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Evaluation of Rapeseed (*Brassica napus* L.) as a Honeybee Plant and Effect of some Environmental Factors on Nectar Production

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ABSTRACT

Over the past decade, Iraqi beekeepers have begun cultivating canola (*Brassica napus* L.) to support their bees with natural winter pasture. They applied consecutive planting dates ensuring successive and extended flowering period for their bees. The main aim of this study was to assess the impact of environmental factors like temperature and humidity on nectar production, including nectar quantity, sugar concentration, flowering dates, number of flowers, and flowering duration. In a field experiment four sowing dates were applied in 2022(15th of Sept., 1st of Oct., 15th of Oct. and 1st of Nov.). The study found that high temperatures negatively impacted the quantity of nectar while strong relationship was detected between relative humidity and the increase in the produced nectar and the decrease in sugar concentration. T1 resulted the longest flowering period (120 days), followed by T2 (111 days) and T3 (85 days). T1 and T2 also produced more flowers per plant (477 and 358, respectively) compared to T3 (169 flowers). T3 plants had the longest period of vegetative growth (61 days) but the lowest average plant height (165 cm). T1 and T2 had shorter vegetative growth periods (48 and 44 days, respectively) but achieved higher plant heights (223 and 204 cm). The study concludes that consecutive sowing dates are not beneficial for beekeepers in Iraq, and mid-September being the optimal sowing date for an extended flowering period and increased flower production. This is the first ever research of rapeseed as a honey plant in Iraq.

تقييم نبات الكانولا (*Brassica napus* L.) كأحد النباتات الرحيقية في العراق وتأثير بعض العوامل البيئية على إنتاج الرحيق

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الخلاصة

يعد محصول الكانولا من المحاصيل الزيتية الاقتصادية المهمة في العالم، إلا أنه لم تتم زراعته في العراق لهذا الغرض. في العقد الأخير بدأ النحالون في العراق بزراعته على نطاق ضيق لدعم نحلهم وتوفير مرعى طبيعي في فصل الشتاء، كما اعتمد بعض النحالين أسلوب التدرج في مواعيد الزراعة من الخريف (أيلول) حتى بداية الشتاء (تشرين الثاني) من أجل الحصول على مواعيد إزهار متتالية وبالتالي توفير أطول فترة إزهار للنحل. هدفت هذه الدراسة إلى تقييم تأثير بعض العوامل البيئية (درجة الحرارة، الرطوبة النسبية) الناتجة عن تعدد مواعيد الزراعة وأثرها على خصائص إنتاج الرحيق في أزهار الكانولا (كمية الرحيق، تركيز السكريات في الرحيق) بالإضافة إلى اختلاف مواعيد الإزهار وعدد الأزهار المتكونة على النبات وفترة التزهير. تم زراعة الكانولا في أربعة مواعيد بدأت في منتصف سبتمبر (T1) وأوائل أكتوبر (T2) ومنتصف أكتوبر (T3) وأوائل نوفمبر (T4) 2022. لم تنجح المعاملة الرابعة T4 حيث لم تستمر النباتات في النمو وتقزمت لذلك تم استبعادها. أظهرت الدراسة تأثيرًا سلبيًا لارتفاع درجة الحرارة على كمية الرحيق في الأزهار. كما أظهرت النتائج وجود علاقة قوية بين الرطوبة النسبية وزيادة كمية الرحيق المنتج وانخفاض تركيز السكر في الرحيق. لم يتم العثور على فروق معنوية في كمية الرحيق المنتج وتركيزه بين المعاملات الثلاثة لنفس اليوم. أعطت T1 أطول فترة إزهار (120) يومًا، و T2 (111) يومًا، بينما أعطت T2 (85) يومًا فقط. كما تفوقت المعاملة T1 و T2 على المعاملة T3 من حيث عدد الأزهار المتكونة على النبات (477، 358، 169 زهرة / النبات على التوالي)، وأعطت نباتات المعاملة T3 أطول فترة نمو خضري (61 يوماً) وأقل متوسط ارتفاع للنبات (165 سم). واستغرقت المعاملتان T1 و T2 (48 و 44 يوماً) على التوالي من النمو الخضري، كذلك أعطت المعاملتان أعلى متوسط ارتفاع للنبات (223 و 204 سم) على التوالي. وخلصت هذه الدراسة إلى أن اسلوب التدرج في مواعيد الزراعة ليست مفيدة لمربي النحل في منطقة الدراسة، وأن الزراعة في منتصف شهر أيلول هي أفضل موعد للحصول على أطول فترة تزهير وأكبر عدد من الأزهار خلال فترة الندرة التي تعاني فيها مستعمرات النحل في العراق من الجوع وقلة المراعي الطبيعية.

