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Change in the quantity and acute toxicity of pesticides sold in South African crop sectors, 1994 –1999

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Abstract

BACKGROUND—South African pesticide market sales data, for two years, 1994 and 1999, were audited to identify change in total and per hectare mass sold and acute toxicity indicator (ATI) (kg sold/rat oral LD50) in the grape, pome, stone fruit, potato and wheat sectors.

RESULTS—Total pesticide sales (62%), amount per hectare (42%) and number of active ingredients (23%) increased in 1999 compared to 1994 with the grape fruit sector, the most significant contributor over the two years. Total (14%) and per hectare ATI (19%) decreased in 1999, but not substantially with the potato sector the most significant contributor.

CONCLUSIONS—Toxic pesticides were still used in 1999 which highlights a need to develop alternative agricultural and non-chemical pest control methods that reduce usage of pesticides.

Keywords

Pesticides; risks; agriculture; crop sectors; acute toxicity indicator

Introduction

International environmental policy in the past two decades has increasingly focused on the threats to global sustainability especially on the impact of environmental degradation on public health (Von Schirnding et al., 2002). Pesticides feature prominently in international environmental policy especially due to the fact that many pesticides banned or restricted in developed countries, continue to be used in developing countries because of their low cost, lack of institutional capacity to regulate, and lack of awareness (United Nations Environment Program, 1989; PIC Secretariat, 1999; Kishi et al., 2001; United Nations Environment Program, 2001).

Pesticides cause acute pesticide poisoning amongst those occupationally exposed. Increasing attention is also being directed at the long-term health effects associated with pesticide exposure, and to risks associated with non-occupational exposures. For example, different pesticides have been implicated in chronic neurotoxicity, endocrine disruption, immune

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impacts, genotoxicity, mutagenicity and carcinogenesis (Maroni and Fait, 1993; Abou-Donai, 2003; Galloway and Handy, 2003; Choi et al., 2004).

South Africa is the largest market for pesticide use in Sub-Saharan Africa (Dinham, 1993). For example, in 1990, South Africa's expenditure on pesticides was over \$ 268 million and this had risen to over \$600 million by the mid 1990's (London, 1992; Rother and London, 1998). By far the largest sector consuming pesticides in South Africa is agriculture, with a smaller proportion devoted to vector control for public health and for domestic pest control operations. A previous audit based on 1989 data, found agricultural pesticide sales for crop protection in the southern part (Western Cape and Eastern Cape to East London) of South Africa (crop sectors in the region included grape fruit, pome fruit, stone fruit, potato, wheat and citrus fruit) to be more than 7400×10^3 kg (London and Myers, 1995a & b).

Evidence for environmental contamination arising from agricultural application come from a number of studies that have found the presence of pesticides in rural water sources in South Africa in air and in humans (Davies, 1997; Schulz, 2001; Bouwman et al, 2006; Dalvie et al., 2003; Dalvie and London, 2006).

This paper aimed to evaluate the change in usage of pesticides and associated hazards over the period 1994–1999. The data presented in this manuscript forms part of a study which aimed to update crop sector pesticide usage information for a job-exposure matrix used to estimate pesticide exposures of farm workers in the Western Cape (London and Myers, 1995a & b).

Material and methods

The statutory collection of quantitative information on pesticide usage is lacking in South Africa (London and Myers, 1995a) and market related data is the only available sources of pesticide usage information. South African pesticide market sales data for the years 1994 and 1999 for 5 major crop protection sectors namely the grape fruit, pome fruit (apples and pears), stone fruit (apricots, peaches and nectarines, plums), potato and wheat sectors reviewed in a previous study that focussed on pesticide usage in the southern region of South Africa, were purchased and audited to identify changes over time (London and Myers, 1995a & b). Data on insecticides, herbicides, fungicides, seed dressings, nematicides, oil and miscellaneous applications were available. Growth regulator data, which was not available for 1999, have not been included in the paper. Acaricide data have been incorporated in the insecticide data as not all acaricide classifications were clear in the data.

