

Short Communication

Opposing Effects of Strychnine and Brucine on the Germination and Growth of Lettuce Seeds

M. Ghazi and D. P. Matthees

Station Biochemistry, Animal Science Building, South Dakota State University, Brookings, South Dakota 57007, USA

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Abstract. Strychnine and brucine, two related alkaloids that occur in plants belonging to the *Strychnos* species, were shown to have opposing effects on the elongation of the radicle of lettuce seeds. Strychnine was found to be inhibitory, whereas brucine was found to be stimulating to radicle elongation. Alkaloids, generally, are more commonly known for their inhibitory effects on plant growth rather than on their stimulating effects.

Strychnine and brucine are alkaloids found in plants belonging to the *Strychnos* species. Alkaloids are cyclic compounds containing nitrogen in their rings or side chains and are one of a number of known chemicals involved in allelopathy. The term "allelopathy" was first introduced by Molisch in 1937 and refers to the effect, positive or negative, of a chemical(s) produced by one plant on itself, or on another plant. Most of the literature dealing with the allelopathic effects of alkaloids, however, have dealt with their negative or inhibitory effects.

Little work has been done on the role and importance of alkaloids in allelopathy in recent years. Evenari (1949) pointed out that alkaloids strongly inhibited seed germination. He found that strychnine was among the strongest alkaloid inhibitors. Some of the weak inhibitors were narcotine, scopolamine, and atropine. Evenari's bioassay was carried out on wheat grains using 1/200 dilutions of the pure alkaloids. Harris (1984) found that the tropane alkaloid, scopolamine, and hyoscyamine from

the seeds of *Datura stramonium* were phytotoxic to germinating seeds of *Helianthus annuus*. Vendrig (1964) stated that α -tomatine (a steroidal alkaloid found mainly in tomatoes) has an auxin-like activity in the *Avena* coleoptile test. This was later contradicted by Roddick (1972), who showed that α -tomatine suppressed the elongation of wheat and oat coleoptile segments.

This study shows the opposing effects of strychnine and brucine, two closely related alkaloids, on the growth of lettuce seed radicles. Strychnine was found to be inhibitory, as reported by Evenari (1949), to growth, whereas brucine was stimulating.

Materials and Methods

Solutions of each of the two alkaloids with molar concentrations ($\times 10^{-4}$) of 0, 1, 2, 4, 8, and 16 were made in deionized water. The pH at the higher concentrations was 5.3 for brucine sulfate and 5.5 for strychnine nitrate. A 5-ml aliquot of each concentration was pipetted onto two layers of Whatman No. 1 filter paper in a polystyrene petri dish (100 \times 15 mm). Thirty lettuce seeds were placed in each petri dish and incubated at 25°C. Germination counts were taken at 24 h after application of each treatment. Seeds were considered to be germinated when 1 mm of the radicle was visible. The experimental design was completely randomized with two replications (dishes) per treatment. Each experiment was repeated twice. Radicle lengths were measured 48 h after germination. Strychnine nitrate was USP grade from Rosengarten Company (Philadelphia, PA, USA), 82.8% pure, chromatographically homogeneous at 254 nm as determined by HPLC. Brucine sulfate was Fisher certified grade from Fisher Scientific (Pittsburg, PA, USA). The lettuce seeds (*Lactuca sativa* L.) were "Black seeded Simpson." Data were analyzed using the *t* test and by calculation of least significant differences (LSD).

Results and Discussion

The two treatments, strychnine nitrate and brucine

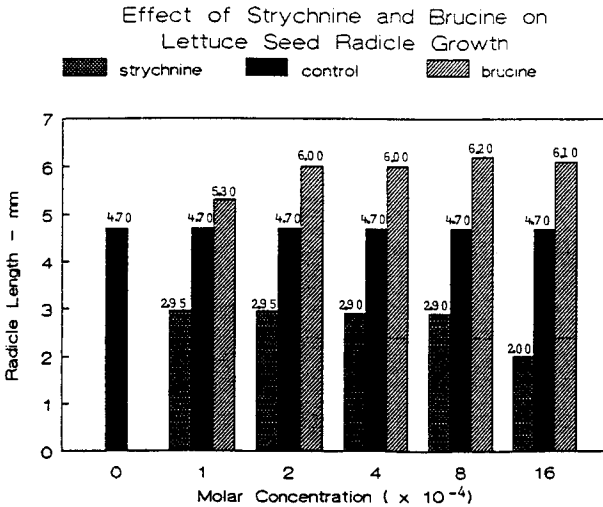


Fig. 1. Mean radicle length (mm) of 60 lettuce seeds 48 h after germination. LSD = 0.13 at $p = 0.05$.

sulfate, did not have any effect on the germination of lettuce seeds. Germination counts were the same as the control. The two treatments, however, did have an effect on the elongation of the radicle of the seeds. The bar chart in Fig. 1 shows the effects of the two treatments in relation to the control. Strychnine was inhibitory to radicle elongation, whereas brucine had a stimulating effect. All strychnine treatments significantly inhibited radicle elongation (Fig. 1). The inhibitory effects of strychnine were observed with a concentration as low as 1×10^{-4} M and remained the same up to 8×10^{-4} M. However, further inhibition occurred at 16×10^{-4} M. The inhibition of radicle elongation at 8×10^{-4} and 16×10^{-4} M was accompanied by browning of the radicle and by loss of root hair formation.

All brucine treatments significantly stimulated radicle elongation (Fig. 1). Stimulation was detected with a concentration as low as 1×10^{-4} M. Figure 1 shows that the two treatments are signifi-

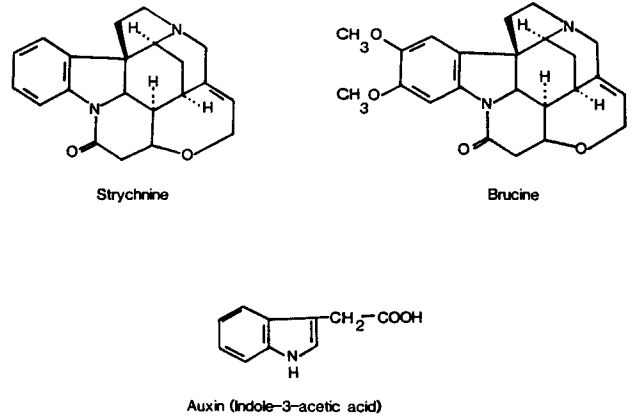


Fig. 2. Chemical structure of strychnine, brucine, and indole-3-acetic acid.

cantly different from the control at all concentrations.

It is interesting to note that the two alkaloids, strychnine and brucine, are based on the indole nucleus as is auxin (indole-3-acetic acid), the natural growth regulator found in plants. The three have an indole nucleus (Fig. 2). The results show that strychnine inhibits root growth as auxin does. Brucine, which differs from strychnine only in that it contains two methoxy groups, was found to have an opposite effect. It stimulated radicle growth.

References

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