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POTENTIAL REDUCTION IN CUCUMBER YIELD (*Cucumis sativus* L.) IN POLAND CAUSED BY UNFAVOURABLE THERMAL CONDITIONS OF SOIL

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Abstract. The aim of the work was to evaluate the risk of cultivation of cucumber pickling cultivars in Poland caused by unfavourable thermal conditions of soil. To achieve the goal of the work used starting data collected from 28 experimental stations of the Research Centre for Cultivar Testing (COBORU) and 47 meteorological stations of the Institute of Meteorology and Water Management (IMGW) in 1966–2005 were used. Curvilinear regression analysis was used to determine the relation between the total and marketable yield of cucumber and soil temperature at the depth of 5 cm in the period of sowing-the end of harvesting. Potential, at least of 5%, reduction in the total yield of cucumber occurred when average soil temperature at the depth of 5 cm in the period from sowing to the end of harvesting amounted to ≤17.9°C and of the marketable yield ≤17.3°C. The highest reduction in yield, occurring in south-west and south-east part of Poland. The reduction was from 15 up to over 18% in the case of the total yield and from 12 up to 15% in the case of the marketable yield. On average, it occurred respectively every 1.5–2 years and 2.5–3 years. Taking into account the data from the whole country area in 1966–2005, a considerable increase appeored by 0.2°C/10 years in soil temperature in the period from sowing to the end of harvesting. The highest increase by 0.4°C/10 years was recorded in southern and central Poland and in the western part of the Masurian Lakeland where a risk of cucumber cultivation caused by too low soil temperature will probably in the incoming years undergo the quickest reduction.

Key words: cucumber, soil temperature, cultivation risk, reduction in yield, Poland

INTRODUCTION

Because of its origins in the subtropical climate zone cucumber belongs to a group of plants of the highest thermal requirements of soil. Cucumber in all of its development stages requires suitably high soil temperature for its proper growth and development

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[Gosselin and Trudel 1985, Liebig 1985, Sysoeva et al. 1999]. In Poland thermal conditions and, most of all, soil temperature in years and habitats which are sufficiently moist is the most important agrometeorological element determining growth and productivity of plants, especially thermophilous ones [Koźmiński 1981]. Knowledge of temporal and spatial variability of the temperature of soil surface layer on one hand enables determination of germination and emergence thermal conditions of a range of crop plants and, on the other hand, provides evaluation of effectiveness of chemicals used to protect these plants. Publications describing effect of soil temperature on the course of cucumber vegetation in greenhouse conditions are represented in the specialist literature most widely and there are no studies on field cultivation encompassing the whole country and based on multiannual research periods [Krug and Thiel 1985, Lederle and Krug 1985, Liebig 1985, Marcelis and Hofman-Eijer 1993]. Quite a big number of publications concern estimation of soil temperature on the basis of the course of meteorological conditions and comparison of the course of soil temperature in fallow land with various agrobiocenoses [Kossowski and Kołodziej 2003, Vajda and Venäläinen 2005, Tveito et al. 2005, Michalska and Nidzgorska-Lencewicz 2008].

Therefore, the aim of the current work was to evaluate the risk of cultivation of cucumber pickling varieties in Poland caused by unfavourable thermal conditions of soil in the 1966–2005 period.

MATERIAL AND METHODS

Results concerning the total and marketable yield for a standard of cucumber pickling varieties (average values of all varieties in a given year) constituted the materials. Use of a collective research standard was based on an assumption that intraspecific differences do not obfuscate general regularities searched for the species. Starting data were collected in 28 experimental stations of the Research Centre for Cultivar Testing (COBORU) in whole Poland through 1966–2005, except for two years: 2003 and 2004 when the research was not conducted (fig. 1). Cucumber marketable yield comprised fruits of the length of 6–10 cm and the diameter of 2.5–4.0 cm, however, not smaller than half of fruit length. Field experiments were conducted on soils typical for cucumber cultivation: a very good wheat complex, a good wheat complex and a very good rye complex. The cultivation usually used complete organic manuring, at a dose from 30 to 40 $t \cdot ha^{-1}$, which was ploughed in autumn. Mineral fertilisation in spring, on average, amounted to 400 kg per 1 hectare of the crop, with N and P_2O_5 respectively at the amount of 115 and 90 kg, and K_2O at the amount of 195 kg.

In the work also were used data concerning soil temperature at the depth of 5 cm in the period from sowing to the end of cucumber harvesting which in Poland, on average, begins on 16th May and ends on 4th September. The data were collected from 28 experimental stations of COBORU and 47 stations of IMGW in the 1966–2005 period (fig. 1). Soil temperature was characterized taking into account temporal variability, determining a linear trend for the whole country and for a single research station, and spatial variability with consideration of the multiannual 1966–2005 average and in boundary years – the coldest one and the warmest one.

