Research article

Biodiversity of Soil Invertebrates in Sugar Cane Plantations with the Different Application of Sugar Distillery Spent Wash

DUANGRAT THONGPHAK*
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
E-mail: duathg@kku.ac.th

CHULEEMAS BOONTHAI IWAI
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

THAMMARED CHAUASAVATHI
Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

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Abstract The objective of this study was to compare the biodiversity of soil invertebrates in the various utilization of spent wash liquor in sugar cane plantations. Soil invertebrates were collected in the four different spent wash liquor applications: 1) control plot, 2) applied with spent wash liquor for 1 year plot, 3) applied with spent wash liquor for 2 years plot and 4) applied with spent wash liquor for 4 years plot. The soil invertebrate samples were collected by random sampling during November 2012 to October 2013. The results showed that a total of 7 orders comprising 42 species of 31 families were collected in this study. The density of soil invertebrates in the areas of spent wash liquor application was significantly higher than those in the control plot. The Shannon-Wiener's species diversity index indicated that the diversity was the highest in the plantation applied with spent wash liquor for 2 year (2.26), followed by that of applied with spent wash liquor for 4 years (2.06), applied with spent wash liquor at 1 year (2.04) and lastly the control plot (1.57).

Keywords soil invertebrates, spent wash liquor, sugar cane

INTRODUCTION

Thailand is a major producer of sugar and sugar industry offers employment potential and contributes substantially to economic development. There are about 47 sugar cane mills in Thailand. The sugar industry produces a huge amount of wastes every day, which is rich in organic material and characteristically less toxic and easily amenable for microorganisms. Alcohol is produced by the fermentation of molasses. The liquor left after the sugar production is spent wash. The application of spent wash liquor in the sugar cane area can increased nutrients content in soil such as phosphorus potassium calcium and magnesium (Soongsud et al., 2007). Soil invertebrates are important in the functioning of nearly all environments, with changes in species composition potentially reflecting changes in the ecosystem (Madden and Fox, 1997). Knowledge of diversity helps in understanding changes in ecosystem complexity. Soil macro-invertebrates play a fundamental role in soil processes. They are integral to the cycling of organic matter and associated nutrients, and physically alter soil structure through movement (Jouquet et al., 2006; Wolfe and Klironomos, 2005). Loss or high of invertebrate diversity can adversely affect soil processes, ultimately altering the availability and composition of nutrients within the soil (Ehrenfeld and Neal, 2001; Jouquet et al., 2006; Belnap and Susan, 2001). Soil invertebrates also contribute to the succession of above ground vegetal communities through provision of resources, as well as selective consumption of available resources (De Deyn et al., 2003). Thus, maximum retention of invertebrate biodiversity is beneficial to biotic communities above and below the soil surface. The function of soil invertebrates within their communities, and their effects upon the environment, are

often disproportionate to their abundance (Lavelle, 1996). The objective of this study was to compare the biodiversity of soil invertebrates in various utilization of spent wash liquor in the sugar cane areas.

METHODOLOGY

The study was carried out monthly in the Nampong district, Khon Kaen province in the north-eastern part of Thailand during November 2012 to October 2013 (Fig. 1). The study sites were located within four sugar cane plantations were selected based on different management: 1) control plot, 2) applied with spent wash liquor for 1 year, 3) applied with spent wash liquor for 2 years and 4) applied with spent wash liquor for 4 years. The soil insect and soil invertebrate were collected using hand collecting and Berlese funnel methods (Southwood, 1994) (Fig. 2). For hand collecting on soil surface was set five sampling sites (1 m^2/site) in each plot. The sampling sites were sampled for soil invertebrates lived on soil surface and within soil depth at 10 cm using Berlese funnel methods. The samples were then classified by morphospecies and stored in 75% ethanol. All insect specimens were identified at least up to taxonomic order using the identification guides of Triplehorn and Johnson (2005) and Bolton (1994). The specimens were also compared with the reference collections at the Insect Museum, Faculty of Agriculture, Khonkaen University. The Shannon-Wiener's diversity index (Krebs, 1999), was used to calculate the diversity of soil invertebrates collected. The formula of the Shannon-Wiener's diversity index used is presented as follow

$$H' = \sum_{i=1}^{s} (pi)(\ln pi) \quad (1)$$

where H'= Species diversity index, s = Number of species and p_i = Proportion of the total sample belonging to i_{th} species.

