Int. J. Environ. Res., 9(3):1047-1054, Summer 2015
ISSN: 1735-6865

Relationship Between Environmental Risk and Pesticide Application in Cereal Farming

Bozdogan, A. M. [1*], Yarpuz-Bozdogan, N. [2], Tobi, I.[3]

[1]Cukurova University, Agriculture Faculty, Dept of Agr Machinery, 01330, Adana, Turkey
[2]Cukurova University, Vocational School of Technical Sciences, 01350, Adana, Turkey
[3]Harran University, Agriculture Faculty, Osmanbey Campus, Sanliurfa, Turkey

Received 8 Sep. 2014; Revised 17 Nov. 2014; Accepted 19 Nov. 2014

ABSTRACT: In 2013, 8 active ingredients (a.i.) in cereal farming were applied for insect and fungus control in Sanliurfa, Turkey. These a.i. were alpha-cypermethrin(EC), chlorpyrifos(EC;WP), difenoconazole(EC), indoxacarb(WG), lambda-cyhalothrin(EC), lufenuron(EC), propiconazole(EC) and tebuconazole(DS). In the present study, environmental risk of these a.i. was calculated via The Pesticide Occupational and Environmental Risk (POCER) indicators. From the results of this study, it was determined that the highest environmental risk is chlorpyrifos(EC). For this pesticide a.i., Exceedence Factor (EF) was assessed at 3.446 for the environment. Regarding the total score, chorpyrifos(EC) had potential risk at 49.2 percent for the environment. The lowest risk was found for tebuconazole(DS) due to its 0.000 EF value for the environment. In this study, it was concluded that the pesticide exposure of environment could be minimized by using appropriate application techniques and equipment for reducing pesticide drift, considering buffer zones according to pesticide formulation and toxicity, training in special educational programs, and using the manufacturer's recommended dosage during pesticide application.

Key words: Environment, Insecticide, Fungicide, Cereal, Agriculture

INTRODUCTION

Pesticides that are commonly applied to improve the quality and yield of agricultural crops have negative effects on human health and the environment. In 2011, the global pesticide market was valued at US$37.5 billion and total market value is expected to reach US$65.3 billion in 2017 (Anonymous, 2014a). The value of sales in the European Union (EU-15) crop protection sector was 6.2 billion Euro in 2010. This comprised 2.3 billion Euro for fungicides and 0.8 billion Euro for insecticides. Total expenditure on fungicides and insecticides accounted for 50 percent of the total expenditure on pesticides. The amount of EU-15 pesticide active ingredients (a.i.) used exceeded 0.2 billion kg in 2010. Fungicide and insecticide consumption was approximately 0.085 and 0.025 billion kg, respectively (ECPA, 2014). In Turkey, the value of the agrochemical market in 2010 was 222 million Euro, consisting of approximately 65 percent insecticide and fungicide (ECPA, 2014). Approximately 23 million kg of pesticides a.i. were used for agriculture in Turkey in 2010 (ECPA, 2014). Of pesticides used in 2010, approximately 35.14 percent were insecticides and 31.74 percent were fungicides (ECPA, 2014). In Turkey, cereals are cultivated over 16.0 million hectares (ha). In Turkey each year, cereal crops are generally composed of 50% wheat, 20% barley, 5% maize, and the other cereal crops. In 2012, cereal crops were cultivated in 600 000 ha in Sanliurfa (TUIK,2013). Sanliurfa has the largest agricultural land area in the Southeast Anatolia Region of Turkey. Wheat, cotton, barley, maize and lentils are cultivated as the main agricultural crops in Sanliurfa. In 2013, insecticides and fungicides were used for *Eurygaster integriceps, Ustilago nigra, Septoria tiritici, Tilletia spp., Zabrus spp., Sesamia nonagrioides, Sesamia cretica, Spodoptera exigua,* and *Puccina striformis* over 185,000 ha in Sanliurfa (Anonymous, 2014b). In 2013, eight pesticide a.i. were applied to control these pests in cereal farming. These a.i. were alpha-cypermethrin(EC), chlorpyrifos(EC;WP), difenoconazole(EC), indoxacarb(WG), lambda-cyhalothrin(EC), lufenuron(EC), propiconazole(EC) and tebuconazole(DS). These a.i. were applied as 10,312 kg of indoxacarb(WG), 1,650 kg of tebuconazole(DS), 1,137

*Corresponding author E-mail: amb@cu.edu.tr

kg of alphacypermethrin$^{(EC)}$, 660 kg of difenoconazole$^{(EC)}$, 660 kg of propiconazole$^{(WP)}$, 561 kg of chlorpyrifos$^{(EC)}$, 250 kg of chlorpyrifos$^{(WP)}$, 72 kg of lambda-cyhalothrin$^{(EC)}$, and 3 kg of lufenuron$^{(EC)}$. A total of 15,306 kg of these a.i. was applied for insect and fungus control in cereal farming (Anonymous, 2014b). Description and structural formula of each a.i. is given below (PPDB, 2014a; Anonymous, 2014c):

