doi:10.14720/aas.2025.121.1.19183 Original research article / izvirni znanstveni članek

Effect of chemical thinning on the fruit organoleptic parameters of 'Majhoul' date palm during the ripening stage

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Received July 01, 2024, accepted February 13, 2025
Delo je prispelo 1. julij 2024, sprejeto 13. februar 2025

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Abstract: The aim of our research work was to study the effect of chemical thinning on the fruit organoleptic parameters of 'Majhoul' date palm during ripening. Trials were carried out in the Tinejdad region. Four thinning treatments, including two NAA (naphthalene acetic acid) treatments were used on the fruits of three flowering phases. Obtained results showed that thinning treatments and flowering phases did not affect ($p < 0.05$) the titratable acidity of the fruit juice, while the two factors affected ($p \leq 0.05$) the pH of the fruit juice (5.16 in not thinned early flowering and 6.75 in the late flowering treated with T2 NAA). The content of sugar in the fruit was higher in the control and manual thinning (17.62-19.58 °Brix) than in NAA treatments (13.89-15.05 °Brix). It was also higher in the early flowering phase (18.35 °Brix) than in the other phases (15.50-15.76 °Brix). At the ripening stage, thinning treatments and flowering phases affected significantly ($p \leq 0.001$) the rate of ripening, but there was no interaction between the two factors. Thinning treatments and flowering phases affected some parameters of the fruit (pH, sugar content), but did not affect some other parameters (titratable acidity).

Key words: 'Majhoul' date palm, chemical thinning, NAA, flowering phase, fruit ripening, fruit organoleptic parameters.

Učinek kemičnega redčenja v obdobju zorenja na organoleptične lastnosti plodov dateljeve palme 'Majhoul'

Izvleček: Namen raziskave je bil preučiti učinek kemičnega redčenja v obdobju zorenja plodov na organoleptične lastnosti dateljeve palme 'Majhoul'. Poskusi so bili izvedeni na območju Tinejdad. Obravnavanja so obsegala štiri načine redčenja v treh fazah cvetenja, od katerih sta dva vsebovala naftalen ocetno kislino. Rezultati so pokazali, da redčenja in faze cvetenja niso vplivale ($p < 0,05$) na titrabilno kislost soka plodov medtem, ko sta oba dejavnika vplivala ($p \leq 0,05$) na pH soka plodov (5,16 pri plodovih zgodnje faze cvetenja brez redčenja in 6,75 pri plodovih pozne faze cvetenja in obravnavanju T2). Vsebnost sladkorjev v plodovih je bila večja pri kontroli in ročnem redčenju (17,62-19,58°Brix) kot pri obravnavanjih z naftalen ocetno kislino (13,89-15,05 °Brix). Vsebnost sladkorja je bila tudi večja v plodovih zgodnje faze cvetenja (18,35 °Brix) kot v plodovih ostalih faz (15,50-15,76 °Brix). Faze cvetenja in obravnavanja z redčenjem so značilno vplivala ($p \leq 0,001$) na stopnjo zrelosti plodov, vendar med obema dejavnikoma ni bilo povezave. Zaključimo lahko, da so redčenja in faze cvetenja vplivale na nekatere organoleptične lastnosti plodov (pH in vsebnost sladkorja) a ne na nekatere druge parametre (titratibilna kislost).

Ključne besede: 'Majhoul' dateljeva palma, kemično redčenje, naftalen ocetna kislina, faza cvetenja, zrelost plodov, organoleptične lastnosti plodov

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1 INTRODUCTION

To obtain good quality dates with market value, farmers are required to perform the thinning practice, which is an important management practice in the production system of date palm. Because of the expensive cost of manual thinning due to its performance by skilled labor, the need for a thinning practice, which is not expensive, such as chemical thinning, is necessary. The chemical thinning may be an alternative to manual thinning. Preliminary trials have shown that the use of some chemical regulators, such as NAA (naphthalene acetic acid), improved date yield and quality. This synthetic auxin has been shown effective in the chemical thinning of date palm (Ali Dinar et al., 2002; Al-Juburi & Al-Masry, 2003; Abd El-Kader et al., 2008). As reported by several authors, the chemical NAA product is also used to improve dates quality and to control their ripening (Al-Juburi et al., 2000 and 2001; Aboutalebi & Beharoznam, 2006). Abd El-Kader et al. (2008) indicated that to improve dates yield and quality much progress is needed in using the growth regulators such as NAA product.

