Air and root medium temperature and the rooting of chrysanthemum and rose cuttings

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Abstract

Cuttings of the chrysanthemum cultivar 'Horim' and rose cultivar 'Garnette' were rooted at 21°C, 24°C, 27°C root temperature in a factorial combination with 15°C, 18°C and 21°C air temperature. In each of the air and root temperatures, rose cuttings from different positions of the flower shoot were rooted. The effects of air and root temperatures and their interactions on root formation of chrysanthemum and rose cuttings were studied. Increasing the air temperature from 15°C to 21°C accelerated rooting and distinctly increased the number of roots per cutting on both plants. Higher root temperatures (24°C, 27°C) had a favorable influence on the rate of the rooting process but did not enhance the number of formed roots. Increasing both temperatures significantly increased the growth of the roots and their fresh and dry weight. An adverse effect of the root temperature was noticed on the breaking and growth of rose buds. Increasing the temperature from 21°C to 27°C strongly decreased the percentage of breaking buds and their growth. The results are discussed from the point of view of the influence air temperature on the contents of growth substances in the cuttings.

INTRODUCTION

Early work on new propagation methods of potted roses showed that increasing the temperature of the environment from 15°C to 27°C had a favorable effect on the rooting of rose cuttings (Moe, 1973). Similar effects of increasing temperatures (in the appropriate range) on rooting of cuttings have been reported for rhododendrons (Whalley and Loach, 1977), *Euphorbia pulcherrima* (Gislerød, 1975), *Camellia japonica* and *Chrysanthemum morifolium* (Ooishi et al., 1978), *Juni-perus horizontalis* (Lanphear and Meahl, 1967) and plum (Howard and Nahlawi, 1969). Since the majority of these investigations entail-

ed the influence of environmental or root temperatures without a constant air temperature, it cannot be deduced whether the above-mentioned effect of temperatures on rooting of cuttings was mediated by the root-, air temperatures, or by interactions of the two.

Therefore, in the present paper we report the effects of air and root temperatures and their interactions on root formation of chrysanthemum and rose cuttings. In an experiment with rose cuttings we also studied the effect of the position of the cuttings.

MATERIALS AND METHODS

Chrysanthemum plants of the cultivar 'Horim' and of the rose cultivar 'Garnette' were grown at 18°C in a greenhouse. The chrysanthemum stock plants were given a long day (24 h) with incandescent lamps. The rose stock plants were grown under natural lighting condition.

The cuttings were taken from the chrysanthemum stock plants at about 4 week intervals and only once from the rose stock plants. The chrysanthemum cuttings were about 5 cm in length and had 3-4 fully developed leaves. The rose cuttings consisted of a piece of the stem with one 5-leaflet leaf. They were taken from stock plants having buds with visible flower colour. In the experiment, cuttings were used from positions 5, 6 and 7, counting from the bud. The cuttings of both plants were planted in 1 cm thick insulation plates (isopor) with holes for the cuttings. The plates floated in 15 cm deep plastic trays filled halfway with distilled water. The trays were placed in threes in air-conditioned rooms (phytotron) with good control of temperature and air humidity, where temperatures of 15°C, 18°C and 21°C ($\pm 1^\circ\text{C}$) were kept. Each of the 3 trays placed in one air conditioned room had a different water temperature: 21°C; 24°C; 27°C ($\pm 0.5^\circ\text{C}$). Thus, in the experiments with chrysanthemum and rose cuttings air temperatures of 15°, 18°, 21°C and root temperatures of 21°, 24°, 27°C in all combinations were maintained. Additionally, in the experiment with rose cuttings, each of the 9 trays contained cuttings from three positions, 18 pieces from each, so each tray contained 54, also 54 cuttings were contained in one tray in the experiment with chrysanthemum cuttings. Adequate water temperature in the trays was maintained by circulation of warm water through plastic tubules on the bottom of the trays. During the rooting period, the water in both experiments was aerated using special air pumps. The trays were covered with a film of white polyethylene shut 50 cm above the cuttings, in order to obtain lower irradiation and higher, about 90% f.w.c., air humidity. Each treatment was run in duplicate in the experiment with chrysanthemums and one replication in the experiment with rose cuttings.