Alpha-cypermethrin ($C_{22}H_{19}Cl_2NO_3$) is an insecticide used to control chewing and sucking insects (Fig. 1a). Chlorpyrifos ($C_9H_{11}Cl_3NO_3PS$) is a broad-spectrum organophosphate insecticide used to control soil and foliage pests in agricultural crops (Figure 1b). Difenoconazole ($C_{19}H_{17}Cl_2N_3O_3$) is a broad-spectrum fungicide used for protection in agriculture (Figure 1c). Indoxacarb ($C_{22}H_{17}ClF_3N_3O_7$) is an insecticide for use on agricultural crops to control Lepidoptera (Figure 1d). Lambda-cyhalothrin ($C_{23}H_{19}ClF_3NO_3$) is a quick-acting insecticide used to control a wide spectrum of pests including aphids, Colorado beetle and thrips (Fig. 1e). Lufenuron ($C_{17}H_8Cl_2F_8N_2O_3$) is an insect growth regulator used to control biting and sucking insects including Lepidoptera and Coleoptera larvae (Fig. 1f). Propiconazole ($C_{15}H_{17}Cl_2N_3O_2$) is a broad range-activity fungicide used to protect agricultural crops (Fig. 1g). Tebuconazole ($C_{16}H_{22}ClN_3O$) is systemic fungicide used as a seed dressing against diseases in cereals and other field crops (Figure 1h). In pesticide applications, there are potential risks for environment. According to EU 91/EC414, indicators of environmental risk are aquatic organisms, bees, birds, earthworms, beneficial arthropods, groundwater, and soil (Vercruysse and Steurbaut, 2002; De Schamphelerie et al., 2007; Yarpuz-Bozdogan, 2009; Bozdogan and Yarpuz-Bozdogan, 2009).

The aim of this study was to determine the environmental risk of a.i. applied to control insects and fungus in cereal farming in Sanliurfa, Turkey, in 2013.

MATERIALS & METHODS

In the present study, environmental risks were assessed for alpha-cypermethrin$^{(EC)}$, chlorpyrifos$^{(EC;WP)}$, difenoconazole $^{(EC)}$, indoxacarb$^{(WG)}$, lambda-cyhalothrin$^{(EC)}$, lufenuron$^{(EC)}$, propiconazole$^{(EC)}$, and tebuconazole$^{(DS)}$ applied for fungus and insect control in cereal farming in Sanliurfa, Turkey, in 2013. In this study, the recommended dose (kg a.i. ha^{-1}) given on product labels and the toxicity data of each a.i. for environmental risk were used for assessment (PPDB, 2014a). Risk indices (RI) for environment were assessed using the Equations below.

2. 1. Estimation of spray drift (%)

The drift in the downwind field was determined using the German Ganzelmeier drift curve as given below (Equation 1) (De Schamphelerie et al., 2007).

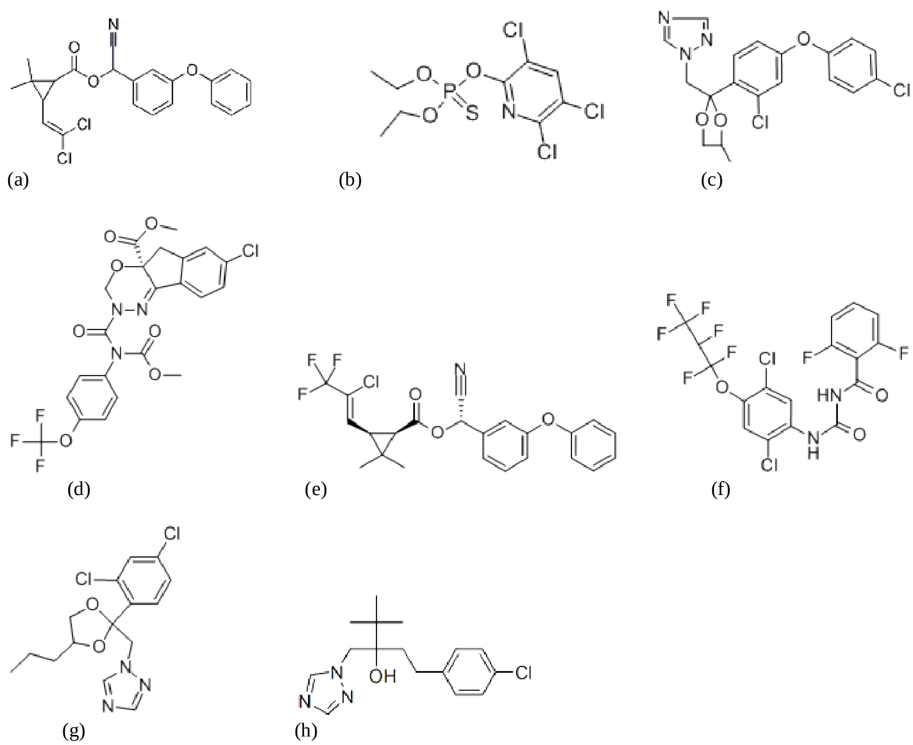

Fig .1. Structural formulas of pesticide a.i. (Anonymous, 2014c)

