



GLOBAL JOURNAL OF SCIENCE FRONTIER RESEARCH: C
BIOLOGICAL SCIENCE

Volume 20 Issue 6 Version 1.0 Year 2020

Type : Double Blind Peer Reviewed International Research Journal

Publisher: Global Journals

Online ISSN: 2249-4626 & Print ISSN: 0975-5896

Effects of Organic and Inorganic Fertilizers on Some Vitamins and Mineral Contents of *Hibiscus Sabdariffa linn* (Sorrel)

By Joy Stephen Pudza, Mohammed Adamu Milala, Adam Lawan Ngala
& Stanley Tella Bwala

Abstract- Hibiscus sabdariffalinn (sorrel) is an annual plant belonging to the family malveceae. It has great potential and high economic value especially in the food, pharmaceutical, textile, cosmetic and paper industries. This work was designed to improve the yield and productivity of sorrel. Soil samples were collected from the University of Maiduguri Agricultural Research farm. Fertilizer treatment application and seed sowing were carried out. Weekly measurements of growth parameters including plant height, stem girth, number of leaves per plant and number of branches per plant were observed. Physicochemical composition of pre-treated soil and the chemical composition of the post-treated soils were determined by standard methods. Vitamin A contents of the calyces were determined by HPLC, Vitamin C contents of the calyces were determined by 2,6-dichloroindophenol titrimetric method, mineral contents (P, K, Na, Ca, Mg, Zn and Fe) of the calyces were determined by Atomic Absorption Spectroscopy (AAS).

Keywords: fertilizer, organic, inorganic, vitamins, minerals, sorrel, soil.

GJSFR-C Classification: FOR Code: 069999



EFFECTS OF ORGANIC AND INORGANIC FERTILIZERS ON SOME VITAMINS AND MINERAL CONTENTS OF *HIBISCUS SABDARIFFA LINN* (SORREL)

Strictly as per the compliance and regulations of:



RESEARCH | DIVERSITY | ETHICS

© 2020. Joy Stephen Pudza, Mohammed Adamu Milala, Adam Lawan Ngala & Stanley Tella Bwala. This is a research/review paper, distributed under the terms of the Creative Commons Attribution-Noncommercial 3.0 Unported License (<http://creativecommons.org/licenses/by-nc/3.0/>), permitting all non commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Effects of Organic and Inorganic Fertilizers on Some Vitamins and Mineral Contents of *Hibiscus Sabdariffa linn* (Sorrel)

Joy Stephen Pudza ^α, Mohammed Adamu Milala ^ο, Adam Lawan Ngala ^ρ & Stanley Tella Bwala ^ω

Abstract- *Hibiscus sabdariffa* (sorrel) is an annual plant belonging to the family Malvaceae. It has great potential and high economic value especially in the food, pharmaceutical, textile, cosmetic and paper industries. This work was designed to improve the yield and productivity of sorrel. Soil samples were collected from the University of Maiduguri Agricultural Research farm. Fertilizer treatment application and seed sowing were carried out. Weekly measurements of growth parameters including plant height, stem girth, number of leaves per plant and number of branches per plant were observed. Physicochemical composition of pre-treated soil and the chemical composition of the post-treated soils were determined by standard methods. Vitamin A contents of the calyces were determined by HPLC, Vitamin C contents of the calyces were determined by 2,6-dichloroindophenol titrimetric method, mineral contents (P, K, Na, Ca, Mg, Zn and Fe) of the calyces were determined by Atomic Absorption Spectroscopy (AAS). The results for vitamins A and C showed treatments involving 1/2NPK+10CD (0.78µg/g) and 0NPK+20CD (2.07µg/g) produced the highest calyx contents of vitamins A and C respectively. Treatments involving fullNPK+10CD (0.22mg/g), 0NPK+30CD (4.87mg/g), 1/2NPK+30CD (538.00mg/g), 1/2NPK+30CD (0.92mg/g), fullNPK+30CD (0.67mg/g), 1/2NPK+10CD (1.42mg/g) and 1/2NPK+20CD (0.29mg/g) produced the highest calyx contents of phosphorus, potassium, sodium, calcium, magnesium, zinc and iron respectively. From the study, fertilizer application has greatly increased the yield and productivity of both growth and biochemical parameters thus, fertilizer treatment is necessary for improving the quantity and quality of a plant and its products.

Keywords: fertilizer, organic, inorganic, vitamins, minerals, sorrel, soil.

