International Journal of Mathematical Analysis and Modelling

(Formerly Journal of the Nigerian Society for Mathematical Biology)

Volume 5, Issue 4 (Nov.), 2022

ISSN (Print): 2682 - 5694
ISSN (Online): 2682 - 5708

International Journal of Mathematical Analysis and Modelling
Volume 5, Issue 4, November 2022, Pages 25 – 37

Modeling the impact of a random perturbation on the yields of tuber crops using a computational approach

B.O. Nwala*†, P. Nwagor*‡, and I.U. Amadi§

Abstract

An application of four dynamical systems of nonlinear first order ordinary differential equations was considered. Therefore, ODE45 was utilized to quantify the impact of a random environmental perturbation on the yields of four competing tuber crops. It was observed that the growth of the four interacting agricultural crops depends on their intra-species coefficients and also on their inter-species coefficient extensively. Hence, the results of this study extensively established that the farmers should endeavor to harvest their crops at harvesting scenario which is vulnerable to biodiversity. Moreover, the analysis of these results also identified that the farmers should cultivate more of cocoyam which produced 760.0240kg, yellow yam 225.4284kg, followed by cassava quantified by 170.7381kg and finally white yam by -66.6667kg. It is therefore recommended that the cultivators should not hesitate to notify the agricultural policy makers for quick intervention immediately they identify the evidence of environmental perturbation on their crops for optimal maximization of profit and adequate food supply in the society.

Keywords: computational; tuber; ode 45; yields; perturbation; biomass.

1 Introduction

The impact of a random perturbation on the food production, ecosystem and human beings is an old environmental global challenge that demands immediate attention to circumvent the issue of food insecurity and lack of food production in the society. [22] reported that "the National Science Academics of G8" including China, Brazil and India affirmed that the impact of a random perturbation is obvious on the ecosystem. To back up this fact, [2] established that the effect of a random perturbation on the earth is a constant process [6, 13,20,3].

The work in [15] revealed that the natural and human activities on the environment such as rain fall, flood, heat, bush boiling, deforestation and diseases are the major well spring of a random perturbation. It is therefore observed that a random perturbation has more influence in African

*Department of Mathematics and Statistics, Ignatius Ajuru University of Education, Port Harcourt, Nigeria
†Corresponding Author. Email: boninwala@gmail.com
‡Email: pnwagor@yahoo.com
§Department of Mathematics/Statistics, Captain Elechi Amadi Polytechnic, Rumuola, Port Harcourt, Nigeria; Email: innocentamadi@portharcourtpoly.edu.ng

regions than any other region [5, 8, 14, 16] etc. In this context, biodiversity loss is a global cost and increasingly endangered through an event of anthropogenic processes [12-23]. Moreover, the increase in a random perturbation affected the agricultural sector globally which threaten all the economy and encouraged raise in food prices [5, 8, 14,23]. In the same vein [8] explained that a computational approach is a calculation conducted using a computer programming that defined a mathematical model for a physical system which is consistent with the research works of [1,4,9] etc.

The work in [18] recently evaluated the impact of a random perturbation on two agricultural species (cassava and yam) using the MATLAB ODE 45 computational approach and his result established that the two crops were vulnerable to biodiversity loss but more vulnerability was captured on yam than the cassava. The study showed that the possibility of having food shortage in the society is certain and this vital prediction is consistent with the research contribution of [3,10 ,17] etc. In the work of [19] investigated numerical and statistical quantifications of biodiversity of two agricultural crops using ODE45 numerical scheme which the result extensively obtained a relative biodiversity loss of the two crops but there was indication of more vulnerability on cassava than yam which could instigate economic downshift in the society which concurred with the contributions of [18].

Having discovered that the previous researchers applied experimental method, theoretical method and two dynamical system of nonlinear first order ordinary differential equations ODE45 to investigate the effect of biodiversity loss in ecosystem which has developed a huge gap in the knowledge base in mathematical modeling. To circumvent this gap, this study has considered the application of four dynamical systems of nonlinear white order ordinary differential equations ODE45 to quantify the impact of random environmental perturbation on the food production of four tuber crops.