Table 1. Active ingredients' name, formulation and recommended dose

Name and Formulation^{+}	Recommended Dose (kg a.i. ha^{-1})*
Alpha-cypermethrin$^{(EC)}$	0.0150
Chlorpyrifos$^{(WP)\&}$	0.1250
Chlorpyrifos$^{(EC)}$	0.8640
Difenoconazole$^{(EC)}$	0.0600
Indoxacarb$^{(WG)}$	0.0375
Lambda-cyhalothrin$^{(EC)}$	0.0100
Lufenuron$^{(EC)}$	0.0100
Propiconazole$^{(EC)}$	0.0600
Tebuconazole$^{(DS)\&}$	0.0075

$^{+}$:EC:Emulsifiable Concentrate; WP:Wettable Powder; WG:Water-dispersible Granules; DS:Soluble Dust. *: Recommended dose from the product labels by manufacturer; $^{\&}$:Chlorpyrifos$^{(WP)}$ and tebuconazole$^{(DS)}$ a.i. were used in seed treatment. In treatment, 50 g a.i. per 100 kg seed was applied for chlorpyrifos, and 2.5 g a.i. per 100 kg seed for tebuconazole.

$$[\%drift = A \times z^{B}] \quad (1)$$

A and B: coefficients (A = 2.7593 and B = -0.9778 for field crops) and z: interval between field boundary and a point in downwind field (m).

2.2. Estimation of RI for environment

2.2.1. $RI_{\text{aquatic organisms}}$

The $RI_{\text{aquatic organisms}}$ is determined via Equation 2 (Vercruysse and Steurbaut, 2002; van Bol et al., 2002; Claeys et al., 2005; De Schamphelerie et al., 2007).

$$[RI_{AquaticOrganisms} = \frac{\left(\dfrac{D \times \%drift \times n}{d_{ditch} \times 1000}\right)}{\min(NORM_{w})}] \quad (2)$$

n: number of applied doses (*default:* 3 for lambda-cyhalothrin, 1 for others a.i.); d_{ditch}: ditch depth (m; *default*: 1.5), and min($NORM_w$): toxicological reference on acute toxicity in aquatic organisms (mg l^{-1}). Min(NORMw) is calculated in three quotients as fish, daphnia, and algae. The lowest of the three quotients below is accepted as min(NORMw) (Vercruysse and Steurbaut, 2002; De Schamphelerie et al., 2007):

For fish: LC_{50} / 100,

(LC_{50}: the median lethal concentration (mg kg^{-1}))

For Daphnia: EC_{50} / 100,

(EC_{50}: the median effect concentration (mg l^{-1}))

For algae: NOEC / 10,

(NOEC: No Observed Effect Concentration (mg l^{-1}))

In this study, daphnia was used as the toxicological reference for alpha-cypermethrin, chlorpyrifos, difenoconazole, indoxacarb and lufenuron a.i. due to having min($NORM_w$). Fish has min($NORM_w$) for lambda-cyhalothrin and propiconazole a.i. Algae was used for tebuconazole a.i. in Equation 2.

2.2.5. $RI_{\text{beneficial arthropods}}$

The $RI_{\text{beneficial arthropods}}$ is determined via Equation 3 (Vercruysse and Steurbaut, 2002; Claeys et al., 2005).

$$[RI_{beneficialarthropods} = \frac{(RC - 25)}{(100 - 25)}] \quad (3)$$

RC: reduction in capacity of the organism by pesticide application (%).

The $RI_{\text{beneficial arthropods}}$ is set up in such a manner that a lower limit of 0 is obtained for an RC-value of 25% and an upper limit of 1 for an RC-value of 100% (van Bol et al., 2002).

2.2.4. RI_{bees}

The RI_{bees} is determined via Equation 4 (Vercruysse and Steurbaut, 2002; van Bol et al., 2002; Claeys et al., 2005).

$$[RI_{bees} = \frac{AR}{LD_{50} \times 50}] \quad (4)$$

AR: application rate (g a.i. ha^{-1}), LD_{50}: the minimum ($LD_{50,Oral}$; $LD_{50,Contact}$) (μg a.i. bee^{-1})

2.2.2. RI_{birds}

The RI_{birds} is determined via Equation 5 (Vercruysse and Steurbaut, 2002).

$$[RI_{BIRDS} = \frac{(PEC_{BIRD} \times 10)}{(LD_{50} \times BW)}] \quad (5)$$

PEC_{BIRD}: the estimated total daily pesticide intake (mg day^{-1}), LD_{50}: acute LD_{50} for birds (mg kg^{-1} body weight), BW: body weight (kg; *default:* 0.01)

The total daily intake of pesticides for birds (PEC_{birds}) eating treated crops is calculated using Equation 6. The average concentration on the crop, immediately after spraying, is estimated by multiplying the application rate with 31 (Vercruysse and Steurbaut, 2002).

$$[PEC_{BIRD} = 31 \times AR \times BW \times 0.3] \quad (6)$$

As in Equation 6, the factor 0.3 refers to the fact that small birds have a daily food intake of 30 percent of their body weight (Vercruysse and Steurbaut, 2002).

