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TEMPERATURE AS A VERNALIZING FACTOR IN CELERY PRODUCTION FOR SEEDS

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A b s t r a c t. During the three-year studies, effects of a natural pattern of spring temperatures on the possibilities of achieving full vernalization of stecklings and good quality and quantity yields of celery seeds were evaluated. The object of the research was celery of cultivar 'Utah 52-70'. Seeds were sown in four different terms: 1st June, 1st July, 1st August and 1st September. The plants grew in a greenhouse till spring.

It was shown that the arrangement of natural temperatures in the field in April and May allowed full vernalization of stecklings. The optimum time of sowing seeds for stecklings was between the 1st June and the 1st July. All the stecklings of that term had high yields of good quality seeds, on the average from 18.8 to 19.5 kg/100 m^2.

A lower yield and worse quality seeds were observed in the case of plants from the later time of sowing. Natural spring colds were not sufficient for the full vernalization of 'younger' stecklings, which resulted in disturbances in their development, blooming and their seed setting. Changes in the climatic factors of the experimental years had significant and modifying effects on the height and the quality of seed yields.

K e y w o r d s: celery, seed production, temperature, vernalizing factor

INTRODUCTION

Celery *(Apium graveolens* L. var. *dulce* Pers.) is a valuable vegetable of which importance will increase in Poland (like it is in other western countries) because of its taste, dietetic and healh values.

Until quite lately celery seeds had been imported. In the years 1978-85, a method of celeriac seed-vessel cultivation in Poland was worked out. A fundamental problem to be solved for this method was a choice of such agronomical practices that would allow the plant full vernalization, which conditioned their passing into a generative stage and a high yield of required quality seeds [2].

Celery plants vernalize after they had undergone a juvenile period (phase of 5-6 proper leaves) under the influence of low temperatures lasting long enough, namely 2-4 weeks [1,4-7]. The cheapest way is the exposition of stecklings to natural coolness during the early spring months (March-April). Before the exposition, the plants must go through a juvenile stage which can be achieved through an appropriate choice of terms of seed sowing for stecklings and of their wintering inside [2,4,5,8,9].

The aim of this work was to study the influence of the natural temperature arrangements during the spring months on the possibilities of achieving full vernalization of stecklings and good quantity and quality yields of celery seeds.

MATERIALS AND METHODS

The research was carried out in the years 1983-85 in the Agricultural Experimental Station in Lublin-Felin. The object of the research was celery plants of cultivar 'Utah 52-70'. Seeds, imported from the USA, were sown in a greenhouse on four different dates: 1st June,

1st July, 1st August and 1st September. After the seedlings had been bedded out to flowerpots of 14 cm in diameter, the plants were left in the greenhouse until the 1st April of the following year, and then they had been exposed to natural temperatures (outside the greenhouse) for 20 days. On the 20th April every year, the plants were transplanted in the field (100 specimens from each combination) and spaced 180-60-60-60-180 x 50 cm, i.e., 2.2 plants per square metre. The experimental unit consisted of a single plant. The celeries were cultivated on a site where maize had been previously grown and in the first year after the application of farmyard manure (Autumn, 40 t FYM/ha). Mineral fertilization $N : P_2O_5 : K_2O = 180 : 80 : 250$ kg/ha was applied in the Spring: Norway salpetre, granulated double superphosphate, potash salt 60 % and potassium sulphate at a 1:1 ratio. Additionally, the field was one time fertilized with top nitrogen dressing (the end of May) in a dose of N=50 kg/ha (Norway saltpetre). Weeds were controlled with Afalon in a dose of 1.5 kg/ha two weeks after planting. During the vegetation period, weeds were removed manually. Plants were protected in accordance with the programme of seed-plants preservation (septoria leaf spot disease and others). Seed-vessels were cut off with pruning shears on the turn of September; they were dried in open foil-tunnels, threshed and cleaned by hand on sieves and additionally on a pneumatic winnower.