الكلمات الافتتاحية: النباتات المزهرة، رحيق الأزهار، العوامل البيئية، تفاعلات النباتات مع الملقحات، تربية النحل.

INTRODUCTION

Brassica napus L. known as canola, rapeseed or oilseed rape is a winter oilseed crop which is one of the major production crops in arid regions due to its water use efficiency and relatively drought tolerance (Albarrak 2006), adaptation ability to a wide range of soil types, its high oil contents (40-44%), and its benefits as a break crop for wheat and other cereals (Friedt *et al*., 2018, Meier *et al*., 2020, Goyal *et al*., 2021). Therefore, canola become the second largest crop in the world in terms of oilseed production, yielding about (13%) of the world supply (Hammed 2005). However, *B. napus* is not considered as an oilseed crop in Iraq yet, it has been cultivated rarely over small areas by local beekeepers only.

B. napus is one of the major forage crops for honeybees worldwide, where honeybees preferred rapeseed, even though other plants are in bloom, due to many reasons such as high rate of nectar secretion and pollen production with high nutritional value, features of flower structure including color and sent, landing platform and the position of nectaries reservoir (Westcott & Nelson 2001, Nedic *et al*., 2013). Furthermore, with the average of 52±17 opened flowers per plant and 375±39 flowers formed during flowering season in each plant (Nedic *et al*., 2013), *B. napus* crop considered a voluble pasture for bee food and colony development. Accordingly, (Farkas & Zajacz 2007) reported that one hectare of *B. napus* can provides nutritional resource for 3 honeybee colonies over three weeks. While (Nedic *et al*., 2013) estimated 10 kg/colony of canola honey was produced in the end of flowering period in Serbia. However, (Delaplane & Mayer 2000) stated that approximate 16-32 kg/colony collected by southern USA beekeepers.

Even though, most honey producer plant species are producing nectar with mixture of three sugars (sucrose, glucose and fructose), the nectar carbohydrates of *B. napus* are almost exclusively composed of glucose and fructose (Kevan *et al*., 1991; Davis *et al*., 1994), therefore, the high glucose:fructose ratio make canola honey crystalized quickly (Westcott & Nelson 2001, Farkas 2008). Genotype, environmental conditions and agricultural practices and circumstances affect the parameter of nectar production (quality and quantity) of canola flowers (Mitchell 2004, Edge 2010, Williams 1985, Nedic *et al*., 2013). Temperature and air humidity considered the most environmental factors that affect floral nectar production (Petanidou 2007, Pacini *et al*., 2003, Southwic 1983). Temperature variation can influence the concentration of nectar components (Gardener & Gillman 2001, Freeman & Head 1990). Robacker et al. (1983) discovered that nectar secretion on soybean flowers increases with an increase in ambient temperature up to 32 °C, while Petanidou and Smets (1996) found that the optimum temperature for nectar production in *Thymus capitatus* is 32.5 °C. Generally, slight increase in the average temperature affects nectar production positively. However, many studies revealed that nectar production decreased at high temperatures (Takkis *et al*., 2015). On the other hand, it was found that the floral nectar secretion of onion was significantly relate to relative humidity, however, the effect of temperature was not significant (Sliva & Dean 2004). Whereas (Kropacova & Haslbachova 1970) states that rising temperature affected nectar production of *Trifolium repens* negatively.

