INFLUENCE OF DAYLENGTH AND IRRADIANCE LEVEL ON GROWTH OF THE STOCK PLANTS AND ROOTING OF *BETULA UTILIS, CORYLUS MAXIMA* 'PURPUREA', AND *PINUS MUGO* CUTTINGS.

S. MARCZYNSKI AND M.K. JOUSTRA

Warsaw Agricultural University
W. Zamiany 5CM98, 02671
Warsaw 13, Poland

REVIEW OF LITERATURE

Betula, Corylus, and *Pinus* are genera to which belong many valuable species of ornamental plants. They are usually propagated by grafting in the greenhouse, but *Corylus* cultivars also by layering (1). They are not generally recommended for propagation by cuttings (8). Ondruska and Schmidt (16) propagated cultivars of *Betula pendula* by cuttings, Pellett and Alpert (17) propagated those of *Betula papyrifera* and they obtained about 80% rooting but over half the cuttings died after potting. It is known that rooting can be influenced by etiolation (9, 13) and daylength; the level of irradiance of the stock plants can also influence rooting (15, 20), but the results depend mostly on the species. Levels of irradiance provided to the cuttings can also influence rooting (4, 20).

MATERIALS AND METHODS

Two-year-old stock plants of *Betula utilis, Corylus maxima* 'Purpurea' and *Pinus mugo* in containers were placed in greenhouse compartments or in growth chambers. They were etiolated or treated with three different daylengths (8h, 16h, 24h). For 8 hours all plants had natural light. Later all compartments were darkened completely. Plants in the long days (16h and 24h) were lighted with high-pressure sodium lamps (SON-T) for additional 8 or 16 hours with irradiance 12.5 Wm-2. In each daylength, three different levels of irradiance were used (100%, 33% and 10%). After etiolation the plants were grown in the 8h or 16h day.

For comparison one set of *Betula* and *Pinus* plants was also left in the greenhouses in natural day conditions. *Corylus* cuttings from natural days were obtained from mother plants that grew outside in the open. All treatments were made in 4 replications with 20 plants of *Betula*, 15 plants of *Corylus* and 30 plants of *Pinus* per replication.

Cuttings received from each stock plant treatment were divided into three groups and rooted under: 100%, 33% or 10% irradiance. Rooted cuttings were potted and overwintered.

RESULTS

Mostly the reduction of daylength and irradiance slowed down the maturation, postponed the date of taking cuttings, and reduced the number and length of shoots. The stock plants from the lowest irradiance were the weakest and most sensitive to *Botrytis.*

Betula utilis and *Corylus maxima* 'Purpurea' were propagated effectively by cuttings when the stock plants were forced in a greenhouse in early spring. Cuttings of *Betula* and *Corylus* most often rooted best when treated with 1% IBA, but in short days 2% IBA was beneficial. In most treatments cuttings rooted best under 33% irradiance. Too much or too little light to the stock plants and/or cuttings usually inhibited rooting and regrowth.

The *Betula* cuttings root and regrew the best after giving the stock plants 16h days with a full light. But it can be seen that the total amount of light on the motherplants and cuttings determined rooting of cuttings (Table 1A). Betula cuttings from stock plants grown in constant and full light (24h/100%) rooted poorly under high irradiance level. Lowering of the irradiance improved rooting. If stock plants grew in an 8h day, lowering of irradiance level, especially to 10%, caused a trend to lowered rooting.

In the case of *Corylus* plants a supraoptimal level of irradiance was not noticed. Reduction of light access to the stock plants by shortening the daylength, or/and by decreasing the irradiance level caused lowered rooting (Table 1B). *Corylus* cuttings rooted and regrew best after giving the stock plants 24h days with full light. A 24h day with 33% light, or a 16h day with 33% light, and etiolation followed by a long day, were also favorable.

At the end of the growing season, the potted rooted cuttings of *Betula*, on an average for the best treatments, reached a height of 63 cm. For *Corylus* this was 34 cm. The plants overwintered successfully and started new spring growth. For the best treatments *Betula* was over 90%,—*Corylus* was over 80% (in relation to the number of cuttings before rooting). *Pinus* cuttings rooted 50% in the best treatments. After potting they started new spring growth (data not shown). An 8h day for the stock plants, or etiolation with a short day after etiolation and the reduction of high irradiance to 33% during rooting, showed a trend for better rooting.

DISCUSSION

All data presented here agrees with the suggestion of Moe (14) that optimal cutting irradiance for rooting is strongly influenced by the previous history of the stock plant's irradiance, but our results can be explained differently. One possibility is the inhibition of rooting caused by supraoptimal or a too low a level of carbohydrates (5, 6,7). In our experiments the carbohydrate content was not determined, but presumably there was more carbohydrate in the cuttings from high irradiance stock plants than in those from low irradiance (7).

