

THE FREQUENCY OF POLYEMBRYONY IN F_2 , F_3 AND F_4 GENERATIONS
FROM MONO- AND TWOEMBRYONIC SEEDS IN PEPPER (*CAPSICUM*
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Summary. The studying material consisted of seeds of intervarietal pepper hybrids. The frequency of twoembryonic seeds in the F_2 and F_3 generations, obtained from monoembryonic seeds and that in the F_4 generation for the seeds constituting the progeny of twin plants, have been determined. The frequency of that phenomenon was similar independently on the seed origin. There occurred large differences also between the progenies of some twin pairs. The obtained results suggest that this phenomenon is genetically determined. The heritability of that phenomenon determined on the basis of 3-year observations was $H = 80\%$.

The phenomenon of polyembryony has been described in two species of the genus *Capsicum* — in *C. frutescens* and *C. annuum*. The twin embryos and plants derived from them differed from one another by the number of genomes. The level of ploidy depends on the way of formation of additional embryos. Morgan and Rappleye (1950, 1954) as well as Campos and Morgan (1958) observed diploid forms among seedlings from polyembryonic seeds and also, though significantly less frequently, plants with the chromosome number increased or reduced to the level of $1n$. These last ones constitute the most interesting material for genetic studies and breeding works. The use of seeds originating from hybrids plants of F_2 and further generations as a studying material leads to the obtaining of many recombinants. The apogamic and androgenetic development of twin embryos permits to obtain haploids, with a different genotype than that of the parental forms of hybrids. Doubling of the chromosome number leads to the production of completely homozygotic diploids. Haploid forms were also obtained from polyembryonic seeds of *C. annuum* (Christensen, Bamford 1943). The frequency of twin embryos is several-fold lower than that of diploid twins. Novak and Betlach (1969) observed 36 seeds containing two embryos each among 12,577 germinating ones, which constituted 0.29%. Only two out of the obtained twin plants were haploids.

Differences in the frequency of twoembryonic seeds between the cultivars are

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likely to be determined genetically. Such a suggestion was made by Morgan and Rappleye (1950, 1954) with regard to *C. frutescens*.

The lack of detailed data concerning genetic determinations of the phenomenon of polyembryony in *C. annuum*, the cultivars of which are grown in Europe, inclined us to undertake the present studies. Their aim was to find the frequency of polyembryony in intervarietal pepper hybrids, including those constituting the progeny of twin plants.

MATERIAL AND METHOD

The material for the studies were seeds of three intervarietal hybrids of pepper:

- cv. Tisana \times cv. Sarga chilli
- cv. Poznańska Słodka \times cv. Cuneo
- cv. Poznańska Słodka \times cv. Paradisoni

The cultivars used for creation of hybrids differed from one another by physiological and morphological traits. The choice of the material for the studies, i.e. the use of hybrids instead of the established cultivars, was determined by the practical value of eventual haploid forms from twin seedlings and by a small fertility of some of them from the established cultivars. The F_1 hybrids of these cultivars obtained as a result of crossing with others, characterizing by a large propagation coefficient gave finally high yields of seeds, so that the required number of them could be prepared for the studies.

In 1978 the frequency of twoembryonic seeds in the F_2 generation was determined. Part of the obtained twin seedlings was brought to physiological maturity. The F_3 generation was propagated the next year. In this way, a required number of seeds constituting the F_4 progeny, was prepared for studies in 1980.

For the sake of comparison, observations were carried out in the F_3 generation in 1979. An object of the studies were seeds presenting the progeny of plants originating from monoembryonic seeds of F_2 .

Germination of seeds and selection of twoembryonic forms were performed according to the method described in another paper (Nowaczyk 1979).

RESULTS AND DISCUSSION

The portion of twoembryonic seeds in relation to the total number of germinating seeds in the F_2 generation was 0.198% (Table 1). Attention is drawn to the F_2 hybrid (Poznańska Słodka \times Paradisoni), which was observed to have a threefold lower frequency of twin seedlings in comparison to that of the remaining two hybrids. Similar differences were revealed during the next year of the studies, using seeds of the succeeding generation (Table 2). The obtained results are within the values given by Morgan and Rappleye (1954) and ranging from 0.06 to 0.65% for the

Table 1. Frequency of twoembryonic seeds in F_2 intercultivar hybrids of pepper

Hybrids between cultivars	Number of seeds		Percent of twoembryonic seeds
	germinating	twoembryonic	
Tisana × Sarga chilli	12 802	32	0.249
Poznańska Słodka × Cuneo	9 677	27	0.279
Poznańska Słodka × Paradisoni	11 340	8	0.070
Total	33 819	67	0.198

Table 2. Frequency of twoembryonic seeds in F_3 intercultivar hybrids of pepper

Hybrids between cultivars	Number of seeds		Percent of twoembryonic seeds
	germinating	twoembryonic	
Tisana × Sarga chilli	7 212	15	0.208
Poznańska Słodka × Cuneo	4 730	8	0.169
Poznańska Słodka × Paradisoni	4 868	4	0.077
Total	16 810	27	0.160

cultivars of *Capsicum frutescens*. When comparing these results, one should be careful, first, because the studied material belonged to different species and, secondly, because vegetation conditions of plants presenting the source of these seeds may have an influence on the frequency of twoembryonic seeds (Cameron 1949).

