Research Article
Journal of Research and Review in Science
14-25 Volume 09, December, 2022

DOI: 10.36108/jrrslasu/2202.90.0230

ORIGINAL RESEARCH

Inhibitory Influence of Leaf Cold Extracts of Three Common Economic Tree Species on Seed Germination, Agronomic Parameters and Nutritional Contents of Maize Grains (Zea Mays)

Ojewumi, A.W., Oluwa, O.K., Oyetunji O.S., Oluwole, S.O., Makinde, S.C.

Department of Botany, Faculty of Science, Lagos State University, Lagos,

Correspondence
ojewumianthony@yahoo.com or anthony.ojewumi@lasu.edu.ng ;

Funding information
None of the authors received any form of Grant for this work.

Abstract:
Introduction: Metabolites released by plants have regulatory effects on growth and physiological functions of plants.
Aims: This study investigated the inhibitory influence of Azadirachta indica.Juss, Senna siamea Lam and Mangifera indica leaf cold extracts (LCE) on Zea mays.
Materials and Methods: Some phytochemicals in leaves of the three plants were determined. Five viable Z. mays seeds each were planted in thirty perforated buckets filled with loamy soil and sprayed with 20 ml, 40ml, 60 ml, 80 ml and 100 ml of A. indica, S. siamea, M. indica LCEs and distilled water as control (100ml). Growth parameters of Z. mays plants and nutritional contents of their grains were evaluated.
Results: Cyanogenic glycolside (3.69 %) and flavonoids (14.27%) were higher in A. Indica leaves, phenol (8.13 mg/kg) in M. indica while saponins (3.44 %) was observed in S. siamea leaves. Highest number of leaf (8.51 cm) and plant height (115.13 cm) were recorded in Z. mays grains sprayed with 100 ml control. Also, vitamin A (1.31µg/100g) was higher in Z. mays grains sprayed with 20 ml A.indica LCE while Vitamin C (5.683µg/100g) was higher in control. Sodium (164.60 mg/100g), potassium (50.79mg/100g), calcium (374.64mg/100g) and magnesium (2.92 mg/100g) as well as crude protein (4.83%), crude fibre (14.54 %) and carbohydrate (9.27%) were higher in Z. mays grains spayed with control.
Conclusion: A. indica, S.siamea and M.indica leaves contained phytochemicals capable of inhibiting plant growth. Hence, 100 ml LCEs of the three plants produced highest inhibitory effects on the germination and growth of Z. mays.
Key words: Inhibition, nutritional contents, forest plants, phytochemical contents, Azadirachta indicia, Senna siamea, Mangifera indica.

All co-authors agreed to have their names listed as authors.

1. INTRODUCTION

Some economic trees in their natural habitats have been observed to be threat to the survival of some food crops planted close to them [1]. This is because the trees have potentials of releasing phytochemicals such as alkaloids, anthraquinone, tannins, terpenoids, saponins, flavonoids and cardiac glycosides among others into the soil. These plant-derived substances have recently become of great interest owing to their versatile applications [1]. The phytochemicals have been proven to play crucial roles in the medicinal and nutritional potentials of plants and they also have the ability to control weeds and care for animals [1].

Although the phytochemicals are non-essential molecules, yet they can influence the growth of other plants by interacting chemically with the physiological processes of other plants [2]. In addition, some of the phytochemicals are released in form of exudates, thereby enhancing the biological activities of microorganisms such as mycorrhiza which in turn help in the absorption of nutrients, while some of them produce inhibitory effects on development or physiological processes of plants [3]. Furthermore, aside the roles of these chemicals in tradio-medicine, they exhibit significant inhibitory impacts on other plants grown wherever they are found through physiological process called allelopathy. There are more than 4,000 different phytochemicals in the plants which regulate their growth, some of which are alkaloids, tannins, flavonoids and phenolics. The substances have beneficial or harmful effects on plants by releasing low molecular weight compounds known as allelochemicals during the process of secondary metabolism or exudation [3].