The chrysanthemum cuttings were rooted for 2 weeks, the rose cuttings for 3 weeks. During the root formation period, the numbers of rooted cuttings were counted and the percentage was calculated. If not otherwise stated, numbers of roots per cutting, length of the longest root, and fresh and dry weight of roots for both plants were recorded at the end of the rooting period. Additionally in the experiment with rose cuttings, the percentage of breaking buds, their growth and dry weight were also recorded. All parameters were analysed statistically, using the doubly cross classification system and Tukey's range of confidence.

RESULTS

The rooting of chrysanthemum and rose cuttings was influenced by the air and root temperatures (Figs. 1, 2). Together with an increase in air and root temperature there was a clear increase in the rate of rooting. However, the influence of air temperature on the rate of rooting of cuttings was more distinct than that of root temperature. The chrysanthemum cuttings rooted at higher air temperatures (18°C and 21°C) reached full rooting 2-3 days earlier (depending on root temperatures), than cuttings rooted at 15°C (Fig. 1). The rose cuttings rooted at 100%

Fig. 1. The effect of air and root temperatures on the percentage of rooted chrysanthemum cuttings after planting in a phytotron at air temperature. A — 15°C; B — 18°C; C — 21°C

when higher air temperatures (18°C and 21°C) cooperated with the highest root temperature (27°C). At 15°C air temperature and 21°C root temperature, the average rooting-percentage did not exceed 50 (Fig. 2). Positions of the rose cuttings had a marked influence on their rate of rooting only at higher air (18°C, 21°C) and root temperatures (24°C, 27°C). At 18°C air temperature and 27°C root temperature, the best rate of

Fig. 2. The effect of air and root temperatures as well as that of position of cuttings on the percentage of rooted rose cuttings after planting in a phytotron

initiating roots was shown by, from position 5. Increasing air temperature to 21°C resulted in a good rate of rooting cuttings from position 5 and 6 (Fig. 2).

The number of roots per cutting, length of the longest root and their fresh and dry weight after a rooting period lasting 2 and 3 weeks for chrysanthemum and rose cuttings respectively, are shown in Table 1 and 2. Furthermore, the appearance of rooted cuttings on both plants, is shown in Figures 3 and 4. The mean number of roots per cutting of the chrysanthemum and rose was increased only with increasing air temperature. The influence of root temperature on the number of roots formed by both plants appeared to be nonsignificant (Tables 1, 2). The length of roots, however, increased with an increase in air and root temperatures. Also, interaction between those two factors had a positive effect on the growth of chrysanthemum roots (Table 1). Increasing air and root temperature during the rooting period resulted in enhanced fresh and dry weight of roots per cutting of both plants. The position of the rose cuttings did not have a significant influence on the number of formed roots or on their growth, therefore this factor was not taken into consideration. Tables 3 and 4 show the effect of air and root temperature as well as that of the position of rose cuttings on bud breaking and their growth. Increasing the root temperature from 21°C to 27°C independently of air temperature or position of the cutting on stock plants, decreased the percentage bud breaking from 58.6 to 27.1 respectively. The percentage of bud breaking also depended on the position of the cutting, but was not dependent on air temperature. Cuttings taken from position 5 had a markedly higher mean percentage bud breaking (62.9) than those from position 6 (37.0) or 7 (27.8) (Table 4). Further it is shown in Table 3 that the growth of the buds from all of the positions used was strongly decreased with increasing root temperature. The dry weight of the buds depended particularly on the position of the cuttings. The buds on cuttings from position 5 had the highest dry weight, the lowest was shown by those from position 7.

DISCUSSION

Increasing the air temperature from 15°C to 21°C markedly increased the number of roots per chrysanthemum and rose cutting. Different root temperatures did not have any effect on the number of initiated roots. Some authors also reported that increasing the environmental temperature in the appropriate range had a positive effect on the rooting of rose cuttings (Moe, 1973) and cuttings of other plants (Ooishi et al., 1978; Whalley and Loach, 1977; Gislerød, 1975; Howard and Nahlawi, 1969; Lanphear and Meahl, 1967). Our results, how-

Fig. 3. The effect of air and root temperatures on the rooting of chrysanthemum cuttings. Rooted cuttings after two weeks at A — 15°C; B — 18°C; C — 21°C; air temperature and root temperature, 21°C, 24°C, 27°C, respectively

ever, are difficult to compare with those cited above, because we studied the effects of air and root temperatures on rooting of the cuttings separately.

