

ISSN: 2695-2556 (Online)

ISSN: 2651-5679 (Print)

AKSU Journal of Agriculture and Food Sciences 8(3) 103-113

© Faculty of Agriculture, Akwa Ibom State University, Nigeria

Outcome of Poultry Manure Rates and Planting Space on Yield, Incidence and Severity of Fusarium Necrotic Leaf Spot on Roselle Plants (*Hibiscus Sabdariffa* L)

***Christian C. Iwuagwu and Chinaza B. Okafor**

Department of Crop Science and Horticulture, Nnamdi Azikiwe University Awka, Anambra State, Nigeria

*Corresponding Authors Email: chrisiwuag@yahoo.com Tel: +2348061156141

Abstract

*Roselle (*Hibiscus sabdariffa* L.) is an annual plant that belongs to the family Malvaceae. It is a plant with a rich history of cultivation and utilization in traditional cuisines and medicinal practices. A field experiment was conducted to study the outcomes of different poultry manure rates and planting space on growth, yield, disease incidence and severity of Roselle plants. The research was carried out at the Research Farm of the Crop Science and Horticulture Department, Nnamdi Azikiwe University, Ifite-Ogwari, Anambra State Nigeria. The experiment was a 4×2 factorial laid out in a Randomized Complete Block Design (RCBD) with three blocks and eight treatment combinations. The two planting distances used were: 60×60 cm and 60×45 cm while poultry manure (PM) rates were: 0, 1.5, 2.5 and 3.5 t ha⁻¹. Data on growth parameters, yield characteristics, and disease incidence were collected over a period of 12 weeks. Analysis of variance (ANOVA) was conducted using the SAS software, and significant differences among treatment means were evaluated using the Least Significant Difference (LSD) at a 5% probability level. The results showed that planting space (60×45 cm and 60×60 cm) and poultry manure rates (0, 1.5, 2.5, 3.5 tons) did not significantly affect plant height, number of leaves, leaf area, number of buds, number of flowers, or total yield. However, the interactive effects of planting space and manure rate showed some variations in growth characteristics. Despite non-significant variations in treatments, poultry manure at 3.5 tons per hectare consistently yielded the best growth parameters, particularly at a planting space of 60×60 cm. Furthermore, there was no significant difference in disease incidence and severity among the treatments. However, higher rates of PM were associated with increased disease severity. In conclusion, the significant effect of the PM rates and the planting space on growth and yield characteristics, disease incidence and severity may be due to the close proximity of the two planting spaces and the PM used. Farmers are recommended to adopt wider planting spaces and higher rates of PM for improved growth and yield. Additionally, purchasing disease-resistant seeds and planting at the onset of the rainy season are advisable practices to mitigate disease incidence and enhance overall crop productivity.*

Keywords: Roselle plants, Poultry manure, Planting space, Yield, Necrotic Leaf Spot

1.0 Introduction

Roselle (*Hibiscus sabdariffa* L.) is an annual plant that belongs to the family Malvaceae (Onyeukwu *et al.*, 2023). The versatile crop is suitable for developing countries due to its ease of cultivation and its ability to be grown as part of multi-cropping systems (Sukkhavanit *et al.*, 2011). It has various local names, such as Roselle, Loisel, Jamaica, Bissap, and Dâ, depending on the region (Mehdi *et al.*, 2013). It is also known as karkade in North Africa and the Middle East, and its name is used in the pharmaceutical and food flavouring trade in Europe (Mehdi *et al.*, 2013). In China, the seeds of *Hibiscus sabdariffa* are used for oil extraction, while the plant itself is valued for its medicinal properties (Sukkhavanit *et al.*, 2011).

The Roselle plant is believed to have originated from the tropical and subtropical regions of West Africa, specifically spanning from Sudan to Senegal (Grivetti and Ogle, 2000). In these regions, it has a long history of cultivation and utilization in traditional cuisines and medicinal practices. This versatile plant is distributed globally, with significant cultivation in Africa, Asia, the Americas, and other regions due to its adaptability to tropical and subtropical climates (Mehdi *et al.*, 2013).

