Tropical Agricultural Research (2022) 33(2): 173-182

Contents available at: Sri Lanka Journals Online

Tropical Agricultural Research

Journal Home Page: https://tar.sljol.info

# Pesticides Used in Rice Cultivation: Application Pattern by Farmers in Trincomalee District, Sri Lanka

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ARTICLE INFO

***Article history:***
Received: 05 May 2021
Revised version received: 19 September 2021
Accepted: 08 February 2022
Available online: 1 April 2022

***Keywords:***
Agriculture
Chronic Kidney disease
Farmer education
Hazard
Health

**Citation:**
Dissanayake, D.M.P.N.K., De Silva, S.N.T., Pathmarajah, S., Kodagoda, K.A.D.A., Chandimal, T.M.R and Herath, H.M.T.D. (2022). Pesticides Used in Rice Cultivation: Application Pattern by Farmers in Trincomalee District, Sri Lanka. Tropical Agricultural Research, 33(2): 173-182.

DOI: http://doi.org/10.4038/tar.v33i2.8474

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**ABSTRACT**

Violation of scientific recommendations and malpractices in pesticide usage is much debated due to the rapid increase in chronic kidney disease in agricultural areas of Sri Lanka. The Government of Sri Lanka has banned the use of several hazardous pesticides based on their harmful effects in recent years. In this context, this study was conducted to assess the present situation and practices of pesticide usage in rice cultivation after these restrictions. A questionnaire survey and face-to-face interviews were conducted in 2019/2020 with 174 farmers selected through a multi-stage cluster sampling method in rice cultivation areas in the Trincomalee district. The WHO hazard class *Ia* and *Ib*, prohibited in the country were not applied in the study area. However, 63% of pesticides belong to the class *II* (moderately hazardous) category, which is not highly recommended by FAO. In addition, we identified poor agricultural practices, such as violations of scientific recommendations (> 50%), not using protective gears when applying pesticides (63%), combining two or more pesticides to produce a mixture (26%), poor control of dumping empty pesticide containers (> 80%), drinking water without checking the quality (55%), and not consulting agriculture extension service (82%). However, young farmers are more aware of the consequences of malpractices in the use of pesticides, while educational level has no significant influence. In this regard, it is necessary to create public awareness of the hazards of pesticide misuse through awareness campaigns, regular monitoring, and follow-up mechanisms at the field level, and regular assessment of pesticide residuals in the ecosystem. Further, farmers should also be encouraged to practice organic agriculture and integrated pest management, which will help to promote sustainable development.

## INTRODUCTION

The primary agricultural crop in Sri Lanka is paddy, and the staple food of Sri Lankans is rice. To minimise yield losses and maintain a high quality of the crop, pesticides are commonly used in rice cultivation to manage pests. It has been observed that the quantity of pesticides use has steadily increased since 1950 (Selvarajah and Thiruchelvam, 2007). One hundred and fifteen active ingredients were registered as pesticides in the country at the end of the year 2014 (Aravinna *et al*., 2017). The continued application of relatively large quantities of permissible pesticides has led to the contamination of the ecosystem with residues of pesticides (Aravinna *et al*., 2017). Further, pesticides have been widely misused and overused over the years in agricultural sector in Sri Lanka (Nagenthirarajah and Thiruchelvam, 2008). A study conducted with local farmers indicated that the frequency of pesticide use exceeds the recommended levels. Farmers commonly misuse pesticides by mixing different varieties and seeking better results through over-application (Ministry of Primary Industries and Ministry of Agriculture, 2016). Further, most farmers do not use safety equipment when handling agro-chemicals and the containers and are thus exposed to higher levels of toxic chemicals (Wimalawansa and Wimalawansa, 2014). Additionally, proper disposal of pesticides is often not carried out in a safe manner; half of the entire pesticide bottles are frequently disposed at the site or with public solid waste, contributing to contamination of the water supply (Ministry of Primary Industries and Ministry of Agriculture, 2016). Chemical pesticides are known to cause adverse health hazards to humans and other beneficial organisms. Pollution of water bodies and the environment, development of resistance to pesticides, and outbreaks of secondary pests are some other adverse effects of pesticides (Dutcher, 2007).