The evenness index (Krebs, 1999) was calculated to determine the equal abundance of soil invertebrates in each study site as follows:

$$\text{Evenness} = \frac{H'}{H'MAX} \quad (2)$$

where H' = Observed index of species diversity and H'_{MAX} = Maximum possible index of diversity.

The diversity values for Shannon-Weiner were classified based on scale developed by Fernando (1998) and is presented in Table 1.

RESULTS AND DISCUSSION

The result showed that a total of fourteen orders comprising 51 species in 24 families were collected in this study (Fig. 3). The diversity of soil invertebrates in applied with spent wash liquor area was significantly higher than those in the control plot. The dominant insects in all areas were Hymenoptera (42.43%) followed by Coleoptera (23.06%), and Araneae (5.75%), respectively (Fig. 4 A and B). The sugarcane area applied with spent wash liquor for 2 years (Plot 3) has the highest abundance of Order Hymenoptera followed by the control plot (Fig. 5). Only one subfamily of Formacinae under Hymenoptera has been found in all areas.

Table 1 Classification of species richness indices (*adopted from Fernando 1998*)

Relative values	Species diversity	Evenness
Very high	>3.50	>0.75
High	3.00 – 3.49	0.50 – 0.74
Moderate	2.50 – 2.99	0.25 – 0.49
Low	2.00 – 2.49	0.15 – 0.24
Very low	<1.99	< 0.14

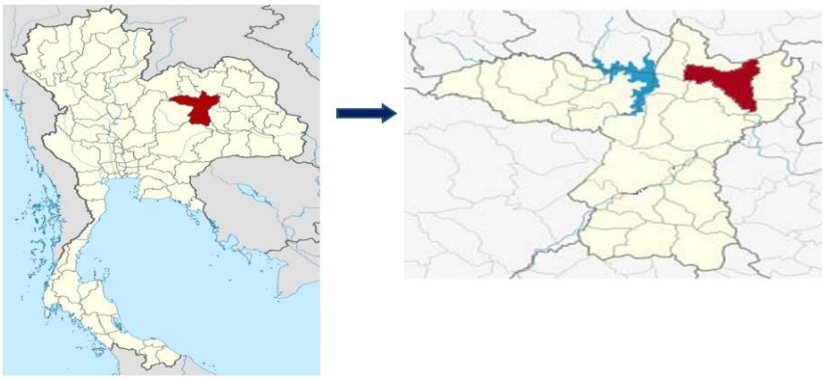

Fig. 1 Study area at Nam Phong district in Khon Kaen Province (red) in Northeastern Thailand

Fig. 2 Soil invertebrate sampling methods

Fig. 3 Example of soil invertebrates (A) Order Coleoptera (B) Order Isoptera (C) Order Hymenoptera (D) Order Diplura

The diversity of insect in this study is presented in Fig 6. Overall, the results show that insect diversity value for all of the sugarcane plantation areas was low diversity with H′=2.04-2.32 while the evenness index were similar in all areas with 0.56-0.46. The Shannon-Wiener's species diversity index indicated that the diversity was the highest in the plantation applied with spent wash liquor for 1 year (2.32), followed by the plantation applied with spent wash liquor for 4 years (2.23), applied with spent wash liquor for 2 years (2.15) and lastly the control plot (2.04).

