieties of maize (Table 2 and 3) were established. The size of plot for crop was 1000 m$^2$. Each year in the area of maize tillage four experimental points were established. Separate localities were described with numerical values corresponding to region of tillage and infection-pressure-zone of potato viruses. Soil conditions in years and in localities as well as technology of maize tillage for grain were similar. Crop of grain, dry mass content, excess of water for evaporation and costs of energy carriers used for drying grain to 15% of water content were assessed in the experiments. Results of the experiments were statistically analysed determining structure of variational components as well as correlation coefficients between the crop and regions of maize tillage and infection-pressure-zones of potato leaf roll and potato Y viruses.

**Table 2.** Location of experimental points with maize
**Tabela 2.** Lokalizacja punktów doświadczalnych z kukurydzą

| No | Locality | Years of experiment | Region of maize tillage | Infection-pressure-zone of PVY | Infection-pressure-zone of PLRV | County |
|---|---|---|---|---|---|---|
| 1 | Dretyń | 2002-5 | 3 | 1a | 1b | bytowski |
| 2 | Janowice | 2004-5 | 3 | 1a | 1b | lęborski |
| 3 | Lenarty | 2002-5 | 3 | 1a | 1a | olecki |
| 4 | Złocieniec | 2002-5 | 3 | 1b | 2a | drawski |
| 5 | Wolinia | 2001-3 | 3 | 1a | 1b | słupski |
| 6 | Gliszcz | 2002-3 | 2 | 3a | 3a | bydgoski |
| 7 | Kurzycko | 2002-5 | 2 | 4a | 4b | gryfiński |
| 8 | Mieszkowice | 2001-5 | 2 | 4a | 4b | gryfiński |
| 9 | Piaski | 2002-3 | 2 | 4a | 4a | grodziski |
| 10 | Palędzie | 2004-5 | 2 | 4a | 4a | poznański |
| 11 | Witosław | 2004-5 | 2 | 3a | 3a | nakielski |
| 12 | Cieleśnica | 2002-5 | 1 | 3a | 2a | bialski |
| 13 | Gniechowice | 2002-5 | 1 | 4b | 4b | wrocławski |
| 14 | Głogówek | 2002-5 | 1 | 4a | 4b | prudnicki |
| 15 | Głuchów | 2002-5 | 1 | 3a | 3a | łańcucki |

**Table 3.** Characteristics of tested maize varieties
**Tabela 3.** Charakterystyka badanych odmian kukurydzy

| No | Variety | FAO earliness class | Earliness group | Years of experiments |
|---|---|---|---|---|
| 1 | LG 32.26 | 250 | mid early | 2001-5 |
| 2 | LG 22.75 | 260 | mid early | 2001-5 |
| 3 | LG 22.65 | 240 | mid early | 2001-5 |
| 4 | LG 22.44 | 240 | mid early | 2001-5 |
| 5 | LG 22.22 | 250 | mid early | 2001-5 |
| 6 | LG 32.15 | 220 | early | 2001-5 |
| 7 | LG 22.43 | 240 | mid early | 2001-5 |
| 8 | Banquise | 220 | early | 2001-5 |
| 9 | LG 21.95 | 220 | early | 2004-5 |
| 10 | LG 32.12 | 210 | early | 2004-5 |
| 11 | LG 32.25 | 250 | mid early | 2004-5 |
| 12 | LG 32.32 | 250 | mid early | 2004-5 |

## 3. Results

Syntheses of results made for 8 varieties of maize included years 2002-2005 (a), and for 12 varieties years 2004-2005 (b). Above mentioned years were characterized by diverse course of weather in the period of vegetation; the most favourable conditions for maize harvesting were in the year 2002, and the least favourable – in 2004. Regions of tillage had the strongest influence on the crop of grain and the content of dry mass among studied factors. Years of tillage, connected with the course of weather in the period of vegetation had slightly less strong influence, variety had weaker influence and the weakest influence had localities in regions of tillage. Effects of tillage regions, years and varieties in each analysis were highly significant. Significant effect of interaction was proved only for co-operation of varieties with regions of tillage at crop of grain.