The elimination of 15, 30, or 45 % of fruits per cluster improved fruit quality, including fruit and pulp mass and the content of sugar in the fruit (Samouni et al., 2016). Applications of 150 and 200 ppm NAA on 'Barhe' and 'Shahl' date palm 10 weeks after fruit set decreased the content of sugar in the fruit compared to the control not treated (Harhash & Al Obeed, 2007). Applying 100 and 200 ppm NAA on 'Majhoul' date palm 20 to 38 days after pollination also decreased the content of sugar in the fruit. The application of 100 ppm NAA decreased the content of dry matter in the fruit and that of 200 ppm did not affect this content of dry matter. While, the pH of the fruit juice was almost similar for all treatments (Arba & Oumou, 2024). However, Taim (2010) reported that applying 100 ppm NAA on 'Barhe' date palm 10 days and 7 weeks after pollination increased the titratable acidity and the content of sugar in the fruit. While, the same application decreased the pH of the fruit juice and the content of dry matter in the fruit. Other authors indicated that application of 80 and 100 ppm NAA on 'Barhee' and 'Succary' date palm fifteen weeks after pollination led to an increase in the acidity and the content of sugar in the fruit (Al Obeed et al., 2003; Al Qurashi & Awad, 2011).

Our research work aimed to study the effectiveness of chemical thinning as an alternative to manual thinning, because it's less expensive for the farmetrs and easy to use. Moreover, the objective of our research work was to study the effect of chemical thinning by using NAA on the organoleptic parameters of the fruits. These organoleptic parameters are amang the physico chemical constituants that are important in the determination of the date quality. They are focusing on the pH and titratable acidity of the fruit, and the content of sugar and dry matter in the fruit. Applications of NAA are used 30 days and 60 days after pollination on different flowering phases of 'Majhoul' date palm: the early flowering phase, the seasonal phase, and the late flowering phase.

2 MATERIALS AND METHODS

2.1 THE SITE OF TRIALS

Trials are carried out on fifteen-year-old plantations in the Tinejdad region, Tafilalet area: latitude 31° 32' north, longitude 4° 52' west, 1062 m altitude. The site of trials is characterized by an arid climate with warm temperatures in summer (mean temperature is 42 °C) and cold temperatures in winter (mean low temperature is -0.5 °C), and low rainfall (less than 100 mm per year) which is poorly distributed in the year. The site of trials is also characterized by warm and dry winds from the east, which can reach more than 57 km per hour during the summer period (May to August) (DGCL, 2015). The soil of the site of trials included 46 % fine sand, 30 % silt, 12 % clay, 7 % limestone, and 0.21 % organic matter.

The irrigation system used in the farm of trials was drip irrigation with two drip rails per row of palm trees and two drips per palm tree (one drip per drip rail). Organic manure was brought once a year, in May, and the amount provided was 150 kg per palm tree and mineral manure was brought twice a year, in February and June. Watering and fertilizing programs used in the cultivation of 'Majhoul' date palm in the farm of trials are presented in Table 1.

2.2 THE EXPERIMENTAL DESIGN

The experimental design adopted was a split-plot with 3 blocks including 4 palm trees each one, and on each palm tree, the three flowering phases were randomly chosen. The spathe-opening and pollination periods of the three flowering phases are presented in Table 2. Studied palm trees were 2-3 m high, the number of palms per palm tree was 72 to 80 and the number of clusters kept per palm tree was more than one per 10 palms because the clusters were not loaded. The pollination was carried out manually by putting three spikelets of male inflorescence inside the female inflorescence.

Table 1: Watering and fertilizing programs used in the cultivation of 'Majhoul' date palm in the farm of trials in the Tinejdad region, Tafilalet area.

