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Impacts of Telfairia Mosaic Virus (Temv) Infection and Defoliation (DF) on the Nutritional Quality of African Yam Bean (Sphenostylis Stenocarpa) (Hochst. Ex. Rich) Harms.

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Abstract: *Assessing the impacts of TeMV and DF on the nutritional composition of Sphenostylis stenocarpa (S. stenocarpa) is important to predict quality of the legume. Results revealed significant (p<0.05) reductions in both TeMV and DF samples with DF having higher reductions compared to TeMV and control in all the nutritional parameters investigated. Infection brought about reductions of 41.1%, 21.3%, 88.8% in alkaloids, tannins saponins against 58.3%, 41.1%, 90.0% respectively for DF. Ash and fiber contents were higher in TeMV compared with DF. DF caused reduction in protein and fat. Higher reductions in Na, Mg, Ca, in DF compared with TeMV. All the vitamins showed reductions in TeMV infected and DF treated samples. Results of amino acids showed reductions in TeMV and DF in all with the exceptions of glutamic acid, aspartic acid, proline,and alanine. Antinutrients depicted increase in TeMV and DF treated samples. Defoliation revealed more reductions in all the nutritional parameters examined with the exception of ash and fiber which were higher in TeMV than in DF. Based on the results of this study, farmers are urged to guard against virus infection and defoliation on S. stenoccarpa as these will impact negatively on the nutritional composition of the legume.*

Keywords*: African yam bean, Defoliation, Nutritional quality, Telfairia mosaic virus*

I. Introduction

Plants are affected by many factors in their environment ranging from physical, mechanical, biotic, and abiotic factors and they respond differently to these stressors. Infection of plants by virus results in a sequence of physiological and metabolic changes in the virus infected plant elucidating a complex host-virus interaction. Diseased plants show derangements in all major metabolic processes such as respiration, photosynthesis and carbohydrate metabolism, growth and development and transpiration [1]. The impact of virus infection on plants results in alteration in morphological, physiological and biochemical characteristics of the infected plant with significant reductions and increases in the nutritional quality of infected host plants [2], [3], [4], [5]. Reduction in fat, fiber and carbohydrate in *P. vulgaris* infected with TeMV has been reported [5]. Decreases in phytochemicals; alkaloids, saponins and tannins. Tefairia mosaic virus caused significant reductions ($p<0.05$) in vitamin A (55.5%), C (43.1%), B_1 (34.6%), B_2 (26.6%), B_6 (17.8%) and B_3 (13.1%) of *P. vulgaris*. Significant reductions were also reported for essential (methionine, isoleucine, lysine, threonine, phenylalanine and leucine) and non essential (valine, cysteine, arginine and glycine) amino acids of *P. vulgaris* [5].Defoliation of plants mechanically or by herbivores has manifold consequences on the plant growth and allocation. Plants exhibit different kinds of defoliation responses; compensatory, overcompensation, partial and full compensation. In compensatory regrowth, the defoliated plants partially or fully compensates for biomass removal. When defoliation increases growth rates, the response is said to be overcompensation [6]. Whereas when defoliation decreases growth rates the plants response may be either partial compensation (Where the reduction of growth is less than expected from the proportion of leaves or biomass removed), or damage (where the reduction in growth is more severe than expected from the proportion of biomass removed). Lastly, when defoliated plants grow as fast as undefoliated plants the response is known as full compensation [7]