The phytochemicals are present in all parts of plant tissues such as leaves, stems, roots, rhizomes, flowers, fruits, seeds and pollen grains, they are released either by volatilisation, leaching, exudation or decomposition from plant residues [5]. Water-borne phytotoxins, such as phenolics, flavonoids, or alkaloids, are released from plants in humid zone areas. Also, many trees have ability to release some of these biochemicals [4]. Typical examples of such plants are *Azadirachta indica*a. Juss., *Senna siamea* Lam and *Mangifera indica* L investigated in this study.

Investigation into the proximate contents, phytochemical analysis and physiological activities of *A. indica, S. siamea* and *M. indica* will provide useful information on the influence of these economic trees on food crops such as *Z. mays*. Allelopathic studies on the three plants may be used to represent the alternative and biological search for natural phytotoxins to be used as sources of natural herbicides with less harmful impact on the environment [1].

2. MATE RIALS AND METHODS

2.1 Sources of plant materials

Leaves of *A.indica, S.siamea* and *M.indica* used for this study were collected from nearby farms in Abeokuta, Ogun State. Visual identification and authentication of the leaves were carefully done in the herbarium unit of Lagos State University, Ojo.

2.2 Collection of Soil Samples

Topsoil was randomly collected from different open fields in Lagos State University, Ojo campus, where there were no trees which could introduce allellochemicals to the soil. The soil was mixed thoroughly to ensure uniform distribution of nutrients. Pebbles and stones were removed from the soil and thereafter the soil was put into 30 perforated buckets and watered for five days according to method of Kadiri et al, [6[.

2.3 Determination of allelochemicals in *A. indica, S. siamea* and *M. indica* leaves

Allelochemical contents in the leaves of the three plants were determined according to the method of Ojewumi et al, [8[, Sofowora [9] and Harborne [10].

2.3.1 Determination of Cyanogenic glycoside

Five grams (5 g) of each sample were weighed into a 250 cm^3 round bottom flask; 200 cm^3 of distilled water was added and allowed to stand for 2 hours for autolysis to occur. Tannic acid was added, and full distillation was carried out in a 250 cm^3 conical flask containing 20 cm^3 of 2.5 % Sodium hydroxide. To 100 cm^3 of each distillate containing cyanogenic glycoside, 8cm^3 of 6 M NH_4OH (ammonium hydroxide) and 2 cm^3 of 5 % potassium iodide was added, mixed and titrated with 0.02 M silver nitrate using a micro-burette against a black background. Permanent turbidity indicated the endpoint. Cyanogenic glycoside contents of the sample were calculated as:

Cyanogenic glycoside

$$= \frac{\text{Titre value } (cm^3) \text{ x08xextract volume}}{\text{Aliquot volume } (cm^3) \text{x sample weight (g)}} \; X100$$

2.3.2 Determination of Phenol

Three grams (3 g) of sample was weighed into a 50 ml beaker, 20 ml of acetone was added and homogenized properly for 1hr to prevent lumping. The mixture was filtered into a 100 ml volumetric flask using acetone to rinse and made up to mark with distilled water. 1 ml of extract was pipetted into 50 ml volumetric flask, 20 ml water was added. Also, 3 ml of phosphomolybdic acid was added followed by the addition of 5 ml of 23 % sodium carbonate and mixed thoroughly, made up to mark with distilled water and allowed to stand for 10 min to develop bluish-green colour. Standard phenol of concentration which ranged 0-10 mg/ml was prepared from 100 mg/L stock phenol solution from Sigma-Aldrich chemicals, U.S.A. The absorbance of the sample and standard concentrations of phenol was read on a digital spectrophotometer at a wavelength of 5l0 nm. The percentage phenol was calculated using the formula:

$$\%\text{Phenol} = \frac{\text{Absorbance of sample X GF X DF}}{\text{WS X } 10{,}000}$$

Where GF = Gradient factor

DF= Dilution factor

WS = Weight of samples

2.3.3 Determination of flavonoids

Two grams (2g) of finely ground sample was weighed into a 100 ml beaker and 80 ml of 95 % ethanol was added and stirred with a glass rod to prevent lumping, filtered into a 100 ml volumetric flask and made up to mark with ethanol. Likewise, 1 ml of the extract was pipetted into a 50 ml volumetric flask, four drops of concentrated hydrochloric acid was added after which 0.5 g of magnesium turnings was added to develop a magenta red colouration. Standard flavonoid solution of range 0-5 ppm was prepared from 100 ppm stock solution and treated in the same way with HCl and magnesium turnings sample. The absorbance of magenta red colouration of the sample and standard solutions were read on a digital Jenway V6300 Spectrophotometer at a wavelength of 520 nm. The percentage of flavonoids was calculated using the mathematical relationship:

$$\text{Flavonoids} = \frac{\text{Absorbance of sample X AGF X DF}}{\text{WS X 10000}}$$

