Kirkuk University Journal for Agricultural Sciences
ISSN:2958-6585
https://kujas.uokirkuk.edu.iq

RESEARCH ARTICLE

https://doi.org. 10.58928/ku24.15421

Effect of planting dates, chilling periods and N/P foliar spray on flowering traits of strawberry (*Fragaria* × *ananassa* Duch) cv. Robygem in a hydroponic system.

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Received: 20/06/2024 **Revised: 20/07/2024** **Accepted: 27/07/2024** **Published: 01/12/2024**

ABSTRACT

This study was conducted in an unheated greenhouse during the 2022 and 2023 growing seasons at the Malta Forest Nursery of the General Directorate of Forests and Rangeland / Duhok city, Duhok governorate, Kurdistan region- Iraq, at an elevation of "526" meters above sea level. The research aimed to investigate the effects of planting dates (15th September, 1st October and 15th October), chilling periods (0, 10 and 20 days) and foliar applications of nitrogen and phosphorus (0 and 100/100), as well as their bilateral and triple interactions on the flowering traits of the strawberry plant cv. Rubygem in hydroponic system. The lowest number of days to flowering obtained on 15th Oct. for two growing seasons 57.708 and 60.792 days respectively. Whereas longest period to flowering was obtained on 15th Sep. in both seasons 72.333 and 73.542 days respectively. Planting date 1st October resulted in a significant increase in number of flowers per plant which reached 18.042 and 16.167, The setting % of flowers, length of flowering period for two growing season 73 and 70.625 days. Chilling periods of 20 days significantly increase the number of flowers per plants, length of flowering period and vitality of pollen. In both growing seasons spraying plants with N/P 100/100 ratio increases the number of flowers per plants 18.222-16.083, setting % of flowers, length of flowering period for both years 73.472 and 71.028 days and vitality of pollen. Both bilateral and triple interactions between the three factors significantly effect on most traits in both growing seasons.

***Keywords*:** chilling ,foliar application, hydroponic , robygem strawberry..

INTRODUCTION

Strawberry (*Fragaria* × *ananasa*) was highly valued by the early Romans as the best fruit in the world. The history of strawberries can be traced back to the temperate regions of the northern hemisphere, especially the Mediterranean. Today strawberries are cultivated in temperate regions worldwide, from North America to Europe. The garden strawberry, or Fragaria ×ananasa, is a hybrid, formed by crossing two wild species: Fragaria "virginiana from North America and Fragaria "chiloensis from Chile [1].

However, strawberry populations thrive best in hilly areas at elevations between 750 and 1500 meters above sea level. While sub-tropical climates are ideal for growing strawberries, they can also flourish in temperate conditions. Strawberries need a warm climate with low humidity, and the optimal temperatures for their successful production is 22–25 °C during the day and 7–13 °C at night. Wild strawberries can grow in a wide variety of habitat from open woodlands and meadows to dunes and beaches [2]. The strawberry's fleshy fruit is categorized as an aggregate fruit [3]. Strawberries are distinctive for their highly desirable taste and flavor, and they are an excellent source of vitamins, potassium, fiber, and sugars [4]. The strawberry is an herbaceous perennial plant with a fibrous root system and a crown that produces shoots, flowers, and fruit. It belongs to the genus Fragaria within the family Rosaceae [5]. According to FAO reports, worldwide strawberry production exceeded 9.18 million tonnes in 2021. Asia was the largest continental producer, with 4.53 million tonnes, followed by America with 2.18 million tonnes, Europe with 1.76 million tonnes, Africa with 634.29 thousand tonnes, and Oceania with 60.31 thousand tonnes [15]. Different varieties of cultivated plants are significantly influenced by weather patterns and the time of planting. The time of planting directly impacts day and night temperatures, the intensity of daylight, and the duration of daylight (photoperiod). These factors affect important aspects of plant development, such as when flowers bloom, the size and quality of fruits, and overall crop yield [10].

Thus, the planting time of strawberries is important for partitioning the assimilates, which directly influences the growth and yield of strawberry [9].