Another explanation could be that a supraoptimal or too low level of light causes decreasing auxin or/and synergestic co-factors levels (15, 18) or an increase of root inhibitor levels (15). In part, this agrees with the results of our experiment on the influence of IBA treatments. The trend for better rooting was noticed when the concentration of IBA was higher, together with lowering of the daylength for the stock plants. It was more clearly seen in the case of *Corylus* cuttings, which were more difficult to root, but it could be recognized also with *Betula*.

Similar results but with changed light intensity for *Malus* stock plants were found by Christensen *et al* (2), while opposite results were found with *Pinus* cuttings by Stromquist and Hansen (20). Other results suggest that increase of length and/or intensity of irradiance influenced the rise of the level of endogenous auxin and, according to species requirements, at different irradiance levels could reach an optimal level for rooting. Addition of a certain amount of exogenous auxin could improve rooting. For *Corylus* cuttings some quantity of exogenous auxin was even necessary for reasonable rooting (without IBA rooting was at the most 20%). It is also possible that an increase of light causes a better supply of rooting co-factors, which, as suggested by Hess (10), in a complex with auxin, are necessary for good rooting. Cuttings taken from *Betula* plants grown in good light conditions rooted reasonably well even without exogenous auxin, but an excess of optimal auxin level inhibited rooting. Supraoptimal content of auxin could also be a cause of reduction in rooting and overwintering of *Betula* cuttings from treatments with high irradiance for stock plants and cuttings (Table 1-A).

Light treatment of stock plants influenced rooting much more strongly than did light treatments of cuttings during rooting, but for both *Betula* and *Corylus* there was a general trend for best rooting under 33% irradiance level. This agrees with the rule presented by Moe (14) that the optimal irradiance level for cuttings is lower than for the stock plants. This is also true for the results of others (4, 20). Grange and Loach (5) supposed that inhibition of rooting in high light intensities could be associated also with a decrease in osmotic potential, probably as a result of the soluble sugar accumulation in cuttings. When the cuttings were grown under low irradiance, rooting was restricted because of the limited availability of photosynthetic assimilates (3).

In our experiments etiolated cuttings rooted well only, if after etiolation, the stock plants were grown in long days (16h). After etiolation the stock plants grew very poorly in short days (8h). With *Betula* the shoots even often died. Therefore there were not enough

Table 1. Influence of light on percent rooting of cuttings of *Betula utilis* and *Corylus maxima* 'Purpurea' in relation to the number of cuttings started. Data taken on April 20

Stock plant treatments		Irradiance level for cuttings			
Daylength	Irradiance level	100%	33%	10%	Mean
		A. *Betula utilis*			
8h	100%	82 9 f-j[1]	78 0 f-j	71 4 e-i	77 6 bc[2]
8h	33	51 3 a-e	66.6 c-h	41.2 a-c	53 1 a
8h	10	50.4 a-e	68 0 d-h	33 9 ab	50 8 a
16h	100%	76 3 e-j	90 9 i-k	86 2 g-j	84 9 bc
16h	33	70 0 d-i	79 8 f-j	87 5 h-k	79 6 bc
16h	10	88 6 h-k	86 9 g-k	31 0 a	71 3 b
24h	100%	32 3 a	44 6 a-d	70.0 d-i	52.1 a
24th	33	71 5 e-i	75.4 e-j	81.3 f-j	76 2 bc
24th	10	90 5 i-k	93 6 jk	52 0 a-e	81 5 bc
Et/8h		x	x	x	x
Et/16h		72 7 e-i	98 7 k	85 2 g-j	88.1 c
Natural		59.2 b-f	64 1 c-g	81 4 f-j	68.7 ab
Mean		69 0 a	79 1 b	68 7 a	
		B *Corylus maxima* 'Purpurea'			
8h	100%	16.6 b-g[1]	37.3 f-l	30.8 e-k	27 8 b[2]
8h	33	—	—	—	—
8h	10	8 5 b-e	9 1 b-3	6 3 a-d	7.9 a
16h	100%	42 0 g-l	77 2 no	58 5 k-o	59 7 cd
16h	33	37 5 f-l	45 7 h-m	52 9 l-o	48.7 c
16h	10	9 8 b-e	24 6 c-i	12 3 b-f	15 0 ab
24h	100%	674 0 l-o	83 4 o	78.8 no	75 8 d
24h	33	52 6 i-n	74 7 m-o	61.9 l-o	63 3 cd
24h	10	3 8 ab	18 6 b-h	4.9 a-c	8 1 a
Et/8h		0 0 a	13.1 b-f	26 4 d-j	8 9 a
Et/16h		55 3 j-n	83 2 o	71.6 m-o	70 7 d
Natural		0.0 a	0.0 a	0.0 a	0 0 a
Mean		24 4 a	46 0 b	39 1 b	

Results were calculated with the use of two-way analysis of variance after Bliss transformation

[1] All values of the different treatments followed by the same letter are not significantly different at the 0.05 level by Duncan's multiple range test.