The aim of this paper is to simulate the impact of random environmental perturbation on the yields of cassava, white yam, yellow yam and cocoyam respectively considering that the growth of the four agricultural crops depends on their intra-species coefficients and on their inter-species coefficients.

This paper considered the following arrangements. Section 2.1 is mathematical formulations, section 2.2 is considered as materials and methods, the presentation of results is seen in section 3 while discussion of results is located in section 4 and finally, conclusion is seen in section 5.

2.1 Mathematical formulations

For the purpose of this, we shall consider the following four continuous dynamical systems of non-linear white order ordinary differential equations according to [19].

$$\frac{dC}{dt} = \alpha_1 C - \beta_1 C^2 - r_1 C Y_1 - r_2 C Y_2 - r_3 C C_y - \mathrm{r}\psi \mathrm{C}\left(1 - \frac{B}{K}\right), \quad C(0) = C_0 > 0 \tag{1}$$

$$\frac{dY_1}{dt} = \alpha_2 Y_1 - \beta_2 Y_1^2 - r_4 C Y_1 - r_5 Y_1 Y_2 - r_6 Y_1 C_y - \mathrm{r}\psi \mathrm{Y}_1\left(1 - \frac{B}{K}\right), \quad Y_1(0) = Y_{10} > 0 \tag{2}$$

$$\frac{dY_2}{dt} = \alpha_3 Y_2 - \beta_3 Y_2^2 - r_7 C Y_2 - r_8 Y_1 Y_2 - r_9 Y_2 C_y - \mathrm{r}\psi \mathrm{Y}_2\left(1 - \frac{B}{K}\right), \quad Y_2(0) = Y_{20} > 0 \tag{3}$$

$$\frac{dC_y}{dt} = \alpha_4 C_y - \beta_4 {C_y}^2 - r_{10} C_y C - r_{11} C_y Y_1 - r_{12} C_y Y_2 - \mathrm{r}\psi\mathrm{Cy}\left(1 - \frac{B}{K}\right),$$
$$C_y(0) = {C_y}_0 > 0, \qquad 4$$

with the initial conditions, $C(0) = C_0 > 0$, $Y_1(0) = Y_{10} > 0$, $Y_2(0) = Y_{20} > 0$ and $C_y(0) = C_{y0} > 0$.

Let $r\psi C(1 - \frac{B}{K}) = K_1$, $r\psi Y_1(1 - \frac{B}{K}) = K_2$, $r\psi Y_2(1 - \frac{B}{K}) = K_3$, $r\psi C_y(1 - \frac{B}{K}) = K_4$.

For the purpose of this study, this research shall consider the following parameter values and its specifications.

Variable	Interpretation
C(t)	Measures the biomass of cassava at time *t*
$Y_1(t)$	Measures the biomass of white yam at time *t*
$Y_2(t)$	Measures the biomass of yellow yam at time *t*
$C_y(t)$	Measures the biomass of coco-yam at time *t*

Parameter	Interpretation	Value
α_1	measures the intrinsic growth rate of cassava that enhances the growth of cassava.	0.133
β_1	measures the biomass of cassava that interacts with itself to inhibit the growth rate of cassava.	0.0024
r_1	measures the biomass of cassava that interacts with the white yam to inhibit the growth rate of cassava.	0.0018
r_2	measures the biomass of cassava that interacts with the yellow yam to inhibit the growth rate of cassava.	0.0014
r_3	measures the biomass of cassava that interacts with the cocoyam to inhibit the growth rate of cassava.	0.0012
α_2	measure the intrinsic growth rate of white yam that enhances the growth of white yam.	0.132
β_2	measures the biomass of white yam that interacts with itself to inhibit the growth rate of white yam.	0.0018
r_4	measures the biomass of white yam that interacts with the cassava to inhibit the growth rate of white yam.	0.0014
r_5	measures the biomass of white yam that interacts with yellow yam to inhibit the growth rate of white yam.	0.0012
r_6	measures the biomass of white yam that interacts with cocoyam to inhibit the growth rate of white yam.	0.00064
α_3	measures the biomass of yellow yam that enhances the growth rate of yellow yam.	0.132
β_3	measures the biomass of yellow yam that interacts with itself to inhibit the growth rate of yellow yam.	0.0016
r_7	measures the biomass of yellow yam that interacts with cassava to inhibit the growth rate of yellow yam.	0.0014

