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Management of insects in Canada – status update

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Abstract

Canadian prairies being in a temperate region, provide cooler temperatures and drier air conditions throughout the year. In some months, ambient temperatures are low enough to control insects. Thus, insect infestations are not a major concern in Canadian grain. However, some infestations do occur on farms and in elevators when warm summer and fall temperatures occur after harvest or during spring and summer months in carried over grain from a previous year harvest. Thus, occasionally control of insects in grains using physical or chemical methods becomes a necessity. This paper summarizes the insect control methods within the context of the climate on the Canadian prairies, and essential requirements for the fumigation, and regulatory aspects of insecticide application.

Keywords: Canada prairies, Insect control method, Fumigation, Regulation

Introduction

Canada annually produced about 98 million tonnes of cereal grains, oilseeds and pulses (together referred to as grains) which are initially stored on farms (Statistics Canada 2021) except that a small quantity (less than 5%) may be delivered directly at harvest to elevators (grain handling facilities) or processing factories. Grains on farms are typically stored in flat bottom corrugated galvanized steel bins or welded steel hopper bins of different diameters and heights. Most of these bins have an air introduction system installed to aerate or dry grain using ambient or near-ambient air. The term near-ambient is used when air is pulled over a fan and frictional heat of fan adds 3-5°C to ambient air. Sometimes supplemental heat may be added to increase air temperature by 5 to 10°C for low-temperature grain drying (usually referred to as natural air drying with heater). Over the years, bin diameters have increased on farms mainly to reduce unit cost of storage and to accommodate larger harvested volumes. Bins with 10 m diameter are common currently on Canadian farms. The capacity of bins and grain handling rates have also increased considerably in elevators, while the number of grain elevators on the Canadian prairies has decreased (Fig. 1). This has also resulted in increased storage capacity on farms where grains maybe stored for up to two years depending on the demand of Canadian grains in the export markets.

While stored on farms, grains are exposed to diurnal and seasonal changes in weather parameters such as temperatures, relative humidity, velocity of air, solar radiation, and precipitation as well

as by the location of the bin with respect to surrounding structures and its orientation if bin is rectangular in shape. These weather parameters affect internal grain conditions, particularly temperature and moisture content, two important parameters affecting development and growth of fungi and insects. The effect of weather parameters is pronounced in the 15 cm of grain near bin walls and at the top surface of grain if head space is large. The interactions of biological, chemical, and physical parameters are best understood by treating stored grain mass as a man-made ecosystem and can be mathematically modelled (Jayas et al., 1995; Jian et al., 2005).

