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EPIZOOTIC OF *ACALITUS VACCINII* (ACARI: ERIOPHYIDEA) CAUSED BY *HIRSUTELLA THOMPSONII* ON SOUTHERN Highbush BLUEBERRY IN NORTH-CENTRAL FLORIDA

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ABSTRACT

The blueberry bud mite (BBM), *Acalitus vaccinii* (Keifer), is gaining importance as a pest of southern highbush blueberries. During a BBM population development study in a north-central Florida location, an epizootic was observed, and the mesothermic acarine mycopathogen, *Hirsutella thompsonii* (Fisher), was identified as the causal organism. In order to better understand the progression of an epizootic resulting from *H. thompsonii*, the area was extensively sampled from Mar 2007 until Apr 2008. Terminal buds of the following developmental stages were collected, as follows: (1) tightly closed buds, (2) symptomatically swollen and reddened buds, and (3) separating or opened buds. A red food coloring staining technique commonly used to stain phyto-parasitic nematodes in or on roots was used to improve the visibility of the microscopic mite. Within 1 year, the population declined from 50% of the flower buds infected (up to 2,000 BBM per bud) to less than 5% of the flower buds infected (about 20 BBM per bud). During the summer, fall, and winter months, the preferred flower buds are scarce, causing low numbers of BBM to colonize less favorable leaf buds. At this time, infection by *H. thompsonii* remained above 50%. In months with average temperatures below 25°C (Dec through Mar), the frequency of the disease was reduced to 50% and less, allowing the BBM population to recover slightly.

Key Words: *Acalitus vaccinii*, blueberry bud mite, epizootic, *Hirsutella thompsonii*, southern highbush blueberry

RESUMEN

El acaro del brote de arándano, (ABA), *Acalitus vaccinii* (Keifer), esta aumentando en importancia como una plaga del arándano de clase alto sureño. Durante un estudio del desarrollo de la población de ABA en un sitio en el norte central de la Florida, una epizootica fue observado, y el micopatógeno mesotérmico de ácaros, *Hirsutella thompsonii* (Fisher), fue identificado como el organismo causante. Para entender mejor la progresión de una epizootica como resultado de *H. thompsonii*, la área fue muestreada extensivamente desde marzo del 2007 hasta abril del 2008. Los brotes terminales de los siguientes estadios de desarrollo fueron recolectados, de la siguiente manera: (1) brotes fuertemente cerrados, (2) brotes sintomáticamente hinchados y enrojecidos y (3) brotes separándose o abiertos. Una técnica de utilizar colorante rojo para comida que se usa para colorear nematodos fito-parasiticos en o sobre las raíces fue usada para mejorar la visibilidad del acaro microscópico. Dentro de 1 año, la población disminuyó desde 50% de los brotes de las flores infectados (hasta 2000 ABA por brote) a menos del 5% de los brotes de flores infectados (aproximadamente 20 ABA por brote). Durante el verano, el otoño y meses de invierno, los brotes de flores preferidos son escasos, causando números bajos de ABA para colonizar los brotes de hojas menos favorables. En este tiempo, la infección por *H. thompsonii* se mantuvo más de 50%. En los meses con un promedio de la temperatura menor a 25°C (diciembre a marzo), la frecuencia de la enfermedad fue reducida un 50% o menos, permitiendo que la población de ABA se recuperara.

The blueberry bud mite (BBM), *Acalitus vaccinii* (Keifer), is an important pest of cultivated blueberries with greatest activity in areas with mild winter climates (Isaacs et al. 2004). It is capable of causing severe yield losses through various degrees of flower bud damage (Cromroy & Kuitert 2001), ranging from a reduction in the number of fruits per cluster to a total desiccation of developing flower buds (Baker & Neunzig 1970). Persistent feeding by large numbers of mites results in reddening and swelling of the