While these data may have untested reliability and validity, they are the best available, and are likely to be reasonably accurate given the commercial motive for industry to have a clear picture of the market. There is also no evidence that categorisation or aggregation practices in the assembly of the data have changed, suggesting that comparisons over time may retain validity even if absolute values may not be completely accurate.

Pesticide risks were estimated in terms of their Acute Toxicity Indicator (ATI) as developed in a previous study by calculating the mass of active ingredient sold/rat oral LD₅₀ for London and Myers, 1995a). The ATI for more than one pesticide was calculated as the sum of the ATIs of individual pesticides.

The market surveys contained data on the hectares (10 000m²) treated per pesticide for each crop sector and therefore mass of pesticides sold/hectare and ATI/hectare was also calculated. The highest area treated by one pesticide in a crop sector was used as the estimate for the total area treated for that crop sector. The total area treated in the 5 crop sectors was therefore the sum of the highest treated area by one pesticide in each crop sector. Similarly, the total number of hectares treated with each application was the sum of the highest treated area by one pesticide

with that application in each crop sector; the total number of hectares treated with each chemical group was the sum of the highest treated area by one pesticide with each chemical group in each crop sector and the total hectareage per active ingredient was the sum of the highest treated area by one pesticide in each crop sector.

The four indices of pesticide use and hazard used in this paper can be explained as follows: mass of pesticide sold can be regarded to reflect volume of use, kg/hectare as intensity of use, total ATI as acute population hazard and ATI/hectare as intensity of acute hazard.

Active ingredients were classified into chemical groups according to the WHO pesticide data sheets (WHO, 2006) and the Extension Toxicology Network pesticide information profiles (Exttoxnet. 2006), but only pesticides with a common mode of action including OP, OC, chlorophenoxy acids, copper salts, carbamates, dithiocarbamates and sulphur were grouped. Mineral oil is categorised separately from other insecticides in view of its major role as a co-formulant or surfactant.

Results

In terms of volume of use, the mass of pesticides sold to the 5 South African agricultural sectors studied increased by about 62% from about 4194×10^3 kg in 1994 to over 6800×10^3 kg in 1999 (Table 1). There were increases in the mass of pesticide sold in 1999 in 4 of the 5 sectors reviewed, with the highest increase occurring in the grape fruit sector which nearly doubled to 3220×10^3 kg. There were increases of over 50% in the mass of pesticides sold in the pome fruit, potato and stone fruit sectors. The grape fruit sector accounted for most pesticides sold by mass both in 1994 (39%) and in 1999 (47%).

In terms of use intensity, the total kg of pesticides sold per hectare also increased by 47% in 1999 (Table 1). Mass sold per hectare more than doubled in the stone fruit and potato sectors and nearly doubled in the pome fruit sector, but decreased by nearly 30% in the grape fruit sector. The highest mass/hectare sold by far in 1994 was in the grape fruit sector but in 1999 the grape and stone fruit sectors had the highest sales per hectare.

In terms of acute population hazard, total ATI decreased by 14% (Table 1) although the total amount of pesticide sold increased in 1999. ATI increased by nearly 50% in the grape fruit sector and 27% in the stone fruit sector, but decreased by 68% in the potato sector and about 25% in the wheat sector. In 1994 the potato sector contributed to more than 50% of ATI followed by the grape fruit sector that contributed 19%, while in 1999 the potato sector contributed 41% of ATI followed by the 32% of grapefruit sector. In terms of intensity of acute hazard, the overall total ATI/hectare decreased by 19% in 1999 (Table 1). In 1994, the potato and grape fruit sectors had by far the highest ATI/hectare and in 1999 the potato sector a substantially higher ATI per hectare compared to the other sectors.