Beekeeping is a significant agricultural and environmental activity, but it is still a poor sector in Iraq where beekeeping projects are declined as evidenced by the degradation of total honey production per year. In 1994, Iraqi beekeepers produced 3710 tons of honey (Hussein 2000) however it declined to 1012 tons in 2015 (Al-Badri 2017). This obvious suffering of beekeeping sector in Iraq due to many reasons (Glaiim 2010, Al-Badri 2017, Sirwan *et al*., 2019), such as the degradation of vegetation cover and desertification phenomenon. Recently, Iraq lags behind in honey production compared to neighboring countries, as the Iraqi annual production did not exceed 100 tons on average for the years 2016-2021, while the average annual production reached 120, 490, and 2601.6 tons per year for Saudi Arabia, Jordan, and Syria, respectively, for the same years as stated in the annual reports of (AOAD 2024). As for Turkey and Iran, Iraq remains very far behind in its production level, Turkey ranked the second and Iran ranked the third in the world in honey production for the year 2021, with 96,300 and 77,200 tons, respectively (FAO 2024).

Iraqi beekeepers produced limited types of honey depending on the vegetative resources like Eucalyptus, Buckthorn, Clover and Citrus honey. Due to the climate of Iraqi area, honeybees often face a scarcity of forage in winter and summer. During winter, most bee colonies in Iraq stop laying eggs (Mansor 2024), causing a decline in bee density and thus reducing the colony's efficiency in maintaining suitable temperatures for the survival of the queen. One of the most important factors in maintaining the hive's activity and the queen's effectiveness in laying eggs during winter is the availability of natural pasture of nectar and pollen, therefore local beekeepers are always seeking for honey plants that can be thrives during these seasons rather than using artificially supplemented feeds to keep their bees alive. In this constant, many local beekeepers cultivated rapeseed as a honey plant despite it is not well-known crop in Iraq. Some Iraqi beekeepers were also observed dividing the field and planting canola with successive planting dates in order to obtain the longest flowering period during the winter.

The main aim of our study is the evaluation the effect of sowing date, temperature and relative humidity on flowering duration, number of flowers, nectar amount and nectar sugar concentration of *Brassica napus*. This is the first ever study on the relationship between climate conditions and properties of nectar production and use of rapeseed as a honey plant in Iraq.

MATERIAL AND METHODS

A field experiment was conducted in Misan University Faculty of Agriculture (N: 31.813292, E: 47.142399 Coordinates) applying four (4) different sowing dates: T1 (15th of Sept., 2022), T2 (01st of Oct., 2022), T3 (15th of Oct., 2022), T3 (01st of Nov., 2022) in order to monitor the flowering date and duration of flowering as well as measuring nectar production properties. The fourth treatment did not succeed as the plants became stunted and did not continue to grow until the flowering period, so it was excluded from taking measurements and results. The field soil texture was examined for some soil's chemical and physical properties (Table 1). Experimental design was based on randomized complete block with 3 replications (2 ×

3 m) for each block. The seeds were obtained from local nursery which were imported from Egypt.

Table 1. The chemical and physical properties of soil before sowing (2022).

Soil characters		Unit	Value
Chemical Properties	Electrical Conductivity (ECe)	$Des.m^{-1}$	3.86
	pH	-	7.71
	Organic Matter	%	0.23
	Na^+		2.4
	P	$mg.\ g^{-1}$	0.1
	K^+		0.9
Physical Properties	Sand		103
	Silt	$g\ kg^{-1}$ soil	460
	Clay		437
	Soil Texture	-	Silty Clay

Sampling Dates and Weather Conditions

The air temperature and relative humidity (Table 2.) were recorded for the days and hours in which the nectar production properties were determined. All nectar sampling was at the afternoon (1:00 – 2:00 PM). Samples collected and Weather Conditions (temperature and relative humidity) were recorded for the sampling days mentioned in (Table 3). The meteorological data for the growing season in the study area was obtained from the Iraqi Agrometeorological Center - Ministry of Agriculture as Mentioned in Table 2 (IAC 2022).