r_8	measures the biomass of yellow yam that interacts with white yam to inhibit the growth rate of yellow yam.	0.0012
r_9	measures the biomass of yellow yam that interacts with cocoyam to inhibit the growth rate of yellow yam.	0.00048
α_4	measures the biomass of cocoyam that enhances the growth of cocoyam.	0.12
β_4	measures the biomass of cocoyam that interacts with itself to inhibit the growth rate of cocoyam.	0.0015
r_{10}	measures the biomass of cocoyam that interacts with cassava to inhibit the growth rate of coco yam.	0.0013
r_{11}	measures the biomass of cocoyam that interacts with white yam to inhibit the growth rate of cocoyam.	0.0013
r_{12}	measures the biomass of cocoyam that interacts with yellow yam species to inhibit the growth rate of cocoyam.	0.00167
R	Measures the natural depletion rate coefficient of $C0_2$	0.0002
ψ	Measures the rate at which carbon dioxide is used during the photosynthesis process by the green plant for their growth	0.65
B	Measure the biomass density of green plant	12.5
K	Measure the environmental carrying capacity per crop due to a random perturbation	200

Source of arbitrary parameter values (Ekaka-a, 2014)

2.2 Materials and method

In this study, a numerical method is used to quantify the impact of a random perturbation on the yields of four competing tuber crops such as cassava, two species of yam and cocoyam respectively using ordinary differential equations (ODE 45) computational approach.
In this particular section, we prove that the crops growth model is well-posed and this is done by proving that the positively, boundedness, existence and uniqueness of the solutions of the model with non-negative initial data remains non-negative for all time t >0.

Lemma 1: The set $\Omega = \left\{(C, Y_{1,} Y_{2,} Cy)\ \varepsilon R_+^4 : N \ \leq \ \frac{a_1 - K_1}{\beta_1}\right\}$ is positively invariant with respect to the growth model (1) to (4).

Lemma 2: (Positivity) let the set of initial data be $\{(C(0), Y_1(0), Y_2(0), Cy(0)), \varepsilon\ \emptyset\}$. Then, the data set $\{(C(t), Y_1(t), Y_2(t), Cy(t)\}$ of the growth model is non-negative for t > 0.

Proof: Assuming that the set of initial data, $\{(C(0), Y_1(0), Y_2(0), Cy(0)) \ \geq \ 0\}$, then equation 1 gives $\frac{dc}{dt} = \ a_1 C - \ \beta_1 C^2 - \ r_1 C Y_1 - \ r_2 C Y_2 - \ r_3 C C y - C K_1$

$$\frac{dc}{dt} = \ C(a_1 - \ \beta_1 C - \ r_1 Y_1 - \ r_2 Y_2 - \ r_3 C Y - K_1),$$

$$\frac{dc}{C} = \ (a_1 - \ \beta_1 - \ r_1 Y_1 - \ r_2 Y_2 - \ r_3 C Y - K_1)\ dt,$$

$$\int \frac{dc}{C} \geq \int (a_1 - \ \beta_1 - \ r_1 Y_1 - \ r_2 Y_2 - \ r_3 C Y - K_1)\ dt$$

$$C(t) \geq C(0) e^{(a_1 - \ \beta_1 C - \ r_1 Y_1 - \ r_2 Y_2 - \ r_3 C Y - K_1) \quad \geq 0}.$$

Similarly, the remaining state variables are obtained as:

$Y_1(t) \geq\ Y_1(0)EXP(a_2 -\ \beta_2 -\ r_4C -\ r_5Y_2 -\ r_6Cy - K_2)\ \geq 0,$
$Y_2(t) \geq\ Y_2(0)EXP(a_3 -\ \beta_3 -\ r_7C -\ r_8Y_1 -\ r_9Cy - K_3)\ \geq 0,$
$Cy(t) \geq\ Cy(0)EXP(a_4 -\ \beta_4 -\ r_{10}C -\ r_{11}Y_2 -\ r_{12}Y_2 - K_4)\ \geq 0$ for all t > 0.