The chemical groups sold in the highest quantities in both years, apart from inorganic pesticides (such as sulphur and copper salts), were dithiocarbamates and organophosphates (Table 2). Apart from inorganic pesticides, the chemical groups that had the highest intensity of use (sales/hectare) in 1994 were chlorophenoxy pesticides (6.4 kg/hectare) and organochlorines (1.1 kg/hectare), and in 1999 were chlorophenoxy pesticides (1.7 kg/hectare) and dithiocarbamates (1.4 kg/hectare) in 1999 (Table 3).

Carbamates and OP's were the 2 chemical groups with the highest ATI and ATI/hectare by far both in 1994 & 1999 (Table 2 & Table 3). Other chemical groups were < 1000 ATI.

A total of 157 active ingredients were sold in the 5 sectors audited in 1994 and this increased by 23% to 193 in 1999. Apart from inorganic chemicals (for eg oil, sulphur and copper), the

fungicide mancozeb was sold the most by mass in both 1994 and 1999, increasing from 487 to 1381×10^3 kg in 1999 (Table 4). Ethylene dibromide (EDB) was sold the second highest by mass in 1994 and third highest in 1999 with the mass sold decreasing by 37%. The herbicide glyphosate was the 3rd highest pesticides sold by mass in 1994 and the 2nd highest in 1999 when the mass sold by weight increased by 300%.

Quintozone was the highest and 2nd highest active ingredient sold in kg/hectare in 1994 and 1999 respectively while thiodicarb was the highest in 1999 (Table 5). EDB was the next highest active ingredient sold in kg sales per hectare in 1994 & 1999.

The active ingredients sold the highest by mass (mancozeb, EDB and glyphosate) and mass per hectare were therefore similar in the two years (quintozone and EDB, amongst the 3 highest).

Aldicarb had by far the highest ATI both in 1994 & 1999 (Table 4). The pesticides with the next highest ATI were mostly OP insecticides including methamidophos, azinphos methyl & monocrotophos, terbufos, parathion and fenamiphos. Aldicarb also had by far the highest ATI/hectare in both years. Others with high ATI/hectare in the two years include phorate, oxamyl, cabofuran, disulfoton and thiodicarb.

Toxic pesticides not listed amongst the highest total and per hectare quantities and ATI sold in the two years include vinclozolin and dicamba.

Fungicides was by far the application that was sold the most by mass in SA during both 1994 and 1999 with sales doubling in 1999. Insecticides & herbicides were the next most highest application sold by mass ($700\text{--}1500 \times 10^3$ kg), with the former decreasing and the latter increasing in 1999. The sale of nematicides increased (more than 10 times) substantially during 1999.

Apart from oil and miscellaneous applications, fungicides and nematicides had the highest kg sales per hectare in both 1994 and 1999 (Table 6). Insecticides & nematocides had by far the highest ATI in both 1994 and 1999, with the former decreasing from 54 000 ATI to 27 000 ATI and the latter doubling to 29 000 ATI in 1999 (Table 6). In terms of ATI per hectare, nematicides was by far the highest in both years.

Discussion

In regard to the change in the usage of pesticides, the first result of note is the substantial increase in the total mass of pesticides sold in 1999. This is partly due to the increase in the amount of agricultural land used, but also due to an overall increase in the mass of pesticides applied per hectare (47%). The latter is probably due to the overall increase (23%) in the number of active ingredients applied in these crop sectors.

The grape fruit sector used the highest mass of pesticides in both years, but there was a change in the crop sector which had the highest intensity of pesticide use from 1994 in which the grape fruit sectors was far higher than the other sectors compared to 1999 when the grape and stone fruit sectors were the highest. It is interesting to note that although the total mass of pesticides sold in the grape fruit sector nearly doubled in 1999, that this was mainly due to an increase in the amount of agricultural land in this sector because the mass sold per hectare actually decreased by 30%. London and Myers (1995a & b) who audited 1989 pesticide sales in the southern part of South Africa (Eastern and Western Cape) found that 80% of the mass of pesticides sold in these sectors were sold to the grape fruit and pome fruit sectors in the region, but this is likely due to the predominance of these sectors in the region. London and Myers (1995a & b), did not calculate amounts sold per hectare.