2.2.6. RI_{soil}

The RI_{soil} is determined via Equation 7 (Vercruysse and Steurbaut, 2002; van Bol et al., 2002; Claeys et. al., 2005).

$$[RI_{persistence} = 10^{(DT_{50}/90-1)\times 2}] \quad (7)$$

DT_{50}: pesticide half-life in soil (days).

2.2.3. $RI_{earthworms}$

The $RI_{earthworms}$ is determined via Equations 8 and 9 (Vercruysse and Steurbaut, 2002; van Bol et al., 2002; Claeys et. al., 2005; De Schamphelerie et al., 2007).

$$[RI_{earthworms} = \frac{PEC_{bottom} \times 10}{LC_{50}}] \quad (8)$$

PEC_{bottom}: the bottom pesticide concentration in soil (mg kg^{-1} soil).

$$[PEC_{bottom} = \frac{D \times \%drift \times n \times (1-f)}{d_{bottom} \times \rho_{bottom}}] \quad (9)$$

f: fraction of depositing a.i. intercepted by crops (fraction; *default*: 0.88), d_{bottom}: bottom depth (m; *default*: 0.05), ρ_{bottom}: bottom density (kg m^{-3}; *default:* 1 350).

2.2.7. $RI_{groundwater}$

The $RI_{groundwater}$ is determined via Equation 10 (Vercruysse and Steurbaut, 2002; Claeys et. al., 2005).

$$[RI_{groundwater} = \frac{PEC_{groundwater}}{0.1}] \quad (10)$$

$PEC_{groundwater}$: predicted concentration in groundwater (µg l^{-1})

2.4. Integration of the RI into a Total Risk Indicator

The risk of a pesticide a.i. to human health and the environment is related to the degree to which the lower limit is exceeded. This exceedence factor (EF) is assessed by Equation 11 (Vercruysse and Steurbaut, 2002).

$$[EF = \left(\frac{X_{TRANSFORMED} - LL^{+}_{TRANSFORMED}}{UL^{+}_{TRANSFORMED} - LL^{+}_{TRANSFORMED}}\right)] \quad (11)$$

RI^+, LL^+ and UL^+, that the relative RI, LL and UL, values are determined by dividing, respectively, the RI, LL and UL by UL. These RI^+, LL^+ and UL^+ values are transformed using Equation 12 (Vercruysse and Steurbaut, 2002).

$$[X_{transformed} = \log\left(1 + \frac{1}{X}\right)] \quad (12)$$

X = RI^+, LL^+ and UL^+. If EF values are lower or equal to 0, they are set to 0, and this means low risk for pesticide a.i. If EF values are higher or equal to 1, they are set to 1, and this means high risk for pesticide a.i. If EF values are between 0 and 1, it means intermediate risk for pesticide a.i. (Vercruysse and Steurbaut, 2002).

The maximum total risk of pesticide a.i. is calculated by adding the indices that consist of 7 for the environment. Thus, using the POCER indicator, maximum total risk for environment of a pesticide a.i. is determined with a value from 0 to 7 (Vercruysse and Steurbaut, 2002).

RESULTS & DISCUSSION

The recommended doses of a.i. used in insecticide and fungicide applications to control pests in cereal cultivation, and EF values of each a.i. determined via Equation 11 and 12, are presented in Figure 2 - 7.

3.1. EF value of used a.i. for aquatic organisms

Risks for aquatic organisms of used a.i. to control insect and fungus in cereal farming were presented in Fig 2.

As seen in Fig 2, due to 0.000 EF values of difenoconazole$^{(EC)}$, indoxacarb$^{(WG)}$, propiconazole$^{(EC)}$, and tebuconazole$^{(DS)}$ they have low risk for aquatic organisms. In calculations, chlorpyrifos$^{(EC;WP)}$ had 1.000 EF value that is maximum value. Chlorpyrifos$^{(WP)}$ is applied as seed treatment in this study. According to Vercruysse and Steurbaut (2002), exposure of aquatic organisms for applications with treated seed is negligible. Yet, in worst scenario, pesticide can be transported into aquatic organisms in excessive rain or irrigation. Alpha-cypermethrin$^{(EC)}$ (0.546), lambda-cyhalothrin$^{(EC)}$ (0.776), and lufenuron$^{(EC)}$ (0.087) have intermediate risk for aquatic organisms. Jeyakumar *et al*., (2014) indicated that pesticides determined in surface water and under water sediments from tanks located nearby the prime agricultural areas. For minimizing risk to aquatic organisms, proper application technology and equipment, and a sufficient buffer zone should be used in pesticide application (Snoo and Witt, 1998; Bozdogan and Yarpuz-Bozdogan, 2008a; Bozdogan and Yarpuz-Bozdogan, 2008b). In the present study, it was calculated that the buffer zone should be at least 2000 m for chlorpyrifos$^{(EC)}$, 10 m for alpha-cypermethrin$^{(EC)}$, and