Table 2. The meteorological data (Monthly average) for the growing season

Month / Env. Factor	Sept. 2022	Oct. 2022	Nov. 2022	Dec. 2022	Jan.2023	Feb. 2023	Mar. 2023
Max. Tem. C°	43	37.8	27.2	20.2	14.8	19.6	26.3
Min. Tem. C°	28.5	17.8	12.4	8.7	6	6.5	11.9
Average Tem. C°	35.7	27.4	19.2	14.4	10.3	13.11	18.9
Relative Hum. %	26.7	35.2	55	69.3	80.4	54.6	60.5
Rain (mm)	0	0	0.3	1.6	1.3	0.2	2.8

Flowers (Figure 1.) were chosen in each plot randomly, covered with pierced envelop of butter paper (Figure 2.) before blooming in order to exclude bees and other flower visitors, after the flower fully bloomed, the envelop was removed, petals and anthers were cut carefully to get easy access for collecting nectar droplets at the base of anthers (Figure 3.). The nectar droplets were collected from the nectaries as the method described by (Dafni 1992) the regular micro-capillary tube was gently drown to a point over a candle, the fine end of the micro-capillary tube attached gently to the nectary, then the collected nectar were spotted on Whatman paper and the spot diameter was measured and converted to volume (µl) according the Protocol 3 (Dafni 1992). For nectar volume, three flowers from three plants were chosen randomly for each replicate. Nectar concentration (total sugar %) was determined by using hand-held refractometer SHEN ZHEN YIERYI Technology Co., Ltd – China. Nectar was collected from 7-8 flowers for each replicate in order to get the required amount for refractometer measurement.

Figure 1. Chosen canola flowers

Figure 2. Isolated flowers

Figure 3. Removed petals and anthers

The flowering period was recorded for each treatment from the first bloom until last flower for each block, five plants were chosen from each block (15 plants from each treatment) and number of flowers were calculated during the flowering period, plant height measured as well.

With reference to Gomez & Gomez (1984), all data was collected, organized interpreted using mathematical and statistical methods. The data were subjected to statistical analysis by MSTAT statistical software, using the randomized complete block design (RCBD) , with three replicates. In addition, the treatment means were compared using the Least Significant Difference (LSD) test at a significance threshold of 5%, as mentioned by Snedecor and Cochran (1980).

RESULTS AND DISSCUSION

The results of nectar volume (µl) per flower and total carbohydrate (%) in produced nectar shows no significant differences between the treatments except last sampling date of T2 (0.517 µl). That means the developmental state of plant does not affect the nectar production rate and its sugar concentration, this is consistent with the statement of (Dmitruk *et al.*, 2024) that the traits of nectar production basically nectar volume and its sugar contents affected by environmental factors (temperature, humidity, and light). Since the samples were analyzed on the same day for all treatments, significant differences were not detected, as the environmental conditions were similar on the day of sample analysis.

Table (3): Nectar Production (Volume) per Flower and Total Carbohydrate Production in Rapeseed According to Sampling Date

Sampling Date	Nectar Volume µl/flower				Total Sugar Cons. %	Temp. °C	Hum. %
	T1	T2	T3	LSD ($P<0.05$)			
02.11.2022	0.3	-*	-*	-	34	31.00	53
06.11.2022	0.35	-*	-*	-	25	29.00	83
13.11.2022	0.225 a	0.275 a	-*	0.1076	28	28.00	62
23.11.2022	0.25 a	0.275 a	-*	0.1076	32	28.00	45
30.11.2022	0.425 a	0.469 a	-*	0.4838	33	26.00	52
12.12.2022	0.475 a	1.033 a	0.433 a	0.5632	33	22.00	64
18.12.2022	0.383 a	0.286 a	0.326 a	0.3997	30	21.00	72
02.01.2023	0.517 a	0.35 a	0.517 a	0.67	29	16.00	78
12.01.2023	1.5 a	1.13 a	0.89 a	0.872	22	14.00	81
29.1.2023	0.392 a	0.3 a	0.25 a	0.2104	25	20.00	62
2.2.2023	0.35 a	0.52 a	0.48 a	0.811	36	19.00	72
20.2.2023	0.358 a	0.325 a	0.183 a	0.2859	27	23.00	39
28.2.2023	0.3 a	0.29 a	0.25 a	0.121	31	29.00	47
2.3.2023	0.183 a	0.517 b	0.25 a	0.1731	30	27.00	49
6.3.2023	-**	-**	0.167	-	32	31.00	52

