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RESEARCH ARTICLE
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The Growth and Yield Response of Selected Apricot Cultivars Grown in Mafraq Governate for Two Growing Seasons to Chilling Hours in Northern Jordan

Ezz Al-Dein M. Al-Ramamneh [1,*], Issam M. Qrunfleh [1] and Monther T. Sadder [2]

[1]Department of Plant Production and Protection, Faculty of Agricultural Technology, Al-Balqa Applied University, Al-Salt 19117, Jordan
[2]Department of Horticulture and Crop Science, Faculty of Agriculture, the University of Jordan, Amman, Jordan
*Corresponding author: ezznew@bau.edu.jo

ABSTRACT

Serious climate changes and new patterns of chilling durations are warned about by the rising temperatures recorded in the Mediterranean basin including Jordan. Therefore, this study sought to determine the appropriate crop-site relationship by examining the timing of bud beak, flowering and vegetative growth, and fruiting in three apricot cultivars for two growing seasons in an orchard situated in the Mafraq governorate. In the first growing season (2022/2023), the cumulative chilling hours (<7°C) were 880 hours; while in the second growing season (2023/2024), which coincided with higher winter temperatures, it fell down to 741 hours. Results of the forcing solution conducted in the first season showed that regardless of the location of the flower bud on the shoot, 50% blooming could be induced at room temperature after at least 500 hours of cold exposure at 4°C. These results aligned well with those of the experimental field and showed that 'Nestor' cultivar was the earliest, whereas 'Mogador' was the last cultivar to bloom. Parallel with the warming observed in the second season, a delay was observed in bud beak and subsequent phenological stages accompanied by canopy adjustment of apricot cultivars. The findings showed that 'Nestor' retained more fruits at harvest than 'Mogador' in terms of the number and weight of fruits per branch after fruit set. This study concluded that Jordan is a hotspot for climate change and cultivars as 'Nestor' could be suitable for current crop-site relationship.

Keywords: Bud break, Climate change, Phenological stages, *Prunus armeniaca* L., Global warming.

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INTRODUCTION

Climate change is predicted to affect crop canopy microclimatic conditions and therefore it is viewed as a serious hazard. It has affected the rates of heat accumulation and chilling in temperate fruit trees, which are both essential for production and flowering (Drogoudi et al., 2023). In order to guarantee consistent flowering and fruit set and to produce a commercially viable yield, economically significant fruit and nut tree species originated in temperate and cool subtropical climates have chilling requirements that must be satisfied each winter (Westwood, 1993; Luedeling et al., 2009; Luedeling & Brown, 2011). Regular blooming in apples, pears, apricots, and plums requires this time of comparatively low temperatures (Ruiz et al., 2007; de Carvalho et al., 2010; Hussain et al., 2015; Cardoso et al., 2015; Fadón et al., 2023; Boutiti et al., 2025). Although dormancy release is caused by meeting a particular cultivar's cold requirement during endo-dormancy and subsequent heat exposure permits flowering, early blooming is driven by the overlap between simultaneous heat and chill buildup (Delgado et al., 2025). However, future warming would lead to less winter chilling and greater growth season temperatures (Atkinson et al., 2013; Lee & Sumner, 2016). This will have a significant influence on the plant species already in use. Fruit yield is probably going to suffer the most from less winter chills (Luedeling et al., 2011; Darbyshire et al., 2013). Different models have been developed for the calculation of climatic conditions which enabled the quantitative creation of appropriate climate change adaptation plans for temperate fruit trees (Salama et al., 2021). The adverse

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impacts of warm temperature waves during winter on chilling accumulation were overlooked in Weinberger's (1950) computation of accumulated hourly temperatures between 0 and 7.2 °C necessary for bud break (Salama et al., 2021). Following, the 'Utah' model was developed addressing partially the drawbacks of the earlier design and used weighted stepwise chilling units, where effective chilling buildup was considered to occur between 2.5 to 12.4°C (Salama et al., 2021). Mapping accumulated chilling hours during winter months for the Mediterranean basin agroecosystems based on datasets from weather stations and NASA POWER data resources for different durations and up to 46 years revealed a drastic chill loss and higher probability of heat waves occurrence during dormant seasons of fruit orchards (Fernandez et al., 2023; González-Martínez et al., 2025). The Mediterranean, which is a hotspot for climate change and origin of the most significant fruit orchards in the world, may be particularly vulnerable to the negative effects of climate change on commercially important crops (Giorgi, 2006; Fraga et al., 2020).

