E D M O N T O N P U B L I C S C H O O L S

May 10, 2011

TO: Board of Trustees

FROM: E. Schmidt, Superintendent of Schools

SUBJECT: Presentation - Canadian Cancer Society

ORIGINATOR: T. Taylor, Director, Executive and Board Relations

RESOURCE STAFF: Anne Sherwood

INFORMATION

Ms Sarah Hawkins, Community Engagement Coordinator Canadian Cancer Society, and a member of the Pesticide Free Edmonton Coalition has requested an opportunity to appear before the Board of Trustees to present information on the health effects of pesticides as it relates to school properties.

In accordance with Board Policy JAB.BP - Comments, Delegations and Presentations at Board Meetings by Public and Staff Representatives (Appendix I), arrangements have been made for Ms Hawkins to make her presentation at the May 10, 2011 board meeting at 7:45 p.m.

Ms Hawkins has provided the following documents with respect to her presentation:

- a backgrounder on the issue of non-essential pesticide use (Attachment #1)
- a systematic review of research on the link between pesticides and cancer (Attachment #2)
- a systematic review of research on the link between pesticides and non-cancer health effects (Attachment #3)
- a cost comparison of maintaining sports fields organically (Attachment #4)

AS:mmf

Appendix I	-	Board Policy JAB.BP - Comments, Delegations and Presentations at Board Meetings by Public and Staff Representatives
Attachment #1	-	Backgrounder on the Issue of Non-Essential Pesticide Use
Attachment #2	-	A Systematic Review of Research on the Link Between Pesticides and Cancer
Attachment #3	-	A Systematic Review of Research on the Link Between Pesticides and Non-Cancer Health Effects
Attachment #4	-	Cost Comparison of Maintaining Sports Fields Organically

Edmonton Public Schools
Board Policies and Regulations

CODE:	JAB.BP	EFFECTIVE DATE:	24-11-2009
TOPIC:	Comments, Delegations and Presentations at Board Meetings by Public and Staff Representatives	ISSUE DATE:	25-11-2009
		REVIEW DATE:	11-2014

GENERAL

The Board values the views of all stakeholders on educational issues and seeks to provide opportunities to hear from the public in a variety of ways.

The intent of this policy is to clarify the Board's procedures for its official board meetings with respect to members of the public and staff group representatives providing general comments to the Board on an educational issue or on specific board meeting agenda items and making formal presentations to the Board.

In accordance with the *School Act*, the Board of Trustees as the Corporate Board of Edmonton School District No. 7 holds its official business meetings in public. Board meeting agendas are posted to the District website www.epsb.ca. No person shall be excluded from the meeting except for improper conduct. Attacks on the personal character or performance of any individual or disruptive remarks shall be ruled out of order and persistence in such remarks shall cause the individual to be excluded from the meeting room.

A. GENERAL COMMENTS ON AN EDUCATIONAL ISSUE AT A BOARD MEETING

1. A member of the public or a staff group representative may address the Board on any educational issue.

2. A member of the public or a staff group representative may speak for three minutes at a public Board meeting under the agenda category *Comments from the Public and Staff Group Representatives*. The total duration of the *Comments from the Public and Staff Group Representatives* section of the agenda shall not exceed 20 minutes. Exceptions to the time limits may be made by a majority vote of the Board.

3. Speakers shall address their comments to the Board Chair.

4. The Board Chair will thank the speaker.

B. COMMENTS ON SPECIFIC BOARD AGENDA ITEMS

1. If a member of the public or a staff group representative wishes to give a position to Board on a specific board agenda item, the individual shall register with the Board Secretary by noon the day of the meeting.

2. The Board Chair will, at the time the item is considered, seek concurrence of the Board to hear the individual.

3. Speakers shall confine themselves to three minutes and address their comments to the Board Chair.

4. The total duration of public comment on a specific agenda item shall not exceed 20 minutes per agenda item. Exceptions to the time limits may be made by a majority vote of the Board.

5. The Board Chair will thank the speaker.

C. FORMAL DELEGATIONS AND PRESENTATIONS TO BOARD

1. The Board Secretary shall advise the delegation on the procedures for submitting a brief and/or making a verbal presentation and assist the delegation in making their request.

2. Groups or individuals who wish to appear before the Board to make a presentation to or a request of the Board shall first discuss the request with the Superintendent of Schools or a designate. This provides the presenter an opportunity to clarify his/her understanding of district practices related to the presentation topic and determine what other assistance may be available through the Administration.

3. If after meeting with the Administration, an appearance before the Board is still desired, the delegation must make their request in writing to the Board Secretary at least three weeks in advance of the preferred meeting at which they wish to appear. Notwithstanding the three week notice, the Superintendent may consider a request to waive the timelines if circumstances warrant; for example, if the Board will be making a decision on the matter before the delegation is scheduled to present to Board.

4. The Board reserves the right to determine whether the delegation will be heard, and if so, whether it will be heard by the Board or by a committee of the Board. For matters clearly within the practice and mandate of the Board, the Board Secretary in consultation with the Superintendent of Schools and Board Chair shall make appropriate arrangements for the delegation to be heard.

5. Written briefs or a digest of the information to be presented must be submitted to the Board Secretary at least five days prior to the meeting. The notice and the brief will be provided to each Trustee with the notice of meeting at which the delegation is to appear.

6. The delegation may have 10 minutes in total to make its presentation and may appoint two spokespersons. The Chair will thank the speaker.

7. Decisions regarding requests made by delegations will be dealt with at the next meeting of the Board or appropriate committee unless the Board will be making a decision on the matter as part of another scheduled item of business on the agenda or it is otherwise agreed to by a majority vote of the members present.

Reference(s):

AB.AR - Appeal Processes
School Act Section 123

EDMONTON PUBLIC SCHOOLS

Canadian Cancer Society / Société canadienne du cancer
ALBERTA / N.W.T. DIVISION

Banning the Use of Non-Essential Pesticides

Summer 2010

Alberta municipalities have illustrated tremendous leadership on issues related to public health and safety and continue to do so by supporting measures that focus on chronic disease and cancer prevention. Currently, the municipalities of Jasper and Grande Prairie have policies prohibiting the non-essential use of pesticides on public green spaces.

The Canadian Cancer Society is very concerned about the non-essential use of potentially cancer-causing substances on public and private property and believes prohibiting the non-essential use of pesticides should be a top priority for municipal governments across Alberta. The Canadian Cancer Society believes that such action should be taken to limit the risk to human health. This is especially true as the reason for using non-essential pesticides is to prevent weeds and take care of other nuisances that can be treated in other potentially less damaging ways.

There is a growing body of evidence suggesting a connection between pesticides and cancer. According to the precautionary principle, when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established scientifically (Canadian Cancer Society, 2007). The use of non-essential pesticides on municipal spaces as well as private lawns and gardens has no countervailing health benefit and the potential for harm exists.

This brief provides background information on the health effects of non-essential pesticides and their impact on children. Also provided is information on the different approaches to lawn management and alternatives measures to non-essential use of pesticides. Information on public support for non-essential pesticides restrictions is highlighted. The brief concludes with policy recommendations.

Background:

The definition of non-essential pesticide: Non-essential pesticides, also known as cosmetic pesticides, may be used to enhance the appearance of private gardens and lawns, as well as parks, recreational facilities and golf courses, by controlling unwanted weeds, plants and pests. When pesticides are used to simply prevent blemishes and other imperfections, it is referred to as the *non-essential use of pesticides*.

Pesticides are a group of substances that include:

- insecticides (for insect control);
- herbicides (for weed control);
- fungicides (for control of disease caused by fungi);
- rodenticides (for rodent control);

- fumigants (substances used in gaseous form to control insects).

People are exposed to non-essential pesticides by:

- absorption through the skin;
- inhalation (breathing into the lungs);
- swallowing (by eating, drinking or touching hands to mouth).

Exemptions: The Canadian Cancer Society's call for restrictions on non-essential pesticide use does not apply to the use of pesticides in agriculture to grow food; using pesticides to ensure public health and safety; or using pesticides to prevent environmental damage. In these instances, the issues are much more complex since there can be health benefits in controlling pests.

Health effects of pesticide use:[1]

Exposure to non-essential pesticides can have a number of health impacts ranging from:

- **Mild:** headaches, sore eyes, rashes, nausea;
- **Serious:** vomiting, diarrhoea, asthma attacks, death;
- **Serious, long-term:** cancer, neurological and developmental problems, birth defects.

There is a significant, growing body of evidence linking chemicals in pesticides to various forms of cancer. This body of evidence includes peer-reviewed published studies and evaluations from organizations like the World Health Organization's International Agency for Research on Cancer; the US National Toxicology Program; and the US Environmental Protection Agency on the carcinogenicity of pesticides. Cancers linked to pesticides include non-Hodgkin lymphoma (NHL), leukemia and multiple myeloma as well as prostate, kidney, brain and lung cancer. A number of studies, including a few in Canada, have found possible links between farmers exposed to pesticides and a higher risk of NHL.

The World Health Organization's International Agency for Research on Cancer (IARC) tests chemicals, including pesticides and pesticide ingredients, to find out if they cause cancer in people. The US National Toxicology Program has identified some active ingredients in pesticides as "reasonably anticipated to be a human carcinogen" (likely to cause cancer). Its evaluations support the evidence that some pesticides have cancer-causing properties. The US Environmental Protection Agency also looks at the cancer-causing properties of pesticides. The research is not yet conclusive, but there is a strong enough connection that precautionary action should be taken. As such the Canadian Cancer Society advises eliminating exposure to pesticides where possible.