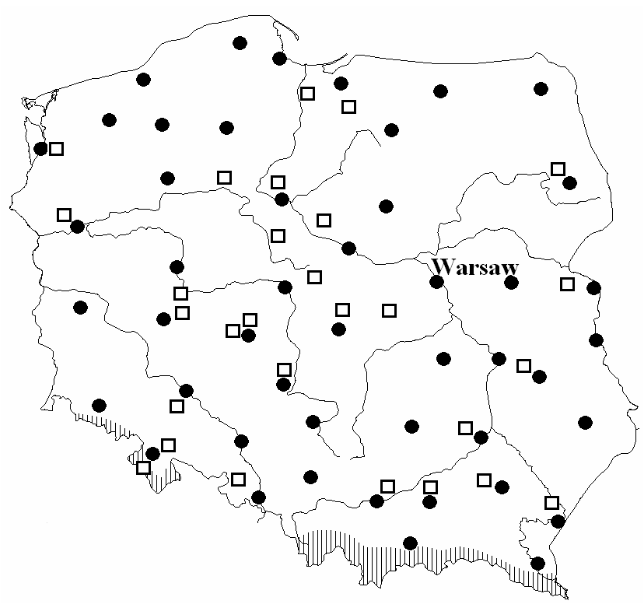

Fig. 1. Distribution of experimental stations of COBORU (□) and meteorological stations of IMGW (●)

Ryc. 1. Rozmieszczenie stacji doświadczalnych COBORU (□) i stacji meteorologicznych IMGW (●)

Relation between the total and marketable yield of cucumber and soil temperature in the period from sowing to the end of harvesting (in the whole vegetation season) was evaluated by means of curvilinear regression analysis. In a regression equation the total or marketable yield constituted a dependent variable and soil temperature in the period from sowing to the end of harvesting and a linear trend, i.e. the successive years of the multiannual 1966–2005 period, constituted an independent variable. The regression equation did not take into account information on soil conditions and fertilisation, because they did not statistically significantly differentiate volumes of yields considered in the research. Lack of differences was proved with the *t*-Student test. Statistical evaluation of the equations was carried out on the basis of the *t*-Student test, the *F*-Snedecor test, the determination coefficient (R^2) and an index describing a difference between a standard deviation of a dependent variable and a standard error of equation estimation ($SD - SY$) [Dobosz 2001]. To verify regression equations a relative forecast error was also used, determined according to the following formula:

$$RFE = \frac{y - y_p}{y} \cdot 100\%$$

and an average relative forecast error for all analysed stations and all considered years of the 1966–2005 period, which was calculated based on the formula:

$$ARFE = \frac{1}{n}\sum_{i=1}^{n}|RFE|$$

where:
y – actual yield (t·ha^{-1}),
y_p – yield calculated according to the equation (t·ha^{-1}),
n – number of years in a time series (number of stations × number of years).

An additionally used test of evaluation accuracy was determining how many times a relative forecast error in the analysed multiannual 1966–2005 period amounted to $|RFE| \leq 5\%$ (a very good forecast) and $5\% < |RFE| \leq 10\%$ (a good one) [Bombik 1998].

In order to determine threats to cucumber cultivation in Poland by unfavourable thermal conditions of soil, on the basis of curvilinear regression equations threshold values for soil temperature, when at least 5% reduction in the total and marketable yield occurs, were determined. Next, an average value of soil temperature was substituted, but only calculated for those years when they exceeded earlier specified threshold values, into each of the formed equations describing the effect of soil temperature in the period from sowing to the end of harvesting on the total and marketable yield. Substituting them into the equations, yield for each considered station of COBORU and IMGW, conditioned by average occurrence of unfavourable thermal conditions of soil, were calculated. Differences between the multiannual actual yield of cucumber determined for whole Poland and the yield calculated according to the above-described procedure enabled determination of potential yield reduction caused by unfavourable soil temperature separately for the total yield and the marketable yield. Frequency of occurrence of low soil temperature (above the specified thresholds) in the period from sowing to the end of cucumber harvesting through 1966–2005 was determined according to the formula:

$$P = \frac{n_1}{N} \cdot 100\%,$$

where:
n_1 – number of periods with low soil temperature,
N – number of all examined periods.

RESULTS

Temporal and spatial variability of soil temperature. In Poland, in 1966–2005, soil temperature in the period from sowing to the end of cucumber harvesting on average amounted to 18.5°C and oscillated between 16.4°C in 1980 and 20.9°C in 1992 (fig. 2). Soil temperature in this period was characterised by a low standard deviation (SD = 0.9°C) and a positive trend for the whole country amounting to 0.2°C/10 years (r = 0.27, $P \leq 0.1$). A higher increase than the country's average was shown in southern and central Poland and in the western part of the Masurian Lakeland where soil temperature through 1966–2005 on average increased by 0.4°C/10 years. However, in some stations of IMGW an increase in soil temperature per decade (10 years) was even higher and equalled: 0.7°C – in Opole, 0.6°C – in Cracow and 0.5°C – in both Kalisz and Łódź.

