Pesticides in Agriculture – A Boon or a Curse? A Case Study of Kerala

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This paper analyses the pesticide use pattern in agriculture and associated management system in Kerala. The recent declining rate in total consumption of pesticides is not a sign of relief as the use of harmful chemicals is rising. The pesticides used in agriculture include chemicals, which are banned and those suggested for restricted use only. The spray fluid concentration and handling pattern are unscientific. The awareness level is very low, which can be attributed to poor training support. The data management and monitoring system is not efficient. The present level of investment in chemical pest control is higher than the optimum and is not economically justified.

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A visible parallel correlation between higher productivity, high chemical input use and environmental degradation and human health effects is evident in many countries where commercial agriculture is widespread. Pesticide use in agriculture and the value of negative externalities are well-documented in Sri Lanka (Van Der Hoek et al 1998; Wilson 2000), Lebanon (Salameh et al 2004), India (Gupta 2004), China (Huang et al 2001), Bangladesh (Rehman 2003), Philippines (Rola and Pingali 1993), Mali (Ajayi 2002), Ecuador (Yanggen et al 2003), Zimbabwe (Maumbe and Swinton 2003) and Vietnam (Dung and Dung 1999). These externalities are reported to be very high and show a rising trend in many of the developing countries (WHO 1990; DTE 2001; Rosenstock et al 1991; Pimentel 1992; Kishi et al 1995; WRI 1998). At the same time, the consumption of pesticides in these parts of the world is comparatively less. This paradox is mainly attributed to the unscientific use and handling practices which are attributed to the general poverty level, low literacy rate and awareness, general lethargy in adopting scientific management practices, an inefficient monitoring system and the climatic factors. Furthermore, the decision to invest in chemical pest control operations is governed by risk perceptions of farmers (Devi et al 2007). The financial rationality based on marginal returns is not considered in decision-making, thus, resulting in inefficient levels of investment and spiralling effects.

The socio-economic scenario in the agricultural sector in many of the developing countries warrants the substitution of labour with machines and chemicals, at a faster pace (Huang and Rozelle 1996). The emerging agricultural scenario in favour of agribusiness is likely to increase the use of pesticides further and the resultant environmental and human health problems thereof.

The alternative pest management models (Integrated Pest Management – IPM) to reduce pesticide use could not find much success due to poor farmer participation due to varying reasons. An all-India survey confirmed that 34% of the respondents as having no idea about IPM and only less than 5% of them as following complete IPM technology (Shetty et al 2008). Moreover, in multi cropped intensive cropping systems, the IPM package is even suspected to result in higher pesticide use. This situation calls for alternative policy formulations to regulate the use and handling practices of pesticides in agriculture.

Against this background this paper tries to analyse the pesticide use pattern in agriculture in a humid tropical climate, in the state of Kerala, which is distinctly different from the rest of India with respect to the cropping pattern as well as socio-economic indicators. The paper compiles the macro level data in related aspects and also analyses the micro level evidence in this regard.

1 Pesticide Consumption Pattern

Pesticide use in India dates back to the year 1948 when Dichloro Diphenyl Trichloroethane (DDT) and Benzene Hexa Chloride (BHC) were imported for malaria and locust control. Currently, India is the leading manufacturer of basic pesticides in Asia and ranks 12th globally. Among the predominant classes of pesticides used in India, insecticides are, which account for 61% of total consumption, followed by fungicides (19%) and herbicides (17%). Globally, herbicides constitute the major share. Furthermore, 54% of the total quantity of pesticides used in the country is used in cotton, with 17% in rice and 13% in vegetables and fruits. Pesticide consumption in India is very low compared to many of the developed countries like Thaiwan (17.0 kg/ha), Japan (12 kg/ha) and Korea (6.6 kg/ha).

The use of pesticides in India has increased steadily from 1950-51 onwards, and currently, covers about 30% of the cropped area. The cropped area under the chemical pest control has increased from 2.4, million hectares (1950) to 137 million hectares. Total consumption was the highest during the 1980s, may be due to post-green revolution spiralling effects. The declining trend observed later may be attributed to the increased awareness on negative externalities by the farmers or the changes in policies reducing subsidies. The subsidy for chemical fertilisers and pesticides constituted 1.4% in 1980-81, which increased to 2.4% in 1990-91, later declined to 1.2% in 1998-99 (Thippaiah and Deshpande 1999). It can also be due to the use of new chemicals which are more harmful and potent, which need to be used in smaller quantities.

Compiling the data on consumption level of pesticides in agriculture in Kerala (1995-96 to 2007-08), the total quantity is estimated at 462.05 metric tonnes (MT) (2007-08) technical grade material of insecticides, fungicides, weedicides and rodenticides. High inter year variation is observed in the data. Over the past 15 years, consumption reached the highest level of 1,381.30 MT in 1994-95 and 1,328.10 in 2001-02 and was the lowest at 271.96 MT during 2003-04 (Table 1) and shows a gradual declining trend.