As pesticides are heavily used in the paddy fields, they would be transported to the surface water bodies and distributed through the interconnected irrigation canal system (Aravinna *et al*., 2017). Continuous use of pesticides has caused environmental damage, human health problems, harmful effects on agricultural production and reduced agricultural sustainability (Wilson and Tisdell, 2001). Approximately 50% to 70% of the water bodies assessed were adversely affected by agricultural non-point source contamination in Florida, United States (Sarathchandra *et al*., 2017). It has been reported that heavy metals found in formulated pesticides may cause chronic kidney disease of unknown etiology (CKDu) spreading in agricultural areas of the country (Aravinna *et al*., 2017; Jayasumana *et al*., 2014, 2015).

According to the FAO's Pesticide Code of Conduct, WHO Ia and Ib pesticides should not be used in developing countries, and if possible, class II should also be avoided. The government of Sri Lanka (GOSL) has already banned the import, use and sale of several pesticides on the basis of their harmful effects in recent years following these guidelines (Padmajani *et al*., 2014). Further, violations of scientific recommendations and malpractices in pesticide usage have been discussed in the recent past, especially after the rapid increase of chronic kidney disease in the farming areas (Jayasumana *et al*., 2014, 2015; Wimalawansa and Wimalawansa 2014). Various studies on pesticide usage in vegetable cultivation have been undertaken, but only a few studies are found on rice cultivation (Ngowi *et al*., 2007; Nagenthirarajah and Thiruchelvam, 2008; Padmajani *et al*., 2014). Hence, this research was conducted to assess the present situation of pesticide usage in rice cultivation after these restrictions. Specific objectives are to;

- study the different types and properties of pesticides used in rice cultivation areas in the Trincomalee district,
- estimate the extent of pesticide overuse and misuse based on the Department of Agriculture (DOA) guidelines, and
- determine farmers' awareness of pollution of water sources due to pesticides and the use of local water sources for drinking in the study area.

## METHODOLOGY

### Study Area

The study was conducted in three divisional secretariat divisions (Kanthale, Seruvila and PadaviSripura) in the Trincomalee district, which is one of the major rice-growing areas in Sri Lanka. It is one of the 25 districts of Sri Lanka, which is situated on the Eastern coast of the country and falls within the Northern longitudes of 8° 5' 55'' to 8° 59' 52'' and Eastern latitudes of 80° 44' 39'' to 81° 27' 54'' (Ministry of Lands, 2016). There are two cultivation seasons: *Maha* and *Yala*, in this area (Ministry of Lands, 2016). The net harvested extent under paddy cultivation in the district during 2019/2020 *Maha* season was 35,567 hectares with an estimated paddy production of 155,592 MT (Census and Statistics, 2020).

## Data Collection and Analysis

A survey was conducted using 174 farmers during 2019/2020 *Maha* season. Farmers were selected through a multi-stage cluster sampling method. The representative sample size for each DS division was decided based on a standard sample size calculation with a margin of error (confidence interval) of 90%. A questionnaire containing, structured and semi-structured questions were designed to collect data through face-to-face interviews. Collected data included; personal details of the farmers, details of the rice cultivar, common pests, application of pesticides, knowledge on pesticides, adherence to the recommended dosage, practices of mixing pesticides and reasons, frequency of using pesticides, method of disposal of pesticide containers, and their adherence to personal protective measures while handling pesticides. Data were subjected to analysis using SPSS (IBM SPSS Statistics Version 22). Frequency distributions and descriptive indicators were used to summarise the data. Correlations between variables were assessed using Pearsons correlations coefficients. The statistical significance of all tests was assessed at 5% level.

## RESULTS AND DISCUSSION

### Socio-Economic Characteristics of Farmers

The mean and standard deviations of the age of the responded population are 50 and 11 years, respectively. Sixty-six percent (66%) of the farmers are above 45 years, and 96% are males. Forty-eight percent (48%) were studied up to G.C.E Ordinary Level. The primary source of income of 87% of the respondents was farming. From farming, 68% of farmers gain less than LKR 30,000 (158 USD) income, while 32% earn more than LKR 30,000 (158 USD) as their monthly income. Fifty-one percent (51%) of farmer's had a land extent of two to four acres (0.81-1.62 Hectares). Forty-seven percent (47%) of farmers used family labour, while 52% tended to subcontract.