RESULTS

The model studies showed that the temperatures below 15.6 °C are vernalizing to celery [6]. The mean decade temperatures of the experimental years (April and the first half of May) were favourable to the plant vernalization and were in the range from 5.2 to 14.5 °C (Fig. 1). However, the dynamics of sprouts growing varied depending on the stecklings. Half of the 320-day-old and 290-day-old stecklings had generative sprouts after 18-27 days from transplanting in the field, and all of them had generative sprouts after 35-40 days. 50 % of the youngest stecklings (228-day-old) formed seedstalks only after 98-99 days (i.e., after 3 months from transplanting in the field).

Modifying effects of the changing climatic factors, in the particular years, on the number and the height of flowering shoots of the tested plants, is illustrated in Fig. 2. The oldest stecklings were barely affected, as varying spring colds were sufficient for their full vernalization. Vernalization was mostly dependent upon the time of the experiment in the case of the 259-day-old stecklings. The youngest plants started to develop very late (flowering shoots were observed to appear even by the end of July). Also, flowering shoots of these plants were shortest and grew only up to about 20 cm (Fig. 2).

Changes in vernalization temperatures in the experimental years and varying age of stecklings significantly affected the quantity and the structure of the seed yield (Table 2). Statistically, the highest seed yield of 100 m^2 was obtained from the oldest stecklings (290- and 320-day-old). For the Ist class the yield was up from 18.1-19.2 kg and for the Ist and the IInd classes together, it was up from 18.8-19.5 kg. Significantly lower seed yield was produced by the 259-day-old stecklings, and the lowest yield was in the case of the youngest ones (228-day-old), accordingly of 100 m^2: the Ist class - 0.3 kg and the Ist and IInd class together - 3.7 kg.

DISCUSSION

Bad storage of celery stecklings disabled production of celery seeds for many years with the traditional method in Poland [3]. Working out a method which would allow stecklings to grow and winter in a greenhouse, required setting optimum terms of sowing seeds and testing the efficiency of natural spring colds as a vernalizing factor in the cultivation for seeds. In countries of mild winters, where temperature does not drop below 0 °C, celery stecklings winter in the field and they naturally undergo vernalization there [4]. If plants are wintering in a greenhouse, the temperatures in spring are too high there to allow for natural vernalization.

The results presented in this study show that the arrangement of natural thermal factors

