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Ranking Of Fungicides According To Risk Assessments For Health And Environment

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ABSTRACT

Denmark has introduced a new indicator for ranking the potential impact of pesticides on health and environment. The new Pesticide Load (PL) makes it possible for farmers to choose the least harmful fungicides and substitute between products which have an equally good efficacy profile. In practice PL varies for fungicide standard rates by a factor of 10. Products including epoxiconazole generally have higher PL's due to the human health profile of this active. PL's per area, crop or product will supplement the previous pesticide statistics based on treatment frequency index (TFI). PL has also been introduced as the basis for a new tax system for pesticides from 1 July 2013, replacing the old value based tax. The Government has asked for a 40% reduction in the PL per ha by 2015, based on substitutions to less harmfull products. As certain pesticide groups will be favoured by the new tax system it is expected that the system could lead to more problems related to pesticide resistance.

INTRODUCTION

Today the common European agricultural policy questions the increasing dependence on pesticides. The framework directive (Directive 2009/128/EC) states that by 2014 all EU members must have implemented Integrated Pest Management (IPM), with the aim to reduce the impact of pesticide use. Eight IPM principles were listed in the directive to support the implementation of IPM. The fifth of the eight principles states that the pesticides chosen must be specific and least harmful to health and environment. So far farmers in the EU have not been provided with tools which enable them to select products that follow this principle.

As part of a new pesticide strategy plan in Denmark for 2013 to 2015 (Anon. 2013a), a new risk indicator for effects on the environment and health was developed named the Pesticide Load (PL). The PL values for each product provide a basis for developing a guide to allow farmers and other users of pesticides to make a selection among pesticides based on their inherent properties. A value added tax system for pesticides has been in place since 1996. Since 1998 the tax has been 33% for herbicides, fungicides and growth regulators and 50%

for insecticides. For several years there has been a general wish to change the value added tax to a tax based on environmental and human health effects of pesticides. PL provides the base for this change.

This paper describes the PL for individual fungicides as well as impact on cost of products and other implications relevant for the choice of fungicides.

CALCULATION OF PESTICIDE LOAD

Three elements have been included in the calculation of PL, impact on health (PL_H), environment (PL_E) and fate (PL_F) (Anon. 2012a). In a dialogue with the agrochemical industry, data from the PPDB database (footprint database) are used as input for the ranking of substances in the area of ecotoxicity and fate. The same data are used in connection with the risk assessment of the substances and subsequent inclusion on Annex 1 to Directive 91/414/EEC or plant protection regulation 1107/2009.

Ranking of the *health risk* of the products is based on the risk phrases of the product, i.e. only operator exposure is considered. Every risk phrase is given a score between 10 and 100. The highest score of 100 points is given to products that are highly toxic or can cause irreversible damage (may cause heritable genetic risk or may cause cancer). Formulations of products are also considered to have an impact on exposure with powder and liquid formulations providing higher risks compared with e.g. tablets and ready for use mixtures. PL_H is calculated based on risk sentences and formulation (Anon. 2012a).

The *environmental fate* of pesticides is determined using 3 subindicators; degradation in soil (Soil DT_{50}), potential for bioaccumulation (BCF) and mobility in soil. For bioaccumulation BCF values are used, and in case these are not available log P_{ow} values are used. Regarding mobility in soil the risk of products leaching to the groundwater is calculated based on the half-life of the active ingredients and possible degradation products (metabolites) and Koc values using a SCI-GROW model. As regards persistence, the longer the lifetime, the greater the PL. PL_F is calculated on basis of the 3 subindicators (Anon. 2012a).

The *environmental toxicity* of pesticides is determined using several subindicators; 8 relating to short-term effects (mammals, birds, fish, daphnia, algae, aquatic plants, earthworms and bees) and 3 relating to long-term effects (fish, daphnia and earthworms). Data from the footprint database are used for the ranking and calculations of the PL_E (Anon. 2012a).

Total PL values including environment, health and fate has been published for all products, and it is clear that the PL varies significantly between products. This is illustrated in Table 1 for the major fungicides currently authorized in Denmark.

