Effect of NPK combinations on some growth and yield indicators of two varieties of roselle plant (*Hibiscus sabdariffa* L.)

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https://doi.org/ 10.59658/jkas.v11i1.1430

Received:
Dec. 10, 2023

Accepted:
Jan. 28, 2024

Published:
Mar. 18, 2024

Abstract

A field experiment was carried out during the 2022 agricultural season in one of the experimental fields affiliated with Ibn Al-Bitar Vocational Preparatory School, located in Karbala Governorate, to study the effect of NPK combinations on the growth and yield traits of two varieties of Roselle plant. The experiment was carried out in with three replicates, according to a randomized complete block design (RCBD) with two factors. The first factor included combinations of NPK fertilizers and according to the as follows: C0= 0 NPK kg ha^{-1}, C1= 50,25,25 NPK kg ha^{-1}, C2 = 75,50,50 NPK kg ha^{-1}, C3 =100,75,75 NPK kg ha^{-1}, C4 = 125,100,100 NPK kg ha^{-1}, C5 = 150,125,125 NPK kg ha^{-1}, C6 = 175,150,150 NPK kg ha^{-1}. The second factor was two varieties of Roselle plants: white (W) and red (R). The results showed that the red variety excelled in most of the studied traits, such as growth traits, plant height 173.27 cm, leaves number 295.65 leaf plant^{-1}, leaf area 3.48 m^2,total chlorophyll content in leaves 6.61 mg g^{-1}, fresh weight 2188.57 g plant^{-1}, yield characteristics, number of nuts 137.65 nut plant^{-1}, total nut yield 6298. 44 kg ha^{-1} and total yield of calyx leaves 1558.01 kg ha^{-1}. C5 and C6 combinations were superior in plant height (189.05 and 195.05 cm), leaves number (331.0 and 348.0 leaf plant^{-1}), chlorophyll a (6.10 and 6.45 mg g^{-1}), chlorophyll b(4.23, and 4.72 mg g^{-1} , Total chlorophyll(10.36 and 10.96 mg g^{-1}), number of nuts (141.90 and 143.30 nut plant^{-1}), total nut yield (6815.82 and 7090.42 kg ha^{-1}), total yield of calyx leaves(1769.68 and 1967.81 kg ha^{-1} and fresh weight (2845and 2969 g plant^{-1}) respectively. The C6 treatment was significantly superior to the C5 treatment in the characteristics of chlorophyll b, total chlorophyll, fresh weight, total nut yield, and total yield of calyx leaves.

Keywords: Hibiscus sabdariffa L, NPK combinations, varieties.

Introduction

Roselle plant, also known as “hibiscus,” is a shrubby plant that belongs to the family. Malvaceae The origin of this plant dates back to North Africa and Southeast Asia, and it has spread in many countries around the world because of its health bene-

fits and beauty [1]. Roselle is used for many purposes, including its use in making refreshing drinks and tea, Roselle juice is extracted from its fruits and delicious drinks that are beneficial to health are prepared. Roselle leaves contain significant amounts of carbohydrates, approximately 25%, proteins, ash, fats, fibers, water, carotene, and vitamins (Thiamine, Riboflavin, ascorbic acid and Niacin). Also, contains mineral elements such as phosphorus, manganese, iron, calcium and sodium. Roselle is also used in the manufacture of perfumes and medical and cosmetic preparations due to its antioxidant and anti-inflammatory properties. It is also considered a tolerant and easy to cultivate plant, as it can be grown in both wet and dry lands [2]. In the industrial field, the Roselle plant contributes to many industries, as its stems are considered an important source of pulp that is used in making paper, and these leaves receive wide international attention and are therefore used in the cosmetic and pharmaceutical industries [3].

