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DEVELOPMENTAL DISTURBANCES IN SUNFLOWER (*HELIANTHUS ANNUUS* L.) CULTIVARS OF VARIOUS ORIGIN

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ABSTRACT. In the present paper developmental disturbances which were observed in five years comparative research on two hybrid cultivars and population variety of sunflower were described. The disturbances concerned stems, flower heads, flowers and fruits.

Key words: sunflower, disturbances, stems, flower heads, flowers, fruits

Introduction

Sunflower (*Helianthus annuus* L.) comes from the south-western USA and northern Mexico (Podsolnechnik 1975). Results of archaeological and ethnographic investigations indicate that American Indians have used its oil as food and for oiling their hair (Olejniny... 1992). The first records on its introduction to Europe date back from 1510, when it appeared in Spain. However, till the late 18th century, it was mainly an ornamental plant, although its seeds were also eaten (**Nowiński** 1970). The first herbarium specimen was collected in Spain in the late 16th century. Both plants with single flower heads and plants with branched shoots have been known since then (Olejniny... 1992). Tsar Peter I the Great introduced it to Russia in the late 17th century or the early 18th century (**Podbielkowski** 1992). As an oil crop it started to be cultivated on a large scale in the early 19th century (**Gonet** 1976). In Poland before the 2nd World War sunflower was virtually unknown (**Kłoczowski** 1967). The earliest Polish records on this plant date back from the 1920's (**Krasińska** 1928), but the first attempts to introduce it into a large-scale cultivation were made in the late 1940's (**Moldenhawer** 1948).

Considering the application, several groups of cultivars can be distinguished within the species: ornamental, fodder, gnawing, and oil-seed, including older population cultivars and hybrid cultivars obtained in the last 40 years by crossing selected inbred lines.

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Among these groups, oil-seed sunflower is the most important, as it is one of the most widely cultivated oil crops in the world, ranking fourth after soybean, palm and rape (**Muśnicki** 1999). It is used for production of edible oil and margarine, characterized by a high concentration of linoleic acid – an essential fatty acid (EFA), necessary for human health (**Andryukhov** et **al.** 1975, **Ziemlański** and **Budzyńska-Topolewska** 1991). Even in Poland, where the climate is colder than the thermal requirements of sunflower, it gives the best yields among spring oil crops (**Muśnicki** et **al.** 1997).

In this study, our aim was to analyse disturbances in development of stems, inflorescences and fruits of two types of cultivars and their inheritance level, as hybrid cultivars are generally believed to have less variable plant habit than population cultivars. Hybrid cultivars, thanks to the more uniform ripening, should be more suitable for mechanical harvesting and produce more uniform material in respect of quality. Moreover, thanks to heterosis in the F_1 generation, they have a higher yielding potential than population cultivars (**Kłoczowski** 1967, 1983, **Fick** and **Swallers** 1972, **Burlow** and **Kostyuk** 1980, **Pirani** 1980, 1981, **Vranceanu** et **al.** 1987, **Łuczkiewicz** 1993, **Yoshida** and **Wimonrat-Sukarin** 1993, **Muśnicki** and **Toboła** 1996, **Toboła** et **al.** 1996, **Toboła** and **Muśnicki** 1997, **Ortegon** and **Diaz** 1997, **Goksoy** et **al.** 1998, **Maruthi** et **al.** 1998). Because of this, hybrid cultivars gradually replace population cultivars in cultivation, even in countries with less favourable climatic and soil conditions for sunflower, including Poland. However, few experimental studies have been conducted to verify this hypothesis in relation to new hybrids. **Kłoczowski** (1975) suggests that in the variable Polish climate, hybrid cultivars may be less reliable in terms of yield than population cultivars, so their economic significance may be smaller here than in the dry climate of southern Europe.

Although the variability of morphological traits, correlations between the traits, and their influence on yield size are well-studied in population cultivars of sunflower (**Łuczkiewicz** 1973), little is known on these properties in hybrid cultivars, especially under the Polish climatic and soil conditions. Insufficient information is also available on the biology of flowering and fruiting of hybrid cultivars, and on disturbances of these processes in the first generation.

