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Assessment of Pesticide Use on Farms in Al-Batinah, Oman

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تقييم إستخدامات المبيدات الحشرية في مزارع بمنطقة الباطنة بسلطنة عمان

جوناثان. ثاكر و قليلة امبوسعيد و مسعود العزري و رولا الفهدي و خالد الهاشمي و راشد الجابري و سالم المخمري و عيسى المنذري و أحمد الشيدي و راشد الشيدي

خلاصة: تم إجراء مسح مبدئي لإستخدام المبيدات في المزارع بشمال عمان ليشمل تسعة عشر مزرعة مساحتها ١٠٠ هكتاراً. كانت كل المزارع التي تم مسحها تزرع الحبوب و الفاكهة و الخضروات و الأشجار. أوضحت النتائج أن مشاكل الإصابة الحشرية تفوق المشاكل المرضية و مشاكل الحشائش القناده. يفضل المزارعون إستخدام المبيدات عن سواها. وقد أوضح المسح أن هناك مزرعة و احدة من المزارع التي تم مسحها لم تستخدم المبيدات لمكافحة الحشرات. إستخدمت المبيدات في ٩٥% من المزارع التي شملها المسح، ٦٠% منها إستخدمت المبيدات الفطرية و ٢٠% استخدمت مبيدات الحشرات. أستخدمت مزرعة واحدة من هذه المزارع تركيبة مبيد بأكتري لمكافحة الحشرات. أتضح أن جميع المزارع تستخدم رشاشات المبيد ذات الضغط الهايدروليكي العالي، وقد لوحظ أن عمال رش المبيدات لا يستخدمون سوى أبسط مقومات السلامة. ويناقش هذا البحث النتائج التي في مجملها لا تختلف عن النسق الذي يسود في دول العالم المتطوره و علاقتها بالتطور الزراعي في سلطنة عمان.

ABSTRACT: A preliminary survey of pesticide use on farms in Northern Oman was carried out. Nineteen farms covering a total area of 100 hectares were surveyed. All of the farms surveyed were under a mixture of cereal, fruit, vegetable and tree crops. The results of the survey showed that pest problems dominated over those associated with pathogenic organisms or weeds. The favored method for pest control on farms was a pesticide application. Only one of the nineteen farms surveyed did not use pesticides to control their pest problems. Insecticides were used on 95% of the farms surveyed, fungicides on 60%, and herbicides on 20%. One of the farms surveyed used a biorational bacterial pesticide formulation to control crop pests. All farms used high pressure hydraulic equipment to apply pesticides. Workers employed to apply pesticides used only rudimentary safety equipment. The results, which are consistent with global patterns of pesticide use in developing countries, are discussed in relation to agricultural development in Oman.

Keywords: pesticide use, assessment, Oman, cereals, fruits.

Since 1970, changes in agricultural production in Oman have been dramatic. For all categories of food, production has just about doubled. Over a 30 year time period Oman has transformed itself from what was essentially a subsistence economy to one in which food exports are now able to contribute to the economic well-being of the country. For example, in 1994 fruit and vegetable exports were calculated to be worth *ca.*11.5 million OR (Omezzine *et al.*, 1998).

Increases in agricultural production in Oman have been achieved as a result of both economic and technical factors (Omezzine, 1997). Production increases have occurred not just as a result of an increase in the land that is cultivated, but also because of an increase in farming intensity. For example, in 1980 *ca.* 2,718 hectares of land were sown with cereals producing a yield of 2,459 metric tons, whereas in 1998 *ca.* 2,600 hectares yielded 5,650 metric tons. These figures