[2] Mean values within the column, or the row, followed by the same letter are not significantly different at the 0.05 level, by Duncan's multiple range test

In the table, treatments from which cuttings were lost by accident are marked by "—" and treatments omitted since there were not enough cuttings are marked by "x".

cuttings available which caused the omission of this treatment. The etiolated *Corylus* cuttings from the short-day treatment rooted very poorly, just as did cuttings from the short-day and the lowest light intensity. It indicated that after etiolation the stock plants require good conditions for active growth—long days and presumably high light intensity. After the cut-off of the possibilities for assimilation, and after the stress caused by darkness (etiolation), further reduction in normal growth conditions negatively influenced rooting and growth of rooted cuttings. This is probably caused by the necessity to increase the carbohydrate content.

Cuttings taken from stock plants of *Acer palmatum, Cornus florida, Magnolia, Hamamelis* grown in the greenhouse often root better than those from outside plants (8, 12). Such a difference was also shown with *Corylus* in this experiment. Stoutemyer (18) suggested that this better rooting could be promoted by increasing air humidity and temperature, or by stopping access of ultraviolet rays.

Pinus mugo cuttings in our current experiment rooted worse than in preliminary experiments, where cuttings obtained from stock plants overwintered in the greenhouse rooted in the spring in over 70%. Data of our current experiments are not in agreement with results of Hansen *et al.* (7) and Stromquist and Hansen (20) where lower light intensity for *Pinus sylvestris* stock plants promoted rooting. On the other hand some lowering of irradiance for cuttings was beneficial in our experiment, similar to the findings of Loach and Whalley (11) for many kinds of plants.

The results presented here show that stock plant manipulation can provide successful rooting of cuttings of plants known to be difficult to root. It can also accelerate nursery production and reduce necessity for auxin treatments.

LITERATURE CITED

1 Bartels, A. 1978 Rozmnazanie drzew i krzewow ozdobnych. PWRIL Warszawa.

2 Christensen, M V, E N. Eriksen, and A. S Andersen 1980 Interaction of stock plant irradiance and auxin in the propagation of apple rootstocks by cuttings. *Scientia Hortic* 12.11-17

3 Eliasson, L 1978. Effects of nutrients and light on growth and root formation in *Pisum sativum* cuttings *Physiol. Plant* 43:13-18

4 Eliasson, L and L. Brunes. 1980. Light effects on root formation in aspen and willow cuttings. *Physiol Plant* 48·261-265

5 Grange, R.I and K. Loach. 1985 The effect of light on rooting of leafy cuttings *Scientia Hortic.* 27.105-111.

6. Hansen, J. 1977 Root formation in pine cuttings. light and carbohydrates. *Plant Physiol.* 59 (6 sup.)·99

7 Hansen, J , L H. Stromquist and A. Ericsson. 1978 Influence of pine seedlings (*Pinus sylvestris L.*) *Plant Physiol* 61·975-979

8. Hartmann, H T and D. E Kester. 1975 and 1983. Plant Propagation Principles and Practices. 3rd and 4th eds Prentice-Hall. Englewood Cliffs, New Jersey.

9 Herman, D E and C E Hess. 1963 The effect of etiolation upon the rooting of cuttings. *Proc. Inter. Plant Prop. Soc.* 13: 42-62.

10. Hess, C E 1962. Characterization of the rooting co-factors extracted from *Hedera helix* L and *Hibiscus rosa-sinensis* L *Proc 16th Inter Hort. Cong* · 382-388.

11. Loach, K. and D N. Whalley 1978. Water and carbohydrate relationships during the rooting of cuttings. *Acta Hortic.* 79.161-168

12 Macdonald, B. 1986 Practical Woody Plant Propagation for Nursery Growers. B T. Batsford Ltd. London.

13 Maynard, B and A Bassuk. 1985 Etiolation as a tool for rooting cuttings of difficult-to-root woody plants *Proc Inter Plant Prop Soc* 35. 488-494

14 Moe, R. 1987. Effect of stock plant environment on lateral branching and rooting *Acta Hortic.* (in press)

15 Moe, R. and A. S. Andersen 1986. Effect of stock plant environment on subsequent rooting. *Norges landbrukshogskole, Institutt far blomsterdyrking og veksthusforsok*, September 1986

16 Ondruska, R. and G Schmidt. 1984 Propagation of *Betula pendula* cultivars by softwood cuttings *A. Kerteszeti Egyeten Kozlemenyei* 48·139-144

17 Pellett, N. E. and K Alpert. 1985 Rooting softwood cuttings of mature *Betula papyrifera* *Proc Inter Plant Prop. Soc.* 35.519-525

18. Stoutemyer, V T. 1961 Light and propagation *Proc. Inter Plant Prop Soc.* 11 252-260.

19 Stromquist, L. H. and L Eliasson. 1979 Light inhibition of rooting in Norway spruce (*Picea abies*) cuttings *Can. Jour Bot.* 57 1314-1316

20 Stromquist, L H. and J. Hansen. 1980. Effects of auxin and irradiance on the rooting of cuttings of *Pinus sylvestris. Physiol. Plant* 49:346-350