Fertilizing program				Watering program	
Fertilizers used	Principal constituants	Amount brought per palm tree on February	Amount brought per palm tree on June	Watering dose per palm tree and frequency of the apports	Periods of the apports
Composed fertilizers	14 % N, 7 % P_2O_5, 21 % K2O, 3 % MgO	2 kg (0.28 kg N, 0.14 kg P_2O_5, 0.42 kg K_2O and 0.06 kg MgO)	1 kg (0.14 kg N, 0.07 kg P_2O_5, 0.21 kg K_2O and 0.03 kg MgO)		
Silica-based fertilizers	60 % SiO2, 3.7 % MgO, 3.4 % Fe_2O_3, 3 % CaO	1 Kg (0.6 kg SiO_2, 0.037 kg MgO, 0.034 kg Fe_2O_3, 0.03 kg CaO)	1 Kg (0.6 kg SiO_2, 0.037 kg MgO, 0.034 kg Fe_2O_3, 0.03 kg CaO)	400 to 600 liters per palm tree per 4 days	December to April
Ammonium nitrate	33,5% N	2 kg (0,67 kg N)	1 kg (0,335 kg N)		
Potash nitrate	13 % N, 46 % K2O	-	1 kg (0.13 kg N, 0.46 kg K2O)	400 to 600 liters per palm tree per 2 days	May to November
DAP Diammonium-triphosphate	18 % N, 46 % $P2O_5$	1 kg (0.18 kg N, 0.46 kg $P2O_5$)	-		

Table 2: Spathe-opening and pollination periods of the three flowering phases, thinning treatments used, and application dates of NAA treatments on 'Majhoul' date palm in the Tinejdad region, Tafilalet area.

		Flowering phase		
		Early flowering	Seasonal flowering	Late flowering
Spathe-opening period		March 15 to 25 2017	March 26 to April 5 2017	After April 5 2017
Pollination period		March 30 to April 6 2017	April 7 to 14 2017	April 15 to 21 2017
Thinning treatments used	T0	Control treated with liquefied water		
	T1	150 ppm NAA 30 days after pollination and 300 ppm 60 days after pollination		
	T2	250 ppm NAA 30 days after pollination and 500 ppm 60 days after pollination		
	T3	Manual thinning used by the farmer: retaining 8 to 10 fruits per spikelet and removing the rest		
Application dates of NAA	1st application	30 days after pollination of the early flowering phase (May 08, 2017)		
	2nd application	60 days after pollination of the early flowering phase (June 10, 2017)		

2.3 THINNING TREATMENTS USED IN THE STUDY

Thinning treatments used in the study and their applying dates are presented in table 2. They were applied to the fruits of the early, seasonal, and late flowering phases of 'Majhoul' date palm to study their effect on the fruit organoleptic parameters. The fruit morphological parameters as affected by thinning treatments, including NAA treatments, during fruit development are published in another journal (Arba et al., 2023b). Manual thinning began on May 15, 2017, 45 days after pollination and the fruit diameter at this stage was 12-13 mm. It was used to assess the effectiveness of chemical thinning using NAA on 'Majhoul' date palm. The diameter of the fruits during the first treatment of NAA was 8 mm for the early flowering phase, 6.5 mm for the seasonal flowering, and 5 mm for the late flowering phase, and their diameter during the second treatment was 22 mm for the early flowering, 20 mm for the seasonal

flowering and 18 mm for the late flowering. Each palm of the trial received a thinning treatment, which was repeated three times per flowering phase. Precautions were taken during NAA treatments because the NAA product is sensitive to climatic conditions. The mean temperature should be 18-24 °C, the relative humidity between 5-17 %, and the wind speed should not exceed 5 km per hour. The NAA product used was a powder with 99 % purity and the amounts used were measured using a precision balance with an error of 0.01 mg.