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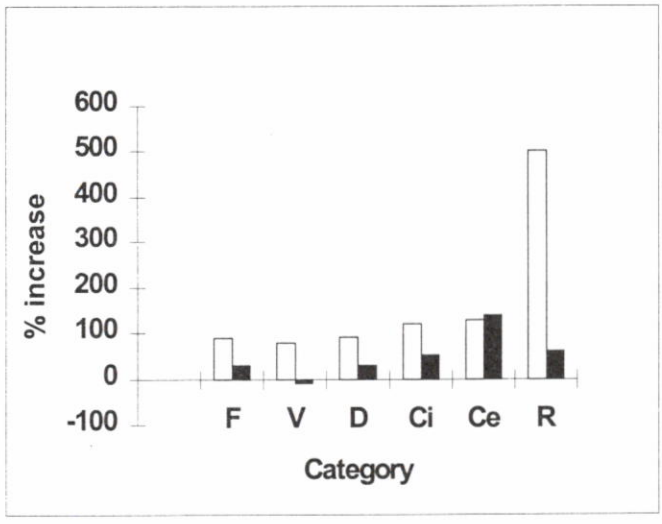

Figure 1. Percentage increase in Oman's crop production (open bars) and yields (closed bars) between 1980-2000. F = fruit, V = vegetables, D= dates, Ci = citrus, Ce = cereals, R = root crops.

thereby represent both a doubling in absolute production and yield (Figure 1; FAO Statistical Database).

Changes in farming intensity, as has occurred in Oman, are generally distinguished by a number of factors. These include (1) an increase in mechanization, (2) an increase in the use of agrochemicals, and (3) an increase in the use of high-yield crop varieties and the development of associated plant breeding programmes (Tivy, 1991). In this paper we are primarily concerned with the second of these factors, an increase in the use of agrochemicals. In particular, we are concerned with the increase in pesticide use that has occurred in Oman. Since 1960 the national value of pesticide imports has increased more than 10-fold (FAO Statistical Database) and for many farmers, pesticides are now essential tools in the production process. While the use of pesticides is typical of high intensity farming operations these chemicals are not without their problems. For example, it is well known that pesticides can have adverse effects on humans and on the environment in general (Pimental *et al.*, 1980; Edwards, 1987). Pesticides may also cause problems associated with resistance and resurgence in the target pest population itself (Dover and Croft, 1986; Roush and McKenzie, 1987).

The aims of the present paper were fourfold. First to find out which pesticides were in use on farms in Northern Oman. Second, to determine how these pesticides were applied to crops. Third, to investigate what, if any, safety procedures were adhered to concerning the mixing and application of pesticides. Finally, we also attempted to discover which pests, pathogens, and weeds presented the largest constraint to increasing agricultural production in the Sultanate. To address our aims we followed a survey approach.

Materials and Methods

Nineteen farms in Northern Oman were selected for the survey. The farms were located in Al-Khaburah, Barka, Nizwa, Rustaq, Saham, and Sohar. The criteria for farm selection were that (1) the farm was a small, family run operation and (2) that the farm was under a diversity of crops. These criteria excluded large scale and specialist commercial farms. All of the farms selected were sown with a mixture of fruit, vegetables, and field crops. Most of the farms also had tree crops in the form of date palm and/or citrus. At each farm, detailed information was collected for the following categories: (1) *crops* - the diversity of crops, the area given to each crop, the total size of the farm; (2) *pests* - the range of pest, pathogen and weed problems found on the farm; (3) *pest control* - the measures used for pest control, including the names of specific products; (4) *pesticide application* - equipment used to apply pesticides, frequency with which products were applied; and (5) *safety* - equipment used in relation to pesticide handling, mixing, storage and disposal. Collected data were then pooled for analysis. The results provide summary data for the categories of information described above.

Results

Summary statistics for the 19 farms that were surveyed are given in Table 1. The average farm was 5.46 hectares in size, was sown with *ca.* 6 different crops, and was treated with *ca.* 5 different pesticides. The large standard errors shown in the summary statistics indicate that there was a great deal of heterogeneity in the data. Overall, just over 100 hectares of farmland was surveyed.