In terms of changes in pesticide acute hazards, it is notable that despite the increase in the total mass of pesticides sold and the mass sold per hectare, as well as the increase in the number of active ingredients, that the total ATI decreased by 14% and the overall ATI per hectare by 19% implying shifts to pesticides of lower acute toxicity. The total ATI and ATI per hectare were similar in the two years. The potato sector was the largest contributor in terms of the total ATI in both years and 2nd highest and highest in 1994 and 1999 respectively, in terms of ATI per hectare. It is interesting that the ATI per hectare decreased substantially in the grape fruit sector in 1999 but increased in the stone fruit sector. In the study by London and Myers (1995a & b), the grape fruit sector contributed 41% of the total ATI in these sectors in the southern part of South Africa while the pome and potato sectors contributed about 25% each. The 2 chemical groups with the highest ATI by far both in 1994 & 1999 were also the same namely carbamates and OP's and the former also had the highest ATI/hectare both in 1994 and 1999. Insecticides & nematicides had by far the highest ATI in both 1994 and 1999 and the latter also had the highest ATI per hectare (London and Myers, 1995a & b).

It is a concern that the highly toxic carbamate insecticide, aldicarb, which is listed amongst the Pesticide Action Network (PAN) dirty dozen pesticides, was the active ingredient with the highest ATI and ATI per hectare in both years, although substantially reduced in 1999 (PAN, 2008). EDB was another of the dirty dozen pesticides and also listed in the Rotterdam Convention which featured prominently amongst the largest quantities sold and those with the highest ATI (PIC Secretariat, 1999). There were in total 7 (aldicarb, chlordane, EDB, lindane, paraquat, parathion, methyl parathion) out 18 of the PAN dirty dozen pesticides sold during both 1994 and 1999 (PAN, 2008).

The pesticides endosulfan and chlorpyrifos, which were amongst the highest quantities active ingredients and ATI sold in total and per hectare in 1994 and 1999, have been detected frequently in rural environmental water systems and in rural residents in South Africa and have been associated with developmental and neurotoxic effects in humans (Davies, 1997; Den Hond, 2006; Schulz, 2001; Bouwman et al, 2006; Dalvie et al., 2003; Perera et al., 2005; Dalvie and London, 2006). Endosulfan is also listed in the Rotterdam Convention (PIC Secretariat, 1999).

Additionally amongst those sold in both 1994 and 1999, were pesticides such as lindane which has not been registered in SA since 1979; parathion that is registered only for certain uses since 1993; chlordane, DNOC and monocrotophos that were banned after 2001, dicamba and MCPA that was prohibited in another province (Natal) in 1991 (National Department of Agriculture, 2008). Paraquat, amongst the highest quantities of active ingredients and ATI sold in total and per hectare in 1999, has been found to be associated with long-term respiratory defects amongst Western Cape farm workers (Dalvie et al, 1999). The organochlorine fungicide, vinclozolin, for which there is a concern in many countries about its persistence in the environment and reproductive toxicity in humans, was still used in South Africa in 1999 (Younglai et al., 2007). All of the above-mentioned pesticides which are on the PAN UK dirty dozen list, detected in the environment in SA, banned or restricted in SA, paraquat and vinclozolin were amongst obsolete pesticides (includes expired stocks of currently registered pesticides) found in studies conducted in Stellenbosch in 1995 and 2003 (Dalvie and London, 2001; Dalvie et al., 2006).

ATI may have important drawbacks in that they rely on the same assumptions underlying LD₅₀. They measure acute toxicity and do not take into account long-term health effects, synergism of multiple chemicals or the effect of contaminants.