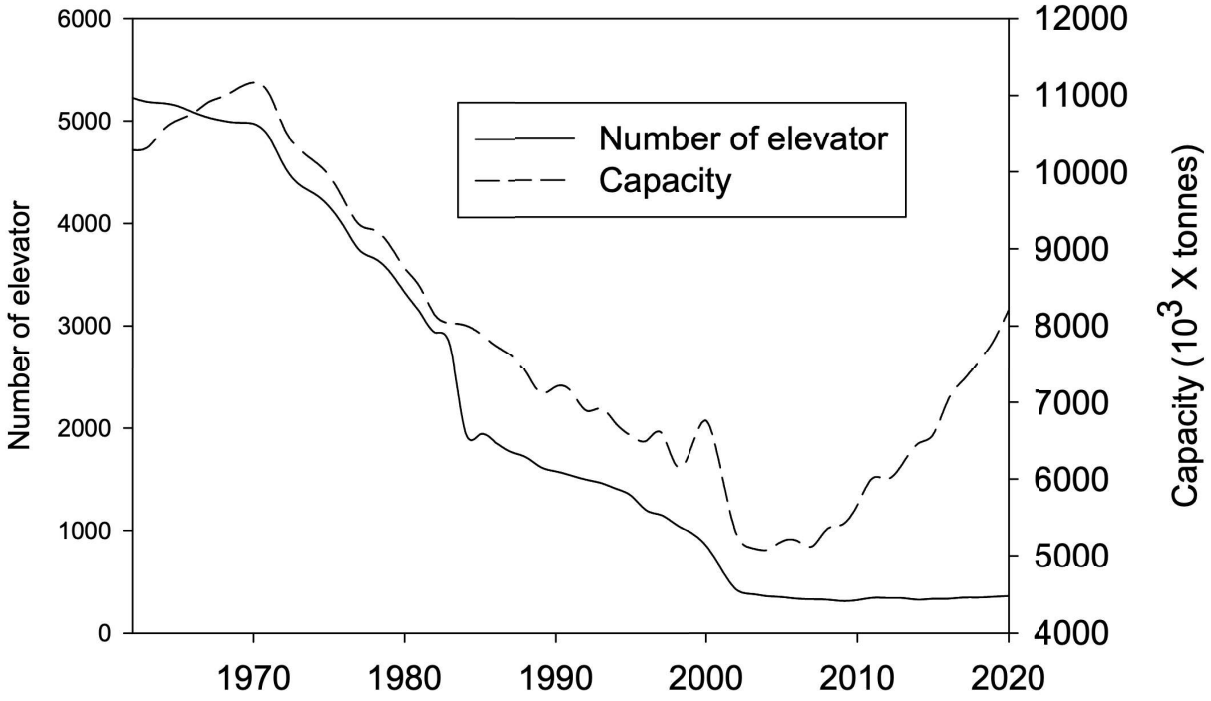

Fig. 1. Total elevator number and handling capacity of the elevators in Canada.

The Canadian prairies are considered to be a temperate region that provides cooler temperatures and drier air conditions throughout the year (Fig. 2). In the period between December and March, ambient temperatures can be low enough to control insects in grains in small diameter bins, while aeration to lower grain temperatures in large diameter bins is needed due to thermal properties of stored cereals. Even during the months when temperatures are not low enough to kill insects, temperatures are often low enough to keep grains at temperatures below 10°C where insect activity as well as fungal development is minimal. Thus, insect infestations are not a major concern in Canadian grains. However, some infestations do occur on farms and elevators after harvest with a warm summer and fall or during following spring and summer. Thus, control of insects in grains using physical or chemical methods occasionally becomes a necessity. Therefore, purpose of this paper is to provide an overview of status of methods used to control insects in Canada.