Lemma 3: (Boundedness) assuming that the initial condition for growth model (1) to (4) satisfies N(0) $\leq \frac{a_1 - K_1}{\beta_1}$.

Then, whenever the solution exists on an interval 1, it satisfies the property of boundness.
$N(t) \leq \frac{a_1 - K_1}{\beta_1}$.

Proof: Since 1(t) $\geq 0,$

$$\frac{dN}{dt} < \frac{a_1 -\ K_1N}{\beta_1}$$

$N(t) \leq \qquad \frac{a_1 - K_1}{\beta_1}\ +\ N(0) - \left(\frac{a_1 - K_1}{\beta_1}\right)e^{\beta_1 t}\ where\ (0) \leq\ \frac{a_1 - K_1}{\beta_1}, we\ have\ N(t)\ \leq\ \frac{a_1 - K_1}{\beta_1}.$
Consequently, 1(t) $\leq\ \frac{a_1 - K_1}{\beta_1}$.

Lemma 4: Existence and uniqueness
Let $\dot{t}$ > 0, if the initial condition satisfies, $\{(C(0), Y_1(0), Y_2(0), Cy(0)), >\ 0\}.$
Then, $\forall\ t\ \varepsilon\ R,$ the solution set $\{(C(t), Y_1(t), Y_2(t), Cy(t)\}$ exists in R_t^4 and is unique.
Proof: The growth model (1) – (4) could be written as

$$x = \begin{vmatrix} C(t) \\ Y_1(t) \\ Y_2(t) \\ Cy(t) \end{vmatrix}\ and\ F(x) = \begin{vmatrix} C(a_1 -\ \beta_1C -\ r_1Y_1 -\ r_2Y_2 -\ r_3Cy - K_1) \\ Y_1(a_2 -\ \beta_2Y_1 -\ r_4C -\ r_5Y_2 -\ r_6Cy - K_2) \\ Y_2(a_3 -\ \beta_3Y_2 -\ r_7C -\ r_8Y_1 -\ r_9Cy - K_3) \\ Cy(a_4 -\ \beta_4Cy -\ r_{10}C -\ r_{11}Y_1 -\ r_{12}Y_2 - K_4) \end{vmatrix} \qquad 5$$

Therefore, F is continuous and locally satisfies lipschirz condition in R_t^4 using the picart – lindedof theorem and the white – two (1 and 2) lemmas proved the positively and boundedness of the solutions, there exist $\dot{t}$ > 0 such that the solution set of the growth model (1) to (4) exists locally at least on an interval [0, $\dot{t}$] and is unique. Hence, lemma 4 defined the production validity of growth model (1) to (4).

Lemma 5: Therefore, the growth model (1) to (4) is well-posed and valid in the set
$\int \Omega = \int (C(t), Y_1(t), Y_2(t), Cy(t))\ \varepsilon\ R_t^4; N \leq\ \frac{a_1 - K_1}{\beta_1}$.

It is obvious to report that the intrinsic growth rate parameter values undergo more vulnerability than any other parameter value in the event of a random perturbation scenario. To quantify the effect, we considered when the new biomass is higher than the old biomass, that indicated increased in production has been occurred [9], [18] and [19] etc. Therefore, we applied the formula stated below to evaluate the extent of biodiversity gain.

$$EPMY\ (\%) = \left(\frac{New\ crop\ biomass - Old\ crop\ biomass}{Old\ crop\ biomass}\right)(100)$$

Note: EPMY (%) represents the estimated proportion of more in yields in percentage quantification with respect to cassava, yellow yam, and cocoyam respectively.

$$EPMC\ (\%) = \left(\frac{New\ cassava\ biomass - Old\ cassava\ biomass}{Old\ cassava\ biomass}\right)(100)$$
$$= \left(\frac{0.1008 - 0.0533}{0.0533}\right)(100) = (0.8912)(100) = 89.1182\%$$

Similarly,

$$EPMY_2\ (\%) = \left(\frac{New\ yellow\ yam\ biomass - Old\ yellow\ yam\ biomass}{Old\ yellow\ yam\ biomass}\right)(100)$$
$$= \left(\frac{0.1263 - 0.0781}{0.0781}\right)(100) = (0.6172)(100) = 61.7158\%$$