Chilling requirement is a critical factor that determines the successful growth and yield of strawberries. In temperate regions, strawberry plants undergo dormancy in response to short daylight periods (photoperiods) and low temperatures during autumn and winter. During this period, the plants accumulate sufficient chilling hours and store carbohydrates in their roots and crowns. This dormancy phase is essential for subsequent growth and flowering, ensuring optimal fruit production when conditions become favorable. [7, 6].

Urea, which provides nitrogen (N) to plants, can be applied in liquid form directly onto foliage. This method, as highlighted by [14]. Enhances nitrogen management, offering an effective way to supply plant nutrients [16]. Foliar nutrition of fruit crops. Hort. Reviews 6, 287–356. Phosphorus is crucial in various growth processes, including root development, increased stem length; stalk development, improved flower production, and seed development. Plants treated with a high dose of potassium have shown significant improvements in yield [8].

The objective of this study is to evaluate the impact of fertilization treatments on strawberry flower parameters and Investigate the response of strawberry flowering parameter to different periods of cold, moreover evaluate the effect of combination among the two factors on flowering parameters.

Material and methods

The experiment comprised three main factors. The first factor involved different planting dates: September 15th, October 1st, and October 15th. The second factor subjected the transplants to varying periods of chilling (4 $\pm$1), including 0, 10, and 20 days before planting. The third factor included spraying plants with N and P (100:100 mg L^{-1}) in urea and P_2O_5 forms at three stages: at the beginning of growth, flowering, and fruiting. A full-strength copper nutrition solution was used throughout the experiment. The culture medium consisted of washed and sterilized building sand, which underwent continuous sterilization at intervals, with stones placed beneath pots before adding sand. Pots of 20 cm in diameter were used, equipped with a drip irrigation system comprising two drippers per pot. Plants were spaced at 25*25 cm intervals. Transplants of the Robygem cultivar, sourced from a private nursery as runner plants, were uniform in growth, crown diameter, and vigor. Before planting, these plants were dipped in fungicide for 10 minutes, with remaining leaves kept intact and runners removed weekly. PH and EC levels of the solution and drained water were monitored and adjusted weekly using KOH and phosphoric acid (H3PO4), with the solution renewed every 15 days.

The experimental design followed a Split-Split Plot arrangement in a Randomized Complete Block Design (RCBD). There were 3 main plots (for planting dates), 2 subplots (for N and P spray), and 3 sub-subplots (for chilling periods), totaling 360 plants across 4 replications with 5 plants per experimental unit. Treatment means were compared using the Duncan Multiple Range Test at a significance level of 5%, and data analysis was conducted using the SAS program.

The experimental measurements were as follows:

1. Number of days from planting to first flower (days):
2. Length of flowering period (days):
3. Number of flowers per plant:
4. Setting percentage of flowers (%):
5. Vitality of pollen grains (%):
6. Germination percentage of pollen grains %:

Results and Discussion:

1. Number of days to flower:

Results in table (1) shows the effect of planting dates, chilling periods and N/P ratio on number of days to flower. It can be seen that the different planting date differences are rather considerable; the highest number of days to flowering obtained on 15th Sep. for two growing season compared with two other planting dates, 72.333 and 73.542 respectively. Lowest values were 57.708 and 60.792 obtained on 15th Oct. respectively in both growing seasons. The mean effect with chilling periods were gave higher number of days at 0 chilling days 68.13 and 71.5 respectively in both years compared to other chilling periods, minimum days were recorded at 20 days of chilling for two years. N/P treatment effects were significant in control treatment for both growing season.

Concerning the double interaction for the planting date and chilling. 15th Sep. and control treatment of chilling which was showed significant increase in number of days to flowering for both seasons 77.25 and76.25 respectively. Minimum days were 54.63 and 55.5 from interaction between 1st Oct. and 20 days chilling. The planting date * N/P ratio combination were significant on first and second growing season only on 15th September and control compared to other combinations which recorded highest values 73.75 and 75.75. Chilling*N/P ratio had significant effect on number of days to flowering at control treatment* 100/100 N/P spray (68.5 and 72.083) in 2022 and 2023.