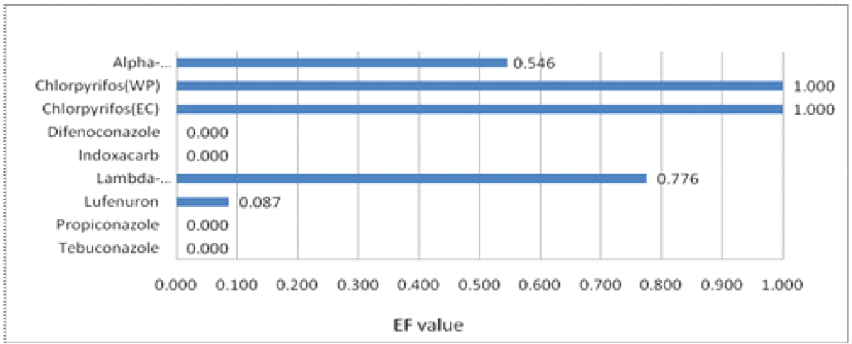

Fig. 2. EF values for aquatic organisms

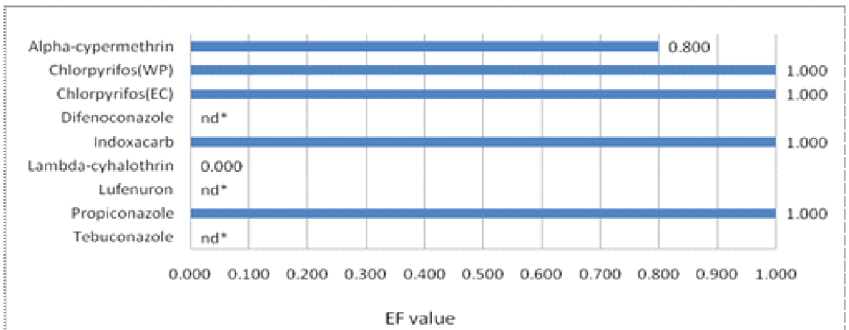

Fig. 3. EF values for beneficial arthropods

2 m for lufenuron(EC). According to the manufacturer of lambda-cyhalothrin(EC), it is recommended that this a.i. is applied three times applications at 15 day intervals to control *Sesamia nonagrioides* and *Sesamia cretica*. Therefore, the buffer zone was calculated as 30 m for lambda-cyhalothrin. Buffer zone distance can be reduced using vegetation on field/water bodies border. Wan (2013) indicated that environment Canada's main aquatic protection strategy was a 10 meter buffer zone. Ucar and Hall (2001) reported that buffer zone distance depends on the formulation, sensitivity of non-target neighbor, specific weather conditions, etc. Application doses and replicates of pesticide are a major determining factor for distance of buffer zones (Bozdogan and Yarpuz-Bozdogan, 2008b).

3.2. EF value of used a.i. for beneficial arthropods

Risks for beneficial arthropods of used a.i. to control insect and fungus in cereal farming were presented in Fig 3. As seen in Fig 3, lambda-cyhalothrin(EC) has low risk 0.000 EF values for beneficial arthropods. Yet, RC value was not determined for difenoconazole(EC) , lufenuron(EC), and tebuconazole(DS). Chlorpyrifos(WP;EC), indoxacarb(WG), and propiconazole(EC) have high risks owing to their 1.000 EF value. Alpha-cypermethrin(EC) (0.800) has intermediate risk for beneficial arthropods. Yet, according to Vercruysse and Steurbaut (2002), the EF value of chlorpyrifos(WP) is negligible due to seed treatment. Biddinger *et al* (2014) indicated that conventional spray programs have negative effect on arthropods in peach orchards. Also, Ristyadi *et al* (2013) determined that the abundance of arthropods was significantly different for site treated with biopesticide and site treated with synthetic pyrethroids, and non-sprayed site to site treated with biopesticide. For this reasons, to protect beneficial arthropods in pesticide application area for agricultural sustainability, farmers have to carefully decide environmentally friendly pesticide application technology and selective pesticide. On the other hand, pesticides have negatively effect on beneficial arthropods in long-term.

3.3. EF value of used a.i. for bees

Risks for bees of used a.i. to control insect and fungus in cereal farming were presented in Fig 3.

As seen in Fig 4, difenoconazole(EC), lufenuron(EC), propiconazole(EC), and tebuconazole(DS) had low risk for bees (EF 0.000). Chlorpyrifos(EC) had the maximum EF value (1.000). In calculations, owing to EF values between 0.000 and 1.000, chlorpyrifos(WP) (0.868), alpha-cypermethrin(EC) (0.543), indoxacarb(WG) (0.512), and lambda-cyhalothrin(EC) (0.413) had intermediate risk. For minimizing bee exposure, beekeepers should be kept currently informed via local media during pesticide applications. Moreover, drift have to be reduced using appropriate spray application technologies and anti-drift