Table 1. Examples of Pesticide Load (PL) for cereal fungicides and the changes of cost following introduction of a new tax. The products are ranked according to PL. New prices are based on www.middeldatabasen.dk (Anon. 2013b)

Products g a.i per litre/kg	**Stan-dard dose l/ha**	**PL per stan-dard dose**	**Price with old tax €/kg-L**	**Price with new tax €/kg-L**	**Change in cost (€) per standard dose**
Bell *(67 g epoxiconazole + 233 g boscalid)*	1.5	3.12	49	70	32
Ceando *(83 g epoxiconazole + 100 g metrafenon)*	1.5	2.90	39	59	30
Opera *(50 g epoxiconazole + 133 g pyraclostrobin)*	1.5	2.76	53	71	27
Osiris *(38 g epoxiconazole + 28 g metconazole)*	2.0	2.20	22	37	30
Rubric *(125 g epoxiconazole)*	1.0	1.99	43	65	22
Tern *(750 g fenpropidin)*	0.8	1.12	37	49	10
Comet *(250 g pyraclostrobin)*	1.0	0.79	51	56	5
Dithane NT *(750 g mancozeb)*	1.5	0.78	7	17	20
Folicur *(250 g tebuconazole)*	1.0	0.77	27	32	5
Prosaro *(125 g tebuconazole + 125 g prothioconazole)*	1.0	0.54	52	47	-5
Juventus *(90 g metconazole)*	1.0	0.45	42	40	-2
Aproach *(250 g picoxystrobin)*	0.5	0.41	53	53	0
Flexity *(300 g metrafenone)*	0.5	0.38	84	86	1
Proline *(250 g prothioconazole)*	0.8	0.37	73	62	-9
Bumper *(250 g propiconazole)*	0.5	0.27	25	28	2
Amistar *(250 g azoxystrobin)*	1.0	0.26	53	46	-7

TAX BASED ON PESTICIDE LOAD

It was decided by the Danish government (Anon. 2013a) that the existing value added tax will be replaced by a new tax based on the PL. By using the PL as the basis for the tax system, it is envisaged that new pesticide tax will be based on objective data. The tax is 107 DKK (14.3€) per PL, supplemented by a basic tax 50 DKK per kg active substance in the products (6,7 € per kg).

The objective of the new tax system is to introduce a significant price differentiation to provide incentives for the farmers to choose the least harmful pesticides thereby minimizing the impact on health and environment. Compared to the present tax the new tax will lead to bigger price differences between products. As illustrated for fungicides in Table 1 some products will become significantly more expensive, others will become cheaper or the prices will remain unchanged. The values for the products were at the time of printing still

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preliminary and minor adjustments can be expected depending on how the companies finally price their products.

Plant protection products only approved for closed greenhouses are exempted for the part of the tax relating to environmental effects as these plant protection products are not expected to give rise to significant environmental effects. Seed treatments are also handled in a specific way and in this case the risk to mammals and birds gives rise to a higher load for the environmental toxicity (Anon. 2012a).

The total tax revenue is expected to increase by 150 billion DKK once it will be fully implemented. The majority of the tax revenue is returned to farmers as a compensation for land taxes (approximately 10 € reduction/ha). The tax is also used to support green initiatives and pesticide related research activities. The tax was implemented on1th July 2013.

IMPACT ON USE STRATEGIES.

The economical benefit of using fungicides will be influenced by the new tax. This is illustrated in Tables 2 and 3 showing data from trials carried out in winter wheat and spring barley, comparing typical Danish control strategies. The impact of the new tax will generate changes in the ranking of the economically most profitable treatments assessed on the basis of economic net returns (in which cost of treatment and fungicide cost has been deducted from the gross return). As the Danish solutions traditionally include significantly reduced dose rates, the changes are not as dramatic as the figures in Table 1 might indicate. In spring barley several solutions (Table 2) are providing similar control and yield responses (Anon. 2012b), and substitutions to products not containing epoxiconazole will be likely and provide competitive solutions.

In wheat, treatments have traditionally included products containing epoxiconazole once or twice per season, but as indicated in Table 3 similar control and yield responses can be obtained by substituting at least one of the two epoxiconazole treatments with products containing other active ingredients. As epoxiconazole is still seen as the most effective azole for control of septoria tritici blotch (*Mycosphaerella graminicola)* in Denmark it is not likely that the farmers will completely skip the use of products containing this active.

