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EFFECTS OF PESTICIDES ON LICHENS

Vagn Alstrup

Institut for Økologisk Botanik, Københavns Universitet, Øster Farimagsgade 2d, 1353 København K, Denmark

Lichens are among the most threatened organisms in Denmark. Out of about 900 lichen species 372 are either extinct, endangered, vulnerable or care-demanding. A further 264 are rare and the status of 110 is uncertain. The reason for this situation are diverse. Air pollution with SO_2 is responsible for a dramatic reduction of epiphytic lichen vegetation in towns and along roads. Modern forestry methods are a great danger to forest lichens, both epiphytic and the soil-inhabiting. In the agricultural landscape lichens are found on trees in windbreaks, on buildings and especially on stone fences. Stone fences have been built by farmers during centuries to protect forests and cultivated fields against domestic animals, and are now the most important habitat for stone-lichens in most parts of Denmark. The total length of the fences has been reduced by more than 80 % in this century, but probably still exceeds 10.000 km.

Pesticides are widely used in agriculture to eliminate weeds and to control attacks of fungi and insects on the crops. As literature records on the effects of pesticides on lichens were not available, small-scale experiments with the application of 2 fungicides and 2 herbicides to stone-inhabiting lichens were performed, and the effects studied for almost a year.

Methods

The following commonly used pesticides were tested:

Herbatox Combi 3 (herbicide). Normal dose 3 l/ha
Dantril (herbicide). Normal dose 2.5 l/ha
Tilt Turbo (fungicide). Normal dose 1 l/ha
Rival (fungicide). Normal dose 1 l/ha

For agricultural purposes, the pesticides are diluted in water, so that about 200 l are applied per hectare. For the experiment the concentrations were 0.1 x, 0.33 x, 1 x, 3.33 x and 10 x normal concentrations, and the doses applied to the test spots therefore varied between 0.1 and 10 times the recommended dose. The solution was applied with a small atomizer (flower-sprayer) in May 1990.

Test plots were about 2.5 m^2. Before spraying the greatest diameter of up to 10 thalli of all the present lichen species were measured and it was noted whether the lichens were healthy. The plots were investigated several times during the next 5 months and visible damages were noted. After 6 months the same lichen thalli were measured again and their growth was calculated. Damaged lichen thalli were investigated microscopically in an attempt to see whether algae or fungi were primarily damaged. A final visual inspection took place almost a year after spraying.

Results

Different lichen species showed diverse reactions to the pesticides. Damaged

Table 1. Summary of effects of pesticides on lichen species at high doses. 1 = No visible damage, perhaps reduced growth; 2 = with visible damage but still living; 3 = dead. () = only observed at doses equal to or smaller than the normal dose. * = parasitized; # = browsed by invertebrates; & = reduced; spore production: ! = great production of spores or conidia

	Herbicides		Fungicides	
	Herbatox	Dantril	Tilt t.	Rival
Acarospora fuscata	1		2	2
Acarospora veronensis			2	1
Aspicilia caesiocinerea	2	1	2	
Aspicilia cinerea	2		3	
Aspicilia radiosa			2	2*
Caloplaca flavovirescens				3&
Caloplaca holocarpa			2	
Caloplaca marina				2
Candelariella vitellina	3	2	3	3
Cladonia spp	2	1		
Haematomma ochroleucum	2	2	3	1
H.o. var. *porphyrium*	1		2	2
Hypogymnia physodes		3		3
Lecanora campestris		1*		1
Lecanora dispersa			1	
Lecanora hageni	1	1	2	2
Lecanora muralis	2*	1	3*&	2#
Lecanora rupicola	2	2	3*	2
Lecanora salina		2	2	
Lecanora sulphurea		3		
Lecidea fuscoatra		2	3	
Lecidea soredizodes	3	2	2	2
Lecidella scabra	2	(2)	3	3
Lecidella stigmatea				2
Lepraria incana	1	1	1	1
Leptogium schraderi				2*
Ochrolechia parella	2	2		1
Opegrapha zonata	1	3	2	1
Parmelia fuliginosa	2	2	3	1
Parmelia glabratula	1		2	3
Parmelia saxatilis	1			3
Parmelia sulcata	2			
Parmelia verruculifera	2#	2	3	3
Peltigera praetextata				1
Pertusaria amara	2	2		3
Pertusaria chiodectonoides		2#	1	1#
Physcia caesia		2*	3*#	3*#
Physcia dubia	1			
Porina chlorotica	2		2	1
Psilolechia lucida	1	1	2	1
Rhizocarpon distinctum	3	2!	1	1
Rhizocarpon geographicum			3	
Rhizocarpon obscuratum	2		3	2

Table 1. (cont.)

Sarcogyne clavus				1
Scoliciosporum umbrinum	1	1	1	1
Tephromela atra	3	2*	3	2#!
Trapelia placodioides		2		
Xanthoria parietina	2#	3		2#

thalli normally turned redbrown or decolorized, in some cases they peeled off the stones. Some lichens were not visually damaged but showed reduced growth. Some species also seemed to be grazed by invertebrate animals or parasitized by lichenicolous fungi more frequently than references, and the competition pattern between lichen species and between lichens and mosses seemed to have altered. Some plots were sprayed before a rainy period and these showed effects after 1 month. Other plots did not receive rain after spraying, and they remained undamaged for 4 months, but after rain in the autumn, the damage became obvious. In the spring of 1991 the damaged, but still living lichens started to recover.

Microscopical examination showed that both symbiontic partners apparently were affected at the same time. The effects are summarized in Tab. 1.

Discussion and conclusions

The greatest damage was seen at high doses of pesticides, but even small doses undoubtedly affect many lichen species by reducing their vitality and thereby their competitive strength and their resistance against browsing and parasitism. The effects of a single application of pesticide can be seen even a year later, and repeated spraying undoubtedly leads to an impoverishment of the flora, although the vegetation can seem to be relatively unaffected. A recent survey of the lichen flora on stone fences in the Copenhagen area (Alstrup 1989, in a report) showed that fences around permanently grazed areas which had not been sprayed with pesticides nor been fertilized had a richer flora than fences around cultivated fields which were often exposed to such events. The investigation also indicated that pesticides which are normally rapidly broken down in nature were taken up by dry lichens and shown to be effective after several months.

Pesticides have to be tested for their toxic effects against man and animals, their behavior in soil and water, before they are permitted to be used in agriculture. However, their effects on lichens and other economically unimportant plants and animals of wild nature are not taken into consideration before they are permitted. Further studies of the permitted pesticides, their single components, and mixtures of pesticides, are needed to specify the effects of these. The effects of repeated application of small doses on the competition between lichen species and between lichens and other plants such as mosses should be studied, as should the uptake and possible release of bound pesticides to the air. Physiological studies of photosynthesis and respiration, and of the production of protective compounds against browsing and parasitism, also need to be undertaken in order to avoid the most damaging compounds.