

An evaluation of some morphological traits in doubled haploid lines and their F₁ hybrids of head cabbage Kamienna Głowa in the vegetative phase

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Abstract. The internal stump length, head mass and head shape of doubled haploid (DH) lines and their F₁ hybrids of head cabbage Kamienna Głowa were compared. It was found that the range of variation in the investigated traits of DH lines was higher than that of their F₁ hybrids. The head mass of the DH lines indicated some level of inbreeding depression, but their F₁ hybrids showed a significant effect of heterosis. Genes responsible for flattened head shape were dominant over rounded shape genes. The longer internal stump trait was dominant over the shorter one.

Key words: *Brassica oleracea* var. *capitata*, doubled haploids, F₁ hybrids, heterosis.

Introduction

Head cabbage (*Brassica oleracea* L. var. *capitata* L.) Kamienna Głowa, because of its excellent flavour and suitability for sauerkraut processing, is one of the most popular cultivars in Poland. In the Research Institute of Vegetable Crops in Skierniewice, investigations aimed at improving the uniformity of this cultivar by applying the anther culture technique were performed (GÓRECKA et al. 1997). Doubled haploid (DH) lines are completely homozygous and some recessive traits as well as inbreeding depression can occur (NIEMIROWICZ-SZCZYTT 1997). However, DH lines of head cabbage were quite uniform and stable in consecutive generations (DORE, BOULIDARD 1988).

The aim of this study was to evaluate some morphological traits (the mass and shape of the head and the length of the internal stump) and the range of diversity of

Received: March 13, 2000. Revised: August 11, 2000. Accepted: September 15, 2000.

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the DH lines and their F_1 hybrids of head cabbage Kamienna Głowa in the vegetative phase. Effects of heterosis and influence of crossing direction towards F_1 hybrids were evaluated.

Material and methods

Material for the study covered eight doubled haploid lines of R_1 generation and 15 F_1 hybrids obtained from the crosses between selected DH lines of head cabbage (KAMIŃSKI et al. 1998, 1999a).

Doubled haploids were derived from commercial cultivar Kamienna Głowa by anther culture technique (GÓRECKA et al. 1997). Lines under study were obtained from androgenetic R_0 plants by selfing (KAMIŃSKI et al. 1999b).

The field experiment to evaluate the DH lines and F_1 hybrids was conducted at Skierniewice in 1998. The tested plants developed from seeds in the greenhouse. One-month-old seedlings were planted in mid-May in a completely randomised block design with three repetitions. Each block consisted of 12 plants. Fertilisation, pest and disease control followed the current recommendations. As a control, three foreign hybrids of head cabbage: Delus F_1 , Lenox F_1 , Atria F_1 and the commercial cultivar Kamienna Głowa were used. Cabbage heads were harvested in the mid-October, when they reached maturity. Head mass, length and width as well as the internal stump length were measured and head shape coefficient (length/width) was calculated.

Two pairs of DH lines (PS1, PS7 and PS3, PS8) and their both crossed F_1 hybrids (F1.7, F7.1, F3.8, F8.3) were selected for analyses of heterosis, crossing direction influence, and inheritance of investigated traits. An analysis of variance of the data was performed. The significance of differences among means was evaluated by the use of Student's *t* test ($\alpha = 0.05$). The range of variation was calculated by comparison of extreme values of investigated traits for all DH lines and F_1 hybrids.