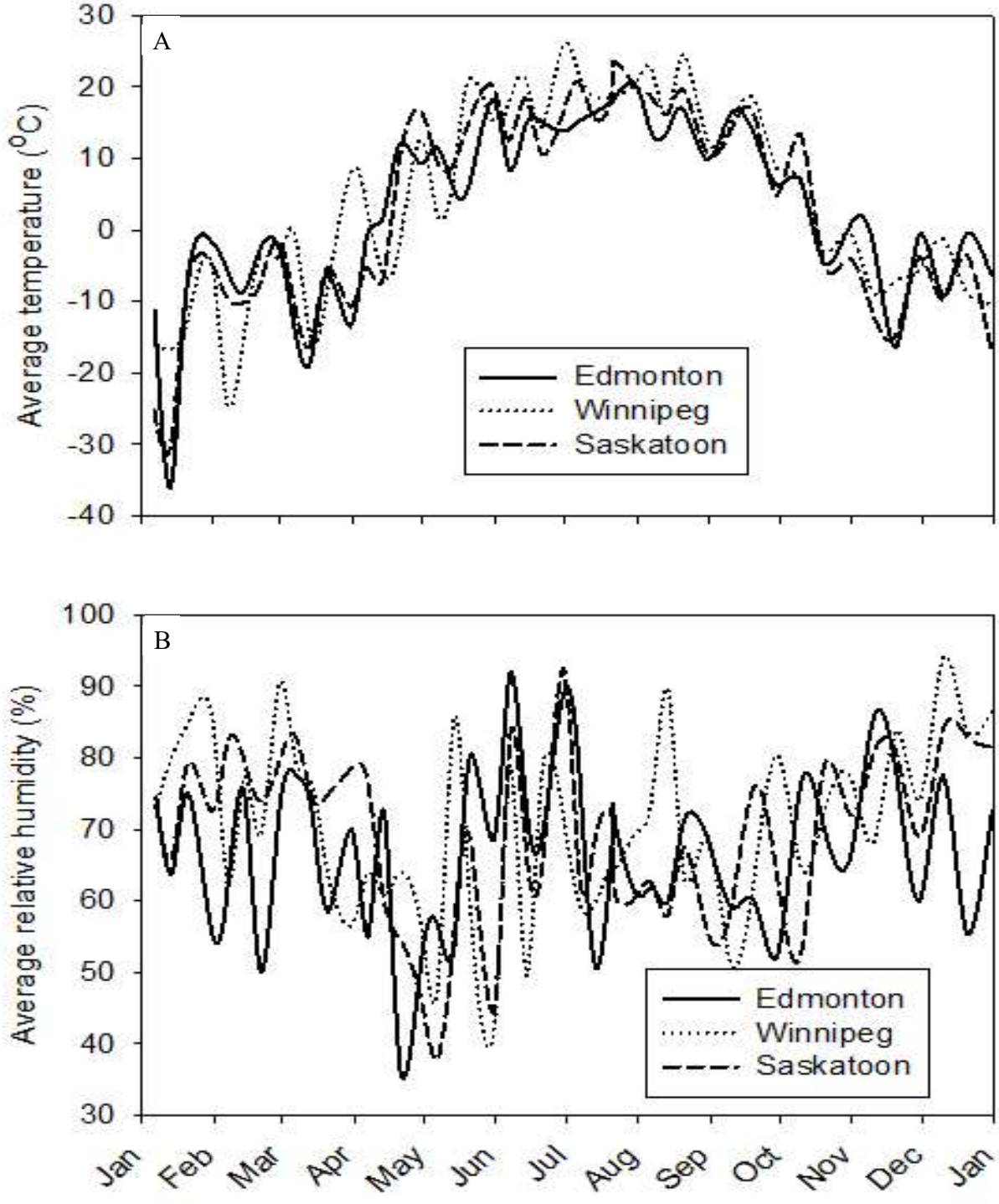

Fig. 2. Average temperatures (A) and relative humidity (B) at Edmonton, Winnipeg, and Saskatoon in 2020.

Insect control methods

Insect control methods can be broadly grouped into three categories: biological, physical, and chemical. Biological control methods are at the research stage in Canada and are not used to control insects in grain. Physical control methods that have been researched in Canada include impact, sieving, low temperature, high temperature, microwaves, infrared radiation, high carbon dioxide (CO_2) concentrations, high nitrogen (N_2)/low oxygen (O_2) concentrations, ozone, and irradiation using high energy electron beams or gamma rays from Cobalt-60 irradiator (Timlick et al., 2002; Neethirajan et al., 2007; Jian et al., 2016). Out of these only high CO_2 concentrations to control insects has been adopted by organic producers and grain industry. For example, an export terminal elevator in Vancouver is equipped to conduct high CO_2 fumigations. Chemical control methods can be grouped into two categories: contact insecticides and fumigants (Table 1). Contact insecticides can be used to treat structures (empty storage structures and cracks and crevices in buildings) and grains. The main contact insecticides are malathion, pyrethrins, cyfluthrin, and diatomaceous earth. Out of these, only diatomaceous earth is used directly on grain and all others are used for treatment of structures. Malathion, in dust or emulsifiable concentrate form is permitted for direct use on grain but its effectiveness is questionable and therefore is rarely used. Chemical fumigants available for use in Canada are Aluminum phosphide, Magnesium phosphide, Sulfuryl fluoride, and Methyl bromide. Cylinderized mixtures of phosphine and carbon dioxide are also sold for use.

On farm control of insects in stored grains is almost exclusively performed through aeration/temperature management. In years when harvest conditions are warmer, grain producers may choose to proactively apply malathion or diatomaceous earth as grain is being moved into storage. Contact insecticides such as pyrethrins are also often used to treat valves/venting to stop insects from entering bins when fresh grain is binned.

At export terminals, grain is received from railcar unloads that are typically in 90 tonnes in size. Grain is sampled using automatic crosscut sampling devices that typically takes 10 kg from each railcar. The collected samples are assessed for various aspects of quality including insect infestation. By the time grain has been determined as infested it may already be binned and the complete contents of the bin require fumigation. Large terminal silo bins are approximately 1000 tonnes. In the event infestation is discovered prior to binning the unloaded grain with the grain of same type and class, it may be diverted to smaller bins for independent fumigation.

Terminal elevators typically unload 8,000 to 12,000 tonnes within an 8 h working shift. Sampling systems used are for determining grain quality and therefore there are statistical limitations on the detection of insects from these systems. However, given that grain is sampled in a similar fashion at: farm delivery, country elevator loading, receival into an export terminal and when grain is being loaded onto vessels, the system is relatively robust.

Essentials for fumigation

Fumigants are toxic to humans, so the utmost care must be taken when handling these chemicals. To avoid accidental exposure to fumigant chemicals, treatments are only performed by registered applicators in Canada. Information that is helpful to regulators is generated through research and published literature.