It is evident that fruit production in Mediterranean orchards, particularly in the Middle East and southern European countries, may be highly susceptible to changing climatic circumstances (Luedeling et al., 2011; Atkinson et al., 2013; Osorio-Marín et al., 2024). The steady crop-site association created by producers carefully choosing plant varieties that fit the pedoclimatic parameters of the site for their growth is in danger due to climate change. With the recent drastic changes in the earth's climate, this relationship lost all significance. As a matter of fact, there has been a change to the scheduled interval between rests chilling and forcing that is necessary for fruit establishment and blooming, particularly in Mediterranean deciduous fruits. Strengthening climate change resilience can help in ensuring fruit tree productivity and sustainability under climate change (Karagatiya et al., 2023). These resilience-boosting tactics include choosing and breeding climate-resilient cultivars, implementing effective irrigation systems, adopting better horticultural practices, and using precision farming methods. However, according to Fernandez et al. (2023), climate change adaptation strategies are considered challenges to farmers. Farmers hesitate to change cultivars, however with their knowledge and experience they have adopted strategies to adapt to climate change such as delaying pruning. In fact, to compensate for chill reduction, options include the use of dormancy-breaking chemicals, forceful defoliation, low-chill cultivar planting, and other methods as backup plans (Melke, 2015). For this, exogenous application of chemicals, such as copper sulfate (10%), zinc sulphate (5%), and urea (10%), or the use of more environmentally safe organic compounds such cinnamon, coffee, ginger, clove, colocynth, olive, garlic, red chilies, nigella, and turmeric extracts could make up for a fruit tree's lack of chilling hours in a mild-winter region (Salama et al., 2021).

Apricots are significant fruit trees in Jordan because of their beautiful appearance and great consumer demand. This is due to their usage in nutrition and pharmaceutical properties (Al-Soufi et al., 2022). Although local and introduced cultivars are grown in various parts of Jordan, there has been a noticeable interest in introduced cultivars. Local varieties, such as Mistikawi, Hamawi, and Al-kalabi, are still well-known in tiny home gardens and farms. Jordan exported 547 tons of apricots, according to a study by Mourad et al. (2010), therefore expanding the production of cultivars that are suitable for the region could seem fair. Between 2011 and 2015, Jordan's fresh apricot exports increased rapidly, with a production area of 9.158 dunum (Leeters & Rikken, 2016). Growers in several parts of Jordan have confirmed the phenomena of reduced chilling hours required to meet the blooming requirements of pome and stone fruits. Growers started cultivating and introducing low- to medium-chill types in orchards in an effort to align blooming and bud break with the newly documented patterns in chilling durations as a result of their awareness of the changing climate. However, the process of replacing older cultivars with new ones is still in its early stages and has not yet been assessed in terms of the trees' anticipated performance.

In this regard, climate change is no longer a forecast for the future but rather a reality that needs to be addressed immediately. Therefore, this research was conducted in a farm in Mafraq governate, a well-known region for producing stone fruits, including apricots. It aims to investigate the effect of the change in the accumulated chilling hours of the study farm over two years period, 2022/2023 and 2023/2024, on flowering, growth behavior and fruit yield of the selected apricot cultivars. This will help to determine the proper apricot cultivar-site relationship for farmers to adopt in the studied area.

MATERIALS & METHODS

Experimental Site

The study was carried out on five-year-old apricot cultivars ('Mogador', 'Mikado', and 'Nestor') that are grown at a private apricot orchard near the border of Zarqa/Mafraq governate, Northern Jordan (latitude 32.16, longitude 36.19, altitude 549 m asl) (Fig. 1). The soil of the experimental orchard is clay loam with a pH of 7.8 and EC of 2.7 dS m^{-1}. Trees were treated with standard agricultural procedures in terms of fertilizers, irrigation, and other requirements. Drip irrigation was used, and the schedule was modified based on the plants' requirements. In this case, trees received daily watering in the summer, every other day in the spring, and irrigation was reduced to once every 15 days in winter. Trees were pruned lightly during the summer of 2022 and the winter of 2023.

Determination of Chilling Requirements in a Growth Chamber

For each cultivar, ten shoots with the same length and number of buds were taken in fall and winter of the 2022-2023 season. The leaves were thinned out. The shoots were bundled, wrapped in paper, submerged in water and sterilized with a fungicide. The shoots were then sealed in plastic bags and stored in the refrigerator at 4°C for 300 and 500 hours. A stock of the forcing solution developed by Read et al. (1984) containing 200mg 8-hydroxyquinoline citrate (8-HQC)/l and 2% sucrose was prepared and poured in autoclaved containers.