The responses of plants to defoliation are complex and depend on many variables [3]. Defoliation triggers a series of morphological, physiological and anatomical adjustments in order to cope with tissue removal, mobilization of reserves, priority allocation of carbon and nutrients to leaf production and decrease in height. Physiologically, plants require energy for growth and maintenance. Photosynthesis, the primary source of plant energy occurs in the form of carbohydrates and plant leaves are the sites of photosynthesis. Plants serve as a source of mineral nutrient for man. Alteration in plant physiological processes due to defoliation has great consequence on the biochemical component of the plant. The impact of defoliation on plants depends on more than just the total amount of leaf area that is lost affecting photosynthesis [3]. A single severe defoliation causes immediate decrease in photosynthesis [8], and a reduction or cessation in root growth [9]. Senescence of the root or tiller may occur after a single severe defoliation. Respiration and nutrient uptake show a rapid decline after defoliation [10]. Results of the impact of defoliation on the nutritional quality of crop plants have been conflicting. Significant reduction in carbohydrate, total phenolics and tannin concentration in leaves of defoliated plants has been reported [11]. [12], documented no significant difference in crude protein and mineral contents between leaves from defoliated and non-defoliated plants.Legumes are major staple for people in different parts of the world. *Sphenostylis stenocarpa* is a less utilized legume among others such as *Mucuna cochinchinensis* and *Mucuna flagellipes*. *Sphenostylis stenocarpa* is a grain legume cultivated in southeastern Nigeria where the seeds are roasted and eaten with the kernel. The seeds are also eaten as porridge with yam. In northwestern Nigeria, the plant is found in Southern Kaduna where it is called Majingba. In South-south Nigeria, the seeds are either boiled separately or prepared with yam as porridge [13]. It is a popular food item in some parts of Nigeria and has been reported [14] to have a range in protein of 18.1 to 25.8% which is comparable with a range of 16.9 to 25.4% for Bambara groundnut, 21.2 to 22.5% for pigeon pea and 24.4 to 28.0% for cowpea. This legume has been rated as superior to pigeon pea and cowpea in the content of methionine and lysine [14]; [15]. African yam bean contains about 505 carbohydrates and 5 to 6% fibre [16]; [17]. The guest for low cost natural proteins and minerals sources in Nigeria and other third world countries is increasing. Most rural and urban poor cannot afford animal proteins and over three million children lack sufficient proteins and therefore suffer grossly retarded physical growth and development [18]. Deficiencies in protein and other minerals have a direct or indirect affect health with attendant effect on the economic productivity of the adult populations [19]. With the dependence of the populace on plants to meet their nutritional needs, it has become imperative to protect plants from pathogenic attacks and physical disturbance in their growing environment so as to improve on their nutritional quality for the benefit of man.A lot of research has been done on the nutritional composition of African yam bean [20], [21], [22], [23] and plant responses to defoliation [24], on growth and yield [25], [26], [11], [12]. Information is scare on the effect of virus infection and defoliation on the nutritional content of *S. stenocarpa*. This study investigates the impacts of Telfairia mosaic virus (TeMV) and defoliation (DF) on the nutritional quality of African yam bean.

II. Materials and Methods

2.1 Seed collection and planting

In order to assess the impact of Telfairia mosaic virus infection and defoliation on the nutritional composition of *S. stenocarpa*, seeds were obtained from local farmers in Akparabong, Ikom Local Government Area of Cross River State, Nigeria. The seeds were sorted, and healthy ones planted in a 16 cm in diameter polyethylene bags. Plants were grown in the greenhouse, Botanical Garden of the University of Calabar, Calabar Nigeria.

2.2 Experimental design

The seedlings were allowed to grow for a period of two weeks before defoliation treatment began. Prior to defoliation, the plants were arranged in a randomization block design. A total of twenty plants were arranged in three groups; (1) TeMV infected plants (2) Defoliated plants and (3) Control plants with three replicates giving a total of one hundred and twenty plants. Defoliation treatment was carried out at two weeks intervals and continued to a period of two weeks before harvest. On germination, seedlings were inoculated at three leaf stage with Telfairia mosaic virus. Inoculation of young leaves at the stem apex was repeated trice at an interval of two weeks and the plants allowed to growth to maturity.

2.3 Samples preparation for analysis

At four months post inoculation treatments, TeMV (PIT), defoliation treatment (PFT), the African yam bean pods were harvested, the seeds removed from the pods and sun-dried for one week. The dried grains were milled into powdered form and used for the analysis of all the nutritional parameters of *S. stenocarpa*. The control plants were similarly handled.