Similarly,

$$EPMY\ Cy(\%) = \left(\frac{New\ cocoyam\ biomass - Old\ cocoyam\ biomass}{Old\ cocoyam\ biomass}\right)(100)$$

$$= \left(\frac{0.0709 - 0.0254}{0.0254}\right)(100) = (1.7914)(100) = 179.1339\%$$

Eventually, when the old biomass is greater than the new biomass which indicated depletion in yields has established [18]. The formula stated below is considered to calculate the effect of biodiversity loss.

$$EPMY\ (\%) = \left(\frac{New\ crop\ biomass - Old\ crop\ biomass}{Old\ crop\ biomass}\right)(100)$$
$$EPMY\ \ Y_1(\%) = \left(\frac{Old\ white\ yam\ biomass - New\ white\ yam\ biomass}{Old\ white\ yam\ biomass}\right)(100)$$
$$= \left(\frac{0.0781 - 0.0749}{0.0781}\right)(100) = (0.04097)(100) = \mathbf{-4.0973}\%$$

3 Results

This section presents the results in the tables which we obtained in section 2.

Note that LGs represents the length of growing season, CB represents the cassava biomass, Y_1B represents the white yam biomass, Y_2 represents the yellow yam biomass while Cy represents the cocoyam biomass.

Table 1: Evaluating a random perturbation impact analysis on the yields of cassava and the white yam using ODE45 computational approach of 0.05 RPV in scenario one

LGS Months	Old CB(kg)	New CB(kg)	Effect 1(%)	Old Y_1B (kg)	New Y_1B (kg)	Effect 2(%)
0	0.0400	0.0400	0.0000	0.0600	0.0200	-66.6667
1	0.0533	0.1008	89.1102	0.0781	0.0749	-4.0973
2	0.0710	0.1696	138.8680	0.1016	0.1381	35.8006
3	0.0946	0.2424	156.2317	0.1322	0.2116	60.1290
4	0.1260	0.3228	156.2317	0.1719	0.2916	69.5812
5	0.1678	0.4273	154.7551	0.2235	0.3850	72.2348
6	0.2231	0.5410	142.4298	0.2905	0.4868	72.2348
7	0.2966	0.6554	120.9411	0.3772	0.5937	57.3550
8	0.3938	0.7688	95.2355	0.4895	0.7087	44.7458
9	0.5222	0.9081	73.9291	0.6346	0.8191	29.0666
10	0.6911	1.0445	51.1423	0.8216	0.9160	11.4817
11	0.9126	1.1523	26.2557	1.6618	1.0293	-3.0673
12	1.2016	1.2563	4.5500	1.3692	1.1262	-17.7662
13	1.5761	1.3324	-15.4648	1.7607	1.2337	-29.9261
14	2.0572	1.3858	-32.6387	2.2557	1.3138	-41.7530
15	2.6689	1.4250	-45.6705	2.8768	1.3615	-52.6731

Table 2: Evaluating a random perturbation impact analysis on the yields of cassava and the white yam using ODE45 computational approach of 0.05 RPV in scenario two

LGS Months	Old CB(kg)	New CB(kg)	Effect 1(%)	Old Y_1B (kg)	New Y_1B (kg)	Effect 2(%)
0	0.0400	0.0400	0.0000	0.0600	0.0200	-66.6667
1	0.0533	0.1015	90.4315	0.0781	0.0755	-3.3291
2	0.0710	0.1722	142.5890	0.1016	0.1429	40.6755
3	0.0946	0.2513	165.5244	0.1322	0.2071	56.6367
4	0.1260	0.3413	170.7381	0.1717	0.3003	74.6956
5	0.1678	0.4417	163.3288	0.2235	0.3900	74.5078
6	0.2231	0.5454	144.4253	0.2905	0.4941	70.1462
7	0.2966	0.6594	122.3392	0.3772	0.6006	59.2167
8	0.3938	0.7743	94.6277	0.4895	0.7218	47.4640
9	0.5222	0.8962	71.6300	0.6346	0.8385	32.1244
10	0.6911	1.0079	45.8396	0.8216	0.9557	16.3396
11	0.9126	1.1170	22.4046	1.0618	1.0725	1.0051
12	1.2016	1.2065	0.4018	1.3692	1.1837	-13.5510
13	1.5761	1.2739	-19.1788	1.7607	1.2829	-27.1354
14	2.0572	1.3256	-35.3635	2.2557	1.3649	-39.4918
15	2.6689	1.3589	-49.0839	2.8768	1.4266	-50.4102