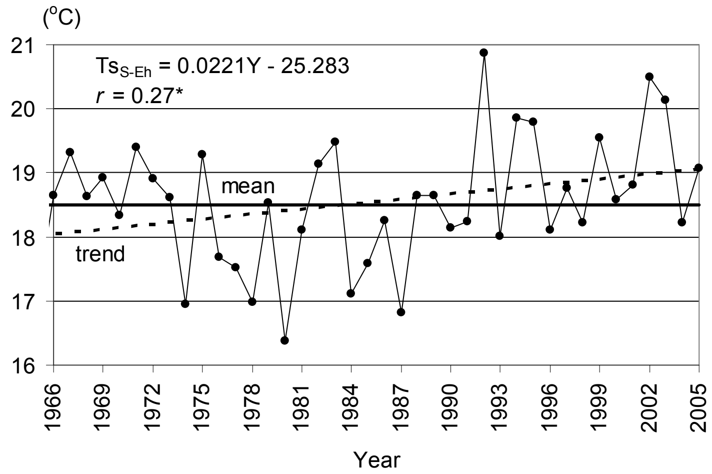

Fig. 2. Soil temperature in the period from sowing to the end of cucumber harvesting in Poland, 1966–2005

Ryc. 2. Temperatura gleby w okresie siew-koniec zbioru ogórka w Polsce. Lata 1966–2005

In Poland, distribution of isotherms characterising average soil temperature in the whole period of cucumber vegetation was of an irregular character (fig. 3). In 1966–2005, soil temperature oscillated in most parts of Poland between 17.5 up to 19.5°C, the lowest temperature was recorded in the submontaneous area, situated in south-western and south-eastern Poland, the highest temperature – in the central-western area. Figure 3 presents also spatial distribution of isotherms, characterising temperature in 1980 and 1992, which generally corresponds with the multiannual distribution, but temperature values in the warmest regions were in 1980 by 2.5°C lower than the norm, and in 1992 by 2.0°C higher. In 1980, soil temperature in Poland was characterised by a low diversity, as it oscillated only between 16.0 and 17.0°C, in contrast with 1992, when temperature ran from 20.0 to 22.0°C. The lowest temperature in these two years occurred in the north, north-east, south-west and south-east of Poland.

Regression equations and their statistical description. Curvilinear regression equations formed for the relation between cucumber yield and soil temperature in the period from sowing to the end of harvesting considering a linear trend accounted for variability of the total yield in 49% and the marketable yield in 44% (tab. 1). A standard error of estimation of both equations was lower than natural variability (standard deviation) of the total and marketable yield. All regression coefficients and the absolute term of both equations were significant at the level of $P \leq 0.01$, and values of the *t*-Student test were higher than |3.1|. The average relative forecast error calculated for the equation