2.4 Determination of nutritional composition of *S. stenocarpa*

Alkaloids and fat were determined by the method of [27], tannins [28], saponin, flavonoids [29], [30]. Proximate composition was determined by method of Association of Official Analytical Chemists [31]. Vitamins and minerals were analyzed by [31]. Antinutrients [30], [32], [31], amino acids [31].

2.5 Data Analysis

Data were subjected to analysis of variance (ANOVA). Results were also expressed as percentage difference and differences between mean values were determined at 95% probability.

III. Results

Table 1: Impacts of Telfairia mosaic virus (TeMV) infection and defoliation (DF) on percentage crude phytochemicals of *Sphenostylis stenocarpa*

mg/100 g dry weight					
Phytochemicals	**Control**	**TeMV[a]**	**% Difference[c]**	**DF[b]**	**% Diffrerence[c]**
Alkaloids	17.01 ± 0.1	10.02 ± 0.02	41.1	7.10± 0.2	58.3
Tannins	0.61 ± 0.02	0.48 ± 0.01	21.3	0.36 ± 0.1	41.0
Saponins	2.81 ± 0.01	0.32 ± 0.1	88.8	0.28 ± 0.02	90.0
Flavonoids	ND	ND	-	ND	-
Reducing sugars	9.80 ± 0.02	10.40 ± 0.2	6.1	10.60 ± 0.03	8.2
Phenols	13.25 ± 0.01	16.94 ± 0.03	27.8	18.34 ± 0.01	38.4

a and b = Means ± SD of three replicates, c = values were obtained by expressing the difference between the values for control, TeMV and DF as a percentage of the control. ND = Not detected.The analysis of variance showed a significant ($p<0.05$) difference on the impact of TeMV infection and DF in all the nutritional components of *S. stenocarpa* examined. Defoliation treatment caused significant ($p<0.05$) reductions in alkaloids (58.3%), tannins (41.0%) and saponins (90.0%) as against reductions of 41.4% and 21.3%, 88.8% respectively for TeMV infected samples. Phenols and reducing sugars were significantly higher in Higher 38.4% and 8.2% in DF sample and 27.8% and 6.1% in TeMV infected sample. Defoliation resulted in more reductions and increases when compared with TeMV infected sample (Table 1).

Table 2: Impacts of Telfairia mosaic virus (TeMV) infection and defoliation (DF) on the proximate content of *Sphenostylis stenocarpa*

g/100 g dry weight					
Proximate	Control	TeMV[a]	% Difference[c]	DF[b]	% Difference[c]
Moisture	89.60 ± 0.1	86.42 ± 0.03	3.5	84.73 ± 0.02	5.4
Ash	2.37 ± 0.2	3.50 ± 0.1	47.7	3.00 ± 0.1	26.6
Protein	24. 40 ± 0.1	17.10 ± 0.1	29.9	12.01 ± 0.2	50.8
Fat	2.50 ± 0.1	1.80 ± 0.1	28.0	2.10 ± 0.1	16.0
Fiber	17.53 ± 0.01	21.30 ± 0.2	21.5	18.60 ± 0.2	6.1
Carbohydrate	54.67 ± 0.02	51.80 ± 0.2	5.2	47.98 ± 0.02	12.3

a and b = Means ± SD of three replicates, c = values were obtained by expressing the difference between the values for control, TeMV and DF as a percentage of the control.Considered across all proximate parameters of *S. stenocarpa, the* impacts of TeMV infection and DF resulted in significant reductions in proteins, fat, carbohydrate with significant ($p<0.05$) increase in ash and fiber content. ANOVA revealed significant reductions in fat ($F=18.5$: $p<0.05$), protein ($F=87.3$: $p<0.05$), fiber (37.7: $p<0.05$), carbohydrate ($F=8.16$: $p<0.05$) with increase in ash ($F=13.7$: $p<0.05$) as against ($F= 3.69$: $p<0.05$) in both TeMV and DF samples (Table 2). More reductions occurred with DF than with TeMV treatments. However, increase in ash and fiber and reduction in fat were higher in TeMV infected plant samples compared with defoliated and control samples.