Conclusions

The results show a substantial increase in the total volume (62%) of pesticides used in 1999 compared to 1994 in the 5 South African agricultural crop sectors studied. This is partly due to an increase (14%) in the intensity of pesticides sold probably resulting from the increase (23%) in the number of active ingredients. Otherwise there was not much difference in the two years with respect to the volume and intensity of pesticides used as the number of chemical groups, active ingredients sold in the highest quantities and highest quantities per hectare were similar. The grape fruit sector was the predominant sector in terms of the volume and intensity of pesticides used in 1994 while the grape fruit sector was the predominant sector in 1999 in terms of the volume used and the grape and stone fruit the highest in terms of intensity of pesticides used. Fungicides were by far the application that was used the most by volume in SA during both 1994 and 1999.

The total acute population hazard and the overall intensity of acute hazard of the pesticides used decreased in 1999, but not substantially. Also, some of the most highly toxic pesticides, those de-registered, restricted or subsequently banned, those found amongst unwanted stocks and those that have been detected in the environment and in rural residents in SA were still used in 1999. The potato sector used pesticides with the highest ATI both in 1994 and 1999 and was the 2nd highest and highest of the crop sectors in 1994 and 1999 respectively in terms of ATI/hectare.

The increase in the volume and intensity of pesticides used has resulted in most of the acute population hazard and acute hazard intensity posed by pesticides to remain in the SA agricultural crop sector and this highlights a need to develop alternative agricultural and non-chemical pest control methods that reduce usage of pesticides. Alternative pest control methods such as Integrated pest management (IPM), the use of natural predators, the use of trap crops which attract the insects away from the fields and organic farming are important examples of approaches that lessen dependence on chemical control of pests but has yet to find widespread application in South African agriculture outside of certain sectors. Legislation should also be used to control irresponsible marketing strategies by pesticide manufacturers that promote inappropriate purchasing, and to provide education and training to farmers and farm workers

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Table 1
1994 and 1999 crop sector agricultural sales in South Africa

Crop Sector	1994				1999					
	Mass active ingredient (kg *10 ³)	Hectares (*10 ³)	Mass active Ingredient (kg/hectare)	ATI	ATI/hectare	Mass active ingredient (kg *10 ³)	Hectares *10 ³	Mass active Ingredient kg/hectare	ATI	ATI/hectare)
Grapes	1638.8 (39%)	133.2	12.3	13119.9 (19%)	98.5	3219.7 (47%)	369.9	8.7	19239 (32%)	52.0
Pome	613.9 (15%)	188.0	3.3	5743.6 (8%)	30.1	950.7 (14%)	163.7	5.8	5374 (9%)	32.8
Stone	427.63 (10%)	118.9	3.7	2286.4 (3%)	19.2	670.6 (10%)	72.2	9.3	2913 (5%)	40.5
Potato	873.27(21%)	427.2	2.0	36925.0 (54%)	86.4	1340.6 (20%)	308.7	4.3	25166 (41%)	81.5
Wheat	640.61(15%)	460.4	1.4	10299.8(15%)	22.4	629.9 (9%)	523.3	1.2	7743 (13%)	14.8
Total	4194.21	1327.7	3.2	70254.0	51.5	6811.5	1437.6	4.7	60435.2	42.0

Table 2
Highest pesticide chemical groups sold by mass and by ATI in 1994 and 1999

Chemical group	Mass of chemical groups sold ($\times 10^3$ kg)		Chemical groups sold in ATI	
	1994	1999	1994	1999
Sulphur	982.18	1784.8	Carbamates	38044.2
Dithiocarbamates	703.05	1532.4	Organophosphates	26752.0
Organophosphates	652.59	624.8	Chlorophenoxy	475.3
Copper salts	298.32	516.7	Sulphur	327.4
Chlorophenoxy	225.49	267.0	Copper salts	237.2
Carbamates	82.95	125.0	Dithiocarbamates	213.3
				26995.4
				28562.6
				531.2
				594.9
				360.2
				338.4

Table 3
Highest pesticide chemical groups sold per hectare by mass and by ATI in 1994 and 1999

