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TWO NEW FUMIGATION PREPARATIONS (EDN® AND BLUEFUME™) TO CONTROL SOIL, WOOD, TIMBER, STRUCTURAL AND STORED PRODUCT PEST ARTHROPODS — AN OVERVIEW

Гнатек, Й., Стейскал, В., Йонас, А., Малкова, Й., Аулицкі, Р., Вайс, В. Два нові препарати для фумігації (EDN® та BLUEFUME™) для захисту від членистоногих шкідників ґрунту, дерев, деревини, продуктів і запасів — огляд. *Вісті Харків. ентомол. т-ва*. 2018. Т. XXVI, вип. 1. С. 115–118.
Наведена підсумкова інформація стосовно інсектицидного потенціалу двох фунгіцидних препаратів: BLUEFUME™ (HCN — ціанід водню) та EDN® (Етандінітрил). Основне використання EDN® — обмеження ризику поширення шкідливих членистоногих і нематод у сільськогосподарській і деревообробній галузях. Його можливо також використовувати для фумігації заготовленої деревини та колод, стерилізації ґрунту, захисту від комах, хвороб, нематод та інших паразитів перед садінням. Науковці та інженери Драсловки розробили методику безпечного застосування BLUEFUME™, що враховує всі сучасні вимоги безпеки. Вона базується на застосуванні з газових циліндрів, розташованих ззовні приміщення, яке оброблюють, з використанням трафарету. Нові експериментальні дані щодо просторового розподілу газу BLUEFUME™, часової динаміки та біологічного ефекту стосовно жуків, тарганів, постільних клопів, гризунів є достатніми для реєстрації препарату як біоциду в Європейському Союзі у 2017 році (тип продукту (PT) 08 — консервант деревини, PT 14 — родентицид, PT 18 — інсектицид і акарицид). 28 назв.
Ключові слова: членистоногі, нематоди, комахи, кліщі, фумігація.

Гнатек, И., Стейскал, В., Йонас, А., Малкова, Й., Аулицки, Р., Вайс, В. Два новых препарата для фумигации (EDN® и BLUEFUME™) для защиты от членистоногих вредителей почвы, деревьев, древесины, продуктов и запасов — обзор. *Изв. Харьк. энтомол. о-ва*. 2018. Т. XXVI, вып. 1. С. 115–118.
Приведена итоговая информация относительно инсектицидного потенциала двух фунгицидных препаратов: BLUEFUME™ (HCN — цианид водорода) и EDN® (Этандинитрил). Основное применение EDN® — ограничение риска распространения вредных членистоногих и нематод в сельскохозяйственной и деревообрабатывающей отрасли. Его возможно также применять для фумигации заготовленной древесины и кругляка, стерилизации почвы, защиты от насекомых, болезней, нематод и других паразитов перед посадкой. Учёные и инженеры Драсловки разработали методику безопасного применения BLUEFUME™, которая учитывает все современные требования безопасности. Она основана на применении из газовых цилиндров, размещённых снаружи обрабатываемого помещения, с использованием трафарета. Новые экспериментальные данные по пространственному распределению газа BLUEFUME™, временной динамике и биологическому эффекту относительно жуков, тараканов, постельных клопов, грызунов достаточны для регистрации препарата как биоцида в Европейском Союзе в 2017 году (тип продукта (PT) 08 — консервант древесины, PT 14 — родентицид, PT 18 — инсектицид и акарицид). 28 назв.
Ключевые слова: членистоногие, нематоды, насекомые, клещи, фумигация.

Hnatek, J., Stejskal, V., Jonas, A., Malkova, J., Aulicky, R., Weiss, V. Two new fumigation preparations (EDN® and BLUEFUME™) to control soil, wood, timber, structural and stored product pest arthropods — an overview. *The Kharkov Entomol. Soc. Gaz*. 2018. Vol. XXVI, iss. 1. P. 115–118.
This contribution provides summary information regarding insecticide potential of two fumigation preparations: BLUEFUME™ (HCN — hydrogen cyanide) and EDN® (Ethanedinitrile). The EDN® main use is aimed at limiting the risks of arthropod and nematode pests, within the agricultural and timber industry. It can be also used to fumigate harvested timber and logs, and to sterilize soil and control insects, diseases, nematodes, and other parasites, before planting. Draslovka based scientists and engineers developed safe application of BLUEFUME™ method, meeting all modern safety requirements that is based on application from gas cylinders placed outside of the treated volume using reticulation system. New experimental data on BLUEFUME™ gas spatial distribution, temporal dynamics and its biological efficacy on pests (beetles, cockroaches, bed bugs, mites, rodents, etc.) has been produced in a sufficient amount allowing its registration as biocide in European Union in 2017 (product type (PT) 08 — wood preservative, PT 14 — rodenticide, PT 18 — insecticide and acaricide). 28 refs.

