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Optimizing Planting Dates for Enhanced Growth and Yield of White Roselle in Upper Egypt

تحديد مواعيد الزراعة لتعزيز نمو وإنتاجية الكركديه الأبيض في صعيد مصر

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Abstract:

Abstract— White roselle, a newly introduced variety in Egypt, exhibits comparable pharmaceutical properties to traditional red roselle varieties. This study, conducted during the successive seasons of 2022 and 2023, aimed to investigate the effects of different planting dates i.e. 15th April, 1st May, 15th May and 1st June on the growth and yield properties of white roselle. The results demonstrated that planting dates significantly affected on the growth characteristics of white roselle. The lowest values of growth characteristics and yield components were recorded under late planting date on 1st June. On the other hand, the greatest value of growth characteristics including plant height, stem diameter, number of branches, fresh and dry weights of shoots as well as number of fruits were shown in planting date of 1st May. Meanwhile the greatest yield properties including fresh and dry weights of calyxes and in turn fresh and dry calyxes yield per feddan were proved under the earliest planting date on 15th April. The study concluded that planting date has significant effects on both growth characteristics and yield components of the newly introduced white roselle variety under Upper Egypt conditions. The highest values of growth characteristics and yield components were observed under earlier planting dates 15th April and 1st May. Therefore, the study recommends planting white roselle in the second mid of April to improve the growth and yield under Upper Egypt conditions.

Keywords— white roselle; planting dates; yield components; growth characteristics

ملخص

الكركديه الأبيض، وهو صنف جديد تم إدخاله إلى مصر، يُظهر خصائص صيدلانية مماثلة لأصناف الكركديه الأحمر التقليدية. هدفت هذه الدراسة، التي أجريت خلال مواسم متعاقبة ٢٠٢٢ و٢٠٢٣، إلى التحقق من تأثير مواعيد الزراعة المختلفة أي ١٥ أبريل و١ مايو و١٥ مايو و١ يونيو على خصائص النمو والمحصول للكركديه الأبيض. أظهرت النتائج أن مواعيد الزراعة أثرت بشكل كبير على خصائص نمو الكركديه الأبيض. تم تسجيل أدنى قيم لخصائص النمو ومكونات المحصول تحت موعد الزراعة المتأخر في ١ يونيو. من ناحية أخرى، ظهرت أعلي قيم لخصائص النمو بما في ذلك ارتفاع النبات وقطر الساق وعدد الفروع والأوزان الطازجة والجافة للمجموع الخضري وكذلك عدد الثمار في موعد الزراعة ١ مايو. في حين تم إثبات أفضل خصائص للمحصول بما في ذلك الأوزان الطازجة والجافة للكؤوس وبالتالي محصول الكؤوس الطازجة والجافة للفدان تحت موعد الزراعة المبكر في

١٥ أبريل. وخلصت الدراسة إلى أن موعد الزراعة له تأثير معنوي على كل من خصائص النمو ومكونات المحصول لصنف الكركديه الأبيض الجديد تحت ظروف صعيد مصر، حيث تم تسجيل أعلى قيم لخصائص النمو ومكونات المحصول تحت مواعيد الزراعة المبكرة ١٥ أبريل و١ مايو، لذلك توصي الدراسة بزراعة الكركديه الأبيض في منتصف أبريل الثاني لتحسين النمو والمحصول تحت ظروف صعيد مصر.

Introduction

Hibiscus sabdariffa L., widely known as Roselle, belongs to the Malvaceae family. It is referred to by different names globally, such as roselle, hibiscus, and red sorrel in English, and karkadeh in Arabic **[1],[2]**. This herbaceous shrub typically grows to a height of 1.5 to 2 meters and is believed to be native to tropical regions of Central and West Africa. *Hibiscus sabdariffa* L. thrives in tropical and subtropical climates **[3]**.