base of the bud scales. Buds appear rosetted, are delayed in their development, and often fail to open. The symptoms are easily confused with winter damage. Populations of BBM remain frequently undetected by the growers (Isaacs et al. 2004). From several highbush blueberry groves in north-central Florida, blueberry bud mites have been isolated and identified by Dr. Marjorie Hoy. In this region, a rapid expansion of the blueberry acreage has occurred for more than a decade (Williamson & Lyrene 2004). In selected locations, up

to 50% of the developing flower buds were symptomatic. Recommendations for control are currently limited to selective pruning of infected plants, application of horticultural oil, and post-harvest application of the organochlorine insecticide, endosulfan (Thiodan®) (Krewer et al. 2008). The chemical cannot be used safely in the vast majority of cases for which it is currently approved, and may be banned by 2011 (Anonymous 2009a).

Hirsutella thompsonii (Fisher) is a mesothermic mycopathogen of various invertebrates including insects, mites, and nematodes (Boucias et al. 2007). The fungus requires an optimal temperature of 25 to 30°C and a RH of 98% for growth and sporulation (Boucias et al. 2007; Gerson et al. 1979; Kenneth et al. 1979; McCoy 1996). As a parasite it has been reported to cause epizootics of several eriophyoid mites including *Calacarus heveae* on rubber trees (Tanzini et al. 2000), *Phyllocoptura oleivora*, citrus rust mite (Fisher et al. 1949), and *Aceria guerreronis* on coconut (Gopal & Gupta 2001).

In Apr 2007, the presence of *H. thompsonii* became apparent during a population study con-

ducted in a commercial southern highbush blueberry planting in Windsor, FL (Fig. 1). *Hirsutella thompsonii*, has previously been found in association with the BBM in North Carolina (Baker & Neunzig 1968, 1970) but an epizootic has not been observed in Florida.

The objective of this study was to determine the seasonal development of a well-established BBM population and its mycopathogen, *H. thompsonii*, in a commercial planting of southern highbush blueberries under north-central Florida conditions.

MATERIALS AND METHODS

The selected study site was a 1.2-ha commercial southern highbush blueberry (*Vaccinium corymbosum* L. X *V. darrowi* Camp.) planting, infested with high populations of BBM. Bushes were 1.6-2 m high (approximately 10 years old) and consisted of a mixed planting of Windsor and Star cultivars. Blueberry bushes were spaced about 1 m apart. No insecticide or acaricide was applied to the field prior to field survey. However, foliar fungal pathogens were controlled with Ca-