Crop of maize dry grain from region III of tillage was 2.01 and 1.74 $t\ ha^{-1}$ that is 22.0-20.6% lower than from region I in both analyses, and gathered grain contained 5.7-6.9% less dry mass (Table 4). So grain of maize from region III of tillage contained more water which should be removed during drying. This caused, that costs of drying grain coming from the region III of tillage in the relation to region I were 22.4-26.4 $zloty \cdot t^{-1}$, that is 39.0-43.1% higher.

Analyses of correlations between crop of maize grain, dry mass content and costs of energy carriers used for drying grain and regions of maize tillage in Poland and infection-pressure-zones of PVY and PLRV showed extremely significant negative dependence (Table 5). This is connected with the fact that the smallest infection-pressure by potato viruses takes place in the coolest regions (infection-pressure-zone I), and those conditions are the least favourable for maize tillage (regions of maize tillage III and IV).

**Table 4.** Influence of regions of maize tillage on grain crop, content of dry mass and costs of energy carriers used for drying grain to 15% of water content in a and be analyses

**Tabela 4.** Wpływ rejonów uprawy kukurydzy na plon ziarna, zawartość suchej masy oraz koszt nośników energii zużytych do wysuszenia ziarna do wilgotności 15% w analizach a i b

| Maize tillage region | Crop of grain with 15% of water content, t ha$^{-1}$ | | Percentage of dry mass in grain, % | | Costs of energy carriers for drying 1 ton of grain to 15% of water content, zł·t$^{-1}$ | |
|---|---|---|---|---|---|---|
| | a | b | a | b | a | b |
| III | 7.12 | 6.72 | 64.4 | 62.3 | 79.8 | 87.7 |
| II | 8.23 | 8.29 | 68.7 | 68.1 | 62.8 | 65.4 |
| I | 9.13 | 8.46 | 70.1 | 69.2 | 57.4 | 61.3 |
| $NIR_{0,05}$ | 0.92 *** | 1.09 ** | 2.3 *** | 3.2 ** | 8.9 *** | 12.5 ** |

*Significance with F Fisher-Snedecor test at: * α=0.05; ** α=0.01 and *** α=0.001*

**Table 5.** Correlation coefficients between regions of maize tillage and PVY and PLRV infection-pressure-zones at grain crop, dry mass content in grain and costs of energy carriers used for drying grain to 15% of water content

**Tabela 5.** Współczynniki korelacji pomiędzy rejonami uprawy kukurydzy a strefami zagrożenia PVY i PLRV przy plonie ziarna, zawartości suchej masy w ziarnie oraz koszcie nośników energii zużytych do wysuszenia ziarna do wilgotności 15%

| Analysed feature | Correlation coefficients between | | |
|---|---|---|---|
| | regions of maize tillage | infection-pressure-zones | |
| | | PVY | PLRV |
| Crop of grain with 15% of water content | -0.415*** | 0.388*** | 0.351*** |
| Dry mass content in grain | -0.472*** | 0.461*** | 0.406*** |
| costs of energy carriers used for drying grain to 15% of water content calculated to 1 t of wet grain | 0.472 *** | -0.461 *** | -0.406 *** |

*Significance with F Fisher-Snedecor test at: * α=0.05; ** α=0.01 and *** α=0.001*

## 4. Discussion

Traditionally in Poland, maize has been grown for silage from whole plants. Importance of such tillage decreased after 1990, but this direction of maize usage is rebuilding again. The interest in maize tillage for grain has grew up after 2000, with insignificant break down of tillage in years 2005-2006. The interest in maize tillage for grain in Poland again has been growing up since 2007, due to its very high price and perspective of its usage for energetic purposes (**Michalski 2007**, **Sulewska 2007**). Presented experiments showed that the maps of threat zones of potato viruses (PVY and PLRV) may be helpful when choosing regions for maize tillage in northern Poland. Yet it is always necessary to take into consideration, that in similar soil conditions, grain of maize from region III of tillage will contain more water and will have to be more intensely be dried. This will enlarge costs of grain drying (**Styszko and in. 2007**). Maize tillage for energetic purposes (production of biogas from silage and bioethanol from wet grain) no longer requires grain drying. That is why maize tillage for wet grain in the area of Pomerania in the zone II of Y and potato leaf coil viruses threat is substantially well-founded. This thesis is also confirmed by experiments conducted by **Majewski** (2007) in the years 2001-2005.