The range of crops grown on the farms surveyed is shown in Table 2. Crops which dominated on the farms were date palm, alfalfa, chilli, tomato lime, mango, okra, eggplant and cucumber. Overall, 31 different crops were grown on the farms. Table 3 presents a ranking of the crops that were found to be most widely grown in our survey in comparison to a ranking of the crops most widely grown in the whole country. The table shows that five of the top 10 survey crops appear in the country top 10.

TABLE 1

Summary statistics concerning farms surveyed.

Parameter	Count	Mean	Standard Deviation
Farm size (ha)	17	5.46	5.00
No. of crops grown	19	6.10	3.70
No. of pesticides applied	19	4.80	4.02

TABLE 2

Summary of crops grown on nineteen farms surveyed at Al-Khaburah, Barka, Nizwa, Rustaq, Saham and Sohar in the Al-Batinah region of the Sultanate of Oman.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Sum	%
Alfalfa			✓	✓	✓	✓	✓	✓	✓		✓									9	47
Banana	✓				✓															2	11
Barley	✓	✓									✓									3	16
Beans		✓			✓				✓							✓				4	21
Cabbage	✓														✓					2	11
Chilli	✓		✓		✓		✓	✓		✓				✓	✓	✓				9	47
Cowpea		✓			✓				✓					✓						4	21
Cucumber		✓	✓	✓								✓	✓							5	26
Date	✓	✓	✓		✓	✓	✓	✓		✓	✓	✓							✓	11	58
Eggplant								✓	✓	✓			✓		✓					5	26
Garlic	✓						✓	✓												3	16
Grapes			✓																	1	5
Grass						✓														1	5
Lettuce	✓																			1	5
Lime	✓	✓	✓	✓		✓													✓	6	32
Maize	✓	✓					✓	✓												4	21
Mango	✓		✓		✓	✓					✓									5	26
Okra		✓		✓	✓				✓							✓				5	26
Onion	✓			✓			✓													3	16
Orange						✓														1	5
Papaya	✓									✓										2	11
Potato		✓		✓																2	11
Radish	✓	✓																		2	11
Sorghum			✓																	1	5
Squash		✓	✓	✓								✓								4	21
Sugar Cane								✓												1	5
Sweet Melon						✓											✓	✓		3	16
Sweet Pepper	✓													✓						2	11
Tomato		✓	✓	✓		✓	✓			✓		✓	✓							8	42
Water Melon																	✓	✓		2	11
Wheat		✓																		1	5
Rank Sum	15	13	10	8	8	8	7	7	5	5	4	4	3	3	3	3	2	2	2		
Farm No. in Fig. 2	1	18	19	17	13	12	9	8	7	10	16	11	14	10	5	4	6	3	2		

TABLE 3

Crops most commonly grown on survey farms and crops most commonly grown in Oman (data abstracted from FAO statistical database at http:/www.fao.apps).

Top 10 Survey Crops	Top 10 Crops in Oman (1998)		
	Crop	Area (ha)	Production
Date	Date	30,000	135,000
Alfalfa	Alfalfa	20,000	580,000
Chili	Mango	4,500	12,000
Tomato	Lime	3,00	31,000
Lime	Banana	2,000	28,000
Mango	Watermelon	1,600	32,000
Okra	Tomato	1,500	34,000
Cucumber	Sorghum	950	2,850
Eggplant	Onion	700	9,400
Cowpea	Wheat	600	1,400

The number of different pesticides that were used on farms is depicted in Figure 2. The intensity of product usage varied from 2 to 17 chemicals per farm. There was no correlation between the intensity of pesticide use and either farm size or crop diversity. Figure 2 shows that all of farms that used pesticides applied insecticides. Figure 3 illustrates these data by pesticide category. Almost all farms utilized insecticides (95%) while *ca.* 60% and 20% applied fungicides and herbicides, respectively. Herbicides were only used on farms that exhibited high intensity of pesticide use (Figure 2).