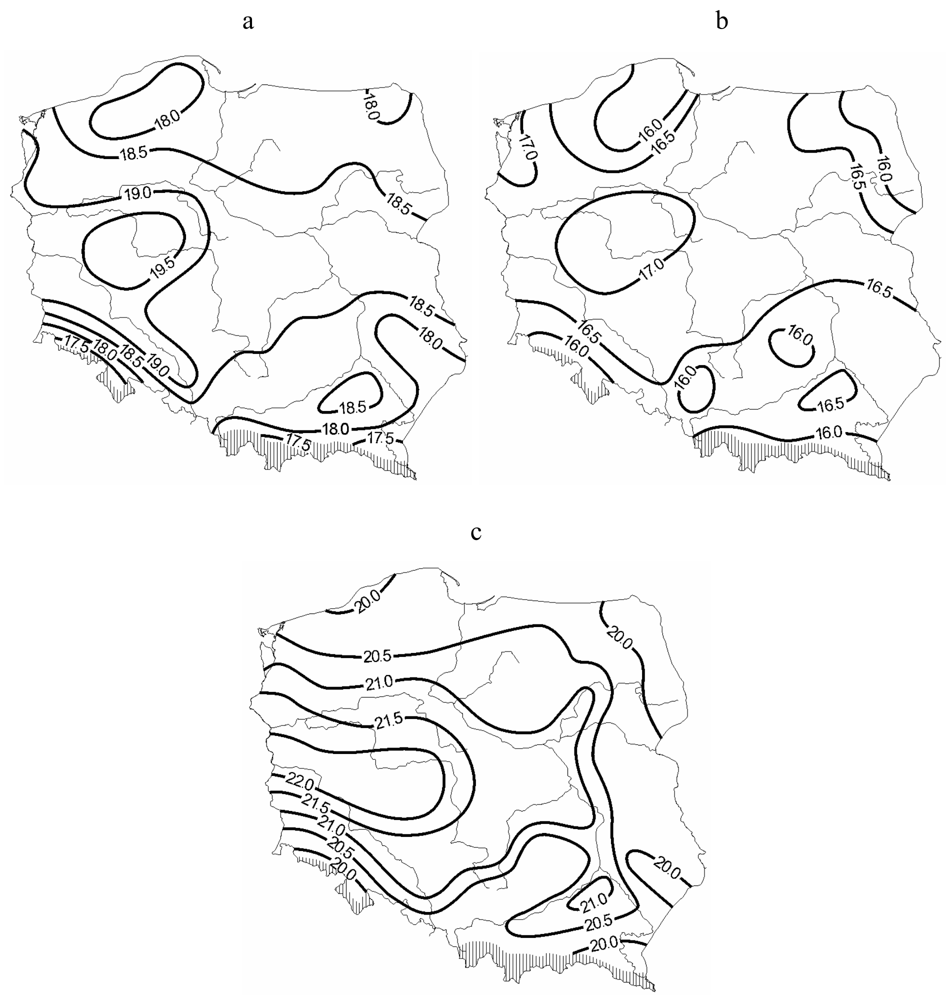

Fig. 3. Spatial distribution of soil temperature in the period from sowing to the end of cucumber harvesting in Poland: a – average (1966–2005), b – in 1980, c – in 1992

Ryc. 3. Rozkład przestrzenny temperatury gleby w okresie siew-koniec zbioru ogórka w Polsce: a – średnia (1966–2005), b – w roku 1980, c – w roku 1992

describing the total yield was lower by 0.6% than for the equation describing the marketable yield and amounted to 9.5%. As for both examined regression equations, more very good forecasts, i.e. those with an error not higher than 5%, and good ones, those with an error between 5 and 10%, were made for the equation describing the total yield (respectively about 37 and 48%) and for the equation describing the marketable yield (respectively about 34 and 44%).

Table 1. Relationships of cucumber yield to soil temperature in the period from sowing to the end of harvesting in Poland, taking into account the linear trend through 1966–2005
Tabela 1. Zależność plonu ogórka od temperatury gleby w okresie siew-koniec zbioru w skali całej Polski, przy uwzględnieniu trendu liniowego w latach 1966–2005

Regression equations Równania regresji	Variable Zmienna		Characteristics – Charakterystyka				
	y ($t \cdot ha^{-1}$)	$Ts_{S\text{-}Eh}$ (°C)	R^2 (%)	$SD–SY$ ($t \cdot ha^{-1}$)	ARFE (%)	frequency of the occurrence of $\|RFE\|$ in range częstotliwośc wystąpienia $\|RFE\|$ w zakresie	
						0–5 (%)	5–10 (%)
$y_t = -913.1069 + 0.329Y + 29.535Ts_{S\text{-}Eh} - 0.744Ts_{S\text{-}Eh}^2$ (-5.2)*** (4.8)*** (3.5)*** (-3.2)***	33.2	18.6	49.3	1.5	9.5	36.5	48.1
$y_m = -1045.30062 + 0.454Y + 17.423Ts_{S\text{-}Eh} - 0.466Ts_{S\text{-}Eh}^2$ (-8.1)*** (9.1)*** (3.3)*** (-3.1)***	18.3		44.1	1.9	10.1	34.2	43.9

R^2 – determination coefficient (%), $SD - SY$ – difference between a standard deviation of a dependent variable and a standard error of equation estimation ($t \cdot ha^{-1}$), $ARFE$ – average relative forecast error (%), RFE – relative forecast error (%), y – average multiannual yield ($t \cdot ha^{-1}$), Y – linear trend of the yield, i.e., the successive years of the 1966–2005 multiannual period, *** significant at $P \leq 0{,}01$, y_t – total yield ($t \cdot ha^{-1}$), y_m – marketable yield ($t \cdot ha^{-1}$), $Ts_{S\text{-}Eh}$ – average soil temperature at the depth of 5 cm in the period from sowing to the end of harvesting (°C). The value of the *t*-Student test was given in brackets
R^2 – współczynnik determinacji (%), $SD - SY$ – różnica między błędem standardowym estymacji równania a odchyleniem standardowym zmiennej zależnej ($t \cdot ha^{-1}$), $ARFE$ – średni względny błąd prognozy (%), RFE – względny błąd prognozy (%), y – średni wieloletni plon ($t \cdot ha^{-1}$), Y – trend liniowy plonu, czyli kolejne lata wielolecia 1966–2005, *** istotny przy $P \leq 0{,}01$, y_t – plon ogólny, y_m – plon handlowy, $Ts_{Sg\text{-}Eh}$ – średnia temperatura gleby na głębokości 5 cm w okresie siew-koniec zbioru (°C). W nawiasie podano wartość testu *t*-Studenta

Effect of soil temperature on yield. It results from the regression equations that cucumber yield was reduced by low soil temperature, the total yield more strongly than the marketable yield. With the soil temperature of 17.9°C in the whole vegetation season there occurred a decrease by at least 5% in the total yield below the multiannual average of 1966–2005, and with 17.3°C – a decrease in the marketable yield by at least 5%. Further drop in soil temperature below the determined threshold values caused even greater reduction in the yield of this plant. For example, with temperature of 16.6°C reduction in the yield for the whole country amounted to about 20 and 11% respectively for the total and marketable yield, and with the temperature of 16.2°C as much as about 26 i 16% (fig. 4).