Chemical group	Chemical group sold in kg/hectare		Chemical group	Chemical group sold in ATI/hectare	
	1994	1999		1994	1999
Chlorphenoxy	6.4	1.7	Carbamates	446.3	275.9
Copper salts	4.9	4.9	Organophosphates	25.4	40.2
Organochlorines	1.1	0.8	Chlorphenoxy	13.6	3.4
Carbamates	0.97	0.01	Organochlorines	4.7	4.5
Organophosphates	0.6	0.87	Copper salts	3.9	3.4
Dithiocarbamates	0.6	1.38	Dithiocarbamates	0.17	0.3

Table 4
Highest pesticide active ingredient sold by mass and by ATI in 1994 and 1999

Active ingredient	Weight active ingredient ($\times 10^3$ kg)		Active ingredient	Active ingredient in ATI	
	1994	1999		1994	1999
Sulphur	982.2	1784.8	Aldicarb	36462.4	24929.9
Mancozeb	487.1	1381.0	Azinphos-methyl	6034.4	5244.9
Copper oxychloride	266.3	465.7	Monocrotophos	4927.1	3121.9
Ethylene dibromide	210.9	132.0	Methamidophos	3684.0	3781.5
Glyphosate	210.7	635.8	Parathion	3646.3	2132.8
Methamidophos	110.5	113.5	Terbufos	3500.0	7029.5
Simazine	106.6	59.3	Fenamiphos	2214.7	3250.9
Chlorpyrifos	97.6	83.7	Carbofuran	960.0	556.1
Azinphos-methyl	96.6	83.9	Ethylene dibromide	732.1	458.2
MCPA	96.5	142.8	Chlorpyrifos	723.0	620.1
Chlorothalonil	95.5	61.5	Demeton-s-methyl	514.5	282.3
EPTC	86.5	36.4	Dimethoate	473.3	315.7
2,4-D-Amine	74.1	68.2	Bromoxynil	380.1	537.8
Protein hydrosylate	73.6	19.5	Disulfoton	365.4	71.2
Bromoxynil	72.2	102.2	Sulphur	327.4	594.9
Dimethoate	71.9	47.4	Oxamyl	316.7	363.8
Monocrotophos	69.0	43.7	Paraquat	264.9	591.5
Metiram	64.8	18.0	Dichlorvos	219.5	227.0
Thiram	57.5	78.2	Endosulfan	203.3	410.0
Calcium polysulfide	56.5	0.0	2,4-D-Amine	197.6	181.8
Glyphosate-trimesium	51.7	0	Copperoxychloride	184.9	373.4
Parathion	47.4	85.3	Methomyl	140.0	737.2
Paraquat	39.7	88.7	MCPA	137.9	203.9
Aldicarb	33.9	49.7	Calcium polysulfide	125.6	0
Fenamiphos	33.2	48.7	Thiram	92.7	139.7
Demeton-s-methyl	20.6	11.3	Glyphosate-trimesium	69.1	0
Endosulfan	16.3	32.8	Mancozeb	60.9	172.6
Dichlorvos	12.3	12.7	EPTC	52.4	22.0

Active ingredient	Weight active ingredient (× 10 ³ kg)		Active ingredient in ATI	
	1994	1999	1994	1999
Carbofuron	7.7	4.5	Glyphosate	37.6
Terbufos	7	14.1	Simazine	21.3
Methomyl	2.4	12.5	Chlorothalonil	9.5
Oxamyl	1.9	2.1	Metiram	6.5
Disulfoton	0.95	0.19	Mevinphos	0.0
Mevinphos	0	4.8	Parathion-methyl	0.0
Parathion-methyl	0	10.8	Terbufylazine	0
Terbufylazine	0.0	105.3	Protein hydrosylate	0
				0

Table 5
Highest pesticide active ingredient sold by kg/hectare and ATI/hectare in 1994 and 1999