Roselle production is a significant industry in Sudan, China, and Thailand, with a focus on the production of calyces. Sudanese roselle calyces are highly sought after in Germany, with export prices reaching approximately \$1700 per ton in the 1992-93 seasons. In Sudan, roselle cultivation is widespread, particularly in Kordofan and Darfur, and serves as a cash crop for traditional farmers. The cultivated area has expanded over the years, leading to increased production from 454 tons in the 1960s to 26,000 tons in the 1999/2000 season (McGregor *et al.*, 2004). In Nigeria, Roselle cultivation is spread across different States, with notable production occurring in northern states such as Kano, Katsina, Sokoto, Jigawa and Gombe as well as South-western States like Oyo and Ogun.

Its leaves, stems, flowers (calyces), and fruits are utilized in different forms (Osei and Dzomeku 2018; Galaudu, 2006). The seeds and fibre serve as raw food materials for foreign exchange, while the seed oil is used in beverages, folk medicine, and pharmaceutical industries (Aryal, 2014). The plant contains chemical components like polyphenols, phytosterols, tocopherols, and vitamins C, iron, calcium, and carotenes. These components contribute to its medicinal properties, including antihypertensive, anticancer, and antioxidant effects. Roselle seeds have a nutritional composition that includes protein, crude fibre, oils, and carbohydrates. The oil derived from roselle seeds contains phytosterols and tocopherols, which can help reduce the absorption of dietary cholesterol. The nutritional composition of roselle can vary depending on factors like variety and growing conditions.

Roselle (*Hibiscus sabdariffa*) can be susceptible to various pests and diseases that can impact its growth and yield (Mahmoud, 2006). Common pests include aphids, whiteflies, and spider mites, which can be controlled using insecticidal soaps, beneficial insects, or oils. Diseases such as fungal leaf spot, powdery mildew, root rot, and bacterial blight can also affect Roselle plants.

The application of poultry manure can have a positive impact on the yield of *Hibiscus sabdariffa* plants (Yirzagala *et al.*, 2023). Poultry manure is rich in essential nutrients like nitrogen, phosphorus, and potassium, which enhance plant growth. Additionally, it improves soil structure, increases organic matter content, and contributes to long-term soil fertility. However, improper application or composting of poultry manure may pose risks by

disrupting nutrient balance or introducing pathogens. Careful management and composting are crucial to harness the benefits of poultry manure while minimizing disease risks in Roselle cultivation.

Also, Baiyeri and Olajide (2023) and Ekwere *et al.*, (2023), reported that using green manure helps manage agricultural pests and diseases, minimize erosion, control weeds. They opined that organic manure is a practical and sustainable solution to minimize the incidence and severity of disease and pests and increase yield (Dadi, 2022 and Yirzalaga *et al.*, 2023), reported that soil amendments in appropriate proportions and general textural characteristics affected the nutrient availability to soil, rate of disease incidence and severity as well as tomato plant's growth.

Planting space significantly affects *Hibiscus sabdariffa* cultivation, influencing growth, yield, and plant health (Basszinew, 2015). Balancing plant density with individual plant performance is key, requiring customization based on specific conditions. Experimentation and expert consultation are vital for determining optimal planting space. Therefore, the broad objective of this study is to investigate the outcome of poultry manure and plant spacing on growth, yield and disease assessment of Roselle plants.

2.0 Materials and Methods

Experimental site: The field experiment was conducted at the research Farm of the Crop Science and Horticulture, Faculty of Agriculture, Nnamdi Azikiwe University, Ifite-Ogwari Premises. Ayamelum Local Government Area, Anambra State. It is located within the Longitude: 6.94886° or 6° 56' 56" East and Latitude: 6.60466° or 6° 36' 17" North.

Source of planting material: *Hibiscus sabdariffa* seeds were sourced from a seed outlet in Gombe state. Poultry droppings were gotten from a poultry farm at Ifite-ogwari, Anambra state.