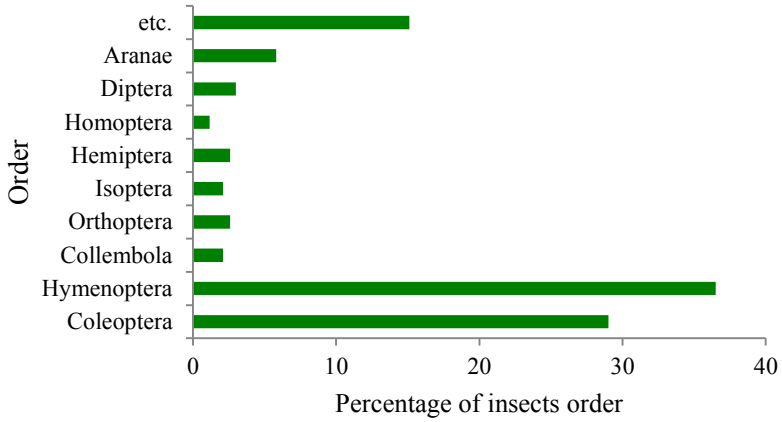

Fig. 4 Taxonomic of soil invertebrate in all areas

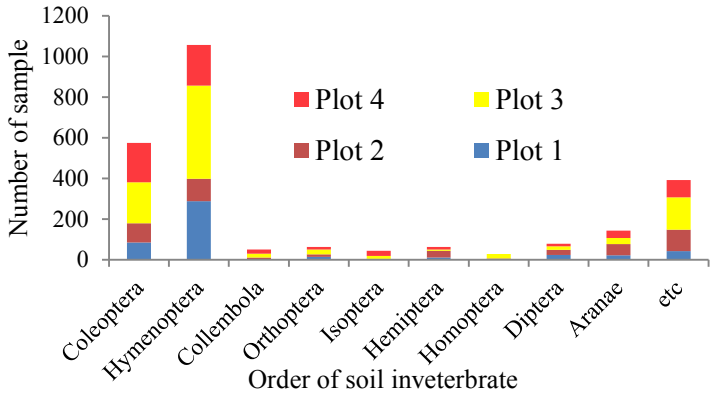

Fig. 5 Taxonomic of soil invertebrate in different land management

Plot 1 = control plot, Plot 2 = applied with spent wash liquor for 1 year , Plot 3 = applied with spent wash liquor for 2 years and Plot 4 = applied with spent wash liquor for 4 years

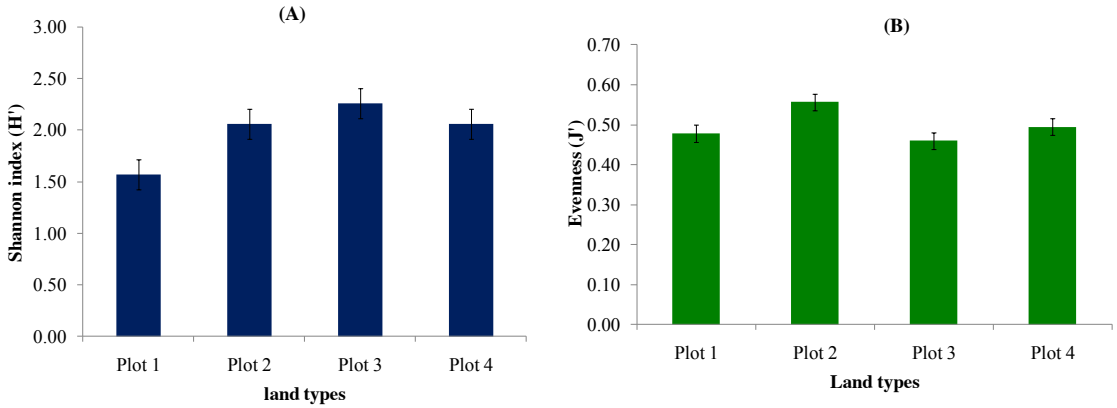

Fig. 6 Comparison between Shannon index (A) and evenness (B) of species diversity in each plantation

Plot 1 = control plot, Plot 2 = applied with spent wash liquor for 1 year, Plot 3 = applied with spent wash liquor for 2 years and Plot 4 = applied with spent wash liquor at 4 years

Results of this study show that the sugar cane plantations after land application of spent wash liquor has high diversity and abundance of insect fauna compare with the control plot. The increase in soil invertebrate diversity in the application of spent wash liquor area may be due to increased

nutrients content in soil. The majority of insects found in this study were Hymenoptera (ants) and Coleoptera (beetles). This is because the ants and beetles may be occurred most of the time in this study. We observed that the ants were the most common and the greatest number of insect species at the sugarcane plantation. Nigel and Paul (1992) stated that ants are found in the most terrestrial habitats. Most are predators and as such are critical component of aboveground and soil communities. They are usually less spectacular effects on the environments.

CONCLUSION

It may be concluded that the diversity of soil invertebrates in the sugar cane plots applied with spent wash liquor was significantly higher than those in control plot. If an understanding of microhabitats used by specific ant species can be developed, along with the key trophic interactions, then the potential of using insects as terrestrial indicator species for detecting environmental changes can potentially be reliably and easily with low cost and time.

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