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Response of different Roselle cultivars to chemical and organic fertilizers

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ABSTRACT

The genetic diversity is agriculturally very interesting to improve the crops using breeding methods. Therefore, the growth inputs possess vital role to extract latent power of genetic diversity in given crops. So, A field trial was conducted out in Alhabaniyah district, Anbar province, Iraq on two points meteors of lat 33.3910°N long 43.5992°E and lat 33.3996°N long 43.5578°E. Where, the objectives included assessing some growth and yield traits of five roselle varieties viz., Red Hit, Oreib, Aswan, Black Hit, Sudan-3 under two types of fertilizers, the organic is bat guano and another one is diammonium phosphate (DAP). Treatments were distributed randomly using RCBD with triplicates. Results pointed that Black Hit was superior in plant height of 191.89 cm, vegetative fresh weight of 848.5 gm and seed yield of 402.7 Kg ha^{-1}, while Aswan excelled in capsules number per plants of 143.9 capsule plant^{-1}, capsule weight of 486.66 gm. the genetic material was variant as its performance was various. Therefore, this diversity could be embedded in breeding project to improve this crop. Deep researches are required to evaluate the impacts of organic nutrition on calyx production, early flowering and nutrients. Such information will assist to maximize the urbanized proximity to fresh ethnic crops. Indigenous nutritional plants such as Roselle could be served as a modelling crop for certain ethno-crops when they are transitted to cash crops.

استجابة أصناف مختلفة من نبات الكجرات للتسميد الكيميائي والعضوي

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الخلاصة

يعد التنوع الوراثي مهم زراعيا لتحسين المحاصيل باستخدام طرائق التربية. لذا فمدخلات النمو تمتلك دورا حيويا في استظهار المقدرة الكامنة للتنوع الوراثي لمحاصيل معينة. لذلك نفذت تجربة حقلية خلال الموسم الصيفي في ١٥\١٥ ٢٠٢٢ باستخدام خمسة

أصناف من الكجرات وهي هيت احمر وعريب واسوان وهيت اسود وسودان-٣ تحت نوعين من الأسمدة عضوي وهو مخلفات الخفاش والأخر هو سماد داب في محافظة الانبار\ مقاطعة الحبانية غرب العراق الواقعة بين نقطتين جغرافيتين **lat 33.3910°N long 43.5992°E and lat 33.3996°N long 43.5578°E**. تضمنت اهداف الدراسة تقيم بعض صفات النمو والحاصل لتلك الاصناف تحت نوعين من الاسمدة. وزعت المعاملات ضمن تصميم القطاعات تامة التعشية بثلاثة مكررات. أظهرت النتائج ان الصنف هيت اسود تفوق في ارتفاع النبات (١٩١.٨٩سم) والوزن الطري (٨٤٨.٥غم) وحاصل البذور (٤٠٢.٧ كغم هـ$^{-1}$)، بينما تفوق الصنف اسوان في عدد الكبسولات (١٤٣.٩كبسولة نبات$^{-1}$) ووزنها (٤٨٦.٦٦غم). لذا يمكن ان نستنتج ان المواد الوراثية اختلفت باختلاف صفاتها المورفولوجية. لذا يمكن ان يستثمر هذا التنوع في مشروع تربية في تحسين هذا المحصول. تعد الدراسة المعمقة ضرورية لتقييم تأثيرات الأسمدة العضوية في انتاج السبلات والتزهير المبكر والعناصر الغذائية. بذا فمثل هذه المعلومات سوف تزيد من الوصول الحضري لهذه المحاصيل الصيدلانية الطازجة. فالنباتات ذات المنشأ المحلي مثل الكجرات قد تكون محصول انموذجي لبقية المحاصيل حينما تتحول لمحصول نقدي.

الكلمات المفتاحية: ***Hibiscus sabdariffa L*** ، كجرات، الاسمدة الكيميائية، الاسمدة العضوية، الاصناف.

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is one of the most important members of the Malvaceae family. It is cultivated in tropical and subtropical regions (Dhar *et al.* 2015). Roselle is a densely branched annual shrub that can grow to a height of approximately 0.5 to 3 m and is characterized by a robust root system. Its sepals of flowers are edible, red, calyx-shaped, and it is described as a medicinal plant (Mostafa *et al*., 2020). Roselle helps lower blood pressure and cholesterol, treats inflammations and liver diseases, reduces the risk of cancer, and aids in digestion and weight maintenance (Yirzagla *et al*. 2023). Various parts of the plant, including leaves, flowers, and calyces, are used to prepare treatments for different diseases (Babajide 2004). Its fruits, roots, leaves, fibers, and seeds are all rich in vitamin C, which is an antioxidant. Along with anthocyanin pigment, one of the most important phenolic compounds, the active substance in roselle is used to treat many diseases (Norhaizan *et al*. 2010; Norhayati *et al*. 2019). Roselle seeds contain 17% oil, while its fruits contain more than 84% water, 1.7% protein, 12% carbohydrates, and 1% oil and fats (Suliman *et al*., 2011).