1. INTRODUCTION

Sorrel (*Hibiscus Sabdariffa Linn*) is a shrub belonging to the family Malvaceae (Mahadevan *et al.*, 2012). It is an annual shrub cultivated in sub-tropical and tropical zones (Kosakowska *et al.*, 2005) for its stem fibres, edible calyces, leaves and seeds. Sorrel is resistant to relatively high temperatures throughout the growing and fruiting period (Tommes, 1990). Sorrel is a short- day crop with a critical photoperiod of 12 to 12.5 hours, and progresses best in hot, dry regions with a high humidity and temperature of about 25°C to 35°C (Hacket *et al.*, 1982). The leaves are consumed as a green cooked vegetable especially in soups (Fasoyiro *et*

al., 2005) while the stems are a source of pulp for the paper industry (Small *et al.*, 1991). The red acid succulent calyces are boiled with sugar to produce sorrel drink. Oil is extracted from the seeds and the residue is usually used in a fermented form as soup or cake (Aliyu, 2000). The most exploited part of a sorrel plant is its calyces which may be green, white, red and dark red (Schippers, 2000). The red calyces contain antioxidants including flavonoids, gossypetine, hibiscetine and sabdaretine (Qi *et al.*, 2005). They are also rich in vitamins and minerals such as riboflavin, ascorbic acid, niacin, carotene, calcium and iron that are nutritionally important (Mahadevan, 2009) as well as amino acids and mineral salts (Cissi'e *et al.*, 2009).

Vitamins and minerals are vital nutrients in human and animal nutrition. Vitamins are indispensable to perform various tasks within the human body in order to promote optimal health and prevent various diseases. Although, vitamins are required in minimal quantities, these quantities cannot be synthesized by the human body, hence, they rely on easily available animal and plant sources for replenishment. Vitamins have diverse biochemical functions. Some, such as vitamin D, have hormone-like functions as regulators of cell and tissue growth and differentiation (such as some forms of vitamin A). Others function as antioxidants (vitamin E and sometimes C) (Bender, 2003). The largest number of vitamins, the B complex vitamins, function as enzyme co-factors (coenzymes) or their precursor.

Minerals are indispensable part of a complete diet of animals. They serve as structural components of body tissues, they are involved in maintenance of acid-base balance and regulation of body fluids, in transport of gases and in muscle contractions. Minerals are chemical elements required as essential nutrients by organism to perform functions necessary for life. (Berdanier *et al.*, 2013). Most of the minerals in a human diet come from plant and animal sources or from drinking water. From the above, the importance of vitamins and minerals cannot be overemphasized and hence, this work was designed to investigate the effects of fertilizer application on some vitamins and mineral contents of sorrel (*Hibiscus sabdariffa*).

Author: e-mail: joystephenpudza@gmail.com

II. MATERIALS AND METHODS

a) Chemicals

All chemicals used for the analysis were of analytical grade and were purchased from Guangdong Guanhua Science Tech. Co. Ltd, Shantou china.

b) Soil collection and Preparation

Soil sample was collected from the University of Maiduguri Agricultural research farm, located in Maiduguri, at a depth of 0-20cm from ground surface. The soil was sieved using a 2.0mm mesh sieve to remove stones and debris. Soil sample was homogenized and weighed. Eight-kilogram (8kg) soil was put into 5litre plastic pot. A total of 36 plastic pots divided into 12 treatments were used. The physicochemical composition of the soil was determined before treatment application using standard procedures which involved Kjeldahl method (Kjeldahl, 1982) for total nitrogen, pH and electrical conductivity (EC) by pH meter and EC meter, soil organic carbon (OC) and organic matter by the Walkley and Blake (1965) method.

c) Treatment / Experimental design

The experiment was a one-season pot experiment which comprised of 12 treatments. Treatments involved the application of two types of fertilizers to the soil sample within the pot. Three levels of inorganic fertilizer (NPK) at 0: 0: 0, 50:30:30, 25:15:15 kg/ha and four rates of organic fertilizer (cow dung) tones/ ha were used. Fertilizer application was in single and in combination. Organic fertilizer (cow dung) was applied and left to equilibrate for a period of one week before seed sowing was carried out. Inorganic fertilizer (NPK) was applied to soil sample after which seed sowing took place. Treatment was replicated three times in a Completely Randomized Design (CRD) which lasted for a period of 12 weeks.

d) Seed Sowing and Measurements

Sorrel seeds were identified and authenticated as viable by a taxonomist from the faculty of Science, Department of Biochemistry University of Maiduguri, and three seeds were sown per pot. Various agronomic practices such as thinning and weeding was carried out to enhance high yield (Babatunde et al., 2001). Measurements of different growth parameters were carried out weekly from the time of germination to the period of termination of experiment. These growth parameters included: plant height, stem girth, number of branches per plant and numbers of leaves per plant. The plant height was measured with the aid of a meter rule, stem girth (distance around the plant) was measured with the help of a Verniercaliper. The number of branches per plant were spotted and counted as well as the number of leaves per plant.