Regarding the triple combination, the higher number of days to flowering obtained on 15th sep. with 0 chilling and 0 N/P ratios (79.75 and 78) respectively in both growing seasons. lowest days to flowering was obtained from trio interaction between 1st October, 20 days of chilling and 100/100 N/P ratio (53.75) days in first year. In second season minimum number of days was (55.5) and obtained twice from interaction between 1st Oct., 20 chilling days once with 100/100 ratio and second time without N/P spraying

Table (1): Effect of planting dates, chilling periods and N/P ratio on No. of days to flowering

Chilling of	N/P ratio		Time*Chilling		Means of Time
	2022	2023	2022	2023	

Planting dates	Transplants (4 ±1 ^{0}C)	0	100/100	0	100/100			2022	2023
15th sep.	0	79.75 a	74.75 b	78 a	74.5 bc	77.25 a	76.25 a	72.333a	73.542 a
	10	72.25 bc	71 bcd	77.25 ab	70.75 c-f	71.625 b	74 ab		
	20	69.25 cd	67 de	72 b-e	68.75 d-g	68.125 c	70.375 b		
1st Oct.	0	69.25 cd	70.25 cd	74.25 a-d	72.75 a-e	69.75 bc	73.5 ab	62.208 b	64.0417 b
	10	66 e	58.5 fg	67.75 efg	58.5 ij	62.25 d	63.13 cd		
	20	55.5 gh	53.75 h	55.5 j	55.5 j	54.63 f	55.5 f		
15th Oct.	0	56.5 fgh	58.25 fg	64 gh	65.5 fgh	57.37 e	64.75 c	57.708 c	60.792 c
	10	60 f	55.5 gh	61.25 hi	58 ij	57.75 e	59.63 de		
	20	60.25 f	55.75 gh	60.25 hij	55.75 ij	58 e	58 ef		
Time *N/P ratio	15th Sep	73.75 a	70.9167 b	75.75 a	71.333 b	Means of Chilling			
	1st Oct	63.583 c	60.83 d	65.83 c	62.25 d				
	15th Oct	58.917 d	56.5 e	61.833 d	59.75 d	2022	2023		
Chilling*N/P Ratio	0	68.5 a	67.75 ab	72.083 a	70.917 ab	68.13 a	71.5 a		
	10	66.083 b	61.6667 c	68.75 b	62.417 c	63.87 b	65.58 b		
	20	61.667 c	58.833d	62.5833 c	60 c	60.25 c	61.29 c		
Means of N/P ratio		65.417 a	62.75 b	67.806 a	64.44 b				

Means of each factor and their nteractions followed by different letters are significant by different from each other according to Duncan's multiple range test at 5%.

2. Number of flowers per plant:

The obtained results of table (2) revealed that planting on 1st Oct. resulted in a significant increase in number of flowers per plant which reached (18.042) and (16.167) respectively in both growing season compared to other planting dates. Chilling periods significantly increase the number of flowers essentiality at two periods (10 and 20) days of chilling compared to control in two growing years. The N/P of 100/100 for both growing season significantly increase the number of flowers per plants (18.222-16.083) compared to control.

The combination between planting time and chilling periods illustrate that there was a significant effect on the number of flowers per plant, where as the highest number (19.5) (18.375) obtained from combination between 1st October and 10 days chilling for both season respectively. The combination between time and N/P ratio, significant effects on 1st Oct. with 100/100 ratio recorded highest number of flowers (19.25) in first year of experiment, in second year the combination between 15th September and 100/100 ratio recorded the highest value (17.75) compared to other interactions. Means value obtained from interaction between NP ratio and chilling periods shows significant differences at 10 days of chilling and 100/100 N/P ration in two growing season which recorded the highest value (20 and 17.667) respectively (table 2).

The best number of flowers per plant from triple interaction was showed from the interaction between 1st Oct., 100/100 N/P ratio and 10 days of chilling (21.56 and 20) in both experiment seasons. Lowest number obtained on 15th Sep. with controls of both chilling and foliar spray processes (12.75 and 10.5) respectively in 2022 and 2023 (Table 2).

