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GENERATIVE REPRODUCTION AND EXTERNAL CONFORMATION OF *ECHINOCHLOA CRUS-GALLI* (L.) P. BEAUV. PLANTS UNDER VARIOUS DENSITY CONDITIONS

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Abstract: The effect of density on individual and population fertility, and selected morphometric characters (height, number of: ramifications, generative branches, inflorescences and leaves) of *Echinochloa crus-galli* plants was studied in a glasshouse. A decrease in individual fertility was observed in all density variants examined, but it did not result in a decrease in population fertility per unit of area. In response to worse developmental conditions there appeared plants characterized by reduced height and simplified external conformation.

Key words: *Echinochloa crus-galli*, density, individual fertility, population fertility, morphometric characters

INTRODUCTION

Numerous experiments show that species fertility is both determined genetically by reproductive potentials, and modified by environmental factors (Aldrich 1997; Cavers and Benoit 1989; Gross and Smith 1991; Koide and Lu 1992; Malicki and Kwiecińska 1999; Pawłowski et al. 1979; Wilkoń-Michalska 1976). Individual fertility is additionally affected by the height and conformation of plants, which are correlated with density (Falińska 1997; Dostatny 1998). In some species higher density is accompanied by lower fertility (Bennington and Stratton 1998; Falińska 1997; Leverich and Levin 1979; Watkinson and Harper 1978; Wilkoń–Michalska 1976). On the other hand, it was found that a negative correlation between individual reproduction and density does not have to be a general rule (Symonides 1974; Symonides 1979; Latowski 1994; Falińska 1997). Density, influencing the structure of a single plant, modifies also the structure of standing crop. The response to density and worse developmental conditions depends on plant species and may take different forms, from limited growth and simplified external conformation, through maximum growth and simplified conformation, to highly differentiated growth and conformation (Harper 1986; Kirby and Faris 1972; Smith 1982; Wilkoń-Michalska 1976).

The aim of the present studies was to examine the effect of density on individual and population fertility, and some morphological characters of *E. crus-galli.*

METHODS AND MATERIALS

A pot experiment was conduced on *E. crus-galli* plants in 1999, in a glasshouse. Three density variants (1, 5 and 10 plants per pot) in five replications were tested on areas covering 177 cm^2 each. In order to determine individual and population fertility, seeds were obtained successively in the course of their dispersal (in the case of *E. crus-galli* the ripening and dispersal of diaspores are unevenly distributed in time). Morphological analyses were made on plants, which managed to complete vegetation. The parameters examined were height, number of ramifications, generative branches, inflorescences and leaves. The results were analyzed statistically by the Duncan test, at a level of significance $p=0.05$.

RESULTS AND DISCUSSION

The results of a pot experiment concerning the individual fertility of *E. crus-galli* show its considerable decrease with increasing density (Fig. 1). The number of caryopses produced by a single plant diminished from 1 561 (1 plant per pot) to 583 (5 plants per pot) and 305 (10 plants per pot). Reduced fertility resulting from high density was also observed in other annual plants, such as *Vulpia fasciculata, Agrostemma githago, Phlox drummondii, Salicornia* (Watkinson and Harper 1978; Zarzycki 1965; Leverich and Levin 1979; Wilkoń-Michalska 1976). Falińska (1997)

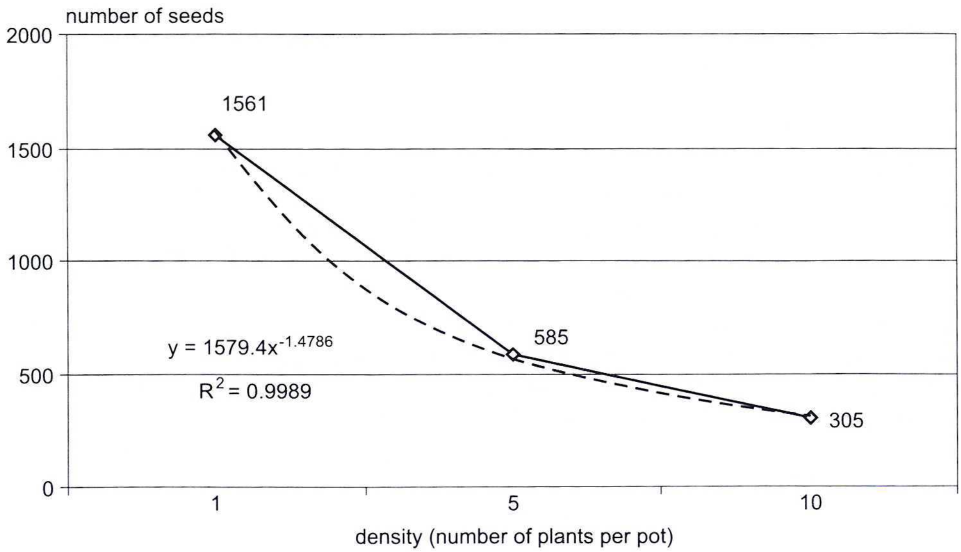

Fig. 1. Effect of density on individual fertility of *E. crus-galli* (L.) P. Beauv.