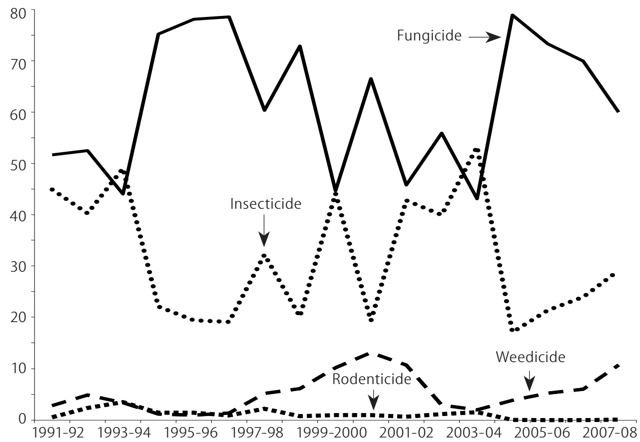
Table 1: Pesticide Consumption in Kerala (Technical Grade MT)

Year	Fungicide	Insecticide	Weedicide	Rodenticide	Total Quantity of Pesticides
1991-92	374.46	325.24	20.46	4.09	724.25
1992-93	394.01	302.17	36.72	17.65	750.55
1993-94	264.50	294.64	20.46	21.10	600.70
1994-95	1,038.90	305.67	16.63	20.12	1,381.30
1995-96	1,001.90	249.37	12.76	18.74	1,282.80
1996-97	895.98	218.41	15.74	10.40	1,140.50
1997-98	359.91	192.16	31.13	13.19	596.39
1998-99	839.53	232.51	70.62	8.90	1,151.60
1999-2000	472.41	467.00	108.27	10.24	1,057.90
2000-01	497.36	144.64	98.41	7.33	747.74
2001-02	608.40	568.29	142.79	8.63	1,328.10
2002-03	157.54	112.56	8.28	3.35	281.73
2003-04	117.32	144.96	5.42	4.26	271.96
2004-05	433.17	940.48	21.36	0.36	548.94
2005-06	481.24	140.63	34.56	0.07	656.50
2006-07	380.10	130.31	32.81	0.14	
2007-08	277.26	134.68	49.56	0.55	

Source: *Economic Review*, Government of Kerala (various issues).

Contrary to the global and national pattern, 73% of the Kerala pesticide market is that of fungicides followed by a mere 20% of insecticides (Figure). This may be due to the climatic factors and cropping pattern in Kerala.

Figure: Proportionate Share of Pesticide Materials in Total Consumption



Is the decline in pesticide consumption real? Does it favour sustainable agriculture? To know more about this we have compiled the data on consumption of pesticide formulations in Kerala from the Directorate of Agriculture, Government of Kerala, for the period 1995-96 to 2005-06. Table 2 (p 201) furnishes the annual compound growth rate of major pesticide formulations.

Out of the 43 formulations of pesticides, 10 exhibited an increasing rate of consumption. The annual compound growth rate varied from the low 0.31% (Aluminum Phosphide) to the high 107.54% (Lindane). Cypermethrin, Fenvalerate and neem based insecticides registered an increase of 21-30% and Methyl Parathion 16.83%. Chloripyriphos consumption rose at 7.5%.

Cuyno et al 2001 have developed an impact scoring system for pesticides based on the risk posed by the chemical to various environmental categories, viz, human beings, animals, aquatic species, avian species and beneficial organisms. A score of 5 (high), 3 (moderate) and 1 (low) is assigned to each aspect like acute/chronic toxicity, leaching potential, residual effects, etc. Thus the maximum aggregate score of 25 entails most hazardous chemical and the minimum of 5, the safest as far as the damage to ecosystem as a whole is concerned.

Lindane is categorised as a high risk chemical, highly toxic and persistent. It is rated with a very high score of 25, with the highest score of 5 in the impact on all environmental categories. A high score for impact on human beings entails a very high acute and chronic toxicity (Class Ia or Ib) with a signal word of danger/poison. Similarly, the impacts on other environmental aspects are also rated as high for this chemical. Thus the high growth in consumption of this chemical is to be viewed very seriously as it may offset the beneficial effects realised through a decline in quantity of pesticide use. This is categorised as a restricted use pesticide (RUP) by the Central Insecticide Control Board in India. But the present market mechanism does not have the arrangements to ensure the strict implementation. Chlorpyriphos also possess an aggregate score of 21 with very severe effects on avian, aquatic and beneficial population and moderate effect on human beings and animals.

Methyl Parathion, the consumption of which increases at 16.83% is a highly toxic insecticide of Toxicity Class I. It is categorised as a RUP in India. Similarly, many products containing Cypermethrin are classified as RUP by the Environmental Protection Agency (EPA) in the United States (US), because of its toxicity to fish. This is suspected to have a possible carcinogenic effect on human beings and is very highly toxic to fish and also to bees. Aluminium Phosphide is also a RUP in many countries including India, and belong to Toxicity Class I.

Monocrotophos is an organophosphorous insecticide which works systemically and on contact. It is extremely toxic to birds and poisonous to mammals. All applications of this chemical were discontinued in the US since 1998. In India, this chemical is banned for use in vegetables.