Figure 4 and Table 4 reveal the pattern of insecticide use recorded by insecticide category and by active ingredient. Organophosphate insecticides were the most widely employed compounds, with 12 different active ingredients recorded in use in 1999. Of the active ingredients used, malathion and dimethoate were by far the most popular. Although the level of overall

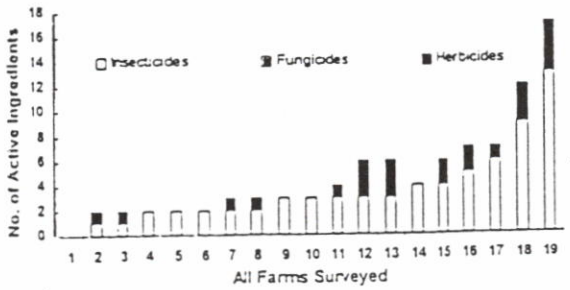

Figure 2. Intensity of pesticide use on nineteen farms in Al-Khaburah, Barka, Nizwa, Rustaq, Saham, and Sohar in Northern Oman.

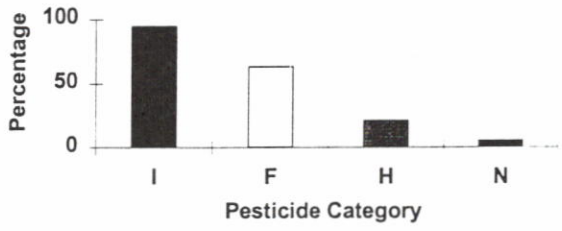

Figure 3. Percentage of farms in the present study using pesticides, by category. I = insecticides, F = fungicides, H = herbicides, N = no pesticide usage.

pyrethroid use on farms was approximately half that of the organophosphates one active ingredient, cypermethrin, appeared to be utilized fairly extensively. Only one organochloride compound was recorded as being widespread.

Figure 5 and Table 5 show the patterns of fungicide and herbicide use recorded by category and by active ingredient. For both categories a relatively small number of compounds were in use. With fungicides there was an approximately even split between protectant and systemic compounds although this data was skewed by considering two copper-based compounds as separate active ingredients. The herbicides that were used were mostly systemic products. Herbicide application in general however, was fairly restricted on the farms surveyed, *i.e.* most farmers did not use herbicides.

Table 6 gives summary data for various pesticide combinations that farmers were exploiting. Most of the combinations represented insecticidal mixtures. One mixture in particular, endosulfan + dimethoate, was widespread on surveyed farms.

All of the farms that did apply insecticides (95% of survey) used hydraulic application equipment. This equipment usually consisted of a high volume system in which a small engine was used to generate the pressure that could be used to force liquid along a long hose fitted with a hydraulic nozzle. Some farmers also used hand-held compression sprayers to apply pesticides. All of the farmers used pesticides at dilution rates of 100 - 200 ml pesticide / 100 - 200 L water. None of the farmers surveyed was sure of their actual volume application rates.

The use of safety equipment on all farms was rudimentary. A small proportion of the farmers (20%)

TABLE 4

Insecticides recorded as being in use in Oman in 1999.

Active Ingredient	Principal Trade Name	Class	% of Farms
Malathion	Malathate	Organophosphate	32
Dimethoate	Dimethate	"	21
Chlorpyrifos	Dursban	"	16
Phosalone	Zolone	"	11
Cadusafos	Rugby	"	5
Diazinon	Diazate	"	5
Dichlorvos	Nogos	"	5
Ethoprophos	Mocap	"	5
Methidathion	Supracide	"	5
Phenthoate	Cidial, Elsan	"	5
Tetradifon	Tedion	"	5
Triazophos	Hostathion	"	5
Cypermethrin	Cyperate	Pyrethoid	32
Bifenthrin	Talstar	"	11
Fenvalerate	Sumicidin	"	11
Permethrin	Kafil	"	11
Alpha-Cypermethrin	Fastac	"	5
Deltamethrin	Decis	"	5
Carbosulfan	Marshall	Carbamate	16
Carbaryl	Sevin	"	5
Thiodicarb	Larvin	"	5
Endosulfan	Thiodan	Organochlorine	21

