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The effect of plant shading on growth and winter hardiness of Blue Holly (*Ilex* × *meserveae* S. Y. Hu.) cultivars

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ABSTRACT

In 1997 – 2000 growth and winter hardiness of four cultivars (‘Blue Boy’, ‘Blue Girl’, ‘Blue Princess’, and ‘Blue Prince’) of *Ilex* × *meserveae* S. Y. Hu. was evaluated in the climatic conditions of central Poland. Plants of ‘Blue Boy’ had the lowest number of primary shoots, while plants of ‘Blue Princess’ – the highest. Plant shading significantly decreased the number of primary shoots of ‘Blue Girl’ plants. Generally, plant shading affected the length of primary shoots. In 1997 and 1998 the length of primary shoots of ‘Blue Boy’ plants did not differ significantly and unshaded plants of ‘Blue Girl’ had longer shoots than shaded plants. Generally, shaded plants of all investigated cultivars had longer primary shoots. During four years of experiment unshaded plants had more lateral shoots. However, in 2000 the differences were fewer and for ‘Blue Boy’ were not significant. Shading of plants significantly increased the length of lateral shoots, except for ‘Blue Girl’ in 1997 – 98 where differences were not significant. In the field conditions there was no

visible plant damage caused by low temperature in winters 1997/1998, 1998/1999, and 1999/2000.

INTRODUCTION

Interspecific hybrid *Ilex* × *meserveae* S. Y. Hu. is a new species that combines relatively good winter hardiness of *I. rugosa* F. Schmidt with ornamental values of *I. aquifolium* L. However, some experiments showed that frost resistance and sensitivity to summer high temperatures depended on the cultivar (Pair and Still 1982). When introducing cultivars of *Ilex* × *meserveae* to Poland, resistance to winter low temperatures is one of the most important characteristics of a plant. The frost resistance of this species was not tested in the climatic conditions of central Europe. On the other hand, resistance to low temperatures can be affected by cultural practices like fertilization (Pellet and White 1969, Havis at al. 1972), plant irrigation (Aniśko and Lindstrom 1995), shading (Robinson and Hamilton 1983), and pruning (Haynes and Lindstrom 1991).

The aim of this work was to evaluate the effect of plant shading on field growth and winter resistance of four *Ilex* × *meserveae* cultivars in the climatic conditions of central Poland.

MATERIAL AND METHODS

Four cultivars of *Ilex* × *meserveae* S. Y. Hu. were used in the experiment - two female ‘Blue Girl’ and ‘Blue Princess’ and two male ‘Blue Boy’ and ‘Blue Prince’. In 1997, two-year-old plants grown in 3 dm^3 pots were transplanted into 11 dm^3 containers filled with a mixture of sphagnum peat and composted pine bark (1 : 1, v : v) amended with 3 g dm^{-3} limestone (to the final pH 6.5). Slow release fertilizer (Osmocote Plus 3-4M) was added (3 g dm^{-3}) to the growing medium each year. Plants were cultivated in the field with containers buried into the soil and irrigated when necessary. The experiments were carried out in 4 replications (8 plants in each replication). Half the plants were covered with polyethylene shading cloth (50% shade). In October 1997, 1998, 1999, and 2000 the number and length of primary shoots and lateral outgrowth was noted. Completely randomized block design was used in the experiment. The data were submitted to two factorial analysis of variance (cultivar × shading) and means were compared using Duncan’s multiple-range test at $p = 0.05$ or least significant difference ($LSD_{0.05}$) for data presented graphically.

RESULTS

Plants of *Ilex* × *meserveae* formed several strong primary shoots. The cultivar had significant effect on the number of primary shoots (Table 1). The lowest number of primary shoots was observed for ‘Blue Boy’ (2.06 shoots per plant), the highest for ‘Blue Princess’ (3.44 shoots per plant). The differences caused by shading were significant only for ‘Blue Girl’ (2.58 shoots per shaded plant and 3.67 shoots per unshaded plant).

Table 1. Effect of plant shading of four cultivars of Blue Holly on number of primary shoots after three years of cultivation

Cultivar	Shaded	Unshaded	Mean
‘Blue Boy’	**2.08 a***	**2.04 a**	**2.06 a**
‘Blue Girl’	**2.58 ab**	**3.67 d**	**3.13 bc**
‘Blue Princess’	**3.50 cd**	**3.38 cd**	**3.44 c**
‘Blue Prince’	**2.88 bc**	**3.08 bcd**	**2.98 b**
Mean	**2.76 a**	3.04 a	

Explanations: * Mean values followed by the same letter are not significantly different at p = 0.05

Plant shading had significant effect on the length of primary shoots of all investigated cultivars of *Ilex* × *meserveae* (Fig. 1). In 1997 and 1998 the length of primary shoots of ‘Blue Boy’ plants did not differ significantly. In 1999 primary shoots from shaded plants were 8 cm longer but in 2000 the difference was 16 cm (Fig. 1).