Table 2: Growth Rates in Consumption of Pesticide Formulations

Sl No	Items	Growth Rates (Positive)				
		<10	10-20	21-30	30-100	>100
A	Insecticides					
1	Chlorpyrifos	7.57				
2	Cypermethrin			29.81		
3	Fenvelarate			22.12		
4	Lindane					107.54
5	Methylparathion		16.83			
6	Neembased insecticides			28.8		
B	Fungicides					
1	Sulphur	2.21				
2	Mancozeb	0				
C	Rodenticides and fumigants					
1	Aluminium phosphide	0.31				
2	Bromadiolone	2.53				
Sl No	Items	Growth Rates (Negative)				
		<10	10-20	21-30	30-100	>100
A	Insecticides					
1	Acephate	-4.17				
2	Carbaryl				-33.84	
3	Carbofuran			-25.25		
4	Dicofol	-1.17				
5	Dichlorovos				-45.2	
6	Dimethoate			-26.47		
7	Endosulfan				-39.55	
8	Ethion			-21.9		
9	Fenitrothion				-54.75	
10	Fenthion				-47.4	
11	Formothion				-36.71	
12	Malathion		-15.31			
13	Monocrotophos	-9.55				
14	Permethrine			-23.32		
15	Phenthoate	-3.52				
16	Phorate		-10.48			
17	Phosalone				-34.59	
18	Pyrethrem	-9.71				
19	Quinalphos	-9.15				
B	Fungicides					
1	Captan				-34.92	
2	Captafol				-43.97	
3	Carbendazim	-1.12				
4	Copper oxychloride			-29.6		
5	Ediphenphos				-59.21	
6	Zineb	-7.76				
7	Thiram				-43.93	
8	Butachlor			-22.37		
9	Paraquate dichloride				-38.35	
10	2-4D		-14.81			
C	Rodenticides and fumigants					
1	Ethyline dibromide			-25.54		
2	Methyl bromide	-6.97				
3	Zinc phosphide				-41.64	
D	Plant Growth Regulators					
1	Ethepon		-16.44			

Thus many of the chemicals that show rising levels of consumption are highly toxic ones. Most of them are either banned or to be used as RUPs.

The number of chemicals that show a declining rate of consumption, however, is more than that of the other group. Out of the 33 formulations which show a declining trend, 19 are insecticides, seven fungicides, three each weedicides and the rest are rodenticides. Nine were showing a rate of decline of less than 10% four in the range of 10-20%, seven in the range of 21-30% and 13 in the range of 30% to 100%.

The highest rate of decline among the insecticides was that of Fenitrothion and the lowest that of Carbendazim (1.12%). Carbendazim is a comparably safe chemical with an aggregate environmental impact score of 17 out of 25. It is of moderate impact (Score 3) on human beings and animals, whereas it has a high negative impact on avian and aquatic species. The chemical is one of the safest for beneficial insects. It is not desirable to observe that its consumption is declining while that of more toxic one is increasing.

Fenitrothion is a contact insecticide belonging to the organophosphate family of insecticides. It is non-systemic and non-persistent and is less toxic. The acute toxicity of Fenitrothion to mammals is considered to be low. But this insecticide is also showing a declining trend in use at a rate of 54.75%.

Fenthion belongs to organophosphate group of pesticides and is a moderately toxic compound in EPA toxicity Class II. It no longer has the approval of the US Food and Drug Administration (FDA) due to poisoning deaths. Dichlorvos is a RUP in the US and may be purchased and used only by certified applicators. The EPA has classified it as Toxicity Class I – highly toxic. Fenthion is banned for the use in agriculture in India. This chemical's consumption level shows a sharp decline, which is relieving to note.

Paraquat a popular herbicide is a highly toxic compound in EPA Toxicity Class I. Paraquat is a RUP in the US. The compound is moderately toxic to birds and slightly to moderately toxic to many species of aquatic life. Paraquat is non-toxic to honey bees. It is one of the "dirty dozen", a pesticide to be prohibited according to the World Health Organisation and Pesticide Action Network. The US EPA has classified it among the products that are possibly carcinogenic for human beings. There is no known antidote for an effective treatment and the symptoms can appear only after a number of days after contact with the pesticide. In Costa Rica, 23% of total pesticide poisoning is due to Paraquat alone. The consumption level of Paraquat in Kerala is declining at a pace of 38.35%, which again is a welcome signal.

Thus it can be seen that, while toxic and more persistent chemicals show a very high growth rate in consumption (Lindane), the chemicals that exhibit a decline in consumption are safer and more in number, but less in the extent of decline. The pesticide risk to environment is related to the amount and type of active ingredient, its toxicity, mobility and persistence characteristics. If farmers reduce the total quantity of pesticide active ingredient applied, but simultaneously substitute highly twice toxic mobile and persistent chemicals for relatively lower quantities, it is difficult to argue that environment has gained (Mullen et al 1997).

Pesticide Use in Kerala

The findings of the micro level studies on the pesticide consumption pattern in major food crops of Kerala support these macro level indications. This section compiles the studies conducted in this aspect in crops like paddy, banana, mango, pineapple and bitter gourd. Pesticide spraying in the crops are prophylactic in nature and is one of the most important risk management strategy. The high risk perceptions naturally result in pesticide spray despite the chances of such infestation are dismally low (Devi 2007).

