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NECTAR SUGAR CONCENTRATION AS A MEASURE OF POLLINATION OF ALFALFA [*Medicago sativa* L.]

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SUMMARY

The visitation rate of honeybees on alfalfa may possibly be measured by determining the sugar concentration of nectar in the honey stomachs of foraging bees. This concentration is shown to be largely controlled by the relative humidity and the time available for nectar evaporation in the alfalfa blossom, which in turn depends on the rate of visitation by honeybees. An adjustment for relative humidity may be necessary in order to compare readings widely separated in time or location. Where conditions are relatively constant from day to day, it may be sufficient to measure the nectar sugar concentration and relative humidity at the same hour each day. In one experiment a highly significant correlation coefficient of -0.867 was obtained between the number of tripped flowers per raceme and the nectar sugar concentration; in another experiment a non-significant value was obtained.

INTRODUCTION

Several years ago the authors discovered that when nectar was centrifuged from the flowers of bagged alfalfa plants, its sugar concentration was about 72%, but that when nectar was taken from the honey stomachs of honeybees (*Apis mellifera*) foraging on unbagged plants, the sugar concentration was only 38%. A similar difference had previously been shown between nectar in flowers of bagged and unbagged alfalfa plants (Pedersen & Todd, 1949). These observations and our later experiments led us to postulate that, if adjustments were made for variations in relative humidity, the visitation rate by bees might be estimated from the sugar concentration of nectar in their honey stomachs. Provided that the sugar concentration of freshly secreted alfalfa nectar varies only within narrow limits, the concentration within the flower at any given time will depend on the relative humidity and the time available for evaporation. The time available for evaporation depends on the frequency of nectar removal, which is a function of the visitation rate by bees.

A negative correlation between nectar sugar concentration and relative humidity was reported by Scullen (1940, 1942) and is indicated by data obtained by the authors from an experimental nursery at Logan, Utah, in 1951 (Fig. 1).

MATERIAL AND METHODS

Tripping of the flowers and nectar sugar concentration were determined on a 3×6 factorial experiment at Logan, and on a 2×2 factorial experiment at Howell, Utah. The 3×6 at Logan was designed to study the effect of six cultural treatments on three varieties of alfalfa. The 5-acre field was divided into 72 plots, each about $1/35$ acre in size. The 2×2 at Howell was designed to study seed production and the activities of honeybees at two moisture levels and two stand densities. The 7-acre field was divided into 20 plots each about $1/4$ acre in size.

Nectar sugar concentrations were determined by catching bees in insect nets on the plots, killing them in cyanide vials, removing the honey stomachs, and determining the

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nectar sugar concentrations with a hand refractometer. Measurements were made on bees from each plot in both fields.

Fig. 1. Scatter diagram with regression line showing relation between nectar sugar concentration and relative humidity at Logan, Utah (17th July 1951)

Fig. 2. Scatter diagram illustrating the relationship between tripping rate and nectar sugar concentration in alfalfa at Howell, Utah (1960)

The tripping rate was determined by counting the number of freshly tripped flowers on 20 racemes on each plot. Averages were calculated from data for nectar sugar concentration and tripping rates on 6 days from the Logan field and on 4 days from the Howell field.

RESULTS

The data from Howell showed a negative correlation between tripping rate and nectar sugar concentration. An r value of -0.867 (s.e. = 0.075 , 14 degrees of freedom) indicated that about 75% of the variation in the number of tripped flowers was attributable to nectar sugar concentration. The regression coefficient (b in Fig. 2) showed an increase of 0.226 tripped flowers per raceme for each decrease of 1% in sugar concentration, an increase of one tripped flower for each 4.4% decrease in nectar sugar concentration.

At the Logan field a non-significant negative correlation of -0.0372 was obtained for nectar sugar concentration and rate of tripping, and none of the variation in tripping rate was associated with nectar sugar concentration. Data were obtained on more than one day at the Logan field, and day-to-day differences in relative humidity may have led to the lack of correlation between nectar sugar concentration and tripping rate. The association between two characteristics is thus uncertain. At the Howell field both tripping and sugar concentration data were taken on the same days. The Logan field data were taken on the first crop, and those at Howell on the second crop: the mean nectar sugar concentration in the stomach of the bee was about 40% at Logan and 57% at Howell. The tripping rate was, however, about the same at both fields.

DISCUSSION

From a seed producer's standpoint, a rapid, objective method of determining the status of pollination on a seed field is desirable. Other measurements, such as number of tripped flowers, bee populations, and number or percentage of pollen collectors, have all been used. Measurement of tripping is difficult. A low rate of tripping is sufficient for moderate seed production, but differences in tripping at low rates are difficult to determine. Also, since the flowers wilt soon after tripping occurs, but at a variable rate depending on temperature and humidity, a comparison of tripping rates on the basis of open, tripped flowers is hardly possible. Thus an attempt to evaluate the progress of seed production on the basis of day-to-day tripping measurements is not usually feasible.

Bee population is also difficult to use, because it depends on flower population, nectar secretion, and perhaps other conditions. If the bees start the day visiting flowers heavily, and tripping them rapidly, nectar volume and the number of untripped flowers will decrease, resulting in reduced bee visitation. Consequently, in alfalfa, a low bee population measured in the afternoon may result from a high population earlier in the day and thus be a poor indication of pollination efficiency. On the other hand, a reading of the nectar sugar concentration in the afternoon is a good indication of the cumulative effect of bee visitation throughout the day.

If pollination is proceeding at a maximum rate, nectar sugar concentration readings are unnecessary, because the tripping rate is so rapid that a casual examination of the flowers in various parts of the field will suffice. As a general rule, however, tripping is slow, and a better index is necessary for an evaluation of pollination.

If effectiveness of pollination can be evaluated by a measurement of nectar sugar concentration, the only necessary procedure is to collect a few bees from a given field and check the nectar sugar concentration in the honey stomach. Before the evaluation can be made, however, it may be necessary to establish the relation between tripping and nectar sugar concentration at different relative humidities. Where relative humidity is fairly constant at a given hour during the day, the humidity factor may possibly be ignored, and the relationship between tripping and nectar sugar concentration ascertained by taking the readings at a specified time each day.

The method outlined here is suggested for further consideration, for estimating the pollination status of alfalfa. Further tests need to be made to compare different methods simultaneously, on the same crop.

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