Table (2):Effect of planting dates, chilling and N/P ratio on number of flower /plant

Time of Planting	Chilling of Transplants (4 ±1 ^{0}C)	N/P ratio 2022		2023		Time*Chilling		Means of Time	
		0	100/100	0	100/100	2022	2023	2022	2023
15th sep.	0	12.75 e	14.25 de	10.5 d	16 a-d	13.5 d	13.25 bc	16.833 ab	14.875 ab
	10	16.25 b-e	21.5 a	13.25 cd	19.75 a	18.875 a	16.5 ab		
	20	16.75 b-e	19.5 abc	12.25 cd	17.5 abc	18.125 ab	14.875 ab		
1st Oct	0	15 cde	16.5 b-e	14.25 cd	12.25 cd	15.75 bcd	13.25 bc	18.042 a	16.167 a
	10	17.5 a-d	21.56 a	16.75 abc	20 a	19.5 a	18.375 a		
	20	18 a-d	19.75 ab	14.75 a-d	19 ab	18.875 ab	16.875 ab		
15th Oct	0	14 de	15.75 b-e	11 d	11 d	14.875 cd	11 c	16.33 b	13.208 b
	10	17.75 a-d	17 b-e	14.75 a-d	13.25 cd	17.38 abc	14 bc		
	20	15.25 b-e	18.25 a-d	13.25 cd	16 a-d	16.75 bc	14.625 bc		
Time*N /P ratio	15th Sep	15.25 c	18.417 ab	12 c	17.75 a	Means of Chilling			
	1st Oct	16.83 bd	19.25 a	15.25 ab	17.083 a	2022	2023		
	15th Oct	15.667 c	17 abc	13 bc	13.417 bc				
Chilling *N/P ratio	0	13.917 d	15.5 cd	11.917 c	13.083bc	14.708 b	12.5 b		
	10	17.17 bc	20 a	14.917 ab	17.667 a	18.583 a	16.292 a		
	20	16.667 c	19.167 ab	13.417 bc	17.5 a	17.917 a	15.458 a		
Means of N/P ratio		15.917 b	18.222 a	13.417 b	16.083 a				

Means of each factor and their nteractions followed by different letters are significant by different from each other according to Duncan's multiple range test at 5%.

3. Flowers setting %:

Table (3) shows that planting strawberry plants on October 1st resulted in significant effect on the setting % of flowers in both growing seasons, the highest value obtained was (94.283) and (88.028) respectively. No significant effect in the setting % was obtained as a result of transplants exposure to different chilling periods. Foliar sparing N/P ratio 100/100 significantly increase the setting % of flowers in both growing seasons (91.969 -88.281) respectively.

Interaction between planting dates and chilling periods indicate that there was significant impact on setting %, highest value obtained from combination on 1st October and 20 days of chilling (95.01) in first year and (90.729) in second year between 15th October and 20 days of chilling. Planting time 1st October combined with 100/100 N/P spraying resulted in highest value of setting % in two growing seasons (96.653 and 90.81) respectively. The chilling periods and N/P ration interaction resulted in significant effects on setting %, highest setting was obtained between 10 days of chilling and 100/100 ratio (93.602) in first year, in second year the highest value was (90.531) from combination between 100/100 ratio and control.

Combination between planting dates, chilling periods and N/P ratio resulted in significant effects on setting percentage, the highest setting was obtained between 1st October, 20 days of chilling and 100/100 n/p ratio (98.175) in first growing season, the second year triple interaction highest value (92.815) was obtained on 15th October, 0 chilling and 100/100 N/P. Lowest setting % was 81.77 and 72.508 between controls and 15th Sep. in both years (table 3).

Table (3):Effect of planting dates, chilling and N/P ratio on the setting percentages of flowers

Time of Planting	Chilling of Transplants (4 ±1 ^{0}C)	N/P ratio 2022		2023		Time*Chilling		Means of Time	
		0	100/100	0	100/100	2022	2023	2022	2023
15th sep.	0	81.77 c	83.78 bc	72.508 c	87.443 ab	82.775 c	79.975 c	85.728 b	83.948 b
	10	85.025 bc	89.2 abc	86.205 ab	86.885 ab	87.113 bc	86.545 abc		