The flower part, represented by dried and fresh calyces, is rich in organic acids beneficial to the body, such as oxalic, malic, citric, and tartaric acids (Hanan *et al*. 2019). the plant described as a "nutritional and industrial" because the mature calyx can be consumed directly, either fresh or dried (Gibbon and Adam 1985). It is used in producing beverages, sauces, and canned goods (El Naim *et al*. 2017). Additionally, it is used in making jams, juices, cakes, ice creams, spices, and other foods and beverages (Alhasan 2012). Industrially, various parts of the plant, such as seeds, leaves, and fruits, are used in pharmaceuticals and the textile industry. The fibers from the plant's stem can be utilized in making ropes (Babajide *et al*. 2005). One of the most significant problems facing agricultural production of various crops, both in terms of quantity and quality, globally is the issue of nutrient availability for plants in the soil (Tewari and Arora 2016). As a result, most farmers use chemical fertilizers to increase agricultural production, which can simultaneously cause problems such as soil degradation, ecological farming system disruption, and water resource contamination (Arora *et al*. 2016). This highlights the need for an alternative source of readily available soil nutrients, such as organic fertilizers, including bird and animal manure. These organic fertilizers release nutrients slowly over a longer period compared to chemical fertilizers, contributing to reduced soil pollution. Additionally, they help preserve nutrients from being lost through surface runoff and increase fertilizer use efficiency compared to chemical fertilizers (Ladan *et al*. 2021). Studies have shown that the continuous use of organic fertilizers improves soil structure and biomass (Shahram and Ordookhani 2011; Suresh *et al*. 2004). Using the organic fertilizers enhances the physical and biological properties of the soil, reflecting positively on the growth and yield characteristics of the planted crops. Despite containing fewer nutrients compared to chemical fertilizers, organic fertilizers release nutrients slowly, ensuring their availability over longer periods

(Mohamed *et al*. 2012). The application of 75% NPK improved fruits number and weight and sepals yield (**El-Dissoky** *et al*., 2020). It recommended to fertilize roselle with2.5 t/ha of cowdung and 60 kg ha^{-1} of Nitrogen in some area of the world (**Yirzagla** *et al*., 2023). Moreover, applying the chemical and organic fertilizers led to improve growth parameters (Ibrahim *et al*., 2020).

In a study conducted in Pakistan to compare the phosphorus added from chemical fertilizer and an organic source on Roselle plants, Alam *et al*. (2016) observed that both organic and chemical phosphorus sources increased growth and yield indicators compared to the control treatment. Moreover, the organic phosphorus source outperformed the chemical source in providing the highest values for all studied indicators. Calyces of certain genotypes are differed in their consistency (Suliman *et al*., 2011) their number per plant and their yield (Hinojosa-Gómez *et al*., 2022**)**. Where these genotypes revealed their latent potency as phenotypic traits like sepals dry weight and yield components (Abou-Ellail *et al*., 2014; Gebremedin and Asfaw, 2017; Ramos-Gutiérrez *et al*., 2020; Sanders *et al*., 2020; Al-Baik and Alamery, 2024). Each genotype possesses ecotypes which had different performnce reflected in their phenotypic traits (Atta *et al*., 2017). Given the conditions of Iraqi soil, which suffers from a deficiency in most readily available nutrients and a lack of organic matter due to the arid conditions of desert areas, this study was conducted to compare the effects of organic and chemical fertilization on the growth and yield of Roselle under Iraqi soil conditions.

MATERIALS AND METHODS

Location and materials

A field experiment was conducted during the spring and autumn seasons of the year (2022-2023). A clay-textured agricultural soil in the Al-Habbaniyah district, 20 km east of Ramadi. Soil samples were taken from the field at a depth of 0-30 cm before planting to measure the chemical and physical properties of the soil (Table 1)

Table 1. Chemical and Physical Properties of the Soil

pH	Sand %	Clay %	Silt %	Ec dSm^{-1}	CaCO3 %	O.M. %	N ppm	K_2O ppm	P_2O_5 ppm	Permeability cm/hour
10.81	٣١	٤٤	٢٥	2.22	12.74	0.39	403	200	5.6	5.95

the site of experiment is located between two meteorological points lat 33.3910 long 43.5992 and lat 33.3996 long 43.5578 (figure 1).