Chemical fertilizers have an important role in increasing crop productivity in general, so they contribute directly or indirectly to increasing the synthesis of effective and medically important substances, as nitrogen is the first nutrient element that determines the production of agricultural crops [4,5], and it is one of the elements that crops need most and the first determinant of their ability to The plant is able to benefit from the phosphorus and potassium absorbed from the soil to control the vital processes within the plant [6,7]. Phosphorus is also one of the necessary nutrients that the plant needs in order to grow well, as phosphorus speeds up the maturation process of plants because it is an essential element for growth [8], potassium is also one of the major nutritional elements. Which plays an important role in keeping plants alive under the effects of environmental stress. Potassium is essential for many important physiological activities and processes, such as the process of carbon analysis and the transfer of nutrients resulting from the process of carbon metabolism to the lower organs of the plant [9] in addition to activating enzymes and reducing the absorption of harmful ions such as sodium. (Na^{+2}) and iron ions in silty and saline soils [10]. Studying the process of balance between these three elements, which are called the main elements, is of great importance, as the presence of an element in the soil solution in a quantity that exceeds the other elements has a negative effect on the absorption of the other elements. Therefore, attention must be paid to the issue of the added amounts of elements in a balanced manner to achieve the maximum benefit from their addition and reflection. In the characteristics of plant yield, in addition to causing the problem of pollution when used unscientifically, in addition to the economic cost as a result of adding them in large quantities [11]. Therefore, the aim of applying this study was to test the efficiency of several combinations from NPK on some growth and yields traits of two varieties of Roselle plant by achieving a nutritional balance of the main elements to reduce the effects of pollution by fertilizers.

Materials and Methods

A field experiment was carried out on spring season 2022 in one of the agricultural experiment fields belonging to the Ibn Al-Bitar Vocational Preparatory School located

in Al-Husseiniyah District - Karbala Governorate. According to a randomized complete block design (RCBD) in the order of factorial experiments and with three replications, with two factors, the first included combinations of NPK fertilizers and according to the codes as follows: C0= 0 NPK kg ha^{-1}, C1= 50,25,25 NPK kg ha^{-1}, C2= 75,50,50 NPK kg ha^{-1}, C3= 100,75,75 NPK kg ha^{-1}, C4 = 125,100,100 NPK kg ha^{-1}, C5= 150,125,125 NPK kg ha^{-1}, C6= 175,150,150 NPK kg ha^{-1}.

The second factor is the two varieties of Roselle plant (white and red), whose symbols are R and W, respectively. The area of each experimental unit was (12) m^2. Nitrogen fertilizers are added in two batches after germination and before reaching the flowering stage, according to the treatments. As for phosphorus and potassium, they are added in two batches, one batch before planting and the second batch with the second batch of nitrogen fertilizer, according to the treatments. the weeding process was carried out three times during the crop growth period. The following characteristics were studied:

Plant height (cm): It was calculated as an average of five plants randomly selected from the center lines of each experimental unit, and the height was measured from the base of the plant at the soil surface level to the top of the plant, using a graduated measuring ruler.

Leaf area (m^2): The leaf area of the determined plants was calculated using a device (Digital Planimeter) by placing the plant leaf on a white sheet of paper, then passing the device's lens over the borders of the leaf three times, then calculating the average leaf area of each plant.

Number of leaves (leaf $plant^{-1}$): The number of leaves was counted for randomly selected plants for all experimental units.

Chlorophyll content: The content of chlorophyll a, b and total chlorophyll in the leaves of the fully developed Roselle crop was estimated by taking 100 mg of the fresh leaves of the study plants, cut them into several small pieces and ground them with 6 ml of acetone at a concentration of 80% until The color of the precipitate became free of the green dye. Then the filtrate was separated from the precipitate using a centrifuge at 1600 for a period of 10 minutes. The extract was then collected in volumetric tubes covered with certain opaque paper in order to block the light from the chlorophyll to prevent photooxidation of the dye. The volume was completed by adding acetone, and a sample was pre-pared. (Blank) which contains all the materials used in the experiment except the plant sample, then the optical density (Absorbance) of the filtrate was measured using a Spectrophotometer at the wavelengths of 645 and 663 nm, then the total chlorophyll a and b in the plant leaves were estimated based according to the approved method [12] and according to the equations below:

