Identification and Evaluation of Factors Affecting Nectar Volume and Concentrations of *Croton Macrostachyus* Hochst.ex Delile

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Research

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Abstract

Background:

Secretion of nectar is highly influenced by many factors and the objective of the study was also to evaluate factors affecting concentrations of nectar of *Croton macrostachyus* Hochst.ex Delile. Age of plants highly affect nectar concentration and volume. Honey quality and its medicinal values depends on plants species variety and their sucrose concentration quality and quantity which is governed by many biotic and abiotic factors as well micro climate of the area. Wholesale of nectar and concentration of tend to show more differences in time of day for species study undertaken.

Results: As results publicized that nectar concentration and volume of youngest age was not more affected by temperature and relative humidity like that of medium and oldest ages. Temperature and age have significant effect on volume ($p = 0.0001$) and their interactions is also significant ($p = 0.01145$). Temperature has significant effects on nectar concentration ($p = 0.000$). Interaction of relative humidity, time, and layers has significant effects on nectar concentration ($p = 0.0024012$). The oldest plants had the highest concentration of 10.1 w/w mornings and afternoon 36.5 w/w at 4:00 PM for whereas medium plants had nectar concentration of 5.7 w/w morning and afternoon 16.7 w/w and the smaller or younger plants had nectar concentration of 2.7 w/w mornings and afternoon 9.1 w/w and this shows age significantly affect nectar concentration and volume.

Conclusions:

Concentration and volume were affected by many biotic and abiotic factors. I conclude imminent fever intensification could harm nectar production since for croton also no nectar could be collected at 30 C and no nectar recreation was observed after this peak temperature this indicates environmental change can increase the temperature which will have negative influences on honey production in the future unless we combat against climate change which will affect honey production and productivity for the country and we will lose honey and its medicinal values also.

Introduction

C. macrostachyus Hochst. ex Delile, known as broad-leaved called croton in English and is named by various vernacular names in the different areas of Ethiopia (Meresa *et al.*, 2019). *C. macrostachyus* Hochst. ex Delile is a species of the genus *Croton*. Euphorbiaceae family, commonly known as the spurge family (Obey *et al.*, 2018). *Croton macrostachyus* occurs as a pioneer species commonly on degraded mountain slopes, on disturbed areas, in borders of cultivated fields, on waste ground, along with river habitats at altitudes between 1,100 and 2,500 m. a. s. l (Alemayehu, 2018). The response of nectar secretion to external environmental and variation in nectar traits associated with intrinsic plant characteristics (Lu *et al.*, 2015). Nectar secretion is strongly influenced by plant age (Cawoy, 2008). Plants' ability to sense their environment and respond to it is critical for their survival (Veits *et al.*, 2018).

The species of bee, colony within species, a month of the year, and the time of day when the nectar is collected all has a significant effect on the sugar concentration of collected nectar (Robert, 2007). Watery exudation from plants accumulates when atmospheric humidity is high and evaporation thereby is retarded this can easily be demonstrated in connection with bleeding from several tissues (Rodríguez-Peña et al., 2016). The east African highland *Musa* cultivars having the highest nectar volume have the lowest sugar concentration, while the dessert types with the least nectar volumes have the highest sugar content (Rutikanga et al., 2016). Decreased soil moisture significantly reduced the leaf relative water content (Zhang et al., 2004). It is a general assumption amongst plant physiologists and Ecologists that stomata have evolved to provide a Controlling water loss from plants while allowing photosynthesis (Jones, 2015). Daylight time has significant effects on nectar volume and concentrations of *Callistemon citrinus*. L (Kasim, 2019).

Volume and concentration tend to show more differences in time of day (Edge, 2010). The other revealed that there was great variability in the nectar production and it is evident that higher nectar production occurred at high humidity and low temperature (Adjaloo, 2015). Differences in microclimate can also lead to the variation observed between populations at different habitats (Farkas, 2012). The accumulation of sugar in and near the flower under the influence of low temperatures and increased permeability of the plasma membrane under the influence of high temperature (Stoner et al., 2016). It was compared that the changes in nectar secretion under temperatures expected by the end of the century and estimated the effect of climate warming on nectar secretion of plants flowering in different seasons and of very high temperatures has negative effects in all species (Takkis et al., 2018).

When humidity increases, the secretion of water, but not that of sugar, from nectaries is increased and excessive water supply lessens the sugar surplus in the parts of the flower and nectar is more dilute when humidity is high (Kasim, 2019).

Watery exudation from plants accumulates when atmospheric humidity is high and evaporation thereby is retarded this can easily be demonstrated in connection with bleeding from several tissues (Stoner et al., 2016). Nectar is more dilute when humidity is high, and honey that is stored at such times is likely to be high in water content (Stoner et al., 2016).

Materials And Methods

Study area description

Hawassa is a city in Ethiopia, in the Valley. It has latitude and longitude of 7°3'N 38°28'E 7°3'N 38°28'E and an elevation of 1708 meters above sea level (www.hu.edu.et Background of Hawassa University October 2, 2013).