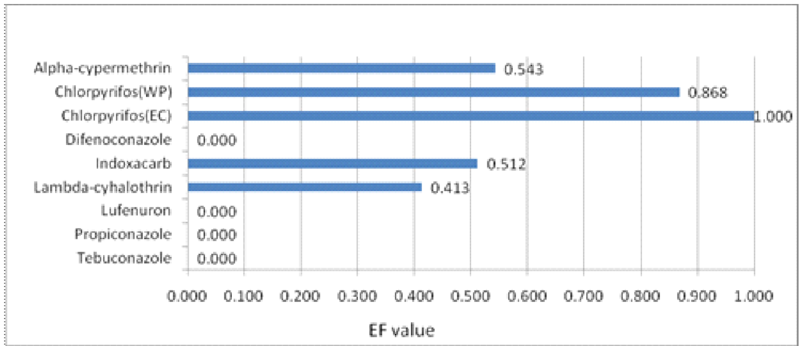

Fig. 4. EF values for bees

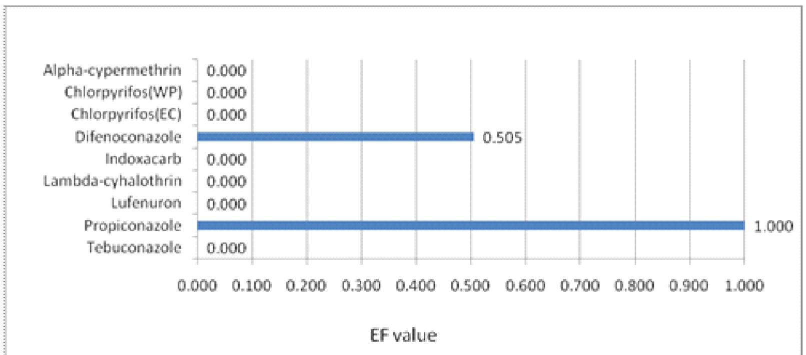

Fig. 5. EF values for persistence in soil

nozzles. No risk to bees is expected due to the fact that chlorpyrifos$^{(WP)}$ is applied as a seed treatment according to Vercruysse and Steurbaut (2002). Yet, during pneumatic sowing procedure, pesticide dust in coated seeds can be drifted via pressured air, and it may contaminate to honeybee. Cutler *et al*. (2013) determined that spray application is more damage to bee colonies. Honeybee samples from different areas of Greece were analyzed for the pesticide residues, and 14 pesticide a.i. was observed with concentrations ranging from 0.3 to 81.5 ng g^{-1} on honeybee (Kasiotis *et al*., 2014).

3.4. EF value of used a.i. for persistence in soil

Risks for persistence in soil of used a.i. to control insect and fungus in cereal farming were presented in Fig 5. Propiconazole$^{(EC)}$ had the highest EF value (1.000) for persistence in soil. While difenoconazole$^{(EC)}$ (0.505) had intermediate risk, the other a.i. had low risk due to their 0.000 EF values (Fig 5). In pesticide applications, soil is contaminated by pesticides and heavy metals. Tabassum *et al* (2014) determined that agricultural soil as compared to barren soil is more efficient adsorbent for methyl/ethyl parathions, at optimum batch condition of pH7. The soil sorption coefficient K and the soil organic carbon sorption coefficient Koc are the basic parameters used for describing the environmental fate of the herbicides (Maheswari and Ramesh, 2012).

3.5. EF value of used a.i. for birds

Risks for birds of used a.i. to control insect and fungus in cereal farming were presented in Fig 6. As seen in Fig 6, chlorpyrifos$^{(EC)}$ had intermediate risk for birds due to its 0.446 EF value. Others a.i. had low risk.

3.6. EF value of used a.i. for earthworms and leaching to groundwater

In this study, EF value for earthworms and leaching to groundwater was calculated as 0.000 in all a.i. It means all used a.i. has low risk for earthworms and leaching to groundwater.

3.7. Total Risks for Environment

In the present study, tebuconazole$^{(DS)}$ had low risk to the environment owing to its 0.000 EF values. Due to their 1.000 EF values, chlorpyrifos$^{(EC;WP)}$, indoxacarb$^{(WG)}$, and propiconazole$^{(EC)}$ had high risk for some environmental indicators. Among these a.i., chlorpyrifos$^{(EC)}$ (1.000) had the highest risk for beneficial arthropods, aquatic organisms and bees. The environmental fate and ecotoxicology values of chlorpyrifos$^{(EC)}$ show that it is harmful to beneficial arthropods, aquatic organisms and bees (PPDB, 2014b). As seen in Fig 7, tebuconazole (0.000) had the lowest total risk for the environment. Yet, chlorpyrifos$^{(EC)}$ had the highest total risk for the environment due to its 3.446 EF value. This value equals 49.2% of the maximum