Land preparation and planting: The land was cleared of existing vegetation, ploughed, and harrowed with the use of hoes and the beds were constructed. Poultry manure was applied after ploughing and bed formation, where each bed received the requisite amount as the treatments were randomly assigned and allowed to cure for one week before planting. The *Hibiscus sabdariffa* seeds were planted on beds of size 2m x 2m with the spacing of 0.5m, and with inter block space of 1m each to ease movement during cultural operations. The experimental layout was divided into 3 blocks, each block containing 8 beds to give a total of 24 beds.

Data collection: Data were collected on the following parameters: Plant height (cm) at 4 weeks interval, calculated leaf area (cm²) at 4 weeks interval, number of leaves at 4 weeks interval, number of flowers per plant, number of buds per plant, disease incidence, disease severity and yield per plant.

Disease incidence: Assessment of disease incidence was carried out by visual observation and recording of infected plants in the plots sampled. The percentage disease incidence of the Roselle plants was determined as suggested by Iwuagwu *et al.* (2019) by the following equation:

$$\text{Disease incidence (\%)} = \frac{\text{number of diseased plants}}{\text{Total number of plants sample}} \times 100 \dots \dots \dots \text{Equation 2.1}$$

Disease severity: This was assessed by recording the extent or degree of the disease infected Roselle plants of sampled plots. A five-point scale of 0-5 was used (Iwuagwu *et al.*, 2019). Where: 0 = No infection, 1= 1-20% of plants infected, 2= 21-40% of plants infected, 3= 41-60% of plants infected, 4= 61-80% of plants infected and 5= 81-100% of plants infected

Statistical analysis: The data collected were subjected to analysis of variance (ANOVA) using the SAS software package and significant differences among treatment means were evaluated with the Fishers Least Significant Difference (LSD) at a 5% probability level.

3.0 Results

3.1 Effect of Poultry Manure and Planting Space on Some Growth Characteristics of Roselle Plants

Table 3.1 showed that there was no significant effect of poultry manure and planting space on plant height, number of leaves and leaf area. For plant height, at the 4, 8 and 12th week the highest numerical height (31.47cm) was obtained at a planting space of 60×45cm at the 12th week followed by 31.17cm obtained at planting space of 60×60cm at the 12th week while the least 9.61cm was obtained at 60×60cm at the 4th week. The same trend was also observed in the effect of poultry manure rates where the highest numerical plant height (33.33cm) was obtained when 2.5 tons of poultry manure was applied at week 12 followed by 31.88 cm where 1.5 tons was applied at same week and the least (0.96cm) where no poultry manure was applied at week 4.

For number of leaves, the highest numerical value 16.67 was obtained at a planting space of 60×45 cm at the 12th week followed by 16.08 obtained at planting space of 60×60 cm at the 12th week while the least (7.58) was obtained at 60×60 cm at the 4th week. The same pattern was also observed in the effect of poultry manure rates where leaf number of 19.00 was obtained when 2.5 tons of poultry manure was applied at week 12 followed by 18.34 when 3.5 tons was applied. The least (7.00) number of leaves was obtained at week 4 where no poultry manure was applied. For leaf area: the largest numerical leaf area (23.7cm²) was obtained at planting distance of 60×45 at week 12 followed by 22.8 cm² at planting distance 60×60 in the same week while the least (12.01 cm²) was seen at planting distance 60×45cm at the 8th week. A similar trend was observed in the effect of poultry manure rates where the highest (27.0 cm²) was recorded when 3.5 tons was applied at the 12th week followed by (23.6 cm²) in the same week where 1.5 tons was applied and the least (9.03 cm²) at the 8th week.

There was no significant interaction between plant space and poultry manure on all parameters measured (Table 3.1). Generally, the effect of poultry manure on plant height, number of leaves and leaf area were the same at both plant spacing studied.

