Taiwan Epidemiology Bulletin
August 21, 2012/ Vol.28 / No.16

Original Article

Efficacy of Insecticide with Ethylene Glycol to *Aedes aegypti*

Wei-Tai Hsia[1], Ho-Sheng Wu[1], Yi-Chieh Yang[1], Cheo Lin[1] ,Ya-Wen Cheng[2]

1. Research and Diagnostic Center, Centers for Disease Control, Taiwan
2. Department of Public Health, National Taiwan University, Taiwan

Abstract

Recently, insecticide with ethylene glycol (EG) sprayed by portable thermal fogger to conduct space spray has become the most popular method in Taiwan to control dengue fever vectors. As an adjuvant, EG could help pest control operator to observe the spread and distribution of insecticide droplets, also to increase the positive impression of residents. However, there was no evidence about its synergic effect and environmental pollution problem. Our study was conducted by Net Cage Test to evaluate the efficacy of insecticide with or without EG to *Aedes aegypti*. Droplet parameters were measured by Sizing Master. Results showed that EG could not kill mosquitoes, its concentration and droplet parameters are positive related, 50% solution has the best nebulization (Span=0.6, DR=1). Blending with EG would decrease the number of insecticide droplets and widen the droplets diameter, though nebulization remained in an appropriate range, result to enhance the efficacy of insecticide to *A. aegypti*. The number of droplets decreased may cause by the hydrophilic property of EG which produces larger droplets than insecticide alone. The inhibition of evaporation caused by EG prevents the drift of droplets and prolongs its suspension time; therefore, increase the efficacy of insecticide to *A. aegypti*. Although EG not only can create visible smog for operator, but also increase insecticides' efficiency, its toxicity to the operator and resident should be concerned.

Key words: ethylene glycol(EG), *Aedes aegypti*, droplet sizing, insecticide

Introduction

In the last few decades, dengue fever has become a perennial insect-borne disease in southern Taiwan. The most common way to control the dengue fever vector is to spray oil-based insecticide by portable thermal fogger. This method could shorten the time of spraying, easily observed of the insecticide droplet diffusion and distribution in the form of fog, moreover, make good impression of control efficiency to the public [1]. However, using lots of organic solvents usually cause pollution problem and is difficult to transport [2]. Flammable character, high temperature and smoke of fogging also increase the risk of fire accidents and traffic problems [1]. Bad smell and difficult to clean up of the oil residue cause residents resentment and reject spraying [3], which obstruct control effort and become the main issue between governmental agencies and the public.

Chemical control is one of the major methods in Integrated Pest Management to eliminate vectors and prevent local spreading [4]. To control dengue vector, need to spray indoors and outdoors with insecticide synchronously. As dengue usually occurred in densely population area, so the insecticide needs to be low toxicity, high efficacy, slight irritation and without bad smell to reduce the impact to community environment and residents life and ensure the control plan smoothly on going. Using water-based insecticide with lesser disadvantage than oil-based has become an alternative way for house spraying. Without smoky effect, residents may doubt the efficacy of water-based insecticide, so is the pest control operator who could not evaluate the completion of operation by vision easily. Recently, the pest control operator blends water-based insecticide with ethylene glycol and spray by portable thermal fogger in order to create smog and enhance the visual appraisal, also to satisfy the residents' anticipation of control effect.

Ethylene glycol (EG, $HOCH_2$-CH_2OH) is the most used agent blended in insecticide to create smoke, which is a simple stable polar dihedral alcohol liquid compound, colorless, odorless, with a sweet taste. Its hydroxyl group can form hydrogen bond with water molecules, so can be easily mixed with water in any rate and possesses hygroscopic. It has low freezing point (-12.9℃) and high boiling point (197.3℃) and self ignition on 400℃. EG is mainly used as an antifreeze in the houses, pipelines and cars, also in flux, surfactant, bitumen emulsifiers, foam stabilizer and wetter in industry, and polyester fiber and plastic material too [5]. In laboratory, it can be used to preserve specimen [6] or protein extraction, besides, the smog has drama, educational and entertainment effect. Eating by mistake, EG could cause unconsciousness, unsteady gait, inarticulate, hypertension, palpitation, congested heart failure, back pain, calcium oxalate crystallization urine, anuran and renal failure in humans [7-8].