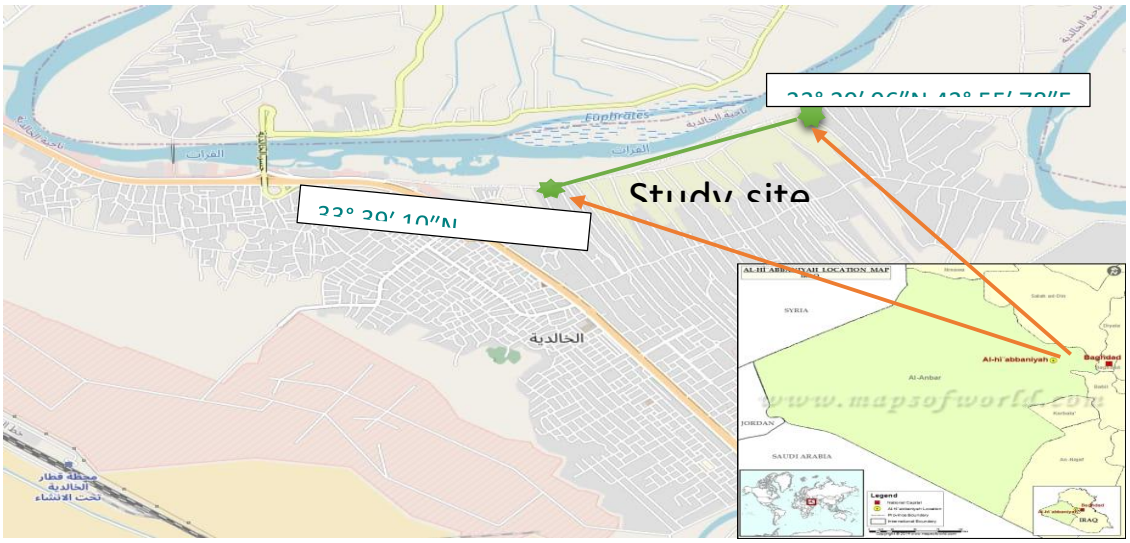

Figure 1 map of experimental area with meteorological dimensions (USGS, 2024)

Materials

Air dried seeds of five Roselle (*Hibiscus sabdariffa* L.) cultivars; Sudani were obtained from the Department of Conservation Agriculture, Center of Desert Studies, University of Anbar, Ramadi, Iraq. These cultivars were selected to implement the experiment of planting five cultivars of roselle, namely, Red Hit, Oreib, Aswan, Black Hit, Sudan-3 the description of these cultivars is shown in table 2. The objective was to determine their response to two types of fertilizer: first organic bat guano at a rate of 400 kg ha^{-1}, labeled O, and the second being chemical DAP (Diammonium Phosphate) fertilizer at a rate of 400 kg ha^{-1}, labeled K.

Table 2 some historical information of the five roselle cultivars

cultivars	habit	country	Introduction year	description
Aswan	cultivar	Egypt	2010	Dense growth, dark blood color stem, branches and sepals, late flowering
Red hit	ecotype	Iraq	Cultivated in west Iraq	Common growth, red stem, branches and sepals, early
Black hit				Common growth, black sepals, early
Oreib	genotype		Locally in desert soils west Iraq	Common growth, red stem, branches and sepals, early
Sudan-3	cultivar	Sudan	2010	Dense growth, red stem, branches and sepals, moderate flowering

Agricultural practices

After determining the experimental site, weeds growing in the field were controlled using Paraquat herbicide at a concentration of 4 ml $liter^{-1}$ (Taufikurahmana et al. 2024).
The experimental land was plowed perpendicularly, followed by smoothing. Furrows were made in the field with dimensions of 55 x 8 m, each 2.5 meters long represented as experimental unit, 1 m between two furrows and the width of each furrow is 0.7 m. The five Roselle cultivars were randomly distributed across the furrows, with a distance of 50 cm between each furrow and 50 cm between each plant. Bat guano (table 3 shows some macronutrients) was added as organic fertilizer and DAP fertilizer **a**t **a rate of 10 grams $plant^{-1}$ using the** method of making a slit from the first plant to the last plant in a row and **covering it with soil.**

Table 3. Some macronutrients of Bat Guano (*Otonycteris hemprichii*).

