production in Fiji. When compared with other LDC cash crop production systems such as rice, cocoa, maize, soybean, and fruit and vegetable production, the application of pesticides in Fijian sugarcane is relatively low intensity use. Reducing pesticide use in sugarcane would have a small net effect on productivity because the relatively small decrease in use levels would be largely offset by a general increase in overall health of the farm population leading to increased labour productivity.

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work lost per year due to general illness and an average expenditure of $328 per year, significantly lower than the user group. This appears to reinforce the findings of users' health levels significantly below those of farmers that do not use pesticides.

Noteworthy in the above results is the initial positive health assessment by the great majority of users followed by a willingness to be straightforward about the health problems they have experienced and that continue to trouble them. We expect the former positive assessment is affected to a great extent by the socio-cultural environment surrounding the Indian male in rural society. Male dominant cultures put great stock in strength, vitality, and virility, conditions obviously directly affected by the state of one's health. It should not be surprising that the majority of men surveyed would claim to conform to these hallmarks of the dominant male model despite the middle aged character and the stated medical problems of the user population.

We interpret the frankness with which medical problems were reported to be, in part, due to a type of cognitive dissonance at work in the user population. That is, knowing what the social norms of the culture require and paying obeisance to these but also acknowledging the risks involved in using pesticide products and willing or even anxious to report the effects of engaging in this risky activity. It appears that proximity to pesticides has had a significant negative influence on the overall health of users of pesticide products.

Policy and research implications

Our survey results indicate that farmer health is negatively affected by the types of exposure that are common in farm pesticide use. Impaired health has the potential to negatively affect farm productivity. Therefore policies aimed at educating the farm population about both the acute and chronic effects of pesticide exposure are necessary to rationalize the use of pesticide products in sugarcane production. Educational approaches could include better handling, disposal, and protective measures that could be used to mitigate the effects of pesticide exposure. But a more effective way to decrease acute and chronic risks involved in pesticide use would be to devote resources toward research and implementation of alternative weed management measures in sugarcane. Some of these methods could include the development of economic thresholds for specific weeds common to sugarcane fields; more efficient and effective hand weeding tools; and, the development of weed resistant (rather than pesticide resistant) sugar cultivars that provide self-protection from nutrient-leaching weeds.

We think it noteworthy that the survey evidence of impaired health resulted from exposure to herbicides which are generally less toxic relative to insecticides. However, the most popular herbicidal materials used in sugarcane production in Fiji are some of the more toxic of the herbicidal compounds including paraquat and 2,4-D. We believe that focusing resources to provide farmers with effective alternative materials and methods thereby helping to remove the more hazardous materials from general farm use would contribute significantly to improved rural health and increased productivity in the farm sector.

This study establishes an initial link between pesticide use and health impairment among sugarcane farmers in the Pacific region. Diminished health levels have the potential to negatively affect farm productivity. Reducing pesticide use may decrease overall sugarcane productivity but the improvement in short and long term health in the rural population may offset these production losses from a social welfare perspective.

Insufficient resources are currently being devoted to the development of efficient feasible alternatives to chemical pesticide products in sugarcane

Table 14. Pesticide application characteristics and health impacts; pesticide use and health impacts study, Fiji, December 1998.

	Users				Non-users			
	Mean	Median	Min	Max	Mean	Median	Min	Max
Pesticide applications	1.9	2.0	1	10	-	-	-	-
pesticide expenditures ($)	515.	300.	30.	5000.	-	-	-	-
Average # of days of work lost per year over the past 5 years due to pesticide related illness	2.4	0.5	0	70	-	-	-	-
Average medical expenses incurred per year over the past 5 years due to pesticide related illness ($)	33.00	5.00	0.00	1000.	-	-	-	-
Average # of days of work lost per year over the past 5 years due to general illness	35.3	9.0	0	250	12.5	7	0	75
Average medical expenses incurred per year over the past 5 years due to general illness ($)	821.	400.	0.	5000.	328.	200.	5	1000