	20	89.05 abc	85.543 bc	85.468 ab	85.178 ab	87.296 bc	85.323abc		
1st Oct	0	91.388 ab	95.81 a	85.17 ab	91.335 ab	93.599 ab	88.253 ab	94.283 a	88.028 a
	10	92.503 ab	95.975 a	86.058 ab	91.44 ab	94.239 a	88.749ab		
	20	91.845 ab	98.175 a	84.508 ab	89.655 ab	95.01 a	87.082 abc		
15th Oct	0	89.837 abc	90.088 abc	86.013 ab	92.815 a	89.963 ab	89.414 ab	91.013 a	87.658 ab
	10	88.627 abc	95.63 a	84.65 ab	81.015 bc	92.128 ab	82.833 bc		
	20	88.368 abc	93.525 ab	92.693 a	88.765 ab	90.946 ab	90.729 a		
Time *N/P ratio	15 Sept	85.282 c	86.174 c	81.393 b	86.502 ab	Means of Chilling			
	1st Oct	91.912 ab	96.653 a	85.245 ab	90.81 a	2022	2023		
	15th Oct	88.944 bc	93.081 ab	87.785 a	87.532 a				
Chilling* N/P ratio	0	87.665 b	89.893 ab	81.23 b	90.531 a	88.779 a	85.88 a		
	10	88.718ab	93.602a	85.638 ab	86.447 ab	91.16 a	86.042 a		
	20	89.754 ab	92.4157 ab	87.556 a	87.867 a	91.086 a	87.711 a		
Means of N/P atio		88.713 b	91.969 a	84.808 b	88.281 a				

Means of each factor and their nteractions followed by different letters are significant by different from each other according to Duncan's multiple range test at 5%

4. Length of flowering period:

It is clear from table (4) that planting on 1st October causes a significant increase in the flowering period of two growing seasons respectively compared to other planting dates, results in the same table display that there was significant effect of chilling strawberry plants in 10 and 20 days on the length of flowering period compared to control in two studied years. Spraying 100/100 N/P resulted in significant effect on the length of the flowering period for both years (73.472 and 71.028) respectively. The data from combination of planting times and chilling periods show that 1st October and 10 days of chilling had significant impact on the length of flowering period for two experiment years recording the highest values (76.375and 74.5) respectively.

Combination between planting time and N/P ratio caused significant effect in plants on the three planting dates and sprayed with 100/100 N/P in two years except those planted on 15th September with 100/100 NP in the second year. Combination between chilling and NP significantly affect the length of flowering period, the most potent interaction were 10 days of chilling and 100/100 NP spray in two year which gave the highest value (75.5 , 75.333) respectively. There were significant differences among the means of flowering period length due to triple interaction between planting dates, chilling periods and N/P spray. However, the highest mean was obtained from the combination of 1st October, 10 days chilling and 100/100 N/P ratio in first season, the second season highest mean value was on 15th September, 10 days chilling and 100/100 NP spray (77.25).

Table (4):Effect of planting dates, chilling and N/P ratio on strawberry flowering period

Time of Planting	Chilling of Transplants (4 ± ^{0}C)	N/P ratio 2022		2023		Time*Chilling		Means of Time	
		0	100/100	0	100/100	2022	2023	2022	2023
15 sept	0	66.75 ef	71 a-f	64.5 fg	66 fg	68.875 c	65.25 c	71.458 ab	69.167 ab
	10	72.25 a-e	76.25 ab	67 efg	77.25 a	74.25 ab	72.125 ab		
	20	68.75 def	73.75 a-d	67.25 def	73 abc	71.25 bc	70.125 b		
1 Oct	0	66 f	70.75 b-f	66.5 fg	64.75 fg	68.375 c	65.625 c	73 a	70.625 a
	10	76.25 ab	76.5 a	72.75 a-d	76.25 a	76.375 a	74.5 a		

	20	73.5 a-d	75 abc	68.25 c-f	75.25 ab	74.25 ab	71.75 ab		
	0	66 f	73.25 a-d	66 fg	61.5 g	69.625 c	63.75 c		
15 Oct	10	67.5 ef	73.75 a-d	67.5 c-f	72.5 a-e	70.625 bc	70 b	70.333 b	68.375 b
	20	70.5 c-f	71 a-f	70 b-f	72.75a-d	70.75 bc	71.375 ab		
Time*N/P ratio	15 Sept	69.25 bc	73.667 a	66.25 b	72.083 a	Means of Chilling			
	1-Oct	71.917ab	74.083 a	69.167 ab	72.083 a	2022	2023		
	15 Oct	68 c	72.667 a	67.833 b	68.917 b				
Chilling*N/P ratio	0	66.25 c	71.667 b	65.667 c	64.083 c	68.958 b	64.875 b		
	10	72 b	75.5 a	69.083 b	75.333 a	73.75 a	72.208 a		
	20	70.917 b	73.25 ab	68.5 b	73.667 a	72.083 a	71.083 a		
Means of N/P ratio		69.722 b	73.472 a	67.75 b	71.028 a				