Danger to children:

Swallowing pesticides or pesticide residue, especially by children, can be very dangerous. Children are particularly vulnerable to pesticides because of their rapidly growing and developing bodies. They may

[1] www.cancer.ca. *Pesticides and Cancer.* March 2010.

also be at greater risk of exposure to pesticides because they are more likely to crawl and play on grass. If the grass has been sprayed with pesticides, this means they may inhale the pesticides and absorb them through their skin. They may also swallow pesticide residues because they place their hands and other objects in their mouths.

Perhaps most disconcerting is the fact that pesticides are easily tracked indoors where, in the absence of degradation by soil microbes and sunlight, they can persist. A study of a common active ingredient in herbicides found that house dust can contribute up to 30% of a child's total exposure before application to lawns and up to 76% of exposure, post-application.[2]

Danger to pets & wildlife:

Although the work of the Canadian Cancer Society is focused on the health of humans, we must not neglect pets and other wildlife also affected by pesticide use. Animals are particularly vulnerable since, like children, they are at closer proximity to the ground, are more likely to ingest pesticide residue, and are more likely to have direct skin contact with pesticides when their habitats are treated with the chemicals.

Support for a ban on the use of non-essential pesticides:[3]

- **Albertans support a ban:** A 2008 Check Mate poll of 790 Alberta residents shows an average of 87% (or nearly 9 out of 10 Albertans) would support a ban on the use of non-essential pesticides when considering children's health, the health of pets, and the risks to the environment/air quality/water quality.
- **Majority of Albertans do not use pesticides:** 65% of Alberta's residents do not use pesticides in their private homes and gardens. The most common reasons for abstaining from use are health concerns (57%) and environmental concerns (51%).
- **Albertans believe pesticide use is a health issue:** 90% of respondents feel that pesticide use in the community is a health issue. Just 3% didn't believe pesticides were harmful.
- Total number of completed surveys: A sample of 790 respondents provides statistical confidence levels of (+) or (-) 3.49%, 19 in 20 times.

Other Jurisdictions:

Currently, over 160 Canadian municipalities and 3 provinces are already protecting their residents with pesticide legislation. As well, retailers are proactively removing pesticide products from store shelves. As of May 2009, a number of large retailers including Loblaws, Home Depot, and Rona moved to end the sale of pesticides for home use.

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[2] Sears M., Walker C.R., van der Jagt R. H.C. and Claman P. "Pesticide assessment: Protecting public health on the home turf." *Paediatric Child Health*, Vol. 11, No. 4, (April 2006): 230.

[3] Check Mate Strategic Planning Inc. *Canadian Cancer Society - Alberta - Pesticide Poll Research Report.* 2008

Recognizing the potential for harm, Alberta Environment recommended that herbicide-fertilizer (weed and feed) products be banned. Thus, as of January 1, 2010, herbicide-fertilizer combination products are no longer sold in Alberta.

Understanding different approaches to lawn management:

- **Integrated Pest Management (IPM):** is an approach that focuses on prevention and turns to pesticides when alternatives prove to be ineffective. This method is also known as sustainable pest management. **The Canadian Cancer Society does not support the use of IPM for lawn and garden management as this approach allows for the non-essential use of pesticides.**

- **Total Phase out:** A total phase out puts strong measures in place to ensure that the use of non-essential pesticides is phased out over time. A total phase out or ban combined with a public education campaign is most effective at eliminating the non-essential use of pesticides. A total phase out should be a high priority at golf courses and sporting facilities that:
  - Children regularly use and for long periods of time;
  - Are next to residential and public areas.

Alternative Measures to Pesticides:

The Society supports the use of safer ways to improve the appearance of lawns, gardens, parks and other green spaces. This includes:

- Picking or digging weeds out at the root.
- Keeping lawns watered but not over-watered.
- Never cutting off more than one-third of the height of your grass.
- Aerating your lawn to allow moisture and nutrients to reach the roots of the grass.
- De-thatching your lawn if necessary.

Policy Recommendations:

The Canadian Cancer Society believes that non-essential use of potentially cancer-causing pesticides on municipal green spaces and private lawns and gardens should be prohibited in order to limit the risk to human health. This is especially true when the main reason for using non-essential pesticides on green spaces is to prevent weeds and plants that can be removed in other potentially less damaging ways.

The Canadian Cancer Society recommends that municipalities pass bylaws to prohibit the use of non-essential pesticides that are applied to private lawns and gardens as well as other public spaces such as municipal parks, recreational facilities and golf courses.

Attachment 2

Cancer health effects of pesticides

Systematic review

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ABSTRACT

OBJECTIVE To review literature documenting associations between pesticide use and cancer.

DATA SOURCES We searched MEDLINE, PreMedline, CancerLit, and LILACS to find studies published between 1992 and 2003 on non-Hodgkin lymphoma, leukemia, and 8 solid-tumour cancers: brain, breast, kidney, lung, ovarian, pancreatic, prostate, and stomach cancer.

STUDY SELECTION Each title and abstract was assessed for relevance; disagreements among reviewers were resolved by consensus. Studies were assessed by a team of 2 trained reviewers and rated based on methodologic quality according to a 5-page assessment tool and a global assessment scale. Studies rated below a global score of 4 out of 7 were excluded.

SYNTHESIS Most studies on non-Hodgkin lymphoma and leukemia showed positive associations with pesticide exposure. Some showed dose-response relationships, and a few were able to identify specific pesticides. Children's and pregnant women's exposure to pesticides was positively associated with the cancers studied in some studies, as was parents' exposure to pesticides at work. Many studies showed positive associations between pesticide exposure and solid tumours. The most consistent associations were found for brain and prostate cancer. An association was also found between kidney cancer in children and their parents' exposure to pesticides at work. These associations were most consistent for high and prolonged exposures. Specific weaknesses and inherent limitations in epidemiologic studies were noted, particularly around ascertaining whether and how much exposure had taken place.

CONCLUSION Our findings support attempts to reduce exposure to pesticides. Reductions are likely best achieved through decreasing pesticide use for cosmetic (non-commercial) purposes (where children might be exposed) and on the job.

EDITOR'S KEY POINTS

- There is increasing controversy over the use of pesticides in the community. Studies looking at pesticide use and cancer have shown a positive relationship between exposure to pesticides and the development of some cancers, particularly in children.
- Because most studies assessed use of multiple pesticides, the authors recommend that exposure to all pesticides be reduced.
- The quality of studies looking at the association between pesticide use and cancer is variable, consisting mainly of cohort and case-control methodologies.

This article has been peer reviewed.
Can Fam Physician 2007;53:1704-1711

Pesticides et cancer

Revue systématique

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RÉSUMÉ

OBJECTIF Faire une revue de la littérature portant sur l'association entre les pesticides et le cancer.

SOURCE DES DONNÉES On a repéré dans MEDLINE, Premedicine, CancerLit et LILACS les études publiées entre 1992 et 2003 qui traitaient de lymphomes non hodgkiniens, de leucémies et de 8 tumeurs cancéreuses solides: cerveau, sein, rein, poumon, ovaire, pancréas, prostate et estomac.

CHOIX DES ÉTUDES La pertinence de chacun des titres et résumés a été évaluée : toute discordance entre réviseurs a été résolue par consensus. Une équipe de 2 réviseurs expérimentés a évalué la qualité de la méthodologie à l'aide d'un outil d'évaluation de 5 pages et d'une échelle d'évaluation globale. Les études obtenant un score global inférieur à 4 sur 7 ont été exclues.

SYNTHÈSE La plupart des études sur les lymphomes non hodgkiniens et sur les leucémies montraient une association positive avec l'exposition aux pesticides. Certaines montraient une relation dose-réponse et quelques-unes avaient pu identifier des pesticides spécifiques. Certaines études montraient que les cancers étudiés étaient plus fréquents chez les enfants et les femmes enceintes exposés à des pesticides, mais aussi chez les parents qui y étaient exposés au travail. Plusieurs travaux montraient une association positive entre l'exposition aux pesticides et certaines tumeurs solides. Les associations les plus fréquentes concernaient les cancers du cerveau et de la prostate. On a également observé une association entre le cancer rénal chez les enfants et l'exposition des parents aux pesticides au travail. Ces associations étaient plus fréquentes lors d'expositions fortes et prolongées. On a noté des faiblesses spécifiques et des limitations inhérentes dans les études épidémiologiques, en particulier dans la façon de déterminer s'il y avait eu exposition et à quel degré.

CONCLUSION Nos observations viennent à l'appui des efforts pour réduire l'usage des pesticides. La meilleure façon d'y arriver est probablement en réduisant l'exposition professionnelle ainsi que l'usage à des fins cosmétiques (non commerciales), qui risque davantage d'exposer les enfants.

POINTS DE REPÈRE DU RÉDACTEUR

- L'utilisation de pesticides dans la communauté est de plus en plus remise en question. Certaines études ont montré une relation positive entre l'exposition aux pesticides et le développement de certains cancers, notamment chez les enfants.
- Comme la plupart de ces études portaient sur l'utilisation de plusieurs pesticides, les auteurs recommandent qu'on réduise l'exposition à tous les pesticides.
- Les études examinant l'association entre les pesticides et le cancer sont de qualité variable, reposant surtout des cohortes ou des cas-témoins.