Table 3: Major Pesticides Used in Food Crops of Kerala

		Mango	Banana	Bitter Gourd	Pineapple	Paddy
1	Asataf					✱✱
2	Ambush					✱✱
3	Atom					✱✱
4	BHC		✱✱			
5	Cymbush . . . ..EC	✱✱				
6	Daksh 14.5EC			✱✱		
7	Dimecron					✱✱
8	Ekalux 25 EC	✱✱	✱✱	✱✱		
9	Endosulfan 35 EC	✱✱			✱✱	
10	Furadan 3 G		✱✱			
11	Hilban 20 EC		✱✱		✱✱	
12	Hostathion					✱✱
13	Karate			✱✱		✱✱
14	Kargill 400					✱✱
15	Lanite					✱✱
16	Lindane					✱✱
17	Malathion 50 EC	✱✱				✱✱
18	Manik			✱✱		
19	Metacid					✱✱
20	Monocrotophos					✱✱
21	Nuvacron 36 EC		✱✱			✱✱
22	Nurelle D-505		✱✱			
23	Neem Oil		✱✱			
24	Phorate 10 G		✱✱	✱✱		
25	Profex	✱✱				
26	Rogor 30EC			✱✱		✱✱
27	Sevin 50 WP	✱✱	✱✱			✱✱
28	Spark			✱✱		
29	Tatamida			✱✱		✱✱
30	Tatareeva					✱✱
31	Trebone					✱✱
32	Thimet 10 G		✱✱			
	Fungicides					
1	Bavistin 50 WP	✱✱	✱✱	✱✱		✱✱
2	Bordaux mixture	✱✱	✱✱			
3	Companion			✱✱	✱✱	
4	Contaf			✱✱		✱✱
5	Emisan 6		✱✱	✱✱		
6	Esso Wettable Sulphur	✱✱				
7	Hinosan					✱✱
8	Indofil WP		✱✱	✱✱		
9	Kitazin					✱✱
10	Saaf				✱✱	
	Weedicides					
1	Almix					✱✱
2	2, 4-D					✱✱
3	Diuron WP				✱✱	✱✱
4	Gramaxone 20EC	✱✱	✱✱	✱✱	✱✱	
5	Klass 80WP				✱✱	

✱✱ The chemical shown in that row is applied in crops shown in the respective column.
Source: Survey conducted in study areas.

All the farmers who practise commercial agriculture regularly adopt chemical plant protection methods on a preventive basis. For instance, the pesticide application in bitter gourd starts from the time of transplanting. Of the 15 chemicals applied for pest control in bitter gourd, eight are insecticides, four are fungicides, and one weedicide and the rest are plant growth stimulators. Phorate granules are placed in the pit while seedlings are transplanted. The prophylactic application of the pesticides is resorted to at an interval of two weeks initially, which gets reduced to two days as the crop nears flowering and fruit set. There is a tendency among farmers to change the chemicals in each spray. So on an average, Acetamaprid is sprayed six times, Phorate and Dimethoate five times each, Quinalphos and Indoxacarb four times each and the rest 3-4 times each. During a crop cycle of 90 days, in bitter gourd, farmers apply pesticides as many as 50 times. Kerala Agricultural University recommends only Carbaryl, Malathion, Dimethoate and Phosphamidon for the crop, on a need based manner. Mechanical and cultural management practices are recommended. Similar is the case with the crops like banana, mango, pineapple and paddy when it is grown on a commercial scale (Devi 2009).

Pesticides used in the food crops in the state include chemicals which are banned for sale in Kerala (Endosulfan), banned for use in fruits/vegetables (Monocrotophos) and those permitted for restricted use only (Methyl Parathion, Lindane and Methoxy Ethyl Mercury Chloride). Many of the chemicals are banned/not approved in many other countries and belong to the PAN Bad Actor Chemical group (Mancozeb, Carbendazim, Paraquat, Lambda Cyhalothrine, Diuron, quinalphos) (Table 3).

The government of Kerala has banned the sale/use of Endosulphan consequent to the controversies over the environmental and human health problems due to the aerial spraying of the chemical in cashew plantations in the state. Still the chemical is used by the farmers. The chemical is seen prevalent among pineapple growers and they declined to reveal the source of purchase. It is also reported to be used in the mango plantations in Palakkad district, though the traders and farmers vehemently deny it. Informal interaction with the labourers working in the farms and some of the local people and a few respondents confirm the use of Endosulphan in the area.

Majority of the chemicals used belong to organo phosphate group which is reported as the major cause of health damages due to insecticides in India (Puri 1998).

Farmers generally opt for quick results and apply most toxic chemicals, even while the safer ones are technically suitable. In our study we could see that in 54% of the cases of spraying in banana, the most toxic chemicals (class Ia or Ib) are used. This amounts to 83% of the quantity applied. Class II chemicals are sprayed in 48% of spray events in mango and 38% in banana. The safest chemical (class U) was applied only in 2% of spraying in mango and none in banana.

Many a time farmers buy the chemicals from the dealers based on the advice by fellow farmers or dealers. Apart from this the agents of pesticide manufacturers/distributors directly approach the farmers and sell the material. Often the chemical is not identifiable, as it does not bear the required details on the bottle. These non-descript forms are generally the mixtures of different chemicals.

Moreover, the spray fluid concentration is found to be much higher than the technically suggested level. In majority of cases of pesticide use, the quantity of chemical used is found to be much higher than the recommended levels (21% to 275% higher in mango and 150% to 400% higher in banana). The application level is higher than the recommended level of the chemical by 0-550% in pineapple and 0 to 900% in bitter gourd. At the same time, the water used for diluting the chemical to the desired concentration level is often less than the recommended level (Devi 2007).

Kerala Agricultural University suggests 500 litres of water for spraying a hectare of field, under normal conditions. The scientific handling of pesticides warrants the use of protective gadgets, which include a facemask with replaceable filters, goggles, head-cover, rubber gloves, full-sleeved shirts and full pants, and boots. In our study covering the farm workers (pesticide applicators) in Kuttanad paddy lands, we could not find any worker who adopted all the suggested protective measures in full. Jeyaratnam et al (1987) and Sivayoganathan et al (1995) have also attested to this situation in the case of Sri Lanka and Yassin et al 2002 from Palestine. The findings of other studies done in developing countries also support this observation (Wilson 1998; Gomes et al 1999; Murphy et al 1999; Salameh et al 2004; Atreya 2007). The cost factor (which makes the applicators reluctant to adopt the recommended gadgets and opt, instead, for cheaper substitutes), general lethargy, and the discomfort associated with the use (in the hot and humid climate and under puddled paddy land conditions) were reported as the reasons for non-adoption. Moreover, there is no monitoring mechanism to ensure their use. Nevertheless, some form of protective covering of body parts was adopted by 71% of the respondents while spraying. In 21% of the cases, it was mainly the full-sleeved shirts. However, it was noted that some were rolling up the sleeves while the spraying/mixing was being done. Forty-eight per cent tied a piece of cloth around their noses. A mere 1% used some form of eye protection (e g, ordinary spectacles, which were actually there even otherwise) though most of them reported eye irritation after spraying. These unscientific methods of aversion often fail to achieve the desired objectives.