Table 3: Evaluating a random perturbation impact analysis on the yields of cassava and the white yam using ODE45 computational approach of 0.05 RPV in scenario three

LGS Months	Old CB(kg)	New CB(kg)	Effect 1(%)	Old Y_1B(kg)	New Y_1B(kg)	Effect 2(%)
0	0.0400	0.0400	0.0000	0.0600	0.0200	-66.6667
1	0.0533	0.1001	87.8048	0.0781	0.0775	-0.7683
2	0.0710	0.1690	138.0036	0.1016	0.1462	43.8854
3	0.0946	0.2492	163.3939	0.1322	0.2196	66.1281
4	0.1260	0.3300	161.3939	0.1719	0.2943	71.2180
5	0.1678	0.4311	157.0205	0.2235	0.3846	72.0210
6	0.2231	0.5367	140.5158	0.2905	0.4854	67.0822
7	0.2966	0.6580	121.8593	0.3772	0.5957	57.8860
8	0.3938	0.7860	99.5921	0.4895	0.7151	46.0988
9	0.5222	0.9176	75.7313	0.6346	0.8392	32.2470
10	0.6911	1.0395	50.4262	0.8216	0.9474	15.3222
11	0.9126	1.1657	27.7132	1.0618	1.0609	-0.0887
12	1.2016	1.2609	4.9381	1.3692	1.1498	-16.0303
13	1.5761	1.3391	-15.0344	1.7607	1.2487	-29.0780
14	2.0572	1.3853	-32.6656	2.2557	1.3133	-41.7817
15	2.6689	1.4092	-47.1992	2.8768	1.3796	-52.0434

Table 4: Evaluating a random perturbation impact analysis on the yields of yellow yam and the cocoyam using ODE45 computational approach of 0.05 RPV in scenario four

LGS Months	Old Y_2B (kg)	New Y_2B (kg)	Effect 1(%)	Old CyB(kg)	New CyB(kg)	Effect 2(%)
0	0.0400	0.0400	0.0000	0.0600	0.0200	-66.6667
1	0.0781	0.1263	61.7158	0.0254	0.0709	179.1339
2	0.1016	0.2090	105.6828	0.0323	0.1363	322.3292
3	0.1322	0.3181	140.5074	0.0410	0.2216	440.5801
4	0.1720	0.4588	166.7216	0.0521	0.3272	528.6197
5	0.2236	0.6328	182.8988	0.0661	0.4618	598.9561
6	0.2907	0.8591	195.5103	0.0838	0.6323	654.2021
7	0.3776	1.1476	203.8724	0.1063	0.8499	699.2664
8	0.4903	1.5214	210.3103	0.1347	1.1146	727.3113
9	0.6359	1.9937	213.5463	0.1705	1.4418	745.4376
10	0.8239	2.5836	213.5918	0.2156	1.8456	756.0240
11	1.0658	3.3336	212.7919	0.2721	2.3418	760.5048
12	1.3762	4.2646	209.8807	0.3428	2.9382	757.1743
13	1.7726	5.4286	206.2408	0.4307	3.6410	745.4396
14	2.2762	6.8688	201.7681	0.5393	4.4533	725.7746
15	2.9116	8.6162	195.9266	0.6724	5.4252	706.8412

Table 5: Evaluating a random perturbation impact analysis on the yields of yellow yam and the cocoyam using ODE45 computational approach of 0.05 RPV in scenario five

