# Environmental Parameters Related to Winter Mortality of the Russian Wheat Aphid (Homoptera: Aphididea): Basis for Predicting...

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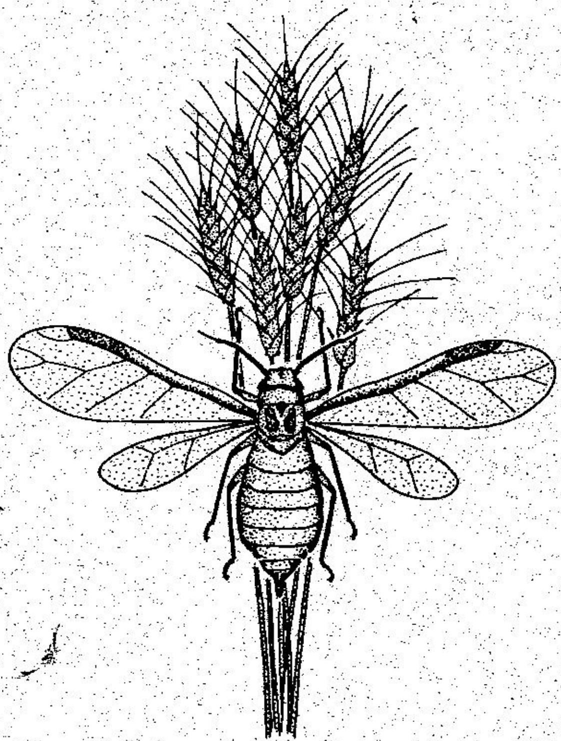
# PROCEEDINGS OF THE SIXTH RUSSIAN WHEAT APHID WORKSHOP



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# THE OVERWINTERING BIOLOGY OF THE RUSSIAN WHEAT APHID *Diuraphis noxia* (Mordvilko)

by

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If the Russian wheat Aphid (RWA) *Diuraphis noxia* Mordvilko overwinters on the northeastern plains of Colorado, it can result in the increased cost of several million dollars for control measures to prevent yield loss. The overwintering biology of the RWA was researched in the field and in the laboratory starting the winter of 1988, and continuing to the spring of 1992. The major effort of the research was to determine what type of winter environmental conditions are responsible for 100% mortality in an overwintering population of Russian wheat aphids infesting winter wheat. Environmental data from both the field and laboratory (1988-1992) were used to develop statistical models that explain how environmental factors interact with one another to cause mortality.

Supercooling points were determined for first instar through adult life stages of RWA reared under both growth chamber (room temperature) and outdoor (acclimated) conditions. Supercooling points were also determined for alate bird-cherry oat aphids *Rhopalosiphum padi* (L.) and 1 cm sections of TAM 107 for comparison purposes. Literature was used to find the SCP of wheat crown tissue (Fowler et al. 1981) and the egg of the black willow aphid *Pterracomma smithiae* (Somme 1964).

Cryoprotectants in the form of monosaccharides (glucose, fructose) and polyols (myo-inositol, glycerol, galactinol, sorbitol, mannitol) were assayed for in greenhouse and field reared RWA using high pressure liquid chromatography during 26 November and 02 February 1991, and 05 March 1992.

The field studies involved artificially infesting Tam 107 plants in mid October and periodically sampling them through the winter. Sampling involved removing 0.3 m linear drill row of wheat plants that had been infested with 30 nymphal Russian wheat aphids for the winters of 1989, 1990, and 1991. Environmental parameters measured were soil surface temperature, (hourly averages for every day starting in October and continuing until the first of April), soil moisture, snowfall depth, number of days with snowcover, and solar radiation. Two different methods of accumulating subzero temperatures were the basis of independent variables used in mortality models. The first method involved summing average hourly soil surface temperatures below 0 degrees C. The second involved accumulating one hour degree for every hour average soil surface temperature was below 0 C. The data were analyzed using the Statistical Analysis Systems (PC SAS version 6.03, SAS Institute 1986) MAX R option with Russian wheat aphid numbers as the dependent variable and the environmental factors as independent variables. An accumulative freeze index was developed to determine the effect of accumulated long term exposure to sub zero temperatures. Russian wheat aphid numbers were regressed against the accumulative freeze hours.

## RESULTS

### Supercooling Points

The SCP of any aphid species can only be considered the lowest threshold for survival because mortality may occur prior to reaching supercooling temperatures (Clough et al. 1987). Figure 1 gives the average SCP for instar one through adult of the Russian wheat aphid (-26.7 C) (Armstrong, unpublished data 1994), the egg of the black willow aphid *Pterracomma smithia* (-41.2 C) (Somme 1964), an adult of the bird cherry oat aphid (*Rhopalosiphum padi*) (Armstrong, unpublished data), a 1 cm section of Tam 107 wheat leaf (-16.0 C) (Armstrong, 1994 unpublished data), and the average SCP for crown tissue of 41 different winter wheat varieties from Canada (-18.0 C) (Fowler et al. 1981). Aphid eggs in general supercool in a range from -35 to -42 C. It is obvious that should RWA eggs appear in the United States, its overwintering capacity would greatly improve.

### Cryoprotectants In The Russian Wheat Aphid

Although cryoprotectant assays were conducted on 26 November, 02 February 1991, and 5 March 1992, only the results of the 05 March assay are shown (Fig 2). Glucose was found to be the most important carbohydrate with cryoprotectant activity. It was found in amounts as high as 32 moles/g fresh weight. It did not differ in aphids reared outside during the winter compared with aphids reared at an consistent warm temperature in the greenhouse (Fig 2). Glycerol, one of the most common cryoprotectants found in terrestrial arthropods was found in the RWA but only in 2-3 moles/g fresh weight (Fig 2). Mannitol was the most prevalent polyol found in the RWA (Fig 2). The high level of glucose along with low levels of other cryoprotectants found in the RWA, allow it to supercool to -26.6 C.

**Mortality Models**

From the environmental data used to develop mortality models, the hourly and degree accumulation of sub degree C temperature resulted in the highest correlations and were used for the basis of the models. These mortality models are also in agreement with laboratory exposure data of Rick Butts in Canada (Butts 1994, unpublished data). Snow depth and duration were the second most important independent variables used in modeling, followed by soil moisture and solar radiation. The most useful best-fit linear regression model ($R^2$ = .99, df = 47), that explained the greatest amount of variation across all years in RWA mortality was the degree accumulation + average daily snow cover + soil moisture + solar radiation. Further data analysis will be required to use the models for more accurate prediction of when 100% mortality occurs in an overwintering RWA population.

Should these overwintering models be used to predict when RWA succumbs to winter weather, the minimum environmental variables measured during the winter should be the accumulation of sub (0C) degree accumulation, and snow cover duration in days.

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