Gastro-intestinal problems: The gastro-intestinal tract is another important site for the metabolism of many pesticides. Exposure to 2,4-D, paraquat, and dichlorprop can cause GI problems including nausea, vomiting, diarrhea, GI pain, and bleeding. Ten percent of the users reported nausea related to pesticide exposure while 32 percent reported chronic GI problems. Thirty six percent of non-users reported similar problems. Diet may be a significant contributing factor in both groups in this instance. The predilection for "hot" spices by the Indo-Fijian as both a condiment and an integral cooking ingredient makes the Indian more susceptible to GI distress. Many survey respondents in both groups blamed diet for their gastric problems.

Application characteristics and health impacts

Users averaged two pesticide applications per season, generally herbicides, but also an insecticide application if their vegetable production warranted. Average yearly expenditure on pesticide products amounted to $515 (table 14).

Some users were able to link pesticide exposure to acute episodes of ill health and reported losing 2.4 work days per year to the effects of pesticide "poisoning". However the more telling statistic is the average loss of 35 work days per year to general illness. The range of days lost from work varied from zero to 250 with the median at 9 days lost. By comparison the non-user group reported 12.5 days of

Table 12. Self-ranking of non-user farmer health status.

Question: Please rank your overall health status over the past 5 years	Percentage of non-user farmers				
	Chronically ill with major illnesses (1)	frequently ill with minor illnesses (2)	average # of illnesses based on friends and family (3)	very rarely ill (4)	perfect health - never sick (5)
	12.9	0.0	29.0	22.6	35.5

Table 13. Long term medical problems reported by non-user farmers.

Question: Over the last 10 years have you experienced medical problems associated with your:	Percent of non-user farmers				
	eyes	skin	respiratory tract	nervous system	gastrointestinal tract
	12.9	9.7	19.4	12.9	35.5

Dermal problems: The main mode of entry into the body of pesticide materials is through the skin. Contamination occurs typically when mixing materials in preparation for application as well as during the application process. Approximately 16 percent of users reported having experienced skin problems, skin lesions or rash, which they traced directly to pesticide exposure. Thirty percent described themselves as suffering from chronic skin problems. Ten percent of non-users suffered from chronic maladies of the skin.

Respiratory problems: The lungs are an important site for the metabolism of many pesticidal compounds. Typical complaints that could originate or be aggravated by pesticide exposure include asthma, chronic cough, excess sputum, and wheezing. Twenty percent of farmers reported respiratory problems linked directly to pesticide exposure. Smoking cigarettes also contributes to respiratory problems. Approximately 37 percent of users smoked cigarettes regularly. Forty percent of users surveyed complained of long term problems with their respiratory tracts. Thirty one percent of non-users smoked cigarettes though only nineteen percent reported chronic respiratory problems.

Neurological problems: Many pesticide compounds disrupt neurological transmission. Most insecticides rely on this mode of action to be effective in controlling target insect pests. However, many herbicides also have neurotoxic characteristics as an adjunct to their principal action pathways for control of weeds. 2,4-D, paraquat, and glyphosate all exhibit neurotoxic effects. Sixteen percent of users complained of tingling in fingers directly related to pesticide exposure; 5 percent complained of desensitization in their extremities. Chronic neurological problems were reported by 26 percent of surveyed users. Thirteen percent of the non-user group had similar complaints.

Table 10. Percent of farmers reporting clinical symptoms as a direct result of pesticide exposure.

Question: What symptoms have you experienced directly related to pesticide exposure?	Percent of user-farmers								
	headache	nausea	tingling in fingers	difficulty breathing	blurred vision	loss of appetite	skin lesions	rash	decreased feeling in extremities
	35.4	10.4	16.0	20.1	24.3	3.5	16.0	27.8	5.6

Table 11. Long term medical problems reported by farmers.

Question: Over the last 10 years have you experienced medical problems associated with your:	Percent of user-farmers				
	eyes	skin	respiratory tract	nervous system	gastrointestinal tract
	49.3	31.3	37.5	26.4	31.9

without directly implicating pesticides, half the user respondents reported problems with their eyes, while lesser numbers reported problems with their skin, nervous system, respiratory and gastrointestinal tracts (table 11).