### Types and Properties of Pesticides Used in Rice Cultivation

Farmers in the study area used 26 commercially branded pesticides including 11 herbicides, 11 insecticides, and 4 fungicides. The most commonly used type of pesticide by rice farmers is herbicides (93%), followed by insecticides (70%). Very few farmers used fungicides (4%). Considering the active ingredients of the pesticides used in the study area, 63% belongs to class II, which is moderately hazardous, 31% belongs to class U, which is unlikely to cause any acute hazard in normal use and only 6% belongs to class III, which are slightly hazardous (WHO, 2019). The Pesticide Code of Conduct by FAO (2003) recommended that WHO Ia and Ib pesticides should not be used and if possible, class II should also be avoided in developing countries (Food and Agriculture Organization (FAO) of the United Nations and World Health Organization (WHO), 2014; Padmajani *et al.*, 2014). In this study area, class Ia and Ib pesticides were not used, but class (II) pesticides were heavily applied (Figure 1).

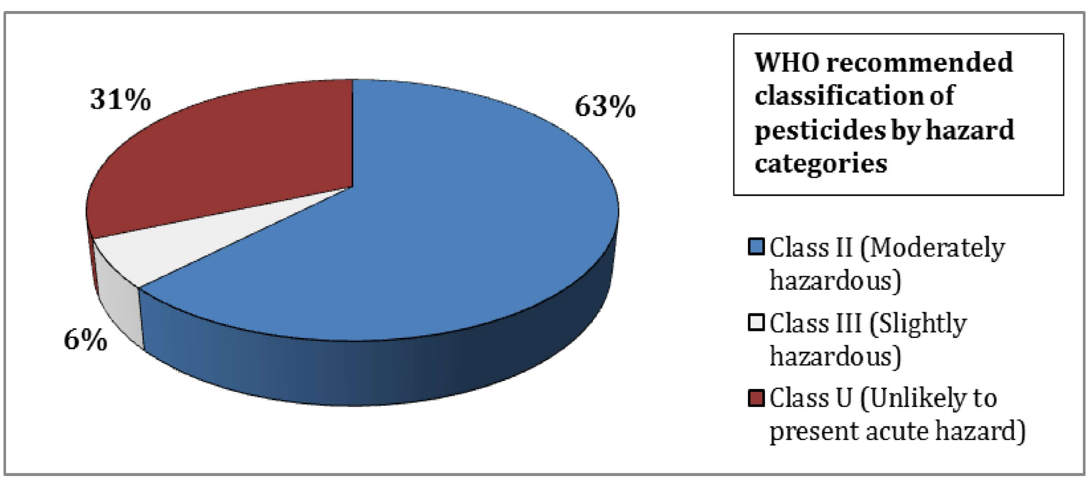


**Figure 1: Level of different classes of pesticides used in the study area.**

This study reveals that 52% of the herbicides and 51% of insecticides used belong to WHO hazardous class II, and 10% of the herbicides belongs to class III. Thirty-four percent (34%) of the herbicides and 19% of insecticides belong to class U. Even though the fungicides applied are rare among farmers, those which are used belong to class II category (Table 1).

## Herbicides Usage Pattern in Rice Cultivation

### Common Weeds

Based on the farmers' observations, grasses are the major problematic weed group in the district. Among the weedy grasses, *Echinochloa crus-galli* (Bajiri) (32%) and *Ischaemumrugosum* (Gojarawalu) (31%) are the top rankers that are considered critically harmful in rice fields. *Fimbristylis spp*. (Kudametta) (16%) followed by *Cyperusiria* (Thunessa) (8%) are the most critical sedges that are problematic, next to grasses. However, broadleaf weeds do not cause a significant harmful impact on rice cultivations in the study area.