Generally, insecticides mix with adjuvant may result in synergism, antagonism or independence effect. Synergism is that some insecticides blend with adjuvant have better efficacy than without it, such as some synthetic pyrethroid insecticide mix with N-(2-Ethylhexyl)-5-norbornene-2,3-dicarboximide (MGK-264) could increase the efficacy to *Blattella germanica* for several fold[9] and some insecticides with adjuvant was strongly synergized by piperonyl butoxide (PBO) in *Ae*. *Aegypti* [10-11]. Antagonism means the efficacy will be reduced, while, independence is no difference after blended. Adjuvant is not included in the category of "Environmental insecticide" by Taiwan EPA; also the efficacy of adjuvant blended with insecticide to vectors is unknown. Besides, the smog of insecticide with space spraying will suspend in the air for a long time, and it would threaten the health of elderly, children, or the person with liver or kidney dysfunction. Therefore, the purpose of this study is to evaluate the efficacy of EG alone and mixed with liquid or emulsion pyrethroid to *Aedes aegypti*, and to interpret its mechanism by droplet sizing.

Materials and methods

A. Preparation and Strains of Mosquitoes

A. aegypti were collected in Tainan area during 1987, and reared in the mosquito breeding room by Vector Laboratory at Taiwan CDC (around 600^{th} generation now). Larvae were raised in separate plastic basins and fed on Tai-sugar yeast and swine liver powder (1:1) every day. The superficial layer of floating material was scraped away before feeding. After pupation, each pupa was picked up from the rearing basins and put into another water cup, and then set in an adult breeding cage (30x30x20 cm). Adults were fed on sugar solution (10%). The mosquito breeding room was maintained at 25~28℃ with relative humidity 70±5％ and photoperiod 12 hours [10].

B. Insecticides and Sprayer

1. Insecticides

The formulations of insecticide commonly used including solution, emulsifiable concentrate, oil and ultra-low volume liquid (ULV). Oil insecticide usually contains kerosene when spray by portable thermal fogger would produce smoke without adding any adjuvant; and ULV were designed to spray directly without dilution or extra additive, so these two forms of insecticide were excluded in this study. The insecticide with low toxin (organophosphate:pirimiphos-methyl) and high safety (pyrethroids:permethrin and etofenprox excluded) were chosen. The chosen insecticides with its recommended dilution rate were represented by A:Cypermethrin 10%, 640~1280X; B:Tetramethrin 2% and Cypermethrin 6%; 1400X; C:Pirimiphos-methy 12.5%, 50~100X; D:Cypermethrin 10.6%, 300X; E:Pirimiphos-methyl 25%, 100X; F: Alphacypermethrin 3.0% and Tetramethrin 3.0%, 75~150X; G:Pirimiphos-methyl 10% and Cypermethrin 2%, 10~20X.

2. Adjuvant

EG (99.8%, $C_2H_4(OH)_2$, Chinlin Chem Co.) were diluted into five concentrations (20, 35, 50, 65 and 80%) with pure water.

3. Sprayer

Portable thermal fogger (puls fog K10,0.8μm) was used as its high performance of nebulization (Span＜2,DR≈1) and commonly used for indoor space spraying when dengue outbreak in Taiwan. The principle of its nebulization is to vaporize the insecticide with high temperature then pulse-jet out of the nozzle, when contact with air, it would condense into visible smoke.

C. Bioassay

1. Flow Rate of Portable Thermal Fogger

Before test, fogger needs to warm up (30 seconds) and pretest (15 seconds) to ensure the pipeline is filled up with test solution. At first, 2 liter of pure water was added to the insecticide tank. After 3 minutes of spraying, the remaining amounts of water in the tank were measured by consumption method. The measurement was repeated three times to obtain the average flow rate and the coefficient of variance (CV) was calculated. Results showed that the average flow rate of puls fog K-10 was 196.7±5.8ml per minute (CV=2.9).