Table 12 provides the results of the health status question posed to non-user farmers.

Table 13 reports long term medical problems by the non-user group.

When compared with the control group the user-farmers had significantly greater incidence of systemic organic disease. The user group's exposure and proximity to pesticide materials may be an important factor in contributing to these higher rates of chronic illness and morbidity. Certainly there exist other contributory factors to ill health in the rural population besides pesticide exposure; diet, access to health care facilities for acute care needs and/or health maintenance; a hereditary predisposition to chronic illness, or other social or environmental factors. However, the nature of the specific pesticide materials in common use in sugarcane production strongly suggests the culpability of pesticides in these higher rates of illness and disease in the user group.

The following describes specific medical disorders associated with the use of the more popular herbicides in Fiji cane production.

Eye problems: Herbicides such as 2,4-D and paraquat are known eye irritants. Chronic irritation can lead to a number of eye problems including cataracts and the development of a vascular membrane over the eye (pterygium) leading to decreased vision. Forty-nine percent of user-farmers reported chronic eye problems compared with thirteen percent of the non-users.

Table 8. Farmers attitude towards the use of pesticide products.

Question: How do you rate your attitude toward pesticide products?	Percentage of farmers responding				
	no concern	some concern but time and money saving	concerned but safe if used properly	very concerned but benefits > risks	very concerned and use when all else fails
	6.9	13.9	39.6	25.7	14.6

Table 9. Self-ranking of user-farmer health status.

Question: Please rank your overall health status over the past 5 years	Percentage of user-farmers				
	Chronically ill with major illnesses (1)	frequently ill with minor illnesses (2)	average # of illnesses based on friends and family (3)	very rarely ill (4)	perfect health - never sick (5)
	9.0	16.7	9.7	43.8	21.5

not necessarily associated with pesticide exposure.

Recent research has indicated this self-ratingmethod of assessing personal health status to be as effective in determining actual physical condition of survey respondants as evaluating medical records (Idler and Benyamini, 1997). Self-ratings of health in population studies are many times employed because they are "simultaneously economical measures of health status as well conversational ways to open the topic of health status when it is to be covered in the interview in more detail" (op. cit.), which suscinctly describes our motivation for using the methodology.

Most users (79%) expressed concern about the health impacts of using pesticides but in general thought the benefits outweighed the risks (Table 8). Only 7% of users had no concern about the impact of pesticide use on their health. Despite this generally positive view of using pesticides, significant numbers of users reported suffering acute episodes of what could be termed "pesticide poisoning", or having experienced an adverse reaction to pesticide exposure.

Although a majority of users described their overall health status as being good (rarely ill) to excellent (never sick) (table 9), relatively large numbers of respondents reported suffering from acute pesticide poisoning symptoms as a direct result of pesticide exposure including headache, rash, blurred vision, difficulty in breathing, skin lesions, and tingling in fingers (table 10).

When asked the overall status of organ systems that are typically affected by pesticide exposure during World War II by American scientists to be used as a defoliant against Japanese food crops in preparation of a planned allied invasion of the Japanese home islands in an attempt to end the war in the Pacific. While not used for its intended purpose 2,4-D was commercialized at the end of WWII and quickly adopted by farmers and used as a method to decrease labour input in farming. It paved the way for the intensification of research and development by both public agencies and private chemical firms into expanding the variety of chemical pesticide products available to agriculture.

In recent years 2,4-D and the chlorophenoxy herbicides group have been implicated as causal factors in the development of certain cancers in agricultural workers in Northern Europe and the United States (Hardell and Sandstrom, 1979; Hoar et al. 1986; Hardell and Eriksson, 1988). In addition, 2,4-D has been identified as having medium to high acute toxicity ratings as established by the WHO.[6] Other studies have linked 2,4-D to a wide range of long term toxic effects including heart, liver, and kidney damage, and central nervous system disorders (Sjoden and Soderberg, 1978).