Results and discussion

The results of the evaluation of head mass, head shape coefficient and internal stump length of all DH lines and F_1 hybrid plants presented in Figure 1A, B, C. It was found that the average head mass of seven out of eight DH lines was lower than that of the commercial cultivar Kamienna Głowa (Figure 1A). According to HOSER-KRAUZE (1993) during the inbreeding process the head size of head cabbage may be decreased. In this study the only exception was PS11 DH line, whose mean of head mass was significantly higher than that of the commercial cultivar. In contrast to DH lines, the yield of the F_1 hybrids was higher than that of Kamienna Głowa. It was shown that the average head mass of nine F_1 hybrids was

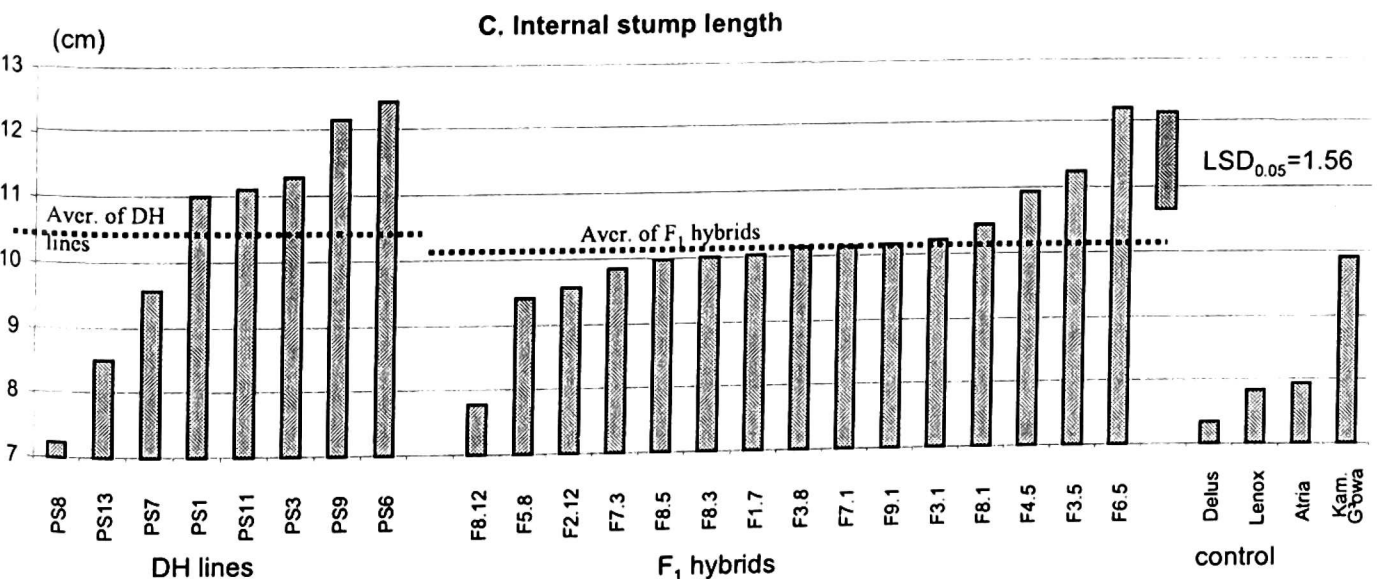
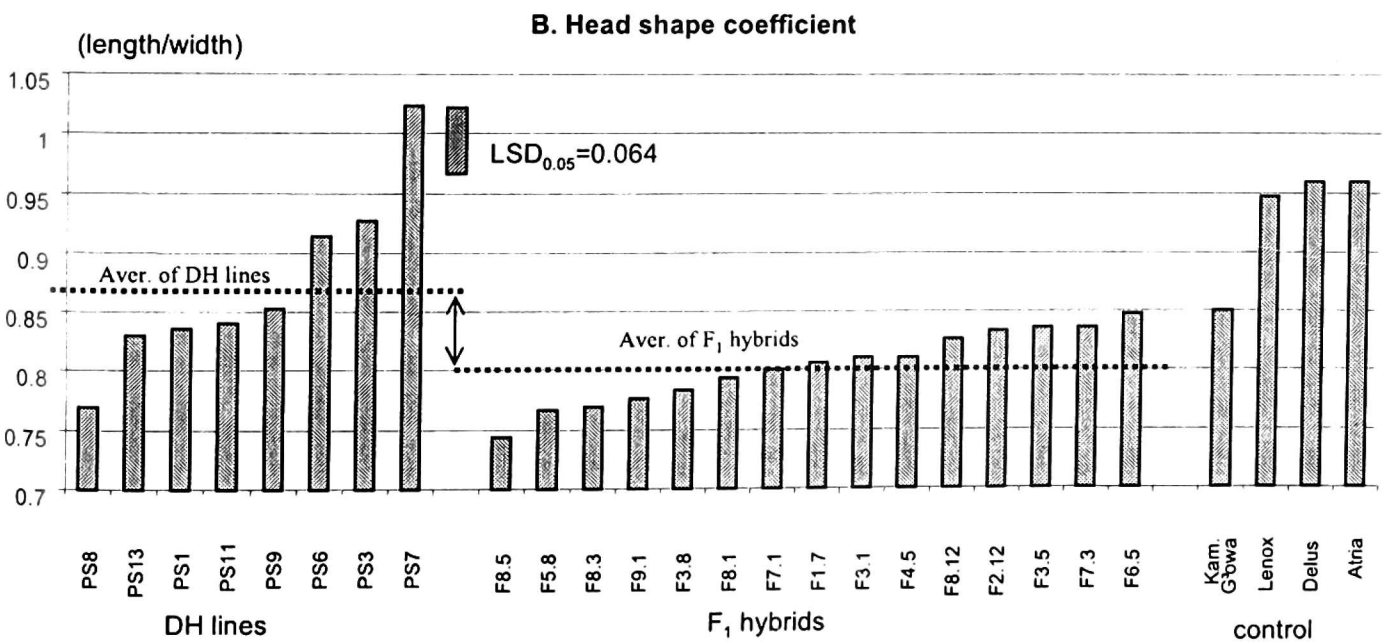
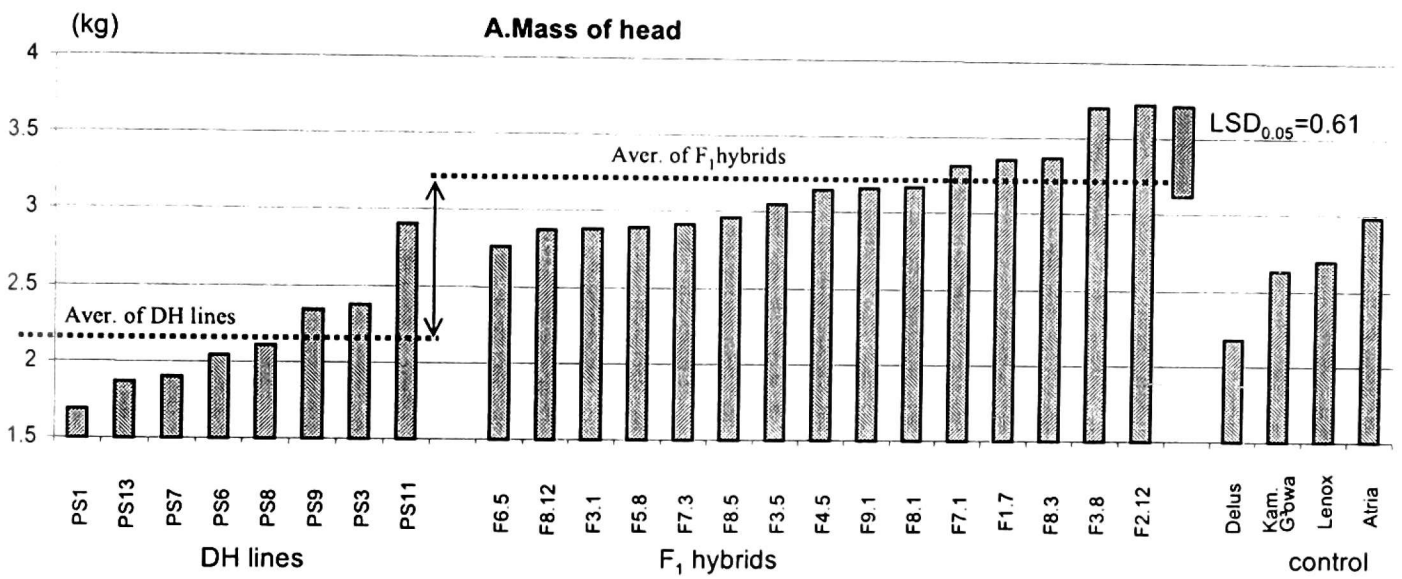
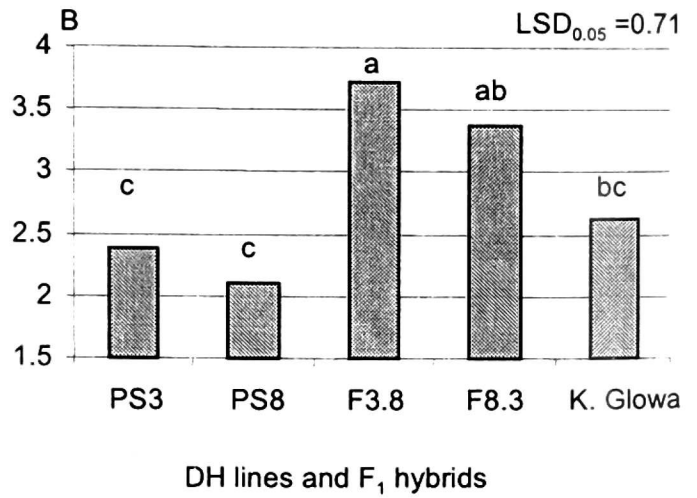
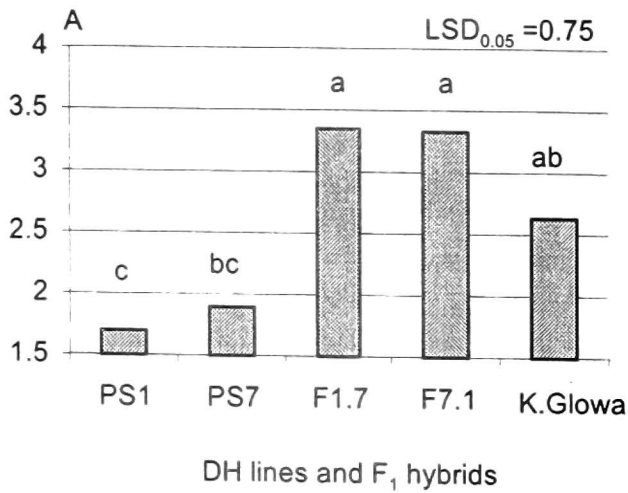
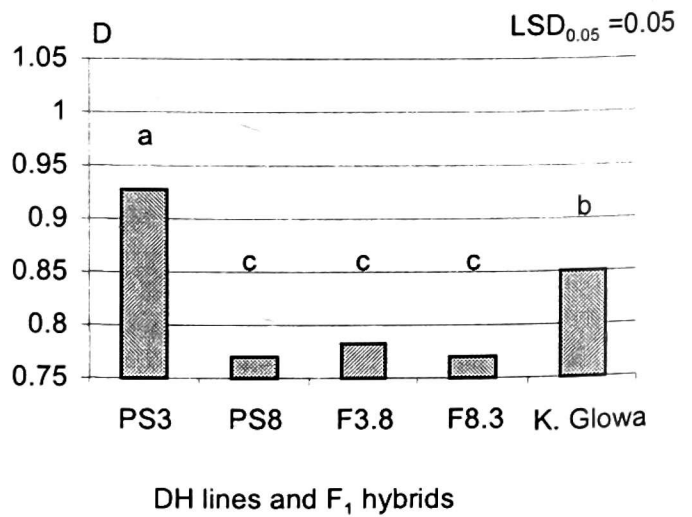
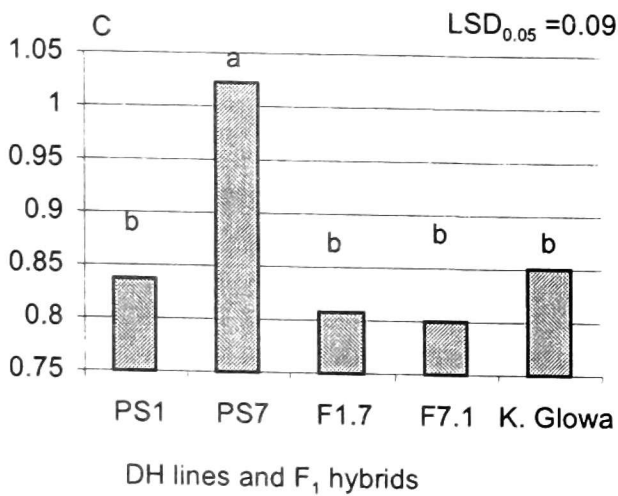


