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Yield of Roselle (*Hibiscus sabdariffa* L.) as Influenced by Manure and Nitrogen Fertilizer Application

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Abstract

Field experiments were carried out on roselle (*Hibiscus sabdariffa* L) during the 2019 and 2020 cropping seasons at the CSIR-SARI Research Station at Manga in the Upper East Region of Ghana. The aim of the experiment was to study the response of roselle to cowdung, nitrogen fertilizer and their interaction on the growth and yield of roselle. The treatments consisted of factorial combination of five rates of cowdung (0, 1.5, 2.5, 3.5 and 4.5 t/ha) and five levels of nitrogen (0, 20, 40, 60 and 80 kgN/ha) laid out in a randomized complete block design and replicated three times. Data were collected on days to 50% flowering, plant height, number of leaves per plant and dry calyx yield. The results indicated that differences in dry calyx yield due to the manure and nitrogen fertilizer effects were highly significant ($P < 0.01$). Application rate of 2.5 t/ha manure recorded the highest yield of 340 kg/ha and 308.1 kg/ha in 2019 and 2020 respectively. Increasing manure rate from 2.5 - 3.5 t/ha did not result in significant increases in dry calyx yield. The four rates differed significantly from the control which had the least calyx yield of 190.3 kg/ha and 180 kg/ha in 2019 and 2020 respectively. Nitrogen rate of 60 kg/ha recorded the highest dry calyx yield of 510.5 kg/ha and 370.4 kg/ha in 2019 and 2020 respectively which were significantly different from calyx yields recorded by other treatments. The trend on partial budget analysis was consistent in both seasons with the highest yielding treatments (2.5 t/ha cowdung manure and 60 kg/ha) recording the highest net benefit while the control (0 kg/ha) ranked last. The application rate of 2.5 t/ha of cowdung and 60 kg/ha of Nitrogen is thus recommended for optimum roselle production and productivity in the study area.

Keywords

Calyx Yield, "Sobolo", Sepals, Cowdung, Nitrogen Fertilizer

1. Introduction

Roselle (*Hibiscus sabdariffa* var sabdariffa L.) is an important crop in tropical and sub-tropical regions. It is different from other species in view of its bushy branches, which are either reddish or greenish in colour, and its red or pale yellow inflated edible calyces. It is an erect and branched annual sub-shrub (0.5 - 3 m tall) with a strong tap-root system. The flowers are borne on very short peduncles in the axils of the upper leaves, the epicalyxes are made up of 10 linear fleshy bracteoles and the calyx is 8 lobed, becoming large and fleshy after flowering [1]. The plant, normally grown as annual plant, is 0.5 to 2 meters in height. It has a bushy shape with somewhat dense canopy of dark green leaves. The color of the calyx plays an important role in determining the quality of the crop. The crimson red color is the characteristic and most popular and desirable color of roselle, while other shades and colors exist, including the white or greenish white color [2].

The crop is produced in traditional growing conditions by smallholder farmers, and has many industrial and domestic uses. Traditionally, the tender leaves and shoots are eaten as salads and used as pot-herb [3]. The calyx of the red type when partially boiled in hot water is strained and sweetened to taste and is taken as a soft drink commonly known as "Sobolo" in Ghana. Currently, it has good prospects for industrial purposes [4]. Roselle is grown extensively in the semi-arid savanna for local consumption and for export to the Middle East and Europe. The economical part of the plant is the fleshy calyx (sepals) surrounding the fruit (capsules). Fully developed fleshy calyx is peeled off from the fruit by hand and dried naturally under shade to give the dry calyx, which is the consumable product [5]. The red acid succulent calyx is boiled with sugar to produce sorrel drink and is also made into jellies, sauces, chutneys and preserves [1]. The seeds contain about 17% oil, which is similar in properties to cottonseed oil. The seeds are boiled, fermented and dried for use as condiment for local soup preparations (Yakuwa or Batso in Hausa) before the arrival of modern substitutes (e.g. maggi). The fruit contains approximately 84.5% water, 1.7% protein, 1.0% fats and oil, and 12% carbohydrate. Its calyx contains 4% citric acid [6]. It is rich in Vitamin C, contains minerals such as flavonoids and has laxative properties.