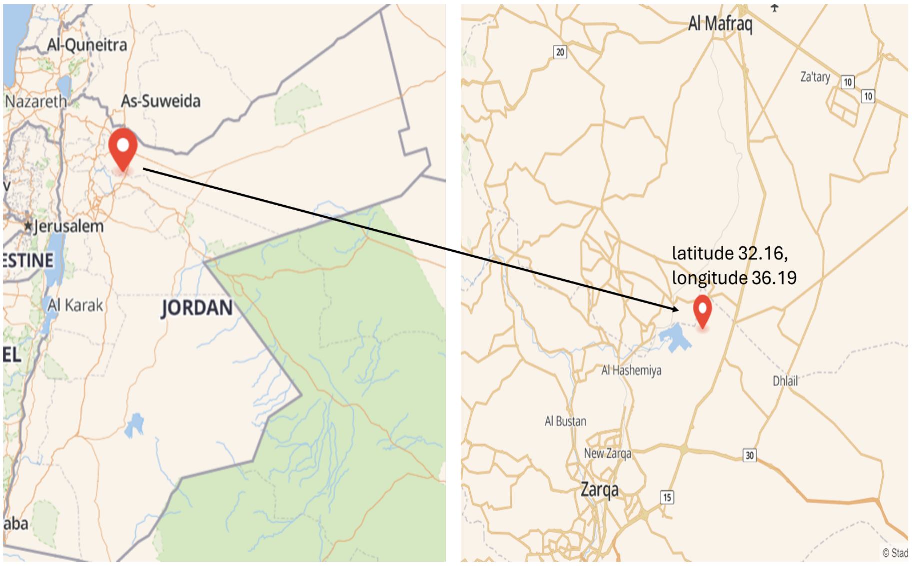

Fig. 1: Study site of apricot orcahrds near the border of Zarqa/Mafraq governate, Northern Jordan (latitude 32.16, longitude 36.19, altitude 549 m asl).

To eliminate bud position effect, each shoot was divided into two parts (upper and lower) each containing five buds. At the end of the assigned hours, the shoots were placed vertically (proximal ends down) in the containers containing 100ml of forcing solution. The solutions were replaced with 100ml of freshly prepared forcing solution every four days, and the basal 0.2cm ends of the cuttings were cut off each time the solutions were changed. The containers were placed in a growth chamber where the temperature was approximately 25°C under a (16h light: 8h dark) photoperiod and 70% relative humidity. Number of days for bud break was recorded when three of the five buds reached petal opening.

Accumulated Chilling Hours

Calculations were made for the total number of chilling hours (<7°C) (Weinberger, 1950), in December, January, February, and March of 2022/2023 and 2023/2024 seasons. This range includes the time from the beginning of the period of continuous cooling that caused adverse effects until the release of dormancy, which is indicated by the onset of bud break (Gao et al., 2012).

Monitoring of Phenological Stages and Growth Parameters

The studied cultivars are considered to have low- to medium-chill requirements. Myrobalan 29C rootstock was used to graft apricot trees, which were planted three meters apart in rows that were five meters spaced (3m x 5m). Ten trees were chosen for each cultivar at the beginning of study, and three uniform branches on each tree were tagged. The branches were trimmed to the same number of buds (30). The characterization of the different stages of flower and fruit development is based on that reported by Pérez Pastor et al. (2004), and phenological stages of apricot cultivars were observed twice a week starting at the end of January for the two studying seasons. In late April, the number of new shoots per tagged branch, shoot length, and number of leaves per shoot and branch were measured. Early in August, leaf samples were taken in order to determine the mineral contents of N, P, and K as well as chlorophyll. Mineral analysis was done in soil teaching laboratory, Faculty of Agriculture, Jordan University of Science and Technology on leaf dry weight bases employing Kjeldahl method-Automatic system for N, dry digestion procedure-Spectro photometry using ammonium-vanadomolybdate reagent for P, dry digestion procedure-Flame photometry for K, and proper calibration curves were plotted for quality assurance. Chlorophyll was measured by CL-01 chlorophyll metre (Hansatech, Norfolk, England) and expressed by SPAD units.

Fruit Yield Parameters

The following parameters were measured for each apricot variety during fruit harvesting in May each year: number of fruits per branch, fruit weight, fruit firmness, and total soluble solids of the fruit pulp. Total soluble solids were expressed in °Brix and measured using refractometer (Erma, Swastik Company, Tokyo, Japan). Fruit firmness was measured in percent (%) using digital firmness tester (Agro-technologie, France).

Statistical Analysis

Tagged trees of the studied cultivars were arranged in a randomized complete block design (RCBD); and were replicated five times with two trees of each cultivar were assigned for each block (five blocks, six plants/ block, total 30 plants). Indeed, the use of sufficient experimental designs, such as RCBD, can be employed to statistically make up for possible site homogeneity constraint (Neuhoff et al., 2024). In such cases, cultivars represent the fixed effects, where inferences are intended for the performance of the particular cultivars. Environmental factors over the two growing seasons represent random effects, because the two years represent a sample of the climatic conditions that might occur, and the desire is to generalize the findings beyond just those two specific years to future growing seasons. Readings for each parameter were averaged for the three tagged branches on each tree. The data for each season was subjected to general linear model to perform two-way analyses of variance (ANOVA) and analyzed by SAS software version 9.0. Separation of means was done by Tukey-Kramer range test at 1% and 5% level.