Where AGF = Average Gradient factor

DF= Dilution factor

WS = Weight of samples

2.3.4 Determination of saponins

Two (2g) of finely ground sample of samples of each plant was weighed into a 250 ml beaker and 100 ml of isobutyl alcohol was added. The mixture was shaken on a UDY shaker for 5 hours to ensure uniform mixing. Thereafter, the mixture was filtered through a Whatman No.1 filter paper into a 100 ml beaker and 20 ml of 40 % saturated solution of magnesium carbonate was added. The mixture obtained with saturated magnesium carbonate was again filtered to obtain a clear colourless solution. 2 ml of the colourless solution was pipetted into a 50 ml volumetric flask and 2 ml of 5 % Iron (III) chloride solution was added and made up to mark with distilled water. It was allowed to stand for 30 min for blood red colour to develop. Also, 0-10 ppm standard saponin solutions were prepared from saponin stock solution. The standard solutions were treated similarly with 2 ml of 5 % Iron (III) chloride solution as done for 1 ml sample above after which absorbance of the sample and standard saponin solutions were read after colour development in a Jenway V6300 Spectrophotometer (380 mm).

$$\%\ \text{Saponin} = \frac{\text{Absorbance of sample X GF XDF}}{\text{WS X 10000}}$$

Where GF = Gradient factor

DF= Dilution factor

W S = Weight of samples

2.4 **Preparation of cold extracts using *A. indica*a.Juss. *S. siamea* lam and *M. indica* leaves**

Two hundred grams (200 g) of *A. indica, S. siamea* and *M. indica* leaves were pulverized separately and each pulverized leaf sample was soaked in one liter of water for twenty-four hours and filtered using Whitman paper No 42. The filtrate (cold extract) obtained was used for the experimental trial. 20 ml, 40 ml, 60 ml, 80 ml and 100 ml of leaf cold extract (LCE) of each plant was exogenously sprayed on the *Z. mays* seeds and seedlings.

2.5 Experimental design of the study

2.5.1 Germination percentage

Germination percentage was determined according to the method of Ashafa et al*,* [7] after which the buckets were arranged using a complete randomized design. Five viable seeds of *Z. mays* were separately sowed in each bucket containing the soil at 2cm depth. Each treatment was separated from the next by 0.5 m row spacing. The seedlings were thinned to one per bucket after emergence.

2.5.2 Application of *A. indic*a*, S. siamea* and *M. indica* leaves cold extracts

Extract application commenced two weeks after seeds emergency. The *Z. mays* seedlings were sprayed with 20, 40, 60, 80 and 100ml of the extracts daily. *Z. mays* seedlings sprayed daily with only 100 ml distilled water served as control. Also, all the seedlings were equally sprayed with 100 ml distilled water as they grew. The experiment was carried out at botanical garden, Lagos State University, Ojo Campus.

2.6 Determination of proximate contents in *Z. mays* grains

2.6.1 Determination of Crude fibre

Two grams of *Z. mays* grains powder were boiled in 20 ml of 1.25 % H_2SO_4 for 30 min, filtered and the filtrate was boiled using 200 ml of 1.25% NaOH for 30 min. Spotless beaker was dried(100±5^{o}C), cooled and weights of the contents were determined. Both the spoutless beakers with its content were dried using muffle furnace (9320F-11120F) for 2-4-hours, cooled, weighed and crude fibre was determined as shown below;

Crude fibre=$\frac{\text{weight of spoutless beaker containing crude fibre} - \text{WSCF}}{WS} x100$

WSCF= Weight of spoutless beaker and crude fibre

WS= Weight of samples

2.6.2 Determination of Crude protein

The total nitrogen in the content was determined using Micro-Kjeldahl procedures illustrated by Harborne [10[. Protein content (%) was determined using the formula below:

Protein (%) =$\frac{\text{V} \times 1.4 \times 6.25 \times 0.1\text{N HCL} \times \text{Vol (used)}}{\text{W} \times \text{A} \times 1000} x100$ where;

V = Titer value.