Table 3: Impacts of Telfairia mosaic virus (TeMV) infection and defoliation (DF) on mineral content of *Sphenostylis stenocarpa*

mg/100 g dry weight					
Elements	**Control**	**TeMV[a]**	**% Difference**	**DF[b]**	**% Difference**
Sodium	3.58 ± 0.01	3.02 ± 0.1	15.6	1.62 ± 0.02	54.7
Potassium	1512.02 ± 0.03	1420.01 ± 0.02	6.1	1380.20 ± 0.2	8.7
Calcium	61.20 ± 0.2	41.40 ± 0.02	32.4	30.30 ± 0.2	50.5
Magnesium	2.16 ± 0.3	1.20 ± 0.02	44.4	1.00 ± 0.1	53.7

Iron	5.08 ± 0.1	4.98 ± 0.02	2.0	4.91 ± 0.2	3.3
Copper	14.10 ± 0.2	11.43 ± 0.02	18.8	9.30 ± 0.01	34.0
Zinc	3.02 ± 0.01	2.43 ± 0.02	19.5	1.65 ± 0.01	45.4
Phosphorus	308.30 ± 0.2	285.10 ± 0.1	7.5	269.40 ± 0.02	12.6

a and b = Means ± SD of three replicates, c = values were obtained by expressing the difference between the values for control, TeMV and DF as a percentage of the control. Impacts of TeMV and DF treatments on the mineral elements of *S. stenocarpa* (Table 3) show significant decreases in Na, Mg, Ca, Zn, Cu, P and K. Decrease in Fe was insignificant. Analysis of Variance depicts significant reductions in Na ($F=9.00$: $p<0.05$), Mg ($F=396.7$: $p<0.05$), Ca ($F=429.0$: $p<0.05$), Zn ($F=6.99$: $p<0.05$), Cu ($F=50.0$: $p<0.05$), P ($F=1134.2$: $p<0.05$) and K ($F=155.0$: $p<0.05$). Fe ($F=1.15$: $p<0.05$) as against $F=3.69$ was insignificant.

Table 4: Impacts of Telfairia mosaic virus (TeMV) infection and defoliation (DF) on the antinutrients content of *Sphenostylis stenocarpa*

mg/100 g dry weight					
Antinutrients	Control	TeMV[a]	% Difference[c]	DF[b]	% Difference[c]
Total oxalate	10.97 ± 0.02	11.46 ± 0.02	4.5	11.97 ± 0.01	9.1
Soluble oxalate	3.86 ± 0.01	4.68 ± 0.1	17.5	6.48 ± 0.02	67.9
Hydrocyanide acid	0.70 ± 0.01	1.09 ± 0.2	55.7	1.24 ± 0.02	77.1
Phytic acid	0.170 ± 0.01	0.180 ± 0.02	5.9	0.190 ± 0.01	11.8

a and b = Means ± SD of three replicates TeMV and, c = values were obtained by expressing the difference between the values for control, TeMV and DF as a percentage of the control.Statistically, analysis of variance revealed that both treatments (TeMV and DF) caused significant increases in soluble oxalate and hydrocyanide acid with insignificant increases in total oxalate and phytic acid. Soluble oxalate ($F=15.9$: $p<0.05$) and hydrocyanide acid ($F=9.6$: $p<0.05$) were statistically significant while total oxalate ($F=0.55$: $p<0.05$) and phytic acid ($F=-10$: $p<0.05$) were insignificant (Table 4).

Table 5: Impacts of Telfairia mosaic virus (TeMV) infection and defoliation (DF) on the vitamin content of *Sphenostylis stenocarpa*