2. Spraying Time

Space of the bioassay room is 29.7m^3(3.3 x3.1 x2.9 m) measured by a laser distance meter (Trimble HD150). With the flow rate of the sprayer and the volume of the spray space, we could obtain the spraying time is 9 seconds.

3. Net Cage Test

Mosquitoes (3～5 days-old female, unfed with blood meal) were placed into a foldable cage (25x11x11 cm) covered with a fine polyester fiber net(16 mesh). Each cage contained 20 mosquitoes separately. Each test using 5 cages, hung on the door opposite wall (four in each corner respectively and one in the center of the wall) of the bioassay room. Control groups were placed in the mosquito breeding room. The fogger was positioned 145cm height above the floor with its nozzle elevated at a 30 degree angle. After 9 seconds of spraying, turned off the fogger and kept the room closed for 30 minutes. Thereafter the cages were moved out of the room and the numbers of knockdown mosquitoes was recorded. Subsequently, all mosquitoes in each cage were taken out and placed in a paper cup containing a soaked cotton ball with 10% sugar solution respectively. After 24 hours observation in the growth chamber (25±2℃, RH 70±5%, photoperiod 12 hrs.), the mortality of mosquitoes was recorded [11].

D. Droplet Sizing

Insecticide droplets suspended at 3 meters away from the nozzle and 2.2 meters height above the floor were measured by Sizing Master (LaVision Inc.) [12] with speed of 2 photos per second(0.6cm2) for 2 minutes since spraying[13] The measurement was repeated three times. Definitions of droplet parameters used were described as below: Numbers:total number of droplets measured during the test; D10:NMD (number median diameter), a diameter which divides the total number of droplets into two equal parts; DV10:10% of the droplets have a diameter less than this value; DV50:VMD (volume median diameter), 50% of the droplets have a diameter less than this value; DV90: 90% of the droplets have a diameter less than this value; Span = (DV90-DV10)÷DV50 and DR = D10÷DV50.

E. Statistic Analysis

1. Flow rate: If the CV value of the flow rate is larger than 5, the fogger needs to be repaired or replaced by another.
2. Net Cage test: In the bioassay, if the mortality rate of mosquitoes in control group is higher than 10%, the test will be re-conducted.
3. T test: If $t<0.05$, means there is a significant difference between two test groups.
4. ANOVA: If $p<0.05$, means in 95% confidence limits, different letter shows significant difference in the same line. Same letter shows no difference in the same line.

Results

A. The efficacy of EG and droplet parameters

We evaluate the efficacy of adding pure water and EG (20, 35, 50, 65, 80%) to *A. aegypti* by bioassay test. Results showed that the knockdown rate, in terms of the concentration, were

5.0±2.2, 0.0±0.0, 7.0±1.9, 1.0±0.4 and 2.0±0.5% and the mortality were 5.0±2.2, 4.0±1.8, 6.0±1.1, 10.0±1.6 and 5.0±0.7% respectively. Analysis by ANOVA and T test, the result showed that there were no significant difference (P>0.05) in knockdown rate and mortality of *A. aegypti* between spraying pure water (2.0±0.5, 0.0±0.0) and EG solutions respectively. The knockdown rate and mortality of control groups were less than 5% and had no significant difference (t>0.05) with experimental group. This suggested that EG solution is inefficient to kill mosquitoes.

The droplet parameters of pure water and EG (20, 35, 50, 65, 80%) sprayed by fogging machine were measured by Sizing Master (Table 1). The outcome showed significant difference (P<0.05) between droplet parameters in distinct EG concentrations. There was a positive correlation (D10：y=0.7x+16.1, R^2=0.89; DV10：y=0.47x+11.6, R^2=0.94; DV50：y=0.3x+12.8, R^2=0.91; DV90：y=0.2x+9.9, R^2=0.89) between droplet parameters and concentration of EG solutions, and a negative correlation (y= -0.9x+161.4, R^2=0.98) between droplet numbers and concentration of EG solutions. Droplet sizes would increase with the solution concentrations increased and the number of droplets would decrease while the solution concentrations increased. Though the droplet sizes were different between each concentration of EG, but still remained consistent and even distributed (Span<2, DR≈1). 50% EG solution has the best nebulization (Span＝0.6, DR＝1) and was selected for further test.