2.4 CHEMICAL ANALYSIS OF THE FRUITS

For chemical analysis of pH and titratable acidity, a sample of 10 fruits per flowering phase or thinning treatment was washed with tap water, cleared of their seeds, and finely ground in mixture with a double their volume in distilled water. The grind was centrifuged for 40 minutes, the recovered supernatant was filtered and the filtrate was adjusted with distilled water up to 200 ml to constitute the raw solution to be analyzed. The pH of juice was measured with a pH meter and the titratable acidity was determined by titration of 10 g juice diluted with 10 ml distilled water using a 0.1 N NaOH solution until a pH of 8.1 is obtained with a pH meter. The juice of 10 g fruit per flowering phase or thinning treatment, which was crushed using a garlic press was used to determine the content of sugar or the Brix using a refractometer. The content of dry matter in the fruit was determined according to Shamim et al. (2013) by measuring the fresh mass of 3 fruits per combination of thinning treatment-flowering phase and their dry mass after cutting them into small pieces and drying them in an oven at 70 °C for 48 hours. Fruit ripening monitoring was performed on a sample of 10 spikelets on the two clusters (5 per cluster) of each combination of flowering phase-thinning treatment.

2.5 STATISTCAL ANALYSIS OF DATA

Data processing of studied parameters, as well as the determination of the means and the design of the graphs, were carried out using Microsoft Excel 16. The analysis of variance (ANOVA) amang the means values of repeated mesures and the multiple comparison of means according to the Tukey test, with a significance level of $p \leq 0.05$, were carried out using Minitab 16 statistical software.

3 RESULTS AND DISCUSSION

3.1 THE ORGANOLEPTIC PARAMETERS OF THE FRUITS

3.1.1 Titratable acidity and the content of sugar in the fruit

Obtained results showed that thinning treatments and flowering phases and the interaction of the two factors did not affect significantly ($p > 0.05$) the titratable acidity of the fruit juice. The titrable acidity of the fruit juice was 0.16 to 0.21 % citric acid for all thinning treatments and flowering phases (Table 3). Our results are different from those of several authors who reported that applying 80 to 100 ppm NAA on 'Barhe' and 'Succary' date palm fifteen weeks after pollination led to an increase in the titratable acidity of the dates (Al Obeed et al., 2003; Al Qurashi & Awad, 2011). Taaim (2010) also reported that applying 100 ppm NAA on 'Barhe' date palm 10 days to 7 weeks after pollination increased the titratable acidity of the dates. However, Harhash & Al Obeed (2007) indicated that an application of 150 and 200 ppm NAA on 'Barhe' and 'Shahl' date palm ten weeks after fruit set led to a decrease in the titratable acidity of the dates. The difference between their outcome and our results is probably due to the difference in studied date palm varieties and the ripening stage where chemical analysis of the fruits is carried out. In our case the chemical analysis of the fruits is carried out at the end of the 'Khalal' stage and in their case the chemical analysis is realized during the 'Tamar' stage, which is the late ripening stage in date palm.

However, thinning treatments and the flowering phases affected significantly ($p \leq 0.05$) the content of sugar in the fruit, but there was no interaction between the two factors for this chemical parameter. The content of sugar in the fruit was higher in the control and manual thinning treatment (17.62-19.58 °Brix) than in T1 and T2 NAA treatments (13.89-15.05 °Brix) (Table 3). Our results are consistent with those of several authors who reported that applying 150 and 200 ppm NAA on 'Succary' date palm seven weeks after pollination (Harhash & Al Obeed, 2005) or on 'Barhe' and 'Shahl' date palm ten weeks after fruit set (Harbash & Al Obeed, 2007) led to a decrease in the content of sugar in the fruit. Arba & Oumou (2024) also indicated that applying 100 and 200 ppm NAA on 'Majhoul' date palm 20 to 38 days after pollination resulted in a decrease in the content of sugar in the fruit of the NAA treatments (9.60-9.67 °Brix) compared to the fruits of the manual thinning treatment (12.88 °Brix). Some other authors reported that manual

Table 3: Titratable acidity and the content of sugar in the fruit according to thinning treatments used (T0, T1, T2, and T3) and flowering phases (early, seasonal, and late flowering) of 'Majhoul' date palm in the Tinejdad region, Tafilalet area.