RESULTS

Chilling Hours

Fig. (2) shows a low accumulation of chilling hours for the previous season to the start of the study (2021/2022) reaching 595h, while it was the best for the first season of the study (2022/2023) reaching 880 h (year-to year percentage change in chilling hours: +47.8%). However, the trend did not continue but rather sloped down in the second season to reach 741 h (2023/2024) (year-to year percentage change in chilling hours: -15.8%).

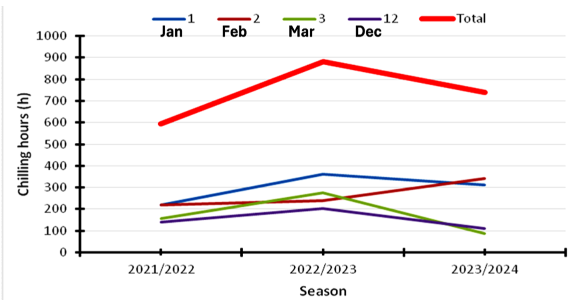

Fig. 2: Chilling hours for experimental orchard for months December, January, February, and March for three seasons 2021/2022, 2022/2023 and 2023/2024.

Phenological Stages of Reproductive Organs

The phenological flower bud stages are shown in Table (1). The studied cultivars showed different earliness behavior in the field for their bud break and subsequent flowering and fruit set (Table 1). Bud break was in general delayed by up to one week in the second season compared to that in the first season. The bud break in 'Nestor' cultivar commenced 23 February 2023, and 1 March 2024, and was earlier than that in 'Mikado' cultivar (25 February 2023; 2 March 2024) and in 'Mogador' cultivar (1 March 2023; 5 March 2024). The difference between the early-bud break and late-bud break cultivar was up to seven days in the first season and four days in the second season. The lag time between the two seasons for each phenological stage was the highest in Stage F for 'Mogador' cultivar, reaching up to 13 days, but it was in stage D for 'Mikado' and 'Nestor' cultivars, reaching up to 11- and 12-days lag time respectively. However, minimal differences were observed for the last two stages; Stage g and harvest time; of no more than three days lag time.

Determination of Chilling Requirements in Growth Chamber

All three cultivars that received 300 hours failed to show bud break using the forcing solution technique. However, after receiving 500 hours chilling requirements, all three cultivars showed bud break using the forcing solution technique. The results are represented in Table (2). The forcing solution technique did not force out bud break for the three cultivars after receiving 300 hours. This clearly indicates the climate change effect since they were taken in late fall and early winter of 2022-2023 season, which was preceded by low acculation of chilling temperature in 2021-2022 season. The selected cultivars in the study are considered low to medium chill requirement apricot cultivars. However, the results show that there are significant differences in respect to which to consider an early, medium or late cultivar. 'Nestor' could be considered an early cultivar, 'Mikado' a medium cultivar, and 'Mogador' a late cultivar. There were no differences in respect to bud position on bud break and blooming. The results of the forcing solution are in alignment with the results of the field work of the study.

Table 1: Flowering period and penological stages of the studied cultivars in the experimental field for the seasons 2022/2023 and 2023/2024

Cultivar/Season	Stage					
	[1]Bud break	[2]Stage D	[3]Stage E	[4]Stage F	[5]Stage g	[6]Stage 89
Mogador						
2022/2023	1 March	3 March	5 March	6 March	18 March	12 May
2023/2024	5 March	12 March	16 March	19 March	21 March	15 May
Mikado						
2022/2023	25 February	28 February	3 March	6 March	16 March	9 May
2023/2024	2 March	10 March	13 March	15 March	19 March	11 May
Nestor						
2022/2023	23 February	23 February	2 March	5 March	16 March	2 May
2023/2024	1 March	6 March	9 March	12 March	16 March	5 May

[1]30% flowers are in Baggiolini's stage B–C; [2]Flower petals perceptible; [3]Flower open/pistil anther perceptible; [4]Full flowering; when not less than 80-90% of branches bear flowers that are fully open; [5]End of flowering; coincides with petal falling and beginning of ovary growth; [6]Harvest date.