Vitamin	Control	TeMV[a]	% Difference[c]	DF[b]	% Difference[c]
Vitamin A (ug/100 g)	95.40 ± 0.02	70.80 ± 0.03	25.8	63.27 ± 0.01	33.7
Ascorbic acid Vit. C (mg/100 g)	36.43 ± 0.02	30.40 ± 0.01	16.6	18.20 ± 0.1	50.0
Thiamine (Vit. B_1) (mg/100 g)	48.61 ± 0.3	42. 27 ± 0.2	13.0	31.36 ± 0.2	35.5
Riboflavin (Vit. B_2) (mg/100 g)	52.11 ± 0.1	46.30 ± 0.1	11.1	40.01 ± 0.1	23.2
Niacin (Vit. B_3) (mg/100 g)	1.54 ± 0.3	1.45 ± 0.3	5.8	1.36 ± 0.2	11.7
Biotin (mg/100 g)	50.21 ± 0.1	48.12 ± 0.1	4.2	46.98 ± 0.1	6.4

a and b = Means ± SD of three replicates, c = values were obtained by expressing the difference between the values for control, TeMV and DF as a percentage of the control.Results show significant percentage reductions in vitamin C (50.0%), B_1 (35.5%), A (33.7%) and B_2 (23.2%). Insignificant reductions were obtained for vitamins B_3 (11.7%) and biotin (6.4%) (Table 5).

Table 6: Impacts of Telfairia mosaic virus (TeMV) infection and defoliation (DF) on the amino acids content of *Sphenostylis stenocarpa*

g/16N					
Amino acid	Control	TeMV[a]	% Difference[c]	DF[b]	% Difference[c]
Histidine	3.29 ± 0.01	3.01 ± 0.1	8.5	3.0 ± 0.02	8.8
Arginine	4.90 ± 0.26	3.64 ± 0.06	25.7	3.64 ± 0.02	25.7
Lysine	8.44 ± 0.1	8.05 ± 0.02	5.1	8.01 ± 0.01	4.6
Cysteine	1.10 ± 0.06	0.86 ± 0.06	21.8	0.84 ± 0.1	23.6
Aspartic acid	12.13 ± 0.13	14.87 ± 0.1	22.6	15.01 ± 0.06	23.7
Threonine	4.21 ± 0.6	3.26 ± 0.03	22.6	3.20 ± 0.06	24.0
Serine	7.37 ± 0.13	6.61 ± 0.26	10.3	6.50 ± 0.03	11.8
Glutamic acid	13.01 ± 0.03	14.98 ± 0.6	15.1	15.55 ± 0.01	19.5
Proline	1.42 ± 0.1	1.50 ± 0.1	5.6	1.53 ± 0.1	7.7
Valine	5.73 ± 0.06	4.70 ± 0.03	18.0	4.61 ± 0.02	19.5
Alanine	8.10 ± 0.06	9.06 ± 0.03	11.9	9.09 ± 0.06	12.2
Isoleucine	4.20 ± 0.01	3.03 ± 0.1	27.9	2.08 ± 0.6	50.0
Leucine	8.61 ± 0.01	6.56 ± 0.1	23.8	5.05 ± 0.1	41.3
Methionine	1.18 ± 0.03	0.90 ± 0.03	23.7	0.88 ± 0.1	25.4
Tyrosine	5.0 ± 0.1	4.16 ± 0.06	16.8	4.02 ± 0.06	19.6
Phenylalanine	6.15 ± 0.2	5.90 ± 0.2	4.1	5.61 ± 0.1	8.8
Glycine	10.1 ± 0.06	9.20 ± 0.06	8.9	9.00 ± 0.06	10.1

a and b = Means ± SD of three replicates, c = values were obtained by expressing the difference between the values for control, TeMV and DF as a percentage of the control. Results in Table 5 present the impacts of TeMV and DF on amino acids content of *S. stenocarpa*. Percentage decreases in essential amino acids recorded for TeMV and DF samples range from 5.1% (lysine) to 27.9% (isoleucine) and 4.65 (lysine) to 50.0% (isoleucine). Nonessential amino acids had a range in value from 8.9% (glycine) to 25.7% (arginine) for TeMV infected plant samples and from 10.1% (glycine) to 25.7% (arginine) for DF ones. Aspartic acid, glutamine acid, proline and alanine were significantly higher in TeMV and DF than in the control sample.