The diagram shown in figure 4 enabled to evaluate a potential reduction of cucumber yield caused by too low soil temperature for the whole country. However, low soil temperature may lead to various yield losses depending on a region of Poland. Potential reduction in the total cucumber yield caused by low soil temperature in the period from sowing to the end of harvesting in most parts of Poland oscillated between 12 and 18% (fig. 5a). The biggest yield losses amounting to, at least, 18% occurred within a small area of the country, covering south-western and south-eastern Poland. Smaller losses, at

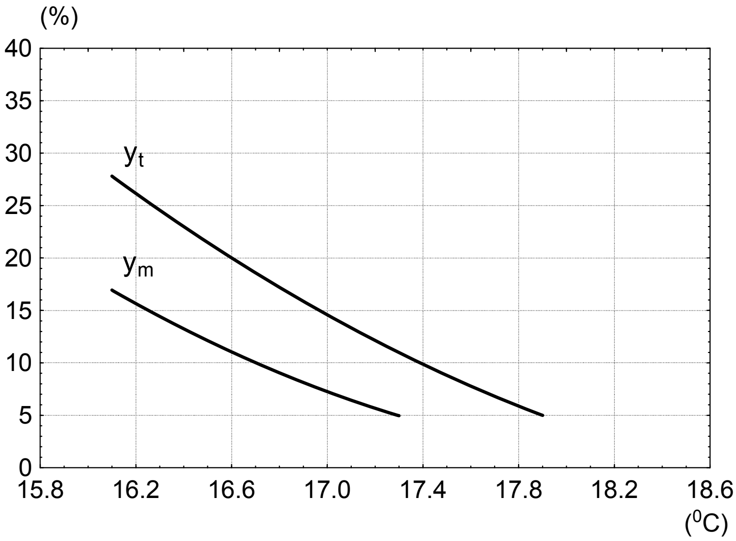

Fig. 4. Potential reduction in the total (y_t) and marketable (y_m) yield of cucumber caused by low soil temperature in the period from sowing to the end of harvesting in Poland

Ryc. 4. Potencjalne zmniejszenie plonu ogólnego (y_t) i handlowego (y_m) ogórka powodowane niską temperaturą gleby w okresie siew-koniec zbioru w Polsce

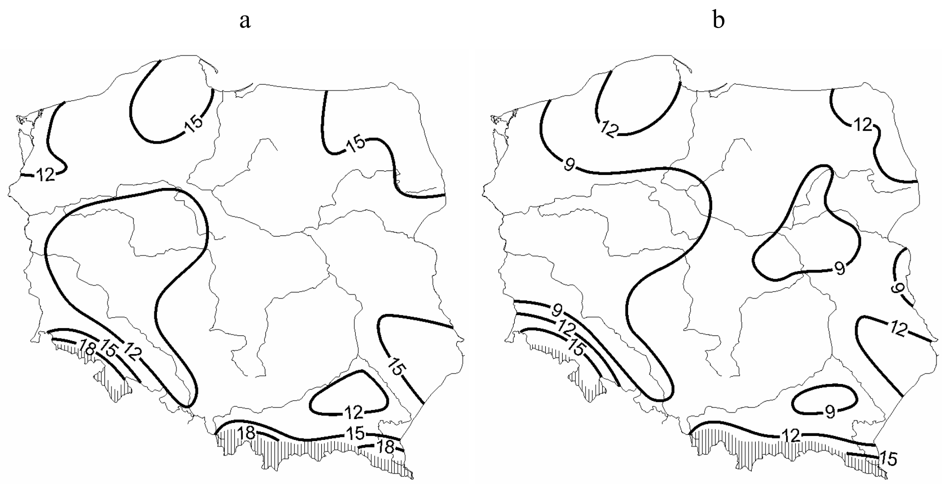

Fig. 5. Potential reduction in the total (a) and marketable (b) yield of cucumber caused by low soil temperature in the period from sowing to the end of harvesting

Ryc. 5. Potencjalne zmniejszenie plonu ogólnego (a) i handlowego (b) ogórka powodowane niską temperaturą gleby w okresie siew-koniec zbioru