* No Flowers (vegetative growth). ** No flowers (End of flowering time).
Small letter means significantly different ($p < 0.05$) means between sowing dates (treatments) or sampling dates?

The plants of the first treatment took approximately (49 days) of vegetative growth until flowering began (15th of Sept., 2022 – 2nd of Nov., 2022) (Table 3), flowering of the plants continued for four months (120 days) (Table 4 & 5), ending at the beginning of March 2023. While the second treatment took (44 days) from the planting date until the first flower appeared (1/10/2022 - 13/11/2022), and the plants continued to flower for approximately three and a half months (110 days), and flowering also ended in early March 2023 as in the previous treatment. However, the third treatment took approximately two months (61 days) of vegetative growth until flowering began (15/10/2022 - 12/12/2022), and the plants continued to flower for approximately three months (85 days).

Table (4): Effect of Planting dates on plant height, No. of flowers, Period of Vegetative Growth and period of flowering.

Characters / Treatments	plant height (cm)	No. of Flowers per plant	Period of Vegetative Growth* (days)	Period of Flowering (days)
Date of sowing				
T1	223.4 a	477.0 a	48.67 a	120.00 a
T2	204.8 a	358.0 a	44.00 b	110.00 b
T3	165.0 b	169.0 b	61.33 c	85.00 c
LSD($P<0.05$)	**27.40**	**266.9**	**1.851**	**3.463**

* Period from planting until the first flower appear.

Table (5): Analysis of variation for the studied traits.

S.O.V	**D.F**	**Plant height (cm)**	**No. of Flowers**	**Period of Vegetative Growth / Days**	**Period of Flowering / Days**
Block	2	32.7	3255.0	0.33	1.333
Date	2	2670.3**	72610.0*	241.3**	975.0**
Error	4	146.1	13863.0	0.6	2.333
Total	8				
C.V.%		**6.1**	**35.2**	**1.6**	**0.6**

**Significant at a 0.01 level, *Significant at a 0.05 level, and ns denotes non-significant.

The delay in planting date in mid of October resulted in prolonging the vegetative growth period (61 days) compared with first and second treatment (49, 44 days respectively), maybe due to the decreasing of temperature caused declining of physiological activities and plant growth. These results are not match with the findings of (Ehteshami *et al.*,2015) where the shortest period of vegetative growth was obtained when canola was planted in October, while the growth period until the appearance of the first flower bud was the longest for planting dates in September. That difference could be due to the difference between the climate conditions of the two countries (Iraq & Iran). In spite of the long vegetative period of T3, the average plant height where shorter (165 cm) compared to the T1 & T2 (223.4, 204.8 cm respectively). This finding supports our conclusion of the effect of temperature decrease on growth rate.

The delay in planting affected flowering period significantly, where the flowering periods for treatments 1, 2 and 3 were 121, 110 and 85 days, respectively. This is consistent with (Ehteshami, *et al.*,2015) which reported the longest flowering period for canola planting date at early September and the shortest flowering period when canola was planted at late October. These results are also consistent with (Robertson *et al.*, 2004) where it was reported that the time to reach 50% flowering and maturity of canola was shorter with delayed planting.