DISCUSSION

Treatment Frequency Index has been the main indicator of the intensity of pesticide use in Denmark since 1985. The Pesticide Load per ha is seen as a better indicator for the potential adverse impacts of pesticides on the environment and human health. Based on the use pattern of pesticides in 2011, it is foreseen that the PL per ha will be reduced significantly in the future as the farmers are expected to select the cheaper products solutions and thus the least harmful pesticides. The new pesticide strategy sets a goal of a 40% reduction in PL per ha by 2015 (Anon. 2013a), which is expected to be achievable through substitution of products.

Table 2 Results from 10 spring barley trials from 2011-2012. Treatments were carried out at gs 37-39. Impact of new tax on the net return from different solutions has been calculated. Data from the Knowledge Centre for Agriculture, Skejby. Grain price fixed at 20 € per dt and cost of application at 9.3 €.

Treatments applied at GS 37-39	% control of Rhynchosporium	Yield increase dt/ha	Net return Old tax €	Net return New tax €
Untreated	8	59.2	-	-
0.25 Folicur + 0.25 Comet	63	+3.9	48.7	46.5
1.0 Osiris	87	+3.9	46.7	31.5
0.35 Prosaro + 0.15 Comet	75	+4.5	54.4	55.7
0.5 Prosaro	87	+4.7	58.7	60.7
0.75 Bell	87	+5.4	61.2	46.4
LSD_{95} (between treatments)		0.9		

Table 3 Results from 4 trials in winter wheat from 2011-2012. Treatments were carried out at gs 37-39 and 51-55. Impact of new tax on the net return from the different solutions have been calculated. Data from Aarhus University - Flakkebjerg. Grain price fixed at 20 € per dt and cost of application at 9.3 €.

Treatment at GS 37- 39 & 51-55	% control of Septoria	Yield and yield increase dt/ha	Net return Old tax €	Net return New tax €
Untreated		77.2	-	-
0.5 Bell + 0.17 Comet/1.0 Osiris	93	+11.9	162.7	137.2
2 x 0.5 Rubric	85	+12.1	175.7	159.7
0.75 Bell/0.4 Proline	91	+12.1	157.0	146.6
1.0 Osiris/0.75 Bell	88	+13.7	195.9	165.9
2 x (0. 5 Bell + 0.17 Comet)	90	+14.3	199,7	179.0
0.5 Bell + 0.17 Comet/0.4 Armure	92	+14.3	208.2	197.9
0.5 Bell + 0.17 Comet/0.5 Prosaro	87	+14.6	213.7	205.7
LSD_{95}		2.5		

It is expected that the new tax will result is a reduction in the number of products on the market as the most harmful products due to uncompetitive prices will most likely be withdrawn. Another drawback of the new tax system is the influence on behaviour. Stock building is expected to have taken place during the last two seasons, and it is also foreseen that the farmers will be more tempted to illegal use of pesticides bought e.g. in Germany, where there is no tax on pesticides. To prevent this scenario the authorities will intensify the inspections both as random checks of lorries crossing the borders and at farm level.

Increasing problems with pesticide resistance are expected as the new tax system will favour certain groups of pesticides. The greatest concern is resistance to the sulfonylurea herbicides as these will become significantly cheaper compared to some of the older but less resistant prone chemistries. Within the fungicides certain triazoles will be strongly favoured compared with others, which could increase the risk of selection in the fungal

pathogens. Unfortunately, already today the number of available fungicides with different modes of action is very limited due to the stricter requirements for authorization in Denmark and although theoretically possible (Brent & Hollomon 2007) the options for implementing specific anti-resistance strategies are very limited or non-existant in Denmark. The problems related to resistance could well increase in future as also new fungicides e.g. new SDHI fungicides, now on the market in other European countries, are not expected to fulfill the specific Danish requirements demanding a higher protection level of the groundwater.

The new tax system has many similarities with the comparative assessments system proposed by the framework directive (Directive EC 1107/2009). With the Danish tax system the most harmful products will in case of appropriate alternatives be substituted with less harmful products based on economic judgements, but the harmful products can, however, stay on the market.

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