Material and methods

The objects of the study were two hybrid cultivars (F_1) of sunflower: the French cv. Frankasol, bred by Cargill, and the American cv. Coril, bred by Pioneer, as well as the Polish population cultivar Wielkopolski, grown in the IHAR station at Borowo. Seeds were obtained every year from these firms.

Field trials were conducted in 1997-2001 at Przybroda near Poznań (West Poland). The studied cultivars were sown in 18 plot variants, with the use of two doses of nitrogen fertilization (60 and 120 kg N/ha) and three sowing density levels (50, 75 and 100 thousand individuals/ha). The frequency of various disturbances was estimated for 100 individuals from each plot every year. During ripening, fruits from such individuals were collected and sown next year, to analyse their inheritance in the next generation.

Results

Cultivated forms of oil-seed sunflower are characterized by an erect, unbranched stem with a single terminal flower head. Sometimes the stem branches monopodially or – extremely rarely – even dichotomously (Olejniny... 1992). In this study, stem branching was also observed, especially in the lower part of the stem, but sometimes just below the flower head. Such anomalies were observed in the population cultivar (Wielkopolski) and in the hybrid cv. Frankasol at nearly the same frequency, irrespective of agrotechnical conditions, while in the hybrid cv. Coril they were sporadic. In Wielkopolski, two individuals did not flower at all (in 1998). Among the thousands of the examined individuals in all years of the study, only one case of stem fasciation was observed – also in Wielkopolski in 1998. Several cases of dichotomous branching of the stem, sometimes even in the terminal part of the stem, leading to development of two flower heads, were also observed then in this cultivar. The disturbances are illustrated in Photograps 1-4. After sowing of seeds of these specimens, the disturbances were observed very rarely in the next generation, and occurred by chance.

Abnormal development of flower heads was caused by fusion of two or even three normal ones. Rarely, as a result of dichotomous division of the developing flower head, two independent flower heads were formed. Most frequently, in the centre of the flower head, additional ligulate florets developed, or with green phyllaries at the centre of the flower head. Quite frequent was also branching of the stem, leading to formation of multiple flower heads, usually smaller in size and with smaller fruits than normal (Phots 5-12 and 2-3). Such disturbances were nearly equally frequent in Wielkopolski and Frankasol (6% and 5%, respectively), while in Coril they were sporadic. They did not depend on agrotechnical factors and were inherited casually.

Several thousand flower heads were examined and nearly all of them were protandrous. Only in one flower head of Wielkopolski, the female and male reproductive organs matured simultaneously.

About 1% of flower heads, mainly in their intermediate and inner parts, contained florets with 2-4 fused ovaries. Usually they were surrounded by only one corolla but with a higher number of teeth (> 5). Such florets had numerous styles or only one fasciated style with 4-8 stigmas. These disturbances were most common in Coril, and the least frequent in Wielkopolski. We observed also transitional forms between tubular and ligulate florets (Phots 13-14). In all years of the study, only one ligulate floret with a developed style (i.e. fertile) was found.

Among thousands of the examined individuals, only one had albino fruits. The last type of disturbances consisted in fusion of 2-3 or even 4-5 fruits (Phot. 15). They resulted from abnormal development of flowers, so they were also the most common in the intermediate and inner parts of the flower head. Such disturbances were the most frequent in the hybrid cv. Coril and the least frequent in the population cultivar Wielkopolski.

Most cases of abnormal development of stems, inflorescences and fruits were observed in 1999. Our observations suggest that more frequent occurrence of fused florets and fruits in that year could be caused by intensive rainfall during the flowering period.

