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The Influence of Plant Hormones on Leaf Movements of *Mimosa pudica*

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Summary

WATANABE S. & UMRATH K. 1983. The influence of plant hormones on leaf movements of *Mimosa pudica*. — Phyton (Austria) 23 (1): 49—54. — English with German summary.

On petiols with cut leaf blades on plants of *Mimosa pudica* the ability to move can be maintained by IAA (indol-3-acetic acid) in a concentration dependent manner. 5-HO-IAA (5-hydroxy indol-3-acetic acid) is much less effective.

The opening movement of the leaflets on cut pinnae of *Mimosa pudica* in the dark was induced by 2.10^{-3} to 5.10^{-4} M IAA much earlier than by water, independent of the concentration. Lower concentrations were ineffective. 5-HO-IAA even in 3.10^{-3} M solution shortend the time to begin of opening to a lesser extent, but it had some effect in 3.10^{-3} to 5.10^{-6} M solutions. An explanation is given in the conclusions.

Substances which liberate the excitatory substance of *Mimosa* prolong in high concentrations the time in that the leaflets are closed, so that we did not observe opening in these experiments. Some effects of lower concentrations of such substances are mentioned in the results.

Zusammenfassung

WATANABE S. & UMRATH K. 1983. Der Einfluß von Pflanzenhormonen auf die Blattbewegungen von *Mimosa pudica*. — Phyton (Austria) 23 (1): 49—54. — Englisch mit deutscher Zusammenfassung.

An Blattstielen mit abgeschnittener Spreite an Pflanzen von *Mimosa pudica* kann die Bewegungsfähigkeit durch IAA (Indol-3-Essigsäure) in kon-

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zentrationsabhängiger Weise erhalten werden. 5-HO-IAA (5-Hydroxy-Indol-3-Essigsäure) ist weniger wirksam.

Die Öffnungsbewegung der Blättchen an abgeschnittenen sekundären Blattstielen von *Mimosa pudica* im Dunklen wird durch 2.10^{-3} bis 5.10^{-4} M IAA viel früher bewirkt als durch Wasser, unabhängig von der Konzentration. Geringere Konzentrationen sind unwirksam. 5-HO-IAA verkürzt selbst in 3.10^{-3} M Lösung die Zeit bis zum Öffnungsbeginn weniger, sie wirkt aber im ganzen Bereich von 3.10^{-3} bis 5.10^{-6} M Lösungen, abnehmend mit abnehmender Konzentration. Eine Eklärung wird in den Conclusions gegeben.

Substanzen, welche die Erregungssubstanz von *Mimosa* freisetzen, verlängern in hoher Konzentration die Zeit in der die Blättchen geschlossen sind, so daß wir in diesen Versuchen kein Öffnen beobachten konnten. Einige Wirkungen niedrigerer Konzentrationen solcher Substanzen sind in den Results erwähnt.

Introduction

As Watanabe & Sibaoka 1973 demonstrated, the site of photoreception to the opening of *Mimosa* leaflets is the abaxial side of the pulvinuli. The stimulation of a pulvinulus has a local effect, not conducted to the neighbouring pairs of leaflets. Later Watanabe & Sibaoka 1982 showed, that auxins cause opening of leaflets in the dark.

Umrath & Thaler 1980, 1981 pointed out, that IAA besides its action as an auxin liberates the excitatory substance of some plant families and that 5-HO-IAA has a similar action as an auxin but is much less effective in liberating the excitatory substance in *Mimosaceae* and in *Fabaceae*.

We investigated the leaf movements of *Mimosa pudica* as influenced by IAA, 5-HO-IAA and by other substances liberating the excitatory substance of Mimosa.

Methods

The experiments were performed on *Mimosa pudica* in the greenhouse described by Umrath 1928 without any shading. Two kinds of experiments were performed.