Besides food, the traditional preparations from various parts of the plant such as flowers, leaves, calyx and corolla of the roselle are used as remedy for various illnesses. According to [7] in India, Africa and Mexico, all the above parts of the plant are valued in native medicine. The health benefits of hibiscus tea include relief from high blood pressure and high cholesterol and inflammatory problems. It helps to cure liver disease and reduces the risk of cancer. Hibiscus tea has been known to prevent hypertension, lower blood pressure, reduce blood sugar levels. It keeps the liver healthy, helps with menstrual cramps, depression, aids digestion and helps with weight management.

In spite of its economic importance, not much research work has been conducted on it when viewed in relation to the amount of work undertaken on its closely related species, such as cotton [8] [9]. Relatively little has been reported on the agronomy of roselle in the study area (Manga) in the Upper East Region of Ghana. There is currently little information on fertilizer recommendation in the study area for optimal production of the crop; soil nutrient management is based on traditional practices. It is discovered that excessive nitrogen application adversely affects crop yield; increase the cost of production and pollutes the environment [10]. The use of lower dose of nitrogen could lead to significant yield reductions. Thus, the little information on recommended fertilizer application has the potential to hinder the productivity of the crop. With the calyx yield considered as important as the ribbon yield of roselle, there is a need to understand the appropriate application of farmyard manure and nitrogen fertilizer required for its optimum yield. The soils in the Upper East Region of Ghana (Semi-arid Tropics) are very low in organic matter and N, P and K content and these are very necessary for growth and yield of roselle. There is increasing evidence that the non-application of fertilizer is a yield limiting factor in roselle production. [11] reported that the nutritional requirements of roselle are unknown. [12] also reported that variety sabdariffa is adapted to a wide range of soil conditions and is often grown on relatively infertile soils, but that economic yields are obtained on soils which are well supplied with organic matter and essential nutrients. There is therefore, the need to determine appropriate levels of essential nutrients to be supplied through manuring for optimum production. This study was therefore undertaken in Manga Agricultural Research Station of Savannah Agricultural Research Institute of the Council for Scientific and Industrial Research (CSIR-SARI) the Upper East of Ghana to determine optimum rates of cowdung manure and N fertilizer for sustainable roselle production.

2. Materials and Methods

2.1. Description of Study Area

Field experiments on Roselle were carried out in 2019 and repeated during the 2020 cropping season at the Manga Station (11˚01N, 0˚16'W)) of CSIR-SARI, Bawku of the Upper East Region (UER) of Ghana. The region lies in the Sudan savanna agro-ecological zone, which forms the semi-arid part of Ghana. The area is part of what is sometimes referred to as the interior savanna and is characterized by level to gently undulating topography. Important crops cultivated here include millet, sorghum, maize, rice, sweet potato, groundnut, cowpea, soybean, cotton onion and tomato. The Region has alternating wet and dry seasons with the wet season occurring between May and October during which about 95% of rainfall occurs. Maximum rainfall occurs in August, and severe dry conditions exist between November and April each year. Annual rainfall ranges from 900 - 1100 mm. There is wide fluctuation in relative humidity with values as low as 30% in dry season and above 75% in the wet season.

2.2. Land Preparation, Experimental Treatment and Design

During the major cropping seasons (in 2019 and 2020), the experimental area was ploughed, harrowed and ridged using bullock-drawn implements. Lining and pegging were done to establish the plots for the treatments. The ridges were separated by a distance of 1 m. The treatments consisted of factorial combination of five rates of cowdung manure (0, 1.5, 2.5, 3.5 and 4.5 t/ha) and five levels of nitrogen (0, 20, 40, 60 and 80 kgN/ha) laid out in a randomized complete block design, replicated three times. Three seeds per hill were sown at an intra-row spacing of 50 cm inter-row spacing of 75 cm. The three seeds per hill were later thinned to one plant per stand at the first weeding two weeks after sowing. Forty-five (45) kg P_2O_5/ha as single super-phosphate was applied as basal dose at the time of plot layout. The manure was applied and worked into the plots one week before to allow further decomposition before planting. All the manure rates were applied during the field layout while the fertilizer-N rates were split in two equal doses. The first dose was applied after the first weeding two weeks after sowing (2 WAS), while the second dose was top-dressed at 6 WAS. Weeding was done manually at 2 and 6 WAS using hand hoe. The plot with zero level of both nitrogen and manure was used as a control treatment.