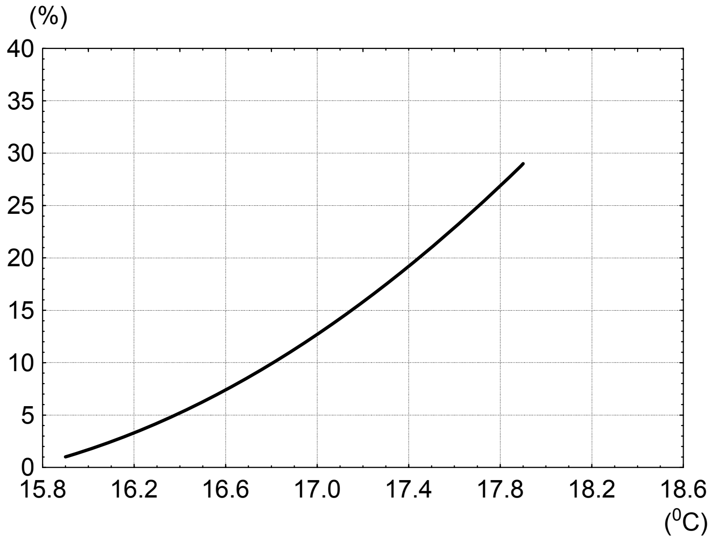

Fig. 6. Frequency of occurrence of low soil temperature in the period from sowing to the end of cucumber harvesting in Poland, 1966–2005

Ryc. 6. Częstość występowania niskiej temperatury gleby w okresie siew-początek zbioru ogórka w Polsce. Lata 1966–2005

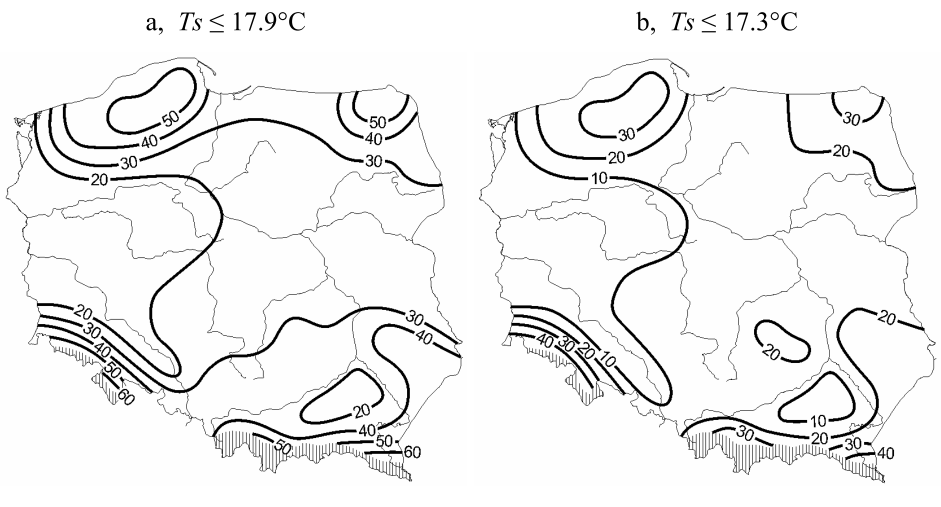

Fig. 7. Frequency of occurrence of low soil temperature in the period from sowing to the end of harvesting causing at least a decrease by 5% in the total (a) and marketable (b) yield of cucumber, 1966–2005

Ryc. 7. Częstość występowania niskiej temperatury gleby w okresie siew-początek zbioru powodującej co najmniej 5% zmniejszenie plonu ogólnego (a) i handlowego (b) ogórka. lata 1966–2005 least 15%, were recorded, apart from the submontaneous regions, also in central east (the Lublin Upland), north and north-east. On the other hand, the best conditions for cucumber cultivation, taking into account unfavourable thermal soil conditions, occurred in north-west, central west and the Valley of the Upper Oder (the Silesian Lowland), where reduction in the total yield did not exceed 12%. Spatial distribution of reduction in the marketable yield of the fruits caused by low soil temperature was similar to the distribution of reduction in the total yield (fig. 5b). The biggest losses of the marketable yield, like of the total yield, were recorded in south-west and south-east and they amounted to, at least, 15%. The area of the country in which the smallest losses were recorded, not more than 9%, was much bigger as it encompassed the western and central parts of Poland and central east and the region of the Sandomierz Basin.

For the whole country, frequency of occurrence of low soil temperature in the period from sowing to the end of harvesting oscillated between about 29% for $Ts \leq 17.9°C$ and about 18% for $Ts \leq 17.3^{o}C$ and about 3% for $Ts \leq 16.2°C$ (fig. 6). In the whole country, low soil temperature resulting in reduction in cucumber yield at least by 5% occurred with frequency from 10 to 60% (fig. 7). The highest risk of occurrence of low soil temperature was in south-west and south-east, while $Ts \leq 17.9°C$ occurred with frequency of above 60%, and $Ts \leq 17.3°C$ – above 40%. Most seldom low soil temperature was recorded in the western part of the country: for $Ts \leq 17.9°C$ once in 5 years, and for $Ts \leq 17.3°C$ – every 10 years.