Various parts of the Roselle plant are edible, including its leaves, seeds, flowers, and roots. However, the calyces are the most valuable, being utilized in numerous food products such as hot and cold beverages, sauces, and jams. Occasionally, extracts from boiled Roselle leaves are also used in beverage production. The nutritional and medicinal properties of Roselle calyces have been well-documented, with research indicating that they are rich in calcium, niacin, riboflavin, iron, vitamins (particularly vitamin C), carbohydrates, proteins, antioxidants, and minerals **[4],[5]**. It was observed that 100 g of roselle calyces contain 84.5% water, 12.3 g of carbohydrates, 1.99 mg of protein, 0.1 g of fat, 2.3 g of fiber, 1.2 g of ash, and provide 11.7 calories. Additionally, they are rich in macro- and micronutrients such as phosphorus (57 mg), calcium (1.72 mg), and iron (2.9 mg), along with significant amounts of vitamins, particularly vitamin C (14 mg) and vitamin A (300 μg). Moreover, Roselle extracts are abundant in phytochemicals, vitamins, and essential minerals **[6]**.

The consumption of roselle calyx drinks is increasing worldwide, attributed not only to their nutritional and medicinal properties but also to their availability, ease of preparation, and appealing taste, aroma, and color **[7]**. Similarly, the roselle plant is distinguished by its content of biologically active compounds with therapeutic properties and pharmacological functions, including anthocyanins, organic acids, polysaccharides, flavonoids, and phenolic compounds. **Okereke *et al*. [6]** Studies have reported that Roselle calyces contain 20% flavonoids, 17% tannins, 2.14% alkaloids, 1.1% phenols, 1% saponins, and 0.13% glycosides. Extracts from the calyces have been shown to regulate blood viscosity and manage chronic diseases. Additionally, they exhibit antimicrobial, diuretic, febrifugal, antihypertensive, and antihelminthic properties **[8],[9]**.

Recent studies have investigated the antioxidant and antibacterial properties of different varieties of *Hibiscus sabdariffa* L., with particular attention given to the white variety. Assessment of the antioxidant and antibacterial capacities (ABAC) of five *Hibiscus sabdariffa* varieties revealed that the white calyx variety exhibited the highest ABAC. The white roselle variety demonstrated inhibitory effects comparable to those of chloramphenicol, with its ABAC being approximately 40% greater than that of the red calyx varieties **[10]**. Contrarily, **Borrás-Linares *et al*. [11]** reported high ABAC in extracts from both white and red calyces. The observed high ABAC in the white calyxes' variety has been attributed to the presence of non-colored phenolic compounds such as protocatechuic acid **[12]**.

In contrast, **Tahir *et al*. [13]** conducted a study evaluating the antioxidant properties of *Hibiscus sabdariffa* by analyzing three red varieties (Al-Rahad, Al-Fashir, Al-Gezira), and one white variety using spectrophotometric techniques. Their results indicated that while the red varieties displayed superior overall antioxidant properties and aroma profiles, the white variety showed significant potential for antioxidant applications. Notably, the extract from the white variety exhibited the highest radical scavenging activity (RSA %) among all tested varieties.

Numerous studies have investigated the phenolic composition of *H. sabdariffa* calyxes with varying pigmentation **[11],[14],[15]**. The principal distinctions between red and white calyx varieties include the presence of anthocyanins in the red varieties and a higher content of flavanols in the white varieties **[15]**. Additionally, the phenolic acid profiles of white and red *H. sabdariffa* varieties differ notably in the proportions of p-hydroxybenzoic acid derivatives, with a higher concentration found in the white calyces compared to the red ones **[14]**.