Awareness in Pesticide Use

The user's understandings about the pesticide toxicity levels, health impacts and resultant behaviour decide the level and extent of negative externalities associated with pesticide use. Responses to the questions related to reading and following, awareness on toxicity, ecological impacts, human health impacts and training support provide some information in this regard (Table 4).

One-third of the workers read the label on the pesticide packet either themselves or seeking help. But only less than 3% follow the instructions. The workers often relate the toxicity of pesticides to the odour of the chemical and more pungent ones are considered as most toxic. The scientific categorisation based on colour code is rarely understood. Sixty-three per cent of the farm workers know that pesticides with different levels of toxicity are available in the market, starting from relatively safe ones to highly toxic. But 99.5% of them could not understand the toxicity level reading the colour code on the bottle. We asked the respondents their understanding of the toxicity level of pesticides they handle by giving four options, based on the colour code suggested by the World Health Organisation. Simultaneously, we also verified the chemical they actually sprayed. Nearly three out of four workers thought they were handling safer chemicals (slightly/moderately toxic), while actually the majority (69.65%) were spraying toxic (highly/extremely) ones. Unfortunately, they were not trained to understand the level of toxicity by reading the colour code on the label.

However, the behavioural pattern, with respect to personal health and hygiene while handling the pesticides, is a desirable pattern. But when it comes to social behaviour the care is comparatively less. The ecological impact of pesticide spray can be assessed by the spraying pattern and disposal habits of empty containers. Forty-two per cent of them wash the bottle/sprayer in the nearby water bodies. Most of them consider the wind direction while spraying. But they do not postpone the spraying even when there is wind. This result in higher chances of drift, affecting the non-target population.

The institutional support mechanism for creating awareness on pesticide use and handling is mainly managed by the department of agriculture. They conduct training programmes on the topic on regular basis. But it is seen that only 4% of the respondents have ever attended the training on pest control aspects. It is understood that the department trainings are mostly focused on farmers. But our study shows that in majority of cases of spraying (79%), the farmer does not supervise and prefer to stay away from the field, entrusting the work with the applicator. This highlights the need for refocusing the training programme targeting the farm labours.

Quality Control and Monitoring System

The department of agriculture, government of Kerala, is the monitoring and licensing agency as envisaged in the insecticides control order. The agricultural officers (one officer each for every panchayat) are designated as the insecticide inspectors. In addition, there are separate quality control laboratories in various parts of the state. As per the reports of the department the

Table 4: Awareness on Pesticide Use and Handling

Sl No	Particulars	Percentage of Respondents	
		Yes	No
1	Do you read the labels on the package?	33.00	67.00
2	If you cannot read, do you seek help from others?	3.00	97.00
3	Do you follow the instructions given on the label?	2.50	97.50
4	Are you aware of pesticide toxicity levels?	63.00	37.00
5	Are you able to understand the level of toxicity, reading the sign on the label?	00.50	99.50
6	Do you eat, drink or smoke while spraying pesticides?	80.00	20.00
7	Do you take bath right after spraying?	93.00	7.00
8	Do you change clothes right after spraying?	9.00	91.00
9	Do you keep the pesticide bottle along with food items?	42.00	58.00
10	Do you store food items in pesticide bottle after use?	0.00	100.00
11	Do you wash the sprayer/bottle in the pond/canal/river/others?	0.00	100.00
12	Do you determine the wind direction first and then spray?	97.00	3.00
13	Do you spray when it is windy?	97.00	3.00
14	Have you attended any trainings/workshops/discussions on pesticide use and care?	4.00	94.00

(N=280)

number of retail trade outlets in the state is declining over the years. The supply arrangements are led by the private sector with 1,442 sale points followed by cooperatives (627 outlets). The role of public sector is slowly becoming insignificant.

Though there is a licensing system in this sector, the sale is often unregulated. The pesticides can be brought over the counter without any prescription or scientific supervision. Studies reveal that a large majority of farmers are consulting the traders for choosing the chemical and the dose, against specific symptoms (Saijyothi 2005; Divya 2007). But these traders have neither the technical expertise nor the training support to offer scientific technical advice. They are often guided by producing or marketing firms. Mostly the recommendation of a pesticide is influenced by the level of commission offered by the producer. Refocusing the extension mechanism on the traders and training the traders on preparation of plant-based preparations can show results of a better environmental quality.

In an effort to ensure the quality of the pesticides, the department has an ongoing system of collection of samples from the market and getting it tested at the quality control lab located at different parts of the state. The results of the analysis and action taken report when compiled shows that substandard pesticide samples are often reported. Until recently, little action was taken on such reports. The only action was often to stop the sale of the particular substandard batch of pesticide; however, by the time such decisions were implemented, most of the pesticides were already sold.