Cet article a fait l'objet d'une révision par des pairs.
Can Fam Physician 2007;53:1704-1711

In recent years, few environmental issues have aroused public concern as much as use of and exposure to pesticides, especially with respect to children's health. Despite many published studies on the relationships between exposure to pesticides and human health, deep controversy surrounds these associations. Since the Supreme Court ruling in 2001 allowing the municipality of Hudson, Que, to pass a bylaw restricting use of pesticides for cosmetic purposes (non-commercial use), many municipalities across the country have passed similar bylaws. Cosmetic use of pesticides remains a complex issue involving arguments about the rights of lawn-care companies and property owners, and increasingly, the effects of pesticides on health. Because randomized controlled trials on the health effects of potentially harmful chemicals cannot be conducted and because of the difficulty of measuring exposure to pesticides and the limitations innate in observational studies, we are still unsure about the effects of pesticides on human health.

As family physicians, cancer specialists, and epidemiologists, we initiated a systematic review of the literature on the effects of pesticide use on chronic health outcomes in order to assess the evidence currently available.

DATA SOURCES

Primary peer-reviewed studies were found by searching PreMedline, MEDLINE, CancerLit, and LILACS (Spanish- and Portuguese-language articles) databases. These databases were selected as we considered them to be the most comprehensive for studies of causes of cancer among humans. The references lists of all studies were checked to identify papers not captured in our search. We included studies that were systematic in their approach; peer reviewed; and published in English, French, Spanish, or Portuguese. Decisions regarding language restrictions were based on the language capabilities of the reviewers. Studies on organochlorines were excluded, as most of these chemicals are no longer used as pesticides in Canada. Studies were collected and organized according to health effect (**Table 1**) rather than specific pesticide exposure, because most of the literature considers mixed pesticide exposures.

Ms Bassil *is a doctoral candidate in the Department of Public Health Sciences at the University of Toronto in Ontario.* **Dr Vakil** *is an Assistant Professor in the Department of Family Medicine at Queen's University in Kingston, Ont.* **Dr Sanborn** *is an Assistant Clinical Professor in the Department of Family Medicine at McMaster University in Hamilton, Ont.* **Dr Cole** *is an Associate Professor of Medicine in the Department of Public Health Sciences at the University of Toronto.* **Dr Kaur** *is an Associate Professor of Oncology at the Mayo Clinic College of Medicine in Rochester, Minn.* **Dr Kerr** *is a lecturer in the Department of Family and Community Medicine at the University of Toronto.*

Study selection

Our search strategy was designed to be comprehensive. To ensure this, all searches included the key MeSH heading "pesticides" and the MeSH headings for the cancers of interest. Our inclusion criteria were that studies be peer reviewed, that they looked at a cancer with an important burden in Canada, and that they were published between 1992 and 2003. The Canadian Cancer Statistics webpage[1] lists cancers in terms of greatest incidence and associated morbidity and mortality. From this list, 8 categories of solid tumours were selected for inclusion. No studies of acceptable quality were found for testicular cancer or colorectal cancer. We chose 1992 as the starting point for our search because a previous review had covered the period to 1991.[2]

A list of abstracts was produced from each search and distributed to reviewers for evaluation. Reviewer pairs read the abstracts and selected articles that met the inclusion criteria. When articles lacked abstracts or contained too little information on which to make a selection, the original primary studies were obtained for evaluation. Disagreements between reviewers concerning selection of articles for inclusion were resolved by discussion and input from a third reviewer. After abstract selections were agreed upon, the primary studies were collected and distributed back to the reviewer teams for evaluation.

Each study was evaluated by 2 independent reviewers using a quality-assessment and data-extraction tool designed to assess the methodologic quality of each study and developed through consultation with colleagues with experience in systematic reviews. All members of the reviewer team participated in a pilot exercise to test the tool, which was revised until we achieved high interrater reliability ($\kappa > 0.8$ on global assessment scores). A global assessment scale that integrated reviewers' judgment of various methodologic components was used to decide which studies would be included in the final report. This scale used a 7-point response format; all studies ranked below 4 were considered of insufficient methodologic quality to provide valid data to the review and were excluded.

Data extraction and synthesis

Data from the 104 studies included were transferred to tables by cancer type and study type. Reviewers tabulated the number of studies and calculated mean quality scores. Synthesis was based on number and quality of studies and aspects of heterogeneity relevant to the studies included. Tables by cancer type are available in the full report on the Ontario College of Family Physicians' website.[3]

Table 1. Global quality score of studies included: *Studies are organized by type of cancer; 104 studies were found, and 83 were included.*

TYPE OF CANCER	NO. OF STUDIES FOUND	NO. OF STUDIES INCLUDED	SUMMARY OF RESULTS	AVERAGE GLOBAL QUALITY SCORE OF STUDIES INCLUDED
Lung	4	4	2/4 found positive associations	4.1
Breast	12	6	5/6 found positive associations; 1 found decreased risk with exposure	5.0
Pancreatic	3	3	All found positive associations	4.7
Non-Hodgkin lymphoma	32	27	23/27 found positive associations	4.5
Leukemia	23	16	14/16 found positive associations	4.5
Brain	11	11	All found positive associations	4.7
Prostate	10	8	All found positive associations	4.8
Stomach	1	1	Found a positive association	5.0
Ovarian	1	1	Failed to find an association	5.5
Kidney	7	6	All found positive associations	4.2

SYNTHESIS

Non-Hodgkin lymphoma

We reviewed 32 papers on non-Hodgkin lymphoma (NHL)[4-35]; 27 met the quality criteria for inclusion.[4-6,8,11-30,32,34,35] Cohort studies looked at exposure to a variety of pesticides. Subjects were usually adult white males in occupational groups such as farmers, pesticide applicators, workers in pesticide factories, landscapers, lumberjacks, and golf course superintendents.

Results were positive in 10 of the 12 studies; results reached statistical significance in 4 studies. A large study of 155 000 farmers found an increased risk of NHL with exposure to pesticides (relative risk [RR] 2.11, 95% confidence interval [CI] 1.1 to 3.9) that increased with the number of acres sprayed.[25] Another study found an increased rate of NHL (proportionate mortality ratio 237, range 137 to 410) among golf course superintendents who had been exposed to pesticides as well as other chemicals, such as diesel fumes and fertilizers.[20]

Results of 12 of the 14 case-control studies were positive; 8 reached statistical significance. The 1 study of children found elevated odds ratios (ORs) in children from homes where pesticides were used most days (OR 7.3, $P<.05$), where pesticides were used for professional home exterminations (OR 3.0, $P=.002$), when children had had direct postnatal exposure (OR 2.4, $P=.001$), and when parents had had occupational exposure (OR 1.74) (not statistically significant).[8]

Most studies revealed an elevated risk of NHL with several classes of pesticides. A well-designed Canadian study assessed risk, first with major classes of pesticides and then with individual compounds within these classes, including dicamba, mecoprop (both commonly used weed-killers available in hardware stores) and carbamate (an insecticide).[24] One pooled study found elevated ORs for NHL and hairy cell leukemia, a rare form of NHL, for men exposed to herbicides, insecticides, fungicides, and impregnating agents (chemicals added to assist in applying pesticides). Elevated risk was also seen with some individual compounds, such as the herbicides glyphosate and MCPA (2-methyl-4-chlorophenoxyacetic acid). A dose-response effect was found with certain other pesticides and classes.[16]

Leukemia

This review assessed 23 studies on leukemia,[36-58] 16 of which met the quality criteria for inclusion.[36-39,43-50,52-54,58] Most of the 6 cohort studies looked at occupationally exposed adult white males. Exposure histories in most of the studies were estimated indirectly from information such as amount of money spent on pesticides, location of farm, type of crop, number of acres treated, and duration of employment. Two studies showed elevated rates of leukemia associated with livestock farming.[45,46] A study of golf course superintendents found an increased rate of leukemia, but it was not statistically significant.[20]

Results of all 8 case-control studies were statistically significantly positive. One of the few studies that included women found an elevated OR of 4.4 (95% CI, 1.7 to 11.5) for chronic myelocytic leukemia and acute myelocytic leukemia, though specific pesticides were not named or quantified.[37]

Several case-control studies analyzed rates of leukemia among children exposed to pesticides. Increased rates of all types of leukemia were found in children whose parents used insecticides in the garden and on indoor plants and whose mothers had been exposed while pregnant.[44] A case-only cytogenetic study within this study found that the presence of 1 of 3 "poor metabolizer" mutations increased the risk of all types of leukemia when subjects had been exposed to pesticides.[44]

An excellent study showed increased rates of childhood leukemia with exposure to insecticides. Timing of exposure seemed to be critical (preconception, and both prenatal and postnatal periods).[48] The most crucial exposure period for later development of leukemia was during pregnancy.

An interesting laboratory study found a different pattern of chromosomal aberrations, cytologic features, peripheral blood and bone marrow indices, prognosis, and resistance to treatment in leukemia patients who were exposed to pesticides compared with patients who were not.[39] This pattern resembled the pattern found in patients with secondary leukemia, usually caused by radiation, chemotherapy, or other chemical exposure, suggesting that exposure to pesticides might be a precipitant to development of leukemia.