No.	**Macronutrients**	**Unit**	**Value**
1	Total Nitrogen	mmol L^{-1}	28.39
2	Total Phosphorus	mmol L^{-1}	29.71
3	Total Potassium	mmol L^{-1}	38.89
4	Total Magnesium	mmol L^{-1}	38.74
5	Total Calcium	mmol L^{-1}	50.04
6	Total Sodium	mmol L^{-1}	48.72

The seeds were soaked in water for 24 hours before planting. Planting took place on 5/5/2022, and the seeds began to germinate after four days .The weather information is shown in table 4.

Table 4 seasonal weather information during crop growth of 2022 (Climate.org)

Month	Jan	Feb	Mar	Apr	growth season							Dec	Yearly mean
					May	Jun	Jul	Aug	Sep	Oct	Nov		
Record high °C	19.21	21.68	27.48	33.6	40.33	45.29	47.94	47.57	44.01	36.82	26.46	20.53	34.24
Average high °C	15.95	18.34	23.5	29.54	35.96	41.5	44.68	44.43	40.48	33.08	23.36	17.57	30.7
Daily mean °C	12.54	14.64	19.57	25.54	32.23	37.54	40.38	39.93	35.79	28.82	19.93	14.32	26.77
Average low °C	8.34	9.77	13.7	18.72	25.33	29.64	31.88	31.43	27.66	22.17	15.15	10.22	20.33
Record low °C	1.39	2.29	5.23	9.19	14.87	20.58	24.08	24.08	19.6	14.4	8.2	3.79	12.31
Average precipitation (mm)	48.97	41.2	55.65	37.67	27.22	1.12	0.18	0.27	1.01	24.84	41.91	44.18	27.02
Average precipitation days (≥ 1.0 mm)	4.88	4.96	6.3	5.74	4.81	0.35	0.06	0.09	0.25	3.93	4.83	4.61	3.4
Average relative humidity (%)	48.66	44.03	37.38	30.39	22.56	14.24	12.46	13.16	15.56	24.66	38.49	46.21	28.98
Mean monthly sunshine hours	8.06	8.33	11.02	12.87	13.74	14.4	14.09	13.27	12.3	9.41	8.31	8.13	11.16

This trial was applied underwith completely randomized block design with two-way factorial experiments system with three replicates.

Studied Traits:

1. Number of branches (branches plant^{-1})
2. Plant height (cm)
3. Vegetative Fresh weight (g plant^{-1})
4. Vegetative Dry weight (g plant^{-1})
5. Number of capsules in Roselle (Capsules plant^{-1})
6. Weight of capsules in Roselle (g plant^{-1})
7. Seed yield per hectare in Roselle (Kg ha^{-1})

STATISTICAL ANALYSIS

Data analysis was laid out using GenStat Release 12.1 (Payne, 2009). furthermore, the means of morphological traits were compared via least significant difference (LSD) under probability level of 0.05 (Al-Mohammedi and Al-Mohammedi, 2012). Pearson coefficients and their expression using color matrix were extracted using PAST4.12b (Hammer et al., 2001).

RESULT AND DISCUSSION

1. Number of branches

Notably, from table 5., the application of organic fertilizer led to an increase in the number of branches (33.44 branches plant^{-1}) compared with chemical fertilizer (31.4 branches plant^{-1}). This demonstrates a robust response, resulting in the highest overall average (32.44). However, it is crucial to note that this improvement might be cultivar-specific, Conversely, for Cultivar Oreib, the employment of organic fertilizer resulted in a slight reduction in branches (21.22 branches plant^{-1}) compared on the chemical counterpart (22.89 branches plant^{-1}), yielding an average of 22.05 (branches plant^{-1}). This suggests that the response to organic fertilizer is cultivar-dependent. In contrast, Cultivar Aswan exhibited a substantial response to organic fertilizer, significantly increasing the number of branches (28.5 branches plant^{-1}) compared on the chemical alternative (21.5 branches plant^{-1}). This contributed to an average of 25 (branches plant^{-1}), highlighting the positive impact of organic fertilizer on this cultivar. While Cultivar Black Hit demonstrated a decline in branches with organic fertilizer (22.33 branches plant^{-1}) compared on the chemical variant (26.33 branches plant^{-1}), the overall average remained relatively high at 24.33 (branches plant^{-1}). This indicates that the response to organic fertilizer may vary among different cultivars. Notably, Cultivar Sudan-3 displayed the smallest average number of branches, particularly with organic fertilizer

(11.11 branches plant^{-1}). This led to an overall average of 13.44 (branches plant^{-1}), emphasizing the variable impact of organic fertilizer on different cultivars. In contrast, the ecotypes could contribute in growth traits such as number of branches per plant (Atta *et al*., 2017).