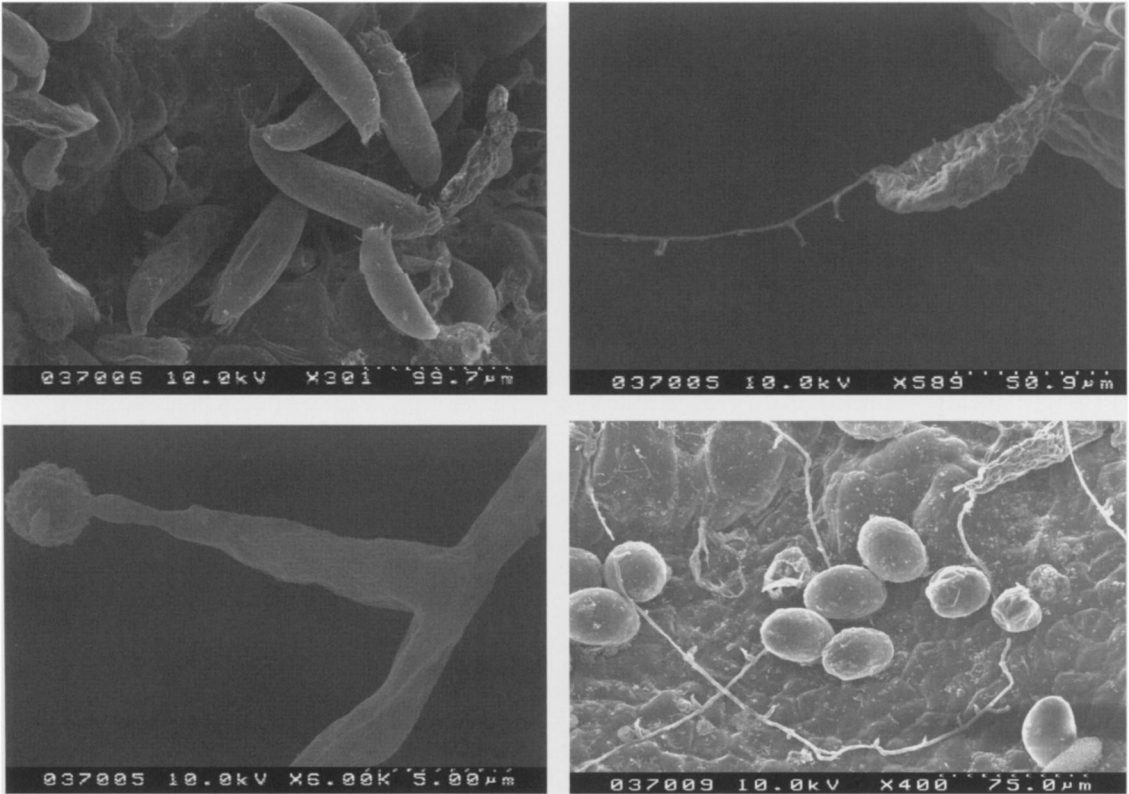


Fig. 1. Scanning electron microscopy images of blueberry bud mites, *Acalitus vaccinii* (Keifer), healthy (upper left) and infected by the micopathogen, *Hirsutella thompsonii* (upper right), isolated from blueberry flower buds of commercially grown southern highbush blueberry. The fungus forms single conidia (lower left), and may also colonize mite eggs (lower right).

brio®, Switch®, Pristine®, Bravo®, Indar®, and Elevate®. The fungicides were applied according to the recommended calendar spray technique (Krewer et al. 2008). With the first appearance of the fungal infection, distorted BBM were plated on sterilized water agar, incubated at 27°C (Boucias et al. 2007), and sporulating fungal structures were submitted for expert identification. The fungus was identified by Dr. Drion Boucias in the insect pathology laboratory at the University of Florida.

In order to determine the population dynamics of BBM, 10 terminal flower buds were collected randomly from the cultivar 'Windsor' in the following developmental stages: (1) tightly closed buds, (2) symptomatically swollen and reddened buds, and (3) separating or opened buds. Buds were collected bi-weekly from two, 10-m sections of the planting from Mar until Jun 2007. After Jun, when BBM populations are known to decline to low numbers (Barker & Neunzig 1970), samples were collected every 8 weeks from the same two 10-m sections. At each sampling date, the percent of symptomatic buds was estimated visually by examining bushes for at least 1 min, and counting and recording the number of buds that appeared reddened and rosetted, as well as the number of buds with healthy appearance. The percentages of 10

plants were averaged for each section at each sampling date.

Buds were placed in a cooler, brought to the Small Fruit and Vegetable IPM Laboratory at the University of Florida, and stained with red food coloring (McCormick & Co., Hunt Valley, MD) by a slightly modified technique commonly used to stain phyto-parasitic nematodes in or on roots (Thies et al. 2002). The number of mites per bud was determined by dissecting the stained buds and counting individual mites of all life stages (excluding the eggs) on the inside of the bud scales with the aid of a dissecting microscope at X63. Based on their appearance, blueberry bud mites were differentiated into healthy, oblong to cigar-shaped individuals of reddish color, and other distorted and grayish individuals.

A sub-sample of symptomatic buds was preserved in 1% glutaraldehyde and prepared for scanning via electron microscopy (SEM) applying the critical point drying technique commonly used for soft bodied specimen. Samples were observed on a Hitachi S-400 FE-SEM (Hitachi High Tech America). Average relative humidity and temperature data were recorded by the Florida Automated Weather Network station in Citra, FL, with a CSI 107 temperature probe and a CSI CS215 temperature and humidity probe (Anonymous 2009b).