The objective of determining the optimal sowing date is to identify the most suitable time to plant cultivars, ensuring that the prevailing environmental conditions are conducive to the plants' germination and overall vitality **[16]**. In Egypt, particularly in regions with hot summers and mild winters such as Upper Egypt, roselle cultivation holds significant importance. Upper Egypt benefits from a comparative advantage in roselle production, particularly with the expansion of land reclamation projects aimed at increasing agricultural areas. However, climate change poses a threat to agricultural production in food-insecure regions, with extremes such as drought, heat waves, storms, and emerging pests adversely affecting farmers' livelihoods. Future climate projections indicate substantial temperature increases and erratic, intense rainfall patterns, underscoring the necessity for climate-smart and resilient agricultural practices to ensure sustainable productivity **[17]**. Given these challenges, identifying the optimal sowing date for roselle crop has become a crucial agricultural practice, especially in recent years as a response to climate change. Sowing date plays a critical role in crop production, performance, and yield. Selecting the appropriate sowing date is crucial, especially when cultivating a crop for the first time in a region. The optimal sowing date is determined by ensuring that plants establish well and their vulnerable growth stages do not coincide with adverse environmental conditions. For roselle cultivation, determining the ideal sowing date is essential to achieve maximum crop yields and optimal economic benefits **[18]**.

In light of these considerations, this experiment aimed to explore morpho-physiological traits and yield of the white roselle, newly introduced to Egypt, as influenced by planting date under Upper Egypt conditions.

MATERIAL AND METHODS

This study was carried out during the 2022 and 2023 seasons at a private farm in Esna, Luxor, Egypt. The aim of study was to investigate the effects of planting date on the growth and yield components of the white roselle variety, newly introduced to Egypt.

A. Plant materials and experimental design:

Seeds of white roselle, *Hibiscus sabdariffa*, variety were obtained from the National Research Centre, Cairo, Egypt. The experimental site was prepared as recommended before sowing the seeds. Plot size was 3 × 1.4 m comprising two rows. Roselle seeds were directly sown in soil at ٦٠ cm in a row, and ٧٠ cm between rows. The experiment was designed in a randomized complete block in a factorial design. The plots were comprehended four planting dates replicated three times. The seeds were planted on 15th April, 1st May, 15th May or 1st June in both seasons. After 30 days, the plants were thinned to one plant per hill (١٠ plants/plot) i.e. 10,000 plants/fed.

B. Data recorded:

The plants were harvested in the middle of October for both seasons and the following data were recorded:

1) Vegetative growth characteristics

1. Plant height (cm): length of the main stem from soil surface to plant apex has been measured using a ruler.
2. Stem diameter (mm) was measured at the base above soil surface by 10 cm using a caliper.
3. Number of lateral branches per plant distributed on the main stem.

4. Fresh weight of shoots per plant (g) excluding fruits were recorded directly after harvesting during both seasons.
5. Dry weight of shoots per plant: the shoots were air dried in shade till constant weight was reached (almost one week).

2) Yield components

1. Fruits number per plant distributed on the main and lateral branches.
2. Calyx fresh weight per plant (g) was recorded after separating the calyxes from plants in fresh form.
3. Calyx dry weight per plant (g); calyxes were air dried in shade conditions for one week, and then weighed.
4. Calyx fresh weight per feddan (kg) was calculated by multiplying calyxes fresh weight per plant and plants number per feddan.
5. Calyx dry weight per feddan (kg) was calculated by multiplying calyxes dry weight per plant and plants number per feddan.

C. Statistical analysis:

The obtained data were subjected to statistical analysis using "F" Test **[19]** and the means were compared using a least significant difference (L.S.D.) test according to **[20].** Statistical analysis was performed using Microsoft Office 365 Excel program.

RESULTS

Analysis of variance proved high differences in term of plant height of white roselle during the two seasons as affected by planting date. As shown in (Table 1), the tallest plants (approx. 85 cm) were recorded with the 2nd planting date (May 15th) in both seasons. Meanwhile the shortest plants (approx. 70 cm) were recorded in plant sowing on 1st June in both seasons. Applying different planting date caused significant differences in stem diameter (Table 1). Higher values of stem diameter of white roselle (15.1 and 15.8 mm) were recorded with planting on 15th May, and the lower values (12.2 and 12.8 mm) were recorded with planting on 1st June in the 1st and 2nd seasons, respectively. Table (1) showed the number of branches/plant of white roselle as affected by planting date. The highest values of number of branches (4.3 and 4.3) were registered when planting on 15th May in the 1st and 2nd seasons, respectively, compared to approx. 3 branches/plant when planting on 1st June.