Solid tumours

Brain cancer. All 11 studies from the United States, Canada, and Europe examining the association between pesticide exposure and brain cancer showed increased risk.[20,45,59-67] A large European study also found this relationship in the children of parents exposed to pesticides at work, particularly for non-astrocytic neuroepithelial tumours.[45] A strong association was also found for exposure to pesticides indoors at home.[63]

Breast cancer. Six studies analyzed the association between pesticide exposure and breast cancer.[68-73] Most of them supported an association. One exception was a study that found that women who farmed had a decreased risk of breast cancer.[69] This might have been due to the protective effect of physical activity against breast cancer, or exposure to sunlight, which might reduce risk by increasing vitamin D levels. Even within this group of farmers, however, those who reported being in the field during or shortly after pesticide application and those who reported not using protective clothing while applying pesticides had an increased risk of breast cancer. A study of female greenhouse workers in Crete found that exposure to pesticides for more than 4 hours daily for at least 10 years increased the risk of benign breast disease (as seen on mammography).[70]

Although most of these studies considered a mix of pesticides, 1 study looked at exposure to triazine herbicides and atrazine (a corn herbicide) as a specific example. While the results did not support a positive association between atrazine and breast cancer, there was an increased risk of breast cancer with medium and high levels of exposure to triazine herbicides as a class.[73]

Kidney cancer. Six papers evaluated the relationship between pesticide exposure and kidney cancer, and all found positive associations.[74-79] The association was found not only in directly exposed populations, but also in children of exposed parents, and was most consistent when people had had prolonged exposure.

Lung cancer. Four studies examined the association between lung cancer and pesticide exposure.[20,61,80,81] Results of these studies are somewhat difficult to interpret as only 2 collected information regarding smoking status. One of these studies[80] found an elevated risk of lung cancer among women exposed to pesticides at work, and the other found an increased risk in a cohort of Florida pest-control workers who had been exposed to specifically named pesticides. The confidence intervals were extremely broad, however, making interpretation difficult.

Ovarian cancer. Few studies were found on pesticide exposure and ovarian cancer. One paper included ovarian cancer as a health effect of interest and evaluated its association with exposure to atrazine. No association was found.[72]

Pancreatic cancer. Three studies evaluated the relationship between pancreatic cancer and pesticide exposure, and all 3 found positive associations.[82-84]

Prostate cancer. Eight papers examined the association between prostate cancer and pesticide exposure and consistently showed positive associations.[20,85-91] One well-designed US study investigated more than 55 000 men who applied pesticides and found an increased risk of prostate cancer, especially among those with a family history of prostate cancer, and particularly with use of methyl bromide, a fumigant.[85]

Stomach cancer. One study investigated the relationship between stomach cancer and nitrates and atrazine.[92] A higher rate of stomach cancer was found in areas with high levels of atrazine contamination in the water.

DISCUSSION

The preponderance of evidence uncovered in our systematic review indicated a positive relationship between exposure to pesticides and development of some cancers, particularly brain, prostate, and kidney cancers, as well as NHL and leukemia. A number of the studies on children found increased risk of cancer associated with critical periods of exposure, both prenatal and postnatal, and with parental exposure at work. Most studies showed increased risk, and many showed dose-response relationships. Other reviews have suggested a possible link between pesticide exposure and certain cancers, and further studies have been recommended due to limitations innate in the design of cohort and case-control studies.[2,93] The studies varied in terms of

number and types of subjects, types of pesticides studied, ways of measuring exposure, covariates examined, and follow-up times.

Limitations

In studying any potentially harmful substances, such as pesticides, where randomized controlled trials are not ethically possible to do, researchers rely mostly on cohort and case-control studies. Each of these designs have limitations, given the difficulty of measuring pesticide exposure. Cohort studies typically rely on indirect measures of exposure, such as type of occupation, duration of employment, and agricultural census data. Usually, specific pesticides are not named or quantified. Covariates, such as family history, smoking, and race, are not always available. Follow-up times are sometimes too short to account for the long latency period between exposure and onset of illness. Recall bias (relying on subjects' memories) is a limitation to case-control studies, as are low response rates and use of proxy respondents. Publication bias (lack of publication of negative studies) is also a potential limitation, as is incomplete collection of all relevant studies in any particular systematic review.

A promising newer method of studying the effects of pesticides is to examine chromosomal aberrations, and, therefore, future cancer risk,[94] in people exposed to pesticides. Looking at gene polymorphisms (the genetically determined ability to metabolize substances slowly or quickly) will also be a very exciting method of studying the health effects of pesticides.

Conclusion

We believe that there is enough evidence to recommend that patients reduce use of pesticides. Because most studies analyzed exposure to multiple rather than individual pesticides, our recommendation is to reduce exposure to all pesticides. The results of this systematic review have prompted the Ontario College of Family Physicians to recommend that everyone, especially children and pregnant women, reduce exposure to pesticides whenever possible, both at home and in the workplace. Bans on the cosmetic use of pesticides (used only for appearance and not for major infestations and risks to human health) are also supported by the Ontario College of Family Physicians, the Canadian Paediatric Society, the Canadian Cancer Society, the Canadian Nurses Association, the Registered Nurses' Association of Ontario, the Toronto Board of Health, both the Canadian and the Ontario Public Health Associations, and many other physician and health professional associations.

The public has expressed concern about the issue of pesticides, especially regarding the risk to children. More than 100 municipalities across the country have implemented bylaws restricting and banning cosmetic use of pesticides, including Toronto, Vancouver, Montreal, and Halifax, and these bylaws have been supported by the public.

Family doctors should consider asking about pesticide exposure during periodic health examinations and make recommendations about minimizing exposure. They should also encourage use of protective clothing and masks for patients who use pesticides on the job and encourage them to be attentive to the timing of re-entry into recently sprayed areas. Family doctors can also advocate for reductions in pesticide use in communities, schools, and hospitals, and to governments, and can educate patients about the potentially harmful effects of pesticides on health.

Contributors

Ms Bassil, **Dr Vakil**, **Dr Sanborn**, **Dr Cole**, **Dr Kaur**, *and* **Dr Kerr** *contributed to concept and design of the study, data analysis and interpretation, and preparing the article for submission.*

Competing interests

The systematic review was completed with funding from the Laidlaw Foundation and the Ontario College of Family Physicians. **Dr Vakil** *has received teaching honoraria from the Ontario College of Family Physicians and the International Joint Commission Health Professional Task Force.* **Dr Sanborn** *received honoraria for working on this project.* **Dr Cole** *has received funding from the International Development Research Centre and the Canadian Institutes for Health Research.* **Dr Kerr** *has received honoraria from the Ontario College of Family Physicians and from the Foundation for Science and Education.*

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Attachment 3

Non-cancer health effects of pesticides

Systematic review and implications for family doctors

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ABSTRACT

OBJECTIVE To investigate whether there are associations between exposure to pesticides and 4 chronic non-cancer health effects: dermatologic, neurologic, reproductive, and genotoxic effects.

DATA SOURCES We searched PreMedline, MEDLINE, and LILACS using the key word *pesticide* combined with the term for the specific health effect being searched. Reviewers scanned the references of all articles for additional relevant studies.

STUDY SELECTION Studies since 1992 were assessed using structured inclusion and quality-of-methods criteria. Studies scoring <4 on a 7-point global methodologic quality scale were excluded. In total, 124 studies were included. These studies had a mean quality score of 4.88 out of 7.

SYNTHESIS Strong evidence of association with pesticide exposure was found for all neurologic outcomes, genotoxicity, and 4 of 6 reproductive effects: birth defects, fetal death, altered growth, and other outcomes. Exposure to pesticides generally doubled the level of genetic damage as measured by chromosome aberrations in lymphocytes. Only a few high-quality studies focused on the dermatologic effects of pesticides. In some of these studies, rates of dermatitis were higher among those who had had high exposure to pesticides on the job.

CONCLUSION Evidence from research on humans consistently points to positive associations between pesticide exposure and 3 of the 4 non-cancer health outcomes studied. Physicians have a dual role in educating individual patients about the risks of exposure and in reducing exposure in the community by advocating for restrictions on use of pesticides.

EDITOR'S KEY POINTS

- Due to the unethical nature of cause-effect studies on pesticide exposure, the growing body of literature on pesticide health effects cannot be used to establish a cause-effect relationship between the use of pesticides and non-cancer health effects.
- However, there is consistent evidence in the literature that pesticide exposure does increase the risk of 3 non-cancer health effects (neurologic, reproductive, and genotoxic).

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Pesticides: effets sur la santé, outre le cancer

Revue systématique et implications pour le médecin de famille

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RÉSUMÉ

OBJECTIF Déterminer s'il existe une association entre l'exposition à des pesticides et 4 types d'effets nocifs chroniques sur la santé, outre le cancer: effets d'ordre dermatologique, neurologique, reproducteur et génotoxique.

SOURCES DES DONNÉES On a consulté PreMedline, MEDLINE et LILACS à l'aide du mot-clé *pesticide* combiné à chacun des termes désignant les effets spécifiques à l'étude. Les analystes ont scruté la bibliographie de chaque article pour identifier toute autre étude pertinente.

CHOIX DES ÉTUDES Le choix des études publiées depuis 1992 était basé sur des critères d'inclusion structurés et des critères de qualité méthodologique. Les études obtenant un score inférieur à 4 sur une échelle de qualité méthodologique globale de 7 points ont été exclues. Au total, 124 études ont été retenues, avec un score de qualité moyen de 4,88 sur 7.

SYNTHÈSE On a trouvé des preuves convaincantes d'une association entre l'exposition aux pesticides et l'ensemble des issues neurologiques, la génotoxicité et 4 des 6 effets sur la reproduction: malformations congénitales, mort fœtale, anomalie de croissance et autres issues. De façon générale, l'exposition aux pesticides a doublé le niveau de dommage génétique tel que mesuré par les modifications chromosomiques dans les lymphocytes. Seules quelques études de bonne qualité ont porté sur les effets dermatologiques des pesticides. Dans certaines de ces études, on a observé un taux plus élevé de dermatites chez ceux qui avaient été fortement exposés en milieu de travail.