Table 3.1. Effects of poultry manure rates and planting space on some growth characteristics of Roselle (*Hibiscus sabdariffa*)

Treatments	Plant height (cm)			Number of leaves			Leaf area (cm ²)		
Planting space (cm)	4WAP	8WAP	12WAP	4WAP	8WAP	12WAP	4WAP	8WAP	12WAP
60x45	10.01	17.21	31.47	8.00	10.58	16.67	19.9	12.01	23.7
60x60	9.61	15.28	31.17	7.58	10.08	16.08	17.7	13.83	22.8
LSD _(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Poultry manure rates (tons/ha)									
0	0.96	13.83	28.18	7.00	7.33	12.83	18.7	9.03	20.9
1.5	9.67	17.28	31.88	8.33	10.83	15.33	17.3	13.47	23.6
2.5	9.87	17.30	33.33	7.33	12.33	19.00	15.9	17.2	21.6
3.5	10.07	17.10	31.90	8.50	10.83	18.34	23.3	12.10	27.0
LSD _(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction									
PS×MR	NS	NS	NS	NS	NS	NS	NS	NS	NS

MR=Poultry manure rates, PS=Planting space, WAP=Weeks after planting, NS=Not significant at 5% probability level

3.2 Effects of Poultry Manure and Planting Space on some Yield Characteristics of Roselle Plants

Table 3.2 showed that there was no significant effect of poultry manure and planting space on number of buds, number of flowers and total yield. For number of buds, highest numerical number of buds (6.17) was obtained at the planting space of 60×60cm at the 12th week followed by (6.08) at a planting space of 60×45cm at the 12th week while the least (3.17) was obtained at a planting space of 60×60cm at week 8. The same trend was seen in poultry manure rates applied where the highest numerical (7.67) was seen at week 12 when both 3.5 and 2.5 tons were applied respectively and the least (2.50) when no poultry manure rate was applied at week 8.

There was an equal number of flowers seen at both planting space 60×60 and 60×45 respectively. For poultry manure rates, mean value of 3.33 flowers was seen when 3.5 tons of poultry was applied at the 12th week followed by 2.67 when 2.5 tons of poultry manure was applied and the least 2.00 when no poultry manure was applied in the same week.

For the yield results: the highest numerical yield 185kg was seen in planting distance of 60×45 followed by 173kg seen in planting distance of 60×60 at the 12th week. The same trend was seen in poultry manure rates where the highest yield 273kg was recorded when 3.5 tons was applied followed by 222kg when 2.5tons was applied and the least 91kg when no poultry manure was applied. There was no significant interaction between both treatments on the yield parameters too.

Table 3.2 Effects of poultry manure and planting space on yield and some characteristics on Roselle (*Hibiscus sabdariffa*)

Treatments	No of buds	No of flowers	Yield/plot (kg)	Yield (ton/ha)
Planting space (cm)	8 WAP	12 WAP	12 WAP	12 WAP
60×45	3.42	6.08	2.58	0.185
60×60	3.17	6.17	2.58	0.173
LSD (0.05)	NS	NS	NS	NS
Manure rates (t/ha)				
0	2.50	4.00	2.00	0.091
1.5	3.17	5.17	2.37	0.130
2.5	4.00	7.67	2.67	0.222
3.5	3.50	7.67	3.33	0.273
LSD (0.05)	NS	NS	NS	NS
Interaction				
PS×MR	NS	NS	NS	NS

MR=Poultry manure rates, PS=Planting space, WAP=Weeks after planting, NS=Not significant at 5% probability level

3.3 Effect of Poultry Manure and Planting Space on Disease Incidence and Severity

Table 3.3 showed that there was no significant effect of poultry manure and planting space on disease incidence in most weeks of measurement. Numerically, the highest incidence (99.75%)

occurred at a planting space of 60×45cm at the 12th week followed by 99.33 at planting space of 60×60cm at the 12th week while the least (88.5) occurred at 60×60cm at the 4th week. The same trend was also observed in the effect of poultry manure rates where the highest incidence (99.67%) was seen when 0, 1.5 and 3.5 tons of poultry manure was applied at week 12 followed by the incidence value of 99.17% where 2.5 tons was applied at same week and the least (85.0%) where 3.5 tons of poultry manure was applied at week 4.