Table 5. Effect of organic and chemical fertilizer on number of branches (branches plant^{-1}) in five roselle cultivars

Cultivars	chemical	organic	average
Red Hit	31.4	33.44	32.44
Oreib	22.89	21.22	22.05
Aswan	21.5	28.5	25
Black Hit	26.33	22.33	24.33
Sudan-3	14.78	11.11	13.44
L.S.D $_{0.05}$	5.68		4.9
average	23.39	23.52	
L.S.D $_{0.05}$	n.s		

Considering the overall average, organic fertilizer (23.52 branches plant^{-1}) demonstrated a slightly higher impact on branch development than chemical fertilizer (23.39 branches plant^{-1}).

In synthesis, these findings emphasize the complexity of the interaction between cultivars and fertilizer types in influencing branch development. Future research endeavors could delve into the genetic factors influencing these responses and explore the long-term sustainability of organic fertilizer practices across diverse cultivars. Where, Ibrahim *et al*. (2020) point that chemical and organic fertilizer nonsignificantly impacted number of branches per plant and the cultivars only differed in nodes per plant.

2. Plant Height (cm)

The average height across all cultivars (174.66 cm) favors organic fertilizer application compared to chemical (172.43 cm). However, individual cultivar responses vary considerably, table6.

Cultivar Red Hit: Organic fertilizer promotes taller plants (171.55 cm) compared to chemical (161.11 cm). This suggests organic matter improves soil structure and nutrient availability, enhancing growth. Cultivar Oreib: Organic fertilizer showcases a remarkable impact, leading to significantly taller plants (196.89 cm) compared to chemical (164.11 cm). This exceptional response hints at potential synergy between organic amendments and the cultivar's specific needs.

Table 6. Effect of organic and chemical fertilizers on heights of five roselle cultivars

Cultivars	chemical	organic	average
Red Hit	161.11	171.55	166.33
Oreib	164.11	196.89	180.5
Aswan	183.5	137.83	160.67
Black Hit	178.44	205.33	191.89
Sudan-3	175	161.67	168.33
L.S. $D_{0.05}$	6.26		4.43
average	172.43	174.66	
L.S. $D_{0.05}$	n.s		

Cultivar Aswan: Chemical fertilizer initially appears beneficial (183.5 cm) compared to organic (137.83 cm). However, this difference is statistically insignificant. Further investigation is needed to understand the underlying mechanisms and potential cultivar-specific limitations of organic amendments.

Cultivar Black Hit: Similar to cultivar Oreib, organic fertilizer significantly boosts plant height (205.33 cm) compared to chemical (178.44 cm). This reinforces the notion that organic matter can be highly effective for certain cultivars.

Cultivar Sudan-3: Both fertilizers produce comparable average heights (175 cm vs. 161.67 cm). This suggests the cultivar may be less responsive to fertilizer type, or other factors like genetics or environmental conditions play a stronger role. Where, Ibrahim et al. (2020) point that chemical and

organic fertilizer nonsignificantly impacted plant height and the cultivars only differed in nodes per plant. The different varieties materials contributed in different morphological like plant height as in (Al-Baik and Alamery, 2024).

3. Vegetative Fresh weight (gm)

The presented data reveal in table 3 about compelling insights into the influence of organic fertilizer on average weight across diverse Gujarat cultivars. While a generalized enhancement in average weight (810.3 vs. 666.7) is observed with organic application, individual cultivar responses paint a nuanced and intriguing picture (Table 7).

These cultivars exhibit pronounced and statistically significant increases in average weight with organic fertilizer (871.3, 927.8, and 955.2 respectively). This highlights the potent ability of organic amendments to promote average weight in some cultivars.

Furthermore, the similarity between cultivars Red Hit and Aswan suggests the potential for shared mechanisms, perhaps related to inherent average weight propensities or efficient utilization of specific organic components.

Conversely, cultivar Black Hit exceptional response underscores the broad applicability of organic amendments across diverse cultivars, potentially leading to significant agricultural implications for maximizing average weight and yield.