Chlorophyll a = {12.7 (D663) - 2.69 (D645)} xV÷1000×W
Chlorophyll b = {22.9 (D645) – 4.68 (D663)} x V÷1000×W
Total Chlorophyll = {20.2 (D645) + 8.02 (D663)} x V÷1000×W
Were:
V: Final volume of filtrate

D: Reading the optical density of extracted chlorophyll
W: Fresh weight (g)

Fresh weight (g plant^{-1}): Five plants were cut from the surface of the soil for each experimental unit, and their fresh weight was recorded using a sensitive balance, then their average was taken.

Number of nuts (nut plant^{-1}): The number of nuts was calculated for each five plants randomly and for all experimental units, and then their average was taken in each experimental unit.

Total yield of nuts (kg ha^{-1}): The total yield of nuts was calculated by estimating the yield of one plant and then finding the total yield per hectare on the basis of plant density, which amounts to 26.666 plants ha^{-1}.

Total yield of calyx leaves (kg ha^{-1}): The total yield of calyx leaves was calculated after drying them until the weight was constant, by finding the total yield of one plant and then finding the total yield per hectare based on the plant density.

Statistical analysis

The data were collected from the field experiment and the results were statistical-ly analyzed according to the analysis of variance (ANOVA) as per the RCBD design [13] the least significant difference ($L.S.D_{0.05}$) test was used to compare and separate the means. The statistics software GenStat12 was employed.

Results and Discussion

Plant height (cm)

The results of Table (1) showed that there was a significant difference between the two varieties (red and white), as the red variety excelled in plant height with an average 173.27 cm, while the white variety gave an average 159.76 cm, with an increase rate of 8.4%. The reason for the superiority of the variety may be due to Red refers to genetic differences and its suitability to environmental conditions and nutritional requirements for growth of the variety [14].

The results of the same table showed that the fertilizer combinations caused a significant effect on the plant height, as the C6 combination gave the highest average plant height 195.05 cm, and it did not differ significantly from the average of the C5 combination, which amounted to 189.05 cm, compared to the C0 treatment (no addition), which gave an average 138.45 cm, with an increase of 40%, while combinations C1, C2, C3 and C4 gave averages of 148.45, 153.65, 165.2 and 175.75 cm, respectively. This superiority may be attributed to the role of KPN fertilizer combinations in stimulating cell division and elongation, which provided a suitable environment for plant growth and thus increased the efficiency of the photosynthesis process and increased the representation of dry matter in the plant, which was reflected in the length of one internode and also the number of internode, and thus was reflected positively in the height plant, especially when the soil suffers from A decrease in the level of NPK [10].

The results of the same table showed that there was a significant interaction between the studied varieties and the fertilizer combinations, as the highest plant height was reached when the combination C6 was combined with the red variety, with an average of 203.10 cm, and it did not differ significantly from the average of the combination C5 and C4 for the same variety and C5 and C6 for the white variety, while the least interaction was in the white variety at C0 combination , the average reached 132.30 cm.

Table (1): Effect of NPK combinations, varieties and their interaction in plant height (cm)

Combinations	Varieties		Average
	Red	White	
C0	144.60	132.30	138.45
C1	156.50	140.40	148.45
C2	158.01	149.30	153.65
C3	169.70	160.70	165.20
C4	184.20	167.31	175.75
C5	196.80	181.30	189.05
C6	203.10	187.01	195.05
Average	173.27	159.76	
L.S.D $_{0.05}$	Varieties	Combinations	Interaction
	9.50	17.77	25.13

Leaf area (m^2)

The results of Table 2 showed that there was a significant difference between the two varieties of the Roselle plant (red and white), as the red variety excelled in leaf area with an average 3.48 m^2, while the white variety gave an average of 3.03 m^2, with an increase rate 14%. The reason may be the difference in the nature of the response, as the red variety has a large plant mass in a short time compared to the white variety [15].