1.4-Weight of nitrogen expressed in gram in the formula.

6.25 = Protein factor.

W = Weight of sample.

A -Aliquot digested sample used for distillation

2.6.3. Determination of Crude Fat

Two grams of the samples was kept using paper thimble in a known weight fat extractor. Seventy 70 ml of hexane (C_6H_{14}) was further added, refluxed and allowed to cool then weighed. The crude fat was determined as shown below.

Crude fat (%) =$\frac{\text{Weight of flask with fat} - \text{weight of empty flask)}}{\text{Weight of original sample}} x100$

2.6.4 Determination of moisture

Hot air oven technique was used to determine moisture of the sample as shown below

Moisture $= \frac{\text{Weight of sample before drying – weight of sample after drying}}{\text{Weight of sample before drying}} x100$

2.6.5 Determination of Ash content

Ten (10g) of powder sample of each plant was added to a known weight crucible, weighed and dried (932^0F) for 3-4hours and reweighed. Ash content was determined using the formula shown below;

Ash (%) $= = \frac{\text{Weight of ash}}{\text{Weight of sample}} x100$

2.6.6 Determination of Carbohydrate

Available carbohydrate was determined as shown below;

Carbohydrate (%) = 100 - (moisture + crude fat + ash + crude protein) %

2.7 Determination of mineral contents in *Z. mays* grains

Mineral constituents (calcium, potassium, magnesium, zinc, iron, phosphorus and sodium) present in the samples were analysed using Atomic Absorption Spectrophotometer (Perkin-Elmer Model 2280). Phosphorus content of the digest was determined calorimetrically according to the method of Sofowora [9].

2.8 Determination of vitamins contents in *Z. mays* grains

2.8.1 Determination of Vitamin A

Vitamin A was determined according to the method Harborne [10]. 2 g of powder sample of *Z. mays* was weighed into a flat bottom reflux flask, 10ml of distilled water was added and shaken to form a paste after which 25ml of alcoholic KOH solution was added. The mixture was heated using boiling water bath for one hour, shaken, cooled rapidly. About 30 m1 of water was added after which hydrolysate obtained was transferred into a separatory funnel. In addition, 2g anhydrous Sodium sulphate was added to the extract to remove traces of water. The mixture was then filtered into l00 ml volumetric flask and made up to mark with chloroform. Thereafter, 0.003g of standard L-carotene (0 – 50 µg/mi) was dissolved in l00ml of the chloroform. The above gradients of different standard solutions prepared were determined with reference to their absorbance from which average gradient was taken to calculate Vitamin A using Spectrophotometer (Metrohm Spectronic 21D Model) at 328nm.

2.8.2 Determination of Vitamin B

High performance liquid chromatography method of Ashafa et al, [7[as adopted to determine vitamin B1(thiamin) and vitamin B2(riboflavin) in the sample.

2.8.3 Determination of Vitamin C

One gram of the sample was weighed in a 25 ml conical flask. Then 10 ml of oxalic acid (0.05 M)-EDTA (0.02 M) solution was added and placed in the sample for 24 hours and filtered. Then 2 ml of the sample was transferred to a separate 25 ml volumetric brown flask and 2.5 ml of oxalic acid (0.05M)-EDTA (0.02 M) solution was added. Also, metal phosphoric acid was added with acetic acid (0.5 ml), H_2SO_4 (5 % v/v) solution (1 ml) and ammonium molybdate solution (2 ml). The absorbance was measured at 760 nm in a UV/visible spectrophotometer [10].

2.9.0 Statistical analysis

Data obtained were analysed using statistical analysis system [11]. One way Analysis of variance (ANOVA) was conducted to determine significant differences between the parameters. Means were separated using Duncan's Multiple Range Test at $p < 0.05$.

3. RESULTS AND DISCUSSION

Many higher forest plants have a network of biological and environmental actions on lower plants found in their rhizosphere. These networks are achievable through ability of plants to synthesize and release secondary metabolites into their rhizosphere by processes such as leaching, exudation and decomposition. The compounds are capable of suppressing the growth or physiological functions of plants found within their environment [2].