## 5. Conclusion

Highly significant correlations were reached for the crop of maize grain, dry mass content in it and for costs of the energy carriers used for grain drying among regions of maize tillage and infection-pressure-zones of viruses Y and potato leaf roll in Poland. Crop of maize dry grain from region III of tillage was 21% lower than from region I. Gathered grain contained 5.7-6.9% of dry mass less and its drying was 22.4-26.4 zloty$\cdot t^{-1}$ more expensive that is 39.0-43.1% higher in comparison to region I. Maize tillage for energetic purposes (biogas and bioethanol) does not require grain drying which makes possible maize tillage in Pomerania in infection-pressure-zone II of PVY and PLRV. Infection-pressure-zones of potato leaf roll and Y viruses seem to be good practical indicators for allocating regions of maize tillage for grain in northern regions of Poland.

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# Związek pomiędzy rejonami uprawy kukurydzy na ziarno a strefami zagrożenia upraw ziemniaka PVY i PLRV w Polsce

## Streszczenie


Ocieplający się klimat w Polsce spowodował, że w latach 1990-2007 zaczęła wzrastać powierzchnia uprawy kukurydzy na ziarno przy malejącym areale uprawy ziemniaka, w tym także na północy Polski (tab.1). Rejon ten wcześniej był uznany za niesprzyjający (III) do uprawy kukurydzy na ziarno. Kukurydza jest rośliną o bardzo szerokiej możliwości użytkowania: na paszę, cele konsumpcyjne oraz energetyczne (biogaz i bioetanol). Rejon Pomorza jest zróżnicowany pod względem klimatycznym. Pomorze Zachodnie ma lepsze warunki do uprawy kukurydzy, niż Pomorze Środkowe oraz Wschodnie.

Porównując mapy rejonów uprawy kukurydzy w Polsce (rys.1.) wydaje się, że mogą być one ujemnie skorelowane ze strefami zagrożenia upraw ziemniaka wirusem liściozwoju ziemniaka (PLRV) (rys. 2) i wirusem Y ziemniaka (PVY) (rys. 3).

Celem badań było określenie relacji pomiędzy rejonami uprawy kukurydzy na ziarno a strefami zagrożenia wirusami liściozwoju i Y ziemniaka w Polsce. W latach 2001-2005 założono doświadczenia polowe jednoczynnikowe łanowe w dwóch powtórzeniach w 15 miejscowościach z 12 odmianami kukurydzy.

Analiza wyników wykazała wysoce istotne korelacje dla plonu ziarna kukurydzy, zawartości w nim suchej masy oraz dla kosztów nośników energii zużytych na suszenia ziarna pomiędzy rejonami uprawy kukurydzy a strefami zagrożenia wirusami Y i liściozwoju ziemniaka w Polsce. Plon ziarna suchego kukurydzy z rejonu III jej uprawy był niższy o 21% niż z rejonu I. Zebrane ziarno zawierało mniej suchej masy o 5,7-6,9%, a koszty jego suszenia były o 22,4-26,4 $zł \cdot t^{-1}$ tj. o 39,0-43,1% w porównaniu do rejonu I. Przy uprawie kukurydzy na cele energetyczne (biogaz i bioetanol) suszenie ziarna nie jest warunkiem koniecznym.

Strefy zagrożenia upraw ziemniaka wirusami Y i liściozwoju ziemniaka okazały się dobrymi praktycznymi wskaźnikami wydzielania rejonów uprawy kukurydzy na ziarno obszarze północnej Polski.