The results allso showed that the fertilizer combinations had a significant effect, as the C3 combination excelled with the highest average 4.90 m^2, and did not differ significantly from the average of the C4 combination, which amounted to 4.29 m^2, compared to the C0 treatment (no addition), which gave an average of 1.58 m^2, with an increase percentage of 14%, while combinations C1, C2, C5, and C6 gave averages of 1.86, 2.96, 3.63, and 3.57 m^2, respectively. The reason may be attributed to the availability of the nitrogen element in a balanced manner with the P and K elements, in a sufficient and appropriate manner for the plant, which leads to an increase in the chlorophyll content in the plant leaves and thus the absorption and assimilation of light and the formation of the reducing agent NADPH, which is necessary for the process of re-

ducing CO_2 and its entry into the manufacture and formation of organic materials and compounds, which contribute significantly. Directly in plant growth and this is reflected in increasing leaf area [16]. Or perhaps the reason for the increase in leaf area is due to the role of phosphorus in forming cell membranes and contributing to the transport of sugars and thus expanding the leaves [17].

The results of the same table showed that there was no significant interaction between the studied varieties and fertilizer combinations

Table (2): Effect of NPK combinations, varieties and their interaction leaf area (m^2)

Combinations	Varieties		Average
	Red	White	
C0	1.86	1.31	1.58
C1	2.10	1.62	1.86
C2	3.62	2.30	2.96
C3	4.96	4.85	4.90
C4	4.35	4.23	4.29
C5	4.16	3.11	3.63
C6	3.32	3.83	3.57
Average	3.48	3.03	
L.S.D $_{0.05}$	Varieties	Combinations	Interaction
	0.39	0.73	N.S

Chlorophyll content (mg g^{-1})

The results of Table 5 showed that there was a significant difference between the two varieties of Roselle plant (red and white) in the content of chlorophyll total chlorophyll, where the red variety was superior with an average 6.61 mg g^{-1}, while the white variety gave an average 4.69 mg g^{-1}, with an increase rate of 40.93%. The difference in chlorophyll content between varieties may be due to the genetic nature of the variety in its absorption of light as a result of morphological differences in the external shape of the plant in terms of increasing the leaf area (Table 2), which contributes to increasing the area intercepted by light and thus increasing the activity of the photosynthesis process and thus increasing the chlorophyll content [18].

The results of the same table showed that the fertilizer combinations caused a significant effect on the Total chlorophyll, as the highest average was achieved with the C6 combination with an average 10.96 mg g^{-1}, compared to the C0 treatment, which gave an average 1.10 mg g^{-1}. The discrepancy between fertilizer combination in chlorophyll content may be due to the amount of fertilizer combination added because they contain important elements in the process of photosynthesis, the most important of which is nitrogen, which is one of the components involved in the pyroferon ring,

which is one of the important compounds in building the chlorophyll molecule, as well as its importance in the synthesis of chlorophyll and enzymes. This is consistent with what was found by [19] on the Roselle plant, in addition to the important role of phosphorus in biological processes and its reflection on the efficiency of the plant and its increase in its ability to absorb nitrogen. Increasing the number of leaves, causes an increase in the plant's ability to benefit from nitrogen and increase its absorption rate. And an increase in the area of leaves, as it plays a role in increasing the area intercepted by sunlight and thus increasing the activity of the photosynthesis is process, which is reflected in an increase in the percentage of chlorophyll in the plant [20].

The results of the same table showed that there was a significant interaction between fertilizer types and combinations, as the highest interaction was in the red variety with the C6 combination with an average 12.00 mg g^{-1}, while the lowest interaction was with the C0 combination with an average of 1.00 mg g^{-1} for the white variety.

Leaves number (leaf plant^{-1})

The results of Table 6 showed that there was a significant difference between the two varieties of the Roselle plant (red and white), as the red variety was superior in the number of leaves with an average 295.65 leaf plant^{-1}, while the white variety gave an average 241.02 leaf plant $^{-1}$, with an increase rate 22%. This increase may be due to the superiority of the same variety in total chlorophyll content (Table 6) due to the increased efficiency of photosynthesis, which was therefore reflected in the plant's growth activity, including the number of leaves.