DISCUSSION

There are no typical agroclimatic research studies devoted to the evaluation of influence of unfavourable thermal conditions of soil on the cucumber yield and determination of potential risk of cucumber cultivation caused by low soil temperature. The few studies on this topic concern other crop plants and also different yield-limiting factors [Koźmiński et al. 1992, Koźmiński and Michalska 2001]. Also, there are not many scientific reports concerning dependence of cucumber growth and development on the course of soil temperature; those which have been published are most frequently based on one-year experiments and, what is more, have been usually conducted in the greenhouse and not in field conditions [Karlsen 1981, Liebig 1985, Yoshida and Eguchi 1990, Grimstad 1993, Marcelis 1994].

It results from scientific reports that optimum soil temperature for germination of cucumber seeds amounts to 27–28°C and seeds can germinate when soil temperature amounts to 14–16°C, but then the germination is limited [Liebig 1985]. At lower temperatures seeds emerge longer and very erratically, at extremely unfavourable temperatures they do not emerge at all or die out, irrespective of a cultivar [Babik 2004]. In the lowland area of Poland an average duration of the period with soil temperature of above 15°C at the depth of 5 cm oscillates between 105 days in the Biebrza river basin and in Kaszuby and 125 days in the Silesian Lowland, the Wielkopolska Lowland and the Sandomierz Basin [Koźmiński 1981]; an average duration of the cucumber vegetation season amounts to about 110 days [Kalbarczyk 2009]. Some authors suggest [Ingratta 1980, Liebig 1985] that heating of soil partly counteracts unfavourable influence of low air temperature at night on the growth of cucumber plants. In conditions when the soil is heated to 14°C cucumber, without any big damage, may survive even for a longer period at the air temperature of only 10°C [Liebig 1985]. According to Karlsen [1981] optimum soil temperature in the root zone oscillates between 20 and 30°C. When day or night temperature of soil in the root zone is lower than the optimum temperature, then there is a drop in the growth rate of the overground cucumber part. In the case when day temperature is low and night temperature is optimum, there occurs reduction in the root growth. Kharkina et al. [2003] examined effect of temperature with the illumination of intensity of 100 $W \cdot m^2$ and a 12-hour day on parameters describing dynamics of the growth of germs and rooting of cucumber plants. The highest values of the analysed parameters were obtained with constant day-and-night soil and air temperature amounting to 25 and 20°C respectively in the case of the first and second group of indexes. Results of the experiments also suggest that the size of a gradient (the difference between day temperature and night temperature) significantly affects the growth of cucumber roots. In the case when the gradient amounts to 10°C (35/25 and 25/35°C) the growth of the roots is stimulated and in the case of 20°C (35/15 and 15/35°C) – stopped. Low temperature in the root zone may considerably limit water intake, especially the passive intake which is strictly dependent on viscosity, even if there is abundance of water [Yoshida and Eguchi 1989, Yoshida and Eguchi 1990]. According to Lee et al. [2005], thickness of the phloem tissue and formation of additional vessel elements of the xylem tissue in cucumber roots significantly depend on the temperature in the root zone, at lower temperature the length and branching of roots decrease. With the growth of soil temperature in the root zone availability and absorption of elements and enzyme activity also grow; however, the optimum values of temperature depend on particular nutrient elements and types of enzymes [Beck et al. 1990]. According to Tachiban [1988] both movement and absorption of nitrates happen faster when temperature in the cucumber root zone amounts to 20°C, much slower at 13°C. On the other hand, Pramanik et al. [2000] in their hydroponic research stated that the number and the rate of excretion of organic acids by cucumber roots increase together with a rise in temperature and days growing longer. Yoshida and Eguchi [1989], on the basis of the research on effect of temperature (within the range from 8 to 28°C) in the cucumber root zone on gas exchange and water absorption in controlled conditions of hydroponic cultivation, stated that intensity of these processes dropped at the temperature of below 12°C, and rose at the temperature of above 16°C. In another work Yoshida and Eguchi [1990] write that lowering of soil temperature from 32 to 8°C completely stops water intake by cucumber roots.