Table 1. Chemicals used for controlling stored-product insects in Canada

Insecticides		Salient features
Fumigants	Aluminum Phosphide	Numerous forms, used for broad number of pests, temperature limitations for mortality
	Magnesium Phosphide	Fast acting, used for broad number of pests, temperature limitations for mortality
	Sulfuryl fluoride	Fast acting, used in cylinderized product for broad number of pests, insect stage limitations for mortality
	Carbon Dioxide	Used in commercial and organic production in elevators for broad range of pests, requires effective monitoring of concentration, logistical temperature limitations for mortality
	Methyl Bromide	Used in cylinderized product for broad number of pests, highly regulated - quarantine use only
	Phosphine / CO_2	Used in cylinderized product, fast acting, concentration highly controllable
Directly applicable contact insecticides	Malathion	Easy to use (Emulsifiable Concentrate (EC) or dust), low mammalian toxicity, levels of resistance/tolerance, organophosphates not well accepted
	Diatomaceous earth	Low mammalian toxicity, used in commercial and organic production, long residual activity, impacts flowability/test weight
Contact insecticides for structural application	Pyrethrin	Some residual activity, low mammalian toxicity, some concerns over resistance
	Malathion	Easy to use (EC), some residual activity, organophosphates not well accepted
	Diatomaceous earth	Long term activity, loses activity in the presence of organic dust and moisture

Necessary information required for proper fumigation includes: (i) insects to be eliminated and their response to fumigants; (ii) resistant stages of insects to be controlled; (iii) appropriateness of grain temperature (>10°C) and moisture content (>10% wb) for fumigation; (iv) commodity (cereals vs oilseeds) being treated; (v) application process (e.g., aluminum phosphide pellets added during grain loading or inserted using probes); (vi) any surfaces (copper) that can be corroded due to exposure from fumigants; (vii) structure airtightness for fumigation; (viii) the brand name (i.e., Aluminum phosphide is sold as Phostoxin, Phosfume, and Weevilcide) and other trade names for

formulation (i.e., tablets 5/8" dia, pallets 3/8" dia, pellets individually or held within in a sachet or porous bag); and (ix) appropriateness of fumigation time (i.e., avoid sunny, windy periods). For large structures it is advisable to use a closed loop system with recirculation capability to enhance uniformity of fumigant distribution. Monitoring of fumigant is critical during fumigation to ensure that right concentration (C) is maintained for the required period (t) to ensure desired Ct product.

Regulatory aspects for pesticide use on stored products in Canada

The use of pesticides in Canada on stored grains is governed by a number of authorities. The Pest Management Regulatory Agency (PMRA), as a department within the Health Canada organization is responsible for registering and reviewing the established submitted labels of pesticides that are allowed to be sold and used within Canada. Companies seeking to register pesticides in Canada must submit efficacy, toxicological and environmental impact assessment studies for the products being put forward for registration. Only when the PMRA is satisfied with all of the submitted data, will registration for a product be granted. Products registered by the PMRA may be used for prevention/control and the label is considered to be a legal document as it contains information on product efficacy, safety, dosage and application prerequisites.

Dosage is established by the registrant with the pesticide submission and this information must demonstrate effectiveness and data must show that residual activity is acceptable from a safety perspective but that it also is congruent with the information on the label.

The Canadian Grain Commission (CGC) is responsible for regulating standards and overseeing quality attributes associated with grain exported from Canada. The Research Laboratory within the CGC continuously monitors over 100 different chemicals that may be associated with grain and includes residues of insecticides, herbicides, fungicides in addition to heavy metals that may be picked up by plants on the fields and by grains during postharvest storage and handling. Information from the monitoring program is used to support grain quality statements required in contracts for grains to access various international markets. The CGC will provide pesticide residue information and compare it with levels established in Codex Alimentarius and other internationally established standards. The CGC also has the authority to stipulate grain treatment if inspection staff determine infestation of the grain being monitored.

The Canadian Food Inspection Agency (CFIA) is Canada's National Plant Protection Organization (NPPO) and like other countries' NPPOs, is responsible for provision of Phytosanitary certificates for grain being exported. As a part of the phytosanitary certification process, the CFIA's requirements include inspection programs that demonstrate that the grain, grain handling facility and the conveyance receiving the grain meet established protocols and are essentially free from various pests. In the event one of the criteria is not meeting compliance to established standards, the CFIA may withhold the issuance of the phytosanitary certificate. They may also order offloading or treatment of a commodity, a handling facility or a conveyance if deemed appropriate.

Conclusions

Usually insects are not a major concern in Canadian grains but when insects are detected in stored grains then mainly fumigants (Aluminum phosphide, Magnesium phosphide, Sulfuryl fluoride) and high CO_2 concentrations are used for insect control. Occasionally Diatomaceous earth is used on grain for insect control. Methyl bromide is only permitted for quarantine purposes. Pyrethrin,

malathion, cyfluthrin and diatomaceous earth are used for treating storage structures only. Canada has an excellent regulatory framework for registration, use of chemicals for treatment of grains and structures and for issuance of phytosanitary certificates. Also, chemical treatments are only conducted by trained personnel.

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