Table 7. Effect of organic and chemical fertilizers on fresh weight (gm)of five roselle varieties

Cultivars	chemical	organic	average
Red Hit	562.4	871.3	716.9
Oreib	790.3	869.2	829.8
Aswan	664.5	927.8	796.2
Black Hit	741.8	955.2	848.5
Sudan-3	574.4	412.8	493.6
$L.S.D_{0.05}$	22.75		16.09
average	666.7	807.3	
$L.S.D_{0.05}$	10.17		

Despite a positive trend (871.3), the statistically insignificant difference with chemical application indicates a unique response. This suggests cultivar Oreib might require additional factors or specific organic components for robust average weight. Intriguingly, despite similar increases in branch number compared to Red Hit and Aswan, the lack of significance implies distinct underlying mechanisms at play. Exploring cultivar-specific nutrient requirements or tailoring organic amendments could be crucial for optimizing average weight in Oreib (Table 7). In contrast, the difference materials possess various phenotypic traits such as fresh weight (Al-Baik and Alamery, 2024).

Cultivar Sudan-3 the unexpected decrease in average weight with organic fertilizer (412.8) presents a captivating anomaly. This exceptional response necessitates further investigation into potential cultivar-specific interactions with organic components or limitations related to soil fertility or application timing. Understanding this negative response is paramount to avoid unintended consequences and tailor organic fertilizer strategies for cultivar Sudan-3.

4. Vegetative Dry Weight (gm)

The results revealed a fascinating interplay between fertilizer type and cultivar, with both organic and chemical fertilizers significantly influencing roselle dry weight ($p < 0.05$), as shown in table 8.

Across all cultivars, on average, organic fertilization yielded significantly heavier plants (390.4 g) compared to chemical fertilization (263.7 g). This suggests that organic fertilizers may provide a more holistic nutritional profile that promotes roselle growth. However, it's noteworthy that the magnitude of this difference varied between cultivars due to genetic material Where, Sanders *et al.* (202) observed like this difference in other genotypes from another region on this trait.

Delving deeper, we observe cultivar-specific responses. Cultivars Red Hit, Oreib, Aswan and Black Hit all exhibited significantly higher dry weight with organic fertilizer compared to chemical fertilizer. For instance, cultivar Aswan displayed a remarkable increase of nearly 200 grams (447.7 g

vs. 248.5 g) with organic fertilization. This implies a potentially stronger dependence on organic nutrients for these cultivars.

Table 8. Effect of organic and chemical fertilizer on dry weight (gm) of five roselle varieties

Cultivars	chemical	organic	average
Red Hit	167.1	412.4	289.8
Oreib	391.9	503.9	447.9
Aswan	248.5	447.7	348.1
Black Hit	330	470.6	400.3
Sudan-3	180.8	117.2	149
L.S.D0.05		22.04	15.59
average	263.7	390.4	
L.S.D 0.05	9.86		

Conversely, cultivar Oreib displayed a contrasting pattern. Here, chemical fertilizer yielded the highest average dry weight (391.9 g) compared to organic (503.9 g). While the organic treatment still produced heavier plants, the difference was statistically insignificant. This suggests that cultivar Oreib may be more responsive to specific components present in chemical fertilizers, or potentially less reliant on the broader spectrum of nutrients offered by organic amendments. Where, Ibrahim et al. (2020) point that chemical and organic fertilizer nonsignificantly impacted plant dry weight and the cultivars only differed in nodes per plant.

The variations observed across cultivars highlight the importance of considering cultivar-specific needs when selecting fertilization strategies. Future research could explore the underlying mechanisms behind these differential responses. Additionally, the relatively high Least Significant Difference (LSD) values for cultivars (L.S.D0.05 = 22.04) and fertilizer types (L.S.D0.05 = 9.86) indicate some level of variability within the data. Increasing sample size or employing more controlled experimental conditions could potentially refine these findings.

5. Number of Capsules (Capsules Plant^{-1}).

The results presented in Table 9 indicate a significant effect of the cultivars, with cultivar Aswan showing the highest average of 143.9 capsules plant^{-1} compared to cultivar Sudan-3, which gave the lowest average of 48.5 capsules plant^{-1}. This variation could be due to differences in the genetic makeup of the roselle, reflecting different responses to nutrients, including nitrogen and phosphorus, which affect growth and yield traits. This is consistent with the findings of (Ibrahim *et al*. 2020; Mohammed *et al*. 2020), who found variations in the number of capsules in roselle depending on the cultivated cultivars, the same results were extracted by (Atta *et al*., 2017). Additionally, the type of fertilizer significantly affected the average number of capsules, with plants treated with chemical fertilizer showing the highest average of 96.4 capsules plant^{-1}, a significant difference of 19.1 capsules compared to the organic fertilizer treatment. This is in agreement with the findings of (El Naim *et al*. 2017), who reported a significant effect of nitrogen fertilizer on this trait.