Figure 1. The average head mass (A), head shape coefficient (B) and internal stump length (C) of doubled haploid (DH) lines and their F₁ hybrids of R₁ generation of head cabbage Kamienna Głowa and control F₁ cultivars

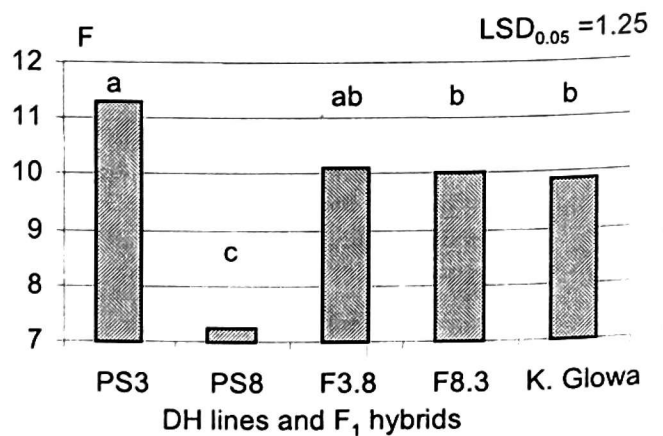
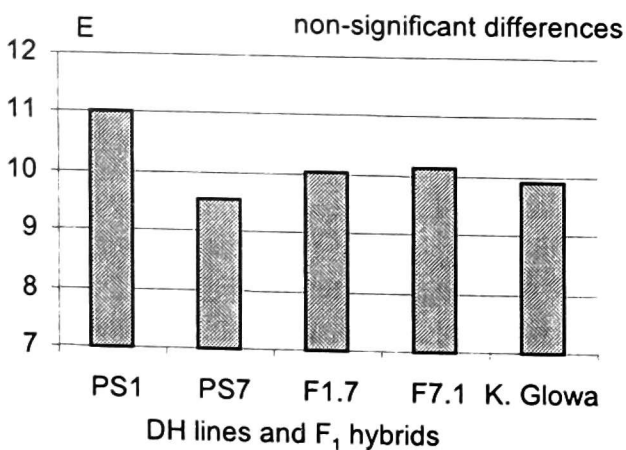
Head mass (kg)



Head shape coefficient (length/width)



Internal stump length (cm)



DH lines: PS1, PS7, PS3, PS8

F₁ hybrids: F1.7 (PS1 x PS7), F7.1 (PS7 x PS1), F3.8 (PS3 x PS8), F8.3 (PS8 x PS3)

a,b,c: groups marked with the same letters are not significantly different from each other