Statistically, it was found that planting date had a significant effect on the shoot fresh and dry weights during the two seasons (Table 1). White roselle planted on the earliest date (April 15th) showed maximum plant fresh weight (228.3 g) in the 1st season, and date 1st May showed the maximum (303.7 g) in the 2nd season. Meanwhile, the highest shoot dry weight (60.0 and 52.0 g) were associated with those planted on May 15th and June 1st in the 1st and 2nd seasons, respectively.

Table 1: Effect of Sowing Dates on plant height (cm), stem diameter (mm), number of branches, plant fresh weight (g) and plant dry weight (g) of roselle plant.

Sowing dates	Plant height (cm)		Stem diameter (mm)		No. of branches		Shoot fresh weight g/plant		Shoot dry weight g/plant	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
15-Apr	77.2	75.0	13.6	13.4	4.0	4.1	228.3	293.3	48.9	52.8
1-May	85.6	84.4	15.1	15.8	4.3	4.6	219.4	303.7	44.4	48.3
15-May	80.0	78.3	13.0	13.0	3.6	3.3	168.3	168.3	60.0	45.0
1-JUN	70.0	69.4	12.2	12.8	3.1	3.0	119.4	109.0	51.1	52.2
F value	4.9	4.1	1.5	0.6	1.8	1.6	8.6	6.4	8.2	6.2
Probability	*	*	ns	ns	ns	ns	**	*	**	*

*, ** represent significant probability at level 0.05 and 0.01, respectively. While "ns" represent non-significant.

Statistically, it was found that planting date have high effect on number of fruits per plant during the two seasons (Table 2). Planting roselle plants on the May 1st date showed maximum number of fruits (72.0 and 75.6 in 1st and 2nd seasons, respectively), while the planting on June 1st showed the minimum number of fruits (27.0 and 19.2 in 1st and 2nd seasons, respectively). Applying different planting date caused significant differences in the calyxes' fresh and dry weights per plant as well as fresh and dry yield per Feddan (Table 2).

The highest values of calyxes' fresh weight of roselle (187.1 and 149.4 g/plant) yielding (1871 and 1494 kg/Feddan) were recorded with planting on April 15th in the 1st and 2nd seasons, respectively. In the same line, the highest weights of dry calyxes of roselle (36.7 and 30.0 g/plant) which resulting total calyx dry yield (366.5 and 300.0 kg/Feddan) were recorded in roselle planting on April 15th in the 1st and 2nd seasons, respectively. In contrast, the lowest values were recorded when white roselle planted on 1st June in both seasons.

Table 2: Effect of different sowing dates on number of fruits, calyxes fresh and dry weight per plant (g), and calyxes fresh and dry yield per feddan (kg) of white roselle plant.

Sowing dates	No. of fruits		Calyx fresh weight g/plant		Calyx dry weight g/plant		Calyx fresh yield kg/feddan		Calyx Dry yield kg/feddan	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
١٥-Apr	61.8	63.9	187.1	149.4	36.7	30.0	1871	1494	366.5	300.0
1-May	72.0	75.6	112.2	126.7	30.0	28.4	1122	1267	300.0	283.5
15-May	35.7	40.0	85.6	112.8	11.7	21.7	856	1128	116.5	216.5
1-Jun	27.0	29.2	68.3	72.9	16.7	20.4	683	729	166.5	203.5
F value	21.0	21.1	41.9	31.7	15.0	12.8	41.9	31.7	15.0	12.8
Probability	***	***	***	***	***	***	***	***	***	***

*** represent significant probability at level 0.001.

DISCUSSION

Given the economic importance of the roselle plant, noting that the common varieties are the varieties with red sepals, and the emergence of a new variety, the white roselle, which was recently introduced to Egypt and is known for its high pharmaceutical value and high demand for export, it was necessary to investigate the growth and yield of the white roselle under the conditions of Upper Egypt as an added value. So, the current study was conducted to investigate the performance of white roselle plant grown in different planting dates under Upper Egypt conditions.