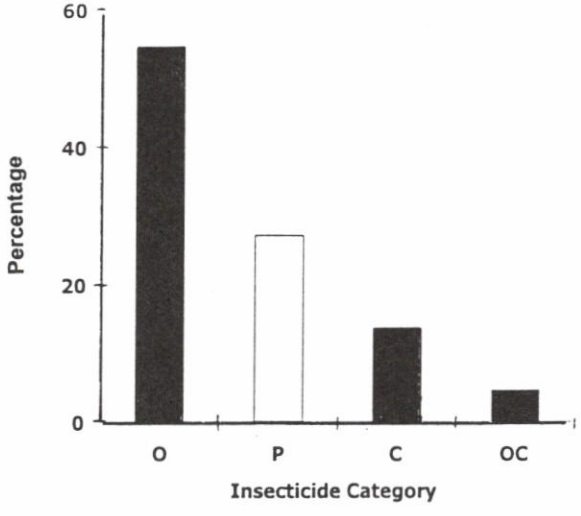

Figure 4. Percentage of farms in the present survey using insecticides, by category. O = organophosphate, P = pyrethroids, C = carbamates, OC = organochlorines.

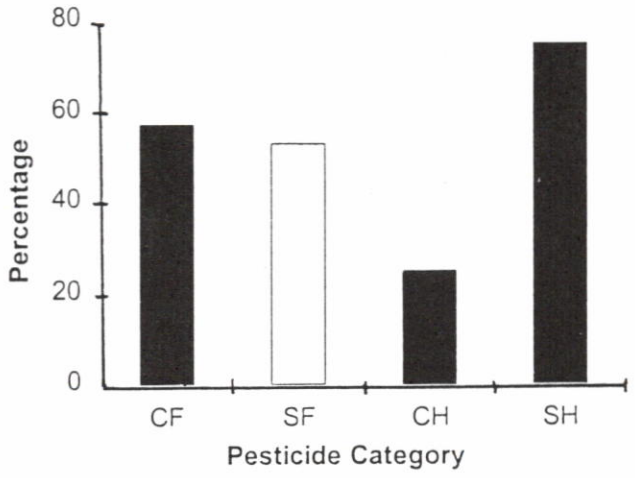

Figure 5. Percentage of farms in the present survey using fungicides and herbicides, by category. CF = contact fungicide, SF = systemic fungicide, CH = contact herbicide, SH = systemic herbicide.

used gloves to mix their pesticides however, none used either masks or designated overalls during spraying. Pesticide containers were not disposed of in an organized fashion and could usually be found lying discarded around the farm.

Pests, pathogens and weeds targeted by farmers for control with pesticides were an amorphous group. Where pesticides were used for insect pest control, farmers spoke in general terms about aphids, thrips, bugs, leafminers, grasshoppers, scale insects and mites. With fungicides the most commonly mentioned problems were blight, downy mildew, leafspot and rust. Pesticide use followed this general identification of problems. Most of the farmers surveyed would routinely spray all of the crops on their farm once the pesticide was diluted, *i.e.* spraying would not necessarily be targeted towards the crop with the perceived problem. As a result, it was not possible to analyze the data in terms of pesticide use per crop or pest problem.

TABLE 5

Fungicides and herbicides recorded as being in use in Oman in 1999.