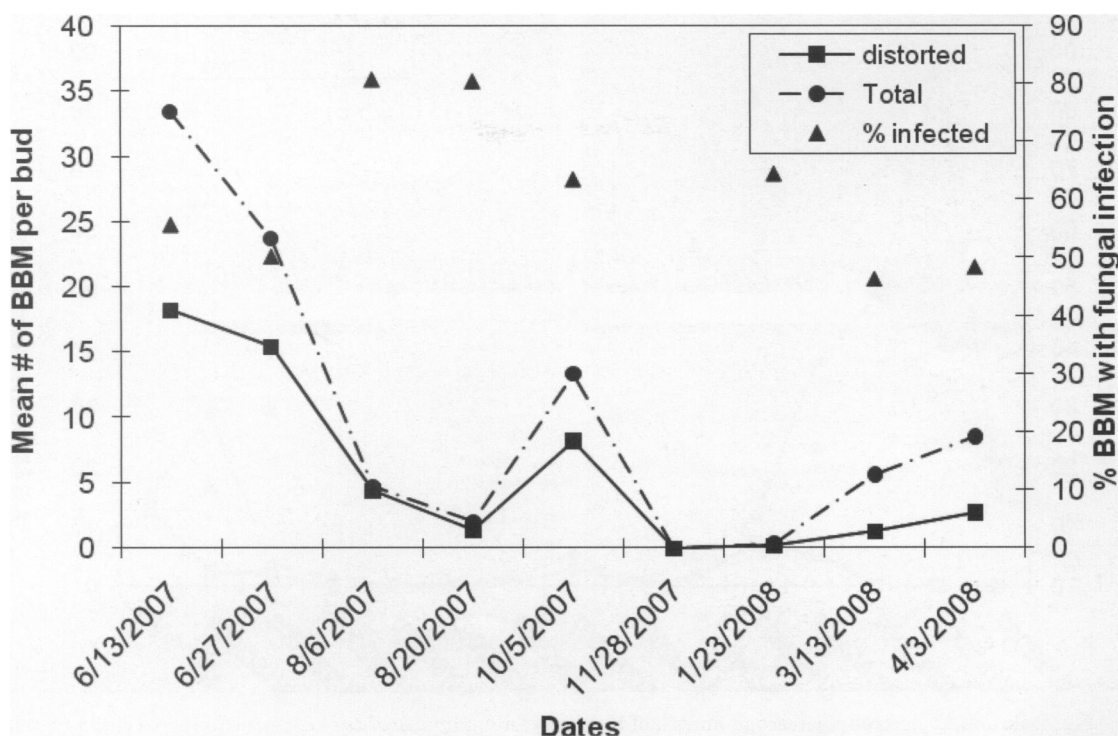


Fig. 2. Mean population density and health of blueberry bud mites (BBM) in tightly closed flower buds of southern highbush blueberry cv. Windsor, Florida.

The total population density was determined by pooling the data from healthy and distorted BBM. The population health (healthy versus distorted) was determined by subtracting the number of distorted BBM from the number of healthy BBM. We used paired *t*-tests to compare symptomatic and opened buds for the period of 5 Mar–5 May 2007 to determine statistical differences (SAS Institute 2003).

RESULTS

Blueberry bud mites and its fungal parasite, *Hirsutella thompsonii*, were present in all 3 developmental stages of the blueberry buds (Figs. 1-4). From the first sampling (5 Mar 2007) to the end of the observation period (3 Apr 2008), the BBM population declined drastically. The percentage of symptomatic buds recorded visually was reduced from over 50% to less than 5% (data not shown). Infection by *H. thompsonii* remained undetected until mid Apr 2007. By mid May 2007 and thereafter, the infection rate by *H. thompsonii* exceeded 50% in months with an average temperature higher than 25°C (Figs. 2-5). Voucher specimens of *Acalitus vaccinii* and *H. thompsonii* were

saved and deposited in the Entomology and Nematology collection at the University of Florida.