The allopathic properties in *A. indica, S. siamea* and *M. indica* leaves investigated are presented in Fig 1. Cyanogenic glycoside (3.69 %) and flavonoids (14.27%) were significantly higher ($p < 0.05$) in *A. indica* leaves, phenol (8.13%) in *M. indica* while saponins (3.44%) were relatively higher in *S. siamea* leaves. This observation is in agreement with the findings of Ahmad et al, [12[, Mesnage et al, [13] and Hoda et al, [2[who opined that phytochemicals such tannins, phenolic acids, alkaloids, flavonoids, coumarins and terpenoids are found in the leaves, stems, roots, rhizomes, flowers, fruits, seeds and pollen grains of plants including *S. siamea*, *A. indica* and *M. indica* investigated.

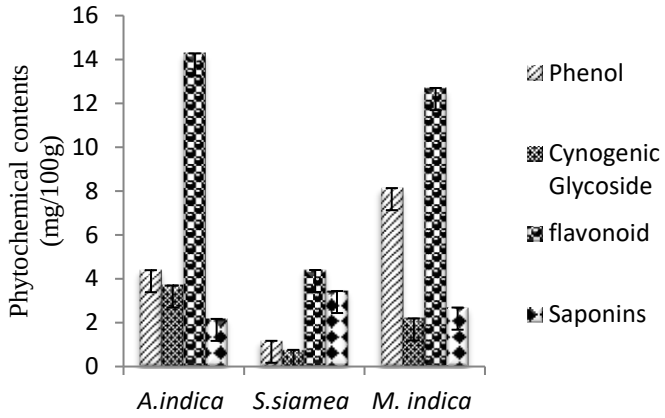
High concentration of allelochemicals such as cyanogenic glycoside and flavonoids observed in the leaves of *A. indica* and phenol in *M. indica* as shown in Fig 1 may indicate presence of a number of molecules suspected to be capable of suppressing growth and retardation of physiological processes of other plants.

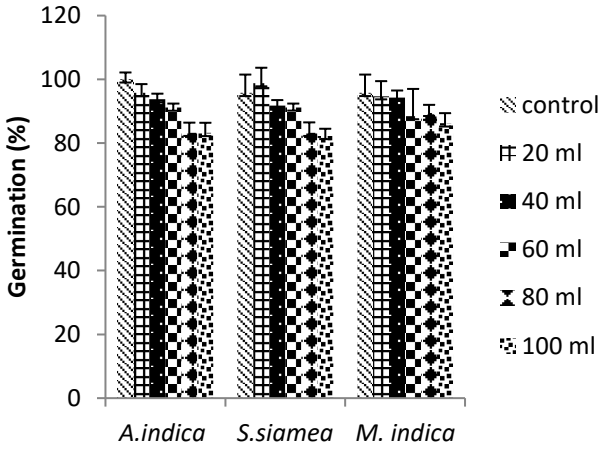
These submissions are in line with findings of Bagavathy and Xavier [14] and Ademiluyi [15] who reported that allelochemicals play significant roles in the growth and development of plants.

Also, there is significant difference ($p<0.05$) in the germination percentage of *Z. mays* grains studied. Highest germination (100%) was recorded in *Z. mays* grains sprayed with 100 ml distilled water compared with the percentage germination recorded in *Z. mays* grains sprayed with other volumes of cold extracts of the other three plants investigated (Fig 2). Least percentage germination recorded in the grains of *Z. mays* sprayed with 100 ml LCEs of the three plants as shown in Fig. 2 may depict inhibitory potentials of the plants on *Z. mays*. This observation indicate that phytochemicals are gibberellins antagonists or contain growth inhibitory substances capable of retarding the metabolic activities of *Z. mays* thereby disturbing growth stimulation effects of the hormones on radicle and plumule emergence.

The extracts at 100 ml might have caused delay in stimulation of physiological and biochemical changes such as deactivation of hydrolytic enzymes and immobilization of nutritional metabolites necessary for sprouting of radicle and plumule Ashafa et al, [7].