Climate changes and weather conditions significant impacts on plant physiology and essential oil production. The increased temperature and carbon dioxide concentration can lead to changes in plant morphology, including reduced leaf size and altered root-shoot ratio **[21]**. These changes affect plant growth and development, which ultimately impacts the yield and quality of medicinal crops **[22].** In addition, exposure to high temperatures can lead to oxidative stress, which can damage cell membranes and decrease the efficiency of photosynthesis **[23], [24]**.

Applying different planting date caused significant differences in the plant height, stem diameter, branches number per plant, shoot fresh weight and shoot dry weight (Table 1). Analysis of variance revealed that planting on May 1st consistently yielded higher values across vegetative traits such as plant height, stem diameter, number of branches, fresh and dry shoots weights (Table 1) as well as number of fruits per plant (Table 2). The observed growth performance during first-May could be attributed to favorable conditions for plant development during this period. The increment in growth measurements in the first of May could be due to

the fact that the conditions for plant growth were suitable during these periods, especially temperature in Upper Egypt, which was more suitable for plant height and number of branches, reflecting in the plant growth measurements. These results were in harmony with the previous studies **[25]-[29].** Also, **Motlagh *et al.* [30]** showed that it seems sowing roselle from late of March to 22nd of May under hot and dry climate condition would be suitable for improve plant growth of roselle. On the other side, **Attia and Khater [31]** at El-Qantara Sharq Research Station, North Sinai Governorate, North-Eastern part of Egypt studied the effect of planting dates (15th April, 1st May and 15th May) on growth and productivity of roselle. They proved that early planting date (15th of April) resulted in increasing in all growth parameters, while delaying the planting date decreased it. They suggested that these effects might be attributed to the environmental conditions of the experiment such as day length and temperature. Moreover, **Seghatoleslami *et al*. [32]** revealed that the maximum plant height, stem diameter and number of branches per plant were obtained from the sowing at 10th of May 10. They suggested that prolonged of the growth period allowed plants to perfectly use nutrients, water and radiation which increased the photosynthesis and the plant growth.

On the other hand, the planting on April 15th demonstrated superior performance in terms of calyxes' fresh and dry weights per plants and in turn the yield per feddan (Table 2). This effect might be due to the environmental conditions, especially temperature and day length. The increase in the fruit characteristics and productivity of roselle may be due to the fact that the growing conditions at those dates are suitable for the growth and development of the plant. These results were consistent with previous studies **[26],[27],[29],[31],[33],[34]. Ado *et al.* [35]** pointed out that planting dates significantly influenced seed and calyx yield/ha of *Hibiscus sabdariffa*. They added that sowing at the mid July significantly had more productivity compared to the other planting dates. These results were in agree with those of **[36],[37]**.

Recently previous study on red roselle under Upper Egypt conditions suggested that the positive effect might be influenced by environmental conditions, particularly temperature and day length. Conclusively, the study emphasizes that planting on May 15th significantly enhanced the economic yield of red Roselle, manifested through improved plant growth and increased fruit quantity per plant **[38]**. In contrast, this study emphasizes that planting on May 1st enhanced the growth parameter while planting on April 15th significantly enhanced the economic yield of white Roselle. This difference may be due to differences between the two varieties in the thermal requirements needed for growth and production.

CONCLUSION

In this study, we investigated the effects of different sowing dates on the growth and productivity of white roselle variety. According to the obtained results, it can be concluded that different planting dates had significant effects on the growth, yield and its related traits of roselle. Sowing plants on May 1st improved plant growth characteristics, however sowing plants on the 15th of April significantly induced its economical yield (calyxes yield). Therefore, in light of this study, to increase the growth and productivity of white roselle, we recommend sowing plants in the second middle of April.

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