For disease severity, there was also no significant effect ($P>0.05$) of planting space and poultry manure at the 4, 8 and 12th weeks after planting. However, the highest severity (4.667) was seen at planting space of 60×45cm at the 12th week followed by (4.500) observed at planting space of 60×60cm at the 12th week while the least (1.75) was seen at 60×60cm at the 4th week after planting. The same pattern was also observed in the effect of poultry manure rates where the highest severity (4.667) was seen when 3.5 and 1.5 tons of poultry manure was applied at week 12 followed by incidence value of 4.5 observed when where 2.5 tons was applied at same week and the least (1.67) at week 4 where no poultry manure was applied. In addition, planting space x manure rates interaction revealed no significance difference.

Table 3.3 Effects of poultry manure and planting space on disease incidence and severity

Treatments	Disease incidence in percentage			Disease severity		
Planting space (cm)	4WAP	8WAP	12WAP	4WAP	8WAP	12WAP
60×45	90.3	98.75	99.75	2.177	3.75	4.677
60× 60	88.5	96.00	99.33	1.75	3.17	4.500
LSD (0.05)	NS	2.743	NS	NS	NS	NS
Manure rates (t/ha)						
0	91.8	97.17	99.67	2.00	3.33	4.500
1.5	89.2	97.50	99.67	2.00	3.67	4.667
2.5	91.7	97.67	99.27	1.67	3.50	4.500
3.5	85.0	97.27	99.67	2.17	3.33	4.677
LSD (0.05)	NS	NS	NS	NS	NS	NS
Interaction						
PS×MR	NS	NS	NS	NS	NS	NS

MR=Poultry manure rates, PS=Planting space, WAP=Weeks after planting, NS=Not significant at 5% probability level

3.4 Identification of Fungi Associated with Roselle Plants (*Hibiscus sabdariffa*) in the Field

The result of isolation of pathogen associated with Roselle plant in the field shows that the organism isolated and identified was *Fusarium solani*.

4.0 Discussion

4.1 Effect of Planting Space and Poultry Manure Rates on some Growth Characteristics of Roselle Plant

The non-significant effect of plant spacing on plant height, leaf number and leaf area could be because of the closeness of the two-planting space (60×60 and 60×45cm) that was used in the experiment. This result agrees with the findings of Iwuagwu, *et al.* (2019), who reported in his work that there was no significant effect of planting space of 60cm x 30cm, 60cm x 40cm and 60cm x 50cm on some growth and yield parameters assessed which included plant height, number of leaves, number of flowers, number of branches, number of flowers, leaf area and yield of egg plants. However, Zaman *et al.* (2021) found out that wider planting space had significant effect on growth parameters than close planting spaces among cotton. Similarly, Monirul *et al.* (2007) reported that plant spacing of 50×50 cm, 50×40 cm, 50×30 cm had significant variation in most growth characteristics of sweet pepper plants.

Furthermore, the non-significant effect of poultry manure on some growth characteristics could be as a result of slight difference in the poultry manure rates and this result corroborates with the findings of Iwuagwu, *et al.* (2022) who worked on Influence of variety and poultry manure rates on diseases incidence and severity of three pepper varieties where they reported that there was no significant difference on number of fruits, fruit length and fruit girth. It could also be that application of fertilizer did not match the crops demand for nutrient or it was as a result of loss of nutrients due to leaching or run off (Adekiya and Agbede, 2017; Efretuei and Udounang, 2020).

4.2 Effect of Planting Space and Poultry Manure Rates on some Yield Characteristics of Roselle Plants

The non-significant effect of planting space on number of buds, flowers and yield could be as a result of the close proximity between the two-planting space (60×45 and 60×60). This result agrees with the findings of Iwuagwu, *et al.* (2019,) and Adekiya and Agbede, (2017), who reported that there was no significant difference seen in some yield parameters in their work on Egg plants and Tomato respectively. Furthermore, Zaman, *et al.*, (2022) added that a wider planting space should be adopted to achieve an increase in the yield of the crop when they worked on cotton.

In addition, the table 3.2 shows that there was no significant difference ($P>0.05$) in the effect of poultry manure rates on the yield parameters of Roselle plants throughout the periods of study which could be as a result of the slight difference in the poultry manure rates (1.5, 2.5, 3.5) used. In the experiment, there was comparatively low yield which might be as a result of the growth period which coincided with the peak of harmattan and dry season. The time of application of the manure was of great implication in that there was no significant effect of poultry manure; this may be because the manure had not mineralized to release the needed nutrient for the Roselle

plants or that the manure was washed off as a result of heavy rainfall at the time of application (Adekiya and Agbede, 2017).