Diuron 90 (90% a.i.), and Karmex (diuron 80% a.i.) was used by 71% of the survey respondents. Diuron is a residual herbicide used for both pre and post-emergence applications. The herbicide has been classified as having low to medium acute toxicity while exhibiting carcinogenic, mutagenic, and growth inhibiting long term effects (Council on Scientific Affairs, American Medical Association, 1988).

Gramaxone (paraquat 20% a.i.) was used by 43 percent of respondents. Paraquat is a non-selective compound used to control grasses and broadleaf weeds and is one of the more toxic materials usedfor weed control. Its acute toxicity ratings range from high to very high while chronic effects cover the entire spectrum of mammalian susceptibility topesticidal compounds including mutagenicity, neurotoxicity, all major organ system damage and may be a possible contributor to the onset of Parkinson's Disease (Bocchett and Corsini, 1986).

Agroxone (MCPA), used by 20 percent of surveyed farmers, is a phenoxy-acetate compound in the same chemical family as 2,4-D and is a post-emergence chemical used to control broadleaf weeds. It is classified as having medium oral acute toxicity while its dermal and inhalation impacts have not been established. Its long term impact is as a suspected carcinogen and teratogen.

Canespray (30% 2,4-D plus 7.5% dicamba) was used by 11 percent of farmers surveyed. Dicamba when combined with 2,4-D is used post-emergence to control broadleaf weeds. Combining 2,4-D and dicamba in a single pesticide product increases the coverage and potential effectiveness of the pesticide application but also increases the tandem product's potential toxicity.

Assessing the health effects of pesticide exposure

We asked user-farmers initially their attitude with regard to the use of pesticides in their production system and then to evaluate their health status from three different perspectives: a) an overall subjective evaluation of their personal health; b) health problems they had recognizably experienced from pesticides through either accidental or habitual exposure; and, c) long term health problems

[6] Acute toxicity ratings are determined according to LD50 and LC50 laboratory results in measuring oral, dermal, and inhalation poisoning. LD50 refers to the dosage that is sufficiently high to cause mortality in 50 percent of the laboratory animals, usually rats, to which that dose has been given. LC50 refers to the concentration in the air of a gaseous material sufficient to cause mortality in 50 percent of laboratory animals exposed to the altered atmosphere.

Table 7. Percent of sampled farmers using mentioned herbicides; pesticide use and health impacts study, Fiji, December 1998.

Herbicides (active ingredient)[4]	% of sample
Weedkiller E40 (40% 2,4-D) Weedkiller E80 (80% 2,4-D)	88.9%
Diuron (Diuron)	70.8
Gramaxone (paraquat)	43.1
Agrazone (MCPA)	20.1
Canespray (2,4-D+Dicamba)	11.1
Roundup (glyphosate 360g/l)	4.2
Sting (glyphosate 120g/l)	5.6
Weedone (2,4-D+dichlorprop)	0.7
Asulox (Asulam)	0.7

The tropical climate and rich soils of Fiji are conducive to the growth of generally all tropical plant species. Weed species pose problems for the farmer because of their competition with cash or subsistence crops for water, sunlight, and mineral nutrients in the soil, the specific competition dependent on the growth patterns and size of the weed relative to the agronomic crop. Unchecked weed growth in Fiji cane fields has been demonstrated to decrease cane production by between 20 and 50 percent (Sugar Technical Advisory Mission, 1996).

The Fiji sugar farmer uses an array of herbicides in response to weed infestations. Sampled farmers reported using 20 different commercially available products. However four different compounds dominated the responses (table 7).

The chlorophenoxy herbicide 2,4-D in two different formulations, 40% active ingredient (a.i.) (Weedkiller E40) and 80% a.i. (Weedkiller E80), was reported applied by 89 percent of the sampled farmers. These two formulations of 2,4-D are selective and systemic herbicides applied mainly in post-emergence applications for the control of broadleaf weeds.[5]

2,4-D is the most popular pesticide by volume worldwide (United States Department of Agriculture, 1996). It is also the oldest having been developed

[4] Active ingredient is that portion of the commercial pesticide formulation that is the pesticidal agent. Other components of the commercial product may include water, surfactants, and other inert ingredients.