B. The efficacy of blended insecticide and droplet parameters

Seven kinds of insecticide (A, B, C, D, E, F, G) were diluted with pure water into several concentrations and sprayed by fogging machine in order to determine the 50% lethal concentration to *A. aegypti*. According to the former test result, the appropriate dilution for insecticide A, B, C, D, E, F, and G were 25000, 28000, 1000, 40000, 10000, 2500 and 18000-fold respectively. The efficacy of above insecticide solutions blended with 50% ethylene glycol solution or water were prepared to *A. aegypti* were evaluated by Net Cage Test

Table 1. Droplet parameters of Ethylene glycol solutions

Droplet parameters / Concentration(%)	Numbers[2]	D10[3] (μm)	DV10[4] (μm)	DV50[5] (μm)	DV90[6] (μm)	Span[7]	DR[8]
0[1]	489.0±42.3	15.0±0.3	11.7±0.4	14.9±0.5	23.0±0.7	0.8±0.0	1.0±0.0
20	423.0±32.1	17.7±0.3	14.1±0.5	18.3±0.4	27.8±0.5	0.8±0.1	1.0±0.0
35	378.0±27.3	20.7±5.9	16.3±0.3	22.0±1.4	33.0±1.7	0.7±0.1	0.9±0.3
50	366.0±21.3	29.3±0.6	24.0±0.7	29.9±0.6	41.2±0.5	0.6±0.0	1.0±0.0
65	321.0±21.9	28.6±1.2	22.5±1.3	35.2±1.6	67.9±1.0	1.3±0.0	0.8±0.0
80	258.0±11.1	39.9±2.9	32.6±1.5	46.2±1.1	72.7±1.2	0.9±0.0	0.9±0.1

Note：1.pure water 2.total number of droplets measured during the test. 3.NMD (number median diameter), a diameter which divides the total number of droplets into two equal parts 4.10% of the droplets have a diameter less than this value 5.VMD (volume median diameter), 50% of the droplets have a diameter less than this value 6.90% of the droplets have a diameter less than this value 7.(DV90-DV10)÷DV50 8.D10÷DV50 respectively (Table 2). Results showed that, there was a significant difference between the knockdown rate and mortality of each insecticide with and without EG (t<0.05). For knockdown rate, insecticide C was 3.1-fold higher after blended (rate goes from 10% to 31%), insecticide D, E, F, G were about 2-fold, and insecticide A and B were about 1.5-fold higher. For mortality, insecticide C was 2.1-fold higher after blended, insecticides D, E, F, G were about 1.9-fold, and insecticides A and B were about 1.4-fold higher. The efficacy of insecticide (knockdown and killing) to *A. aegypti* do increase after blended with EG.

The droplet parameters of insecticides with or without EG were measured by Sizing Master (Table 3). Results showed that, there was a significant difference (P<0.05) among each droplet parameters and the numbers of droplet was significant decreased in all insecticides blended with EG. D10 (NMD) and DV10 of insecticides A, C, D, G were significant increased (t<0.05) with EG blended, while B, E, F also showed a raising tendency, but the increasing rate did not reveal significant (t<0.05). Except for insecticide E, others showed a significant increased (t<0.05) in DV50 after blended with EG. DV90 were significantly increased (t<0.05) in all kinds of insecticide with EG blended. Accordingly, insecticides blended with EG could enlarge the droplet thus its diameter increased and numbers decreased.

The value of Span showed a significant increase (t<0.05) in most of the insecticides (except for C and G) after EG blended, but still remained in the ideal range of nebulization and the size of droplets were even distributed (Span<2). There are only two insecticides (A, C), which the value of DR were significant increased (t<0.05), others were not (DR＝1). The droplets size remains consistent after EG blended. In summary, the insecticide blended with EG could increase the size and decrease the numbers of droplet, but would not affect its distribution and consistency.