4.3 Effect of Planting Space and Poultry Manure Rates on Disease Severity and Incidence of Roselle Plant

Table 3.3 shows that there was no significant difference ($P>0.05$) on the effect of planting space on disease incidence and severity this could be because the Roselle plants exhibited similar growth and development regardless of planting space. This result corroborates with the findings of Orji *et al.* (2015) in his work on the effect of poultry manure on the incidence and severity of foliar diseases of *Telfairia* they reported that there was no significant effect of poultry manure on disease incidence and severity of the plant.

Results in Table 3.3 also showed no significant effect of different poultry manure rates on disease incidence and severity this could be as a result of already pre-existing soil fertility which means that there shouldn't have been need for additional nutrient or that the poultry manure rates used in this experiment were not substantial enough that should have supplied marginal nutrients that could have led to significant impact as suggested by Iwuagwu, *et al.* (2022) in his work on different pepper varieties and introduction of the plant to the environment where it has not existed.

5.0 Conclusion and Recommendation

This study led to conclusion that planting space and poultry manure had no significant effect on growth parameters, yield parameters, disease incidence and severity of Roselle plants. Although there were no significant differences between manure rates and plant spacing the numerical data suggest that plants with poultry manure at 3.5 tons and a spacing of 60x 60 cm will perform better than plants subjected to lower poultry manure rates and closer plant spacing. Additionally, the result also showed high disease incidence and severity even when no poultry manure was applied and the pathogen identified was *Fusarium solani*. From this study, it is therefore recommended that farmers should adopt wider planting spaces than the ones used in this experiment and higher poultry manure rates in order to have better growth and yield characteristics. Farmers should ensure they plant at the onset of raining season when there is the least pest and disease prevalence and as well purchase seeds that are resistant to pests and diseases from reputable seed outlets in order to obtain a higher productivity.

References

- Adekiya A.O. and Agbede, T.M (2017) Effect of methods and time of poultry manure application on soil and leaf nutrient concentrations, growth and fruit yield of tomato (*Lycopersicon esculentum* Mill). *Journal of the Saudi Society of Agricultural Sciences* (2017) 16, 383–38.
- Aryal, S. (2014). A review on the medicinal, phytochemical, and pharmacological properties of Roselle (*Hibiscus sabdariffa* L.). *American Journal of Phytomedicine and Clinical Therapeutics*, 2(9), 1146-1162.
- Baiyeri, K.P. Olajide, K. in: M. Jawaid, A. Khan (Eds.), Impacts of Green Manure Amendment in Cropping System, Manure Technology and Sustainable Development. *Sustainable Materials and Technology*, Springer Nature Singapore, Singapore. Pp. 241–272.
- Basszinew, D.G. (2015). Influence of variety and plant spacing on yield and yield attributes of Roselle (*Hibiscus sabdariffa*) *Science, Technology and Art Research Journal* 4(4), 25-30.
- Dadi, T.L (2022). Evaluation of yield and economic profitability of using NP and FYM for the production of Roselle. *International Research Journal of Plant Science*. 13(4), 01-10, DOI: <http://dx.doi.org/10.14303/irjps.2022.021>.
- Efretuei, A.O and Udounang, P.I (2020) Maize yield response to NPK fertilizer rates in the tropical rainforest of South-east. *Nigeria. International Journal of Tropical Agriculture and Food systems* 23 (1), 4858-4865.
- Ekwere, O.J., Udounang, P.I., Efretuei, A.O and Umoh, F.O (2023) Evaluation of Rabbit Urine as Bio-fertilizer for the Growth and Yield of Cowpea (*Vigna unguiculata* (L.) walp). *AKSU Journal of Agriculture and Food Sciences* 7(3), 37-48.
- Galaudu, B.M. (2006). Comparative studies of the chemical composition of seeds of roselle (*Hibiscus sabdariffa*), baobab (*Adansonia digitata*), sesame (*Sesamum indicum*) and African locust bean (*Parkia biglobosa*). *African Journal of Biotechnology* 5(3), 283-287.
- Grivetti, L. E. and Ogle, B. M. (2000). Value of traditional foods in meeting macro- and micronutrient needs: the wild plant connection. *Nutrition Research Reviews*, 13(1), 31-46.
- Iwuagwu, C.C, Okeke D.O, Onejeme F.C, Iheaturu, D.E, Nwogbaga, A.C, Salaudeen M.T. (2019). Effect of Plant spacing on yield and disease assessment on two varieties of Eggplant (*Solanum melongena*). *East African Journal of Agriculture and Life Sciences*. 2(5), 281-289.
- Iwuagwu, C.C, Agbodo M.I, Nwogbaga A.C, Agwuwa U.O, Iheaturu D.E, Ejiofor M.E. (2022). Influence of Variety and Poultry manure Rates on Growth, Yield, incidence and severity