Means of each factor and their nteractions followed by different letters are significant by different from each other according to Duncan’s multiple range test at 5%

5. Vitality of pollen percentage:

Data In table (5) shows that the planting on 1st and 15th October causes significant effect on the vitality of pollen percentage in first year, in second year the significant impact on vitality was on 15th September which recorded the highest value (93.491). The chilling effect shows no significant on vitality in the first year, but effects were significant in second year especially with 0 and 20 days of chilling as compared to 10 days. NP (100/100) spraying significantly increase the vitality of pollen compared to control in both growing season. The combination between planting dates and chilling shows significant differences between means value on 1st and 15th October compared to 15th September the highest vitality percentage (95.065) obtained on 15th October and control in first year. In second year the highest value obtained from combination between planting on 15th September with 20 days of chilling (95.9). The combination between planting dates and N/P significantly increase the vitality percentages except on 15th Sep. date and control which recorded the lowest value (82.628) in the first year. Highest value (95.463) was obtained from interaction between 15th Oct. and 100/100 ratio. In second year, data showed that the only significant interaction was obtained between 15th Sep. and 100/100 ratio (94.702) and lowest value (86.604) between 15th October and control interaction. The combination of nitrogen/phosphorus ratios and chilling duration resulted in significant differences in mean values across both years. In the first year, the highest vitality percentage (95.156%) was achieved with 10 days of chilling and a 100/100 N/P ratio. The lowest vitality (82.628%) was observed in the control. In the second year, the highest significant vitality (92.334%) was recorded with 20 days of chilling and a 100/100 N/P ratio, while the lowest (82.476%) was from the 10 days of chilling and control combination.

Data of the triple interaction of planting dates, chilling duration, and N/P ratio are presented in Table 5. In the first year, the combination of September 15th , no chilling, and control N/P ratio had no significant effect on vitality, recording 71.953%. The highest vitality percentage (97.6%) was noted on October 15th with 10 days of chilling and a 100/100 N/P ratio. In the second year, the highest vitality (96.528%) was observed with September 15th, 20 days of chilling, and a 100/100 N/P ratio. The lowest percentage (75.165%) was recorded from the triple combination of October 1st, 20 days of chilling, and a 0/0 N/P ratio.

Table (5):Effect of planting dates, chilling and N/P ratio on vitality %

Time of Planting	Chilling of Transplants (4 ± ^{0}C)	N/P ratio				Time*Chilling		Means of Time	
		2022		2023					
		0	100/100	0	100/100	2022	2023	2022	2023
15th sep	0	71.953 b	91.11 a	90.368 abc	93.888a	81.531 b	92.123 ab		
	10	86 a	91.84 a	91.2 ab	93.69 a	88.92 ab	92.445 ab	86.545 b	93.491 a
	20	89.933 a	88.438 a	95.273 a	96.528 a	89.185 ab	95.9 a		
1st Oct	0	91.425 a	94.64 a	96.1 a	83.325 bcd	93.033 a	89.713ab	92.8138 a	88.048 b
	10	91.578 a	96.028 a	75.165 d	89.11 abc	93.803 a	82.133c		

	20	90.938 a	92.275 a	91.663 ab	92.925 ab	91.606 a	92.294 ab		
15th Oct	0	94.055 a	96.075 a	89.9 abc	95.1875 a	95.065 a	92.544 ab		
	10	92.168 a	97.6 a	81.063 cd	92.955 ab	94.884 a	87.0095 bc	94.498 a	89.2508 b
	20	94.375 a	92.715 a	88.85 abc	87.55 abc	93.545 a	88.2 bc		
Time*N/P ratio	15th Sep	82.628b	90.463 a	92.28 ab	94.702a	Means of Chilling			
	1Oct	91.313 a	94.314a	87.643 bc	88.453 bc	2022	2023		
	15 Oct	93.533 a	95.463 a	86.604c	91.898 ab				
Chilling*N/P ratio	0	85.811 b	93.942 a	92.1225 a	90.8 a	89.876 a	91.461 a		
	10	89.915 ab	95.156 a	82.476 b	91.9183 a	92.535 a	87.197b		
	20	91.748 ab	91.143 ab	91.928 a	92.334 a	91.445 a	92.131a		
Means of N/P ratio		89.158 b	93.413 a	88.842 b	91.684a				

Means of each factor and their interactions followed by different letters are significant by different from each other according to Duncan's multiple range test at 5%.