Experimental design and sample size of the experiment

Maximum variation purposive sampling techniques were used to select trees based on their age. Each plant was categorized into three layers (layer one is the bottom layer, layer two is medium and layer three is the top layer for oldest, medium, and youngest plants leveled similarly) for the experiments. Inflorescences were selected randomly but flower heads were selected purposively. The idea behind Maximum variation sampling is to look at a subject from all available angles, thereby achieving a greater understanding (Etikan *et al.*, 2017). Nine trees with each replication for three ages of plants proposed for experiments or three oldest trees, three medium trees, and three youngest trees and three layers were taken for the experiment from each tree = $3 \times 9 = 27$.

Collection and measuring of nectar volume and concentration

Nectar volume and concentrations were taken and measured from all three layers of the trees and four flower heads were taken from each layer of trees from all ages. Each sample of flowers was representing separate layers of the trees. Nectar volume was measured after being collected by micropipette tips and brought to the laboratory.

Collection of soil sample and measuring its moisture contents

Soil samples were collected from the area of the oldest, medium, and youngest plants of *C. macrostachyus* Hochst. ex Delile and their weight were measured by sensitive balance.

Caging of trees inflorescences for nectar collections after selected based on their ages

Nine trees of *C. macrostachyus* Hochst. ex Delile were selected; three oldest, three medium, and three youngest plants, and then their age of inflorescences was determined based on maximum variation purposive sampling methods, and then their nectar was collected and measured. Nectar was measured from four flower heads of each layer after inflorescences were selected randomly for each layer (upper layer, medium, and bottom layers or lower layers) in the morning and afternoon to evaluate time effects on nectar concentration and volume. Nectar sugar concentration in the nectar produced per flower was measured in the field (as sucrose equivalent) using a hand refractometer (American Optical 10431, Buffalo, NY; range concentration 0-45, BRIX units, at the time of peak nectar secretion in the day, as sucrose equivalent (Das *et al.*, 2014). Sugar concentration and nectar volume were quantified (Veits *et al.*, 2018).

Data compilation and analysis

Sequences of steps were used: First, all plants in a population were counted, samples were selected and sampled. After sampling, data were inserted into computer Microsoft excel 2010 and imported to R software version 3.44. Multilevel analysis was used to see the interaction between variables affecting nectar volume and concentration of *C. macrostachyus*. ANOVA was used to see the significance of these variables on nectar volume and concentration.

Result And Discussions

Associations of nectar volume, humidity of soil, and nectar concentration of *C. macrostachyus* indicated that medium plants taken from the area of soil humidity of 30.4 % had a moderate nectar concentration of 27.2% and youngest plants taken from the area of the soil humidity of 62.4 % had lower nectar concentration of 16.7% Oldest plants taken from the area of soil humidity of 27.29 % had highest nectar concentrations 36.5% this infers effect of soil humidity is significant on nectar concentration ($p = 0.000$). Effects of nectar concentration is significance on nectar volume ($p = 0.000$). Interaction of soil humidity and nectar concentration has no significant ($p > 0.05$) effects on nectar volume when nectar concentration increases, whereas nectar volume decreased. This finding is in line with the finding of (Rutikanga *et al.*, 2016).

An effect of daylight time is significant on concentration of nectar ($p = 0.000$) and effects of trees layers is significant on concentration of nectar ($p = 0.000$) (**Figure 2**). Interaction of daylight time and tree layers significantly affect nectar concentration with $p > 0.05$. Nectar concentration increased after lunch for the oldest, medium, and youngest age of *C. macrostachyus*. This infers the age of plants and daylight time determined volume and concentrations of nectar. A similar finding reported that nectar secretion largely growing trend early in the early hours of the day, peaking toward noontime (Adgaba *et al.*, 2017).

The interaction among relative humidity, daylight time, and nectar volume of croton indicated that daylight time and relative humidity affected nectar volume as shown below (Figure 3). An effect of relative humidity is significant on nectar volume ($p = 0.000$). An effect of daylight time is not significant on nectar volume ($p > 0.05$) and interaction of relative humidity and daylight time has no significant effects on nectar volume ($p > 0.05$). Nectar volume was higher before lunch than in after lunch for all three-age categories at the time where relative humidity was higher. This speculation in the morning more humidity is found in an air that increases nectar volume. Nectar volume was lower after lunch at the time relative humidity decreased that might be due to reduction of relative humidity because of increment of evaporation in the afternoon than in the morning since temperature increases.

Relative humidity has significant effects on nectar concentrations ($p = 0.000$) and daylight time has significant effect on nectar concentration with ($p = 0.000$) (**Figure 4**). Nectar concentration was lower at the time relative humidity was higher in the morning, but in the afternoon nectar, concentration was higher at the time relative humidity was lower which means relative humidity and nectar concentrations are inversely comparative to each other. Interaction of daylight time and relative humidity has significant effects on nectar concentration with $p = 0.0001$ and this result is parallel to reports on *Callistemon citrinus* L. (Kasim, 2019).