Keywords: arthropods, nematodes, insects, mites, fumigation.

I n t r o d u c t i o n . Fumigation technologies, based on usage of gaseous pesticide substances, are among the most important pillars of any integrated pest management, phytosanitary and food pest control program (Stejskal et al., 2015). Fumigants provide — unlike other chemical formulations of pesticides/biocides — rapid

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control of internally infested commodities by harmful organisms (i.e. pests hidden inside wood, grain, fruit, soil, etc.). In addition, they usually leave little or almost no chemical residues in the treated agricultural commodities.

Historically, in the USA and Europe, the most accelerated research and development of fumigation formulations as well as the development of new fumigation technologies occurred mainly in the pre-war and interwar time period (i.e. 1887–1941) (see e.g. Bond, 1984). In the post-war period, fumigants were partially replaced by seemingly safer pesticide sprays, such as DDT, organochlorines and organophosphates. However, in the last two decades, interest in fumigants is growing due to rising pest risks associated with rapidly increasing international trade and changing climate. Part of these historical fumigations trends is described in the work of the leading French expert on fumigation, Patrick Ducom, in his paper entitled as 'The return of the fumigants' (Ducom, 2006). Nevertheless, despite this revived interest in the fumigation, the agricultural practice has to overcome the current lack of availability of efficient (i.e. with low resistance incidence and high efficacy on eggs of pests) and registered fumigants. Fumigation practice has to deal with the main challenge which is a restriction of methyl bromide as pilot fumigant. Until present, methyl bromide has been banned in most countries of the world. In addition to that problem, pest resistance to the major remaining commodity fumigant phosphine is on the rapid increase (Nayak et al., 2017). Therefore the alternatives to methyl bromide or 'resistance phosphine breakers' (e.g. Nayak et al., 2016) are urgently needed.

There are only few candidate active ingredients available even at the worldwide scale (Ducom, 2006). The primary issue of availability of new fumigation formulations is the administrative and financial burden of their registrations. Currently two of them (ethanedinitrile and HCN) are produced in Europe (Lučební závody Draslovka a.s., Kolín, Czech Republic).

The goal of this contribution is to provide summary information regarding insecticide potential of the two novel fumigation EDN® and BLUFUME™ preparations.

Results and discussions.

EDN® has been developed and patented in Australia (Desmarchelier, Ren 1996). EDN® is an ozone-friendly alternative to methyl bromide. Currently, the exclusive producer is the Czech Republic based company Lučební závody Draslovka a.s. (Kolín).

EDN® advantages are good penetration characteristics, high efficacy and short application time (Ryan et al., 2006). The active constituent of EDN®, ethanedinitrile, is a colorless, flammable, toxic gas at room temperature and atmospheric pressure. The EDN® main use is aimed at limiting the risks of pests and disease spreading, within the agricultural and timber industry. It can be used to sterilize soil and control insects, diseases, nematodes, weeds and other parasites, before planting. It can also be used to fumigate harvested timber and logs. Its excellent penetration characteristics and high efficacy make EDN® a great solution for eliminating wood-boring insects in timber as well as pathogens and nematodes which present a direct biosecurity risk to many importing countries.

EDN® shows high activity on various group pests, including wood and timber infesting insect species (Wright, Ren, Dowsett, 2002; Dowsett, Ren, Waterford, 2004). International group of scientists (Ren et al., 2006) described a high fumigation toxicity of EDN® to larvae of a serious phyto-quarantine pest Asian Long Horned Beetle (*Anoplophora glabripennis* — Coleoptera: Cerambycidae). Cho et al. (2011) confirmed good the biological efficacy of EDN® to another timber or wood related insect pests such as Japanese Termite and Yellow Minute Bark Beetle. The New Zealand scientists (Najar-Rodriguez et al., 2015) compared laboratory toxicity of EDN® to that of reduced rates of methyl bromide, using different life stages of the Burnt Pine Longhorn Beetle (*Arhopalus ferus*); pests were fumigated under naked conditions at 10 °C and 20 °C for 4 h and 3 h. The mortalities and the CT products achieved indicated that EDN® has potential as a phytosanitary alternative to MB for the treatment of logs. The prerequisite of good wood fumigation activity of the pesticide product is a quick penetration (ad in sufficient dose) of the particular active ingredient trough bark and wood (Hall et al., 2015). Fumigant must be able to penetrate wood with various moisture content (Pranamornkith et al., 2014). Ren, Lee and Padovan (2011) compared penetration of methyl bromide, sulfuryl fluoride, EDN® and phosphine in timber blocks and the sorption rate of the fumigants. They found that EDN® has much higher wood penetration ability than methyl bromide.