Table 2: Mean number of day's ± SE to reach 50% blooming for the upper and lower shoots of the three cultivars after receiving 500 hours chilling requirements in the study using forcing solution

Cultivar	Upper	Lower
Mogador	60.25±2.2a	59.10±1.3a
Mikado	51.05±2.5b	49.40±1.9b
Nestor	41.85±1.5c	43.80±2.3c
	**	**

Values that are followed by different letters within a column are significantly different at *$P\leq0.05$, **$P\leq0.01$.

Shoot Growth and Leaves Differentiation

The three cultivars showed a changed growth strategy for number of shoots per branch and shoot length in the second season compared to the first (Table 3). Whereas the number of shoots per branch ranged from 14 for 'Mogador' to 24 for 'Mikado' in 2022/2023, the number dropped to a range of, 1.4 for 'Nestor' to 2.9 for 'Mikado' in 2023/2024. The leaf count increased by 52% for the 'Mogador' cultivar during the second growing season but decreased by 19% and 34% for the 'Mikado' and 'Nestor' cultivars, respectively, in comparison to the first season. Although 'Mogador', 'Mikado' formed more shoots and leaves per branch than 'Nestor' cultivar, 'Nestor' exhibited the longest shoots of the three cultivars in the second season. Regarding the leaf chlorophyll content of the three cultivars, the earliest-bud break cultivar 'Nestor' showed significantly higher chlorophyll content compared to the two other cultivars in 2022/2023, though leaf chlorophyll was not significantly different than 'Mikado' cultivar in 2023/2024 (Fig. 3). The mineral status of the leaves taken from the trees of the three cultivars in late July and early August during the summer displayed a similar pattern for the two seasons (Fig. 3). 'Mogador' had the lowest K and the highest P, whereas 'Mikado' and 'Nestor' had the

Table 3: Shoot and leaf characteristics of the studied cultivars for the seasons 2022/2023 and 2023/2024

Cultivar/Season	No. shoots branch^{-1}		Shoot length (cm)		No. leaves shoot^{-1}		No. leaves branch^{-1}	
	2022/2023 20 April	2023/2024 1 May	2022/2023 20 April	2023/2024 1 May	2022/2023 20 April	2023/2024 1 May	2022/2023 20 April	2023/2024 1 May
Mogador	14.26c	2.13ab	0.94b	33.60b	4.42b	51.26	64.47c	97.93ab
Mikado	24.10a	2.90a	1.54a	34.43b	5.30a	51.55	129.04a	104.12a
Nestor	19.37b	1.37b	1.40a	46.16a	4.79ab	53.70	93.22b	61.78b
	**	**	**	**	**	ns	**	*

Values that are followed by the same letter within a column are not significantly different at *P*=0.05 (ns); Values that are followed by different letters within a column are significantly different at *$P\leq0.05$, **$P\leq0.01$; Ten trees were chosen for each cultivar at the beginning of study, and three uniform branches on each tree were tagged. The branches were trimmed to the same number of buds (30).