This observation is consistent with submissions of Luningning and Mendoza [16], Muscolo et al, [17], and Md. Abdus and Hisashi [18]] who opined that *M. indica* leaf extracts inhibited seed germination in mustard due to the presence of allolochemicals. Also, findings from Ashafa et al, [7] showed that *M. indica* leaf extract inhibited radicle and plumule growth and also germination of *Cassia occidentalis* seeds. Similarly, growth of *Cyperus rotundus* and radicle growth of *Oryza sativa* were inhibited by aqueous extract of *T. diversifolia,* while *A. indica* reduced germination of six plant species [19].





Furthermore, higher leaf number (8.51), root length (9.97 cm), and plant height (115.13cm) were recorded in *Z. mays* under control treatment compared with values of the parameters recorded in *Z. mays* sprayed with lower volume of the extracts (Table 1). This observation indicates retardation potential of the extracts. In addition, inhibitory activities of LCE of *A. indica, S. siamea* and *M. indica* as indicated in Table 1 were proportional to the concentrations of the extracts however, higher concentration of the extracts produced stronger inhibitory effect on meristematic and other developmental tissues of agronomic characters of the *Z. mays* [20].

Also, Ashafa et al, [7] reported that allelochemicals decreased cell elongation, expansion and division, which are growth prerequisite. The inhibition shown in in Fig 2 and Table 1 may be a clear indication that the chemicals have the ability to impair metabolic activities on the development of root and shoot length of *Z. mays* plants [21,22] and synthesis of gibberellic acid in the *Z. mays* [1,23]. On the other perspective, result of this study shown in Table 1 suggests that *A. indica, S. siamea* and *M. indica* may be adopted as strategic approach of controlling weeds and pests. This corroborates reports of John et al, [24], and Andrew et al, [25], who opined that crop with allelopathic properties can be effectively used to control weeds Singh et al, [26].

Table 1: Allelopathic effects of *A. indica, S. siamea* and *M. indica* leaf cold extract on agronomic parameters of *Z. mays*