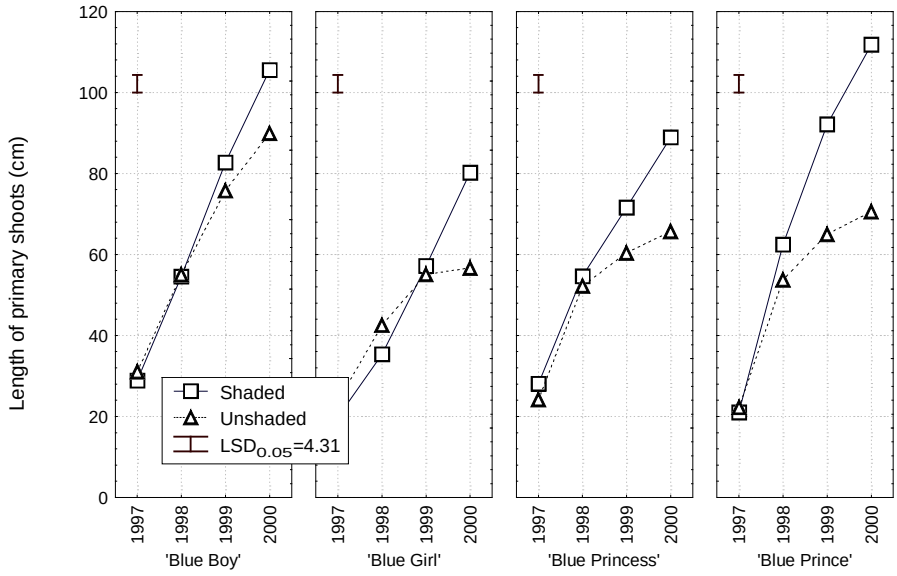

Figure 1. Effect of plant shading on the length of primary shoots of four Blue Holly cultivars

Similar reaction of plants to shading was observed for ‘Blue Princess’ and ‘Blue Prince’, but differences in 1999 and 2000 were much higher than for ‘Blue Boy’ (12 cm and 24 cm for ‘Blue Princess’ and 27 cm and 42 cm for ‘Blue Prince’, respectively). In the case of ‘Blue Prince’ plants there was significant difference also in 1998 (9 cm). Unshaded plants of ‘Blue Girl’ had longer primary shoots in 1997 and 1998. In 1999 the difference was not significant and in 2000 the shoots of shaded plants were significantly longer (Fig. 1).

Plant shading had significant effect on number of laterals formed on plants of investigated cultivars (Fig. 2). In the year 1998 unshaded plants of all investigated cultivars formed more lateral shoots (19-31 shoots per plant) when compared to shaded plants (8-15 shoots per plant). In 1999 these differences were even greater (79-105 shoots per plant compared to 29-55 shoots per plant). In 2000 these differences decreased and in the case of ‘Blue Boy’ the difference was not significant.

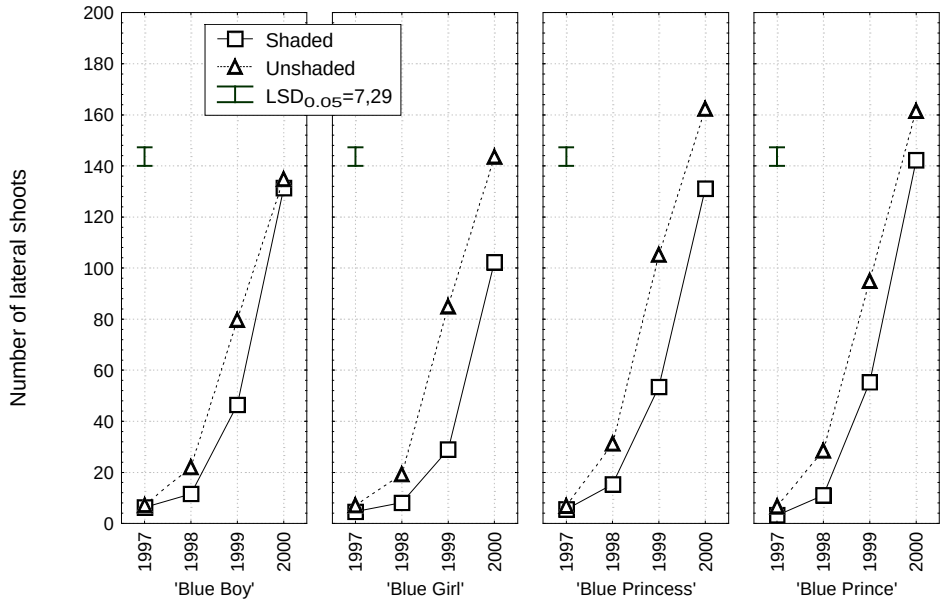

Figure 2. Effect of plant shading on the number of lateral shoots of four Blue Holly cultivars