Table 9. Effect of organic and chemical fertilizers and their interaction on number of capsules (capsules plant^{-1}**) in Roselle**

Cultivars	chemical	organic	average
Red Hit	58.7	72.0	**65.3**
Oreib	87.1	92.9	**90.0**
Aswan	175.0	112.8	**143.9**
Black Hit	93.0	80.1	**86.6**
Sudan-3	68.2	28.8	**48.5**
L.S.D$_{0.05}$	32.21		22.78
average	**96.4**	**77.3**	
L.S.D$_{0.05}$	14.41		

The interaction between cultivars and fertilizer type caused a significant difference in this trait, with the organic fertilizer treatment combined with cultivar Aswan showing the highest average of

112.8 capsules plant^{-1}. This was a significant difference of 84 capsules plant^{-1} compared to the organic fertilizer treatment with cultivar Sudan-3, which gave the lowest average. This finding is consistent with the results of (El Naim *et al*. 2017), who reported a significant effect of nitrogen and organic fertilizers on roselle plants. These traits associated with capsule weight and fresh weight (table 12, figure 2). Where, Ibrahim et al. (2020) point that chemical and organic fertilizer just impacted leaves per plant and the cultivars only differed in nodes per plant.

6. Weight of Capsules (g plant^{-1})

The results in Table 10 showed a significant effect of fertilizer type on the cultivars for the average weight of capsules in Roselle plants. Cultivar Aswan significantly outperformed with the highest average of 486.66 g plant^{-1}, while cultivar Sudan-3 gave the lowest average of 89.28 g plant^{-1}. This may be due to the superiority of cultivar (Aswan) in the trait of dry weight, which positively reflected an increase in capsule weight per plant. There is a strong correlation between the traits of plant dry weight and capsule weight (Table 12). This is consistent with the findings of (Diouf *et al*. 2017; Javadzadeh and Saljooghianpour 2017), who found significant differences between cultivars for capsule weight In contrast, the difference materials possess various phenotypic traits such as capsules weight (Al-Baik and Alamery, 2024).

The type of fertilizer also had a significant effect on capsule weight, with the chemical fertilizer treatment showing an average of 232.51 g plant^{-1}, a significant difference of 59.84 g compared to the organic fertilizer treatment. The superiority of the chemical fertilizer treatment is attributed to the role of phosphorus in stimulating and encouraging the growth of fibrous and adventitious roots, as well as increasing the growth of flowers and fruits, thereby increasing fruit weight (El-Dissoky *et al*. 2020; Abdel-Kader and Saleh 2017).

Table 10. Effect of organic and chemical fertilizers and their interaction on the average weight (g plant^{-1}) of capsules in roselle

Cultivars	chemical	organic	average
Red Hit	121.00	237.33	179.16
Oreib	130.67	106.33	118.50
Aswan	688.33	285.00	486.66
Black Hit	112.33	166.33	139.33
Sudan-3	110.22	68.33	89.28
L.S.D$_{0.05}$	8.31		5.87
average	**232.51**	**172.67**	
L.S.D$_{0.05}$	3.71		

The results indicate a significant interaction effect between cultivars and fertilizer type. The chemical fertilizer treatment combined with cultivar Aswan showed the highest average of 688.33 g plant^{-1}, compared to the organic fertilizer treatment with cultivar Sudan-3, which gave the lowest average of 68.33 g plant^{-1}. The superiority of the chemical fertilizer treatment with cultivar Aswan could be due to the correlation between this trait and the plant's dry weight trait, which also showed similar behavior in this treatment (Al-Enzy et al. 2019). The capsule weight correlated with capsules number (table 12, figure 2).

7. Seed Yield per (kg ha^{-1})

The results in Table 11 indicate significant differences between cultivars. Cultivar Black Hit significantly outperformed with the highest average yield of 402.7 kg ha^{-1}, while cultivar Aswan had the lowest average seed yield of 217.5 kg ha^{-1}. The lower yield of cultivar Aswan despite its superior vegetative growth traits could be due to the effect of nitrogen in both chemical and organic fertilizers, which promoted vegetative growth at the expense of fruit growth. This is consistent with the findings of (Ibrahim *et al*. 2020; Mohammed *et al*. 2020; Javadzadeh and Saljooghianpour 2017), who also found significant differences in seed yield traits which is parallel with (Al-Enezy *et al*. 2023) on fababean cultivars. In contrast, the ecotypes could contribute in yield components such as **hundred seed weight** (Atta *et al*., 2017) which reflected in seed yield. Where, the genotypes that possessing tallest calyx having highest yield (**Hinojosa-Gómez** et al., 2022).