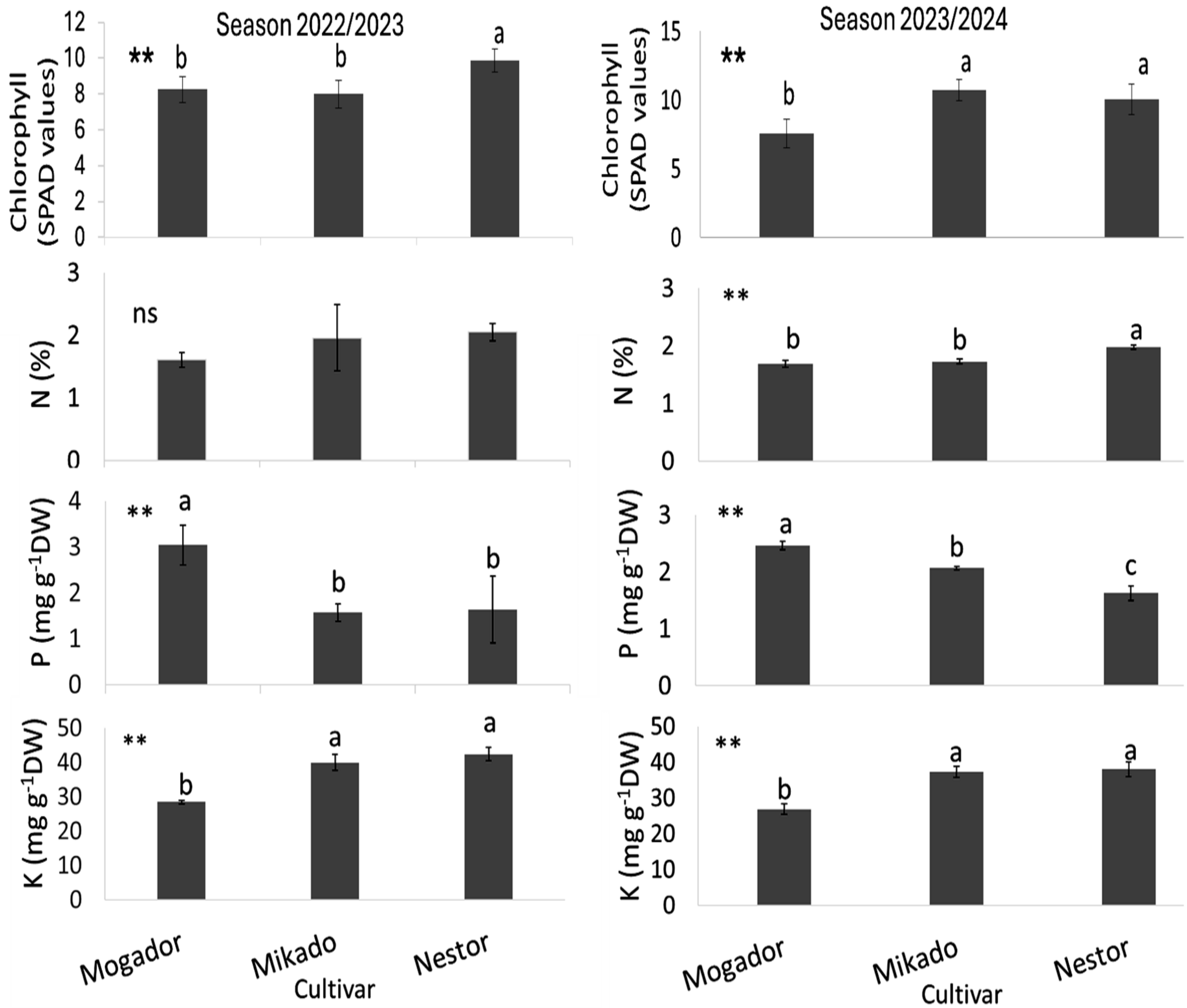

Fig. 3: Content of chlorophyll (SPAD values), and minerals N, P, and K in leaves of selected cultivars. Leaves were sampled on 10 August 2023 and 9 August 2024, respectively. Ten trees were chosen for each cultivar at the beginning of study, and three uniform branches on each tree were tagged. The branches were trimmed to the same number of buds (30). Values are means ± Standard deviations (SD), No. of replicates (N)=5.

lowest P and the greatest K content. There were no significant discernible variations in the nitrogen content of the leaves between cultivars in 2022/2023, but during the 2023/2024 growing season, the 'Nestor' cultivar showed the highest content compared to the 'Mogador' and 'Mikado' cultivars (Fig. 3).

Fruit Characteristics

Comparing the number of fruits per branch at harvest time between the two seasons showed a clear drop in the second season than in the first season, with the maximum decline being observed in 'Mogador' cultivar (Fig. 4). Tracking the number of fruits per branch in early fruit growth (end March-onset April) and during harvest (May) in the two growing seasons, showed that 'Nestor' cultivar retained stable more fruits per branch during harvest time than the two cultivars (percentage of fruit retained at harvest to that after fruit set for 'Mogador', 'Mikado', and 'Nestor' in that order were: 65%, 61%, 99% for season 2022/2023; 42%, 133%, 94% for season 2023/2024) (Fig. 4). 'Nestor' cultivar recorded 2.3 fruits per branch, though not significantly different than the other cultivars in 2022/2023, and 1.5 fruits per branch which was the highest among the three cultivars in 2023/2024 (Fig. 4). Although 'Mikado' showed the highest average fruit fresh weight over the two growing seasons (37.76, 41.95 g for 2022/2023, 2023/2024 seasons respectively), the calculated fresh weight of fruits per branch was in the following order for the two growing seasons; 'Nestor'>'Mikado'>'Mogador' (70.03, 56.64, 44.56g FW per branch in 2022/2023, and 47.68, 27.97, 19.14g FW per branch in 2023/2024 in that order, respectively) (Fig. 4). Although ripened fruits harvested in 2022/2023 showed variable significant total soluble solids, with 'Mogador' and 'Mikado' having higher contents (16.4, 16.1°Brix) than 'Nestor' (13.1°Brix), firmness and total soluble solids of fruit generally showed no significant differences among cultivars during the two growing seasons (Fig. 4).