Average length of lateral shoots varied from 7 to 18 cm depending on the year and the cultivar (Fig. 3). Shaded plants of all compared cultivars had longer lateral shoots. Only shoots developed on plants of ‘Blue Girl’ in 1997 and 1998 did not differ significantly. For all cultivars these differences were greater in 1999 and 2000 than in the first two years of experiment (Fig. 3).

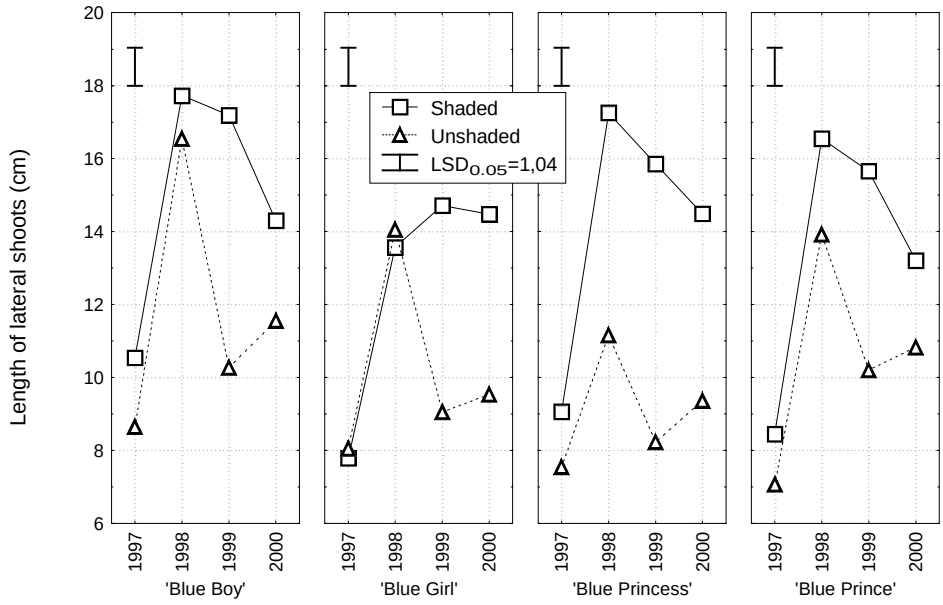

Figure 3. Effect of plant shading on the length of lateral shoots of four Blue Holly cultivars

DISCUSSION

The results obtained in the present experiment showed that plant shading increased shoot length, and male cultivars had longer primary shoots than female cultivars. These data confirm the results obtained by Pair and Still (1982). Additionally, shaded plants formed lower number of primary and secondary shoots than unshaded ones. Increase of shoot length is one of many responses to shade, which are known as a shade avoidance syndrom (Morelli and Ruberti 2000). Other responses of plants to shade are reduction of leaf development, strengthening of apical dominance and inhibition of lateral outgrowth (Morelli and Ruberti 2000). In *Arabidopsis thaliana*, a model plant, which is used to study genetic control of those phenomena, perception of light signal from the environment depends on three groups of photoreceptors that recognize different wavelengths of light: phytochromes (the red/far red sensing photoreceptors), cryptochromes (that recognize blue and UV-A light) and photoreceptors UV-B (Devlin et al. 1999, Morelli and Ruberti 2000). Growth hormones, i.e. auxin, ethylene, and brassinosteroids probably contribute in plant responses to shade (Finlayson et al. 1998, 1999, Morelli and Ruberti 2000, Luccioni et al. 2002).

Contrary to the results obtained by Pair and Still (1982) no damage caused by sun to unshaded plants was observed during summer (data not shown), probably due to lower maximal temperatures. In the present experiment maximal temperature observed in the summer was about 38°C (Fig. 4). Another reason of those differences might be location of plants – in the experiment reported in this work plants were cultivated in the open field, while in the research reported by Pair and Still (1982) plants were located close to the structure that dramatically increased temperature in some locations. There was no plant damage observed in three subsequent winters (1997/98, 1998/99, and 1999/2000) in the present experiment, independently of cultivar or plant shading (data not shown). During this period the lowest temperature was -20°C (-25°C at the ground level). Other experiments conducted on *Ilex* × *meserveae* (Pair and Still 1982) and on interspecific hybrid *Ilex rugosa* × *cornuta* 'China Girl' (Pair 1987) showed that both taxa survived the temperature of -23°C without any injuries. However, in the locations where temperature reached -28°C, some plants of *Ilex* × *meserveae* were frozen to the snow level (Pair and Still 1982). To verify, if more severe winter conditions could be detrimental to Blue Holly plants, further long term field experiments are necessary.