Fig. 4. The effect of air and root temperatures on the rooting of rose cuttings. Rooted cuttings after three weeks at A—15°C; B—18°C; C—21°C; air temperature and root temperature, 21°C, 24°C, 27°C, respectively

The present results very clearly show that the main effect on the number of initiated roots was exerted by the air temperature. The influence of air temperature on adventitious root formation is explained

Table 1

The effect of air and root temperatures during the rooting of chrysanthemum cuttings on the number of produced roots, root length, and fresh and dry weights of roots after a rooting period of 2 weeks in a phytotron under natural light*

Air temperature °C	Roots per cutting			Length of longest root cm			Fresh weight of roots mg/plant			Dry weight of roots mg/plant		
	root temperature °C											
	21	24	27	21	24	27	21	24	27	21	24	27
15	26.1	24.7	25.8	1.8	2.8	4.3	45	97	141	5	9	13
18	29.1	28.3	30.1	2.5	6.1	7.2	93	205	246	8	17	23
21	36.5	32.7	32.8	4.2	5.1	7.0	147	164	240	14	15	22

Significance of main effects and interactions

	roots per cutting	root length	fresh weight of roots	dry weight of roots
Air temp.	**	**	**	**
Root temp.	NS	**	**	**
Air temp. × root temp.	NS	**	*	NS

* — significant at 0.05; ** — significant at 0.01; NS — nonsignificant.

Table 2

The effect of air and root temperatures during the rooting of rose cuttings on the number of produced roots, root length, and fresh and dry weights of roots after a rooting period of 3 weeks in a phytotron under natural light*

Air temperature °C	Roots per cutting			Length of longest root mm			Fresh weight of roots mg/plant			Dry weight of roots mg/plant		
							root temperature °C					
	21	24	27	21	24	27	21	24	27	21	24	27
15	3.1	3.2	3.1	3.7	6.1	14.9	12.8	22.3	44.5	1.8	2.7	5.0
18	2.6	3.4	4.2	7.2	9.1	17.5	26.6	37.5	54.8	2.6	3.4	6.7
21	4.9	3.7	4.4	12.8	11.9	23.6	62.4	39.4	88.0	4.8	3.9	9.2

Significance of main effects and interactions

	roots per cutting	root length	fresh weight of roots	dry weight of roots
Air temp.	**	**	**	*
Root temp.	NS	**	**	**
Air temp. × root temp.	NS	NS	NS	NS

Explanations as in Table 1

Table 3

The effect of air and root temperatures and of the position of the cuttings on the bud breaking percentage, bud growth and dry weight after a rooting period of 3 weeks of rose cuttings in a phytotron under natural light

Air temp. °C	Root temp. °C	Bud breaking %			Bud growth cm			Dry weight of buds mg		
		position of cuttings								
		5	6	7	5	6	7	5	6	7
15	21	77.8	66.7	50.0	1.7	1.7	1.2	55.9	46.9	25.9
	24	55.5	38.9	22.2	1.3	1.5	0.8	57.2	48.3	17.5
	27	33.3	22.2	16.7	1.2	0.9	0.5	60.2	27.7	17.0
18	21	88.9	50.0	44.4	2.0	1.6	2.0	54.2	52.0	49.0
	24	88.9	22.2	33.3	2.1	1.3	1.5	80.3	47.0	52.2
	27	55.5	22.2	16.7	1.5	0.6	0.6	67.4	29.8	31.1
21	21	66.7	55.5	27.8	1.8	2.0	1.5	77.1	60.2	44.9
	24	55.5	38.9	22.2	1.8	1.7	1.3	68.8	64.5	50.7
	27	44.4	16.7	16.7	1.1	0.7	0.6	61.7	40.5	25.2

Significance of main effects and interactions

	bud growth	dry weight of buds
Air temp.	NS	NS
Root temp.	**	NS
Position	NS	*
Air temp. × root temp.	NS	NS
Air temp. × position	NS	NS
Root temp. × position	NS	NS
Air temp. × root temp. × position	NS	NS

Explanations as in Table 1.