Active Ingredient	Principal Trade Name	Mode of Action	% of Farms[1]
Fungicides			
Carbendazim	Trimiltox	Systemic	11
Mancozeb	Dithane	Protectant	26
Metalaxyl	Ridomil	Systemic	11
Oxadixyl	Sandofan	Systemic	11
Copper-Based			
Oxine Copper	Quinondo	Protectant	16
Cu Oxychloride	Cuprosan	Protectant	16
Herbicides			
Ethofumesate	Kemiron	Systemic	5
Glyphosate	Hercampo	Systemic	11
Linuron	Afalon	Systemic	5
Oxadiazon	Ronstar	Contact	11

[1]With the exception of the fungicide mancozeb the use of fungicides and herbicides was limited to 1 or 2 of the nineteen farms surveyed.

TABLE 6

Pesticidal mixtures recorded as being in use in Oman in 1999.

Active Ingredient	Principal Trade Name	% of Farms
Endosulfan + Dimethoate	Aflix	26
Chlorpyrifos + Dimethoate	Dimeclor	11
Cypermethrin + Chlorpyrifos	Nurelle	5
Cypermethrin + Fenitrothion	Dalla	5
Endosulfan + Fenvalerate	n/a	5
Mancozeb + Fenvalerate[1]	n/a	5
Chlorpyrifos + Methomyl	Smash	5
Propargite + Tetradifon[2]	Omite	5

All the above are mixtures of two insecticides except:
[1]Mixture of a fungicide with an insecticide.
[2]Mixture of two acaricides.
n/a = information not available

Discussion

The data presented herein outline some general trends concerning pesticide use on farms in Northern Oman. Firstly, the data show that the average farmer is highly likely to use insecticides, has about a 50/50 chance of using fungicides but is unlikely to use herbicides. These data are consistent with those for pesticide use in a developing country with a sub-tropical climate and a nascent agricultural industry (Yudelman *et al.*, 1998). Second, the data show that pesticide applications, particularly in relation to personal safety and to volume application rate, are fairly haphazard. These are areas for concern. It is well known that pesticide side-effects may be exacerbated by pesticide misuse. The majority of human problems associated with pesticides also occur as a result of pesticide misuse. At a minimum, more information needs to be given to farmers concerning the safe use of pesticides.

Finally, pest and pathogen identification keys need to be devised for farmers to use. The current system of blanket pesticide sprays on farms is very likely to lead to the development of pest species resistance to agrochemicals. Pesticides should be applied more selectively in order to protect beneficial predatory invertebrates on farmland. Pesticide applications should also be restricted to occasions when it is economically justified, *i.e.* economic thresholds need to be developed for pest and pathogen control on farms in Oman.

The data presented here provide a detailed look at pesticide use on farms in Northern Oman. Although the

farms that were surveyed were representative of the majority of farms in Oman only 100 hectares were surveyed. The data therefore, are only preliminary in nature. It is known that there are *ca.* 70,000 hectares of land under agricultural production in the Sultanate. Nevertheless, despite the limited size of the survey, some clear trends emerged. Future research should indicate whether or not these trends exist throughout farms in Northern Oman. If so, then the present study points to areas in which the government may be more proactive in regulating pesticide use. For example, the data suggest that farmers need more education in pesticide handling, particularly in relation to volume application rates. The data also indicate a need for more effective legislation associated with pesticide use, storage, and disposal. In particular, further measures and training are required relating to pesticide safety. In other countries where such legislation has been introduced, *i.e.* Europe and North America, there has been a sharp decline in the number of problems associated with pesticides, particularly operator exposure and consumer exposure to residues in food. In the long term, the regulation of pesticides can only be of benefit. Indeed, the FAO have already produced an International Code of Conduct on the distribution and use of pesticides (FAO, 1986). This code suggests remedies for many of the areas of concern that are discussed in this paper. In Oman itself, a booklet on the safe use of pesticides was produced in 1989 (Al-Mjeni and Mukhtar, 1989). However, the message contained therein has not been taken up by the small farm sector. In conclusion, the data presented in this survey highlight areas which may be of interest, both for current and future policy makers in the Sultanate.

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