At harvest, plants were uprooted, the stems were detached from the roots as well as the calyces from the stems, total fresh weight of stems, roots and calyces were measured with the help of a weighing balance(Gulfex Medical and Scientific England). The variables (stems, roots and calyces) were oven dried at a temperature of 65°C for 24 hours and the total dry weights were measured. Other variables measured included physicochemical composition of the post treated soil, some vitamins and mineral contents.

e) Physicochemical Analysis of Post-Treated Soil

Physicochemical analysis of the post treated soil (after harvest) was carried out. The analysis included total nitrogen, available phosphorus, soil organic carbon (OC), organic matter (OM), electrical conductivity (EC), soil pH and exchangeable cation (Ca^{2+} , Mg^{2+} , K^+ and Na^+).

f) Determination of Some Vitamins (vitamin A and C) from the calyx

Vitamin A was determined by the HPL Cmodified method (Adopted from USF 2007 volume 1). Standard preparation was carried out by dissolving an accurately weighed quantity of USP vitamin A Reference standard in n-hexane and diluted quantitatively, and a step wise to obtain a solution having a known concentration of about 15 μ g (0,015mg) of retinol acetate per ml. Assay preparation was carried out by transferring about 15mg of vitamin A ester (Retinol acetate or retinyl palmitate), accurately weighed to 100ml volumetric flask, dissolved in and diluted with n-hexane to volume and mixed. 5.0ml of this solution was pipetted into a 50ml volumetric flask, diluted with n-hexane to volume, mixed and scanned at 210nm. Sample preparation was carried out by dissolving 1g of the sample in 10ml of n-hexane, it was sonicated for 30minutes then centrifuged at 2500rpm for 10 minutes. Supernatant was collected in a cuvette and scanned in a UV spectrophotometer at 210nm. Concentration of sample was calculated using bear Lambert's law.

Vitamin C (ascorbic acid) content of the calyx was determined by the 2,6-dichloroindophenol titrimetric method (AOAC Method 967.21).

g) Determination of Mineral Elements (Ca, P, Fe, K, Na, Zn and Mg)

Some mineral element contents of the calyx were determined by the standard Atomic Absorption Spectrophotometric method (AAS).

Analysis of variance (ANOVA) was used to analyze the data with the aid of a statistical package statistix 10.0 Microsoft (2005). The differences between the treatment means were separated using the Duncan Multiple Range Test (DMRT) at 5% probability level.

III. RESULTS AND DISCUSSION

a) Physicochemical Properties of Pretreated Soil

The physicochemical properties of the pretreated soil (prior) to experiment is presented in table 1. The pH of the soil was basic (8.8), with an electrical conductivity of 0.64 dS/m. The nitrogen content of the soil was low (6.5g/kg). The soil has moderate amount of organic carbon (13.25%) and a very low phosphorus content (0.11mg/kg). The exchangeable cations recorded respective values of potassium (4.0Cmol/kg), sodium (0.12Cmol/kg), calcium (73.0Cmol/kg) and magnesium (24.0Cmol/kg). Similarly, the texture of the soil was loamy sand in nature which comprised of 77.10% sand, 15.70% silt and 7.20% clay respectively.

Application of fertilizer (organic and inorganic) to the soil have shown significant effects on the soil and biochemical parameters of *Hibiscus sabdariffa* Linn (sorrel). The soil was analyzed appropriately for pre (before experiment) and post (after experiment) physicochemical properties. The physicochemical properties of the post treated soil showed increase in the nitrogen content of the soil, as well as pH and EC. This is as a result of nitrogen fertilization via NPK and cow dung, which is in harmony with the findings of Khandar et al., (1986) and Harrera et al., (1987) who reported that fertilizer improves soil properties, water retention capacity, pH and better availability of micro nutrients.

Table 1: Physicochemical Properties of Pre-treated Soil

Parameter	Value
pH (1:2:5 Soil water)	8.8
EC (dS/m)	0.64
OC (g/kg)	13.25
Total N (g/kg)	6.5
Available P (mg/kg)	0.11
Exchangeable cations (Cmol/kg)	
K	4.0
Na	0.12
Ca	73.0
Mg	24.0
CEC (Cmol/kg)	14.50
Particle size distribution (%)	
Sand	77.10
Silt	15.70
Clay	7.20
Texture	Loamy sand

b) Composition of Cow Dung

The composition of organic fertilizer (cow dung) used in the study is presented in table 2. It was composed of different compositions of mineral elements, with nitrogen (15.5%), phosphorus 10.89%),

calcium (3.05%), magnesium (0.57%), potassium (2.03%), sodium(0.54%), zinc (10.66mg/g), copper (20.29mg/g), iron (5.77mg/g) and manganese (5.11mg/g) respectively.