Population Density

With a population peaking at about 2,000 BBM per bud in Mar 2007, the population was significantly higher in symptomatic buds than in any other buds at any time during the spring 2007 observation period (*t* value = 8.51; *P* < 0.0001). Symptomatic buds opened or desiccated due to mite feeding by the end of May. In the newly formed closed buds, BBM numbers remained very low throughout the late summer, fall, and winter months only to increase slightly during spring 2008 (Figs. 2-4). Symptomatic buds were difficult to detect in Apr 2008, and were not present thereafter.

Population Health

In early Mar 2007, the numbers of healthy BBM in symptomatic buds were significantly higher than numbers of distorted BBM (*t* value = 2.81; *P* < 0.0053). In mid Apr, infection rates in opened buds increased rapidly to exceed 50% un-

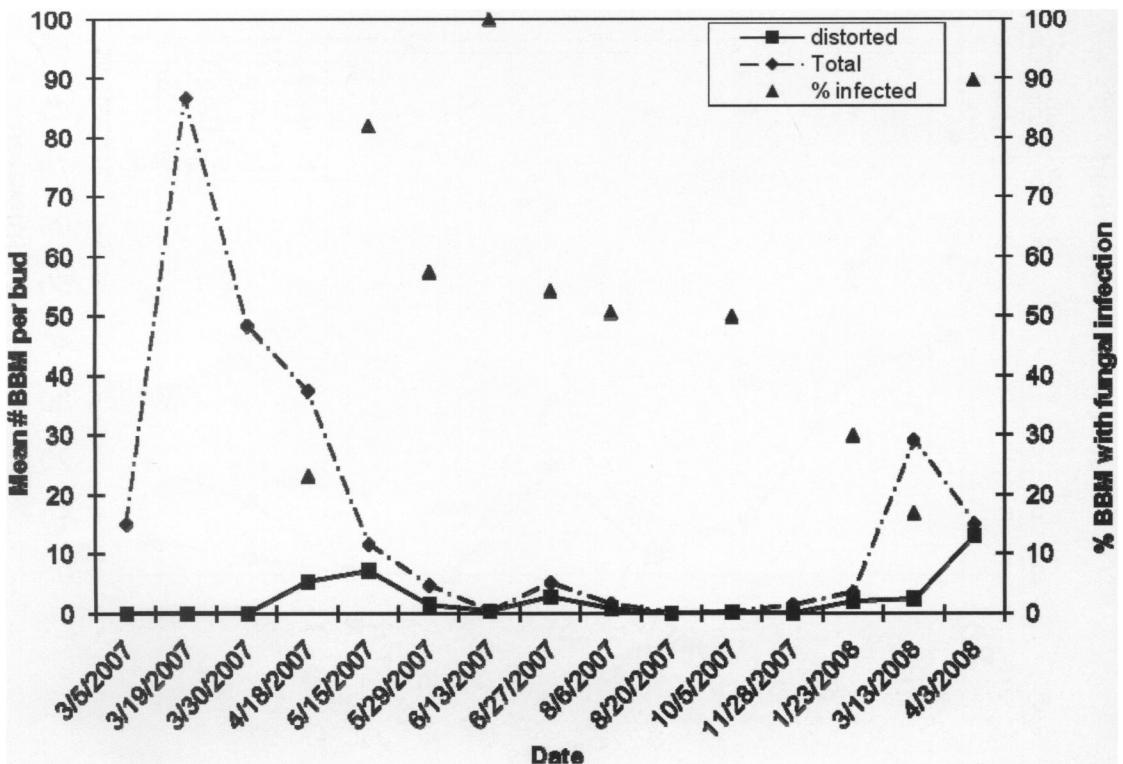


Fig. 3. Mean population density and health of blueberry bud mites (BBM) in opened flower buds of southern highbush blueberry cv. Windsor, Florida.

til the winter months (Fig. 3). In symptomatic buds the same trend was observed with a two-week delay (Fig. 4). In all 3 bud types (closed, opened, and symptomatic), the BBM population and the mycopathogen were nearly undetectable during the months of Sep 2007 through Jan 2008. In 2008, the number of distorted BBM in symptomatic and opened buds started to increase at the end of Jan to exceed 50% in the beginning of Apr, and BBM numbers were suppressed to about 20 per bud.