Table 2. Efficacy of insecticide with ethylene glycol[1] to *Aedes aegypti*[2]

Ethylene glycol Code	Formulation[3]	Knock-down rate[4] (%)			Mortality[5] (%)		
		Without	With	Ratio[6]	Without	With	Ratio[6]
A	S	51.0±7.5	74.0±12.0*	1.5±0.2 b	65.0±8.0	95.0±6.0*	1.5±0.2 b
B	S	40.0±8.0	55.0±3.5*	1.4±0.2 b	43.0±10.5	60.0±11.0*	1.4±0.1 b
C	S	10.0±3.5	31.0±6.5*	3.1±1.2 a	30.0±8.0	63.0±13.5*	2.1±0.4a
D	EC	40.0±8.0	70.0±8.0*	1.8±0.2 b	42.0±5.5	81.0±6.5*	1.9±0.2 ab
E	EC	44.0±4.0	85.0±9.5*	1.9±0.1 b	53.0±12.0	93.0±5.5*	1.8±0.3 ab
F	EC	6.0±2.0	10.0±3.5*	1.7±0.4 b	22.0±5.5	42.0±11.5*	1.9±0.1 ab
G	EC	38.0±4.5	65.0±8.0*	1.7±0.2 b	39.0±14.0	72.0±11.5*	1.8±0.7 ab

Note：1.50% solution 2.3~5 days, female, unfed. 3.S for solution; EC for emulsifiable concentrate 4.30 minutes 5.24 hours. 6.With Ethylene glycol/Without Ethylene glycol *:shows significant difference (t<0.05) between each other, a,b:different letter shows significant difference(p<0.05) in the same column

Discussion

No matter how the concentration, formulation and composition of insecticides altered, EG could have synergic effect to *A. aegypti* when blended with insecticides. The mechanism of EG synergic effect of knockdown rate and mortality may be identical since the increasing ratio was similar (A(1.5,1.5), B(1.4,1.4), C(3.1,2.1), D(1.8,1.9), E(1.9,1.8), F(1.7,1.9), G(1.7,1.8)) for each insecticide. Droplet sizing analysis presented that EG would increase the value of each droplet parameter, thus enlarge the insecticide droplets, but still remain in the ideal nebulization (20～50μm, Span<2, DR≈1) [17].

The synergic effect of EG may come from it's a dihedral alcohol with an aliphatic carbon chain. The two hydroxyl groups on glycols undergo the usual alcohol chemistry result in polar, high activity and water solubility. As, its dihedral structure creates hygroscopic capacity by forming hydrogen bond with water molecule may enlarge the droplet size and it's a key factor of the efficacy for those contact insecticides [18]. Hygroscopic of EG could slow down the evaporation rate of insecticide droplets to prevent inefficient to *A. aegypti* [19] and, its hydrophilic may enlarge the droplets to carry more active ingredients, thus, enhance the efficacy to *A. aegypti* [20,21]. Because the small particles are the major contributor to off-target drift[20], EG blended with insecticides would decrease the number of small droplets and may reduce environment pollution [22].

Insecticides with different formulation and active ingredients have specific different chemical, physical properties and reaction mechanism. Emulsifiable concentrate (EC) is liquid formulation in which the active ingredient has been dissolved in solvents with an emulsifier added so can be diluted with water for spray. Solution (S) is liquid in their original state and completely soluble in water or other organic solvents. The synergic effect of EG blended with insecticides varied from

Table 3.Droplet parameters of insecticides with and without Ethylene glycol[1]