### Herbicide Used

This study reveals that the prominent method of weed control adopted by 97% of farmers was herbicide application; majority of the farmers used *Pretilachlor 30% EC* (Soffit) (34%) (Table 2). Considering the mode of action of herbicides, the most applied group (Class II) in the study area is "cell division inhibitor". According to the Department of Agriculture (DOA), they do not recommend mixing pesticides; however, 26% of farmers mix two or more combinations to control weeds. *Clomazone 200 g/L + Propanil 400 g/L EC* (Compro) + *MCPA 400 g/L SL* (M-40), mixture is the widely used (21%) mixture by farmers. However, *Clomazone 200 g/L + Propanil 400 g/L EC* (Compro) is a grass killer, and *MCPA 400 g/L SL* (M-40) is a broadleaf and sedge killer and recommended to apply as single herbicides. Farmers prefer to use mixtures to reduce labour costs incurred during application. They also believe that a single herbicide is not effective in controlling weeds in the field. Also, they expressed their lack of confidence in DOA recommendations.

It is risky to mix two different formulas, for example, wettable powders (WP) with emulsified concentrates (EC) (Herath *et al*., 2017), but farmers in the study area mix emulsified concentrates (EC) with soluble liquids (SL). *Barnyard grass* (E. crus-galli), the major troublesome grass weed in lowland rice cultivation in Sri Lanka was reported to have developed resistance to propanil (Marambe and Amarasinghe, 2002). Likewise, in the Trincomalee district, weed resistance was developed against herbicide Bispyribac sodium 100 g/L (Nominee); hence it was banned in 2018 (Agriculture Officer, Trincomalee, personal communication, January 2020).

**Table 1: Pesticides used by farmers according to hazardous category.**

| Type of pesticide | WHO recommended classification of pesticides by hazard categories | | Count | Percentage |
|---|---|---|---|---|
| Herbicide | II | Moderately hazardous | 91 | 52% |
| | III | Slightly hazardous | 18 | 10% |
| | U | Unlikely to present acute hazard | 60 | 34% |
| | | Not Cultivated | 5 | 3% |
| Insecticide | II | Moderately hazardous | 88 | 51% |
| | III | Slightly hazardous | - | - |
| | U | Unlikely to present acute hazard | 33 | 19% |
| | | Not Applied | 53 | 30% |
| Fungicide | II | Moderately hazardous | 7 | 4% |
| | III | Slightly hazardous | - | - |
| | U | Unlikely to present acute hazard | - | - |
| | | Not Applied | 167 | 96% |

**Table 2: Percentage distribution of herbicides in the study area.**

| Weedicide Category | Type of Weedicide | Count | Percentage |
|---|---|---|---|
| Grasses/ Sedges/ Broad leaves | *Pretilachlor 30% EC* (Soffit) | 60 | 34% |
| | *Pretilachlor + Propanil 330 g/L EC* (Profit) | 11 | 6% |
| | *Bispyribac sodium 40 g/L SC+Metamifop 100 g/l SC* (Kiseki) | 6 | 3% |
| | *Fenoxaprop-P-Ethyl + Ethoxysulfuron 69+ 20 g/L OD* (Tiller Gold) | 6 | 3% |
| | *Bispyribac sodium 20% WP* (Kensolo) | 1 | 1% |
| Grasses | *Clomazone 200 g/L + Propanil 400 g/L EC* (Compro) | 10 | 6% |
| | *Metamifop 10% EC* (Matari) | 10 | 6% |
| | *Quinclorac 250 g/L SC* (Facet) | 1 | 1% |
| Sedges/ Broad leaves | *MCPA 600 g/L SL* (M-60) | 16 | 9% |
| | *MCPA 400 g/L SL* (M-40) | 3 | 2% |
| | *Carfentrazone-ethyl 240 g/L EC* (Afinity) | 1 | 1% |
| Mixtures | *Clomazone 200 g/L + Propanil 400 g/L EC* (Compro) + *MCPA 400 g/L SL* (M-40) | 36 | 21% |
| | *Fenoxaprop-P-Ethyl + Ethoxysulfuron 69+ 20 g/L OD* (Tiller Gold) + *MCPA 400 g/L SL* (M-40) | 4 | 2% |
| | *Clomazone 200 g/L + Propanil 400 g/L EC* (Compro) + *Carfentrazone-ethyl 240 g/L EC* (Afinity) | 3 | 2% |
| | *Bispyribac sodium 20% WP* (Kensolo) + *MCPA 400 g/L SL* (M-40) | 1 | 1% |
| Not cultivated | | 5 | 3% |