In one sort of experiments an upright shoot from plants grown in the soil was used. One leaf was left intact. From some other leaves the blades were removed by cutting the petioles at 3 cm from the pulvini and polyetilene tubes filled with 10 µl of different solutions were put over the cut ends. Over 4 to 5 days the angle of each petiole with the stem and its alteration by stimulation was noticed.

In the second sort of experiments we followed the procedure of Watanabe & Sibaoka 1982. Pinnae were cut and put into Petri-dishes, 9 cm in diameter, with 1 ml of the test splutions or tap water as a control. The dishes were put slant-wise on the table in the dark room. 2 or 3 pairs of leaflets on the cut end of each rachis were removed to make good contact

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of the rachis with the solution. As a measure of the opening of the leaflets the quotient of the distance between the ends of the paired leaflets by the twofold length of a leaflet was calculated. This is the relative opening value of WATANABE & SIBAOKA 1973. We will call it only opening value.

Abbreviations: IAA = indol-3-acetic acid: 5-HO-IAA = 5-hydroxy indol-3-acetic acid; M = molar.

Results

The experiments on plants with cut petioles were performed on July 9th to August 11 th. By 10^{-3} to 5.10^{-4} M IAA the extent of movement by stimulation was not appreciably different from that of the intact leaf on the 1. to the 3. day. It was reduced on the 4. day to some extent and on the 5. day to about 50% of that of the intact leaf.

With 3.10^{-4} M IAA leaf movement ceased on the 5. day, with 10^{-5} M IAA it ceased on the 3. to the 4. day and with all lower concentrations and with water on the 2. to the 3. day.

With 10^{-3} M 5-HO-IAA the petiole movement ceased on the 5. day, with all lower concentrations and with water on the second day.

The experiments showed besides the persistence of the ability of movement by IAA also a trophic influence of IAA. With water in half of the experiments the petioles fell down by interruption in the pulvinus in the mean on the fourth day. With 10^{-5} to 10^{-3} M 5-HO-IAA and with 10^{-11} to 10^{-7} M IAA they fell on the fourth day, with 10^{-6} to 10^{-4} M IAA they fell on the average on the fifth day and with 10^{-3} M IAA they persisted over the whole time of the experiment as did the uncut control leaves.

In the experiments with cut pinnae in the dark opening of the leaflets occured in water after 190 to 270 min, mostly after 210 to 270 min. WATANABE and SIBAOKA 1982 do not mention this opening in water and probably did not observe it, because they registered the position of the leaflets only over 220 min.

With 2.10^{-3} to 5.10^{-4} M IAA we observed opening of the leaflets beginning after 120 min and reaching the stady state after further 50 to 100 min. Lower concentrations were completely ineffective with the exception of 5.10^{-5} M IAA, which induced opening of only 2 to 3 leaflets in the pinnae after 130 and 140 min. Our results are in agreement with those of WATANABE & SIBAOKA 1892 (they give the concentrations in µg/ml).

In our first experiments, beginning August 17th, the opening value 1,0 was reached, the leaflets were fully open. The opening values declined gradually chiefly in September and reached 0,4 to 0,6 at October 1st.

With 3.10^{-3} and 10^{-3} M 5-HO-IAA the leaflets began to open in 120 to 170 min, which was up to 50 min later as with IAA in the same experiments. The opening value of nearly 1 was reached in approximately the same time with both these substances. In all experiments with 5.10^{-4} to 5.10^{-6} M

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5-HO-IAA opening began after 160 to 220 min. The opening values were not appreciably reduced, as many of these experiments were done in August and September they gradually fell from 0,85 to 0,4.

With water the opening occured a little later, as mentioned above between 190 and 270 min. In experiments carried out long enough to get the maximal opening value it seemed not to be reduced.

The opening of the leaflets was inhibited ower the hole time up to 280 min by 10^{-1} M neutralized mandelic acid, by 10^{-2}, 10^{-3} and 10^{-4} M neutralized hydrocinnamic acid (3-phenylpropionic acid) and by 10^{-1} M glycin. These substances initiate leave movements in cut shoots of *Mimosa* by leberating the excitatory substance.