Figure 2. Comparative analysis of DH lines and their F₁ hybrids of head cabbage Kamienna Głowa in relation to head mass (A, B) head shape coefficient (C, D) and internal stump length (E, F)

even higher than that of the best-yielding hybrid Atria F₁. The average head mass of all the F₁ hybrids (3.16 kg) was significantly higher than that of all DH lines (2.15 kg), which confirms the dominance or partial dominance of the larger heads (HOSER-KRAUZE 1993). Heterosis for head mass was observed among selected F₁ hybrids: F1.7 (3.35 kg), F7.1 (3.32 kg), F3.8 (3.71 kg), F8.3 (3.37 kg), as their values were significantly higher than the values of their parental lines: PS1 (1.69 kg), PS7 (1.90 kg), PS8 (2.11 kg), PS3 (2.38 kg) (Figure 2 A, B). The obtained results are in accordance with those described by DICKSON and WALLACE (1986), who found that the head size of head cabbage is quantitatively inherited and heterosis can occur among F₁ hybrids. Crossing direction had no influence on head mass of the investigated F₁ hybrids. The lower head mass of F8.3 F₁ hybrid in comparison to the reciprocal F3.8 F₁ hybrid was probably caused by the maternal line (PS8) sib effect. According to our previous results the line PS8 had weak self-incompatible alleles and a lower mass (KAMIŃSKI et al. 1999b). The range of variation in head mass among the DH lines ($L_{\max} - L_{\min} = 1.22$ kg) was higher than that of the F₁ hybrids ($F_{\max} - F_{\min} = 0.97$ kg).

Cabbage head shape varies from conical through rounded to strongly flattened. Generally, the conical shape of the head is dominant over the flattened one. However, it is generally agreed that many genetic factors determine cabbage head shape (DICKSON, WALLACE 1986). HOSER-KRAUZE (1993) reported that some groups of F₁ hybrids of head cabbage had more flattened heads than their parental forms. Significant differences were found in the head shape coefficient of the tested genotypes (Figures 1B, 2C, D). Head shape coefficient of DH lines varied from flattened (PS8 – 0.77) to slightly elongated (PS7 – 1.02). In contrast, the F₁ hybrids were less variable regarding head shape and they were usually slightly flattened. The range of variation in head shape coefficient among the DH lines ($L_{\max} - L_{\min} = 0.25$) was wider than that of the F₁ hybrids ($F_{\max} - F_{\min} = 0.10$). The obtained results suggest that the gene/genes responsible for the flattened head of the DH lines from cultivar Kamienna Głowa might have a dominant effect.

Among the tested morphological characters, the average length of the internal stump of the DH lines and F₁ hybrids did not differ and ranged from 10.0 to 10.5 cm. However, one of the F₁ hybrids (F8.12) had significantly shorter internal stumps (7.8 cm), similar to those of Lenox and Atria F₁ hybrids (Figure 1C). DH lines showed a wider range of variation in internal stump length ($L_{\max} - L_{\min} = 5.24$ cm) than the F₁ hybrids ($F_{\max} - F_{\min} = 4.46$ cm). The analysis of inheritance of the internal stump (Figure 2 E, F) indicated that irrespective of crossing direction, F₁ hybrids had longer internal stumps than their parental components. This does not confirm that the internal stump length is controlled by two incompletely dominant genes for short stump (DICKSON, WALLACE 1986).

Conclusions

The range of variation in head mass, head shape and internal stump length was wider for the DH lines than for the F₁ hybrids.

Head mass in DH lines was lower than in the commercial cultivar Kamienna Głowa, which indicates that DH lines had some level of inbreeding depression. F₁ hybrids showed a significantly higher head mass because of heterosis. Some of the F₁ hybrids had the higher yield than the best foreign cultivars (Delus F₁, Lenox F₁, Atria F₁) used as the control.

The gene/genes responsible for flattened head shape and longer internal stump had partially dominant effects over those responsible for rounded or elongated head shape and shorter internal stump.

The obtained results suggest that selection of diversified DH lines of Kamienna Głowa with good morphological traits can be a method for developing vigorous and uniform F₁ hybrids which may be more productive and attractive than the commercial cultivar.

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