DISCUSSION

Drastic changes in the accumulated chilling hours of the study site are clear in the last three years and indicated that study orchard was affected by warming as shown by chilling hours of the seasons 2021-2022 (the year preceding the current study), 2022/2023 and 2023/2024 (the two seasons-study period) (Fig. 2). A study examining climatic factors from various meteorological stations

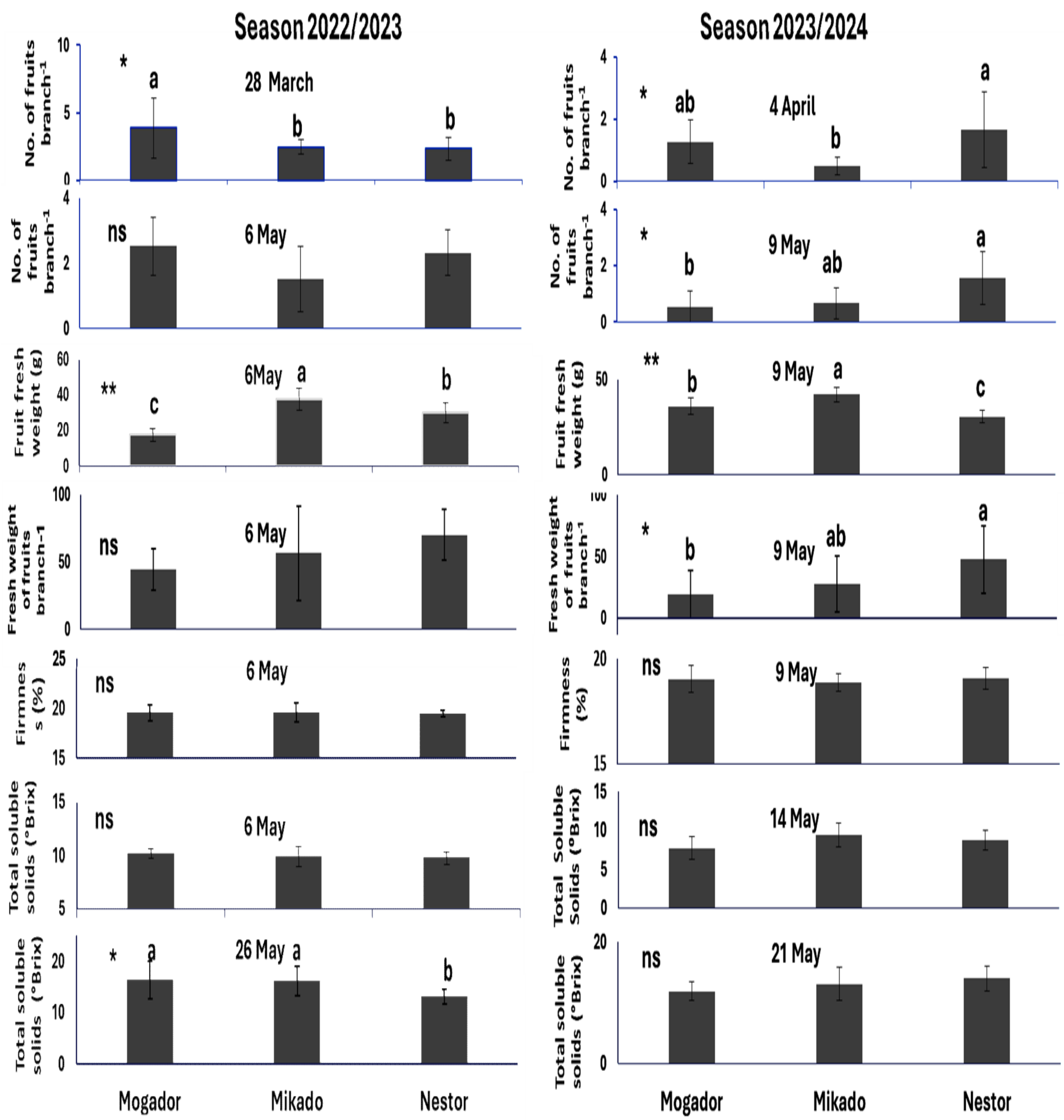

Fig. 4: Fruit characteristics of the selected cultivars at harvest time. However, the number of fruits was monitored twice (28 march, 6 May in 2022/2023 season, and 4 April, 9 May in 2023/2024 season, respectively). Total soluble solids were also determined twice during harvest time (6 May, 26 May in 2022/2023 season, and 14 May, 21 May in 2023/2024 season). Values are means ± Standard deviations (SD), No. of replicates (N)=5.