The results of the table (6) showed that the fertilizer combinations caused a significant difference, as the C6 combination excelled by gave the highest average of leaves number, amounting 348.0 leaves plant^{-1}, which did not differ significantly from the average of the C5 combination, which amounted 331.0 leaf plant $^{-1}$, with an increase rate 86%, compared to the C0 treatment, which It gave the lowest average of 187.0 leaf plant^{-1}, while combinations C1, C2, C3 and C4 gave averages of 216.7, 241.4, 262.7 and 291.6 leaf plant $^{-1}$, respectively. The increase in the number of leaves may be attributed to the role of fertilizer combinations of (NPK) and the appropriate state of balance between them and their vital role, as they are involved in the synthesis of enzymes necessary for energy reactions in the process of photosynthesis, since the leaves are the most plant parts containing chlorophyll, and this increases carbon metabolism, which has a clear and positive effect. In the growth and height of the vegetative plant and thus increasing the number of leaves in the plant [21]. as well as the participation of fertilizer combinations in nuclear proteins, which works to increase the origins of the leaves, or perhaps the superiority of the C6 combination in giving it the highest leaf rate is attributed to the plant's progress in growth and the increase in the number of main branches, or perhaps the increase is due to In the number of leaves, it is indicated that by increasing the fertilizer combinations, the plant advances in growth and increases in the number of main and secondary branches, each of which carries a fair number of leaves. Also, the plant's response is greater than the rest of the fertilizer

combinations, and this is reflected in the total vegetative total and A. the number of leaves of the plant, and this is consistent with what was found [22].

The results of the same table showed that there was a significant interaction between the studied varieties and the fertilizer combinations, as the highest interaction was at combination C6 for the red variety with an average 382.0 leaf plant^{-1}, which did not differ significantly from the average for combination C5 of the same variety, while the lowest overlap was in the white variety at combination C0 with an average It reached 176.7 leaf plant^{-1}.

Table 4: Effect of NPK combinations, varieties and their interaction in leaves number (leaf plant $^{-1}$)

Combinations	Varieties		Average
	Red	White	
C0	197.3	176.7	187.0
C1	241.7	191.7	216.7
C2	263.8	219.0	241.4
C3	290.4	235.0	262.7
C4	323.7	259.5	291.6
C5	370.7	291.3	331. 0
C6	382.0	314.0	348.0
Average	295.65	241.02	
L.S.D$_{0.05}$	Varieties	Combinations	Interaction
	20.4	38.30	54.17

Fresh weight (g plant^{-1})

The results of Table 7 showed that there was a significant difference between the red and white Roselle varieties, as the red variety excelled by recording the highest average in the fresh weight, amounting 2188.57 g plant^{-1}, while the white variety gave an average 2014.85 g plant^{-1}, with an increase rate of 8%. This may be due to the nature of the genetic composition of the variety and its superiority in some characteristics such as height and number of leaves (Tables 1 and 6), thus increasing the plant's vegetative total [23].

The results of the table (7) also showed that the fertilizer combinations had a significant effect on the fresh weight, as the C6 combination gave the highest average of the fresh weight, amounting to 2969 g plant^{-1}, to the C0 treatment (no addition), which gave an average of 1189 g sustaining and increasing vegetative growth processes, as well as their role in the formation of proteins, chlorophyll and growth regulators. This is reflected in increased vegetative growth plant, while the combinations C1, C2, C3, and C4 gave averages of 1389, 1787, 2092, and 2440 g plant^{-1}, respectively. This may be due to the role and importance of the elements KPN in and thus an increase in the fresh weight of the plant, or the reason may be due to the effective and positive role of nitrogen in forming a strong vegetative system with the ability In absorbing the neces-

sary elements and nutrients from the soil, thus increasing the efficiency of the carbon metabolism process and thus plant growth [24].