Hooper et al. (2003) suggested EDN® as a stored product fumigant and grain devitalizing agent. They showed good efficacy on the vast array of stored product insect pests under laboratory conditions. According to Ducom (2006) EDN® is much more toxic towards insect than methyl bromide and kills most of stored product pests very quickly. However, he stated that grain weevils (*Sitophilus* sp.) are exemptions; up to 5 days are required to achieve complete mortality of egg stage (Hooper et al., 2003). However, the preliminary laboratory experiments held at Crop Research Institute and Draslovka suggested that 100% mortality can be reached after 18 h in all stages for the ethanedinitrile dose of 30 g/m^3.

EDN® is considered to be promising pre-plant soil fumigant to be used in vegetables and other specialty crops. Its chemical properties such as (e.g. vapor pressure and boiling point) are more favorable than methyl bromide which could make it an excellent soil fumigant if it provides reliable efficacy on key soil-borne pests (Freeman, Stevens, Boyd, 2017).

BLUEFUME™. A new BLUEFUME™ (based on HCN) formulation, meeting all modern safety requirements, has been developed in the Czech Republic (Lučební závody Draslovka a.s., Kolín). Draslovka developed safe application methods of BLUEFUME™ that are based on application from gas cylinders placed outside of the treated volume using reticulation system. The new application method includes an innovative system for electro-chemical monitoring HCN concentrations during the whole treatment period, new safety features, safe and modern filling method and also improved transportation methodology. Currently, laboratory and/or field BLUEFUME™ efficacy data are available on various species of storage, seed, food, and mill infesting pests. BLUEFUME™ has high efficacy and extremely low Ct-products on all stadia of the tested pests; especially on eggs. The dataset also include penetration studies of HCN into 20 types of wood. There are plans to expand the usage of BLUEFUME™ to historical buildings and churches. The experimental results — performed under on GEP (Good Experimental Practice) regime — showed excellent BLUEFUME™ efficacy on various public health insect pests (e.g. Cockroaches — *Blattella* sp., Bed Bugs — *Cimex lectularius*) and on rodents (*Mus* sp., *Rattus* sp.). Field test proved the ability of BLUEFUME™ to control poultry mites (*Dermanyssus gallinae*). Screening of *Tribolium* pest populations originating from the Czech mills revealed no resistance to BLUEFUME™ (HCN). The obtained experimental data on BLUEFUME™ gas spatial distribution, temporal dynamics and its biological efficacy allowed BLUEFUME™ registration as biocide in European Union in 2017 (e.g. product type (PT) 08 — wood preservative, PT 14 — rodenticide, PT 18 — insecticide and acaricide). BLUEFUME™ received biocide registration as a fumigant in 12 countries of the EU as mutual recognition. Based on this success, Draslovka has also started the registration process of BLUEFUME™ in other countries such as Australia, New Zealand, Malaysia, and South Africa.

From 1887, HCN has been successfully used for control of parasites, public health, and mill and storage pests in USA, Europe and Asia (Rambeau et al., 2001; Lindgren, Vincent, 1965; Lindgren, Vincent, Krohne, 1954). For many decades, in USA and UK HCN has been historically widely used for large scale quarantine port and ship fumigations in order to control pest rodents. HCN as an active ingredient shows quick and high efficacy on structural pests infesting mills (Bond 1984; Rambeau et al., 2001; Aulicky et al., 2015a) and ships (Monro, Cunningham, King, 1952). Aulicky et al. (2015a) demonstrated a higher activity of BLUEFUME™ (HCN) on *Tribolium confusum* eggs than the one documented for phosphine during the commercial mill fumigations in the Czech Republic (Aulicky et al., 2015b). HCN has been historically used for the fumigation of many dry foodstuffs, grains, tobacco, and seeds (Bond, 1984; Emekci, 2010; Stejskal et al., 2014b).

BLUEFUME™ (HCN) also shows promising level of biocidal activity on package and structural wood infesting pests such as European Long Horn Beetle (*Hylotrupes bajulus)*, Asian Long Horned Beetle (*Anoplophora glabripennis),* and Pine Wood Nematode (*Bursaphelenchus xylophilus)* (Stejskal et al., 2014a; Douda et al., 2015). Recent works Zouhar et al. (2016) reported high nematicide potential of hydrogen cyanide against *Ditylenchus dipsaci* nematode present inside garlic seedlings.

Conclusions. The presented two novel EDN® and BLUEFUME™ fumigation preparations are friendly towards the environment since they are not ozone depletory. Pest resistance is currently not a practical issue for both preparations. This published result show good potential of EDN® and/or BLUEFUME™ to be used to combat vast range of pests (insects, mites, rodents, nematodes, fungi, etc.). BLUEFUME™ (HCN) shows promising level of biocidal activity on hygienic pests as well as on package/structural wood infesting pests. EDN® shows high level of pesticide activity on timber and soil infesting pests. Therefore, they can be considered as good alternatives for methyl bromide as the historically most successful (bench-mark) fumigant.

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