The Direct Damages: Human Health Impacts

The expressions of unscientific handling of pesticides in agriculture are not confined to the production system alone. The agro-ecosystem which includes the micro and macro flora and fauna are seriously damaged by these actions. In an anthropocentric perspective, the analysis of the direct impact on human health alone provides sufficient insight in this aspect.

It is seen that pesticide poisoning is intentional in most of the cases (85-97%). Pesticide consumption is reported as the major method of suicides in Kerala. Of the 900 to 1,000 suicides/year, 60% are by consuming pesticides. The autopsy reports from government medical colleges in Kerala showed that more than 95% of poisoning death was due to insecticides. Case reports compiled from the government medical college, Thrissur (causality wing) during January 2006, have shown that out of 32 poisoning cases, 70% as due to pesticides. The commonly used ones are Furadan, Malathion and Rat Poison (Jayakrishnan 2006).

Most often, suicides are regarded as a momentary action which could have been averted if an easy access to methods is not there. In the fight against this social evil, where Kerala tops, pesticide regulation plays a vital role. In this context the appeal of the Association of Psychiatrists (Kerala Chapter) demanding a strict regulation on pesticide trade to restrict its easy access is to be taken very seriously.

The victims of unintentional pesticide poisoning (homicidal and accidental) are often children as evidenced by the reports in mass media. The careless storage and disposal of pesticide containers often lead to unintentional poisoning. The farm workers who enter immediately after the spray also get exposed. First, such case reported from Kerala in 1958, of pesticide contaminated wheat flour and resultant poisoning initiated the formation of legal framework for pesticide use and handling in the country.

The occupational poisoning occurs due to an exposure during the handling and spraying operations by the farm workers and the traders who sell it. However, poisoning due to pesticides is of two types, short-term and long-term. This data covers only the short-term acute effects. The data is drawn from the records of government hospitals and medical colleges only. The information is based on the self-reporting by the victim or family members while admitting in the hospital. The occupational exposure data shows only 16 cases in 2003-04, seven cases in 2004-05 and two cases in 2005-06. However, it is to be borne in mind that the dependence on private healthcare is more in Kerala. When the health damage is perceived to be severe, private hospitals are preferred. Usually, poisoning symptoms (vomiting, cramps and breathing problems) that require immediate medical advice are manifested immediately after the spray event, or during it. In such cases, the nearest medical facilities are explored. Further, due to the social stigma and confusions associated with suicides, the suicide attempts as well as other forms of poisoning are often not properly reported by the victims/relatives. Thus, the possibility of

Table 5: Pesticide Poisoning Report

Year	Total No of Poisoning Cases			No of Suicidal Cases			No of Homicidal Cases			No of Accidental Cases			No of Occupational Cases		
	Survived	Died	Total*	Survived	Died	Total	Survived	Died	Total	Survived	Died	Total	Survived	Died	Total
1998-99*	168 (65)	91 (35)	259 (100)	136 (62)	84	220 (85)	14	4	18 (7)	18	3	21 (8)	-	-	
1999-2000*	394 (69)	174 (31)	568 (100)	346	165	511 (90)	-	4	4	48	5	53 (9)	-	-	
2000-01	1318 (62)	816 (38)	2134 (100)	1184	675	1859 (87)	41	92	133 (6)	93	49	142 (7)	-	-	
2001-02*	2192 (51)	2087 (49)	4279 (100)	2132	2031	4163 (97)	-	-	-	60	56	116 (3)	-	-	
2002-03*	556 (71)	224 (29)	780 (100)	513	222	735 (94)	-	-	-	43	2	45 (6)	-	-	
2003-04*	624 (72)	247 (28)	871 (100)	542	216	758 (87)	9	13	22 (3)	65	14	79 (9)	8	8	16 (2)
2004-05	770 (73)	283 (27)	1053 (100)	711	273	984 (93)	9	3	12 (1.13)	43	7	50 (5)	7	-	7 (0.66)
2005-06	514 (81)	124 (19)	638 (100)	483	122	605 (95)	1	-	1 (0.16)	28	2	30 (5)	2	-	2 (0.31)
2006-07*	208 (83)	41 (17)	249 (100)	196	41	237 (95)	-	-	0	12	-	12 (5)	-	-	-

* Data only for six months. Source: Compiled from the records of Department of Agriculture, Government of India.

The state department of health reports data (on a regular basis) on the status of pesticide poisoning in human beings (Table 5). Compiling the data from 1998-99 to 2006-07, the average level of poisoning due to pesticides ranges from a minimum of 249 (in six months) in 2006-07 to a maximum of 4,279 during 1 October to 2 March. It may be noted that the consumption level of pesticides was the highest in 2001-02 (Table 1), suggesting the positive link between pesticide consumption and human morbidity level due to pesticide poisoning. It is relieving to note that the survival rate has significantly improved to more than 80% compared to the situation in late 1990s (65-69%).

under-reporting of poisoning cases in general is quite high. Hence, this data can only be taken with some caution, and perhaps, can be considered as the lower bound of the actual value.