Table 2: Composition of Cow dung

Parameter	Value
N	15.5%
P	10.89%
Ca	3.05%
Mg	0.57%
K	2.03%
Na	0.54%
Zn	10.66mg/g
Cu	20.29mg/g
Fe	5.77mg/g
Mn	5.11mg/g

c) Chemical Properties of Post Treated Soil (After experiment)

The chemical properties of the post treated soil (after experiment) is presented in table 3. Different rates

of organic fertilizer (cow dung) and inorganic fertilizer (NPK) applied in single and in combinations, recorded respective values for electrical conductivity (510dS/m, 510dS/m, 631dS/m, 437dS/m, 524dS/m, 538dS/m,

336dS/m, 429dS/m, 413dS/m, 430dS/m, 443dS/m and 636dS/m) across the column from treatments 1to12 respectively. Similarly, respective values for nitrogen, phosphorus, potassium, sodium, calcium, magnesium, zinc and copper were also recorded, with manganese

(0.14mg/kg, 0.31mg/kg, 0.21mg/kg, 0.19mg/kg, 0.20mg/kg, 0.30mg/kg, 0.19mg/kg, 0.27mg/kg, 0.33mg/kg, 0.22mg/kg, 0.23mg/kg, 0.14mg/kg) which was also recorded across the column from treatments 1 to 12.

Table 3: Effects of cow dung and NPK fertilizers on the chemical properties of the post treated soils

Fertilizer rates	pH (1:2:5 soil water)	EC (dS/m)	N (mg/kg)	P (mg/kg)	K (mg/kg)	Na (Cmol/kg)	Ca	Mg	Zn	Cu (mg/kg)	Mn
ONPK+OCD	8.40 ^a	510.00 ^b	6.50 ^a	5.00 ^{ab}	5.00 ^{bcd}	0.10 ^b	64.00 ^{cd}	21.00 ^c	0.42 ^b	2.16 ^a	0.14 ^e
ONPK+1OCD	9.00 ^a	510.00 ^b	6.60 ^a	3.07 ^c	3.07 ^{ef}	0.12 ^b	55.00 ^{ef}	17.90 ^d	0.37 ^{bc}	0.16 ^b	0.31 ^{ab}
ONPK+2OCD	8.70 ^a	631.00 ^a	7.20 ^{ab}	4.00 ^{bc}	4.00 ^{de}	0.09 ^b	49.00 ^a	16.00 ^e	0.33 ^{cd}	0.13 ^b	0.21 ^d
ONPK+3OCD	8.60 ^a	437.00 ^c	8.23 ^{d-g}	6.00 ^a	6.00 ^{ab}	0.12 ^b	71.00 ^b	24.00 ^b	0.26 ^e	0.10 ^b	0.19 ^d
1/2NPK+OCD	9.00 ^a	524.00 ^b	7.40 ^a	0.07 ^d	4.67 ^{cd}	0.11 ^b	60.00 ^{de}	19.00 ^d	0.39 ^{bc}	0.18 ^b	0.20 ^d
1/2NPK+1OCD	8.40 ^a	538.00 ^b	8.90 ^{def}	2.68 ^c	4.20 ^{cd}	0.10 ^b	66.00 ^{bc}	22.00 ^c	0.52 ^a	0.20 ^b	0.30 ^{ab}
1/2NPK+2OCD	8.60 ^a	336.00 ^d	9.20 ^{cd}	0.14 ^d	5.00 ^{bcd}	0.10 ^b	48.00 ^a	16.00 ^e	0.41 ^b	0.14 ^b	0.19 ^d
1/2NPK+3OCD	9.10 ^a	429.00 ^c	9.40 ^{cd}	0.20 ^d	2.10 ^f	0.07 ^b	30.00 ^f	10.00 ^f	0.33 ^{cd}	0.16 ^b	0.27 ^{bc}
FullNPK+OCD	8.70 ^a	413.00 ^c	9.00 ^{de}	0.05 ^d	5.20 ^{abc}	0.08 ^b	77.00 ^a	26.00 ^a	0.33 ^{cd}	0.18 ^b	0.33 ^a
FullNPK+1OCD	8.40 ^a	430.00 ^c	10.90 ^c	0.16 ^d	3.00 ^{ef}	0.09 ^b	53.00 ^{ab}	8.00 ^g	0.40 ^b	0.21 ^b	0.22 ^d
FullNPK+2OCD	8.40 ^a	443.00 ^c	13.00 ^b	0.21 ^d	4.00 ^{de}	0.40 ^a	48.00 ^a	16.00 ^e	0.30 ^{de}	0.22 ^b	0.23 ^{cd}
FullNPK+3OCD	9.30 ^a	636.00 ^a	17.50 ^a	0.17 ^d	6.10 ^a	0.06 ^b	20.00 ^f	7.00 ^g	0.41 ^{de}	0.13 ^b	0.14 ^e
SEM±	0.609	16.684	0.612	0.476	0.376	0.476	1.937	0.417	0.022	0.576	0.014