Figure 5: Below shows interactions of temperature, daylight time, and nectar concentrations of *Croton macrostachyus*. Temperature has significant effects on nectar concentration with ($p = 0.000$) and daylight time significantly affect nectar concentration with ($p = 0.0098631$) and their interactions also significantly affect nectar concentrations with ($p = 0.0008304$). After lunch nectar concentration increased this implies daylight time has a significant effect on nectar concentrations due to increment in

temperature after lunch. Nectar concentration was lower before lunch than after lunch. Similarly, it was reported that there was an increasing concentration as temperature increases with a corresponding decrease in relative humidity (Adriana de Fidalgo and Astrid deep Kleinert, 2011, Adjaloo, 2015).

Figure 6: Below shows interactions of temperature, daylight time, and nectar volume of *Croton macrostachyus*. Temperature has significant effects on nectar volume ($p = 0.0002499$). Daylight time did not significantly affect nectar volume ($p > 0.05$) and their interaction has also no significant with ($p > 0.05$). After lunch, nectar volume decreased which means that daylight time affects nectar volume due to higher temperature after lunch that decreased nectar volume. Similarly, reported as nectar volume of Melliferous plants was higher in the morning (Adjaloo, 2015). This implies nectar volume is affected by daylight time for different species also that might be due to temperature increases in the after lunch than in the pre-lunch hours of the day.

Temperature and soil moisture has significant effects on nectar volume ($p = 0.00016$ and 0.0000) respectively, and their interactions has also significant effects with ($p = 0.0005800$) (**Figure 7**). Age and relative humidity have significant effects with ($p = 0.000$ and 0.000) respectively and their interaction has significance effects with ($p = 0.0003717$). Time has no significant effects on nectar volume with ($p > 0.05$), but age has significant effects on volume ($p = 0.000$), but their interaction has significant on volume with p-value of ($p = 0.006993$). This is in line with the finding demonstrated with defoliation experiments conducted on *Impatiens glandulifera* that only a fraction of the day's nectar secretion depends on the day's photosynthesis (Cawoy, 2008).

Age, humidification, then daylight time has significant effects with ($p = 0.000$, 0.000 and 0.0003643) respectively and their interaction has significant effects with ($p = 0.0004939$) (Figure 8). Interactions of age and layers of trees have significant effects with ($p = 0.007700$). Interaction of daylight time and humidification, has significant effects with ($p = 0.0002$). Interaction of age and daylight time has significant effects with ($p = 0.000$). This deduces age and daylight time has significant effects on nectar volume and youngest age produced more nectar volume than medium and oldest age that might be due to bleeding of water from several tissues of youngest than others. Daylight time, relative humidity and layers of trees significantly affect nectar concentration with ($p = 0.0003643$, 0.000 and 0.000) respectively and their interactions has significant effects on nectar concentration ($p = 0.0024012$). Interaction of temperature, age, layers, and daylight time has significant effects with ($p = 0.041298$). The highest nectar volume had the lowest sugar concentration and this finding is in line with the finding of (Rutikanga *et al.*, 2016).

Conclusions

Volume and concentration of nectar of intermediate and eldest age of *C. macrostachyus* was affected by age of plants, daylight time, relative humidity, temperature, layers of trees, and soil moisture, but for youngest plants nectar volume was not affected by relative humidity and nectar concentration was not affected by temperature. Youngest, Medium, and oldest ages had nectar concentrations of 9.1 w/w, 16.7

w/w, and 36.5 w/w respectively in the afternoon and the morning 2.7 w/w, 5.7 w/w, and 10.1 w/w respectively. I generalize that upcoming temperature increase possibly will harm the nectar production of plant species, since for Croton also maximum temperature to produce nectar was 30 C° and above this temperature, no nectar production was seen and may have negative effects on honey productions since nectar quality will be lost if climate changes since temperature rises and that can cause a loose of volatile compounds found in nectar those determine the quality of nectar as well honey since for quality honey quality nectar is necessary. For three ages of *C. macrostachyus* lower layers recorded lower nectar concentration and higher nectar volume when compared to the medium and top layers of the trees in the morning. In the afternoon higher nectar concentration and lower nectar volume were recorded in the top layer than the medium and lower layers of the trees.

Declarations

Ethics approval and consent to participate: Not applicable

Availability of data and materials: The data sets analyzed during the current study are available

Competing interests: The authors declare that they have no competing interests.

Authors' contributions: All authors read and approved the final manuscript for publications

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Figures

Figure 1

Interaction of nectar volume, wetness of soil, and nectar concentration of *C. macrostachyus* Hochst.ex Delile.

Figure 2

Interaction of trees layers, concentration of nectar of *Croton macrostachyus* and daylight time

Figure 3

Interaction of relative humidity, daylight time, and nectar volume of *C. macrostachyus* Hochst.ex Delile

Figure 4

Figure 5

Interaction of temperature, daylight time, and nectar concentration of *C. macrostachyus* Hochst.ex Delile

Figure 6

Interaction of temperature, daylight time, and nectar volume of *C. macrostachyus* Hochst.ex Delile

Figure 7

Interaction of nectar volume and concentration (%) of three age categories of plants in the morning with temperature, relative humidity, and soil moisture and tree layers

Figure 8

Interaction of nectar volume and concentration (%) of three plant age categories in the afternoon with soil moisture, temperature, relative humidity, and layers of trees.