Regarding the average number of flowers formed on the plant throughout its life cycle, there was no significant difference between the first and second treatments (477 flowers) and (358 flowers) respectively, while there was significant difference compared to the third treatment (169 flowers). Canola is a long-day plant, where the period from germination to flowering shortens as the photoperiod increases (Luo *et al.*, 2018). Delayed sowing of canola resulted in the plants facing higher temperatures due to the end of winter and the plants not yet completing their ideal growth, which led to stimulating physiological processes in the plant that accelerated the flowering process at the expense of vegetative growth in order to complete the life cycle and produce seeds. These results are also consistent with the findings of (Mandal *et al*., 1994). The results of the second treatment agree with (Nedic *et al*., 2013), which found that the average number of flowers formed on canola plants under normal cultivation conditions reached 375 ± 39 flowers. While the results of the first treatment exceeded that estimation.

The relationship between climate conditions and properties of nectar production of each treatment was analyzed by Pearson correlation. Positive correlations were detected between nectar volume (N.Vol.) and relative humidity (Hum.) in all treatments (T1, T2 & T3) 0.501, 0.430 and 0.810 respectively (Table 6,7,8). In addition, weak positive correlation found between nectar concentration (N.Con.) and daily temperature (Tem.) for all treatments (T1, T2 & T3) 0.326, 0.389 and 0.428 respectively. Negative correlation was detected between (N.Vol) and (Tem.) in all treatments (T1, T2 & T3) -0.678, -0.482 and -0.796 respectively. Likewise, (N.Con.) and (Hum.) correlated negatively for all treatments (T1, T2 & T3) -0.351, -0.205 and -0.135 respectively. A negative correlation was found between (N.Vol) and (N.Con.) in all treatments (T1, T2 & T3) -0.534, -0.165 and -0.348 respectively.

Table 6. Correlations between variables of Treatment 1 (T1) and their relationships. Abbreviations: N.Vol.: Nectar Volume (µl/flower), Tem.: Temperature (°C), Hum.: Relative Humidity %, N.Con.: Nectar Concentration %

	N.Vol	**Tem.**	**Hum.**	**N.Con.**
N.Vol.	1.00			
Tem.	-0.678	1.00		
Hum.	0.501	-0.552	1.00	
N.Con.	-0.534	0.326	-0.351	1.00

The Pearson Correlation is statistically significant at the 0.05 level.

Table 7. Correlations between variables of Treatment 2 (T2) and their relationships. Abbreviations: N.Vol.: Nectar Volume (µl/flower), Tem.: Temperature (°C), Hum.: Relative Humidity %, N.Con.: Nectar Concentration %.

	N.Vol	**Tem.**	**Hum.**	**N.Con.**
N.Vol.	1.00			
Tem.	-0.482	1.00		
Hum.	0.430	-0.807	1.00	
N.Con.	-0.165	0.389	-0.205	1.00

The Pearson Correlation is statistically significant at the 0.05 level.

Table 8. Correlations between variables of Treatment 3 (T3) and their relationships. Abbreviations: N.Vol: Nectar Volume (µl/flower), Tem.: Temperature (°C), Hum.: Relative Humidity %, N.Con.: Nectar Concentration %.

	N.Vol	**Tem.**	**Hum.**	**N.Con.**
N.Vol.	1.00			
Tem.	-0.796	1.00		
Hum.	0.810	-0.809	1.00	
N.Con.	-0.348	0.428	-0.135	1.00

The Pearson Correlation is statistically significant at the 0.05 level.