- of Fusarium wilt disease on three pepper (*Capsicum annum*) varieties. *Sumerianz Journal of Agriculture and Veterinary* 5 (3), 44-57.
- Mahmoud M.F. Q (2006). Insect pests and predators inhabiting Roselle plants (*Hibiscus sabdariffa* L); A medicinal plant in Egypt. *Archives of phytopathology and plant protection* 39(1), 25-32.
- McGregor, A. J., Camacho, C. D. and Ayuso, M. A. (2004). Post-harvest management of roselle. *International Journal of Horticultural Science*, 10(2), 43-48.
- Mhedi Ansari, Toubia Eslaminejad, Zarrin Sarhadynejad and Tahereh Eslaminejad. (2013). An overview of the Roselle plant with particular reference to its cultivation, diseases and usages. *European Journal of Medicinal Plants*, 3(1), 135-145.
- Monirul Islam, Satyranjan Dahi, M.D Hasanuzzaman Akand, M.D Abdurahim. (2007). Effect of spacing on the growth and yield of sweet pepper (*Capsicum annum* L.). *Journal of Central European Agriculture* 12(2), 328-335.
- Onyeukwu, O.B, Dumebi Chidimma Dibia and Ogochukwu T.N. (2023). *Hibiscus sabdariffa*, uses, nutritional and therapeutic benefits: A Review. *Journal of Bioscience and Biotechnology Discovery* 8(2); 18-23.
- Orji, O. J. Ibeawuchi, . I. I and. Obilo, O. P.(2015). Effect of Poultry Manure on Incidence and Severity of Foliar Diseases and Weed of *Telfairia occidentalis* (Ugu) Intercropped with Cassava and Maize. *Journal of Biology, Agriculture and Healthcare*. 5 (13), 205-211.
- Osei, S. A. and. Dzomeku, I. K. (2018). Plant spacing and time of topping affects growth and yield of roselle (*Hibiscus sabdariffa* L.) cultivated in the Nyankpala Soil Series of Ghana. *Ghana Journal of Horticulture (JHORT)* 13, (1),85-98.
- Sukkhavanit, P; Angkanaporn, K; and Kijparkorn, S. (2011) "Effect of roselle (*Hibiscus sabdariffa* Linn.) calyx in laying hen diet on egg production performance, egg quality and TBARS value in plasma and yolk," *The Thai Journal of Veterinary Medicine* 41(3),337-344. DOI: <https://doi.org/10.56808/2985-1130.2318>.
- Yirzalaga Julius, Peter Quandahor, Ophelia A.A, Listowel A.A, Imoro, A.K.G, Santo and Akanbelum, O.A. (2023). Yield of Roselle (*Hibiscus sabdariffa* L.) as influenced by manure and nitrogen fertilizer application. *American Journal of Plant Sciences* 14, 599-612.
- Zaman, I.; Ali, M. Shhzad, K. Tahir, M.S Wasaya, Allah, Manzer H. Siddiqui and Rahul Datta. (2021). Effect of plant spacings on growth, physiology, yield and fiber quality attributes of cotton genotypes under nitrogen fertilization. *Agronomy* 11, 2589.