CONCLUSION La plupart des données tirées de la recherche chez l'humain indiquent que l'exposition à des pesticides est associée à 3 des 4 problèmes de santé étudiés. Le médecin a le double rôle de renseigner chaque patient sur les risques d'une telle exposition et de promouvoir un usage restreint des pesticides afin de réduire l'exposition dans la communauté.

POINTS DE REPÈRE DU RÉDACTEUR

- En raison de la nature non éthique des études de type cause-effets sur l'exposition aux pesticides, on ne peut utiliser les données de plus en plus nombreuses de la littérature dans ce domaine pour établir une relation de cause à effet entre l'utilisation des pesticides et les effets sur la santé autres que les cancers.
- Il existe toutefois dans la littérature des preuves abondantes confirmant que l'exposition aux pesticides augmente le risque de développer trois effets nocifs autres que cancéreux: effets sur le système nerveux, sur la reproduction et génotoxicité.

Cet article a fait l'objet d'une révision par des pairs.
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Pesticides include all classes of chemicals used to kill or repel insects, fungi, vegetation, and rodents.[1,2] It is well accepted that acute poisonings cause health effects, such as seizures, rashes, and gastrointestinal illness.[1-4] Chronic effects, such as cancer and adverse reproductive outcomes, have also been studied extensively, and the results have been interpreted in various ways as evidence that pesticides are safe or are a cause for concern because they can be detrimental to human health. Bylaw debates across Canada have focused public attention on the cosmetic (non-commercial crop) uses of pesticides and the attendant potential risks of chronic low-level exposure.

Family physicians need evidence-based information on the health effects of pesticides to guide their advice to patients and their involvement in community decisions to restrict use of pesticides. A systematic review by the Ontario College of Family Physicians' Environmental Health Committee was done as a basis for informing family physicians' approach to disseminating information on pesticides to patients and communities.[5]

This article reports on a systematic review of articles published between 1992 and 2003 on 4 non-cancer chronic health effects thought to be associated with exposure to pesticides: dermatologic, neurologic, reproductive, and genotoxic effects. Cardiovascular, respiratory, and learning disability outcomes were not included in the review because of resource constraints. Findings on pesticides and cancer outcomes are reported in another article.[6]

DATA SOURCES

Primary peer-reviewed studies were located using PreMedline, MEDLINE, and LILACS (Spanish- and Portuguese-language articles) databases. All searches included the key MeSH heading "pesticides" combined with the MeSH heading for the health effects under study. Reviewers systematically scanned the references of all articles for additional relevant studies.

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Study selection

The 3 criteria for inclusion in the assessment were being peer reviewed, being a study of human health effects related to pesticide exposure, and being published between 1992 and 2003. A systematic review done in 1993 had covered pesticide health effect studies up to 1991.[7] A total of 150 studies were retrieved by the search for the 4 categories of health effects (**Table 1**). Two independent reviewers each filled out 5-page Data Extraction Forms for each study. A 7-point Likert-type Global Methodological Quality Assessment Scale was used to assess all papers; 26 papers scored <4 out of 7 and were excluded.

SYNTHESIS

Dermatologic effects

Skin is the primary route of exposure to pesticides for sprayers, handlers, and people using repellants. Excluding acute poisonings, contact dermatitis is thought to be the most common health effect of pesticides, through either irritant or allergic mechanisms.[8] Along with eye injuries, it is the health effect most likely to be seen in the office[2] and might be the only indicator of exposure.

In the 10 studies reviewed[9-18] (none from Canada), it was difficult to assess the prevalence of skin disorders attributable to pesticides. In agricultural workers with contact dermatitis, sensitization to both plant material and pesticides was documented,[9,16] but most study designs did not allow attribution of rashes specifically to pesticide exposure. One study that used a biomarker for pesticide exposure found a dose-response relationship between dermatitis and years of fungicide exposure or poor application practices[13]; 61% of pesticide-exposed agricultural workers and 31% of controls had dermatitis ($P<.001$).[13] Pet groomers who gave more than 75 pyrethrin flea treatments per year had more rashes (odds ratio [OR] 2.04, 95% confidence interval [CI] 1.02 to 4.09) and more eye symptoms (OR 4.75, 95% CI 1.14 to 18.23) than those who gave fewer treatments.[10]

Neurotoxicity

Long-term effects of pesticides on the nervous system include cognitive and psychomotor dysfunction, and neurodegenerative and neurodevelopmental effects. Pesticide poisonings result in well-described acute and chronic neurotoxic syndromes.[19] Chronic effects from low or moderate exposures have been less well documented.

Our systematic review began with 4 relevant studies, including a metanalysis on Parkinson disease (PD) and pesticide exposure[20]; 41 primary studies[21-62] were of adequate quality. Most studies analyzed covariates that might affect nervous system function. Differentiating between the effects of chronic or cumulative exposure and current

Table 1. Summary of studies reviewed

HEALTH EFFECT	NO. OF STUDIES FOUND	NO. OF STUDIES INCLUDED*	SUMMARY OF RESULTS	MEAN GLOBAL SCORE OF STUDIES INCLUDED*
Dermatologic effects	11	10	7/10 studies positive for dermatitis with pesticide exposure	4.50
Neurotoxicity	60	41	39/41 studies positive for increase in 1 or more neurologic abnormalities with pesticide exposure	4.99
Reproductive outcomes	64	59	Birth defects: 14/15 studies positive; time to pregnancy: 5/8 studies positive; fertility: 7/14 studies positive; altered growth: 7/10 studies positive; fetal death: 9/11 studies positive; other outcomes: 6/6 studies positive	4.83
Genotoxicity	15	14	11/14 studies positive for increased chromosome aberrations with pesticide exposure†	5.03

*Assessors scored each paper on a 7-point scale for methodologic quality from 1—very poor to 7—excellent. Papers scoring <4 were excluded.
†**Figure 1** aggregates results from all 14 genotoxicity studies.

intense exposure can be difficult. Unfortunately for many exposed populations (eg, Ecuadorian farm families[29,30]), mixed past poisoning, cumulative exposure, and current work and home exposures are overlaid.

Maternal, in-utero, and early childhood exposures are likely all involved in producing neurodevelopmental effects in preschool children in pervasive exposure situations, such as Mexican valley agriculture.[40] Only 2 studies of effects including children were found,[40,42] despite considerable concern about the effects of pesticide exposure on sensitive populations, such as inner-city children.[4]

Most studies documented mixed pesticide exposures. Cross-sectional studies often included exposure biomarkers, such as herbicide or alkyl phosphates in urine or acetylcholinesterase levels in blood. Some studies were exceptional in documenting specific exposures, for example, fumigants.[28]

General neurotoxic morbidity. General malaise and mild cognitive dysfunction might be the earliest neurotoxic responses to pesticide exposure.[62] Most studies using validated questionnaires and performance tests found an increased prevalence of symptoms or mood changes, as well as alterations in neurobehavioural performance and cognitive function.

Studies of the mental and emotional effects of pesticides found associations for current minor psychiatric morbidity,[27] depression,[55] suicide among Canadian farmers,[49] and death from mental disorders,[60] particularly neurotic disorders in women. Keifer et al[42] found substantially higher rates of mental and emotional symptoms in residents (including adolescents) exposed to spray-plane drift compared with those not exposed.

Associations between previous pesticide poisonings, particularly from organophosphates and carbamates, and decreases in current neurobehavioural function were most consistently positive. Those with greater exposures (eg, termiticide applicators[31] or farmers handling concentrates[50]) also showed more consistent decreases in function. Together, these studies provide important evidence of the subclinical effects of pesticides on the nervous system. These effects might become clinically manifest in a few cases.

Neurodegenerative disease. Most of these studies examined mixed occupational exposures. Some focused on herbicides. Health outcomes varied from PD on clinical examination through adjusted incidence of hospitalization for PD to deaths from PD. All found positive associations between exposure and PD. Combined with the earlier meta-analysis,[20] the results of 15 out of 26 studies were positive for associations between pesticide exposure and PD. These data provide remarkably consistent evidence of a relationship between PD and past exposure to pesticides on the job (OR 1.8 to 2.5).

Evidence of other neurodegenerative effects of pesticides is also accumulating. Of 2 studies on Alzheimer disease, 1[38] found no association and 1[24] found an association in men. A study on amyotrophic lateral sclerosis[46] found consistently elevated adjusted ORs associated with pesticide exposure in both men and women.

Reproductive outcomes

Six distinct groups of reproductive outcomes were chosen for study: birth defects, fecundability, fertility, altered growth, fetal death, and mixed outcomes.