2.3. Soil Sampling and Analysis

The soil characteristics were determined in order to know nutrients status of the experimental site before application of the fertilizers. Three composite soil samples were taken for determination of physical and chemical properties. At the beginning of the experiment (in 2019), 15 samples were randomly collected by using an auger and composited. Then, soil samples were also taken from each treatment at harvesting (in 2020). The samples were air dried, crushed with mortar and sieved to pass through 2 mm mesh. The characteristics analyzed for included; Soil pH, Organic matter, Total Nitrogen, Exchangeable Calcium, Magnesium, Potassium, Sodium and Effective Cation Exchange Capacity, and Bray NO.2 Extractable Phosphorus and Potassium. Soil pH was determined using a glass electrode (pH meter) in a soil ratio of 1:2.5 as reported by [13] and [14]. Soil organic matter was determined by the wet combustion method [15]. Percentage total nitrogen was determined by the micro Kjeldahl-technique [15]. The available phosphorus was extracted by the Bray method and determined colorimetrically [16]. Potassium was determined by flame emission photometry [13]. The exchangeable cations calcium, magnesium, potassium and sodium were determined as recommended by [13] using EDTA Titration after extraction with 0.1 N Ammonium Acetate at pH 7. Effective Cation Exchange Capacity (ECEC) was calculated as the sum of the exchangeable bases and exchangeable acidity [13].

2.4. Data Collection

Data were collected on days to 50% flowering, plant height, number of leaves per plant and calyx yield (which was air dried to constant weight). Data collected were subjected to analysis of variance (ANOVA) with GENTSTAT programme, version 12.1 and significant differences among treatment means were evaluated using least significant difference (LSD).

3. Results and Discussion

Results of analysis of soil in the study site showed that the soil was sandy loam and low to very low available P and exchangeable cations (Ca, Mg) (**Table 1**). The pH was acidic for the soil at the experimental site (0 - 20 cm depth). Organic matter content was low while the total N level was high. Exchangeable Ca and K levels as well as available P and K values were also low at the site.

3.1. Effect of Manure (M) and Nitrogen (N) Fertilizer Application on Growth and Development of Roselle

In both years, the effects of manure (M) and nitrogen (N) fertilizer application were highly significant ($P < 0.01$) while M × N interaction effects were not ($P > 0.05$) significant for days to 50% flowering, plant height, number of leaves and dry calyx yield.

Table 1. Selected initial soil chemical properties of the study site in Manga in 2019 cropping season.

Parameter	Measured Value	Required value@ (SRI 2007 guide)
pH (H_2O)	5.1	Acidic: 5.1 - 5.5
Organic Matter (%)	1.0	Low: <1.5
TN ($g \cdot kg^{-1}$)	0.4	High: >0.2
Ex. Ca {Cmol (+)$\cdot kg^{-1}$}	2.02	Low: <5.0
Ex. Mg {Cmol (+)$\cdot kg^{-1}$}	0.32	Not available
Ex. K {Cmol (+)$\cdot kg^{-1}$}	0.16	Low: <0.2
Ex Na {Cmol (+)$\cdot kg^{-1}$}	0.09	Not available
CEC	6.8	Low: <10
Av. P ($mg \cdot kg^{-1}$)	3.8	Low: <10
Av. K ($mg \cdot kg^{-1}$)		Low: <0.2
Depth (cm)	0-20	-
Texture	Sandy loam	-

@SRI: Soil Research Institute of Ghana.

3.2. Phenological Parameters

Days to 50% flowering was significantly earlier ($P < 0.05$) at 2.5 t/ha manure which was 59 days in 2019 and 60 days in 2020. Similarly, days to 50% flowering were significantly earlier ($P < 0.05$) at 60 kg·ha^{-1} kgN/ha which was 61 days in 2019 and 60 days in 2020. Days to 50% flowering were significantly ($P < 0.001$) delayed in the control plots, 78 and 79 days in 2019 and 2020 respectively under manure application and 80 and 79 days in 2019 and 2020, respectively under N fertilizer application. In both seasons, flowering was significantly earlier in plants on treated plots than those on the non-treated plots (control). Flowering was significantly ($P < 0.05$) earlier in plants that received 2.5 t/ha manure and 60 kg·ha^{-1} kgN/ha than other treatments. Early flowering in manure treated plants might be due to optimum P amounts that enhanced early crop development, an observation that is consistent with report by [17] that optimum P rates enhance early crop development. Early flowering in N treated plants is at variance with findings by [18] [19] who reported that application of inorganic fertilizer prolonged flowering and maturity of potato plants. In their view, the prolonged flowering could be associated with the supply of additional nutrients, that may promote the vegetative growth of the plants that in turn prolonged flowering and maturity of potato plants (**Table 2**).

