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Is Winter a Quiet Time? On Top of and Under the Snow in Agricultural Fields...Could it be a Raucous Party?

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Introduction

In the Northern Climate zones of the world we often think that the "dead of winter" is just that...dead. Certainly, with dead crop residue in fields it appears that way. It is easy to conjure up this "dead zone" when one is sitting by the woodstove in Maine, USA, and the outside air temperature is -30º C. However, things are not always as they seem. My opinion is that as agricultural researchers in the North we should get out in the winter, walk fields, observe nature and conduct experiments because winter can be very dynamic with significant implications for pest management. As examples I will highlight two of my experiences in Maine:

a) weed seed dispersal and

b) insect pest predator activity.

Weed seed dispersal into wild blueberry fields is an important phenomenon to understand if one is to design sustainable pest management strategies. Weed management is generally focused on the agricultural field interior and this lends to the reduction of subsequent year infestations [1]. However, weed seeds are also dispersed from outside fields by wind, water, and animal vectors [2].

Wild blueberry is a native North American berry crop comprised of several Vaccinium species, but primarily *V angustifolium* & *V myrtilloides* [3,4]. These berry plants are short woody shrubs 20-30cm in height. My winter snowshoe excursions into wild blueberry fields have provided the following perspective. In the late fall and early winter prior to significant snow accumulation weed seed dispersal by wind (commonly: *Aster* spp., *Eurybia* spp., *Festuca* spp. *Phleum pretense* L., *Spiraea alba* Du Roi and *S. tomentosa* L., *Solidago* spp., and *Symphyotrichum* spp.) results in a Gaussian plume of weed seeds that are highly concentrated outside the field with seeds dropping off steeply as one goes a short distance into the field. This is because the dense low woody stems of the *Vaccinium* crop plants provide a natural fence that inhibits long distance wind transport along the ground surface. This transport phenomenon changes in mid-late winter. It is common to have snowstorms resulting in greater than 40cm of snow depth. Snow depths of this magnitude transform the blueberry fields from a dense mat of woody stems to a smooth layer of snow that becomes packed into a hard, slippery surface by wind and the action of thawing and freezing. When walking from the field edge into the interior, it becomes apparent that weed seeds are blown long distances into the field interior across the newly transformed surface. This "sledding" phenomenon becomes a major highway for weed seed inoculum throughout the field. It is my opinion that this transport system is more significant than water runoff and animal transport. Clearly, well designed experiments need to be conducted in order to determine the significance of this dynamic, but one can already begin to think implementation of management practices that could disrupt this type of weed seed dispersal such as snow fences or tree lines along the edge of fields that are perpendicular and upwind of the prevailing winds in the particular geographic region.

Wild blueberry is a native crop that is not planted [3,4]. Fields are a result of removing the over-story forest and nurturing the exposed blueberry plants so that they grow together and form mats of highly productive berry fields [3]. Despite this, wild blueberry has a large diversity of native herbivorous insects along with a few introduced ones. Some of these herbivores are serious pests resulting in crop loss [5-9]. However, these insect pests have a large diversity of native predators and parasites that commonly inhabit wild blueberry fields and can on occasion reduce pest population densities [8,9]. Farmers, in some cases, can adopt insect pest management tactics that minimize pesticide induced mortality of these important natural enemies either by selecting least toxic insecticides or by timing the application of insecticides to target pest insects but avoid natural enemies [10]. These tactics are designed to be implemented during the crop growing season (spring and summer). But there is also recognition of conservation biological control [11] that enters into farmer insect pest management decision making. For example, it is not recommended that insecticides are used to target the adult egg laying stage of the blueberry spanworm, *Itame argillacearia* Packard. This is because eggs are laid in the leaf litter under the crop in early summer. Once laid the eggs enter dormancy and don't hatch until the following spring. However, it has frequently been noted [12] that egg predation is high over the summer, fall, and following spring frequently resulting in no to little caterpillar damage in the spring after egg hatch. Another example of significant natural predation is with the spotted wing drosophila [9]. Predation rates on pupae have been observed as high as 100% in Maine, but in general, these high predation rates only dampen the population increase of this pest during the summer and do not appear to reduce the need for insecticide applications [9].