[5] Postemergence application implies treating for weed infestations after weeds have germinated and emerged from the soil. Preemergence implies applying a herbicide after a crop is sown but before the crop emerges from the ground.

Table 6. Number of farmers and land area devoted to sugarcane production on Viti Levu and Vanua Levu

Island/ Mill District	1997	
	# Farmers	Land Area (ac)
Viti Levu		
Lautoka	8,249	61,698
Rarawai	5,888	50,763
Penang	2,503	14,462
Vanua Levu		
Labasa	5,477	54,157
Total	22,117	181,080

Source: Sugarcane Growers Council, Fiji Cane Grower, July/August 1998.

hours duration per day generally after school or during school holiday periods.

The non-user farm was significantly smaller comprising on average about 10 acres which may be a contributing factor in the farmer decision not to use pesticides: smaller land area and most probably the associated constrained financial ability to purchase pesticide products. Average output was also correspondingly smaller on the non-user farm while the percentage of farmland devoted to the production of sugarcane was significantly higher. Also noteworthy was the difference between groups in years of land tenure as well as years to lease expiration.

The non-user group had been farming the same property significantly longer which may possibly contribute to a conservative approach to incorporating "new" technologies on the farm. Alternatively, a shorter interval to lease expiration, with uncertainty regarding the possibilities for renewal, may lead to diminished productivity on the farm, with family energies focused on non-farm revenue generating activities. Indeed, 48 percent of non-users worked full or part-time off the farm or had a spouse that did.

Pesticide use in sugar production

In 1997 the farming of sugarcane in Fiji occupied approximately 181,000 acres, or 32 percent of arable land under cultivated agriculture. The total number of sugarcane farms, 22,000, operate on a relatively small average land area; about 8.2 acres. All commercial sugarcane is produced on Fiji's two principal islands, Viti Levu and Vanua Levu with the former having 75% of the total number of farmers and 70% of land area devoted to sugarcane (table 6).

Sugar exports in 1996 were worth F$294 million (A$231) which accounted for 29 percent of total merchandise exported. It is estimated that approximately 200,000 persons of the total Fiji population of 780,000 owe their livelihood either directly or indirectly to the sugar industry (Barbour, 1998).

Table 4. Farm characteristics; pesticide use and health impacts study, Fiji, December 1998.

Farm Characteristics	Users			Non-Users		
	Mean	Min	Max	Mean	Min	Max
Acres	21.8	3	129	10.2	3	32
Sugar production (1994-98 average)	24.4	5	67	20.4	5	40
Years family farming this land	35.7	4	100	57.9	5	120
Number of years to lease expiration	9.0	-5*	50	3.7	-5*	28
Years growing sugar	29.1	3	70	26.3	5	60
% of land in sugar production	84.9	10	100	96.0	50	100
% of land devoted to other crops	7.2	0	68	4.0	0	50

* Negative sign indicates lease expiration had already occurred 5 years prior to the date of the survey (December, 1998).

Table 5. Other demographics, pesticide use and health impacts study, Fiji, December 1998.

Traits	Users	Non-Users
Race	Indo-Fijian = 97% Fijian = 3%	Indo-Fijian = 90% Fijian = 10%
Marital Status	Single/Widow/Widower = 2% Married = 98%	Single/Widow/Widower = 10% Married = 90%
Land tenure status	Lease = 88% Freehold = 12%	Lease = 94% Freehold = 6%
Leases renewed	Yes = 31% No = 69%	Yes = 36% No = 64%
Work for wages off the farm	Yes = 15% No = 85%	Yes = 48% No = 52%
Child (<14) works in the fields	Yes = 33% No = 67%	Yes = 29% No = 71%

Table 2. Demographics of farmers surveyed; pesticide use and health impacts study, Fiji, December 1998.