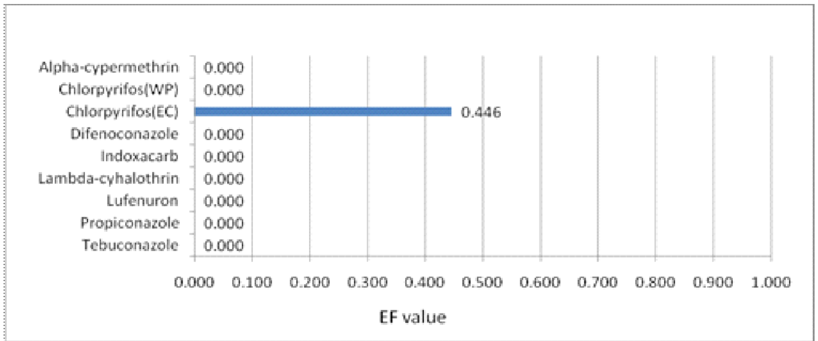

Fig. 6. EF values for birds

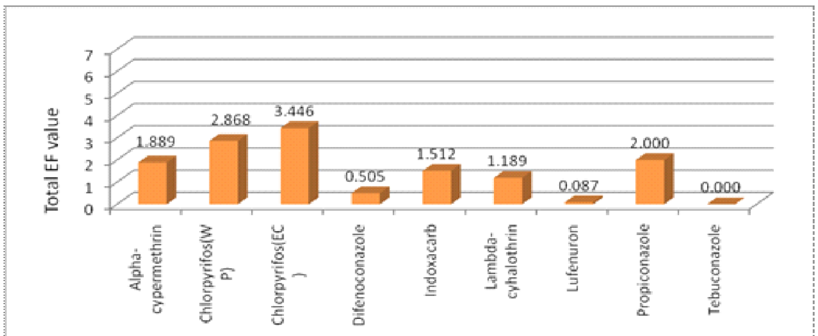

Fig. 7. Total EF value for environment

total score for the environment. This a.i. had high risks for aquatic organisms (EF 1.000), beneficial arthropods (EF 1.000), bees (EF 1.000), and birds (EF 0.446) in the environment. To minimize environmental poisoning and reduce chemical use in pesticide applications, proper nozzle and environmentally friendly spray application technology such as band spraying, spot spraying, and variable rate spraying should be used, and sprayers should be carefully calibrated before application (Snoo and Witt, 1998; Claman, 2004; Tobi *et al*., 2005; Bozdogan and Yarpuz-Bozdogan, 2008a; Bozdogan and Yarpuz-Bozdogan, 2008b; Yarpuz-Bozdogan and Bozdogan, 2009a; Yarpuz-Bozdogan and Bozdogan, 2009b; Yarpuz-Bozdogan *et al*., 2011; Bozdogan, 2014). Pesticide application quality are negatively affected by some factors such as old sprayers, blocked nozzle filters, unadjusted pressure regulators, etc. (Tobi and Saglam, 2012). Bad pesticide application quality means contaminated environment with pesticide. Based on data obtained from survey studies in Sanliurfa province, in general, farmers operate sprayers at very high pressures, do not adjust the travel speed of the boom sprayer based on the calibration, and do not know the values of wind speed, temperature and relative humidity required for pesticide applications (Tobi *et al*., 2011). Application of the dose recommended by the manufacturer is also important for environmental protection. In general, farmers do not take care of it. They often apply excessive dose a.i. in pesticide application. Damalas *et al*. (2006) indicated that 46% of farmers applied doses over the recommended rates given on the label, whereas none reported using less than the label rates.

CONCLUSIONS

From the results of this study, it was assessed that chlorpyrifos(EC) has the highest risk environment (EF 3.446). In 2013, the total use of this a.i. in cereal farming in Sanliurfa was 561 kg. This value equals 3.7% of the total used pesticide a.i. Tebuconazole(DS) a.i. has the lowest total risk to environmental risk due to its 0.000 EF values. All a.i. have low risk on earthworms, and leaching to groundwater. In this study, it was concluded that the pesticide exposure of environment could be minimized by using appropriate application techniques and equipment for reducing pesticide drift, considering buffer zones according to pesticide formulation and toxicity, training in special educational programs, and using the manufacturer's recommended dosage during pesticide application.

REFERENCES

Anonymous, (2014a). Retrieved August 01, 2014, from http://www.bccresearch.com/pressroom.

Anonymous, (2014b). Sanliurfa Il Gida, Tarim ve Hayvancilik Bakanlýgý. Bitki Koruma Sube Mudurlugu.

Anonymous, (2014c). Retrieved August **15,** 2014, from http://www.chemicalbook.com.

Biddinger, D. J., Leslie, T. W. and Joshi, N. K. (2014). Reduced-Risk Pest Management Programs for Eastern U.S. Peach Orchards: Effects on Arthropod Predators, Parasitoids, and Select Pests Journal of Economic Entomology, **107,** 1084-1091.

Bozdogan, A.M. (2014). Assessment of total risk on non-target organisms in fungicide application for agricultural sustainability. Sustainability, **6,** 1046-1058.

Bozdogan, A.M. and Yarpuz-Bozdogan, N. (2008a). Determination of dermal bystander exposure of malathion for different application techniques. Fresenius Environmental Bulletin, **12,** 2103-2108.

Bozdogan, A.M. and Yarpuz-Bozdogan, N. (2008b). Assessment of buffer zones to ditches of dicofol for different applied doses and replication numbers in pesticide applications in Adana province, Turkey. Fresenius Environmental Bulletin, **3,** 275-281.

Bozdogan, A.M. and Yarpuz-Bozdogan, N. (2009). Determination of total risk of defoliant application in cotton on human health and environment. Journal of Food, Agriculture & Environment, **1,** 229-234.

