ASSESSMENT OF GROWTH, YIELD AND NUTRITIVE QUALITY OF TWO OKRA (*Abelmoschus esculentus*) VARIETIES INFECTED WITH OKRA MOSAIC VIRUS

T.H. Aliyu[1*]., O. Arogundade[2]., K.O. Salami[3] and B.A. Tete[1]

[1]*Department of Crop Protection, Faculty of Agriculture, University of Ilorin-Nigeria*

[2]*National Horticultural Research Institute, Jericho Reservation Area, Idi-Ishin, Ibadan-Nigeria*

[3]*Department of Home Economics and Food Science, Faculty of Agriculture, University of Ilorin*

[*]***corresponding author e-mail:*** *aliyutaiyehussein@yahoo.com*

Phone: +2348030472667

ABSTRACT

Clemson spineless and NH-47-H okra varieties were inoculated with Okra mosaic virus (OkMV) at 2 weeks after planting. The objective of the experiment was to assess the effect of OkMV on growth, yield and proximate composition of the okra varieties. The experiment was laid out in a Complete Randomized design (CRD) with five replications in the screenhouse. Data were collected on plant height, number of leaves, pod length and pod weight. The fruit pods at harvest were subjected to proximate analysis using AOAC (2000) methods and all data collected subjected to analysis of variance (ANOVA). The results indicated that OkMV infected plants were significantly (P ≤ 0.05) shorter (13.2cm-19.4cm) than healthy plants (32.6cm - 33.9cm). Clemson spineless inoculated with OkMV averaged the significantly (P ≤ 0.05) lowest number of leaves (12.0) compared to healthy NH-47-H (23.6). The fruit length and weight were also significantly (P ≤ 0.05) lower in OkMV inoculated Clemson spineless (3.9cm and 2.4g) compared with healthy NH-47-H (10.3cm and 8.6g) respectively. Analysis of nutritive content revealed significant (P ≤ 0.05) depletion in the composition of ash, crude protein, crude fat and crude fiber composition in OkMV inoculated plants. The study revealed the damaging potential of OkMV on the two okra varieties and suggests OkMV management to enhance crop growth and nutrition.

Keywords: Nutrition, virus infection, okra, food security, proximate analysis

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is an adaptive and widely utilized species of the family *Malvaceae* (Kumar *et al.,* 2010). It is one of the most important vegetable plants in the tropical and warm temperate regions of the world (Das *et al.,* 2019; Agbenorhevi *et al.,* 2020). It is native to Ethiopia (Dantas, 2021) and widely produced in Africa in five main countries of Nigeria, Sudan, Mali, Côte d'Ivoire and Niger (FAOSAT, 2020).

Okra is grown for its immature fruits and fresh tender leaves that can be consumed as a fried or boiled vegetable or may be added to salads, soups and stews (Akintoye *et al.,* 2011; Kumar *et al.,* 2017). Okra is a good source of carbohydrate, dietary fibre, fat, protein, calcium, iron, thiamine, riboflavin, nicotinamide and ascorbic acid (Ewa *et al.,* 2011). It has medicinal applications when used as a plasma replacement or blood volume expander and binds cholesterol and bile acid carrying toxins dumped into it by the liver (Gemede *et al.,* 2015; Elkhalifa *et al.,* 2021). Due to the high phytochemical and nutritional content, the plant parts serve as important source of raw materials for some

pharmaceutical and other industrial applications (Singh and Ram, 2018; Nadratu *et al.,* 2020).

Okra however, remains a crop that is facing enormous problems and pays the heaviest price to diseases and pests (Abdulraheem, 2022). Viruses and are major constraints of okra production which cause severe crop damage and low yields (Chen *et al.*, 2019; Tiendrebeogo *et al.,* 2010). Okra mosaic virus (OkMV; genus *Tymovirus*; family *Tymoviridae*), is rampant in tropical and subtropical regions across the world and the most commonly studied on Okra (Sayed *et al.,* 2014). Typical symptoms of OkMV infection include mosaic, vein chlorosis and vein-banding and plant stunting (Asare-Bediako *et al.,* 2017). To overcome the biotic stress imposed by virus infestation, plants usually produce different types of secondary metabolites that play significant roles in plant defense. These interactions induce many positive and negative effects on nutritional quality and yield (Mishra *et al.*, 2020).