Data expressed as means; n=3; CD= Cow dung; 1/2 and Full NPK = 25:15:15 and 50:30:30 respectively; Means in column within the same treatment followed by the same letter(s) do not differ significantly at $p < 0.05$.

Effects of Organic (cow dung) and Inorganic (NPK) Fertilizers on Some Mineral Elements and Vitamin Contents of Sorrel Calyces.

The effects of cow dung and NPK on some minerals and vitamin contents of sorrel calyces are presented in table 4.4. The different rates of fertilizers applied, resulted in appreciable values of P, K, Na, Ca, Mg, Zn, Fe, vitamin A and C respectively. Variations were observed among the minerals and vitamin contents as a result of the different fertilizer rates that were used. Treatment involving full NPK + 0 CD (0.22 mg/g) produced the highest contents of P and treatments involving 0 NPK + 10 CD (0.11mg/g) and 1/2 NPK + 10 CD (0.11 mg/g) recorded the lowest P contents of the calyces. Treatment involving 0 NPK + 30 CD (4.87 mg/g) produced the highest K contents of the calyces. Similarly, treatment involving full NPK + 0 CD (0.83 mg/g) produced the lowest K contents of the calyces. Again, treatment involving 1/2 NPK+30 CD (538.00 mg/g) recorded the highest Na content and treatment involving 0 NPK + 20 CD (313.33 mg/g) recorded the lowest Na content. The highest content of Ca was produced with treatment involving 1/2 NPK + 30 CD (0.92 mg/g) while treatment involving 1/2 NPK + 10 CD (0.21 mg/g) recorded the lowest content of Ca in the calyces. Treatments involving full NPK + 0 CD (0.67 mg/g) and 0 NPK, 0 CD (0.12 mg/g) produced the highest and lowest Mg content of the calyces respectively. The table also shows treatment involving

1/2 NPK + 10 CD (1.42 mg/g) and control treatment 0 NPK, 0 CD (0.15 mg/g) which recorded the highest as well as the lowest content of Zn in the calyces. In the case of Fe, treatment involving 1/2 NPK + 30 CD (1.14 mg/g) recorded the highest content of Fe in the calyces whereas, treatment involving full NPK+ 0 CD (0.13 mg/g) recorded the lowest content of Fe in the calyces.

The vitamin A and C (ascorbic acid) contents of the calyces are also presented in table 4.4. Variations were observed among the vitamin contents produced by the various fertilizer rates. Treatment involving 1/2 NPK + 10 CD (0.78 $\mu\text{g/g}$) and the control treatment 0 NPK, 0 CD (0.01 $\mu\text{g/g}$) recorded the highest and lowest contents of vitamin A in the calyces. Similarly, treatments involving 0 NPK + 20 CD (2.07 $\mu\text{g/g}$) and full NPK + 0 CD (0.50 $\mu\text{g/g}$) produced the highest as well as the lowest contents of vitamin C in the calyces.

Similarly, application of fertilizer to the soil also showed significant effect on some minerals and vitamin contents of sorrel. Variations were observed in the nutrient contents of the calyces of sorrel, which has previously been reported by some researchers among whom are Ciss'e et al., (2009), who reported that the fresh calyces of *Hibiscus sabdariffa* Linn are very rich in mineral salts. Wong et al., (2002) also reported that the calyces of *Hibiscus sabdariffa* Linn have been found to be rich in vitamins. Comparably, Babalola et al. (2000) also pointed out that the calyces of *Hibiscus sabdariffa* Linn is rich in minerals. Likewise, Amin et al., (2008)