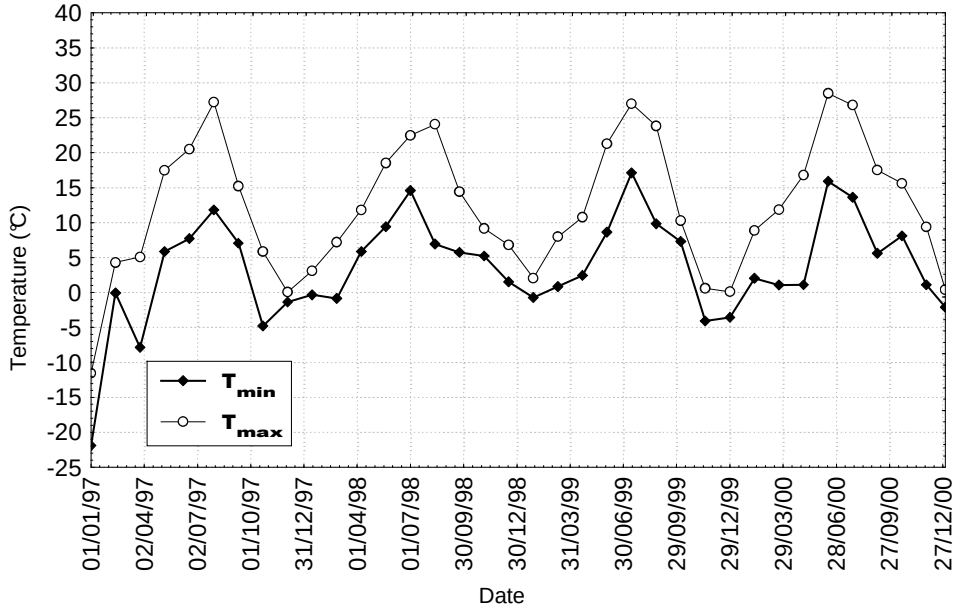

Figure 4. Monthly minimal and maximal temperatures in 1997 – 2000

CONCLUSIONS

1. Shading of Blue Holly plants decreased the number of primary and secondary shoots and increased their length. Plants grown without shading were more compact and more decorative.
1. Cultivars of Blue Holly evaluated in the experiment can be cultivated in a climatic conditions of central Poland. They survived at temperatures -25°C at the ground level.

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WPŁYW CIENIOWANIA NA WZROST I MROZOODPORNOŚĆ ROŚLIN CZTERECH ODMIAN OSTROKRZEWU MESERWY (*ILEX* × *MESERVEAE* S. Y. HU.)

Streszczenie: W latach 1997 – 2000 przeprowadzono badania mające na celu ocenę wzrostu i mrozoodporności czterech odmian *Ilex* × *meserveae* 'Blue Boy', 'Blue Girl', 'Blue Princess' i 'Blue Prince' w warunkach klimatycznych centralnej Polski. Najmniej pędów pierwszego rzędu miała odmiana 'Blue Boy', a najwięcej odmiana 'Blue Princess'. Zacienienie istotnie wpłynęło na zmniejszenie liczby pędów pierwszego rzędu u odmiany 'Blue Girl'. Miało ono również istotny wpływ na długość pędów pierwszego rzędu. W roku 1997 i 1998 pędy roślin cieniowanych i niecieniowanych odmiany 'Blue Boy' nie różniły się istotnie pod względem długości, a rośliny niecieniowane odmiany 'Blue Girl' wytworzyły dłuższe pędy pierwszego rzędu. Generalnie jednak rośliny cieniowane wszystkich odmian miały dłuższe pędy pierwszego rzędu. Rośliny rosnące w warunkach bezpośredniego promieniowania słonecznego w ciągu czterech lat wytwarzały więcej pędów bocznych niż rośliny cienowane, przy czym różnica ta w roku 2000 wyraźnie się zmniejszyła, a dla odmiany 'Blue Boy' była nieistotna statystycznie. Cieniowanie istotnie wpływało na długość pędów bocznych. Dłuższe pędy wytwarzały rośliny cieniowane. Jedynie u odmiany 'Blue Girl' w latach 1997 – 98 nie stwierdzono istotnych różnic w długości pędów bocznych. U żadnej z badanych odmian nie zaobserwowano uszkodzeń mrozowych podczas trzech kolejnych zim w latach 1997/1998, 1998/1999 i 1999/2000.

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