Table 3 gives data concerning the frequency of polyembryony in seeds constituting the progeny of twin plants. Its value expressed as a mean for all the hybrids

Table 3. Frequency of polyembryony in F_4 intercultivar hybrids, originating from twoembryonic seeds of pepper

Hybrids between cultivars	Number of seeds		Percent of twoembryonic seeds
	germinating	twoembryonic	
Tisana × Sarga chilli	1 342	6	0.447
Tisana × Sarga chilli	877	3	0.342
Tisana × Sarga chilli	1 188	4	0.337
Tisana × Sarga chilli	1 592	13	0.816
Tisana × Sarga chilli	965	3	0.311
Tisana × Sarga chilli	1 818	3	0.165
Tisana × Sarga chilli	3 787	6	0.158
Tisana × Sarga chilli	2 892	7	0.242
Tisana × Sarga chilli	2 369	2	0.084
Tisana × Sarga chilli	1 622	2	0.123
Total (for 1 - 10)	18 452	49	0.265
Poznańska Słodka × Cuneo	1 251	1	0.079
Poznańska Słodka × Cuneo	2 084	0	0
Poznańska Słodka × Cuneo	2 656	9	0.339
Total (for 11 - 13)	5 991	10	0.166
Poznańska Słodka × Paradisoni	3 911	1	0.026
Poznańska Słodka × Paradisoni	4 153	5	0.121
Total (for 14 - 15)	8 064	6	0.074
Total (for 1 - 15)	32 507	65	0.199

was similar to that observed among the progeny of plants originating from monoembryonic seeds. A similar finding concerns also individual hybrids. Such a comparison would indicate that the frequency of twoembryonic seeds was not dependent on the fact whether the seeding material presented the progeny of plants from monoembryonic or twoembryonic seeds. Data concerning the progeny of each plant from twoembryonic seeds should be compared in more details, particularly in the case, when we are dealing with the progeny of the both plants constituting a twin pair. Attention is drawn by a very large frequency of twoembryonic seeds in the progeny of plant No. 4 of the hybrid cv. Tisana \times cv. Sarga chilli. It was over twofold larger than in the progeny of its twin form designated No. 3. Therefore, the lack of pronounced differences in the means expressing the frequency of polyembryony between the progeny of plants from mono or twoembryonic seeds does not exclude a possibility of selection towards the obtaining of forms with particularly large inclinations for production of twoembryonic seeds. Differences between hybrids, like those between progenies of individual twin plants suggest genetic control of polyembryony in *Capsicum annum*. A similar suggestion with regard to *Capsicum frutescens* was presented by Morgan and Rappleye (1954). As a result of selection they obtained a homozygous line giving nearly 3% of polyembryonic seeds.

A high heritability of that trait supports the inference concerning genetic determinations of polyembryony in the studied material and a possibility the selection in this respect. The heritability $H=80\%$ was found using the analysis of variance of 3-year observations. Of interest in this respect are also data concerning the hybrids cv. Poznańska Słodka \times cv. Paradisoni. In each of the hybrid progenies, as well as among the seeds constituting the progeny of twin plants, the percentage portion of twoembryonic forms was evidently smaller than in the remaining ones, i.e. also in the hybrid, for the production of which the same maternal form was used. These data, however, cannot be used as a basis for an unbiased conclusion, nevertheless, a tentative suggestion in this respect is justified.

In view a different origin of the material in individual generations (F_2 and F_3 originated from monoembryonic seeds, F_4 — from twoembryonic seeds) no attempt was made to present conclusions concerning the influence of the heterozygosity degree upon the frequency of polyembryony.

CONCLUSIONS

1. Differences in the frequency of polyembryony between individual hybrids in each observed generations indicate an inherent determination of that phenomenon.

2. The obtaining in one of the hybrids of a progeny of plants with a several-fold high frequency of polyembryony and a high heritability of that trait point out to a possibility of selection towards the obtaining of forms with large inclinations to produce twoembryonic seeds.

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CZĘSTOTLIWOŚĆ ZJAWISKA POLIEMBRIONII W POKOLENIACH F_2 , F_3 , F_4 ,
POCHODZĄCYCH Z NASION JEDNO- I DWUZARODKOWYCH U PAPRYKI
(*CAPSICUM ANNUUM* L.)

Streszczenie

Materiałem do badań były nasiona międzyodnianowych mieszańców papryki. Określono częstotliwość występowania nasion dwuzarodkowych w pokoleniach F_2 i F_3 , uzyskanych z nasion jednozarodkowych. W pokoleniu F_4 ustalono ją dla nasion stanowiących potomstwo roślin bliźniaczych. Częstotliwość zjawiska poliembrionii niezależnie od pochodzenia nasion była w każdym pokoleniu podobna. Obserwowano natomiast wyraźne różnice między mieszańcami, a także między potomstwami niektórych par bliźniaczych. Uzyskane wyniki sugerują genetyczne uwarunkowanie tego zjawiska. Odziedziczalność zjawiska poliembrionii, określana na podstawie trzyletnich obserwacji, wynosiła 80 procent.

ЧАСТОТА ПОЛИЭМБРИОНИИ В ПОКОЛЕНИЯХ F_2 , F_3 , F_4 , ПРОИСХОДЯЩИХ ИЗ ОДНО- И ДВУЗАРОДЫШЕВЫХ СЕМЯН СТРУЧКОВОГО ПЕРЦА (*CAPSICUM ANNUUM* L.)

Резюме

Материалом настоящих исследований были семена межсортовых гибридов стручкового перца. Установлена частота появления двузародышевых семян в поколениях F_2 и F_3 , полученных из однозародышевых семян, а в поколении F_4 установлена частота для семян, представляющих потомство растений-близнецов. Частота явления полиэмбрионии в каждом поколении, независимо от происхождения, была подобна. Однако, замечены были отчётливые различия между гибридами. Большие разницы были также между потомствами некоторых пар-близняков. Полученные результаты позволяют предполагать, что это явление генетически обусловлено. Установленная на основании трёхлетних наблюдений наследуемость исследуемого явления составляла $H=80\%$.