around Jordan for approximately 50 years interval (1961-2012) made it abundantly evident that yearly precipitation is declining while minimum, mean, and maximum temperatures are rising (Al-Qinna, 2018). The temperature increase in the second season caused a delay in bud break and a subsequent shift in the timing of later phenological stages for the apricot cultivars in this study. These findings were generally consistent with those observed for apricots in other countries (Krška & Bauer, 2019, Abd El-Naby et al., 2023). The observations on bud break incidence in stone fruits in several Jordanian locales in 2023/2024, where a delay in the flowering time was observed, further supported this phenomena. Warming during autumn and winter, particularly in November and December months, can cause the consumption of carbohydrates in the developing bud organs due to increased respiration and transpiration and may have contributed to the observed delay in bud break and the year-to year irregularities in apricot productivity (Korsakova et al., 2023; Abd El-Naby et al., 2023). The early-bud break in 'Nestor' cultivar, but the late response for 'Mogador' indicated probably that chilling requirement was satisfied earlier for 'Nestor' cultivar (Table 1 & 2). The accumulation of chilling hours to a satisfactory level was shown to influence flowering time in apricot cultivars and may count for yearly variation in flower drop and retained fruits within cultivars (Ruiz & Egea, 2008). This agrees with the present study where 'Nestor' apparently retained more fruits at harvest than 'Mogador' in reference to the number of fruits per branch after fruit set (Fig. 4).

The study's findings indicated that the three apricot cultivars' overall carbon balance was likely altered, as evidenced by the distinct dynamics of leaf and shoot differentiation in the second growing season compared to the first (Table 3). It appears that the three cultivars used fewer resources during the second growing season than during the first. Compared to the 2022/2023 season, cultivars showed a significant decrease in the number of shoots (albeit longer ones) per branch in 2023/2024 (Table 3). The number of shoots per branch formed in 'Mogador', 'Mikado', and 'Nestor' cultivars in the second season were equivalent to 15, 12 and 7% of that of that formed on forementioned cultivars during the first season, respectively. It is apparent that cultivars compensated shoot count drop in the second season by exhibiting longer shoots, an effect that was clearer in 'Nestor' cultivar that exhibited the longest shoots in 2023/2024, though it was the least in number of leaves and shoots than other cultivars in the second season (Table 3). Fruit trees showed different canopy adjustments in the context of a stress avoidance mechanism, for which its details are stress specific (Pallas et al., 2020; Girona et al., 2025). It is reported that the heat stress triggers protective measures inside fruits trees which may have adversely affected metabolism and thus can affect shoot growth, leaf photosynthetic efficacy and the resulting fruit quality (Costes et al., 2016; Lee et al., 2023; Li et al., 2023). The lag time for phases of flowering in the present study was higher than the period extending between end of flowering and harvest (Table 1). The shorter after bloom-to-harvest period has a detrimental effect on the prospective fruit weight of stone fruits as in the second season of the present study because it can reduce carbon acquisition, which isn't compensated by improved carbon influx (Costes et al., 2016). The complex interaction among environmental factors surrounding plants, alongside inhereted traits of plant genotypes significantly influence the yearly anticipated yield of apricot cultivars. The dramatic decline in number of fruits per branch at harvest time in the second growing season of the present study draws attention to the possible role of alternate bearing in apricots. Usually, under favorable conditions apricots set abundant flowers (Roussos et al., 2011). However, in certain cases such as high fruit production, this can cause fruit to leaf imbalance ratio and consequently produce smaller, less desirable fruits, alternate bearing, limb breakage, pre-mature fruit drop, delayed fruit maturation and reduced fruit quality, and exhaustion of reserves in many fruit trees (Wünsche & Ferguson, 2005).

Conclusion

The results indicated clearly that warming in the second season has resulted in less accumulated chilling hours in the microclimate of the studied cultivars, which may contribute to the observed delay in the bud break and subsequent ontogeny of apricot flowers. The findings for the two seasons showed that 'Mogador' is the last cultivar to bloom, while 'Nestor' was the first to bloom, followed by 'Mikado'. cultivar. The change in shoot and leaf differentiation and the fruit biomass characteristic indicated a change in metabolism of the three cultivars in response to heat stress evident by less accumulated chilling hours in the second season. Overall, as an early-blooming choice in Mafraq circumstances, 'Nestor' requires ongoing observation and site-cultivar matching under warming.

DECLARATIONS

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Conflict of Interest: The authors declare that there is no conflict of interest regarding this manuscript.

Data Availability: All the data is available in the article.

Ethics Statement: No live animals/humans were involved in the study; thus, no ethics statement is required.

Author's Contribution: E.M.A. supervised the project, developed the concept of the experiment, make shoot and fruit measurements, wrote the original draft of the manuscript, perform statistical analyses and draw figures, I.M.Q. Performed and wrote the forcing solution

experiment, analyzed total soluble solids, and worked on a critical review of the manuscript. M.T.S. provided a chilling plot for the experimental orchard, supplied an instrument for fruit firmness measurement, and critically reviewed the manuscript. The authors participated in the orchard visits for the experimental orchard and collection of samples.

Generative AI Statement: The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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