Herbicide dosage is another vital factor related to herbicide efficacy (Herath *et al*., 2017). Generally, farmers use a higher or lower dosage of herbicides than the recommendation. When considering the common herbicide, *Pretilachlor 30% EC* (Soffit), only 35% of farmers use the recommended dosages during dilution (product per 16 litre water tank). Strikingly 58% use a higher dosage than the recommended rates imposed by the DOA (DOA, 2015) (Table 3). However, there is no significant relationship between the dosage of pesticide applied to rice cultivation and the yield of rice cultivation (r=0.199, p=0.134). Therefore, the results revealed that herbicide overuse in rice cultivation, is not useful in achieving effective weed management or yield.

**Table 3: Herbicide Pretilachlor 30% EC (Soffit); use practices among the farmers.**

| | | Herbicide use by farmers | | | Recommended values by the DOA* (ml) |
|---|---|---|---|---|---|
| | | Mean (ml) | Count | Percentage | |
| Dilution (product per 16 L tank of water) (ml) | Recommended | 74 | 21 | 35% | 64 - 80 |
| | High | 99 | 35 | 58% | |
| | Low | 46 | 4 | 7% | |
| Rate of application (ml/acre) | Recommended | 640 | 4 | 7% | 640 |
| | High | 712 | 6 | 10% | |
| | Low | 509 | 50 | 83% | |

*Recommended values (Source: DOA, Pest Management Recommendations, 2015).

When considering the total amount applied per acreage, 83% apply a lower amount than the recommended. This is because the number of tanks sprayed by the farmers per acre is less than recommended. However, farmers use higher dosages in diluting products per 16 litre tanks to reduce the number of application cycles. This is not a good practice because the farmers will be exposed to high concentrations of pesticides. Other than that, the control of weeds may be poor due to lower dosages applied per acreage.

## Insecticides Usage Pattern in Rice Cultivation

### Common Insects

Major insect pests based on farmer observations is *Nilapavatalugens* (Brown Plant Hopper) (24%), which is considered critically harmful in rice fields. *Scirpophagaincertulas* (Yellow Stem Borer) (17%), *Cnaphalocrocismedinalis* (Rice Leaf folder) (15%) and *Stenchaetothripsbiformis* (Rice Thrips) (10%) are the other critical insect species in the rice fields in the study area. According to reported responses, *Leptocorisaoratorius* (Paddy Bug) does not cause any harmful impact on rice cultivations in the study area.

### Common Insecticides

Insecticide application is the prominent method of insect control adopted by 70% of farmers. Majority of the farmers used *Carbosulfan 200 g/L SC* (36%), while others used *Chlorantraniliprole 20% + Thiomethoxam 20% WG* (15%) and *Thiamethoxam 25% WG* (6%) (Table 4). This is due to the high insect pressure of *Nilapavatalugens* (Brown Plant Hopper) in the study area. *Carbosulfan 200 g/L SC* shows good insect control efficacy than the available other insecticides. Thirty percent (30%) of farmers do not use insecticides and instead rely on natural farming techniques (organic preparations and herbal extracts) to control insect pests.

Similarly, to herbicides practices, 62% of farmers use higher dosages during dilution (product per 16 litre of water tank) and apply a lower amount per acreage (54%) compared with the recommended rates by the DOA (DOA, 2015) (Table 5).