Thinning treatments used	Titratable acidity of the fruit juice (% citric acid)		Sugar content in the fruit (°Brix)	
T0	0.20 ± 0.04		19.58 ± 1.02	
T1	0.16 ± 0.03	ns	15.05 ± 1.12	*
T2	0.23 ± 0.07		13.89 ± 1.11	
T3	0.21 ± 0.03		17.62 ± 1.36	
Flowering phases				
Early flowering	0.21 ± 0.04		18.35 ± 1.01	
Seasonal flowering	0.21 ± 0.05	ns	15.76 ± 0.74	*
Late flowering	0.18 ± 0.04		15.50 ± 1.02	

T0: Control treated with liquefied water
T1: 150 ppm NAA 30 days after pollination and 300 ppm 60 days after pollination
T2: 250 ppm NAA 30 days after pollination and 500 ppm 60 days after pollination
T3: Manual thinning used by the farmer: retaining 8 to 10 fruits per spikelet and removing the rest
*: significant difference at $p \leq 0.05$
ns: No significant difference ($p > 0.05$)
The numbers after the ± sign indicate the error deviation

thinning in 'Samany', 'Barhe', 'Seewy', 'Saqei', and 'Succary' date palm increased most of physical (fruit mass and length) and chemical properties (total solid solubles) compared to not thinned palm trees (Dawoud & El-Rauof, 2021; Abdelhalim Ahmed, 2022; Ghazzawy et al., 2023; Sallam, 2023; Zakaria et al., 2023). However, our results are different from those of some other authors who reported that applying 80 and 100 ppm NAA on 'Barhe' and 'Succary' date palm fifteen weeks after pollination (Al Obeed et al., 2003; Al Qurashi & Awad, 2011) or 100 ppm NAA on 'Barhe' date palm ten days and seven weeks after pollination (Taaim, 2010) led to an increase in the content of sugar in the fruit. Arba et al. (2023a) also reported that an application of NAA at the 'Hababouk' stage (20-30 days after pollination) improves fruit quality of retained fruits in the clusters. Applying 75 ppm Cytophex on 'Zaghloul' and 'Samany' date palm four weeks after pollination also increased the content of sugar in the fruit (El Kosary, 2009). Jalali et al. (2024) showed that the interaction of manual and chemical thinning improved fruit quality and the content of sugar in the fruit of 'Khadrawi' date palm at the 'Tamar' stage. The chemical thinning affected significantly the titratable acidity of the fruit juice and the manual thinning affected the total phenols and non-reducing sugars in the fruit. Their results also showed that there was an increase trend in the amount of sugars, pH, and total acidity from the 'Kimri' to 'Tamar' stage, but a decrease trend in the amount of total phenols and titratable acidity of the fruit from the first stage to the second one.

The differences in the results of cited authors may be due to the ripening stage of studied varieties and management practices used in each case. The two main factors are the water and mineral supply of plants, and the environmental conditions prevailing in the growing site of date palm in each case of study. Regarding the flowering phases, the content of suger in the fruit was also higher in the fruits of the early flowering phase (18.35 °Brix) than in those of the other flowering phases (15.50-15.76 °Brix) (Table 3) probably because of the long period of the fruit development period and the ripening stage where the fruits of the early flowering phase have accumulated more sugar than those of the other flowering phases due to the shorter period of their fruit development period and ripening stage. However, Arba & Oumou (2024) indicated that at the end of the 'Khalal' stage, the flowering phases did not affect significantly ($p > 0.05$) the content of sugar in the fruit. Probably because of the fruit load of the palm trees, which is less loaded in their study due to the low number of clusters kept per palm tree (a mean of 7 clusters per palm tree).

3.1.2 The pH of the fruit juice

Characterized by high sugar content, the organoleptic quality of the dates depends on several factors, mainly the balance between their content of sugar and acidity. Our results on the pH of the fruit juice showed also that the flowering phases and thinning treatments affected significantly ($p \leq 0.05$) this chemical parameter and that