IV. Discussion

Findings of this study showed that TeMV infection and defoliation treatment of *S. stenocarpa* caused significant ($p<0.05$) reductions in alkaloids, tannins and saponins with increase in reducing sugars. Reductions in these medically useful phytochemicals resulting from TeMV infection are in agreement with previous reports [11], [33], [3], [34], [5]. Phenolic compounds including tannins are a significant component of plant secondary metabolites. They are estimated to be the fourth most abundant chemical compound produced by vascular plant tissue after cellulose, hemicelluloses and lignin. Tannins represent a significant portion of terrestrial biomass carbon [5].The decrease or increase in phytochemicals due to these stressors should not be ignored because these phytochemicals are of medical importance to man as they help in the cure of some ailments. Increases in phenols and reducing sugars obtained in this study correspond with findings of [35], who documented higher amount of stress compounds in virus infected plants. Higher amounts of these compounds in virus infected plants suggest that their synthesis is induced by stress caused by the virus infection and or defoliation. Reductions in phytochemicals could be due to reduction in plant total fresh weight of leaves and the demand for viral components synthesis resulting in host cells competition with normal biosynthetic pathways for essential precursors.

Results revealed higher significant ($p<0.05$) decrease in protein and carbohydrate in DF plant samples compared with TeMV infected samples [36]. Reductions in these proximate constituents caused by TeMV infection are in consonance with earlier reports [37] [5], [34]. Results of reduction in carbohydrate, fat and carbohydrate in defoliated plants are similar to report of reduction in carbohydrate, total phenolics and tannin in defoliated plants [11]. Results of this study contradict reports of no significant difference in crude protein and minerals in defoliated and non-defoliated plants [12]. Protein functions in support, as catalysts, in regulation, as a transport substance, in storage of amino acids, in movement and protection [38]. Impacts of TeMV infection and DF caused decrease in Na, Mg, Ca, Zn, Cu, P and K of *S. stenocarpa*. Results of this research are similar to those of [39], [4], [34], [5]. The reduction in quantities of these minerals sometimes called electrolytes on which life is built is of great concern because when vital minerals are deficient in diet, the body picks up toxic metals in the environment [40]. Minerals are vital for life and survival and cannot be manufactured within the body but must be obtained daily in our plants diets. Thus, eating plenty of these vital minerals is essential in reducing the accumulation of toxic metals in the body since we are exposed to toxic metals and toxic chemicals never seen before this time on this planet [41]. Sodium is the volatility and the solvent mineral that helps to regulate blood pressure, fluid balance, carbon dioxide transport and affect membrane permeability and other cell membrane functions. Sodium deficiency causes fatigue and fluid imbalances such as low blood pressure. Potassium is another solvent and a heart mineral essential for regulation of the heart beat, fluid balance and maintenance of blood pressure. Deficiency causes muscle cramps, weakness, depression and fatigue. Calcium is a structural element responsible for bone and tooth formation, blood clothing, nerve transmission and muscle contraction. Deficiency led to osteoporosis- resulting in bones that fracture readily [41], [42]. Magnesium is an important component of plants chlorophyll. It is required for a large number of enzymes that regulate sugar metabolism, energy production, permeability of cell membrane and muscle and nerve conduction. Magnesium deficiency can cause muscle cramps, fatigue and heart irregularities. Copper is the emotional and nutritive mineral considered as a female element because it is needed for certain functions in women. It is an element that enhances all emotions when present in high amount in the body. Copper is important for women's fertility and sexual function, its amount is influenced by levels of estrogen. It is also required for healthy arteries, pigments in hair and skin, blood formation, energy production and for neurotransmitter substances such as dopamine. Due to the use of copper water pipes, birth control, pills, vegetarian diets and stress, excess copper is more common than deficiency. Symptoms of excess copper include; depression, fatigue, acne, migraine headaches, moodiness, ADD, ADHD, austistic tendencies in babies and children, infertility, premenstrual tension and many others in women as well as boys and men Phosphorus is the most fiery energy mineral. It is an important constituent of adenosine triphosphate (ATP) and nucleic acid and is also essential for acid-base balance, bone and tooth formation [43]. Phosphorus is required for energy production, DNA synthesis and protein synthesis. Phosphorus is needed for calcium metabolism, muscle contraction and cell membrane structure. Zinc is a mineral that is a component of many enzymes and insulin, functions in wound healing. Low zinc especially in vegetarians cause a worsening of copper toxicity [41].