DISCUSSION

During 2007/08 season, favorable temperature and humidity conditions supported an epizootic of BBM by *H. thompsonii* at our study site in north-central Florida. Although the average daily relative humidity (RH) did not exceed 75%, overhead irrigation contributed to the higher humidity ideal for fungal growth. However, from mid-Nov through mid-Mar the average temperature dropped below the optimum of 25°C, causing the frequency of the disease to decrease. During this time, the BBM population recovered only to be suppressed to below an average number of less than 20 BBM per bud in spring of 2008. The lack of symptomatic buds at this time suggests that

the BBM population decreased to non-significant levels.

By the end of May, as opened flower buds desiccated due to mite feeding, BBM appeared to have moved to tightly closed buds, which are newly formed on early summer growth. This observation agrees with Baker & Neunzig (1970), who reported that in North Carolina BBM moved to secondary growth starting in mid Jun. Throughout the observation period, the infection rate of BBM remained high in closed buds. McCoy & Lye (1995) demonstrated that copper sprays applied for foliar disease control in citrus reduced the magnitude of the epizootic of *H. thompsonii* on citrus rust mites, *Phyllocoptruta oleivora*. It is not clear whether the frequent application of fungicides had an effect on the population densities of either organism in blueberries.

The cryptic habits of BBM within the blueberry bud make them difficult to control with miticides, but they can be devastating if allowed to develop in the field. Our research is in agreement with McCoy (1981), who considered *H. thompsonii* a key biological control agent regulating mites. The fungus can play an important role in regulating populations of BBM in southern highbush blueberries in Florida. Although the full extent of the damage caused by BBM and the fre-