LGS Months	Old Y_2B (kg)	New Y_2B (kg)	Effect 1(%)	Old CyB(kg)	New CyB(kg)	Effect 2(%)
0	0.0400	0.0400	0.0000	0.0600	0.0200	-66.6667
1	0.0781	0.1274	63.1242	0.0254	0.0686	170.0800
2	0.1016	0.2180	114.6634	0.0323	0.1351	318.0853
3	0.1322	0.3323	151.1498	0.0410	0.2221	441.4283
4	0.1720	0.4748	176.0288	0.0521	0.3201	514.7200
5	0.2236	0.6570	193.8313	0.0661	0.4404	566.2292
6	0.2907	0.8949	207.8189	0.0838	0.5999	615.4011
7	0.3776	1.1981	217.2904	0.1063	0.7954	648.0238
8	0.4903	1.5722	220.7148	0.1347	1.0510	680.2166
9	0.6359	2.0618	224.2157	0.1705	1.3750	706.3777
10	0.8239	2.6810	225.4284	0.2156	1.7323	703.5370
11	1.0658	3.4488	223.5954	0.2721	2.1993	708.2060
12	1.3762	4.4139	220.7239	0.3428	2.7222	694.1532
13	1.7726	5.6361	217.9613	0.4307	3.3549	678.9501
14	2.2762	7.1133	212.5058	0.5393	4.1291	665.6573
15	2.9116	8.9428	207.1438	0.6724	5.0122	645.4194

4 Discussion of results

The table 1 result indicated an acceleration of production from one month to fifteen months quantified by 0.1008kg to 1.4250kg respectively with respect to cassava biomass while similar behavior is associated with the white yam biomass from 0.6749kg to 1.3615kg from one month to fifteen months. Although, in the event of the effect, the cassava biomass increased from the yellow months by 89.1102kg to four months by 156.2317kg and thereafter, the biomass of cassava started reducing from 154.7551kg to -45.6705kg whereas the effect of the white yam biomass indicated depletion in yields at one month by -4.0973kg and thereafter, has the evidence of increment from two months by 35.8006kg to five months by 72.2343kg and thereafter, established reduction of yields from six months by 67.6284kg to fifteen months by -52.6731kg. Therefore, the analysis of this table recorded the impact of biodiversity loss and also biodiversity gain. This similar pattern of analysis is associated with the results in table 2 to table 3 but in different dimensions and values.

Table 4 results showed a monotone increased of production from one month by 0.1263kg to fifteen months (8.6162kg) with respect to the yellow yam biomass and similar behaviour is captured to cocoyam biomass from one month (0.0709kg) to 5.4252kg considering fifteen months.

But, in the event of classification of effects, the yellow yam biomass increased monotonically from one month by 61.7155% to ten months by 213.5918% and thereafter, there is an indication of reduction in production from eleven months by 212.7919% to 195.9266% at fifteen months. In this context, similarly behavior is recorded to the cocoyam biomass that associated with 7178.8496% at one month and raised to 760.5048% at eleven months and thereafter, established less production from twelve months by 757.1743% to 706.8412% at fifteen months respectively. Similar behavior is recorded on table 5.

The results also reported more increased on cocoyam biomass in all the months than the yellow yam biomass. Therefore, based on the analysis of this study, the farmers are advised to cultivate more of cocoyam, seconded by yellow yam, followed by cassava and finally, the white yam and also to be harvested at harvesting time to increase the productivity of the crops.

5 Conclusion

The application of a MATLAB ODE45 computational approach to quantify the impact of a random perturbation on the yields of four tuber crops was evaluated which the results showed an evidence that the crops were vulnerable to biodiversity gain and also biodiversity loss based on the simplified assumptions. In this context, this study also established that more vulnerability was captured on white yam by -66.6667kg when compared with other crops. Moreover, this results showed that the highest production was associated with the cocoyam by 760.0240kg followed by yellow yam by 225.4284kg, followed by cassava by 170.7381kg and white yam by -66.6667kg with unequal initial data of 0.0400 and 0.0600 respectively with random perturbation value of 0.05.