Demographics	Pesticide Users			Non-Users		
	Mean	Minimum	Maximum	Mean	Minimum	Maximum
Age	49.8	27	83	49.8	24	69
Weight (lbs)	159.7	100	264	155.7	110	220
Height (inches)	67.4	56	77	67.6	62	73
Years of marriage	26.1	1	61	25.1	0	45
School years	8.2	1	19	7.9	0	12
Adult family members	4.4	1	18	4.1	2	10
Children (under 14)	2.4	0	15	2.6	0	7

Table 3. Factors influencing farmers health; pesticide use and health impacts study, Fiji, December 1998.

Activity	% of sample		frequency	Users			Non-Users		
	Users	Non-Users		Mean	Min	Max	Mean	Min	Max
cigarettes	36.6	38.7	Daily (# cigs)	7.5	1	40	2.6	1	10
alcohol	60.7	64.5	Weekly (#bottles)	2.5	1	14	2.2	1	14
yagona	75.2	77.4	Days/wk (bilos/session)	3.6 (10.2)	1 (1)	7 (40)	3.6 (7.4)	1 (1)	7 (20)

working this land for 36 years and he himself had been farming sugar for about 29 years. Half the respondents faced lease expiration within 5 years and 70 percent had either direct information indicating non-renewal of their farm lease or significant doubts about lease renewal (tables 4 and 5).

Users planted 85 percent of their land in sugarcane while devoting about 7 percent of farmland toother crops; in general, vegetables to be used for home consumption. Though the conventional wisdom suggests that many sugar farmers are employed off the farm to augment family income, our user sample included only 15 percent of respondents that engaged in off farm employment (table 5). Approximately 33 percent of users reported using their children to perform field tasks of one to two caused a haphazard and, in general, unsatisfactory rental market in land (Barbour, 1998).

In 1940, The Native Land Trust Board (NLTB) was established to administer the management of native owned lands which comprise 83% of all land in Fiji. Lease lengths were standardised and terms and conditions were made generally uniform on all lands managed under the NLTB. Leased plots were created relatively small in an attempt to maximise lease revenues for native landowners and also to allow access to virtually anyone that wanted to farm the land as a leaseholder.

These factors have contributed to a situation in which mechanization, when it is used, is generally limited to a 60 hp tractor for plowing and cultivation purposes. Harvesting operations employ gangs of manual canecutters; the spreading of fertilizer is many times done manually; and pesticides are applied by means of a backpack sprayer. No attempts to impute efficiencies into cane farming through, for instance, the consolidation of farmland has occurred because of the system of parcelization and lease holding arrangements in place. This situation may change in the near future as most long term leases are due to expire within the next four years. Consolidation may occur to make mechanization viable but all this is dependent on the complexion of the sugar farming industry after the issue of leased lands is resolved. An in depth discussion of this issue is, however, beyond the scope of the present paper.

Small farm size, relatively low income levels, as well as relatively low levels of investment in human capital in the rural areas of the country leads to a situation in which advanced technologies such aschemical pesticides, which require some minimal level of knowledge that goes beyond traditional agricultural practices, may not be used most efficiently nor in a safe manner. We expect that this situation may lead to negative health impacts which in turn hinders the productivity of the farmer, farm worker, and farm family members leading to overall diminished farm productivity.

Rural dwellers affected by pesticide exposure could experience reduced work capacity in the field and a reduction in the ability to make rational farm management decisions. Farmers that do not recognize health impairment as one of the chronic effects of pesticide exposure will not discount the effectiveness of the pesticides being used on their farm to include the risks involved. They will therefore tend to use these materials in excess; that is, beyond the private or socially optimal amount.

Demographics of the surveyed population

The average user in our sample (all male) was 50 years of age, had been married 26 of those years, had spent 8 years in school, had 2.4 children under the age of 14, and lived with those children, his wife, and two other adults in a farm household unit. The average non-user had very similar demographics (table 2).