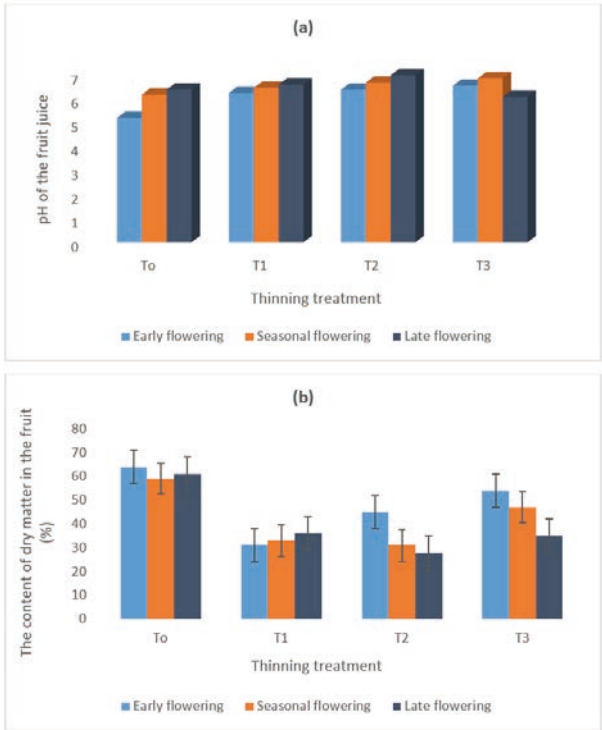

Figure 1: Variation in the pH of the fruit juice (a) and in the content of dry matter in the fruit (b) according to the thinning treatments T0, T1, T2, and T3, and the flowering phases (early, seasonal, and late flowering) of 'Majhoul' date palm in the Tinejdad region, Tafilalet area.

T0: Control treated with liquefied water
T1: 150 ppm NAA 30 days after pollination and 300 ppm 60 days after pollination
T2: 250 ppm NAA 30 days after pollination and 500 ppm 60 days after pollination
T3: Manual thinning used by the farmer: retaining 8-10 fruits per spikelet and removing the rest

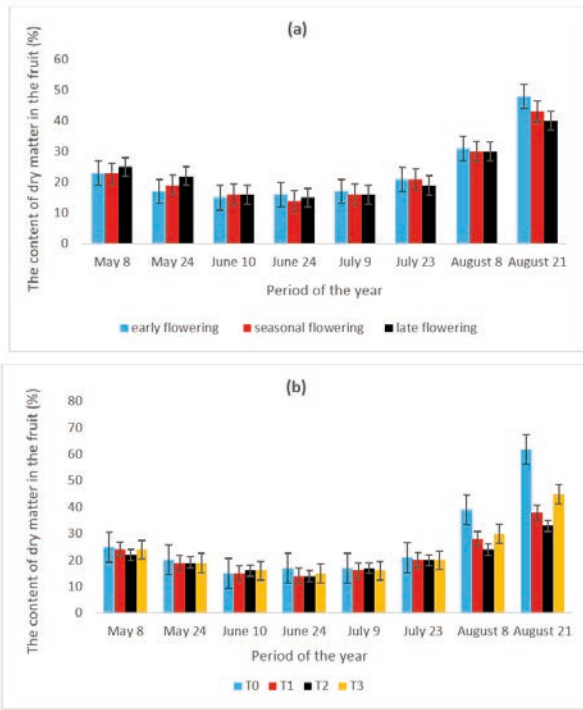

Figure 2: Evolution of the content of dry matter in the fruit of 'Majhoul' date palm according to flowering phases (early, seasonal and late flowering) (a), and thinning treatments used (T0, T1, T2 and T3) (b) in the Tinejdad region, Tafilalet area.

T0: Control treated with liquefied water
T1: 150 ppm NAA 30 days after pollination and 300 ppm 60 days after pollination
T2: 250 ppm NAA 30 days after pollination and 500 ppm 60 days after pollination
T3: Manual thinning used by the farmer: retaining 8-10 fruits per spikelet and removing the rest

there is an interaction between the two factors (Figure 1a). The lowest pH of the fruits (5.16) was obtained in the early flowering phase without thinning treatment (Figure 1a). The fruit load of the clusters, which was higher in this flowering phase and may influence the air circulation in the clusters, might explain this lowest pH in the fruits of the early flowering phase. According to Chafi et al. (2015), this pH value may be the lowest value for 'Majhoul' date palm, and according to Acourene et al. (2001), this pH level may be a bad chemical character for the preservation of dates. The pH of the other thinning treatment-flowering phase combinations is above 5.8 and this may be a good chemical character for the preservation of dates. Our results are different from those of Arba & Oumou (2024) who reported that the flowering phases and thinning treatments used in their study (control without application of NAA, 100 and 200 ppm NAA) did not affect significantly ($p > 0.05$) the pH of the fruit juice. Probably because of the ripening stage and NAA treatments used in their study and which were different from the ours.