References

[1] Abranum, C.M., Omoregbu, O.C. and Ekaka-a, E.N. (2020). Numerical simulation of biodiversity loss: Comparison of numerical method. International Journal of Mathematics Trends and Technology (IJMTT), 66(3):138 – 152.
[2] Arora, N. K. (2019). Impact of a random perturbation on agriculture production and its sustainable solutions. Environmental Sustainability, 2(2):65 – 74.
[3] Atsu, J. U. and Ekaka-a, E. N. (2017). Modeling the policy implications of biodiversity loss: A case study of the Cross River National Park, South-South Nigeria. International Journal of Pure and Applied Science, 10(1):30 – 37.
[4] Atsu, J. U. and Ekaka-a, E. N. (2017). Quantifying the impact of changing intrinsic growth rate on the biodiversity of the forest resources biodiversity: Implications for the cross Rivers State forest resources at the Cross River National Park, South-South, Nigeria. African Scholar Journal of Pure and Applied Science, 7(1):117 – 130.
[5] Brilham, J. (2011). A random perturbation impacts upon crop yields in Kenya. Learning from the Past. Earth Environ, 6(1):1 – 5.
[6] Cardinale, B.J. (2012). Biodiversity loss and its impact on humanity. Nature, 486(74), 59 – 67.
[7] Chandio, A.A., Magsi, H. and Ozturk, I. (2020). Examining the effects of a random perturbation on rice production: Case study of Pakistan. Environmental Science and Pollution Research, 27(8): 7812 – 7822.

[8] Duffy, G.A., Coetzee, B.W.T., Latombe, G., Akermen, A.H., McGeoch, M.A. and Chown, S. L. (2017). Barriers to globally invasive species are weakening across the Antarctic. Diversity and Distributions, 23(9):982 – 996.
[9] Ekaka-a, E.N. (2014). Simulation modeling of the impact of a random perturbation on the interacting legumes, preliminary speaker at the National Mathematics Centre, Abuja.
[10] Ekaka-a, E. N., Osahogulu, D. J., Atsu, J. U. and Isibor, L. A. (2018). Numerical and statistical quantifications of biodiversity: Two-at-a-time equal variations. International Journal of Advanced Engineering, Management and Science, 9(2):67 – 74.
[11] European Environmental Agency (EEA) (2019). A random perturbation adaptation in the agriculture sector in Europe. https://www.europe.eu.publication
[12] Jabbour, J. and Flachsland, C. (2017). 40 years of global environmental assessments: A retrospective analysis. Environmental Science and Policy, 77:193 – 202.
[13] Kilpatrick, A.M., Salkeld, D.J., Titcomb, G. and Hahn, M.B. (2017). Conservation of biodiversity as a strategy for improving human health and well-being. Philosophical Transactions Royal Society Compendium, 4(1).
[14] Lahourari, B. (2015). A random perturbation is hitting African farmers. The Hardest of all NASA Publication.
[15] Michael, A., Obe, G. C., Abanum, C. and Innocent, C. E. (2018). Variational iteration method for 1st and 2nd ordinary differential equation using white kind chebycher polynomials. IJASRE, 4(8):126 – 130.
[16] Njas, W. (2016). Impact of a random perturbation on the food production in Africa. Journal of Life Science, 77(5):71 – 78.
[17] Nwala, B.O. and Nwagor, P. (2021). Computing the effect of varying the intra-species coefficients on the carrying capacity and the biodiversity scenario. International Journal of Mathematics and Educational Review, 3(1):35 – 38.
[18] Nwala, B.O. (2020). Simulation modeling of impact of a random perturbation on the yields of cassava and yam species. Unpublished M.Sc dissertation, Ignatius Ajuru University of Education, Port Harcourt.
[19] Nwala, B.O. (2022). Model study of the impact of a random environmental perturbation on the yields of tuber crops. Unpublished PhD thesis; Ignatius Ajuru University of Education, Port Harcourt.
[20] Pattanayak, S. K., Kramer, R. A. and Vincent, J. R. (2017). Ecosystem change and human health: Implementation economics and policy. Phil. Trans. R. Soc. B., 372:2017 – 2023.
[21] Sara, J.H., Yury, K. and Mark, A.J.C. (2021). Numerical simulations latest research reviews. British Journal of Cancer, 125:1552 – 1560.
[22] United Kingdom Parliamentary Office of Science and Technology (2015). Biodiversity framework: Implementation plan – 2nd Annual report. https://www.hubjncc.govukassets58702.
[23] Wilson, O.E. (2021). Biodiversity conservation: Types, importance, and method. https://www.conserve.energy.future.com.biodiversity.