The results showed that the organic fertilizer treatment had the highest average of 362.1 kg ha^{-1}, with a significant difference of 44.6 kg ha^{-1}. The superiority of the organic fertilizer treatment may

be due to an inverse relationship between seed yield and dry weight, as the organic fertilizer treatment gave the lowest average for the dry weight trait. This is consistent with the findings of (Meligy and Ibrahim 2022; Norhayati et al. 2019; El Naim et al. 2017), who mentioned the superiority of organic fertilizer treatment over chemical fertilizer treatments for this trait.

Table 11. Effect of organic and chemical fertilizers on the average seed yield in roselle (kg ha^{-1})

Cultivars	chemical	organic	average
Red Hit	290.9	469.2	**380.1**
Oreib	437.3	349.8	**393.6**
Aswan	129.0	306.1	**217.5**
Black Hit	334.0	471.3	**402.7**
Sudan-3	396.0	214.0	**305.0**
L.S.D$_{0.05}$	22.18		16.03
average	**317.5**	**362.1**	
L.S.D$_{0.05}$	10.14		

The results indicate a significant interaction between cultivars and fertilizer type (Table 8). The treatment of cultivar Red Hit with organic fertilizer gave the highest average of 469.2 kg ha^{-1}, while the treatment of cultivar Aswan with chemical fertilizer gave the lowest average of 129 kg ha^{-1}. This is consistent with the findings of (Ibrahim *et al*., 2020; Al-Enzy *et al*. 2019), who indicated the positive effect of organic fertilizer on the seed yield. The increased yield could due to be correlated with height (table 12, figure 2). Al-jumaili and ALmohammedi (2023) revealed that Heat Black was dominant in most studied traits in roselle.

Table 12. Pearson correlation coefficients of seven traits for five roselle varieties

	Height	Fresh w	Dry w	Caps w	Caps no	Branches	Yield
Height	**1.00**	0.437	0.352	0.315	0.747	0.903	0.136
Fresh w	0.459	**1.00**	0.008	0.601	0.244	0.300	0.657
Dry w	0.536	0.964	**1.00**	0.793	0.336	0.463	0.547
Caps w	-0.570	0.319	0.163	**1.00**	0.043	0.597	0.111
Caps no	-0.200	0.641	0.551	0.890	**1.00**	0.650	0.325
Branches	-0.077	0.585	0.436	0.322	0.278	**1.00**	0.705
Yield	0.760	0.273	0.364	-0.791	-0.562	0.234	**1.00**

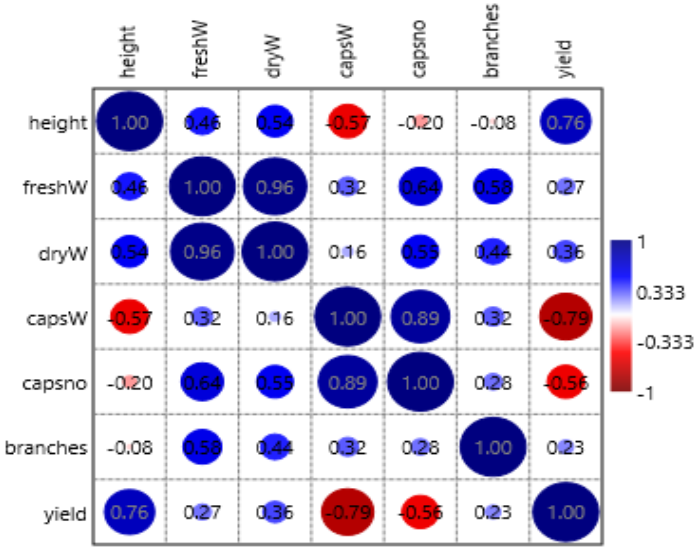

Figure 2. Color analysis of correlation among seven morphological traits

Conclusions

In conclusion, this study provides compelling evidence that organic fertilization generally promotes greater capsules dry weight compared to chemical fertilizers. However, the observed cultivar-specific

responses emphasize the need for a tailored approach to fertilization practices, considering the unique nutritional requirements of each cultivar. The varieties of roselle were genetically divergent in morphological traits. Where the best varieties were Aswan and black hit. Therefore, both varieties could be involved in breeding system to improve them for agricultural purposes.

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