3.1.3 Evolution of the content of dry matter in the fruit during fruit development

The evolution of the content of dry matter in the fruit during fruit development is presented in Figure 2. It shows that except for May 24 and August 21 2017 where the flowering phases affect significantly ($p \leq 0.05$) the content of dry matter in the fruit, these flowering phases do not affect significantly ($p > 0.05$) this content of dry matter during the rest of the fruit development period (Figure 2). During the first days of application of NAA treatments, the content of dry matter in the fruit is al-

most similar for all the thinning treatments. However, during May 22-July 24 2017, a slight decrease in the content of dry matter in the fruit is observed in all the thinning treatments. This may be due to the coincidence of this period with the fruit enlargement stage during which the demand for fruit for water is important. At the end of the fruit enlargement stage (July 24, 2017), there is a resumption in the increase of the content of dry matter in the fruit which is a sign of the beginning of the ripening stage.

The results also showed that there is an interaction between the flowering phases and thinning treatments (Figure 1b). Thus, for the flowering phases without thinning treatment, the content of dry matter in the fruit was higher and reached 64 % for the early flowering phase, 57 % for the seasonal phase, and 61 % for the late phase. Arba & Oumou (2024) also reported that in 'Majhoul' date palm, the content of dry matter in the fruit of the early flowering phase was higher than in the other phases and the late flowering phase was the latest. In the case of the manual thinning and the control without thinning treatment, the content of dry matter in the fruit was similar for all the flowering phases. While the content of dry matter in the fruit of the NAA treatments was the lowest, mainly in the higher NAA treatment in the late flowering phase. These results confirm the difference between thinning treatments and flowering phases in terms of the ripening rate as the increase in the content of dry matter in the fruit is a sign of the beginning of the ripening stage. This difference may be due to the fruit load which is higher in the clusters of the early flowering phase and which contributed to early ripening. This early ripening is due to the high content of dry matter in the fruit, because the higher the fruit load of the cluster is, the faster the fruit reaches its final diameter and its ripening begins. Our results are consistent with those of Harshash & Al Obeed (2007) who reported that applying 50, 100, 150, and 200 ppm NAA on 'Barhe' and 'Shahl' date palm ten weeks after fruit set resulted in a decrease in the content of dry matter in the dates. Arba & Oumou (2024) also indicated that applying 100-ppm NAA on 'Majhoul' date palm 20-38 days after pollination leads to a decrease in the content of dry matter in the fruit, while applying 200 ppm NAA does not affect this content of dry matter in the fruit. This may be due to the studied date palm variety and to the application period of NAA treatments, which coincided with an advanced stage of fruit development.

3.2 FRUIT RIPENING MONITORING

Change in the fruit color may be a criterion for the beginning of the ripening stage of dates. It was observed from July 23, 2017, on the clusters of the early flowering phase without NAA treatment. Fruit ripening monitoring for the period July 23-August 16, 2017 showed that flowering phases and thinning treatments affect significantly ($p \leq 0.001$) the ripening of 'Majhoul' date palm. While there is no interaction between the two factors. The evolution of the ripening rate according to thinning treatments and flowering phases is presented in Figure 3. It shows that the ripening of NAA treatments (T1 and T2) is six days later (July 23-29) compared to the control T0 and manual thinning treatment T3. At the beginning of the ripening stage, all thinning treatments have a ripening rate that is more or less negligible, and one week after there is a slight increase in the ripening rate of the control (6 %) and manual thinning treatment (4 %), while NAA treatments (T1 and T2) are still at a negligible level (Figure 3a). On August 4, 2017, twelve days after the

