much heat was necessary to kill the predisposed rust as the control rust. It emphasizes the high degree of physiological adaptation in organisms, and may be of value in practical heat therapy.

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Formative Response of *Amsinckia intermedia* to the Interrelated Effects of Low Temperature, Thiamin and 2,4-Dichlorophenoxyacetic Acid

THE adverse effect of temperature on plant growth may sometimes be corrected by the external application of certain essential metabolites. As early as 1943, Bonner[1], using *Cosmos sulphureus* Cav. as experimental plant material, found that the growth under sub-optimal temperature conditions was improved by thiamin application. Later work by Bonner[2] and more recently the experiments by Ketellapper[3] showed that both high- and low-temperature effects on several plant species were overcome by chemical treatments. The investigations recorded here were carried out to determine whether or not the response of fiddleneck (*Amsinckia intermedia*, Fisch and Mey) to 2,4-dichlorophenoxyacetic acid (2,4-D) when grown at a low temperature can be changed by treatment with certain metabolites.

Seedlings were grown in plastic pots containing 16-mesh silica sand in the greenhouse for one month and then placed in a growth chamber. Subsequent culture was at 10° C under an 18-h light régime. Illumination was provided by warm white fluorescent tubes supplemented with 60-W incandescent bulbs giving an intensity of 1,250 ft.-candles. Nutrients were supplied to all plants every other day with Hoagland's solution.

In the initial set of experiments, solutions of thiamin were applied with a pipette to individual mature leaves in 0·01 ml. droplets at rates of 0·05–50·0 μg per plant. At the same time, 500 μg of 2,4-D alone or in addition to each of the rates of thiamin was applied to similar plants.

In other experiments, fiddleneck seedlings were established as described here, and weekly treatments of certain metabolites were sprayed on the foliage. Thiamin (20 p.p.m.), vitamin C (1,000 p.p.m.), *d*-biotin (1 p.p.m.), pyridoxin (20 p.p.m.), nicotinic acid (40 p.p.m.), adenine (1 p.p.m.), 2-thiouracil (1 p.p.m.), and a mixture of amino-acids (L-cystine, L-cysteine, L-glutamic acid, DL-aspartic acid and glycine—each at 1 p.p.m.) were sprayed on the leaves. The plants were sprayed with the solutions weekly for four consecutive weeks and then gathered. The root and shoot of each plant were separated and the dry weight measured. The metabolites which caused an improvement in growth at this temperature (10° C) were then applied to similar plants in combination with 2,4-D to determine the interaction. Treatments were 275 μg 2,4-D per plant, plus one of the following additives: amino-acid mixture, *d*-biotin (0·1 and 10 μg), nicotinic acid (10 and 100 μg) or thiamin (10 μg). Observations were recorded one month after treatment.

The untreated and the thiamin-treated plants grew slowly at 10° C with no apparent morphological differences due to the thiamin. 2,4-D applications alone suppressed growth and produced a slight distortion of the apex, 2,4-D plus 0·05 μg thiamin caused 100 per cent mortality (Fig. 1), and 2,4-D plus 0·5 μg thiamin caused mortality to 40 per cent of the plants and severe injury and distortion to 60 per cent. The 2,4-D plus the higher rates of thiamin (2·5, 5·0 and 50 μg) caused severe injury but did not kill the plants.

Fig. 1. *Amsinckia intermedia* plants growing at 10° C. Control plant (*CO*), plant treated with 2,4-D (2,4D) at lower right and plant treated with 2,4-D plus thiamin (24DTH) at lower left. Combination of thiamin and 2,4-D causes increased mortality at this temperature

The plants sprayed with the amino-acid mixture, *d*-biotin or nicotinic acid were darker in colour than the control plants and dry weight of both tops and roots was greater. 2,4-D applied to otherwise untreated plants caused a suppression of the apex and some distortion of the youngest leaves. *d*-Biotin (0·1 μg) plus 2,4-D caused severe swelling of the apex, suppression of new growth and discoloration and necrotic areas in the mature leaves. *d*-Biotin at a dosage of 10 μg plus 2,4-D had much less effect. Nicotinic acid at the rate of 100 μg per plant increased the response of the plant to 2,4-D but did not do so at 10 μg. Thiamin-treated plants were the most severely injured by the 2,4-D, although they showed no improvement in growth from the thiamin treatment.

The results show that: (1) low-temperature effects on *Amsinckia intermedia* may be partially overcome by the application of chemical substances; (2) certain metabolites in combination with 2,4-D are more effective in causing formative and toxic effects on *Amsinckia intermedia* growing at a sub-optimal temperature than 2,4-D alone. Of those tested, thiamin was the most effective.

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A Steroid Growth Factor Requirement in a Fungus

THE homothallic oomycete *Phytophthora cactorum* is frequently grown on oatmeal agar[1], and on this medium it forms oospores readily. On a basal medium of sucrose or glucose, asparagine, mineral salts and thiamine its vegetative growth is less and oospores are not formed, or a very few are found after a long time, and then only at the edge of the colony. The basal medium evidently lacks some growth factor or factors present in oats. The addition of aqueous extracts of ground oat grains to the basal medium stimulates vegetative growth but does not lead to the production of oospores. However, the addition of 500 mg/l. of a petroleum ether or ethanol extract of oats both increases the rate and amount of growth and results in the production of oospores. Aqueous and ethanol extracts of peas have similar effects.