Table 4

Separate effect of air and root temperatures as well as that of positions of rose cuttings on mean percentage of bud breaking

Air temp. °C	Bud breaking %	Root temp. °C	Bud breaking %	Position	Bud breaking %
15	42.6	21	58.6	5	62.9
18	46.9	24	41.9	6	37.0
21	38.3	27	27.1	7	27.8

by the role of air temperature in changes of the level of endogenous auxins and other growth substances. Heide (1967) and Moe (1971) reported that the level of auxins, but Zieslin and Halevy (1976) that also that of gibberellins, was much higher in extracts from shoots grown at a high temperature than in shoots grown at a low temperature. Simultaneously, it was shown by Skarpeid (1951) and Eriksen (1968) for rose cuttings and by Heide (1967), Eliasson (1980), Altman and Wareing (1975), Nanda et al. (1971) for other cuttings, that a high level of auxin markedly promoted root formation. Hansen (1976) demonstrated that also gibberellic acid induced root formation in pea cuttings. Since young leaves have been found to be the principal source for both auxins and gibberellins (Jacobs and Morrow, 1957; Jones and Phillips, 1966; Jacobs, 1962), it is possible that in the experiments carried out at higher air temperatures, the leaves of cuttings of both plants produced more auxins than those at lower air temperatures. Presumably, therefore, the chrysanthemum and of rose cuttings at higher air temperatures reached full rooting earlier (Figs. 1, 2) and initiated more roots than those at lower temperatures (Tables 1, 2).

The growth of the roots and their fresh and dry weight was increased by increasing the air and root temperatures. Thus, this might have been an indirect effect, since the root formation started earlier at high air and root temperatures than at low temperatures. Therefore the roots initiated at the higher temperatures were grown longer than the roots formed at low temperatures. On the other hand, it is well known that increasing the temperature to the optimum markedly increases the growth process of young plant parts.

The root temperature also had a significant influence on bud breaking of the rose cuttings and their growth. It can be seen from Table 2 and 3 that increasing the root temperature had an inverse effect on the growth of roots and buds. A similar adverse effect of shoot growth on root growth was observed by Eliasson (1971) on the cuttings of aspen.

Eliasson (1971) suggested that this effect was caused by limiting the state of available carbohydrates for shoots and roots. Our results show rather that low root temperature stimulated the percentage of breaking buds and the growth of buds by inhibiting the growth process of roots. The roots therefore did not utilize the growth substances thus causing bud breaking and their intensive growth.

Bud breaking also depended on the position of the cuttings. Cuttings taken from the upper positions of the shoot (posit. 5) had a high level of endogenous auxins (Moe 1971) which was sufficient for a good rate of rooting of these cuttings and a high percentage of bud breaking. This fact also indicates that the auxin content in the rose cuttings is connected with their bud breaking ability.

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WPŁYW TEMPERATURY ŚRODOWISKA KORZENI I POWIETRZA NA UKORZENIANIE SIĘ SADZONEK CHRYZANTEM I RÓŻ

Streszczenie

W pracy określono wpływ zróżnicowanych temperatur środowiska korzeni i powietrza na ukorzenianie się sadzonek chryzantem odmiany 'Horim' i róż odmiany 'Garnette'. Sadzonki obu roślin ukorzeniano w wodzie o temperaturze 21°C, 24°C i 27°C ($\pm 0.5^\circ\text{C}$), przy temperaturze powietrza 15°C, 18°C i 21°C ($\pm 1^\circ\text{C}$).

W wyniku przeprowadzonych badań stwierdzono, że wzrost temperatury powietrza w zakresie od 15°C do 21°C wpłynął na przyspieszenie procesu ukorzeniania i istotne zwiększenie liczby korzeni formowanych na sadzonkach obu gatunków roślin. Wyższa temperatura wody (24°C, 27°C) wywierała korzystny wpływ na tempo procesu ukorzeniania, natomiast nie miała wpływu na średnią liczbę korzeni formowanych na sadzonkach chryzantem i róż. Wzrost zarówno temperatury wody jak i powietrza powodował istotne zwiększenie tempa wzrostu wydłużeniowego korzeni, a tym samym podwyższenie ich świeżej i suchej masy. Odwrotny był wpływ temperatury wody na rozwój pąków śpiących na sadzonkach róż. Wzrost temperatury w zakresie od 21°C do 27°C miał wpływ na zmniejszenie liczby wybitych pąków śpiących.