Ethylene glycol	Numbers[2]		D10[3](μm)		DV10[4](μm)		DV50[5](μm)		DV90[6](μm)		Span[7]		DR[8]	
Code	Without	With	Without	With	Without	With	Without	With	Without	With	Without	With	Without	With
A	565.0±1.6	401.0±1.5*	22.1±2.8	29.9±6.7*	18.0±2.8	24.2±7.2*	22.4±3.2	31.9±7.2*	29.8±5.2	48.8±8.1*	0.5±0.2	0.8±0.2*	0.9±0.1*	1.0±0.1
B	527.0±1.5	410.0±1.2*	23.9±2.5	29.4±5.3	19.9±2.2	23.7±5.5	24.0±3.1	31.0±6.3*	32.1±7.2	45.3±7.8*	0.5±0.3	0.7±0.3*	1.0±0.1	1.0±0.1
C	588.0±1.9	441.0±5.8*	18.3±3.1	28.6±5.1*	14.5±2.6	23.0±5.4*	18.6±3.7	30.5±5.6*	30.8±7.2	50.0±8.1*	0.9±0.4	0. 9±0.3	0.9±0.1*	1.0±0.1
D	534.0±1.3	423.0±1.8*	20.6±2.7	31.1±4.2*	16.7±2.8	25.8±4.1*	20.6±3.4	32.2±4.8*	27.1±3.9	50.5±6.8*	0.5±0.2	0. 8±0.2*	1.0±0.1	1.0±0.1
E	574.0±1.5	491.0±1.4*	21.4±2.6	26.2±3.9	17.5±2.4	21.4±3.9	21.3±3.4	26.8±4.4	27.8±4.2	38.2±6.4*	0.5±0.2	0.6±0.3*	1.0±0.1	1.0±0.1
F	491.0±1.3	410.0±1.3*	22.4±2.9	29.4±4.7	18.4±2.9	23.7±4.7	22.6±3.5	31.0±5.4*	29.5±4.3	45.3±9.5*	0.5±0.2	0.7±0.2*	1.0±0.1	1.0±0.1
G	537.0±1.8	441.0±3.3*	20.0±2.1	30.1±4.8*	16.2±1.8	24.4±4.9*	19.8±2.7	31.5±5.8*	29.3±4.7	46.6±7.1*	0.7±0.2	0.7±0.2	1.0±0.1	1.0±0.1

Note:1.50% solution 2.total number of droplets measured during the test. 3.NMD (number median diameter), a diameter which divides the total number of droplets into two equal parts 4.10% of the droplets have a diameter less than this value 5.VMD(volume median diameter), 50% of the droplets have a diameter less than this value 6.90% of the droplets have a diameter less than this value 7.(DV90-DV10)÷DV50 8.D10÷DV50

* shows significant difference (t<0.05) between each other

different formulations. Emulsifiable concentrate (D(1.9), E(1.8), F(1.9), G (1.8) have higher increasing rate of mortality than Solution insecticides (A (1.4), B(1.5)) but insecticide C (Solution) has the highest ratio (2.1). However, with same active ingredient there were no similar situations as in the formulations. As Cypermethrin, Emulsifiable concentrate (D(1.9)) has higher increasing rate of mortality than Solution insecticide (A (1.4)), but in Pirimiphos-methyl, Solution (C(2.1)) is higher than Emulsifiable concentrate (F(1.9)).

EG seems to have higher synergic effect when blended with organophosphate insecticides (C(2.1), F(1.9) than pyrethroids (1.4～1.9), but the tendency is not clear. It probably caused by the poor knockdown effect of organophosphate ingredient and the low concentration used result to low mortality that might highlight the variation. Moreover, the droplet parameters of insecticide C changed more dramatically than other insecticides may partially contribute to the former result. Insecticide E blended with EG has the smallest effect at droplet volume enlargement and more or less different with other insecticides in all droplet parameters, but it has the best nebulization (Span＝0.6, DR＝1) of all. Significant increasing rate of knock down rate (1.9) and mortality (1.8) of insecticide E when blended with EG may related to it contains two pyrethroids active ingredient (Alphacypermethrin,Tetramethrin). Since the droplets volume were similar after blended with EG for each insecticide (D10: 26.2~30.1, DV10: 23.0~25.8, DV50: 30.5~32.2, DV90: 45.3~50.5) imply the mechanism of EG synergic effect may be identical. However, the influence of active ingredient could be blindfolded by high-fold dilution of insecticides, the correlation between EG and different insecticides compositions or formulations remain unclear and need further study.