Okra provides a wealthy source of nutrition and contributes to household food self-sufficiency for a great number of farmers in Nigeria. However, Okra mosaic virus disease has been implicated as playing significant roles in depleting quantity and quality potentials of the crop. The objective of the study was assessment of growth, yield and nutritive quality of two okra (*Abelmoschus esculentus*) varieties infected with Okra mosaic virus**.**

MATERIALS AND METHODS

Experimental Site Description

Screenhouse and laboratory experiments were conducted at the Faculty of Agriculture, University of Ilorin, Kwara State-Nigeria, located in the southern guinea savanna agroecology of Nigeria on latitude 8^0 26^1 N, longitude 4^0 29^1E, and about 344.7m above sea level (Aliyu *et al.,* 2012). The local climate in this area is characterized by distinct wet and dry seasons. The wet season commences in March or April and ends in October, with a dry spell from mid-July to mid-August. The dry season starts towards the end of October and lasts until March or April (Fasakin *et al.,* 2019).

Agronomic Practices and Experimental Design

Clemson spineless and NH-47-H okra varieties that are mostly grown by farmers in the area was used in the experiment. The seeds were obtained from the premier seed company limited in Ilorin - Nigeria. Four seeds of each variety were sown at the depths of 3 to 4cm in plastic pots (4-litre capacity) containing sandy loam soil and cured organic manure. It was steam sterilized at 121^0C for 120 minutes to war-off soil borne pathogens. At 7 days after germination, the seedlings were then thinned to 2 plants per pot and irrigation performed daily for effective crop growth.

The screenhouse experiment consisted of the following treatments:

(i) T1= Clemson spineless variety inoculated with Okra mosaic virus
(ii) T2= NH-47-H variety inoculated with Okra mosaic virus
(iii) T3= Clemson spineless variety not inoculated with virus (healthy control)
(iv) T4= NH-47-H variety not inoculated with virus (healthy control)

Each treatment was replicated 5 times with each pot (20) containing 2 plants (total of 40 plant observations) and arranged in a Complete Randomized Design (CRD) in the screenhouse.

Virus Extraction and Inoculation Procedure

The virus inoculum (OkMV) was sourced from infected leaves from stock in the Department of Crop protection, Faculty of Agriculture, University of Ilorin-Nigeria. The viral extraction was done in the laboratory by homogenizing OkMV infected leaves in 0.05 M Phosphate buffer at P_H of 7.2 at the rate of 1g leaf sample to 5 ml of buffer. The buffer was prepared in the following way: Solution A: 1.36

g KH2PO4 in 1000 ml H20 Solution B: 1.78 g Na2 V-P04 x 2 I-0 in 1000 ml H2O. 51.0 ml of solution B mixed with 49.0 ml of solution A gives 100 ml of 0.01 M phosphate buffer solution pH 7.2 (Noordam, 1973). The procedure of inoculation is by slight dusting of the primary leaves with Carborundum (silicon carbide, 400-600 mesh) and Celite (diatomaceous earth). The abrasive was finely dusted over the leaf surface and also suspended in the inoculum (0.5-1% w/v) after which the leaves were then rubbed with the extracted juice of the inoculum, using cotton wool. The inoculation was carried out by moistening 1 or 2 fingers in inoculum and rubbing gently onto the leaves, while supporting them with the other hand. The plants were thereafter rinsed with distilled water thereafter to reduce inoculation stress (Balogun, 2000).

Data Collection

Data were collected from 1 to 5 weeks after inoculation for growth (plant height (cm) and number of leaves per plant) and yield (pod length (cm) and pod weight (g)) parameters.

Sample Preparation for Proximate Analysis

Harvested okra pods from representative treatments were washed separately with distilled water and sliced to uniform thickness (5 mm) using a stainless-steel knife. The sliced okra pods were then dried at ambient temperature (35 - 38 °C) and milled separately into fine powder using electric grinder. It was then sieved (0.425 mm sieve mesh size) and packed into airtight polyethylene plastic bags until required for analysis (Gemede *et al.,* 2015). Proximate analysis involved the determination of the major components of food such as dry matter, ash, crude fat, crude protein, and crude fibre (Aja *et al.,* 2015). Dry matter was determined by drying in an oven at 105ºC during 24 h to constant weight (Firmin *et al.,* 2018). The AOAC (2011), method was used for the ash content assay. The crude protein was determined by the method of Gandji *et al.* (2019). Crude fiber was determined according to the method adopted by Miteu and Ezeh (2022) and Crude fat by continuous extraction in a Soxhlet apparatus for 8 h using hexane as solvent (Geeth *et al.,* 2020).

Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) using the statistical package for the social sciences SPSS version 15.0. Significant tests were carried out at the 0.05 level of probability and means separated using the New Duncan Multiple Range Test.

RESULTS AND DISCUSSION

Effect of Treatments on Plant Height

Analysis of the result on effect of treatments on plant height showed that at 6 WAI OkMV infected plants were significantly ($P \leq 0.05$) shorter than healthy controls (Table 1). The shortest were Clemson spineless variety inoculated with OkMV (13.2cm) and NH-47-H variety inoculated with OkMV (19.4cm). The healthy plants were expressively taller with range of 32.6cm - 33.9cm for both varieties. In general, the growth of virus infected plants is limited due to inhibitions of certain enzymes involved in biosynthesis of chlorophyll contents thereby resulting in stunted growth in infected varieties (Miteva *et al.,* 2005). This suggests that alterations in plant height of OkMV infected okra varieties was a consequence of virus activity and reactions by host genes. This position is in agreement with submissions by Pazarlar *et al.* (2013); Appiah *et al.* (2020) and Amiteye *et al.* (2021).

Number of Leaves as Affected by OkMV Infection

Clemson spineless inoculated with OKMV averaged the lowest number of leaves per plant (12.0) followed by NH-47-H inoculated with OKMV (17.3). These were significantly ($P \leq 0.05$) lower than healthy Clemson spineless (22.1) and NH-47-H (23.6) varieties (Table 2).

The reduction in number of leaves of virus inoculated plants is vital due to the important role leaves play in photosynthesis (Wright *et al.,* 2004). Virus infection is associated with reduction in plant physiological processes like cell multiplication and photosynthesis and could therefore account for decrease in the number of leaves in OkMV infected varieties. This claim is agreeable to Mofunanya *et al.* (2020) in their assessment of the growth and yield of *Sphenostylis stenocarpa* as affected by virus infection.

Effect on Pod length and Pod Weight as Affected by OkMV Infection

Pod length and pod weight of okra varieties were influenced by stress induced by OkMV inoculation (Table 3). Pod length of OkMV inoculated Clemson spineless (3.9cm) and NH-47-H (5.6cm) were significantly ($P \leq 0.05$) lower compared to healthy Clemson spineless (9.5cm) and NH-47-H (10.3) okra varieties. Table 3 also showed that pod weight was significantly ($P \leq 0.05$) higher in healthy Clemson spineless (7.8g) and NH-47-H (8.6g) varieties. While lower pod weight was reported for OkMV inoculated Clemson spineless (2.4g) and NH-47-H (4.8g) varieties. It has been reported by Kang *et al.* (2006) that growth parameters have a direct link with plant yield. This infers that lesser pod length and pod weight observed in OkMV infected okra varieties might be ascribed to the reduction in number of leaves per plant. Parimala *et al.* (2009) had also reported a decrease in yield of virus-infected okra and attributed it to reduced chlorophyll content and photosynthesis.

Effect on Nutritional Composition

The effect of treatments on the proximate composition of okra fruits is shown in Table 4. The results indicated that most nutritional attributes were depleted by OkMV inoculation. Dry matter content analysis showed okra infected with OkMV (54.3% - 55.9%) was significantly ($P \leq 0.05$) higher than healthy plants (47.4% - 48.1%). Dry matter content of any food is an index of its water activity and used as a measure of susceptibility to microbial contamination (Edak *et al.,* 2013). The higher moisture content in OkMV infected okra makes it more vulnerable to microbial attack and spoilage (Nwofia *et al.,* 2012). The ash content ranged from 4.6% - 4.9% and 5.9% - 6.3% in OkMV infected and healthy plants respectively. This is a hint that ash content was significantly ($P \leq 0.05$) lower in virus infected plants. This is pointer to lessened nutritional status due to OkMV infection as proposed by Gemede *et al.* (2015). The crude protein varied significantly ($P \leq 0.05$) from 10.9% - 11.4% (OkMV infected varieties) to 36.9% – 37.4% (healthy plants). Ali (2010) considered plants with 12% protein to be good sources of protein. Crude fat was lower in OkMV infected plants (7.7% - 7.9%) and was significantly ($P \leq 0.05$) different from the values (9.0% - 9.2%) of healthy controls. Bo (2020) detailed that dietary fat increases food palatability by absorbing and retaining flavor. Crude fibre were significantly ($P \leq 0.05$) higher in healthy (10.7% - 11.9%) compared with OkMV infected plants (8.7% - 8.9%). The fibre content of healthy okra was reported by Adetuyi (2011) to range from 10.1% to 11.6% and this is further evidence of the depletive nutritional effect of OkMV on Okra.