During our investigation for the South Asian Network for Development and Environmental Economics (SANDEE)-funded project, we tried to understand the subject's (pesticide applicators) perception regarding these two types of health risks (pesticides cause health damages of two types – short-term, which get manifested within hours to days of exposure, and long-term, which takes years to get manifested). More than half of the respondents were of the view that there is only mild health risk at short-term. On the contrary, they consider long-term effect as more profound and fatal. Surprisingly, one-fourth of the workers believed that there was no adverse health effect in long-run. In this background, we further explored their past experience in this regard based on self-reporting. Among the respondents 83% of had been working as pesticide applicators for the past 10 years or more followed by 17% for the past 5-10 years. We asked the respondents whether there were any incidence of seeking a professional medical help immediately after the pesticide spray. Every three out of four respondents experienced at least one episode of severe health damage immediately after the spray and sought formal medical help or hospitalised. Some of them reported more than one instance of hospitalisation. But we could not gather the exact number of times of seeking medical help and details thereof, from such individuals owing to recall bias problems. There was an increase in absolute number of respondents getting sick as experience in the job went up. Proportionally more applicators were seeking medical help as they continued to be there in the job (28.13% to 46.25%). This may be due to use of more poisonous chemicals, general carelessness as one becomes more familiar with the work – cumulative effect of pesticide exposure and/or increasing awareness of health effects that they seek medical help. But reports from Gaza strip shows that there is no direct relationship between years of exposure and self-reported health damage symptoms (Yassin et al 2002).

In Kuttanad area, known as the rice bowl of Kerala, the pesticide use was reported to be very high and there were several mass media reports on its impacts on the ecosystem. But the scientific efforts to quantify these externalities are only a few. The attempts by Rakesh (1999) and Krishna (2001) can be considered as pioneering efforts in this regard. Rakesh (1999) examined the externalities present in the estuarine ecosystem of Kuttand. He also analysed the resistant externality cost and the variables influencing them. The study indicated that the pesticide poisoning led to both explicit and implicit costs for the applicator/farmer, which could be considered as a health cost. Majority of farmers (60%) were reported to be suffering from health problems caused by pesticides. Among the health hazards induced by pesticides, the skin allergy and headache were most prominent in Kuttanad (Krishna 2001). Most of the farmers were aware of these negative impacts and were willing to incur an additional cost of Rs 138 per ha of rice farming for an ecofriendly agricultural practice.

The micro level study on this aspect (the SANDEE-funded project) had found 73 cases of hospitalisation due to occupational exposure among a sample of 1,135 spray events in Kuttanad area alone during the summer rice season. The average expected health costs to the pesticide applicators in this case was estimated to Rs 38 per spray event (Devi 2007). This again is the lowest bound of the actual cost of externality as it does not account for the health cost in full and other externalities.

As evidenced by the literature, the conclusive cause-effect relationship is difficult to be established in the case of long-term health impacts of pesticide exposure and we could not gather data on those aspects. However, from the results we have, it can be seen that the perceptions of short-term health damages are not in agreement with their own experiences. Moreover, despite a high literacy rate and awareness level the health risk, perceptions and avertive action are not scientific.

Productivity Impacts

Pesticide is considered as an integral input for crop production during the green revolution regime. The application of pesticides was justified due to social and economic consideration, when food security was the major concern. However, these estimates were made without any regard for the environmental and human health effects of pesticide use. Recent reports on the same topic projects a situation where the impact is often reported as negative or insignificant. The results of analysis by Birthal (2003) implied that it is possible to reduce pesticide use without any concomitant decline in agriculture productivity, though initially crop yields might experience a slight decline.

The trades-off between health and economic benefits from pesticide use has been studied in detail at various parts of the world (Rola and Pingali 1993; Pingali et al 1994; Antle and Pingali 1994; Pingali and Roger 1995; Crissman et al 1994). Simultaneously, a large amount of literature is added to the present volume on the negative impacts of pesticide use which poses questions on the economic, environmental and social rationality. Studies initiated by Rola and Pingali (1993), show that the costs related to pesticide use in crop production as higher than the gains from the reduction in crop yield losses. The economic relevance of pesticide application in crop production is, thus, a widely debated topic in environmental economics.

Despite these reports, in many of the developing countries pesticide policy is basically driven by the productivity (reduction in yield loss) impacts. The primary concern being food production, environmental damages are often relegated to the second position. The decision on pesticide use and investment level is not usually governed by financial aspects of crop production which ideally should have been on the basis of marginal analysis. Here we try to get an indication of the impact of current levels of pesticide application on agricultural productivity indices by regressing the consumption level of pesticides along with that of other critical inputs.

Since we do not have the state level data on cropwise consumption pattern of pesticides, the total pesticide consumption was regressed with the index of agricultural production (all crops, foodgrains, non-foodgrains separately). The results are furnished in Table 6 (p 206).

The Cobb-Douglas Production function, taking production index of all crops as dependent variable shows a significant (at 5%) negative impact of pesticide consumption. It indicates a 0.37% decline in the value of total agricultural production index for every 1% increase in quantity of pesticide application. The fall is estimated at 0.08% for foodgrains production index, which is statistically significant at 1% level.

Table 6: Coefficients and Standard Errors of Estimate of the Production Function
(Agricultural Production Index)

Variables		Coefficient	Std Error	t	F	R^2
Y = Agricultural Production Index (all crops)						
Constant		18.38	9.93	1.85		
% of area irrigated	(X_1)	1.66	0.87	1.906	4.022*	0.523
Pesticide Use	(X_2)	-0.37	0.13	-2.938**		
Fertiliser Use	(X_3)	-1.24	0.77	-1.613		
Y = Agricultural Production Index (foodgrains)						
Constant		7.48	2.57	2.913**		
% of area irrigated	(X_1)	0.78	0.23	3.456*	5.803*	0.613
Pesticide Use	(X_2)	-0.08	0.03	-2.495*		
Fertiliser Use	(X_3)	-0.32	0.20	-1.606		
Y= Agricultural Production Index (non-foodgrains)						
Constant		-1.282	6.181	-0.207		
% of area irrigated	(X_1)	-1.298	0.541	-2.399*	3.575	0.494
Pesticide Use	(X_2)	0.191	0.079	2.414*		
Fertiliser Use	(X_3)	0.628	0.480	1.308		

* Indicates significance of regression coefficients at 1% level of probability.
** Indicates significance of regression coefficients at 5% level of probability.