noted it also in perennial herbaceous plants. However, such a response to density does not have to be a general rule. No significant effect of density on fertility was observed in *Spergula vernalis, Plantago indica, Anthoxanthum aristatum* (Symonides 1974; 1979; Latowski 1994), whereas in *Impatiens noli-tangere* (Falińska 1997) high density was positively correlated with individual fertility. Differentiated reactions to density depend on species-linked characters. According to Symonides (1987), the reproduction of semelparic plants is affected by light conditions, and the response to light intensity depends on the fact if a given species is light- or shade-loving. In plants found in fallow land – *Chenopodium album* and *Polygonum pensylvanicum* – the reproductive power is in direct proportion to light conditions, in contrast to undergrowth plants. Aldrich (1997) described different fertility levels in response to increased shading in the case of weeds, which attacked crops in various historic times, i.e., whose adaptation period was of a different length. *Rottboelia exaltata*, an old species, produces seeds even in shaded placed, whereas in *Setaria faberi*, a much younger species, shading causes a lethal-like state. Beyond a doubt, competition, shading and – as in the present experiment – immediate vicinity of own species are factors regulating individual reproduction.

It was found that lower individual fertility did not cause a decrease in global seed production in the population per unit of area (Fig. 2). It turned out that in the case of high density (10 plants per pot) and low reproductive power (305 caryopses per plant) population fertility is higher than in that of low density and high individual fertility. A relatively constant level of global seed production, despite increased density and a smaller number of diaspores per plant was also observed by other authors (Zarzycki 1965; Palmblad 1968). According to Aldrich (1997), at the population level, weeds are able to produce the number of seeds, which compensates

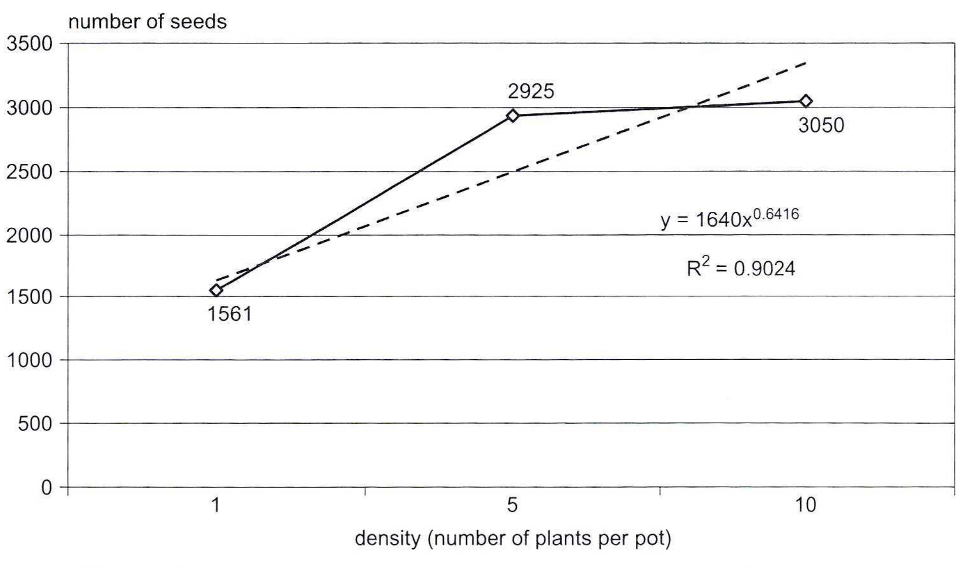

Fig. 2. Effect of density on generative reproduction of *E. crus-galli* (L.) P. Beauv. population

lower intensity of their occurrence. Our investigations and those conducted by other authors show that such a response is typical of many weed species and constitutes a key element of their survival strategy. It allows to stabilize the population when access to growth factors is limited.