CONCLUSION

The study revealed that OkMV infection severely inhibited the growth, yield and nutritional qualities of Clemson spineless and NH-47-H okra varieties. There is need to safeguard vulnerability of the crop varieties to virus infection by deploying adequate virus management procedures. This will boost production and enhance the nutritive composition of the okra varieties.

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Table 1: Effect of treatment on plant height (cm)

	Weeks after Inoculation (WAI)					
Treatment	**1**	**2**	**3**	**4**	**5**	**6**
T1	8.0^{a}	8.7^{a}	9.3^{a}	10.3^{a}	12.0^{a}	13.2^{a}
T2	8.1^{a}	10.0^{b}	10.6^{b}	16.4^{b}	18.3^{b}	19.4^{b}
T3	8.2^{a}	12.4^{c}	16.7^{c}	23.3^{c}	29.1^{c}	32.6^{c}
T4	8.2^{a}	12.6^{c}	17.4^{cd}	24.4^{c}	31.2^{cd}	33.9^{c}
SEM	0.184	0.343	0.774	0.917	1.22	1.41

Means within a column followed by the same letter(s) are not significantly different using the New Duncan multiple Range Test at ($P \leq 0.05$)
Key: T1= Clemson spineless variety inoculated with Okra mosaic virus; T2= NH-47-H variety inoculated with Okra mosaic virus; T3= Clemson spineless variety not inoculated with virus; T4= NH-47-H variety not inoculated with virus. SEM= Standard Error of Means

Table 2: Effect of treatment on average number of leaves per plant

Treatment	Weeks after Inoculation (WAI)					
	1	2	3	4	5	6
T1	3.6^{a}	4.6^{a}	6.6^{a}	8.3^{a}	9.4^{a}	12.0^{a}
T2	3.5^{a}	4.5^{a}	9.0^{b}	11.0^{b}	13.3^{b}	17.3^{b}
T3	3.6^{a}	8.3^{b}	15.6^{c}	16.6^{c}	17.6^{c}	22.1^{c}
T4	3.6^{a}	8.8^{b}	15.8^{c}	16.9^{c}	17.8^{c}	23.6^{cd}
SEM	0.133	0.324	0.689	0.676	0.675	0.716

Means within a column followed by the same letter(s) are not significantly different using the New Duncan multiple Range Test at ($P \leq 0.05$)

Table 3: Effect of treatment on yield attributes

Treatment	Fruit length/plant (cm)	Fruit weight/plant (g)
T1	3.9^{a}	2.4^{a}
T2	5.6^{b}	4.8^{b}
T3	9.5^{c}	7.8^{c}
T4	10.3^{bc}	8.6^{bc}
SEM	0.575	0.746

Means within a column followed by the same letter(s) are not significantly different using the New Duncan multiple Range Test at ($P \leq 0.05$)

Table 4: Effect of treatment on nutritional composition

Treatment	Nutritional parameters				
	Dry Matter (%)	Ash (%)	Crude protein (%)	Crude Fat (%)	Crude Fiber (%)
T1	54.3^{b}	4.9^{a}	10.9^{a}	7.7^{ba}	8.9^{a}
T2	55.9^{b}	4.6^{ab}	11.4^{b}	7.9^{ab}	8.7^{a}
T3	47.4^{a}	5.9^{ac}	36.9^{c}	9.0^{c}	10.7^{b}
T4	48.1^{a}	6.3^{cd}	37.4^{d}	$9..2^{c}$	11.9^{b}
SEM	0.323	0.126	0.214	0.209	0.314

Means within a column followed by the same letter(s) are not significantly different using the New Duncan multiple Range Test at ($P \leq 0.05$)