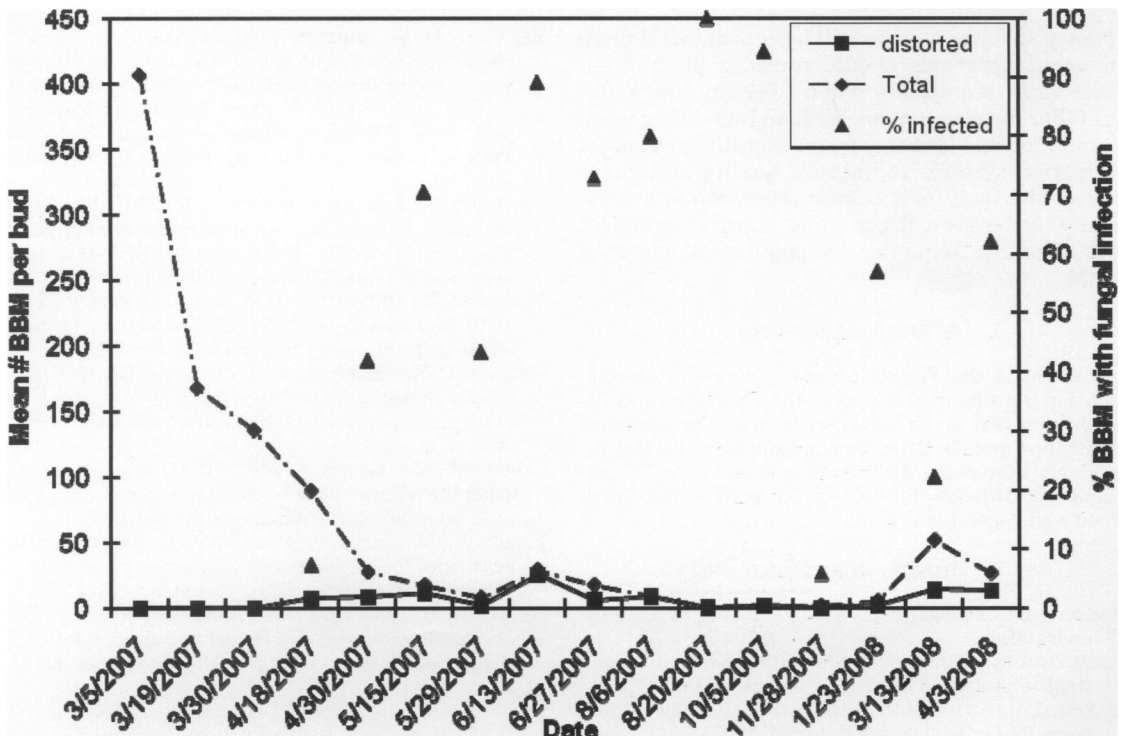


Fig. 4. Mean population density and health of blueberry bud mites (BBM) in symptomatic flower buds of southern highbush blueberry cv. Windsor, Florida.

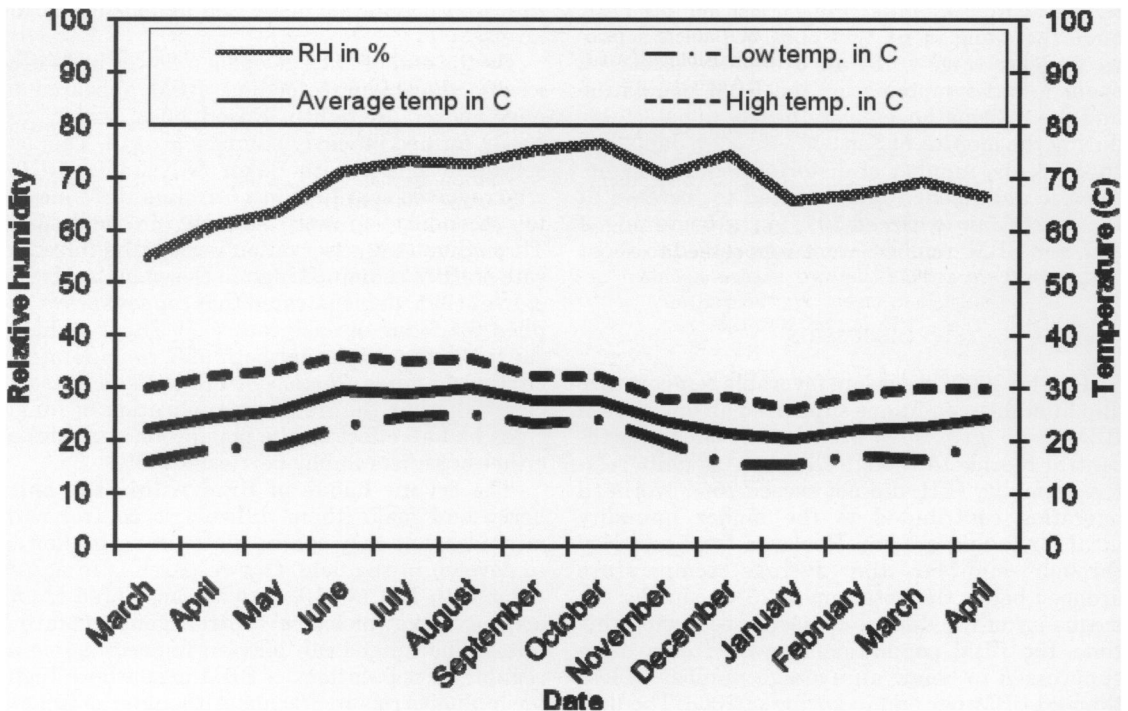


Fig. 5. Climatic data for Windsor, Florida.

quency of epizootics are still unknown, BBM management programs should consider possible effects on *H. thompsonii* when selecting fungicides for foliar disease control. With an increasing number of Florida blueberry farms installing micro-jet irrigation systems to improve quality and quantity of the fruit (Williamson, pers. comm.), it remains to be seen if changing cultural practices will affect the frequency and population density of BBM.

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