reported that the calyces of sorrel contains nine times more vitamin C than citrus (*Citrus sinensis*). Again, Jung et al., (2013), also reported that the calyces of sorrel is rich in ascorbic acid and minerals especially calcium and iron. The findings are also in agreement with the findings of Mahadevan et al., (2009) who found out that the fresh calyces of sorrel are also rich in ascorbic acid, carotenoid, calcium, iron, that are nutritionally important. Other researchers like Seung et al., (2000), have investigated and reported on the effects of fertilizer application on vitamins. He pointed out that fertilizers have influence on vitamin contents of sorrel, which is also in harmony with the findings of Christin et al., (2005), who reported that increasing fertilizer rates increases the concentration of carotene (provitamin A) of parsley. It is also in line with the findings of Biesiada et al., 2008, who reported that increasing nitrogen fertilizer increases the concentration of carotenoids in Lavender, which is also in uniformity with the findings of Zameer Khan et al., (2010) who reported that quality biochemical parameters like carotene and vitamin C contents are also affected with phosphorus and potassium fertilization. This finding also agrees with the finding of Lola, (2009), who reported that vegetables are rich sources of minerals with leafy vegetables being the most sources of minerals.

The concentrations of Mg, Na and Zn from the study carried out are high, which may be recommended

for the consumption of this vegetable. This is so because Magnesium is one of the abundant ions present in living cells, it is involved in many essential metabolic reactions. Mg is an essential cofactor in almost all enzymatic systems involved in DNA processing. It is required by the adenosine triphosphate (ATP) synthesizing protein in mitochondria and required at a number of steps during the synthesis of nucleic acid (DNA and RNA) and proteins. Mg plays a structural role in bone, membranes and chromosomes (Hartwig, 2001). Sodium is necessary for maintenance of electrolyte balance and fluid balance, for heart activity and certain metabolic functions (Pohl et al., 2013). Zinc is important for immune function (McCarthy et al., 1992; Solomons, 1998) wound healing, protein synthesis, DNA synthesis and cell division (Prasad et al., 1995). It is also required for proper sense of taste and smell (Heyneman, 1996; Prasad et al., 1997). It also supports normal growth and development during pregnancy, childhood and adolescence (Simmer et al., 1985; Fabriset et al., 1995; Maret et al., 2006). Vitamin A is required for somatic function or systemic function, reproduction (spermatogenesis, oogenesis, placental development, fetal and embryonic growth) and for visual processes and Vitamin C enhances the human immune defense system.

Table 4: Effects of cow dung and NPK fertilizers on minerals and vitamin contents

Fertilizer rates	P	K	Na	Ca (%)	Mg	Zn (mg/g)	Fe	Vit A(μg/g)	Vit C
ONPK, 0CD	0.21 ^{ab} b	3.50 ^b	398.33 ^{cde}	0.42 ^c	0.12 ^c	0.15 ^f	0.21 ^{cd}	0.01 ^l	1.43 ^{abc}
ONPK + 10CD	0.11 ^f	3.07 ^{bc}	363.67 ^{de}	0.31 ^d	0.57 ^{ab}	0.18 ^{ef}	0.17 ^{d-g}	0.23 ^g	1.53 ^{abc}
ONPK + 20CD	0.21 ^{ab}	3.43 ^b	313.33 ^e	0.42 ^c	0.14 ^c	0.38 ^d	0.22 ^{cd}	0.46 ^e	2.07 ^a
ONPK + 30CD	0.18 ^{bc}	4.87 ^a	502.00 ^{abc}	0.40 ^c	0.51 ^{ab}	0.61 ^b	0.14 ^{fg}	0.02 ^k	1.60 ^{abc}
1/2NPK + 0CD	0.15 ^{cde}	2.67 ^{bcd}	449.00 ^{a-d}	0.33 ^d	0.10 ^c	0.43 ^{cd}	0.16 ^{efg}	0.60 ^d	1.13 ^{bcd}
1/2NPK + 10CD	0.11 ^f	3.60 ^b	449.33 ^{a-d}	0.21 ^e	0.66 ^a	1.42 ^a	0.18 ^{cf}	0.78 ^a	1.40 ^{bc}
1/2NPK + 20CD	0.18 ^{bc}	1.50 ^{ef}	513.00 ^{ab}	0.37 ^{cd}	0.17 ^c	0.45 ^{cd}	0.29 ^b	0.71 ^b	1.47 ^{abc}
1/2NPK + 30CD	0.21 ^{ab}	1.80 ^{def}	538.00 ^a	0.92 ^a	0.32 ^{bc}	0.51 ^c	1.14 ^a	0.03 ^j	1.53 ^{abc}
FULLNPK+0CD	0.13 ^{def}	2.23 ^{cde}	493.33 ^{abc}	0.31 ^d	0.07 ^c	0.17 ^{ef}	0.13 ^g	0.42 ^f	1.40 ^{bc}
FULLNPK+10CD	0.22 ^a	1.80 ^{def}	426.33 ^{bcd}	0.69 ^b	0.20 ^c	1.35 ^a	0.22 ^c	0.67 ^c	1.70 ^{ab}
FULLNPK+20CD	0.17 ^{cd}	1.67 ^{def}	473.67 ^{abc}	0.43 ^c	0.17 ^c	0.47 ^c	0.14 ^{fg}	0.66 ⁱ	0.97 ^{cd}
FULLNPK+30CD	0.13 ^{ef}	0.83 ^f	466.33 ^{a-d}	0.33 ^d	0.67 ^a	0.24 ^e	0.19 ^{cde}	0.20 ^h	0.50 ^d
SEM±	0.013	0.375	36.388	0.224	0.097	0.029	0.013	0.001	0.223