Chances were about one in three that a user was a smoker of cigarettes, three in five that he imbibed alcohol on a regular basis, and three in four that he consumed yagona (piper methysticum) three or four days per week. Population percentages were comparable with the non-user group. However, non-user smokers consumed significantly fewer cigarettes and drank fewer bilos (cups) of yagona than the user population (table 3).[3]

The user worked a farm whose land area comprised about 22 acres, about twice as large as the typical Fiji sugar farm; his family had been

[3] WHO data indicate that the incidence of cigarette smoking in the general male population of Fiji is 59 percent (WHO website, 1999). No similar comparative statistics are available describing alcohol or yagona in the general Fijian population from either an international or domestic Fijian data source.

systematic weed control program. Personal interviews were conducted by the principal researcher accompanied by an FSC Extension officer over a two day period some months after the pesticide users survey. Again farmers were asked to recall *inter alia*, specifics of their medical histories as well as family medical expenditures over the past five years. T-tests were used to determine statistical significance in the means of selected variables between the two farmer groups.

The Physical Environment

Sugar farming in Fiji is strictly a small holder, labour intensive enterprise. While sugar mill operations at the three mills on Viti Levu and one mill on Vanua Levu are deemed to be reasonably efficient relative to other sugar producing developing nations (Landell Mills, 1991), Fiji sugar farms are inefficient when compared with mechanized industrial farm operations due in part to their small size and their intensive use of labour. Both the topographic characteristics of arable land on the two main islands of Fiji and the complex historical evolution of land tenure account for these inefficiencies.

Topography

Much of the land area on the two principal islands in the Fiji group is mountainous, the eroded remnants of volcanic activity that created the islands. Sugarcane farming occurs along the narrow coastal plain regions of the generally dry northern and western portions of Viti Levu and the northern coast of Vanua Levu. The soils are extremely rich in organic matter and with sufficient rainfall and appropriate levels of management expertise are capable of producing in the range of 40 MT of cane per acre (FSC(a),1998). Production averaged approximately 21.2 MT per acre for the industry between 1992 and 1997 (table 1). Surveyed users averaged 24.4 MT per acre while non-users' mean production was 20.4 MT per acre between 1994 and 1998.

Land Tenure

Land tenure is a politically charged issue in Fiji as it is in many of the small island nations in the Pacific region. Large sugarcane plantations which existed under the British colonial administration[2] imported indentured labourers from south India to work the cane fields rather than using indigenous people and risk disrupting the traditional Fijian way of life which revolved around village society and the cultivation of subsistence crops. Shortly after the cession of Fiji to the British Crown in 1874, legislation was enacted prohibiting the sale of native land. In response, Fijians began leasing their lands, in most instances to former indentured Indian labourers desiringto remain in Fiji and farm rather than return to India. Lack of land tenure legislation, however,

Table 1. Land area, sugarcane production, and average production per acre, Fiji 1992-1997.

	1992	1993	1994	1995	1996	1997
Area harvested (000 ac)	178	183	183	183	183	181
Cane production (000 MT)	3533	3704	4064	4110	4380	3280
Avg prod in MT per acre	19.9	20.3	22.2	22.5	24.0	18.1

Source: FSC, Sugar Cane Research Centre Annual report, 1997-98.

[2] Fiji was granted independence from Great Britain in 1970.

sugarcane farms in the country. A control group of pesticide non-users was also surveyed to provide statistical comparisons.

We suppose that establishing a recognizable link between farmer health and pesticide use would cause the rational producer to include this information into the decision criteria used to determine if and to what extent chemical pesticides are used in his production system. With no established link the value and subsequent use of pesticides in sugarcane production are higher than they would be if more complete information existed.

The paper is essentially divided into three parts. The first provides demographic and other descriptive data arising from the survey of farmers as well as background information depicting some important aspects of growing sugarcane in Fiji. The second part evaluates the health impacts of pesticide use on pesticide users and compares these effects with the control group whose members did not use pesticides for weed control on their farm. The final section provides a summary of our findings and offers some policy recommendations to address the potential problems stemming from pesticide use in Fiji sugarcane.