However, for non-foodgrains, which account for 50% of area under cultivation in Kerala, the impact of pesticide application is revealed as positive and significant (5%). It is predicted to affect a 0.19% increase in the value of index for 1% increase in consumption level. None of the other variables (irrigated area and fertiliser use) are proved to have any significant impact on output index.

Most of the attempts in agricultural economics in Kerala, trying to study the resource use efficiency of farm resources in crop production have included pesticide as one of the variable. One of the earlier studies by Norman (1982), in vegetables grown in Malappuram, the impact of pest management investment was found to be negative on the output realisation. Contrary to this, Sreela (2005), while studying the relative economics of major vegetables grown in Palakkad in Kerala, reported a significant (1% level) positive impact of pesticides (quantity terms) on crop output of bitter gourd and snake gourd. Balakrishnan (2000) also reports a significant impact of investments on pesticides on different varieties of banana grown in Kerala. In *nendran* and *palayankodan* varieties it was reported to affect a 0.30% and 0.41% increase respectively in income (Significant at 1% level). In *poovan* variety, the gain in income was to the tune of 0.60% (significant at 5% level). In these studies, however, the cost of pest control, includes only the material cost and not the application and other related costs, and not, of course, the cost of externalities. Moreover, the labour cost, taken as a separate variables showed an inefficient level of use, where the marginal value product (MVP), marginal factor cost (MFC) ratios[1] are less than unity, in all these studies.

Attempts at taking the cost of pest control as a variable (labour plus material cost) in crops like mango, banana, pineapple and bitter gourd, applying the Cobb Douglas production function provides mixed results. The impact of pest management cost on banana and pineapple cultivation was found to be of not significantly different from zero. The expenditure on pest control, in mango and bitter gourd were found to have a significant positive impact on returns. Though the MVP is positive the MVP/MFC ratio is negative suggesting uneconomic levels of investments. These findings underline the observation that investment in chemical pest control in agriculture is irrational.

Conclusions

Recent advances in the science of ecology and environment have paved the way for restricting the use of harmful practices in agriculture and going for alternative farming methods which are more sustainable. Accordingly, the levels of pesticide consumption have been showing a declining trend. However, there are apprehensions as to whether this decline is yielding the desired outcome, or is it a replacement of the present ones with more potent, toxic and persistent ones which need to be used in lesser quantities only? Our analysis indicates a rising level of consumption of undesirable chemicals while the safer ones are used in smaller quantities. However, a positive aspect is that the consumption of some of the harmful ones is also coming down. At the same time, the micro-level explorations shows the use of chemicals which are banned for sale in Kerala (Endosulfan), banned for use in fruits/vegetables (Monocrotophos) and those permitted for restricted use only (Methyl Parathion, Lindane and Methoxy Ethyl Mercury Chloride). Many of the chemicals are banned/not approved in many other countries and belong to the PAN Bad Actor Chemical group (Mancozeb, Carbendazim, Paraquat, Lambda Cyhalothrine, Diuron, Quinalphos).

The handling pattern (spray fluid concentration and the use of protective gadgets) was observed to be unscientific. Farmers usually opt for the most toxic chemicals, while the safer substitutes are technically sufficient. Many a time farmers buy the chemicals from the dealers based on the advice by fellow farmers or dealers. Apart from this, the agents of pesticide manufacturers/distributors directly approach the farmers and sell the material, which are often non-descript. The monitoring and quality control mechanism by the department of agriculture often fails to be very effective. Most often the sales data is not regularly furnished by the retailers, which is mandatory. The training provided on the subject is mostly targeted at the farmers, while the actual spray operation is conducted by the farm workers, unsupervised. Along with this, the awareness of the direct human health impacts of unscientific pesticide handling among the farm workers is revealed to be very low, and does not match with their own experiences in this regard. The data from micro level studies reflects several cases of pesticide poisoning and resultant health damages.

These points highlight the need for effective policy interventions and extension mechanism to regulate the use of pesticides in agriculture, while aiming at the food safety and security issues. This can be achieved as the current investment level is proved to be high, which indicates that we can reduce the investment levels in chemical pest control, without a corresponding decline in output. Along with this an effective data management system and monitoring policy need to be ensured. The present legal framework ensures these arrangements. But the current system does not ensure its implementation effectively. This warrants the necessity of an alternative mechanism for regulating use. Cheap, quick and non-destructive methods of detecting pesticide residues in raw fruits and vegetables should be made more popular. The consumers can use the facility and this can act as a market force for better production management among farmers.

Awareness regarding the legal status of the chemicals is very low. Most of the farmers and many of the pesticide inspectors are not aware of the status, especially with regard to restricted use of chemicals. The training and awareness creation programme may be framed in a manner to disseminate this aspect. It will be better if the information is displayed on boards in front of the sale points, farmers' clubs and agricultural offices. The punishment for violation may also be publicised. Training programmes in safe pest control mechanism may also be focused on farm workers, traders as well as general public. Ecologically safe agricultural management system can only be achieved with combined policy efforts which include adequate legal support, effective monitoring and voluntary action by the stakeholders.

NOTE

1 Marginal Value Product/Marginal Factor Cost Ratios suggest the financially optimum level of input use.

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