Besides the chemical property of EG, another two phenomena: Curvature effect and Solution effect which occurred by diffusion would influence the droplet size. The curvature of a droplet tends to increase water evaporation, but inhibits condensation. Small droplet with high curvature would evaporate faster, and then condensed with other droplets to create larger droplet [23]. If water mingled with other substance to create a solution droplet, the dissolved substance would displace some of the water molecules at the surface of the droplet and reducing the number of water molecules to leave the droplet [21,24].The surface tensions of EG would decrease as its concentration increased [25], the larger the surface tensions the easier the droplet condensed. Therefore, blending EG in solutions would result small droplets evaporate faster due to the weakening of surface tensions. The vapors that come from small droplet then diffuse to the droplets remain in the air, and enlarge the droplet but reduced the numbers of droplet. As the larger droplets with low curvature condense faster than the small droplets, so the droplets that were original bigger would enlarge their volume more obviously in short time. By inference, EG' hygroscopic capacity could help the larger droplets of insecticide to absorb the water molecules in the environment and speeding its condensation. This may be the reason why, the value of DV90 was raised more significantly than DV10 (DV10 increases significantly only in insecticides A, C, D, G, while DV90 increases significantly in all of the seven insecticides).

Droplet size and nebulization are main factors influencing the efficacy of chemical control in dengue vector. Insecticides blending with EG would create smog to facilitate the operator' observation and widen the diameter without influence its nebulization then to improve the control efficacy. However, EG is toxic to human body with half-life of 8.3-83 hours in the air, the safety of operator and public and air pollution problem should be aware. When EG is using as an adjuvant sprayed by fog, the operator needs to wear personal protective gear and the resident's safety should be cautioned. Polyethylene glycol (PEG) is a polymer from EG, also has hygroscopic effect with its dihedral alcoholic structure and is used as humectant in cosmetics commonly. Considering its low toxicity, high safety and also water-based component, it may be another substitute for adjuvant [26].

References

1. Anonymous: Space spray application of insecticides for vector and public health pest control-a practitioner's guide 2003. WHOPES 2003;43.
2. Jhou LK, Jhou H. Efficiency amine and synergized action research. Trans Chin Soc Agric Mach 2007;13(6):468-9. (in Chinese)
3. Hsia WT, Spray technology and efficacy assessment of vector control. Sym Sani Den Con 2007;64-72. (in Chinese).
4. Zou Q. Long standing mistaken in using disinfection insecticides and equipments. Chin J Hygi Inse Equi 2006;12(5):360-1.
5. Hsia WT, Chan CS, Pan CY, et al. Evaluation of the efficacy of dengue emergent control at Kaohsiung City, Taiwan, 2006. Taiwan Epidemiol Bull 2008;24:22-37. (in Chinese).
6. Liu XH, Pan H, and Mazur P. Permeation and toxicity of ethylene glycol and methanol in larvae of Anopheles gambiae. Expe Bio 2003;206:2221-8.
7. Amy S, Church MD, Michael D, et al. Laboratory testing in ethanol, methanol, ethylene glycol, and isopropanol toxicities. Emer Medi 1997;15(5):687-92.
8. LaKind JS, McKenna EA, RP Hubner, et al. A review of the comparative mammalian toxicity of ethylene glycol and propylene glycol. WHOPES Crit Rev Toxi 1999;29(4):331-65.
9. Jhou LK, Jhou H. Efficiency amine and synergized action research. Trans. Chin Soc Agr Mach 2007;13(6):468-9. (in Chinese)
10. Paul A, Harrington LC, Scott JG. Evaluation of novel insecticides for control of dengue vector *Aedes aegypti* (Diptera: Culicidae). J Med Ent 2006;43(1):55-60.