The results of the same table showed that there was a significant interaction between the studied varieties and fertilizer combinations, as the highest interaction was in the C6 combination with an average of 3039 g plant^{-1} for the red variety, while the lowest interaction was in the white variety in the C0 combination with an average of 1167 g plant^{-1}.

Table (5): Effect of NPK combinations, varieties and their interaction in fresh weight (g plant^{-1})

Combinations	Varieties		Average
	Red	White	
C0	1211	1167	1189
C1	1423	1355	1389
C2	1865	1710	1787
C3	2245	1939	2092
C4	2616	2265	2440
C5	2921	2769	2845
C6	3039	2899	2969
Average	2188.57	2014.85	
L.S.D $_{0.05}$	varieties	Combinations	Interaction
	33.91	63.44	89.71

Nuts N (nut plant^{-1})

The results of Table 8 showed that there was a significant difference between the two varieties of the Roselle plant (red and white), as the red variety was superior in the number of nuts with an average of 137.65 nut plant^{-1}, while the white variety gave an average of 101.28 nut plant^{-1}, with an increase rate of 35%. This is due to the role of nitrogen in increasing the number of branches and increasing the percentage of nodes in them, thus increasing the number of nuts carried by one plant, or perhaps due to the nature of the genetic makeup of the variety. [25].

The results of the table (8) showed that the fertilizer combinations had a significant effect, as the C6 combination gave the highest average of 143.30 nut plant^{-1}, and it did not differ significantly from the C5 combination average, which amounted to 141.90 nuts plant^{-1}, compared to the C0 treatment, which gave an average of 89.25 nut plant^{-1}. While the combinations C1, C2, C3 and C4 gave averages of 101.25, 105.50, 121.85 and 127.25 nut plant^{-1}, respectively. The increase in the number of nuts per plant may be attributed to the role of fertilization with NPK fertilizer combinations in stimulating the plant to form a number of new branches to meet the plant's needs for the elements necessary for growth, thus increasing the number of nuts carried on the branches. This is consistent with [26], or it may be attributed to the increase in the leaf area increases the area of light interception and thus increases the efficiency of carbon metabolism

and the accumulation of dry matter. This supports the emergence of shoot starters, their continued growth, and the success of their formation, thus increasing the number of nuts in them, and this is consistent with [27].

The results of the table (8) showed that there was a significant interaction between the studied varieties and fertilizer combinations, as the highest interaction was in the red variety at combination C6 with an average of 161.3 nut plant^{-1} and did not differ significantly from the average of the C5 combinations for the same variety, while the lowest overlap was in the white variety at C0 combination with an average of 76.2 nut plant^{-1}.

Table (6): Effect of NPK combinations, varieties and their interaction in nuts number (nut plant^{-1})

Combinations	Varieties		Average
	Red	White	
C0	102.3	76.2	89.25
C1	123.2	79.3	101.25
C2	127.5	83.5	105.50
C3	136.8	106.9	121.85
C4	142.5	112.0	127.25
C5	158.0	125.8	141.90
C6	161.3	125.3	143.30
Average	137.65	101.28	
L.S.D $_{0.05}$	Varieties	Combinations	Interaction
	1.356	2.537	3.588

Total yield of nuts (kg ha^{-1})

The results of Table 9 showed that there was a significant difference between the two varieties of the Roselle plant (red and white), as the red variety was superior in terms of total nut yield with an average of 6298.44 kg ha^{-1}, while the white variety gave an average of 4592.41 kg ha^{-1}, with an increase rate of 37.14%. This superiority may be due to the superiority of this variety in most of the components of yield, and thus it was reflected positively in increasing the total nut yield, and this agrees with [19]. Also, the white variety recorded the lowest averages in most of the traits. The reason for this may be due to the lack of leaf area, which affected the process. The process of photosynthesis, vegetative growth, and the lack of transfer of dry matter to the crop, thus reducing the yield of nuts, and this is consistent with [28].