6. Germination percentage:

It is clear from table (6) that planting on 1st and 15th October causes increasing in the germination percentage in first growing season which recorded the highest values (67.953 and 69.391) respectively compared to other 15th September. Results from the same table display that there were no significant effects of chilling strawberry and spraying with N/P on germination % in both years.

The data from combination of planting times and chilling periods show that there were significant differences between means values in both years of experiment on the germination percentage. Highest values obtained on 15th October and 10 days of chilling (75.335) in the first season and 15th September and 20 days of chilling (76.1275) in the second season. The combination between planting time and N/P ratio resulted in significant differences between means value. Highest value was (71.243) between 1st October and 100/100 N/P ratio. Lowest value recorded from interaction between 15th September and control (50.516) in first year. In second growing season (75.755) was the highest value obtained from interaction between 15th September and 100/100 N/P ratio and lowest germination (%) was between 1st October and 100/100 ratio (64.018).

Combination between chilling and NP significantly affect the germination percentage in first experiment season in plant with 10 days chilling and 100/100 N/P ratio (74.025), in second year no significant effects on germination percentage obtained.

There were significant differences among the means of germination percentage due to triple interaction between planting dates, chilling periods and N/P spray. However, the highest mean was obtained from the combination of 15th October, 10 days chilling and 100/100 N/P ratio in first season (78.723), the second season highest mean was on 15th September, 20 days of chilling and 100/100 NP spray (81.055)

Table (6): Effects of planting dates, chilling and N/P ratio on germination %

Time of Planting	Chilling of Transplants (4 ± ^{0}C)	N/P ratio				Time*Chilling		Means of Time	
		2022	2023	2022	2023				
		0	100/100	0	100/100	2022	2023	2022	2023
15th sept	0	46.648 d	64.75 a-d	61.955 abc	71.085 ab	55.699 b	66.52 ab	58.975 b	70.745 a
	10	53.705 bcd	65.783a-d	64.05 abc	75.125 ab	59.744ab	69.5875 ab		
	20	51.195 cd	71.77 abc	71.2 ab	81.055 a	61.483 ab	76.1275 a		
1st Oct	0	71.95 abc	75.775 abc	73.575 ab	58.935 bc	73.863 a	66.255 ab	67.953 a	64.099 a
	10	63.84 a-d	77.57 ab	48.293 c	65.355 abc	70.705 ab	56.82375 b		
	20	58.2 a-d	60.385 a-d	70.675 ab	67.765 abc	59.293ab	69.22 ab		
15th Oct	0	71.49 abc	72.75 abc	59.1 bc	76.525 ab	72.12 ab	67.8125 ab	69.391a	64.965 a
	10	71.948abc	78.723 a	64.88 abc	67.42 abc	75.335 a	66.15 ab		
	20	69.583 a-d	51.853 cd	63 abc	58.865 bc	60.718 ab	60.9325 b		
Time *N/P ratio	15 Sept	50.516 b	67.434 a	65.735 ab	75.755 a	Means of Chilling			
	1-Oct	64.663 a	71.243 a	64.181 b	64.018 b	2022	2023		
	15 Oct	71.007 a	67.775 a	62.327 b	67.603 ab				
Chilling* N/P ratio	0	63.363 ab	71.092 ab	64.877 a	68.848 a	67.227 a	66.863 a		
	10	63.164 ab	74.025 a	59.074 a	69.3 a	68.595 a	64.187 a		
	20	59.659b	61.336 ab	68.292 a	69.228 a	60.498 a	68.76 a		
Means of N/P ratio		62.062a	68.818 a	64.081 a	69.126 a				

Means of each factor and their interactions followed by different letters are significant by different from each other according to Duncan's multiple range test at 5%

