Symptomless Effects of Experimental Fungicides on Wheat

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ABSTRACT

The experimental systemic rust fungicide, Hoe-6052, was previously found to reduce the yield of a wheat stem rust-resistant cultivar, and not to increase the yield of a susceptible cultivar, even though it controlled the rust. This compound, as well as EL-273 affected the respiration of the wheat cultivar F.A. 8193, while the experimental fungicide BAS-3050 F did not. Hoe-6052 also affected the photosynthesis of wheat quite appreciably, while EL-273 and BAS-3050 F did not. It is suggested that tests like those of photosynthesis and respiration be included at an early stage of development of fungicides.

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Additional key words: photosynthesis, deleterious effects of fungicides.

A recent development in pesticide science is the introduction of systemic fungicides, i.e. chemicals highly toxic to the fungi which cause plant diseases, that are translocated readily in higher plants. Due to translocation of these fungicides, they are distributed acropetally in the various parts of the plant and thus result in a long-term protection against plant diseases (1). It is obvious that only chemicals which are not phytotoxic to the host plant can serve as fungicides. Therefore, lack of phytotoxicity to agricultural crops is an essential characteristic when chemicals are tested for their potential use as fungicides. However, phytotoxic action of pesticides is usually determined by visual symptoms such as growth, stunting, deformations, chlorosis, necrosis, turgor decline, etc. Limited information is available at present, on subphytotoxic effects of fungicides on plants (7), and tests for such effects are usually not included in screening programs of new pesticides.

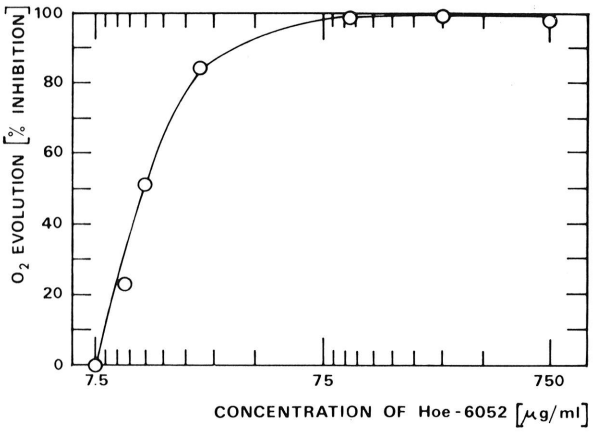

Fig. 1. The effect of Hoe-6052 on the rate of photosynthesis at 21 C in detached leaves of F.A. 8193 wheat. Leaf segments immersed for 1 h in suspension of different concns of Hoe-6052, washed, and then tested.

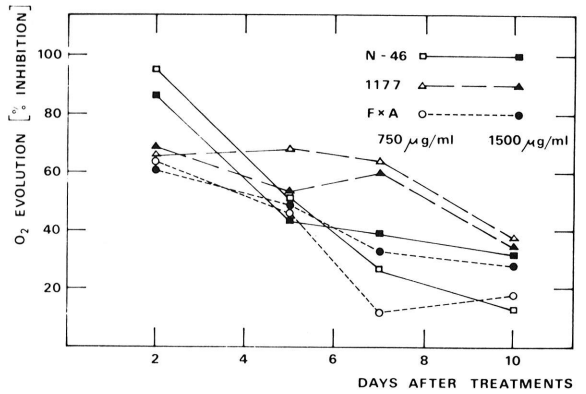

Fig. 2. The effect of Hoe-6052 on the rate of photosynthesis in detached leaves of three wheat cultivars. Attached leaves were dipped in suspension of 750 and 1,500 μg/ml of the fungicide and tested later at different intervals at 21 C.

We report here that some experimental fungicides for the control of cereal rusts may harm the host plants by interfering with the respiration and/or photosynthesis. They might cause an invisible damage to the crop, in spite of the fact that the rust is effectively controlled.

The experimental systemic fungicides tested were: 2-methyl-5,6-dihydro-4-H-pyran-3-carbonoxide - anilide (Hoe-6052, 75% a.i., supplied by Farbwerke Hoechst AG); *O*-methyl benzoic acid anilide (BAS-3050 F, 75% a.i., supplied by Badische Anilin - & Soda - Fabrik AG); and α-(2,4-dichlorophenyl)-α-phenyl-5-pyrimidinemethanol (EL-273, 4% a.i., supplied by Eli Lilly).