11. Chaskopoulou A, Pereira RM, Scharf ME, et al. Vapor toxicity of three prototype volatile insecticidal compounds to house fly (Diptera: Muscidae). J Med Entomol 2009;46(6):1400-6.
12. Wu HH, and Chang NT. Comparison on food ingestion of *Aedes aegypti* (L.) and *Aedes albopictus* (Skuse). Chin J Ento 1990;10:433-42. (in Chinese).
13. Hsia WT, Lin EW, and Lo LC. The influence of insecticide formulation and droplet size on the efficiency of dengue vector control. Taiwan Epidemiol Bull 2008;24:513-2. (in Chinese)
14. Matthews GA, Hislop EC. Application technology for crop protection. CABI Int 1993;35-54.
15. Hsia WT, Wu PF, Lin C, et al. The influence of sprayers and formulations on insecticide droplet subsidence. Form Ent 2010;30(1):1-13. (in Chinese)
16. Reed P, Hall FR, Reichard DL. Influence of atomizers upon efficacy of tridiphane plus atrazine applied postemergence. Weed Tech 1990;4:92-6.
17. Hsia WT, Chan CS, Pan CY, et al. Evaluation of the efficacy of dengue emergent control at Kaohsiung City, Taiwan, 2006. Taiwan Epidemiol Bull 2008;24:22-37. (in Chinese)
18. Prokop M, Veverka K. Influence of droplet size on efficiency of contact and contact systemic fungicides. Plant Protect Sci 2003;49:75-80.
19. Jia JX. Insecticide assistants and application. Soci Agr Eng 2001;7(3):15-20. (in Chinese).
20. Prokop M, Kejklíček R. Effect of adjuvants on spray droplet size of water. Res Agr Engincering 2002;48(4):144-8.
21. Sundaram A, Sundaram KMS, Robinson AG, et al. Drop size spectra and deposit from aerial spraying with and without a polymeric adjuvant. Soci Agr Eng 1992;35:387-94.
22. Hanks JE. Effect of drift retardant adjuvants on spray droplet size of water and paraffinic oil at ultralow volume. Weed Tech 1995;9:380-4.
23. Berry EX. Cloud droplet growth by collection. Journal of Atmospheric Sciences, 1967;24(6):688-701.
24. Cooper WA. Effects of variable droplet growth histories on droplet size distributions. Part I: Theory. Journal of Atmospheric Sciences 1989;46(10): 1301-11.
25. Yong SW, Dong KC, Mills AF. Density, viscosity, surface tension, and carbon dioxide solubility and diffusivity of methanol, ethanol, aqueous propanol, and aqueous ethylene glycol at 25.degree.C. J Chem Eng 1981;26(2):140-1.
26. Jhang YK, Sih YR, and Yan BS. Hygienic pesticide compound prescription choice and application. Chin Pest Con 2003;19(9):516-20.

Outbreak Investigation Express

The Implementation of Health Protection Measures in the Culling Operation in the Poultry Farms with Avian InfluenzaA (H5N2) Outbreak

Sung-Hsi Wei[1], Tsong-Shien Wu[2], Du-Ling Lin[1], Chih-Chung Tu[1], Chao-Mei Huang[2], Fang-E Lin[2], Yen-Nan Chao[3], Chao-Ching Chang[4], Ming-Cheng Lin[1],

1. Third Branch, Centers for Disease control, Taiwan
2. Division of Disease Control, Changhua County Public Health Bureau
3. Second section, Centers for Disease control, Taiwan
4. Fifth Branch, Centers for Disease control, Taiwan

Abstract

The avian influenza A (H5N2) outbreaks were detected in four poultry farms located in central Taiwan in early 2012. Of the four farm poultry outbreaks, three were identified to be caused by highly pathogenic avian influenza (HPAI) strains. This article describes the public health measures performed by Taiwan Centers for Disease Control and the local health authority for personnel involved in the culling operation in two of the three poultry farms with HPAI outbreaks. The culling operation in the first one was executed only by personnel from agriculture units. Those who worked in the farm or involved in the culling operation were requested to perform self-monitoring, receive tests for influenza A (H5N2) infection and receive immunizations against influenza A (H5N1) virus and seasonal influenza virus after the operation. Three were tested positive for avian influenza A (H5N2) infection by hemagglutination inhibition test. All of three personnel did not present symptoms of respiratory tract infections. The other culling operation is executed by agriculture units and public health units. Personnel involved in the operation were required to perform self-monitoring. None of them showed symptoms of respiratory tract infections.

The Taiwan Epidemiology Bulletin series of publications is published by Centers for Disease Control, Department of Health, Taiwan (R.O.C.) since Dec 15, 1984.
Publisher : Feng-Yee Chang
Editor-in-Chief : Yi-Chun Wu
Telephone No : (02) 2395-9825
Executive Editor : Li-Gin Wu, Hsiu-Lan Liu
Website : http://teb.cdc.gov.tw/
Address : No.6, Linshen S. Road, Taipei, Taiwan 100 (R.O.C.)
Suggested Citation :
[Author].[Article title].Taiwan Epidemiol Bull 2012;28:[inclusive page numbers].