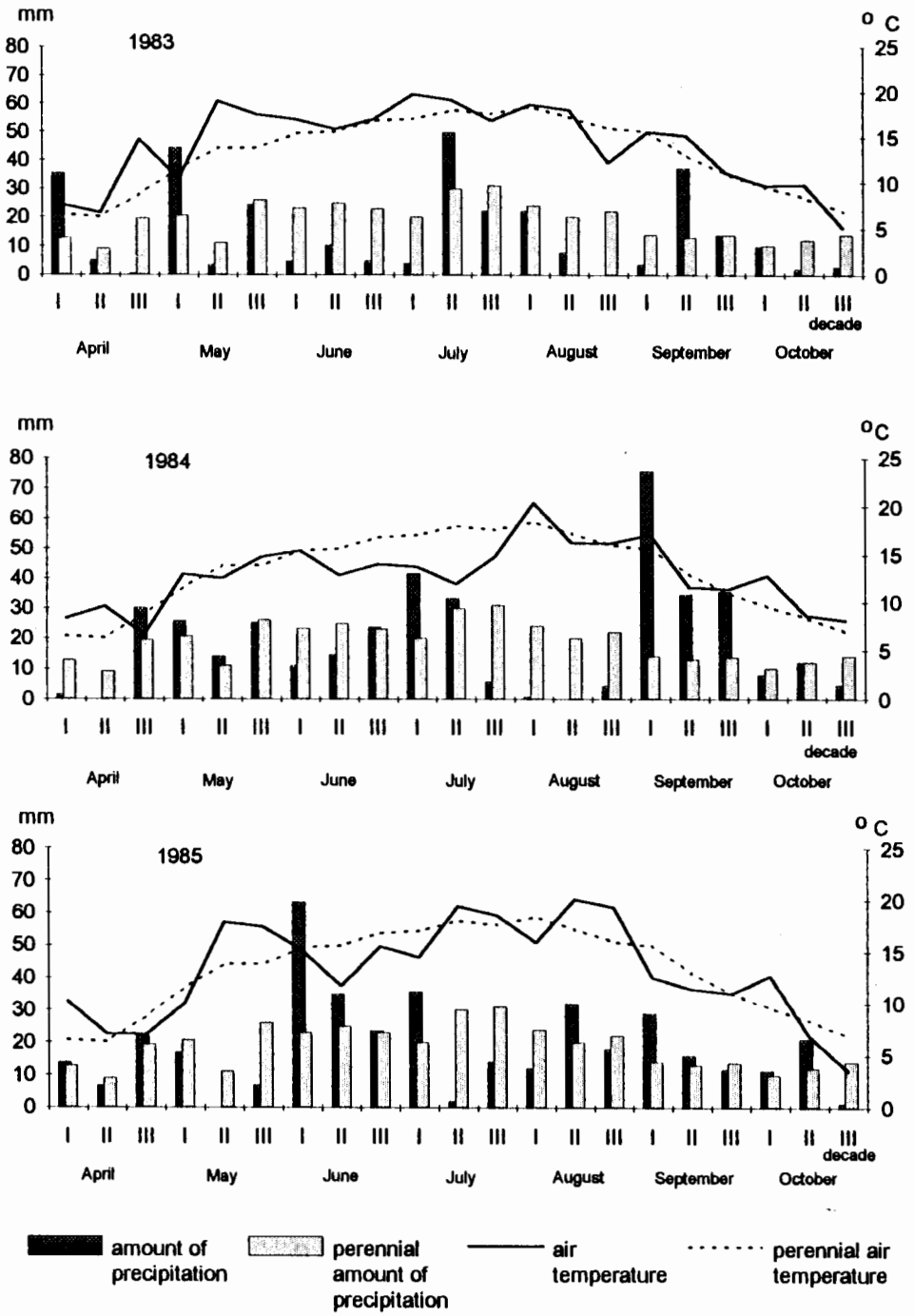

Fig. 1. Average decade air temperatures (0 °C) and decade sum of rainfalls (mm) in the years 1983-85.