The individual fertility of *E. crus-galli* was also affected by changes in plant conformation and modification of morphometric characters (Tab. 1, Fig. 3). In all density variants changes in plant conformation were accompanied by a decrease in individual fertility. In response to worse developmental conditions the plants produced a smaller number of ramifications, generative branches, inflorescences and leaves (Tab. 1). At density of 5 plants per pot the number of ramifications and inflorescences decreased by 50%, and the total number of generative branches and leaves – by ca. 30%. A similar tendency was noted in *E. crus-galli* populations grown under various agricultural and ecological conditions in Żuławy Wiślane (Woźniak and Hołdyński 1991). The highest coefficient of reproduction (the total number of vegetative and generative branches) was observed for the lowest density of its plants, in a sugar beet field. In a maize field and in a control experimental plot (without crops), where the density was much higher, the number of branches diminished by ca. 1/3. It should be emphasized that in a glasshouse all branches produced by *E. crus-galli* headed and fructified (Tab. 1), whereas under natural conditions, with accompanying crops, only some of them entered the generative stage (Woźniak and Hołdyński 1991).

Height was not affected by competition at density of 1 (variant I) and 5 (variant II) plants per pot (Tab. 1). In variant II the plants were on average by only ca. 5 cm shorter than in variant I. However, a group of plants characterized by differentiated height was observed in this density range (Fig. 3). In variant III (10 plants per pot) the values of all parameters examined were by ca. 20–40% lower. The plants were considerably shorter, with fewer ramifications, generative branches, inflorescences and leaves. They all were characterized by reduced height and simplified external conformation.

Table 1. Effect of density on some morphometric characters of *E. crus-galli* (L.) P. Beauv.

Density of plants per pot		Height of plants (cm)	Number of branches	Number of shoots generative			Number of inflorescences	Number of leaves
				total	tall	short (to 9 cm)		
1	$\bar{x}$	63.2 [a]	5.4 [a]	18.4 [a]	9.6 [a]	8.8 [a]	22.2 [a]	21.8 [a]
	l	*47–79*	*2–9*	*14–32*	*6–13*	*5–19*	*15–37*	*18–30*
5	$\bar{x}$	58.2 [a]	2.6 [b]	10.9 [b]	7.8 [b]	3.1 [b]	11.0 [b]	14.6 [b]
	l	*21–91*	*1–4*	*3–22*	*4–14*	*1–8*	*4–22*	*6–22*
10	$\bar{x}$	42.2 [b]	1.5 [c]	7.9 [c]	4.8 [c]	3.1 [b]	8.8 [c]	8.9 [c]
	l	*16–73*	*1–3*	*3–18*	*2–8*	*1–11*	*4–17*	*5–16*

$\bar{x}$ – average; *l* – range; different letters (a,b,c) show significant treatment differences according to Duncan test (p=0.05)