According to Grimstad [1993], stopping of the growth of overground parts of cucumber plants can be caused by short temperature drop at night but also by big temperature difference between day and night – like for the growth of roots. Slow growth of shoots at low temperature of the root zone is caused by reduction in the transport of mineral components, relatively hindering influence of low temperature in the root zone on water absorption by the plant or also on production of substances in the roots regulating the growth of shoots [Lee et al. 2005]. Growth of plant height and cucumber leaf length, without a change in dry mass weight, become stopped when a plant at leaf stage 1 grows at a lowered temperature of 12°C for one hour during two first hours of the night, and a plant at leaf stage 3 – for first two hours of the night [Sysoeva et al. 1997]. Another work by Sysoeva et al. [1999] partly confirms the results published in 1997, saying that lowering of temperature from 20 to 12°C for 2 hours at night causes reduction in dry mass of the plant and shortening of the petiole length in the strongest way. Krug and Thiel [1985] on the basis of the research in the greenhouse evaluated a degree of plant withering on the scale of 0–4° in three stages: one week after planting, in the period of pollen production at node 8 and in the period of fruiting depending on air and soil temperature and solar radiation in different seasons of the year. In spring and autumn minor withering of plants occurred already at the soil temperature of 16°C in all the examined stages of cucumber, in summer at 14°C in the second analysed stage and at 12°C – in the third one. According to Krug and Thiel [1985], the length of cucumber leaves in the first analysed stage was significantly dependent on soil temperature within the range from 16 to 23°C, and the beginning of the date of fruit harvesting was delayed by low soil temperature in the first analysed stage. Ahn et al. [1999] dealt with effect of low temperature in the root zone on physiological parameters of cucumber: dry mass, leaf surface area, chlorophyll fluorescence, leaf temperature and photosynthesis. In an experiment with temperatures: 6, 12, 15 and 20°C they stated that dry mass of cucumber doubled and leaf surface area was increased by 50% as a result of a temperature rise from 15 to 20°C. It results from the research of Marcelis [1994] that in the period of cucumber fruiting a rise in habitat temperature does not affect movement of dry mass in leaves, stems and petioles but reduces the allocation in roots. Fruit increase strongly reduces production of dry mass in all vegetative parts of the plant but only slightly affects its distribution to stems, leaves and petioles. At the temperature of 25°C distribution of dry mass to roots and the vegetative part of the stem does not cause fruit increase but at the temperature of 18°C proportion of the mass of the roots to the vegetative part of the stem decreases with an increase in the number of fruits on a plant.

RECAPITULATION

The highest risk of cultivation of cucumber pickling varieties resulting both from potential reduction in yield and from frequency of years with too low soil temperature in the period from sowing to the end of harvesting occurred in south-western and south-eastern Poland. In this area reduction in yield oscillated between 15 and over 18% in the case of the total yield and between 12 and over 15% in the case of the marketable yield; on average, it occurred respectively every 1.5–2 years and 2.5–3 years.

For the whole country, in 1966–2005, a significant increase by 0.2°C/10 years in soil temperature was shown in the period from sowing to the end of harvesting, and the highest increase, by 0.4°C/10 years, was recorded in south and central Poland and in the western part of the Masurian Lakeland where risk of cucumber cultivation caused by too low soil temperature will probably in the incoming years undergo the quickest reduction.

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POTENCJALNE ZMNIEJSZENIE PLONU OGÓRKA (*Cucumis sativus* L.) NA TERENIE POLSKI POWODOWANE PRZEZ NIEKORZYSTNE WARUNKI TERMICZNE GLEBY

Streszczenie. Celem pracy była ocena ryzyka uprawy konserwowych odmian ogórka na obszarze Polski powodowanego przez niekorzystne warunki termiczne gleby. Do realizacji tego celu wykorzystano dane wyjściowe zebrane z 28 stacji doświadczalnych COBORU i 47 stacji meteorologicznych IMGW w latach 1966–2005. Do określenia zależności między plonem ogólnym i handlowym ogórka a temperaturą gleby na głębokości 5 cm w okresie siew-koniec zbioru zastosowano analizę regresji krzywoliniowej. Potencjalne, co najmniej 5%, zmniejszenie plonu ogólnego ogórka następowało, gdy średnia temperatura gleby na głębokości 5 cm w okresie od siewu do końca zbioru wynosiła ≤17,9°C, a handlowego – ≤17,3°C. Największe zmniejszenie plonu, występujące na południowym-zachodzie i południowym-wschodzie, wynosiło od 15 do ponad 18% w przypadku plonu ogólnego i od 12 do ponad 15% w przypadku plonu handlowego, występowało ono przeciętnie odpowiednio co 1,5–2 lata i 2,5–3 lata. W skali całego kraju, w latach 1966–2005, udowodniono istotny wzrost, o 0,2°C/10 lat, temperatury gleby w okresie siew-koniec zbioru, przy czym największy, o 0,4°C/10 lat, stwierdzono w południowej i środkowej Polsce oraz w zachodniej części Pojezierza Mazurskiego, gdzie ryzyko uprawy ogórka powodowane zbyt niską temperaturą gleby prawdopodobnie w najbliższych latach będzie najszybciej ulegać zmniejszeniu.

Słowa kluczowe: ogórek, temperatura gleby, ryzyko uprawy, zmniejszenie plonu, Polska

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