Data expressed as means; n=3; CD= Cow dung; 1/2 and Full NPK = 25:15:15 and 50:30:30 respectively; Means in column within the same treatment followed by the same letter(s) do not differ significantly at p<0.05.

IV. CONCLUSION

In conclusion, fertilizer treatment has tremendously influenced the soil, as well as some vitamins and mineral contents of sorrel. In particular, combination treatment of organic and inorganic

fertilizers produced the highest nitrogen contents and other essential amount of nutrients that was made available to sorrel plant as nitrogen is the key plant nutrient in the production of crops and an important component responsible for photosynthetic activity and crop yield capacity. Thus, the vitamin and mineral

contents of sorrel were significantly affected by the fertilizer application via the increase of essential nutrients in the soil. Therefore, based on the result of the experiment, combination treatment involving varying rates of organic (cow dung) and inorganic (NPK) fertilizers should be encouraged for maximum levels of vitamins and minerals of sorrel.

REFERENCES RÉFÉRENCES REFERENCIAS

1. Aliyu M. S., Salih W. M, Mohammed A. H., Homeida A.M. (2000). Investigation on the Antispasmodic Potentials of *Hibiscus sabdariffa* Calyces. *Enthnopharmacci*. 31:249-257.
2. Amin I, Hainida EKI, Halimatul SMN (2008). Roselle (*Hibiscus sabdariffa* L.) seeds- National composition, protein quality and health benefits. *Foods*. 2(1):1-16.
3. Babalola, S. O., A. O. Babalola, and O. C. Aworh. 2001. Compositional attributes of the calyces of Roselle (*Hibiscus sabdariffa* L.). *The Journal of Food Technology in Africa*, 6(4): 133-134.
4. Babatunde, FE (2001). Response of Red Variant Roselle (*Hibiscus sabdariffa* L.) to Some Agronomic Practices Unpublished Ph. D.Thesis presented to the Postgraduate School, Abubakar Tafawa Balewa University, Bauchi, Nigeria. pp. 116
5. Bender, David A. (2003). Nutritional Biochemistry of the Vitamins. Cambridge, U.K. *Cambridge University Press*. ISBN 978-0-521-86388-5.
6. Berdanier, Carolyn D; Dwyer, Johanna T, Heber, David (2013). Handbook of Nutrition and Food (Third edition). CRC Press. P. 199. ISBN 978-1-4665-0572-8. Retrieved 3rd July 2016.
7. Biesiada, A.; Sokol-Letowska, A.; A. (2008). The Effect of Nitrogen Fertilization on Yielding and Antioxidant Activity of Lavender (*Lavandula angustifolia*). *Act Science*.7:33 – 40.
8. Christin, H.C.; Dean, A.K.; David, E.K. (2005). Nitrogen Concentration Affects Nutrient and Carotenoid Accumulation in Parsley. *Journal of Plant Nutrition*.28, 285 – 297.
9. Ciss'e M. Dornier M, sakho M, N' Dtaye A Reynes, M, Sack O (2009). Le Bissap(*Hibiscus sabdariffa* L): composition et Principals Utilizatio. *Fruits* 64(3): 179-134.
10. Fabris N, Moc'chegiani 6 (1995). Zinc, Human Diseases and As Redox Sensors and Signal Transducers, Antioxid. *Redox signal*. 8, 1419-1441.
11. Fasoyiro SB, Ashaye OA, Adeola, A, Samuel FO(2005). Chemical and Storability of Fruits Flavored (*Hibiscus sabdariffa*) drinks. *Word J. Agricultural Science*.
12. Hacket C, Carolene J, (1982). Edible Horticultural Crops: A Compendium of Information on Fruits, Vegetables, Spice and Nut Spicies. *Academic Press*. Australia, p. 17.
13. Hartwig A. (2001) Role of Magnesium Genomic Stability. *Mutation Resources*; 475(1-2):112-21.
14. Herrera R, Aranguren J, Escalante G, Acardi A, Navidad E, Toro M and Cuenca G (1987) Coffee and cacao plantations under shade trees in Venezuela. In: Beer J, Fassbender HW and Heuvelodop J, eds, *Advances in Agroforestry Research*, pp 173–181. Serie Tecnica No 117. CATIE, Turrialba, Costa Rica.
15. Heyneman C.A (1996). Zinc Deficiency and Taste Disorders. *Annual pharmacother*, 30:186-7.
16. Jung, E.K.; Kim, Y.J. and Joo, N. (2013). Physicochemical properties and Antimicrobial activity of Roselle (*Hibiscus sabdariffa* L.). *J. Sci. Food Agric.*, 93: 3769–3776.
17. Khandar U. R, Nigam K.B (1986). Effect of Farmacyard Manure and Fertility on Growth and Yield of Ginger (*zingiberofficinale*). *Ind. Journal of Agricultural Science*, 66:549-550.
18. Kosakowska O. (2005). Sterole and Fatty Acid in the Seeds of Roselle (*Hibiscus sabdariffa* L) cultivation inEgypt. *Herbapolonica*58: 108-112.
19. Lola, A. (2009). The Effect of Boiling on Nutrients and Anti-Nutrients in Two Non Conventional Vegetables. *Pakistan Journal of Nutrition*, 18:1430-1433.
20. Mahadevan, N-shivali and P,kamboj (2009). *Hibiscus sabdariffa* Linn, - an overview Natural product radiance, 8(1): 77-83.
21. Mahadevan, N-shivali and P, kamboj (2009). *Hibiscus sabdariffa* Linn, - an overview Natural product radiance, 8(1): 77-83.
22. Maret W, Sandstead HH (2006) Zinc requirements and the risks and benefits of zinc supplementation. *J Trace Elem Med Biol* 20:3–18.
23. McCarthy T.J, Zeelic J.J. Krause D. J. (1992). The Antimicrobial Action of Zinc Ion/Antioxidant Combinations. *Clinical Pharmacology and Therapeutics* 17:15.
24. N. W. Solomons, Mild human zinc deficiency produces an imbalance between cell-mediated and humoral immunity, *Nutr. Rev.* 56, 27–28 (1998).
25. Pohl, Hanna R.; Wheeler, Johns; Murray, H. Edward (2013). "Chapter 2. Sodium and Potassium in Health and Disease". In Astrid sigel, Helmut sigel and Roland K-o-siegel. *Interrelations between Essential metal Ions and Human Diseases. Metal Ions in Life Science. Springer*. 13 Pp 29-47.
26. Prasad A. S. (1995). Zinc: an overview. *Nutrition*, 11:3-9
27. Prasad A.S, Beck F.W, Grabowski S.M, Kaplan J, Mathog R.H (1997). Zinc Deficiency: Changes in Cytokine Production and T-cell Subpopulations in patients with head and neck cancer and in non-cancer subject. *Pix. Association. AM. Physicians*, 109:68-77.