Discussion

The higher value of growth coefficients observed in plants from early planting may be due to the higher temperature and the amount of solar radiation prevailing during the growth period accelerating the vegetative growth of plants which are consistent with [9]. The longest time to flowering was observed with the 15th Sep. planting date 72.333 and 73.542 days, while the shortest duration was recorded with the 15th Oct. planting date 57.708 and 60.792 days respectively in 2022 and 2023, it appears that the prevailing temperature significantly influenced flower initiation. The 15thOctober planting reached temperatures favorable for flowering sooner, taking lower days after planting which corresponds to [11]. The experimental results clearly illustrated that strawberry plants flowered faster and produced more flowers when the seedlings were pre-induced under cold room conditions [13]. The vitality of pollen grains is affected by a range of factors, including unfavorable weather conditions, as well as the genetic trait that leads to pollen with low vitality. Temperature is a crucial environmental factor for pollen germination, fruit set, and seed set. Studies, such as those by [12] have demonstrated that temperature influences the chemical composition of pollen, its viability, and the growth of the pollen tube. Regarding the coefficients associated with the combined impact of these individual factors, there are intervening variables to consider as mentioned above.

Conclusion

The second planting date, October 1st, outperformed the first and third planting dates in most parameters studied, including the number of flowers per plant, the setting percentage of flowers, the length of the flowering period for both growing seasons, and the vitality and germination percentage of pollen. Chilling periods of 20 days increased the number of flowers, the length of the flowering period, and pollen vitality. Foliar applications of N/P at a 100/100 ratio also increased the number of flowers per plant, the setting percentage of flowers, the length of the flowering period for both years, and pollen vitality. Both bilateral and triple interactions significantly impacted most traits.

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تأثير مواعيد الزراعة، فترات التبريد والرش الورقي للنتروجينوالفسفورعلى صفات الإزهار للفراول(Fragaria ananassa) cv. Robygem في نظام الزراعة المائية

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الخلاصة

أجريت هذه الدراسة في بيت بلاستيكي غير مدفأ خلال موسمي الزراعة 2022 و2023 في مشتل غابات مالطا التابع للمديرية العامة للغابات والمراعي/ مدينة دهوك، محافظة دهوك، إقليم كردستان– العراق، على ارتفاع "526" مترًا فوق مستوى سطح البحر. الهدف من البحث هو لدراسة تأثيرات تواريخ الزراعة (15 سبتمبر و1 أكتوبر و15 أكتوبر)، وفترات التبريد (0 و10 و20 يوماً) والرش الورقي للنيتروجين والفوسفور (0 و100/100)، وكذلك تفاعلاتها الثنائية والثلاثية على خصائص الإزهار لنبات الفراولة في نظام الزراعة المائية. أقل عدد أيام للازهار تم الحصول عليها في 15 أكتوبر لموسمي النمو كانت 57.708 و 60.792 يومًا على التوالي. في حين تم الحصول على أطول فترة حتى الإزهار في 15 سبتمبر لكلا الموسمين 72.333 و 73.542 يومًا على التوالي. أدى تاريخ الزراعة 1 أكتوبر إلى زيادة كبيرة في عدد الأزهار لكل نبتة والتي بلغت 18.042 و16.167، ونسبة التلقيح في النبات الواحد، وطول فترة الإزهار لموسمي النمو 73 و70.625 يوماً. فترة التبريد لمدة 20 يومًا زادت بشكل ملحوظ من عدد الأزهار لكل نبات وطول فترة الإزهار وحيوية حبوب اللقاح. في كلا موسمي النمو رش النباتات بنسبة ***N/P 100/100*** ادى الى الزيادة لعدد الأزهار لكل نبات 18.222–16.083 يومًا، و من عدد الأزهار لكل نبات 18.222–16.083 يومًا، و نسبة الأزهار وطول فترة الإزهار لكلا الموسمين 73.472 و71.028 يومًا وحيوية حبوب اللقاح. أثر كل من التفاعل الثنائي والثلاثي بين العوامل الثلاثة بشكل كبير على معظم الصفات في كلا موسمي النمو.

الكلمات المفتاحية :تغطية تربة ،رش ورقي ،الزراعة المائية ،***Robygem***،الشليك.