So, one question is: why is there high variance in predation of insect pests in wild blueberry? Pesticide exposure may be one reason, natural fluctuations in predator communities may be another. However, what about weather conditions? It is commonly known that ambient temperature during the growing season can affect predation rates and predator reproductive increase [13,14]. What about winter conditions? Lack of predator winter survival in wild blueberry fields when there is no snow cover could lead to low predator populations the following growing season. Prediction of predator survival could be a useful tool for insect pest management in alerting farmers if spring insect pests may or may not experience intensive natural predation. However, there is one other winter dynamic that is not often thought of in northern cropping systems, subnivean predator ecology. This is predation on pests during the winter. Insects on the ground surface can be highly active under the snow even when air temperatures are much below physiological activity [15,16]. In 2017, in Old Town, Maine I constructed under-snow pitfall traps (see [15] for details of trap design) to assess arthropod activity in agricultural fields. We captured arthropods during a two-month trapping period (mid-December – mid-February). Non-predatory Collembola were the dominant taxa caught (98%, n=1684). However, out of the remaining 2% of arthropods captured 74% were predators. Figure 1 is a plot of the above snow air temperatures and the ground level under snow temperatures. It can be seen that for much of the winter, even when air temperatures were well below most organism physiological activity thresholds, at the ground surface under the snow temperatures were maintained at or just above freezing (0º C). This subnivean temperature profile allowed the predatory arthropods that we captured to actively forage for prey. If predation is operating on insect pests that overwinter on the ground surface (in the top leaf litter) such as the blueberry spanworm (*I. argillacearia*) and blueberry flea beetle (*Altica sylvia* Malloch), then it might be possible to enhance the probability of long-term winter snow cover in wild blueberry fields by targeted use of snow drift fencing. This practice might at the same time reduce winter injury to susceptible flower bud tissue on the stems [5].

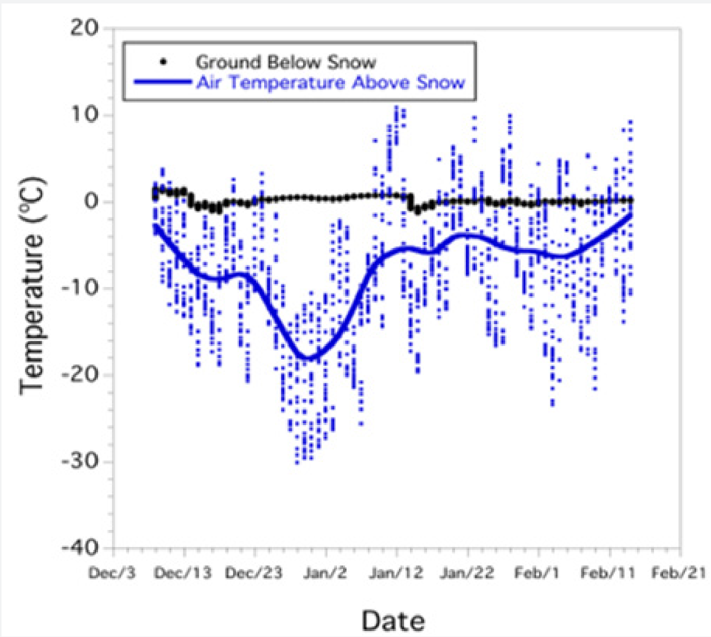

Figure 1: Above snow and under snow ground temperature profile from 9 December 2017 – 14 February 2018 at Roger's Farm Research Station, University of Maine, Old Town, Maine, USA.The blue line is a LOWESS regression to the above snow temperatures.

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Conclusion

It is the author's opinion that northern climate zone agricultural researchers need to put more emphasis on studying crop ecosystems during the winter.

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