Active ingredient	Mass active ingredient/hectare (kg/hectare)		Active ingredient	Active ingredient in ATI/hectare	
	1994	1999		1994	1999
Mineral oil	56.3	17.1	Aldicarb	5036.2	2350.1
Quintozone	29.9	30.0	Phorate	1000.0	1055.6
Ethylene dibromide	18.6	21.9	Oxamyl	494..8	239.1
Calcium polysulfide	15.0	0.0	Carbofuran	312.7	312.4
Sulphur	12.8	5.8	Disulfoton	274.7	273.7
Aldicarb	4.7	4.7	Terbufos	175.1	205.9
Lime sulphur	4.6	12.1	Fenamiphos	129.1	100.4
Copper oxychloride	4.2	4.5	Ethylene dibromide	74.7	76.1
Trifluralin	3.9	3.9	Methidathion	42.5	58.3
Oxamyl	3.0	1.4	Methiocarb	40.0	34.0
EPTC	2.9	2.8	Methomyl	31.8	31.8
Carbofuran	2.5	2.5	Azinphos-methyl	27.4	27.6
Metiram	2.4	2.8	Calcium polysulfide	33.3	0.0
Copper hydroxide	2.2	4.5	Parathion	25.0	25.0
Oryzalin	2.0	1.2	Monocrotophos	17.6	17.3
Dichloran	2.0	3.0	Endosulfan	15.5	22.9
Phorate	2.0	0.1	Vamidothion	15.2	13.2
Chlordane	1.9	2.0	Sulphur	4.3	1.6
Fenamiphos	1.9	1.5	Chlordane	4.2	4.2
Alachlor	1.9	1.5	Copperoxychloride	3.0	3.1
Vamidothion	1.3	1.4	Quintozone	3.0	3.0
Endosulfan	1.2	1.8	Copper hydroxide	2.2	1.8
Methidathion	1.1	1.5	Alachlor	2.1	1.7
Methiocarb	0.8	0.7	EPTC	1.74	1.7
Disulfoton	0.7	0.7	Trifluralin	0.6	0.4
Methomyl	0.5	0.5	Dichloropropene	0.5	25.6
Terbufos	0.4	0.4	Dichloran	0.5	0.75
Azinphos-methyl	0.4	0.4	Metiram	0.24	0.28

Active ingredient	Mass active ingredient/hectare (kg/hectare)		Active ingredient in ATL/hectare	
	1994	1999	1994	1999
Parathion	0.32	0.3	Oryzalin	0.2
Monocrotophos	0.25	3.1	Mevinphos	0.0
Cadusafos	0	4.3	Thiodicarb	0.0
Thiazopyr	0	0.6	Thiazopyr	0.0
Formetanate	0	1.1	Cadusafos	0.0
Mevinphos	0	0.1	Formetanate	0.0
Thiodicarb	0.0	31.0	Mineral oil	0
Polysulfide-sulphur	0.0	15.6	Lime sulphur	0
Dichloropropene	0.0	15.1	Polysulfide-sulphur	0

Table 6

Pesticide applications sold during 1994 and 1999 in South Africa

Application	1994				1999					
	Number of active ingredients	Mass active ingredient ($\times 10^3$ kg)	Mass active ingredient per hectare (kg/hectare)	ATI	ATI per hectare	Number of active ingredients	Mass active ingredient ($\times 10^3$ kg)	Mass active ingredient per hectare (kg/hectare)	ATI	ATI per hectare
Fungicides	53	2078.8	6.3	886.8	2.5	68	4184	4.3	1390.0	1.4
Insecticides	58	1038.9	0.8	53957.6	40.9	65	699.1	0.7	27129.7	29.6
Herbicides	42	904.5	2.1	1542.1	3.5	46	1461.5	2.6	2340.0	4.2
Oil	2	85.6	5.9	12.1	0.8	1	89.1	14.6	0.0	0.0
Seed-dressing	10	75.6	2.5	64.0	2.1	10	56.5	0.2	34.2	0.1
Nematicides	2	24.6	4.9	11945.9	2398.8	6	285.1	8.1	29100.0	826.7
Miscellaneous	3	0.5	2.1	9.5	37.9	4	32.7	43.0	389.0	511.8