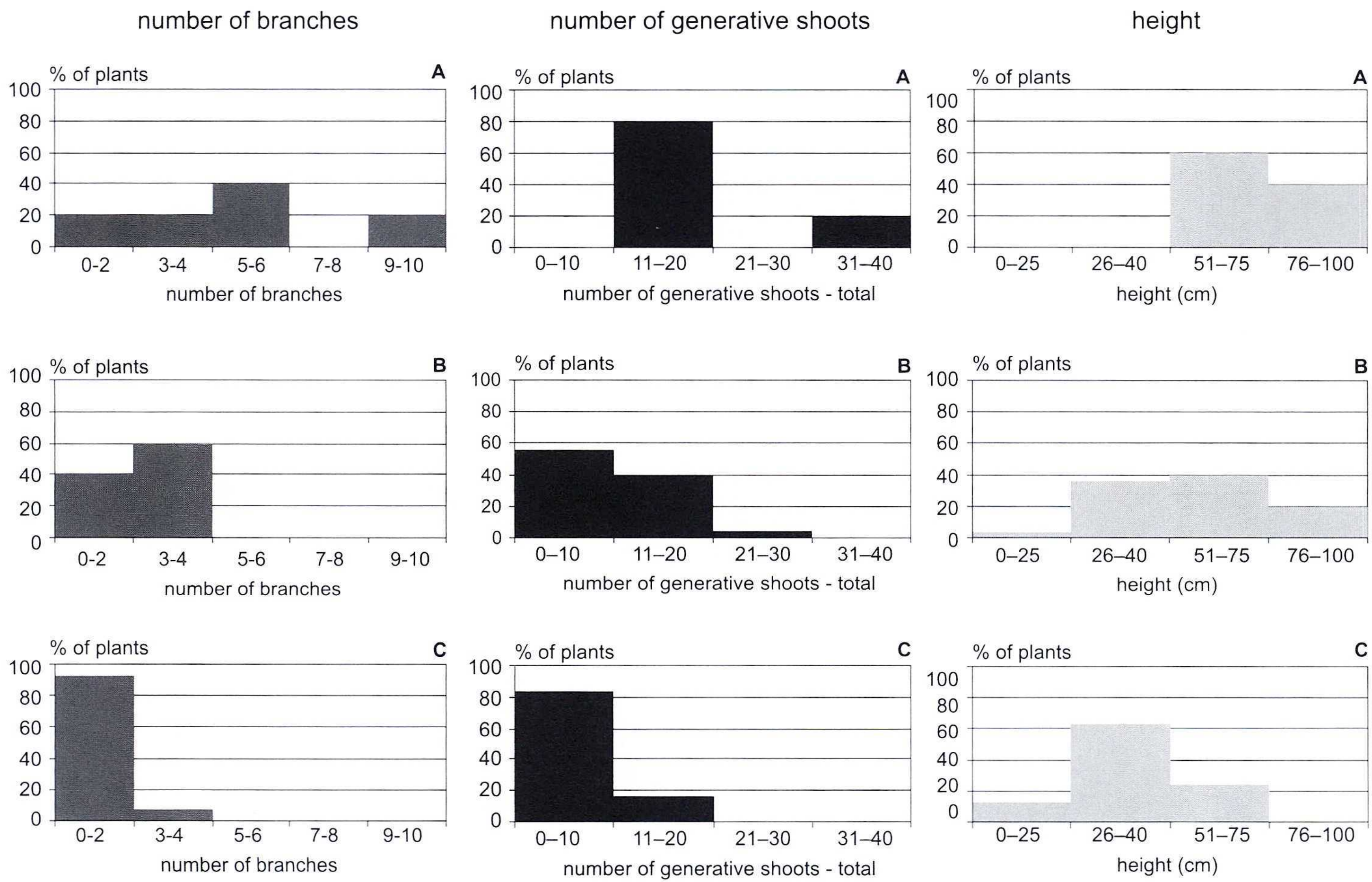

Fig. 3. Effect of density on plant structure of *E. crus-galli* (A – 1 plant per pot; B – 5 plants per pot; C - 10 plants per pot)

CONCLUSIONS

1. The response of *E. crus-galli* to higher density and worse developmental conditions was reduced height and simplified external conformation.
2. In consequence of increasing density (from 1 to 10 plants per pot) the plants produced fewer ramifications, generative branches, inflorescences and leaves. In variant II (5 plants per pot) a decrease in plant height was insignificant. However, a group of plants characterized by differentiated height was observed in this density range. In variant III (10 plants per pot) the plants were considerably shorter.
3. The highest average individual fertility was noted at the lowest density. Increasing density resulted in a decrease in individual fertility of *E. crus-galli* plants.
4. Despite increasing density and a smaller number of diaspores per plant, the global seed production remained at a relatively constant level.

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POLISH SUMMARY

POZIOM REPRODUKCJI GENERATYWNEJ I POKRÓJ ROŚLIN *ECHINOCHLOA CRUS-GALLI* (L.) P. BEAUV. W RÓŻNYCH WARUNKACH ZAGĘSZCZENIA

W celu określenia wpływu zagęszczenia na płodność osobniczą i populacji oraz niektóre cechy morfometryczne roślin *Echinochloa crus-galli* przeprowadzono badania wazonowe w warunkach szklarniowych. Na powierzchniach po 177 cm^2 zastosowano 3 warianty zagęszczenia (1, 5, 10 osobników w wazonie). Wykazano spadek płodności osobniczej w miarę wzrostu zagęszczenia, który nie doprowadził jednak do spadku płodności populacji przypadającej na jednostkę powierzchni. Reakcją na pogarszające się warunki rozwoju była mniejsza liczba wytwarzanych rozgałęzień, pędów generatywnych, kwiatostanów i liści właściwych. W przedziale 1–5 os. w wazonie dwukrotnie zmalała liczba wytwarzanych rozgałęzień i kwiatostanów, śr. o ok. 30% spadła ogólna liczba pędów generatywnych i liści właściwych. Nie obserwowano znacznego spadku wysokości, rośliny były niższe śr. o ok. 5 cm. Postępujące zagęszczenie (10 os. w wazonie) wywoływało dalszą redukcję wartości wszystkich badanych cech o ok. 20–40%.