Birth defects. Fifteen studies from 9 countries[63-77] examined associations between pesticides and birth defects. The studies consistently showed increased risk with pesticide exposure. Specific defects included

limb reductions,[64,67,73] urogenital anomalies,[68,73,75] central nervous system defects,[68,73] orofacial clefts,[74] heart defects,[66,67] and eye anomalies.[77] The rate of any birth defect was also increased by parental exposure to pesticides.[66-71,74,76] In many studies, there were multiple exposures. Two studies identified specific pesticides: glyphosate[64] and the pyridil derivatives.[69]

Time to pregnancy. Eight studies from 6 countries[78-85] analyzed associations between pesticide exposure and time to pregnancy. Data on pesticide exposures and outcome were collected retrospectively by self-report. Five studies showed positive associations, and 3 showed no association between pesticide exposure and time to pregnancy. All 3 papers showing no association collected exposure and outcome information from men only.[79-81]

Fertility. Fertility refers to the ability to become pregnant in 1 year and includes male and female factors, such as semen quality and infertility. Twelve studies from 7 countries were reviewed.[86-99] Results were mixed; several studies found no associations between pesticide exposure and sperm abnormalities. One study found an association between organophosphate metabolites and sperm sex aneuploidies[94]; another study found an association between erectile dysfunction and pesticide exposure.[95] One study found an increased risk of infertility among women who worked with herbicides in the 2 years before attempted conception.[98]

Altered growth. Low birth weight, prematurity, and intrauterine growth restriction are not only important determinants of health during the first year of life, but also of chronic diseases of adulthood.[100] Ten studies, mainly from Europe and North America,[76,77,101-108] examined pesticide effects on fetal growth. Seven of these showed positive associations between agricultural pesticide exposure and altered fetal growth. Two pesticides implicated in the positive studies were pyrethroids and chlorpyrifos, the latter a commonly used ant-killer now being phased out because of health effects.

Fetal death. Fetal death includes spontaneous abortion, fetal death, stillbirth, and neonatal death. Results were consistent across several study designs; 9 of 11 studies[64,76,77,109-116] found positive associations with pesticide exposure. The Ontario Farm Study results suggested critical windows when pesticide exposure is most harmful. Preconception exposure was associated with early first-trimester abortions, and post-conception exposure was associated with late spontaneous abortions.[110] In a study from the Philippines,[76] risk of spontaneous abortion was 6 times higher in farming households with heavy pesticide use than it was among those using integrated pest management (which results in reduced pesticide use).

Other reproductive outcomes. Seven studies examined other reproductive outcomes, such as sex ratio, placental quality, and developmental delay after in-utero exposure.[64,107,117-121] A Mexican study[115] found higher rates of placental infarction in rural women exposed to organophosphate insecticides; exposure was biomarker-documented with depressed red blood cell cholinesterase levels. Results on altered sex ratios were inconsistent.[64,114]

Genotoxicity

Genotoxicity is the ability of a pesticide to cause intracellular genetic damage. In all reported studies, it was measured as percent chromosome aberrations per 100 peripheral blood lymphocytes. Increased frequency of chromosome aberrations was a predictor of increased cancer rates in a large prospective cohort study (n=5271) with follow-up for 13 to 23 years.[122] Similar studies of associations with reproductive outcomes have not been done.

Important confounders are exposures that cause genetic damage: smoking, alcohol consumption, diet, caffeine intake, radiation, and mutagenic drugs. The latter are important since drugs such as methotrexate are now used widely for rheumatoid arthritis and Crohn disease. Few studies measured all confounders; most excluded smokers and subjects who had x-rays or took mutagenic drugs during the previous year.

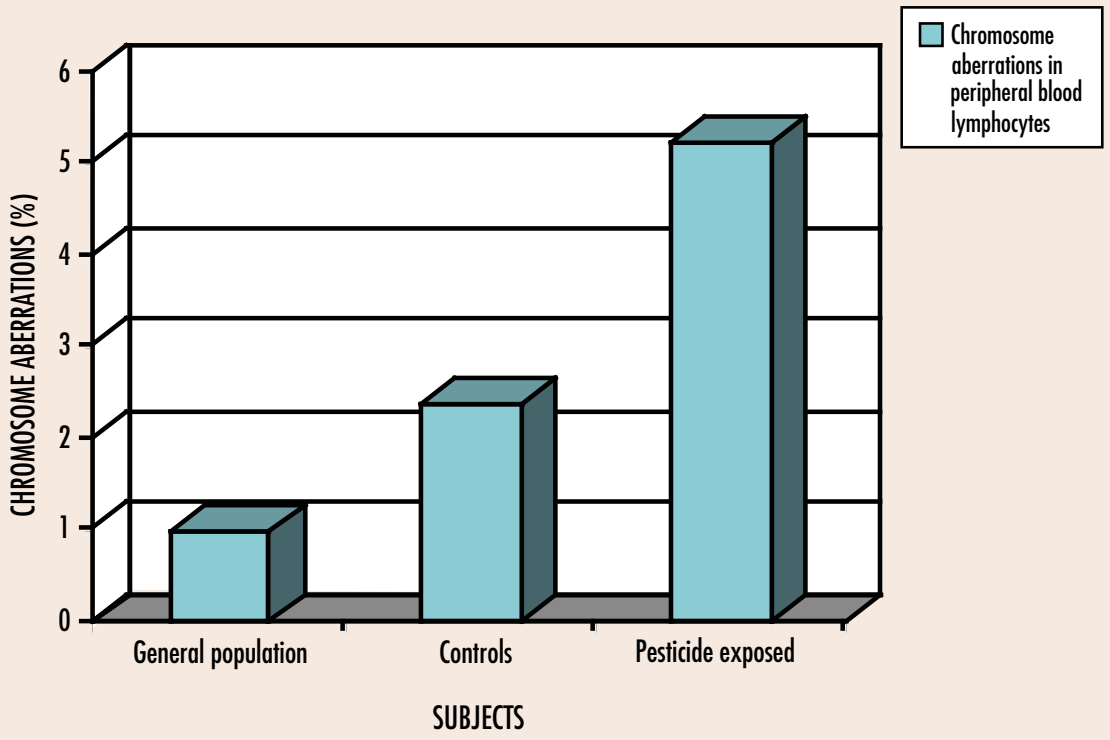
Positive associations between pesticide exposure and elevated percent chromosome aberrations were found in 11 of 14 studies.[123-136] Two studies showing no association had taken blood samples during low-exposure seasons.[128,129] Two studies pointed to synthetic pyrethrins[134] and organophosphates[135] as highly genotoxic. Aggregate results from all 14 studies are shown in **Figure 1**; pesticide exposure doubled the frequency of chromosome aberrations. In clinical practice, these aberrations could present as spontaneous abortion, birth defects, sperm abnormalities, or cancer risk.

DISCUSSION

For the 4 non-cancer effects reviewed, the strongest evidence of association with pesticide exposure was found for neurologic abnomalities, 4 out of 6 reproductive outcomes, and genotoxicity effects (**Table 1**).

The most striking feature of the results of this systematic review is the consistency of evidence showing that pesticide exposure increases the risk of 3 non-cancer health effects: neurologic, reproductive, and genotoxic effects. The results are consistent with those of other reviews published before[20] and since[137,138] this review was completed. Results of dermatologic studies are less consistent and of poorer quality and indicate the need for a primary care prevalence study of pesticide-related skin conditions.

Figure 1. Percent of chromosome aberrations for 500 control and 529 pesticide exposed subjects in 14 genotoxicity studies compared with the general population



Assessment of exposure remains a key problem that is being addressed in newer studies by enhanced biomonitoring. For example, a cohort of children now being followed longitudinally had cord-blood levels of several pesticides measured at birth[139] and by maternal air and blood sampling during pregnancy.[140] The role of genetics in the ability to metabolize pesticides, which varies widely among ethnic groups,[141] is being incorporated into more study designs[41,124,142] and should refine our knowledge and explain some inconsistencies in the international literature.

Limitations

The major limitation of studies of the health effects of pesticides is their inability to demonstrate cause-effect relationships. Study subjects cannot be deliberately exposed to potentially harmful toxins, and few exposure-reduction options are tested in randomized controlled trials. The evidence generated by well-constructed clinical and epidemiologic observational studies is the highest level of evidence we can ethically obtain.

The studies reviewed have methodologic problems, such as exposure misclassification and inadequate exposure assessment (causing mixed results) and recall bias (in retrospective case-control studies). Unpublished literature on health effects that was not accessed would be useful to determine whether there is a publication bias toward positive studies. The effect of unpublished positive or negative studies generated by chemical industry–funded research also cannot be assessed. Many good-quality studies were found in the review, however, and taken together, the results provide sufficient cause for family doctors to educate patients and to act to prevent unnecessary pesticide exposure.

Conclusion

This systematic review provides clear evidence that pesticide exposure increases risk to human health across a range of exposure situations and vulnerable populations. Public support for restrictions on pesticide use is growing; 71% of respondents supported provincewide restrictions in a recent Ontario poll.[143] The Canadian Association of Physicians for the Environment[144] and national pediatric and public health groups in Canada and the United States[145-8] have expressed concern about health effects from cosmetic use of pesticides and recommended that physicians participate in reduction efforts.

Family doctors have a dual role in reducing pesticide exposures. First, during individual encounters, we can educate patients about pesticide health effects,[149] monitor through exposure histories[150] and laboratory tests,[151] and advise when we believe the level of exposure poses a health threat. We should encourage harm reduction through use of protective equipment when pesticide exposure is necessary. Advice about use of protective

Practice tips based on the review

1. Advise patients to avoid pesticide exposure during critical reproductive periods. This includes occupational, indoor, lawn, and garden exposure to pesticides.
- For women, the critical period for early spontaneous abortion is before pregnancy, and for late spontaneous abortion, the first trimester.
- For men, the critical period is the 3 months of spermatogenesis before conception.

2. Take a pesticide-exposure history from patients who have adverse reproductive events, such as intrauterine growth restriction, prematurity, inability to conceive in 1 year, or birth defects.
- Birth defects are associated with both maternal and paternal exposure to pesticides before conception and during the first trimester.
- Most exposures are work related, but transposition of the great vessels is increased with household exposure.