Table 2. Effect of manure, nitrogen and their interaction on the Days to 50% flowering in the 2019 and 2020 cropping seasons.

Treatment	2019	2020
Manure (M) (t/ha)	**DFF**	**DFF**
0	78^{d}	79^{d}
1.5	70^{c}	72^{c}
2.5	59^{a}	60^{a}
3.5	63^{b}	64^{b}
4.5	64^{b}	64^{b}
CV (5%)		
Nitrogen (N) (Kg/ha)		
0	80^{c}	79^{c}
20	81^{c}	80^{c}
40	82^{c}	81^{c}
60	61^{a}	60^{a}
80	73^{b}	72^{b}
CV (5%)	**10**	**12**
Interaction		
M × N	Ns	Ns

* = significant at 5%, ** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

3.3. Plant Height

Manure and Nitrogen application significantly ($P < 0.05$) affected plant height in both cropping seasons (**Table 3**). In 2019, plant height ranged from 95 cm (under 0 Nkg/ha) to 215 cm (under 80 Nkg/ha) whilst in 2020 it ranged from 97 cm (under 0 Nkg/ha) to 230 cm (under 60 Nkg/ha). Thus, the application effects showed that the plant height increased with increased application rates in both seasons. Increased application rates of Nitrogen from zero to the maximum increased plant height by 56% in (2019) and 58% (in 2020) over the control. The reason for this trend could be the availability of nutrients to the crop resulting in increased photosynthetic and metabolic activities. In addition, the trend could be due to stimulation of root growth and development resulting from adequate N supply as well as the uptake of other nutrients [20]. This could be due the function of N in promoting vegetative growth which appears to be more enhanced with the P fertilizer application, an observation which is consistent with reports by [21] who reported that plant height increased with increasing fertilizer levels of nitrogen.

Table 3. Effect of manure, nitrogen and their interaction on plant height of roselle in the 2019 and 2020 cropping seasons.

Treatment	2019	2020
Manure (M) (t/ha)	**Plant height (cm)**	**Plant height (cm)**
0	123.7^a	99^a
1.5	123.6^a	154^b
2.5	126.5^a	160^b
3.5	126.7^a	169^c
4.5	124.5^a	163^b
CV (5%)	**15.0**	**17**
Nitrogen (N) (Kg/ha)		
0	95^a	97^a
20	162^b	188^b
40	167^b	198^c
60	210^c	230^e
80	215^c	213^d
CV (5%)	**12.0**	**10.0**
Interaction		
M × N	Ns	Ns

* = significant at 5%, ** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

3.4. Number of Leaves per Plant

The results revealed significant (P < 0.05) effects of manure and nitrogen applications on number of leaves in both seasons (Table 4). Increasing manure rate from 0 to 2.5 t/ha resulted in significant increase in number of leaves but further addition resulted in significant decrease in leaf number for the two cropping seasons. In 2019, number of leaves ranged from 90 (under 0 t/ha) to 160 (under 2.5 t/ha) whilst in 2020 it ranged from 99 (under 0 t/ha) to 162 cm (under 2.5/ha). Similarly, in 2019, number of leaves ranged from 95 (under 0 Nkg/ha) to 210 (under 60 Nkg/ha) whilst in 2020 it ranged from 97 (under 0 Nkg/ha) to 230 (under 60 Nkg/ha). Thus, the least number of leaves was recorded with the control treatments in both seasons. The positive effect of manure on the number of leaves per plant could be due to the contribution made by manure to fertility status of the soils as the soils were low in organic carbon content. Manure when decomposed increases both macro and micronutrients as well as enhances the physico-chemical properties of the soil. This could have led to high vegetative growth and hence higher number of leaves in comparison to the control. Data in Table 4 further showed that the number of leaves per plant had a positive response

Table 4. Effect of manure, nitrogen and their interaction on the number of leaves per plant in the 2019 and 2020 cropping seasons.