Claeys, S., Vagenende, B., De Smet, B., Lelieur, L. and Steurbaut, W. (2005). The POCER indicator: a decision tool for non-agricultural pesticide use. Pest Management Science, **61,** 779–786.

Claman, P. (2004). Men at Risk: Occupation and Male Infertility. Sexuality, Reproduction & Menopause 1: 19-26.

Damalas, C. A., Theodorou, M. G. and Georgiou, E. B. (2006). Attitudes towards pesticide labelling among Greek tobacco farmers. International Journal of Pest Management, **52,** 269-274.

De Schamphelerie, M., Spanoghe, P., Brusselman, E. and Sonck, S. (2007). Risk assessment of pesticide spray drift damage in Belgium. Crop Protection, **26,** 602-611.

ECPA, (2014). Retrieved August 01, 2014, from http://www.ecpa.eu.

Jeyakumar, T., Kalaiarasi, I., Rajavel, A., Anbu, M. and Kumar, R. (2014). Levels of Organochlorine Pesticide Residues in Water and Sediment from Selected Agricultural Sectors of Kanyakumari District, Tamil Nadu, India. Int. J. Environ. Res., **8,** 493-500.

Kasiotis, M. K., Anagnostopoulos, C., Anastasiadou, P. and Machera, K. (2014). Pesticide residues in honeybees, honey and bee pollen by LC-MS/MS screening: Reported death incidents in honeybees. Science of the Total Env 485-486, 633-642.

Maheswari, S. T. and Ramesh, A. (2012). Adsorption and Degradation of Anilofos in Different Soils and its Environmental Impact in Soils. Int. J. Environ. Res., **6,** 451-456.

PPDB, (2014a). Retrieved December 03, 2013, from http://sitem.herts.ac.uk /aeru/ppdb/en/

PPBD, (2014b). Retrieved August 01, 2014 from http://sitem.herts.ac.uk/aeru/ppdb/en/docs/Background_and_Support.pdf.

Ristyadi, D., Andrew, N. and Waugh, R. (2013). Effect of pesticide types on community structure of arthrop in soy crops. Indonesian Journal of Entomology, **10,** 85-92.

Snoo, G.R. and Witt, P.J. (1998). Buffer zones for reducing pesticide drift to ditches and risks to aquatic organisms. Ecotoxicology and Environmental Safety, **1,**112-118.

Tabassum, N., Rafique, U., Balkhair, K. S. and Ashraf, M. A. (2014). Chemodynamics of methyl parathion and ethyl parathion: Adsorption models for sustainable agriculture. BioMed research International, Article number 831989, 8p.

Tobi, I., Saglam, R. and Bozdogan, A. M. (2005, September). Pesticide Applications in Agriculture in Turkey. (Paper presented at the GAP IV. Agriculture Conference, Sanliurfa, Turkey).

Tobi, I., Saglam, R., Kup, F., Sahin, H., Bozdogan, A. M., Piskin, B. and Saglam, C. (2011). Determination of accuracy level of agricultural spraying application in Sanliurfa/ Turkey. African Journal of Agricultural Research, **6,** 6064-6072.

Tobi, I. and Saglam, R. (2012). Determination of conditions related to ages of field sprayers used in sunnpest spraying in Sanliurfa. J.Agric. Fac. HR.U., **16,** 37-44.

TUIK, (2013). Retrieved December 03, 2013, from http://www.tuik.gov.tr

van Bol, V., Debongnie, P., Pussemier, L., Maraite, H. and Steurbaut, W. (2002). Study and analysis of existing pesticide risk indicators. Veterinary and Agrochemical Research Center. Teruren, Belgium.

Vercruysse, F. and Steurbaut, W. (2002). POCER The pesticide occupational and environmental risk indicator. Crop Protection, **1,** 307-315.

Wan, M.T. (2013). Ecological risk of pesticide residues in the British Columbia environment: 1973–2012. Journal of Environmental Science and Health, Part B: Pesticides, Food Contaminants, and Agricultural Wastes, **5,** 344-363.

Yarpuz-Bozdogan, N. (2009). Assessing the environment and human health risk of herbicide application in wheat cultivation. Journal of Food, Agriculture & Environment, 3&4, 775-781.

Yarpuz-Bozdogan, N. and Bozdogan, A.M. (2009a). Assessment of dermal bystander exposure in pesticide applications using different types of nozzles. Journal of Food, Agriculture & Environment, **2**, 678-682.

Yarpuz-Bozdogan, N. and Bozdogan, A. M. (2009b). Comparison of field and model percentage drift using different types of hydraulic nozzles in pesticide applications. Int. J. Environ. Sci. Tech., **2,** 191-196.

Yarpuz-Bozdogan, N., Atakan, E., Bozdogan, A.M., Yýlmaz, H., Daglioglu, N., Erdem, T. and Kafkas, E. (2011). Effect of dsifferent pesticide application methods on spray deposits, residues and biological efficacy on strawberries. African Journal of Agricultural Research, **4,** 660-670.