Discussion

Branching types, as disturbances of sunflower morphology, have been characterized by **Sandu** et **al.** (1997), who determined the inheritance of this trait by crossing individuals with such anomalies and without them. The branches may be short or long, in the upper or the lower part, single or multiple. In wild *Helianthus* species stem branching is a dominant trait, while in cultivated species (*H. annuus* and *H. tuberosus*) it is recessive. Thus stem branching is a feature of plant wildness in this genus. In cultivated species the occurrence of this disturbance type is affected by the environment. **Gong-She** and **Leclercq** (1987) studied the influence of various factors on the appearance of such disturbances. Individuals were reproduced by self-fertilization. Effects of the site type, date of sowing, and sowing density were significant, and the inheritance was low. **Leclercq** (1984 a) investigated the inheritance of dichotomous branching of stems. In the F_1 generation – plants resulting from self-fertilization of individuals with disturbances – the percentage of such plants was high, but in the F_2 generation it was much lower.

Disturbances of flowering in sunflower, which consist in fusion of flower heads, were observed earlier by **Mowszowicz** and **Hereźniak** (1971). Besides, **Fabry** (Olejniny... 1992) reported on development of multiple heads, occurrence of deformed heads with ligulate florets in the centre, or even heads devoid of ligulate florets. Disturbances in the development of single florets or fruits in the flower head were also observed by **Vranceanu** (Floarea... 1974), as well as by **Hernandez** and **Green** (1993), while disturbances of whole flower heads by **Palmer** and **Hernandez** (1988). Genetic conditioning of formation of multiple heads was studied by **El-Sahookie** (1994), whereas **Secerov-Fiser** (1999) – by diallelic crossing of 5 breeding lines – studied their inheritance and presented its model. **Gong-She** and **Leclercq** (1987), who observed dichotomous branching of stems, noticed that such individuals usually produced 2-3 flower heads.

Artificially, by using various chemical substances (e.g. gibberellic acid), it is possible to produce flowers with earlier developing stigmas. By applying suitable doses of chemicals inhibiting development of the androecium, completely male-sterile lines have been obtained. In this way, new hybrid cultivars were bred by **Schuster** (1962/63). At present, cytoplasmic male sterility is used for creation of inbred lines (**Leclercq** 1984 b, **Trabace** et **al.** 1996). The first author is regarded as the precursor of this method (**Leclercq** 1969).

Conclusions

1. Developmental disturbances in stems, flower heads and fruits were very rare and occurred by chance in the next generation. This suggests that the disturbances are not inherited but are caused by environmental factors, which is consistent with results of other studies.

2. Generally, the occurrence of disturbances did not depend on the type of cultivar. Nevertheless, some types of disturbances were more frequent in hybrid cultivars and others in the population cultivar.

3. Variable agrotechnical factors did not affect the frequency of any type of disturbances in any cultivar.

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ZABURZENIA ROZWOJU RÓŻNYCH TYPÓW ODMIAN SŁONECZNIKA ZWYCZAJNEGO (*HELIANTHUS ANNUUS* L.)

S t r e s z c z e n i e

W trakcie pięcioletnich badań nad porównaniem mieszańców liniowych z odmianą populacyjną słonecznika zwyczajnego, prowadzonych w latach 1997-2001, obserwowano również zaburzenia rozwoju. Dotyczyły one pędów, kwiatostanów, kwiatów i owoców. W doświadczeniu zastosowano dwie dawki nawożenia azotowego i trzy zagęszczenia. Najczęściej spotykano różnorodne zaburzenia budowy koszyczków oraz zwiększenie ich liczby na jednym pędzie. Obserwowano też zrastanie się kwiatów rurkowych, co powodowało powstawanie połączonych owoców.

Zmienne czynniki agrotechniczne nie wpływały na rodzaj i częstość występowania zakłóceń rozwoju różnych odmian słonecznika. Najwięcej takich anomalii zauważono w 1999 roku. Występowanie zaburzeń nie zależało od typu odmiany. Jedne pojawiały się częściej u hybrydów, inne zaś u kreacji populacyjnej. W kolejnym pokoleniu obserwowane zaburzenia pojawiały się bardzo rzadko i w sposób przypadkowy, stąd wniosek, że nie są one dziedziczone, lecz wywoływane jedynie czynnikami środowiskowymi, co potwierdziły badania innych autorów. Na przykład zwiększenie się udziału zrośniętych kwiatów w koszyczku było spowodowane wzrostem ilości opadów w czasie kwitnienia.