In a previous work (6) it was found that under glasshouse conditions, Hoe-6052 showed promising results in controlling leaf and stem rusts of wheat. It was also found under field conditions, that in the cultivar N-46, which is susceptible to stem rust, several of the treatments yielded less than the check plots, despite an appreciable control of the stem rust. In addition, it was found that the same fungicide reduced the yield of the stem rust-resistant cultivar H-1177. These results pointed out an adverse effect of Hoe-6052 on wheat, an effect of such magnitude that it even seemed to negate the beneficial effect of rust control. These findings led us to test possible reasons for the deleterious effect of the Hoe-6052, and to compare it to other fungicides.

We checked the effects of Hoe-6052, BAS-3050 F, and EL-273 on respiration and on photosynthesis of first leaves of wheat cultivar F.A. 8193. The effect of H-6052 on photosynthesis was also checked on cultivars N-46, and H-1177, respectively, the susceptible and resistant

cultivars used formerly in the field trial.

Rates of photosynthesis and respiration were determined by a manometric technique (2, 3, 5). The effects of the fungicides were studied in short- and long-term experiments. In the short-term experiments, photosynthesis and respiration were measured immediately after immersing 7-mm-long leaf segments in the fungicide suspensions for 60 min. In the long-term experiments, 1-wk-old attached seedlings were dipped in the suspensions for 60 sec, and then photosynthesis was measured after 2, 5, 7, and 10 days. In each test eight replicates were used and tests were repeated twice.

Effects on respiration.—Each fungicide was used at a concn which did not show visible symptoms on wheat during preliminary tests, but inhibited normal development of rust. These concns were as follows: Hoe-6052 and BAS-3050 F at 750 μg/ml, and EL-273 at 40 μg/ml. At 21 C, BAS-3050 F did not affect the respiration in seedlings of the cultivar F.A. 8193, while Hoe-6052 and EL-273 inhibited respiration by 13% and 17%, respectively. At 28 C, Hoe-6052 inhibited respiration by 47% and EL-273 by 75%. The differences at 28 C were significant ($P = 0.05$) between the two fungicides, and between each one of them and the control. The effect of BAS-3050 F was not determined at 28 C. The effect of Hoe-6052 at 21 C was different for each of the three cultivars tested: F.A. 8193 suffered 13% decrease, H-1177 10% and N-46 18% (the last two differed significantly from each other and from the check).

Effects on photosynthesis.—EL-273 at 40 μg/ml and BAS-3050 F at 750 μg/ml did not affect photosynthesis of F.A. 8193 at 21 C, whereas Hoe-6052 had an appreciable effect. A range of concns of Hoe-6052 was used (Fig. 1). In a further test, we determined the persistence of this deleterious effect of Hoe-6052 in the three different wheat cultivars. In these tests photosynthesis was determined for treated leaves floating in water, rather than untreated leaves floating in fungicide suspension. Therefore, the effect of the fungicide is assumed to have been milder, and resembled more the application under field conditions. Attached leaves were dipped in the fungicide solution at concns of 750 μg/ml and 1,500 μg/ml (under field conditions the recommended rates are 1-2 kg/ha in 4-8 gallons of water which equals to 2,500-10,000 μg/ml). The effects of Hoe-6052 on photosynthesis under these conditions are presented in Fig. 2. There was not much difference between the two concns of fungicide, but some differences between cultivars were observed. N-46 suffered a significant inhibition during the first two days after application, while in H-1177 the adverse effect persisted more and in the seventh day differed significantly from the other cultivars. Even ten days after the application, photosynthesis was still inhibited 40% in H-1177.

For the sake of comparison, we checked the effects of the conventional protectant fungicide maneb (manganese ethylene-1,2-bisdithiocarbamate) under the same conditions. Attached leaves were dipped in a 0.48% maneb suspension, and 2 h after application, inhibition of photosynthesis was significant and amounted to 14%, but this effect disappeared later.

Our findings stress an important aspect in the development of agricultural chemicals. Invisible phytotoxic or subphytotoxic effects as mentioned in the literature (4) are known for several pesticides, but their magnitude in terms of disturbing vital processes in the plants was not reported. New chemicals being developed are currently evaluated on the basis of their agricultural merits and are rejected on the basis of their visible phytotoxic effects.

Appropriate laboratory tests, are liable to expose disadvantages of pesticides before they are tested in field experiments. It would be safer, cheaper, and more efficient to detect such drawbacks, as depression of photosynthesis, in the laboratory, rather than by inference from field trials. Tests in which leaves were exposed to the fungicides under extremely severe conditions (i.e., immersion in the solution for 1 h) showed that harmful compounds could be distinguished from harmless ones. Such tests can, therefore, identify safe fungicides; and the others could then be evaluated under milder conditions. Therefore, it is suggested that tests of the effects of new chemicals on photosynthesis and respiration of pertinent crops be also included in early stages of pesticides development. The effects of pesticides on other physiological processes should also be taken into consideration.

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