28. Qi, Z., Hao, C.M Langenbach, R.I, Breyer, R.M, Pedha, R., Morrow J. D Breyer, M.D., (2005). Opposite Effects of Cyclooxygenase-land-2 Activity on the Pressor Response to Angiotensin ii. *Journal of clinicalinvestigation*110:61-69.
29. Schippers, R.R. (2000). African Indigenous Vegetables: An Overview of the Cultivated Species. University of Greenwich, *Natural Resources Institute London, UK*, 2000.
30. Seung, K.L.; Adel, A.K. (2000): Preharvest and Postharvest Factors Influencing Vitamin C Content of Horticultural Crops. *Postharvest Biology Technology*. 20:207-220.
31. Simmer K, Thompson R.P (1985). Zinc in The Foetus and New Born. Actapaediator. *Scand suppl*. 319:158-63
32. Small, T. and E.G. Rhoden. 1991. Production and nitrogen uptake of rozelle. *Hort Science* 26:738 (Abstr).
33. Tomme, P, Heriban, V & Claeysens, M (1990) Adsorption of two cellobiohydrolases from *Trichoderma reesei* to Avicel: evidence for 'exo-exo' synergism and possible 'loose complex' formation. *Biotech. Lett*. 121: 525–530
34. Wong, P.K., S. Yusof, H.M. Ghazali and Y.B. Che Man, 2002. Physico-chemical characteristics of roselle (*Hibiscus sabdariffa* L.). *Nutr. Food Sci.*, 32: 68-73.
35. Zameer Khan, M.; Ehsan Akhtar, M.; Naeem Safdar, M.; Masd Mahmood, M.; Ahmad, S.; Ahmed, N. (2010). Effect of Source and Level of Potash on Yield and Quality of Potato Tubers. *Pak. Journal of Botany*.42: 3137 – 3145.