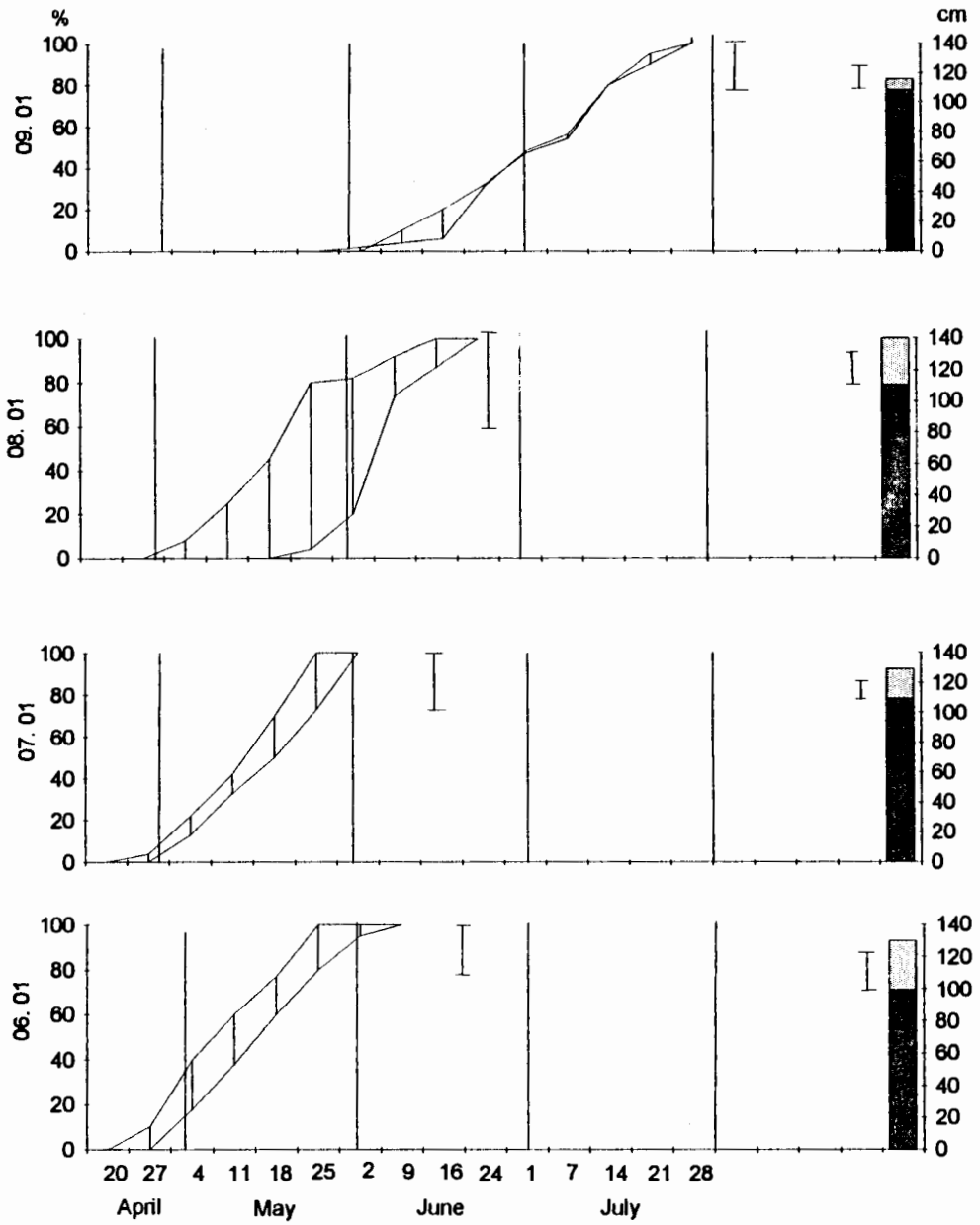

Fig. 2. Number of plants with an appearing flowering shoot (cm), the average number of the years 1983-85.

Table 1. Dates and numbers of days from transplanting of stecklings in the field to the appearance of a flowering shoot of celery (oscillations in the years 1983-85)

Date of seed sowing / Number of days from seed sowing to planting	for 50 % of stecklings		for 100 % of stecklings	
	Dates	Days	Dates	Days
June 1 / 320	May 8 - May 17	18 - 27	May 25 - June 9	35 - 50
July 1 / 290	May 12 - May 17	22 - 27	May 25 - June 2	35 - 43
Aug. 1 / 259	May 19 - June 7	29 - 48	June 16 - June 24	57 - 65
Sept. 1 / 228	June 1 - June 2	71 - 72	June 27 - June 28	98 - 99

Table 2. Yield of celery sowing material (1983-85)