Treatment	2019	2020
Manure (M) (t/ha)	**Leaves /plant**	**Leaves/plant**
0	90^{c}	99^{c}
1.5	142^{b}	154^{b}
2.5	160^{d}	162^{c}
3.5	155^{c}	155^{b}
4.5	156^{c}	153^{b}
CV (5%)	**15.0**	**17**
Nitrogen (N) (Kg/ha)		
0	95^{c}	97^{c}
20	162^{c}	188^{b}
40	167^{c}	198^{c}
60	210^{c}	230^{e}
80	215^{c}	213^{d}
CV (5%)	**12.0**	**10.0**
Interaction		
M × N	Ns	Ns

* = significant at 5%, ** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

to nitrogen application in both years. Plots that received 60 kgN/ha significantly out-yielded the rest in leave number except 80 kgN/ha. The inorganic and organic fertilizer significantly ($p < 0.05$) increased leaf production in soil amended plots more than the control plot. This underscores the importance of nitrogen during the vegetative growth of crop plants [22]. The higher number of leaves in the soil-amended plots might be due to the available nutrients supplied by the organic and inorganic fertilizers which in turn might be due to higher nutrient composition and capacity to increase availability of native soil nutrient through higher biological activity [23]. Earlier flowering observed in plants that received 2.5 t/ha manure and 60 $kg \cdot ha^{-1}$ kgN/ha could be due to adequate supply of nutrients, particularly nitrogen, phosphorus and potassium. These nutrients play major role in cell division, elongation and metabolic processes that enhanced development of leaves. These nutrients have a role in vegetative growth and development in accelerating formation of more leaves. The fertilizers from organic sources improve the availability of plant nutrients by improving soil pH [24] [25] [26]. Studies have also shown that organic fertilizers influence plant growth and production through improving chemical, physical, and biological properties of soils [24] [27] [28].

3.5. Dry Calyx Yield

Dry calyx yield was significantly ($P < 0.05$) affected by both manure and Nitrogen application rates in both cropping seasons (**Table 5**). Application rate of 2.5 t/ha manure recorded the highest yield of 340 kg/ha and 308.1 kg/ha in 2019 and 2020 respectively. The result showed that increasing cowdung manure rate from 2.5 - 7.5 t/ha did not result in significant increases in dry calyx yield, but the other rates differed significantly from the control which had the least dry calyx yield of 190.3 kg/ha and 180.1 kg/ha in 2019 and 2020 respectively. Nitrogen rate of 60 kg/ha recorded the highest calyx yield of 510.5 kg/ha and 370.4 kg/ha in 2019 and 2020 respectively which were significantly different from dry calyx yields recorded by other treatments. This implies that 2.5 t/ha seemed to be adequate for roselle production at Manga under the prevailing circumstances of the trial.

The Nitrogen effect showed that the control treatment had the lowest dry calyx yield (290.3 kgN/ha) and 180.0 kgN/ha in 2019 and 2020 respectively (**Table 4**). The highest yield was obtained when 60 kgN/ha was applied giving an average dry calyx yield of 510.5 and 370.4 kg/ha in 2019 and 2020, respectively. Further increase in the application rate to 80 kgN/ha did not lead to increase in yield. Thus, 60 kgN/ha appeared to produce the highest yield, suggesting it could be the optimum N application rate. [22] also reported a positive response of dry calyx yield to nitrogen application. The increase in dry calyx yield of roselle as a result of nitrogen application may be attributed to an increase in photosynthetic area exhibited as a result of good vegetative growth. The positive response of dry calyx yield of roselle to manure conformed to the findings of [12] who reported that economic yield of roselle is only obtained on soils which are well supplied

Table 5. Effect of manure, nitrogen and their interaction on dry calyx yield in 2019 and 2020 cropping season.

Treatment	2019	2020
Manure (M) (t/ha)	**Calyx yield (kg/ha)**	**Calyx yield (kg/ha)**
0	190.3[a]	180.1[a]
1.5	314.6[c]	277.4[c]
2.5	340.0[d]	308.1[d]
3.5	339.1[d]	310.4[d]
4.5	200.2[b]	242.4[b]
CV (5%)	**11**	**15**
Nitrogen (N) (Kg/ha)		
0	290.3[a]	180.0[a]
20	301.3[a]	292.0[c]
40	402.0[b]	208.7[b]
60	510.5[c]	370.4[d]
80	513.2[c]	280.1[c]
CV (5%)	**12**	**13**
Interaction		
M × N	Ns	Ns

* = significant at 5%, ** = significant at 1%, ns = Not significant. Means in a column followed by the same letter(s) do not differ significantly at 5% level of significance using LSD.

with organic materials and essential nutrients. Similarly, [6] reported that both okra and kenaf, produced best on manured soil rich in humus. [29] obtained the highest dry calyx yield of red variant roselle with 60 kg N/ha at Bauchi, Nigeria. The positive response of dry calyx yield of roselle to nitrogen obtained is in conformity with the findings of [30] and [31] who reported that nitrogen fertilizer increased calyx yield of roselle. Similarly, [32] reported increased calyx with nitrogen application.