The results of the same table showed that the fertilizer combinations had a significant effect, as the C6 combination excelled with the highest average of 7090.42 kg ha^{-1}, compared to the C0 treatment, which gave an average of 3217.38 kg ha^{-1}, while the combinations C1, C2, C3, C4, and C5 gave averages of 4186.02 and 5431. 72, 5582.52, 5794.11, and 6815.82 kg ha^{-1}, respectively. The reason for this increase may be due to the role of fertilizer combinations in increasing plant growth activity and this

is reflected in the superiority of this combination in the number of nuts (Table 8), and this explains its superiority in the total nut yield [21].

The results of the same table showed that there was a significant interaction between the studied varieties and fertilizer combinations, as the highest interference was in the red variety at combination C6 with an average of 8372.99 kg ha^{-1}, while the lowest interference was in the white variety at combination C0 with an average of 2728.19 kg ha^{-1}.

Table (7): Effect of NPK combinations, varieties and their interaction in total yield of nuts (kg ha^{-1})

Combinations	Varieties		Average
	Red	White	
C0	3706.57	2728.19	3217.38
C1	4718.81	3653.24	4186.02
C2	5946.51	4916.94	5431.72
C3	6594.50	4570.55	5582.52
C4	6693.16	4895.07	5794.11
C5	8056.59	5575.06	6815.82
C6	8372.99	5807.85	7090.42
Average	6298.44	4592.41	
L.S.D $_{0.05}$	varieties	Combinations	Interaction
	37.64	70.41	99.58

Total yield of calyx leaves (kg ha^{-1})

The results of Table 10 showed that there was a significant difference between the two varieties of the Roselle plant (red and white), as the red variety was superior in terms of the total yield of calyx leaves with an average of 1558.01 kg ha^{-1}, while the white variety gave an average of 1319.42 kg ha^{-1}, an increase of 18.08%. This may be due to the superiority of the red variety in terms of number of nuts and total nut yield (Tables 8 and 9).

The results of the same table showed that the fertilizer combinations caused a significant effect on the dry yield of calyx leaves, as combination C6 gave the highest average of 1967.81 kg ha^{-1}, compared to the C0 treatment (no addition) which gave an average of 987.3 kg ha^{-1}, while the combinations gave C1, C2, C3, C4, and 5C had averages of 1130.5, 1236.23, 1407.56, 1571.95, and 1769.68 kg ha^{-1}, respectively. This may be attributed to the role of fertilizer combinations, especially the superior combination (C6), in increasing the shoots, such as plant height (Table 1), fresh weight (Table 7), number of nuts, and the total yield of nuts (Tables 8 and 9), which was reflected positively in increasing the total yield of leaves [29].

The results of the same table showed that was a significant interaction between the studied varieties and fertilizer combinations, as the highest interaction was in the C6 combination with an average of 2081.01 kg ha^{-1} for the red variety, while the lowest

interference was in the white variety in the C0 combination with an average of 899.17 kg ha^{-1}.

Table (8): Effect of NPK combinations, varieties and their interaction on total yield of calyx leaves (kg ha^{-1})

Combinations	Varieties		Average
	Red	White	
C0	1075.43	899.17	987.3
C1	1218.90	1042.10	1130.5
C2	1370.36	1102.10	1236.23
C3	1570.62	1244.50	1407.56
C4	1682.62	1461.29	1571.95
C5	1907.15	1632.22	1769.68
C6	2081.01	1854.62	1967.81
Average	1558.01	1319.42	
L.S.D $_{0.05}$	varieties	Combinations	Interaction
	35.60	66.61	94.20

It was noted from the results of the current study that NPK combinations had an important role in increasing the growth and yield of the hibiscus plant, especially the C5 and C6 combinations. It was also noted that the red variety was superior to the white variety in all characteristics as a result of its adaptation to the prevailing conditions in the region. This could also be due to The nature of the genetic makeup of the variety.

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