The characteristics of nectar production are clearly affected by climatic factors, especially the amount of nectar produced by flower and the concentration of sugars in that nectar. Many researchers have found a positive effect of higher temperature on increasing nectar production while ensuring that the plant is not exposed to heat stress and water stress (Jakobsen & Kristjánsson, 1994, Petanidou 2007, Takkis *et al*., 2015, Pacini & Nepi, 2007, Nocentini *et al*., 2013). There were multiple explanations for this phenomenon. This phenomenon is specific to Mediterranean plants, and it is one of their evolutionary adaptive characteristics (Petanidou, & Smets, 1996). Another explanation is that the increasing temperature leads to the stimulation of photosynthesis and some other physiological activities that affecting nectar production properties (Fahn 2000, Pacini *et al*., 2003). While others have attributed the reason to the fact that the rise in the temperature of the surrounding air leads to an increase in transpiration, which encourages the flow of larger quantities of water through the xylem tissue column in the plant and thus stimulates the nectary glands to secrete larger quantities of nectar (Shuel 1992).On the other hand, other researchers reported that the rise in temperature had a negative effect on nectar secretion (Keasar *et al*., 2008, Takkis *et al*., 2018), and this is consistent with the results of this study. Several studies reported that high temperature causes physiological stress in the plant, which reduces nectar production in the flower (Petanidou, & Smets, 1996, Pacini & Nepi, 2007, Scaven, & Rafferty 2013). Moreover, the increase in temperature has led to increased evaporation of water from the soil and the plant being under water stress, which reduced the flow of water through the xylem tissue column and thus reduced nectar secretion (Shuel 1992).

The results of the correlation analysis (Table 6,7,8) showed a negative correlation between temperature and relative humidity, that the decrease in relative humidity resulting from the increase in air temperature leads to increased nectar evaporation and thus decreased daily nectar production (Figure 4), which supports the previous interpretations and the results of this study (Sliva & Dean 2004, Shuel 1992). Romero-Bravo & Castellanos (2024) also claims that the air temperature and humidity are the most conditions affecting nectar traits as they determining the proportion of evaporation. It is worth mentioning that some researchers claimed that the effect of relative humidity is stronger than the effect of temperature on the characteristics of nectar production (Búrquez, & Corbet 1998, Pérez-Bañón 2000).

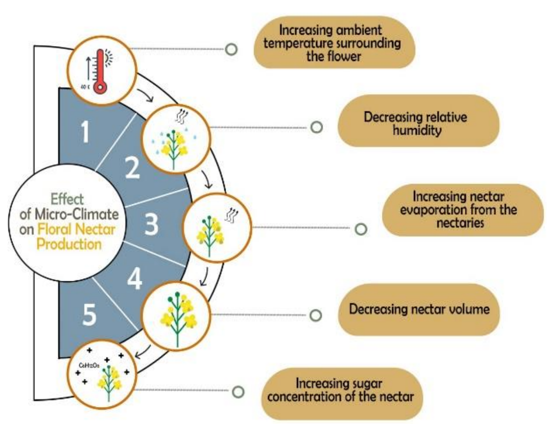

Figure 4: Effect of Micro-Climate on Floral Nectar Production

CONCLUSION

Our study concluded that canola is an important crop that would enhance the beekeeping sector in Iraq due to the amount of nectar produced by the flower and the number of flowers that the plant forms during its life as well as the long flowering period that extends to 3 months. The idea that the consecutive sowing dates of canola, which some beekeepers in Iraq follow, provides them continuous flowering seasons and thus obtaining longer flowering periods, was not supported by the results of our study. Since the gradual planting dates did not give encouraging results compared to the additional efforts made by the beekeepers, where the late planting date (mid-October) did not differ from the first date (mid-September) by more than one week of flowering, while the first date gave a longer flowering period (120 days) and a greater number of flowers (477 flowers) per plant compared to (85 flowering days) and (169 flowers) for the late planting date. But T2 (1st of .Oct., 2022) sowing date resulted in the best nectar production. Considering the spring season in Iraq and the blooming of other plants, the extra week of flowering provided by the late planting date is insignificant (since this period falls within March, which is the most flowering month in Iraq) compared to the first weeks of flowering provided by the advanced planting date, which falls within November, the first month of winter and the scarcity of pasture for bees in Iraq. Further research needs to be conducted to test different canola genotypes, optimize the best sowing date for the highest nectar production.

CONFLICT OF INTEREST

The authors declare no conflicts of interest associated with this manuscript.

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