10^{-2} M neutralized mandelic acid induced opening of the leaflets 20 min earlier than water. In combination with 3.10^{-3} M to 3.10^{-4} M 5-HO-IAA it did not change appreciably the opening time. Mandelic acid, as found by UMRATH & THALER 1980, liberates in *Fabales* not only the excitatory substance but also aboundantly auxin, This may be the reason that it improves opening compared with water.

Hydrocinnamis acid (3-phenylpropionic acid) and trans cinnamic acid liberate in *Fabales* the excitatory substance but only poorly auxin, as found by UMRATH & THALER in jet unpublished experiments. High concentrations of these two substances combined with 5-HO-IAA delayed the opening compared with that in 5-HO-IAA alone, as could be expected.

Only with 10^{-4} M neutralized trans cinnamic acid we got in both our experiments, avery one with all trials in duplicate, opening times a little shorter or as long as in water and in combination with 10^{-3} to 10^{-4} M 5-HO-IAA opening times a little shorter or as long as in the respective concentrations of 5-HO-IAA.

Conclusions

The concentrations of IAA and 5-HO-IAA that maintain leaf movements in our experiments on cut petiols of *Mimosa pudica* are the same or scarcely lower than these causing leaf movements on cut shoot of *Minosa* as found by UMRATH & THALER 1980, 1981. This suggests that besides auxin activity a liberation of the excitatory substance is essential for maintaining the ability to move in *Mimosa* pulvini. These two plant hormones seem to have also a trophic effect against abscission.

In the experiments with cut pinnae in the dark 2.10^{-3} to 5.10^{-4} IAA induced optimal opening of the leaflets. Lower concentrations were ineffective. 3.10^{-3} to 5.10^{-6} M 5-HO-IAA induced opening, but later as IAA and the time to opening was the longer the less the concentration of 5-HO-IAA was.

After UMRATH & THALER 1981 both IAA and 5-HO-IAA have high auxin activity, but the ability of liberating the excitatory substance of

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Mimosa is much higher with IAA. This suggests that IAA liberates the excitatory substance and in concentrations initiating opening of the leaflets has auxin activities suitable as conterparts. Lower concentrations of IAA liberate the excitatory substance but have not enough auxin activity for compensation. In contrast to this 5-HO-IAA even in the highest concentration does not liberate enough excitatory substance for an optimal opening time. In a wide range of lower concentrations its auxin activity shortens the opening time compared with water and very little or no excitatory substance is liberated.

From the literature and our new findings the following conception of the nyctinastic movements is suggested. On the afternoon the transition from the position of the leaves on the day to that in the night is brought about by repeated excitation processes. In *Mimosa* action potentials were recorded (UMRATH 1931), in *Mimosa* and in *Biophytum* repeated movements towards the night position were photographed (UMRATH 1962). Arguments were given, that in non sensitive plants the transition to the night position is principally the same, but the steps of the movement are small (UMRATH 1962). Our experiments indicate that the lack of auxin in the night is a factor stabilising the night position. A second factor is the lack of light on the adaxial parts of the pulvinuli and probably also on the adaxial part of the pulvinus (WATANABE & SIBAOKA 1973). Our finding that substances liberating the excitatory substance prolong noticably the time of closure of leaflets on pinnae in the dark, suggests that the content on the excitatory substance is rised over night, perhaps by repeated excitation processes. In the morning the day position is brought about by auxin, which in our experiments shortens the time to opening of the leaflets in the dark. A second factor is the local excitation by light on the abaxial part of the pulvinuli and probably on the adaxial part of the pulvinus (WATANABE & SIBAOKA 1973). The higher rigidity in the night found by v. BRÜCKE 1848, may be due to lack of light in the night and by this a lack of local excitation and a higher turgor in the abaxial side of the pulvinuli and in the adaxial side of the pulvinus (WATANABE & SIBAOKA 1973).

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