**Table 4: Percentage distribution of Insecticides in the study area.**

| Type of Insecticide | Count | Percentage |
|---|---|---|
| *Carbosulfan 200 g/L SC* | 63 | 36% |
| *Chlorantraniliprole 20% + Thiomethoxam 20%* | 26 | 15% |
| *Thiamethoxam 25% WG* | 10 | 6% |
| *Etofenprox 100 g/L EC* | 6 | 3% |
| *Fipronil 50 g/L SC* | 5 | 3% |
| Other | 11 | 6% |
| Not Applied | 53 | 30% |

**Table 5: Insecticide Carbosulfan 200 g/L SC; use practices among the farmers.**

| | | Insecticide use by farmers | | | Recommended values by the DOA* (ml) |
|---|---|---|---|---|---|
| | | Mean (ml) | Count | Percentage | |
| Dilution (product per 16 L of water) (ml) | Recommended | 30 | 17 | 27% | 32 |
| | High | 58 | 39 | 62% | |
| | Low | 16 | 7 | 11% | |
| Rate of application (ml/acre) | Recommended | 295 | 14 | 22% | 256 - 320 |
| | High | 443 | 15 | 24% | |
| | Low | 168 | 34 | 54% | |

*Recommended values (Source: DOA, Pest Management Recommendations, 2015)

Watawala *et al*. (2010) reported that the overuse of pesticides is due to limited knowledge of the farmers about the adverse effects of pesticides they use. Further, Selvarajah and Thiruchelvam (2007) stated that farmers in the Vavuniya district were unaware of the long-term and short-term effects of pesticide on health. Contradicting to this, Nagenthirarajah and Thiruchelvam (2008) stated that the use of pesticides by Sri Lankan farmers is generally not due to lack of knowledge or lack of awareness of the harmful effects of pesticides. Similarly, findings of this study also reveal that most of the farmers (45%) are well aware of the harmful effect of pesticides, but disregard the guidelines.

## Fungicides Usage Pattern in Rice Cultivation

Farmers of this study area rarely use fungicides. Only 4% of farmers used fungicides. Among those who applied, *Tebuconazole 250 g/L EW* (Folicur) was popular and belongs to class II (Moderately Hazardous) of the WHO pesticides hazard category.

## Use of Local Water Sources in the Study Area

Pollution of water sources due to pesticides is evident from previous research. Runoff from agricultural fields has been one of the major sources of surface and groundwater contamination (Pathmarajah, 2003). Further, Agro-chemical based agriculture had added considerably to the entry of pollutants (nitrogen, phosphorus, and heavy metals) into the water bodies (Sarathchandra*et et al*., 2017). In addition, Jayasumana*et et al*. (2015) stated that the prevalence of CKDu was observed among participants who drank well water in PadaviSripura DS, and it is associated with spraying glyphosate and other pesticides in paddy fields.

As revealed by the survey, 45% of farmers believe that their local water sources are polluted with agricultural pollutants; hence they use only community filters (79%), domestic wells (10%) and other water sources (11%), which are tested for water quality for drinking. However, 55% of farmers use local water sources for drinking. Those who use local water sources for drinking, mainly take water from their domestic wells (53%) and irrigation canals (37%). In addition, 10% of farmers use field wells, tanks and common wells. In most cases, these wells, irrigation canals, and tanks are located very close to the fields and can be categorised as vulnerable to contamination by agro-chemicals.

Eight percent of farmers (8%) were diagnosed with high blood pressure, diabetes (5%), kidney problems (3%), and asthma/respiratory disorders (1%), paralysis (1%) and skin diseases (1%) in this study area. Previous research has shown that kidney problems, respiratory disorders and skin diseases are associated with agricultural pollutants (Ngowi *et al*., 2007; Jayasumana *et al*., 2014, 2015; Padmajani *et al*., 2014). Hence, further analysis is needed in this regard.

## Poor Practices of Pesticide Usage among Farmers in the Study Area

Most of the farmers obtain information to use a particular pesticide with their own experience (47%), agro-chemical dealers (14%), through publications (11%) and neighbouring farmers (10%). Very few numbers of farmers approach government extension staff (18%). This may be the reason for incorrect selection of pesticides, dilution practices and not following guidelines.