The higher dry calyx yield in the soil-amended plots might be due to the available nutrients supplied by the organic and inorganic fertilizers. Control plots recorded delayed flowering, the least number of leaves, and calyx yield while those receiving organic and inorganic fertilizers flowered earlier, produced leaves and calyx yield which were significantly ($P < 0.05$) higher than the control plots. The significant ($P < 0.05$) increase in number of leaves reflects possible utilization of nutrients which affects the overall photosynthetic performance. Increased number of leaves leads to a greater dry matter accumulation of nutrients per unit of land area, because of better utilization of solar radiation. Also, greater number of leaves favours canopy spread, leading to greater photosynthetic activities and suppression of weeds and improvement of calyx yield. [33] reported that, plants absorb sufficient light and increase their photosynthetic efficiency as a result of increased leaf area. This explains why plots that received organic and inorganic fertilizers had higher crop performance. Inorganic fertilizer alone or in combination with cowpdung out-yielded the control plots in dry calyx yield probably due to the contribution of plant nutrients by the cowdung or the N fertilizers. [34] attests to this fact that a positive interaction exists between organic and inorganic inputs when applied simultaneously. Fertilizer inputs have added benefits in terms of improved crop yield, soil fertility status or both [35]. Dry calyx yield was significantly ($P < 0.05$) higher in plants that received 2.5 t/ha manure and 60 kg/ha. This might be due to early flowering as well as optimum rates of nutrients that enhanced early crop development and yield. This observation is in line with report by [17] that optimum plant nutrient rates enhance early crop development.

3.6. Partial Budget Analysis

Partial budget analysis: The economic analysis of the treatments was carried out using benefit-cost ratio (BCR) method. This involved the determination of variable costs, gross returns and net benefits for all treatments. In both seasons, the net benefits (NBs) were generally higher in plots with plants that received cowdung manure or inorganic (Nitrogen) fertilizer application than the control plots (**Table 6**). This could be a result of higher dry calyx yield of roselle in the treated plots. Thus, differences in NBs and BCRs among treatments were basically as a result of differences in dry calyx yield obtained from the different treatments. This is supported by the fact that, treated plots with the highest dry calyx yields consistently also accounted for the highest NBs and BCRs. Thus, the

Table 6. Net Benefit and Benefit Cost Ratio of various treatments during the 2019 and 2020 cropping season.

Treatment	Net Benefit (NB) (GHC)		Benefit Cost Ratio (BCR)	
Manure (M) (t/ha)	2019	2020	2019	2020
0	79.00	68.00	0.71	0.76
1.5	233.10	220.00	1.92	1.80
2.5	392.10	380.50	2.39	2.40
3.5	309.80	327.80	2.04	2.18
4.5	308.09	312.00	2.15	2.16
Nitrogen (N) (Kg/ha)				
0	208.08	209.20	0.80	0.90
20	202.10	208.10	1.90	1.98
40	107.10	178.70	1.90	1.27
60	279.10	219.29	2.91	2.80
80	257.30	200.88	2.19	2.29

trend is consistent, with the highest yielding treatment recording the highest NB and BCR. The trend on partial budget analysis was consistent in both seasons with the highest yielding treatments (2.5 t/ha cowdung manure and 60 Kg/ha) recording the highest net benefit while the control (0 kg/ha) ranked last. The application rate of 2.5 t/ha of cowdung and 60 kg/ha of Nitrogen is thus recommended for optimum roselle production and productivity.

4. Conclusion

There is positive effect of N fertilizer and cowdung manure application on the growth and yield of roselle which could be due to their contribution to fertility status of the soils. Application rate of 2.5 t/ha manure and Nitrogen rate of 60 kg/ha recorded the highest dry calyx yield in both cropping seasons. Roselle plants that received no N application (control) were significantly out-yielded by the other treatments, suggesting the need for N application in Roselle production and productivity. The trend on partial budget analysis was consistent in both seasons with the highest yielding treatments (2.5 t/ha cowdung manure and 60 Kg/ha) recording the highest net benefit while the control (0 kg/ha) ranked last. The application rate of 2.5 t/ha of cowdung and 60 kg/ha of Nitrogen is thus recommended for optimum roselle production and productivity.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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