Vitamins of *S. stenocarpa* were significantly reduced by TeMV infection and DF. Vitamins reductions in TeMV infected samples are in line with previous reports of losses in other plant-virus combinations [44], [45], [4], [5]. Many vitamins play important role as coenzymes in many metabolic pathways, while others are involved in the synthesis of indispensable compounds [39]. Reductions in vitamin A, C, $B_{1,}$ $B_{2,}$ B_3 and biotin caused by TeMV infection and DF reduces the vitamins status of this important legume depriving the poor populace who depend on them to meet their body nutritional needs.Total oxalate, soluble oxalate, hydrocyanic acid and phytic acid were significantly increased in TeMV and DF samples. Higher amount of antinutrients in TeMV infected plants has been reported [34], [4], [5]. Antinutrients are present in high amounts in legume [46]. They act to reduce the bioavailability of minerals and proteins and carbohydrates digestibility. Higher amounts of antinurients induce by these stress conditions should be attended to even though some processing and genetic methods have been reported to drastically reduce antinutrients.Decrease in essential and non essential amino acids resulting from TeMV infection and DF in this research are in line with [3], [5]. Higher amount of aspartic acid, glutamic acid, proline and alanine obtained in TeMV infected and DF samples compared to the control are in consonance with reports that these amino acids can be found at higher concentrations [47], [1], [45] in *Telfairia occidentalis* infected by TeMV [4] in *Amaranthus hybridus* infected by TeMV, [48] in some pepper varieties infected by Tobacco mosaic virus. The accumulation of proline is a common metabolic response to both abiotic and biotic stress which occurs when higher plants are exposed to stress; a large number of plants accumulate high quantity of proline in their tissues [49]. Results of higher amount of proline in diseased samples are supported by [50], [51]. Pathogen (bacteria, viruses, fungi etc) infection [52] may cause the activation of numerous compounds in the cell or proline production [53]. Proline has been reported to act as a potent scavenger of ROS thus, preventing the induction of programmed cell death by ROS [54].

The decrease in essential nutrients in TeMV infected samples in this study may be attributable to physiological stress associated with alteration in plant metabolic functions [1], [55]. [34]. Physiological and biochemical changes in carbohydrate, lipids, proteins and amino acids have been observed under different conditions of stress (induced by water deficit) depending on the level and type [56].Results of this study revealed higher reductions in the nutritional quality with defoliation. These reductions resulting from defoliation could also be due to several physiological changes; a shift in the balance of internal hormone within the plant, the synthesis and secretion of celluloses and pectinases enzymes, the digestion of cell walls and middle lamella digestion between certain cells of abscission by enzymes affecting the quality of the legume. Legumes jointed grasses are slower to recover since new growth must be limited from either the crown or axillary buds on the stems close to the ground and rely on stored energy for initial growth [57]. Repeated defoliation of grasses causes reductions in root growth with effect on the nutritional quality of the legume.

V. Conclusion

Throughout the ages, plants have been a source of food and medicines among other uses to man [58]. Food is a basic necessity for human existence and perhaps the most precious commodity on earth [59]. Findings of this research have revealed the nutritional composition of African yam bean as affected by TeMV infection and DF. These results depict African yam bean as a promising cheap protein source and other minerals that are lacking in most food eaten by man. The results also suggest that African yam bean will go a long way in promoting the health of the Nigerian people by reducing the level of nutritional diseases in regions where it is consumed. The seeds of *S. stenocarpa* contain most essential and nonessential minerals in relatively higher amounts. The reductions in nutritional content posed by TeMV infection and DF are significant. It is thus, recommended that African yam bean plants be protected from virus infection and leaf removal (which are forms of disturbance) in the field and greenhouse to ensure its nutritional value.

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