To protect themselves from any harmful exposure during the handling and application of pesticides, pesticide applicators are expected to follow certain standards prescribed by the FAO (Padmajani *et al*., 2014). Jayasumana *et al*. (2015) reported that farmers do not use personnel protective equipment and wear scanty clothing due to heat when spraying pesticides in Padavi-Sripura DS. Confirming these results, 63% of farmers in this study area did not wear protective gear during pesticide application. Considering the disposal of used containers, 41% of farmers collect the empty bottles near houses, 39% bury and burn them, and 12 % dispose them near fields. Hence, empty pesticide containers must be collected in an appropriate manner at the field level by the relevant authorities or the farmers must be given clear instruction about appropriate disposal methods.

Mohottige *et al*. (2002) also reported that farmers in Sri Lanka are generally aware of the danger of inappropriate use of pesticides and are also knowledgeable about the correct guidelines, as they are regularly advised by the government extension officers. Further, Wilson and Tisdell (2001) have stated that Sri Lankan farmers appear to disregard technical recommendations and rely on their own experience, sometimes leading to indiscriminate application (Padmajani *et al*., 2014). Farmers in the study area also tend to use their own experience rather than seeking advice from extension officers.

In addition, it has been speculated that heavy metals present in formulated pesticide products may be a cause of the chronic kidney disease of unknown etiology (CKDu) in the agricultural areas of the country. This study does not aim to propose any new hypotheses about CKDu. Rather, revealed that these poor agricultural practices identified in the study area are likely to adversely affect the health of farmers.

### Relationship between the pesticide usage practices and socio-economic data

The relationship between the knowledge of farmers on proper pesticide usage practices and socio-economic data was analysed using Pearson correlation coefficient. The knowledge of farmers on proper pesticide usage practices correlated significantly with the age of farmers ($r=-0.166$, $p=0.031$). Young farmers are more aware of the adverse effects of these hazardous chemicals. The education level of the farmer was not significantly correlated with pesticide use practices.

## CONCLUSION

The study revealed that pesticides formulations in WHO hazard class Ia and Ib, which are prohibited in the country, are not used in the study area. However, class II (moderately hazardous) pesticides of WHO pesticide hazard category, which is not recommended by FAO, is heavily applied.

Violation of the recommendations given by the Department of Agriculture for the application of pesticides is also common in the study area. More than half of the farmers do not follow the relevant recommendations. Farmers tend to use higher concentrations of pesticides and apply a lower amount per extent than the recommended to reduce the cost of spraying. This practice will expose the farmers to excessive levels of pesticide, and also lead to poor pest management. Further, many farmers combine two or more pesticides to create a mixture, believing that such a mixture is more efficient in weed management.

Local water sources used for drinking get contaminated by the pesticides transferred through the interconnected irrigation canal system. Poor agricultural practices, such as violations of recommendations when applying pesticides, unprotected ways of handling and spraying pesticides, poor practices in dumping empty pesticide containers, and consuming water without checking the quality, are likely to affect farmers' health. Many farmers do not consult the government extension staff to get relevant information on particular pesticides. Instead, they rely on their own and, neighbouring farmers' experience and pesticide dealers' advice. However, young farmers are more aware of the consequences of malpractices in the use of pesticides, while their educational level has no significant influence on the practice.

Since there are no legal provisions or institutional mechanisms available at the field level to deal with malpractices in the use of pesticides, it is suggested to raise the awareness of the community regarding the consequences of such practices by improving the agricultural extension service. It is necessary to establish regular monitoring and follow-up mechanisms at the field level to regulate the activities of the farmers, and if necessary, take legal actions against malpractices.

## CONFLICT OF INTEREST STATEMENT

The authors certify that they have NO affiliations with or involvement in any organization or entity with any financial interest, or non-financial interest in the subject matter or materials discussed in this manuscript.

## ACKNOWLEDGEMENTS

The authors wish to express their sincere gratitude to all respondents for their valuable cooperation in responding to the questionnaire. A special acknowledgement to extension staff of the Department of Agriculture, Trincomalee district for their assistance provided. Authors gratefully acknowledge the Sri Lanka Council for Agriculture Research Policy (SLCARP) for their financial support (NARP/CARP/16/WUSL/ASC/0).

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