PYRIDAZINONES, Their Influence on the Biosynthesis of Carotenoids and the Metabolism of Lipids in Plants (Survey of Literature)

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Mechanism of Action of Pyridazinones, Chlorophyll, Carotenoids, Lipids, Ribosomes, Hill Reaction, Survey of Literature

The pyridazinone herbicides influence to several degrees, the Hill reaction, the pigment formation, the ratio of saturated to unsaturated fatty acids and the chloroplast ribosomes. Which is the primary effect is not yet known.

Introduction

Up to now there are known at least four types of mechanism of action of the pyridazinones which occur one alone, or several combined, depending on the structure of the compound (compare Fig. 1) :

- inhibition of the Hill reaction
- inhibition of the pigment-formation (chlorophylls, carotenoids)
- changement of the ratio of linolenic/linoleic acid
- influence on the chloroplast ribosomes.

Inhibition of the Hill reaction

Pyrazon (chloridazone) is a typical representative of a inhibitor of the Hill reaction but it is ten times less active than atrazine. The other compounds, so far as investigated, are also inhibitors of the electron flow. We can see three degrees of activity in relation to pyrazon:

- slightly more active: SAN 6706, BASF 4421;
- somewhat less active: SAN 9774;
- much less active: SAN 9789 [4, 7, 17, 19].

Inhibition of the biosynthesis and accumulation of the pigments: Chlorophylls and carotenoids

SAN 6706 and SAN 9789 are highly active, followed in decreasing order by SAN 9774 and SAN 133-410. The compounds SAN 9785 and BASF 13761 show practically no influence on the pigment formation. Plants which are treated with the highly active compounds show no morphological

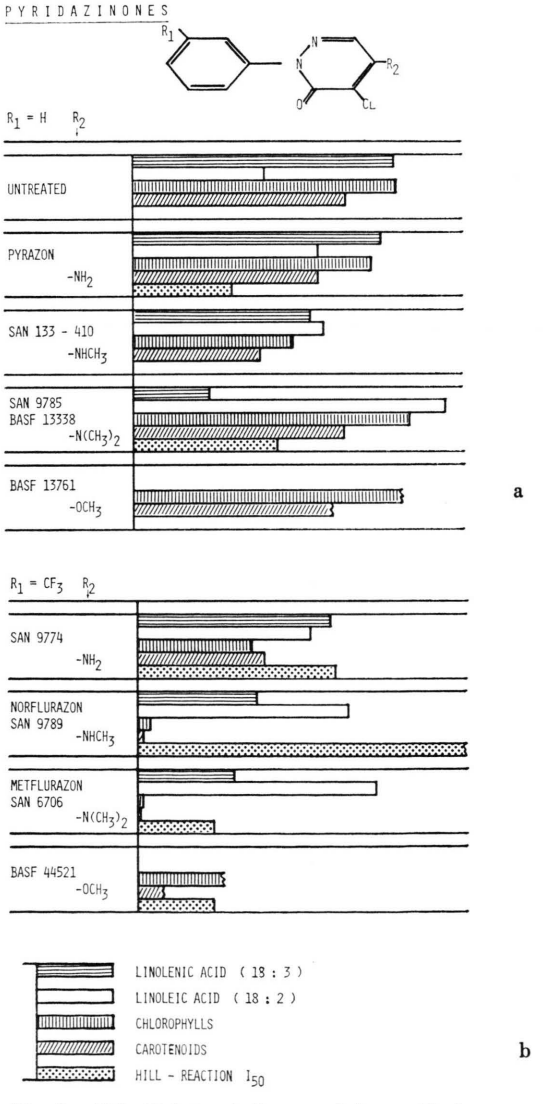

Fig. 1 a / 1 b. Relative influence of the pyridazinones on the fatty acids, pigments and the inhibition of the Hill reaction.

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alternations in comparison to untreated plants, but the leaves are entirely white [1 – 5, 7, 8, 10 – 12, 17, 20, 21]. The inhibition of pigment formation occurs under dark and light conditions, but under dim light a small amount of chlorophyll can be accumulated [1]. There are two hypotheses in discussion for causing the bleaching effect:

1. Photooxidation of the chlorophylls as a consequence to the absence of carotenoids which have a protective function. Plants grown under high light intensity treated with SAN 6706 accumulate no carotenoids and no chlorophylls. If plants grow under dim light for the same period, they produce 60% of chlorophyll but no carotenoids. After transferring these plants for one day in intensive light, the chlorophyll content decreases to practically zero [1, 3, 20].

2. Carotenoids and chlorophyll accumulation is simultaneously inhibited; in the same time period the phytoene and phytofluene content is increased. This applies for the compounds SAN 6706/9789 and BASF 44521. This means that the carotenoid formation is blocked at the C-40 level [13, 15, 21]. Furthermore SAN 9789 inhibits the formation of phytol, which is a precursor of chlorophyll; chlorophyll; and carotenoids, also simultaneously [15].

The use of such herbicides allows quantitative spectrophotometric measurements of phytochrome in plants grown in white light [9].

Ratio linolenic acid/linoleic acid

The pyridazinones alter the fatty acide composition of polar lipids which consist predominantly of galactolipids. The most distinct influence is shown by SAN 9785 (dimethyl substitution of the amine of pyrazon): decrease in linolenic acid accompanied by an increase of linoleic acid without a shift in the relative proportion of saturated to unsaturated fatty acids of the membrane lipids. The trifluorated compounds are related to shift towards a higher proportion of saturated acids [8, 10, 16, 17].

The fact that SAN 9785 highly influences the ratio of linolenic/linoleic acid without affecting the pigment accumulation shows that the biosynthesis of carotenoids and chlorophylls, as well as the formation of the micro structures of the chloroplast are not correlated with the formation of linolenic acid. SAN 6706 and SAN 9789 provoke severe disruptions in the micro structure of the chloroplast [1, 21]. It seems that the changes in the proportion of saturated to unsaturated fatty acids related to the trifluoromethyl-pyridazinones causes the uncoordinated development or the disruption of the grana structures [8, 17]. Simultaneous applications of possible elements of chloroplast lipids such as phytol, α-tocopherol, esters of fatty acids are capable to neutralize the toxic effects of SAN 6706 [8].

It seems further that the ratio of linolenic/linoleic acid influences the chilling resistance of plants, which is partially caused by an enhancement of the linolenic acid content at low temperatures. SAN 9785, indeed, reduces the chilling resistance of wheat and cotton by decreasing the relative accumulation of linolenic acid [18, 22]. There is, however, a contradiction: BASF 13338 and SAN 6706 treated wheat seedlings show a lower content of linolenic acid but are not more susceptible to chilling than untreated plants [14].

Influence on the chloroplast ribosomes

The chloroplast ribosomes of SAN 6706 treated plants grown in dim light are only slightly altered (*i. e.* 70 S : 80 S = 4 : 1). When such plants are transferred to high light intensity the 70 S particles disappear totally. This would be an argument in favour of the photooxidation hypothesis [1].

The absence of the ribulose-1,5-bis P carboxylase after SAN 6706 treatment is in good correlation with the absence of the 70 S ribosomes [6].

But the specific effects on peroxisomal enzymes by these herbicides are not in line with the hypothesis that the bleaching effect of some pyridazinones is based on photooxidation of the chlorophyll [6].

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