Date of seed sowing for stecklings (Terms)	Number of days from seed sowing to planting	Years	Seed yielding in kg/100 m^2					
			Class I > 70 % germination rate		Class II 60-70 % germination rate		Class I + Class II	
			kg/100 m^2	% in total yield	kg/100 m^2	% in total yield	kg/100 m^2	% in total yield
		1983	13.777	82.300	0.000	0.000	13.777	82.300
06.01	320	1984	24.511	91.800	1.495	6.000	26.006	97.800
		1985	16.024	82.600	0.621	3.200	16.645	85.800
		1983	13.717	75.700	0.000	0.000	13.717	75.700
07.01	290	1984	25.877	97.500	0.000	0.000	25.877	97.500
		1985	17.962	85.900	0.815	3.900	18.777	89.800
		1983	10.406	75.300	0.000	0.000	10.406	75.300
08.01	259	1984	16.161	94.400	0.000	0.000	16.161	94.400
		1985	13.337	83.800	0.780	4.900	14.117	88.700
		1983	0.066	1.200	0.600	10.900	0.666	12.100
09.01	228	1984	0.364	3.600	8.834	87.400	9.198	91.000
		1985	0.374	4.300	0.931	10.700	1.305	15.000
LSD 0.05 Terms x years			3.040	-	0.081	-	1.407	-
x for terms irrespective of the years		06.01	18.104	85.600	0.705	3.100	18.809	88.600
		07.01	19.185	86.400	0.272	1.300	19.457	87.700
		08.01	13.301	84.500	0.260	1.600	13.561	86.100
		09.01	0.268	3.000	3.455	36.300	3.723	39.400
LSD 0.05 for terms			1.357	-	0.036	-	0.628	-
x for years irrespective of the terms		1983	9.492	58.600	0.150	2.700	9.642	61.400
		1984	16.728	71.800	2.582	23.400	19.310	95.200
		1985	11.925	64.200	0.787	5.700	12.712	69.800
LSD 0.05 for years			1.067	-	0.029	-	0.494	-

in April and May in the Lublin region is favourable to conduct vernalization of celery stecklings. To succeed, however, it is necessary that plants appropriately developed in growth are exposed to coolness. The optimum time for sowing seeds is the period from the 1st June to the 1st July, then the stecklings undergoing cooling in spring of the following year are 290-320-days old. After the plants transplanted in the field had undergone vernalization, they form flowering shoots, bloom and set seeds. The seed yield and its quality completely follow the standards for sowing material of celery.

CONCLUSIONS

1. The arrangement of natural temperatures in the field in April and May, allow for full vernalization of celery stecklings.

2. The optimum time of sowing seeds for stecklings is between the 1st June and the 1st July. All the stecklings originating from that time of sowing form, after they had been transplanted in the field, generative sprouts which produce high yields of good quality seeds.

3. The later the sowing of seeds (except the optimum term) the bigger decrease in the seed yield and in its quality. Natural spring colds are insufficient to full vernalization of the youngest stecklings which results in disturbances in their development, blooming and in their seed setting.

4. Changes of climatic factors in the discussed experimental years had significant and modifying effect on the height and the quality of yields.

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TEMPERATURA JAKO CZYNNIK JARYZUJĄCY W PRODUKCJI NASIENNEJ SELERÓW NACIOWYCH

W trzyletnich badaniach oceniano zależność pomiędzy układem naturalnych temperatur wiosennych a możliwością uzyskania pełnej jaryzacji wysadków oraz dobrych ilościowo i jakościowo plonów nasion selerów naciowych. Obiektem badań były selery naciowe odmiany Utah 52-70. Nasiona wysiewano w terminach: 1 czerwca, 1 lipca, 1 sierpnia i 1 września, a rośliny rosły do wiosny w szklarni.

Wykazano, że układ naturalnych temperatur na polu uprawnym w miesiącach kwiecień i maj zapewniał możliwość pełnej jaryzacji wysadków. Optymalny termin siewu nasion na wysadki przypada między 1 czerwca a 1 lipca. Wszystkie rośliny wysadkowe z tych terminów wydały wysokie i jakościowo dobre plony nasion, średnio od 18,8 do 19,5 kg ar^{-1}.

U roślin z późniejszych terminów siewu obserwowano spadek plonu nasion oraz jego jakości. Dla 'młodszych' wysadków naturalne chłody wiosenne były niewystarczające do pełnej jaryzacji, co objawiało się zakłóceniem w rozwoju i kwitnieniu roślin oraz wytwarzaniu nasion. Zmienność czynnikow klimatycznych w badanych latach miała istotny, modyfikujący wpływ na wysokość plonu nasion oraz jego parametry jakościowe.

S ł o w a k l u c z o w e: seler, produkcja nasion, temperatura, czynnik jaryzacji.