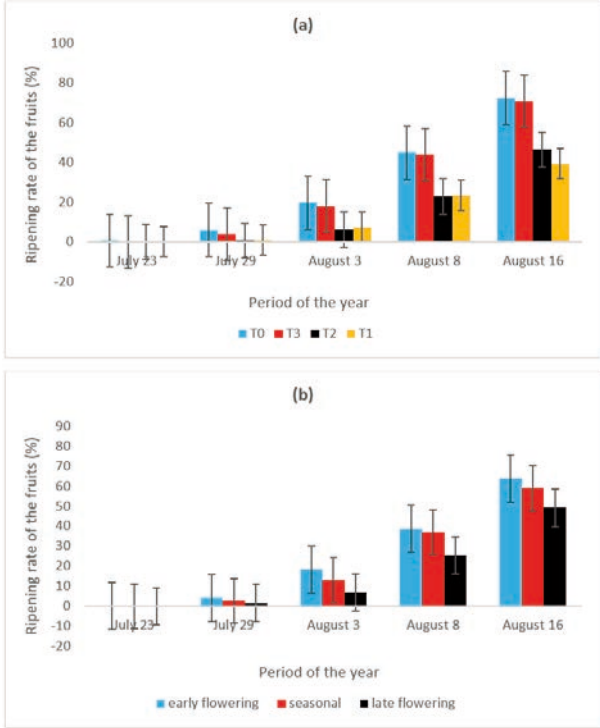

Figure 3: Evolution of the ripening rate of 'Majhoul' date palm according to thinning treatments T0, T1, T2 and T3 (a), and flowering phases (early, seasonal and late flowering) (b) in the Tinejdad region, Tafilalet area.

T0: Control treated with liquefied water
T1: 150 ppm NAA 30 days after pollination and 300 ppm 60 days after pollination
T2: 250 ppm NAA 30 days after pollination and 500 ppm 60 days after pollination
T3: Manual thinning used by the farmer: retaining 8-10 fruits per spikelet and removing the rest

beginning of the change in the fruit color, the ripening rate increased to 20 % for T0, 18 % for T3, 6 % for T1 and 4 % for T2. Following a heat wave at the site of study from the end of July, an increase in temperatures ranging from 30 to 37 °C for the mean temperature and 39 to 44 °C for the maximum is observed increasing the ripening rate of all thinning treatments (Figure 3a). Babahani & Eddoud (2012) also reported that these levels of temperatures might trigger the ripening of dates. At the end of the period of observations on the ripening of dates (August 16, 2017), thinning treatments affect significantly ($p \leq 0.001$) the ripening rate. It is almost similar for T0 and T3 (72 and 71 % respectively), while it is only 46 and 40 % respectively for T1 and T2 NAA treatments.

Regarding the flowering phases, it is obvious that the change in fruit color and the ripening began in the clusters of the early flowering phase, followed by the clusters of the seasonal flowering and the clusters of the late phase are the latest. From the end of July 2017, the ripening rate of the early flowering phase is the highest compared to the other flowering phases, it is followed by that of the seasonal phase and the ripening rate of the late flowering is the latest (Figure 3b). On August 16, 2017 (the end of the period of observations), the ripening rate was 64 % for the early flowering phase, 59 % for the seasonal flowering, and 49 % for the late phase.

4 CONCLUSION

Our study has shown that chemical thinning with NAA affected the organoleptic parameters of the date by improving some biochemical parameters of the dates. Obtained level of pH in the fruits of chemical and all thinning treatments was a good biochemical criterion for the preservation of 'Majhoul' dates. Fruit yield was lower in the chemical thinning treatments than in the control treated with liquefied water and the manual thinning treatment, but chemical thinning has improved some biochemical parameters of the dates. The ripening period was delayed by the chemical thinning what involves a grouped harvesting of dates in a short period and a significant saving in the cost of labor for harvesting dates.

Following these results, we suggest repeating the experiments by using the same concentrations of NAA after a short period of pollination (approximately one month after pollination) because the results we obtained on the chemical thinning of 'Majhoul' date palm using NAA have shown that the application of this product approximately one month after pollination gave the best results (Arba et al., 2023a and b; Arba & Oumou, 2024). We also recommend the use of other products such as Ethephon, Cytophex and gibberellins, with the aim of studying the effect of these products on the chemical thinning of 'Majhoul' date palm and to compare their effect with that of NAA.

Acknowledgements: We want to thank so much the farmer Mr Zahni ho has made his date palm farm to our disposal for the trials. Many thanks also to the Agricultural Research Center (CRA) of Errachidia and Hassan II Institute of Agronomy and Veterinary Medicine in Agadir for their support

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