Methodology and data collection

The farmer survey of pesticide users (users) was conducted over a period of three days in December 1998 shortly after the completion of the sugarcane harvesting season. The Fiji Sugar Corporation (FSC), the monopsonist parastatal which controls production, milling, and the export of sugar in Fiji, identified 150 sugar farmers whose farms were located in the vicinity of the three FSC sugar mills situated on Viti Levu, Fiji's principal island and largest producer of sugarcane. Farmers were interviewed during individual farm visits as well as at FSC field offices where many farmers had travelled to receive governmental drought assistance checks from FSC officers. The 1998 crop year in Fiji was one of severe El Niño-related drought in which the production of sugarcane decreased dramatically from average historical levels. As a consequence the government of Fiji provided farmers with cash subsidies to act as both income support and to assist in rehabilitation of the devastated sugarcane crop.

The survey required farmers to recall from memory details of their use of pesticides. While consulting formal records are, in general, a more reliable method of determining pesticide use patterns and practices, many sugarcane farmers in Fiji do not keep written records of their use of pesticides (FSC(a), 1998). Moreover, as stated previously, pesticide use in sugarcane is generally restricted to the application of herbicides, and for the great majority of farmers just a few varieties of these, making reliance on recollection a reasonable method of data gathering.

Interviews were conducted by student enumerators, each of which was fluent in both Hindi and English. Our user survey contained 97 percent Indian farmers although the actual racial split in the sugarcane farm population is approximately 76 percent Indian and 24 percent indigenous Fijian (FSC(a), 1998). However, we do not believe this discrepancy significantly affected our results.

We also asked farmers to recall the medical costs incurred by them and their families as a result of pesticide exposure as well as average medical expenses incurred for all types of illnesses over the past five years. In addition we inquired about the farmer's personal chronic medical afflictions over the past ten years. Of the 150 potential user contacts, 145 farmers were interviewed and 144 were users of pesticides.

Control Group

The control group (non-users) consisted of 31 farmers who did not use pesticides as part of a

Pesticides and Sugarcane Farming in Fiji: Some Evidence of Health Risks

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The effective and safe use of pesticides requires, *inter alia*, information concerning appropriate pesticide products, dosage and timing of applications, types of protective clothing to be worn to minimize the risk of accidental exposure, appropriate storage and disposal techniques, and minimum time required for safe re-entry of treated fields.[1] Many farmers in LDCs lack such comprehensive pesticide information and therefore place in jeopardy their health as well as the health of their families and rural populations in general when using pesticides in an ad hoc manner. Further, there exists the potential for decreased productivity due to diminished overall health levels associated with pesticide exposure in the rural population, an ironic situation considering the production augmenting or loss prevention intent of pesticide use.

Approximately forty percent of sugarcane farmers in Fiji rely on herbicides for weed control in their fields (Maharaj, 1998). A number of the herbicides commonly used in Fiji sugarcane are classified by the World Health Organization (WHO) as toxicity level II (moderately hazardous) or III (slightly hazardous) and so would be expected to negatively affect the health of those exposed either directly or indirectly. Included among these materials are paraquat (Class II), 2,4-D (Class II), and MCPA (Class III).

Farmers in Fiji and many other LDCs are generally unaware of the actual short term or long term exposure hazards associated with many pesticide products in common use in the production of sugarcane aside from the very obvious taboos of taking pesticides internally or accidently splashing pesticide liquids into the eyes. The acute and chronic hazards therefore do not enter as criteria into the farmer's decision of whether to use pesticides rather than alternative pest management methods.

In this paper we attempt to analyse the farmer health effects associated with pesticide use in the sugarcane farming areas of Fiji. Our approach was implemented through a unique survey of sugarfarmers who used pesticides in Fiji's Western Division which contains the majority of

[1] Some would argue that there does not exist any safe level of pesticide use and that agriculture and in particular LDC agriculture should begin to wean itself from pesticide dependence (Watts, 1995)