3. Screen patients with a history of exposure to pesticides for neurologic conditions (which can be subtle).
- Occupationally exposed adults are at increased risk of neurologic symptoms, including neurobehavioural changes and Parkinson disease.

4. Use biomonitoring as an effective tool to reduce exposure. Biomonitoring for recent (within 3 months) organophosphate insecticide exposure is done by ordering red blood cell cholinesterase tests.[2] The test is covered by the Ontario Health Insurance Plan; in other provinces, it costs $25 to $100, but might be covered for exposed workers.

equipment is an important and neglected area of family practice,[152] although it is an effective intervention for reducing pesticide exposure.[133,153] Then, in our role as public and community health advocates, we need to educate the public about the health effects of pesticide use. We need to reinforce community efforts to reduce cosmetic use of pesticides that can disproportionally affect children, pregnant women, and elderly people.

Contributors

Dr Sanborn, **Dr Kerr**, **Dr Sanin**, **Dr Cole**, **Ms Bassil**, *and* **Dr Vakil** *contributed to concept and design of the study, data analysis and interpretation, and preparing the article for submission.*

Competing interests

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Attachment 4

A Cost Comparison of Conventional (Chemical) Turf Management and Natural (Organic) Turf Management for School Athletic Fields

A report prepared by
Grassroots Environmental Education
A non-profit organization

Written by
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& Doug Wood

March, 2010

A Cost Comparison of
Conventional (Chemical) Turf Management
and Natural (Organic) Turf Management
for School Athletic Fields

Introduction

The mounting scientific evidence linking exposure to pesticides with human health problems, especially in developing children, has increased the demand for non-chemical turf management solutions for schools. One obstacle commonly cited by chemical management proponents is the purported higher cost of a natural turf program.

This report compares the annual maintenance costs for a typical 65,000 square foot high school football field using both conventional and natural management techniques. Both programs are mid-level turf management programs, typical of those currently being used at many schools across New York State.[1]

The analysis of data demonstrates that once established, a natural turf management program can result in savings of greater than 25% compared to a conventional turf management program. (Fig. 1)

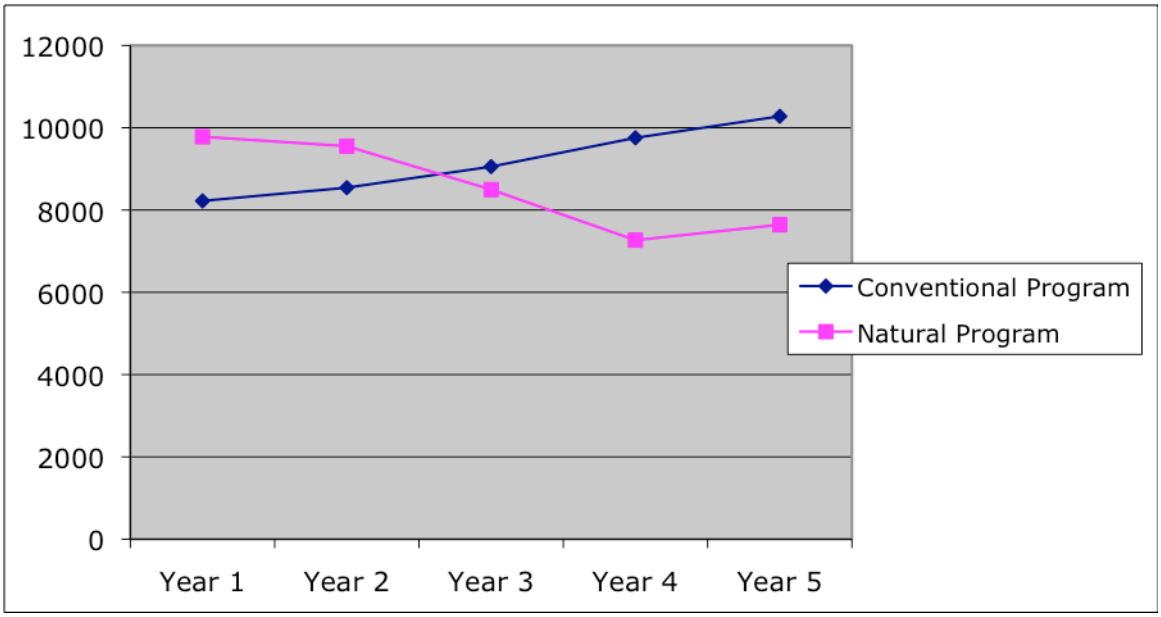

Figure 1: A Comparison of Costs for Conventional and Natural Turf Programs Over A Five-Year Period

[1] We recognize that some schools will spend considerably less for field maintenance than our example, and some will spend much more. The turf management programs chosen for this comparison are designed to yield similar aesthetic results.

Background

Prior to 1950, all school playing fields were maintained organically. The widespread use of chemical pesticides to control weeds, insects and turf diseases on school playing fields began in the post-World War II era, when chemical companies sought to establish markets for their products in the agricultural, consumer and municipal sectors. By the mid-1990s, former New York State Attorney General Robert Abrams estimated that 87% of public schools in the state were using chemical pesticides on their fields.[2]

As awareness of the risks associated with pesticides has grown and demand for non-toxic solutions has increased, manufacturers and soil scientists have responded with a new generation of products and technologies that have changed the economics for natural turf management. Product innovation has resulted in more effective products, and advances in soil science have increased understanding of soil enhancement techniques. Virtually all major turf chemical manufacturers now offer an organic product line. Professional training and education have also increased, with most state extension services and professional organizations now offering training courses in natural turf maintenance.

Sources of Data

The products, costs, application rates and other data for our analysis have been obtained from various sources, including the Sport Turf Managers Association[3], Iowa State University[4], bid specifications from a coalition of public schools on Long Island,[5] bids and proposals from conventional turf management companies, and documented costs for existing natural programs.

Economic Assumptions

This analysis is based on the cost of operating in-house turf programs. Sub-contracted programs typically cost 30-35% more. Both programs include fertilization, seeding and aeration. All product costs are based on quantity institutional purchases, with a calculated 7% annual cost increase. Labor costs have been calculated based on a municipal employee @ $40,000 including

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[2] *Pesticides in Schools: Reducing the Risks*, Robert Abrams, Attorney General of New York State, March 1993.

[3] "2009 Field Maintenance Costing Spreadsheet" published by the STMA. Available online at www.stma.org/_files/_items/stma-mr-tab6-2946/docs/field%20maintenance%20costing%20spreadsheet.pdf

[4] "Generic Football Field Maintenance Program" by Dr. Dave Minner. Department of Horticulture, Iowa State University.

[5] "Invitation to Bid, Organic Lawn Care Field Maintenance and Supplies," Jericho Union Free School District, Jericho, NY on behalf of 31 school districts.

benefits, calculated at $20 per hour. Indirect costs for pesticide applicator licenses, training, storage/security and DEC compliance costs have been estimated at $500 per year. Fertilization for both programs has been calculated at the rate of 5 lbs of nitrogen (N) per 1000 SF. Grub and/or insect controls may or may not be necessary. Compost has been calculated at a cost of $40 per yard. Seeding rate is calculated at 5 lbs/1000 SF. Cost of water is estimated at $0.003212/gal.[6] [7]

Irrigation

Irrigation costs for turf maintenance are considerable, but are generally less for naturally maintained fields due to deep root growth and moisture retention by organic matter. Estimates of irrigation reduction for natural turf programs range from 33% to more than 50%. This analysis uses a conservative diminishing factor for irrigation reduction for the natural management program, starting with 100% in the first year as the field gets established down to 60% in the third year and beyond. Some school districts may experience greater savings.

Soil Biology

One of the most critical factors in the analysis – and the one most difficult to assess - is the availability and viability of microbiology on fields that have been maintained using conventional chemical programs. The microbiology that is essential for a successful natural turf management program can be destroyed or severely compromised by years of chemical applications. In this analysis, we have assumed a moderate level of soil biology as a starting point; the compost topdressing in years 1-3 is part of the rehabilitation process required to restore the soil to its natural, biologically active state.

Reducing Fertilization Costs

Once playing fields have been converted to a natural program and the percentage of organic matter (%OM) has reached the desired level (5.0-7.0), additional significant reductions in fertilization costs can be realized using compost tea and other nutrients (humic acid, fish hydrolysates) applied as topical spray, rather than using granular fertilizers.

The following chart shows the product cost benefits of switching to an organic nutrient spray program, and amortizing the $10-12,000 capital cost for equipment over three years. (Fig. 2)

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[6] Water usage computed using STMA recommended irrigation rate of one inch/week for Junior High football field. Iowa State University recommends 1.75 inches per week for football fields.

[7] Price computed using NUS Consulting International Water Report for 2008 average US water cost per m3 adjusted for inflation.

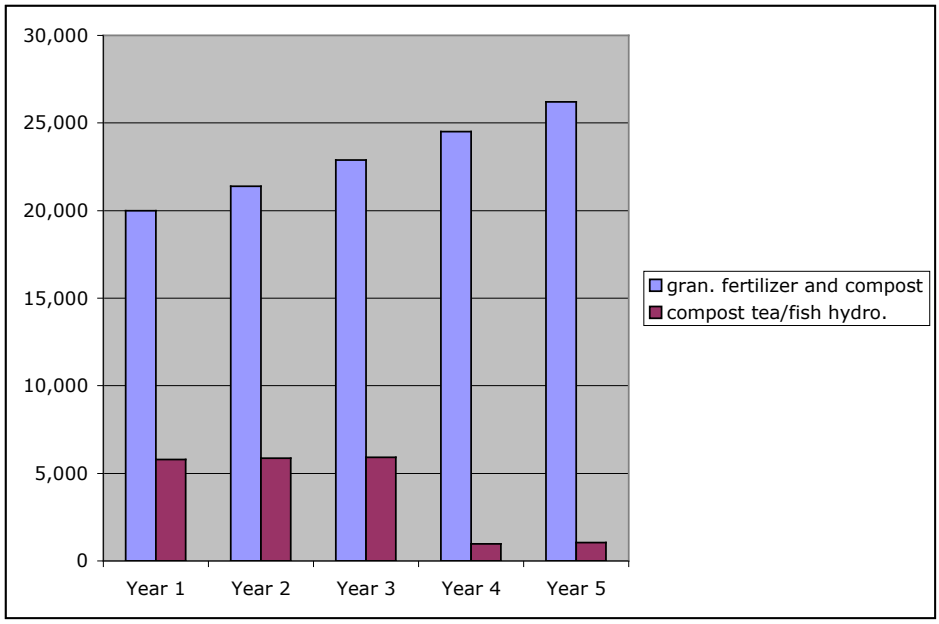

Figure 2: Cost comparison of granular fertilizer and compost compared to spraying compost tea and fish hydrolysates in Marblehead, MA.[8]

Conclusion

This analysis demonstrates that the cost of a natural turf management program is incrementally higher in the first two years, but then decreases significantly as soil biology improves and water requirements diminish. Total expenditures over five years show a cost savings of more than 7% using natural turf management, and once established, annual cost savings of greater than 25% can be realized.

About the authors:

Charles Osborne *is a professional turf consultant, working with municipalities and school districts in the Northeast to help them develop effective natural turf management programs. A professional grower with more than thirty years of experience in greenhouse and turf management, Mr. Osborne is the Chairman of the Town of Marblehead Recreation, Parks, and Forestry Commission where he oversees the management of the Town's school and municipal fields.*

Doug Wood *is the Associate Director of Grassroots Environmental Education, an environmental health non-profit organization which developed the EPA award-winning program, "The Grassroots Healthy Lawn Program." He is also the director and producer of the professional video training series "Natural Turf Pro."*

[8] *To address concerns over the potential phosphorus content of compost tea (contained in the bodies of microbes) only high-quality vermicompost should be used for tea production. Animal manure teas, popular with farmers for generations, are not suitable for use on lawns or playing fields.*

COMPARISON OF CONVENTIONAL (CHEMICAL) AND NATURAL (ORGANIC)
TURF MANAGEMENT PROGRAMS: YEAR ONE

CONVENTIONAL PROGRAM		Year 1	Year 1	Year 1
		cost	cost	total
		prod	labor	
April	fert/pre-emergent	$250	$95	$345
May	fertilizer	$225	$95	$320
June	grub or insect	$325	$95	$420
June	post-emergent	$90	$150	$240
July	fertilizer	$225	$95	$320
Sep	fertilizer	$225	$95	$320
Nov	fertilizer	$225	$95	$320
June	seed	$700	$150	$850
Sep	seed	$700	$150	$850
aerate	3 times	$0	$375	$375
	irrigation	$3,212	$150	$3,362
	indirect costs			$500
	Total Cost			**$8,222**
NATURAL PROGRAM				
		Year 1	Year 1	Year 1
		cost	cost	total
		prod	labor	
April	fertilizer	$610	$115	$725
June	fertilizer	$610	$115	$725
June	liquid humate	$120	$100	$270
July	fish/compost tea	$100	$100	$250
Sep	fertilizer	$610	$115	$725
Jun	seed	$700	$150	$850
Sep	seed	$700	$150	$850
	aerate 3x	$0	$375	$375
Jun	topdress	$1,300	$350	$1,650
	irrigation	$3,212	$150	$3,362
	Total Cost			**$9,782**

COMPARISON OF CONVENTIONAL (CHEMICAL) AND NATURAL (ORGANIC)
TURF MANAGEMENT PROGRAMS: YEAR TWO

CONVENTIONAL PROGRAM		Year 2	Year 2	Year 2
		cost	cost	total
		prod +7%	labor	
April	fert/pre-emergent	$267	$95	$362
May	fertilizer	$240	$95	$335
June	grub or insect	$347	$95	$335
June	post-emergent	$96	$150	$246
July	fertilizer	$240	$95	$335
Sep	fertilizer	$240	$95	$335
Nov	fertilizer	$240	$95	$335
June	seed	$750	$150	$900
Sep	seed	$750	$150	$900
aerate	3 times	$0	$375	$375
	irrigation	$3,436	$150	$3,586
	indirect costs			$500
	Total Cost			**$8,544**
NATURAL PROGRAM				
		Year 2	Year 2	year 2
		cost	cost	total
		prod+7%	labor	
April	fertilizer	$653	$115	$768
June	fertilizer	$653	$115	$768
June	liquid humate	$128	$100	$228
July	fish/compost tea	$107	$100	$207
Sep	fertilizer	$653	$115	$768
Jun	seed	$750	$150	$900
Sep	seed	$750	$150	$900
	aerate 3x	$0	$375	$375
Jun	topdress	$1,390	$350	$1,740
	irrigation	$2,749	$150	$2,899
	Total Cost			**$9,553**

COMPARISON OF CONVENTIONAL (CHEMICAL) AND NATURAL (ORGANIC) TURF MANAGEMENT PROGRAMS: YEAR THREE

CONVENTIONAL PROGRAM		Year 3	Year 3	Year 3
		cost	cost	total
		prod +7%	labor	
April	fert/pre-emergent	$285	$95	$380
May	fertilizer	$256	$95	$351
June	grub or insect	$371	$95	$467
June	post-emergent	$103	$150	$253
July	fertilizer	$256	$95	$351
Sep	fertilizer	$256	$95	$351
Nov	fertilizer	$256	$95	$351
June	seed	$775	$150	$925
Sep	seed	$775	$150	$925
aerate	3 times	$0	$375	$375
	irrigation	$3,676	$150	$3,826
	indirect costs			$500
	Total Cost			**$9,055**
NATURAL PROGRAM				
		Year 3	Year 3	Year 3
		cost	cost	total
		prod +7%	labor	
April	fertilizer	$699	$115	$814
June	fertilizer	$0	$0	$0
June	liquid humate	$137	$100	$237
July	fish/compost tea	$114	$100	$214
Sep	fertilizer	$699	$115	$814
Jun	seed	$775	$150	$925
Sep	seed	$775	$150	$925
	aerate 3x	$0	$375	$375
Jun	topdress	$1,487	$350	$1,837
	irrigation	$2,206	$150	$2,356
	Total Cost			**$8,497**

COMPARISON OF CONVENTIONAL (CHEMICAL) AND NATURAL (ORGANIC) TURF MANAGEMENT PROGRAMS: YEAR FOUR

CONVENTIONAL PROGRAM		Year 4	Year 4	Year 4
		cost	cost	total
		prod +7%	labor	
April	fert/pre-emergent	$305	$115	$420
May	fertilizer	$274	$115	$389
June	grub or insect	$416	$115	$531
June	post-emer	$110	$170	$280
July	fertilizer	$274	$115	$389
Sep	fertilizer	$274	$115	$389
Nov	fertilizer	$274	$115	$389
June	seed	$800	$170	$970
Sep	seed	$800	$170	$970
aerate	3 times	$0	$425	$425
	irrigation	$3,933	$170	$4,103
	indirect costs			$500
	Total Cost			**$9,755**
NATURAL PROGRAM				
		Year 4	Year 4	Year 4
		cost	labor	total
		prod +7%		
April	fertilizer	$0	$0	$0
June	fertilizer	$0	$0	$0
June	liquid humate	$150	$120	$270
July	fish/compost tea	$500	$720	$1,220
Sep	fertilizer	$748	$135	$883
Jun	seed	$800	$170	$970
Sep	seed	$800	$170	$970
	aerate 3x	$0	$425	$425
Jun	topdress	$0	$0	$0
	irrigation	$2,360	$170	$2,530
	Total Cost			**$7,268**

COMPARISON OF CONVENTIONAL (CHEMICAL) AND NATURAL (ORGANIC) TURF MANAGEMENT PROGRAMS: YEAR FIVE

CONVENTIONAL PROGRAM		Year 5	Year 5	Year 5
		Cost	cost	total
		prod + 7%	labor	
April	fert/pre-emergent	$326	$115	$441
May	fertilizer	$294	$115	$409
June	grub or insect	$445	$115	$560
June	post-emergent	$117	$170	$287
July	fertilizer	$294	$115	$409
Sep	fertilizer	$294	$115	$409
Nov	fertilizer	$294	$115	$409
June	seed	$856	$170	$1,026
Sep	seed	$856	$170	$1,026
aerate	3 times	$0	$425	$425
	irrigation	$4,208	$170	$4,378
	indirect costs			$500
	Total Cost			**$10,279**
NATURAL PROGRAM				
		Year 5	Year 5	Year 5
		cost	labor	total
		prod + 7%		
April	fertilizer	$0	$0	$0
June	fertilizer	$0	$0	$0
June	liquid humate	$160	$120	$280
July	fish/compost tea	$535	$720	$1,255
Sep	fertilizer	$800	$135	$935
Jun	seed	$856	$170	$1,026
Sep	seed	$856	$170	$1,026
	aerate 3x	$0	$425	$425
Jun	topdress	$0	$0	$0
	irrigation	$2,525	$170	$2,695
	Total Cost			**$7,642**