Treatments(n)	Periods (weeks)														
	Week 4			Week 6			Week 8			Week 10			Week 12		
	Leaf	Stem	PH.	Leaf	Stem	PH.	Leaf	Stem	PH.	Leaf	Stem	PH.	Leaf	Stem	PH.
Control	7.25± 0.86^{a}	8.05± 0.58^{a}	29.39± 0.47^{a}	8.25± 0.25^{a}	44.93 ± 6.47^{bcd}	57.15± 6.75^{a}	10.5± 0.50^{a}	9.97± 0.62^{a}	101.35± 8.67^{a}	9.50± 0.65^{a}	9.74± 0.41^{a}	110.90± 7.16^{a}	8.51± 0.65^{a}	9.97± 0.47^{a}	115.13± 7.03^{a}
20AI	7.25± 0.48^{a}	7.22± 0.19^{ab}	28.93 ± 1.53^{ab}	7.54± 0.29^{abcd}	8.33± 0.57^{ab}	51.40 ± 3.87^{ab}	9.50± 0.50^{abcd}	8.21± 0.55^{abc}	84.18 ± 11.15^{abc}	9.25± 0.75^{a}	7.71± 0.44^{ab}	91.78± 9.45^{bc}	8.50± 0.50^{a}	7.81± 0.41^{ab}	94.68± 10.94^{abc}
40AI	6.75± 0.48^{ab}	6.90± 0.25^{abc}	27.25± 2.71^{abc}	7.50± 0.35^{abcd}	7.39± 0.36^{abc}	47.55± 5.92^{abc}	9.25± 0.48^{abcd}	7.33± 0.74^{bc}	73.60± 14.54^{abcd}	9.25± 0.25^{a}	7.22± 0.54^{b}	85.58± 16.95^{abc}	8.50± 0.29^{a}	7.39 ± 0.58^{b}	86.30± 16.84^{abc}
60AI	6.50± 0.29^{ab}	6.03± 0.57^{bcd}	24.45±1.99^{abcd}	7.45± 0.25^{abcd}	6.92 ± 0.83^{abcd}	46.63± 3.53^{abc}	9.00± 0.41^{abcd}	6.92 ± 0.89^{bc}	72.38± 9.08^{abcd}	9.23± 0.20^{a}	6.68± 0.42^{b}	80.00± 6.31^{abc}	8.25± 0.48^{a}	7.33± 0.54^{b}	83.90 ± 5.99^{abc}
80AI	6.42± 0.59^{ab}	5.82± 0.70^{bcd}	24.40±1.13^{abcd}	7.25± 0.25^{abcd}	6.82± 0.52^{abcd}	46.50± .41^{abc}	8.75± 0.63^{abcd}	6.81± 30.45^{bc}	70.90± 3.89^{abcd}	8.75± 0.48^{a}	6.65 ± 0.50^{b}	79.00± 7.88^{sbc}	7.50± 0.29^{a}	7.16± 0.44^{b}	81. 78 ± 6.01^{abc}
100AI	6.25± 0.25^{ab}	5.34± 0.29^{cd}	21.40± 2.42^{cde}	6.75± 0.63^{bcd}	6.19± 0.31^{bcd}	44.25± 5.30^{abc}	8.25± 0.86^{bcd}	6.69± 0.50^{bc}	67.65± 10.48^{cd}	8.50± 0.65^{a}	6.39± 0.76$_{b}$	71.95± 11.35^{c}	7.00± 0.41^{a}	6.74± 0.68^{b}	73.60± 10.26^{c}
20S.S	7.1± 0.41^{ab}	6.00± 0.56^{bcd}	29.88± 2.61^{a}	8.00± 0.4^{ab}	7.81± 1.20^{abc}	54.18± 8.61^{ab}	10.00± 0.41^{ab}	8.43± 0.89^{ab}	91.65± 3.09^{ab}	9.27± 0.25^{a}	7.97± 0,89^{ab}	102.75± 9.96^{ab}	8.50± 0.29^{a}	8.57± 1.10^{ab}	110.85± 5.94^{ab}
40S.S	7.00± 0.45^{ab}	5.86± 0.53^{bcd}	25.53±1.42^{abcd}	7.75± 0.25^{abc}	7.78± 0.43^{abc}	54.15 ± 2.01^{ab}	9.75± 0.48^{abc}	8.02± 0.30^{abc}	77.63± 5.24^{abcd}	9.25± 0.35^{a}	7.72± 0.35^{ab}	89.00 ± 12.04^{abc}	8.25± 0.25^{a}	8.42± 0.53^{ab}	110.40± 6.26^{ab}
60S.S	6.75± 0.25^{ab}	5.80± 0.45^{bcd}	25.20±2.70^{abcd}	7.50± 0.29^{abcd}	6.65± 0.36^{abcd}	51.98± 4.13^{ab}	9.50± 0.65^{abcd}	6.43± 0.50^{bc}	73.13 ± 11.86^{abcd}	9.00± 0.41^{a}	6.57± 0.36^{b}	86.19 ± 14.30^{abc}	8.00± 1.08^{a}	75± 1.11^{b}	100.30± 8.50^{abc}
80S.S	6.50 ±0.29^{ab}	5.66± 0.52^{bcd}	24.40±1.53^{abcd}	6.75± 0.25^{bcd}	6.13± 0.86^{bcd}	43. 13± 6.17^{abc}	8.75± 0.48^{abcd}	6.43± 1.11^{bc}	67.05± 10.93^{bcd}	8.50± 0.50^{a}	6.42± 0.57^{b}	83.80± 11.85^{abc}	7.75± 0.48^{a}	7.06± 0.44^{b}	95.68± 12.53^{abc}
100S.S	5.75± 0.25^{b}	5.24± 0.29^{d}	22.65±1.27^{bcde}	6.50± 0.50^{cd}	5.98 ± 1.01^{cd}	7.75± 6.47^{abc}	8.75± 0.25^{abcd}	6.21 ± 0.82^{bc}	43.45± 11.64^{abcd}	8.00± 0.41^{a}	6.12± 0.96^{b}	76.80± 10.10^{abc}	7.50± 0.65^{a}	6.25± 0.70^{b}	86.43± 9.63^{abc}
20MI	6.50± 0.65^{ab}	5.41± 0.88^{cd}	22.43±3.53^{bcde}	7.25± 0.25^{abcd}	8.85± 0.60^{a}	42.38± 7.43^{abc}	8.50± 0.96^{bcd}	6.97± 0.64^{bc}	68.18± 8.43^{bcd}	9.10± 0.41^{a}	7.01± 0.72^{b}	96.50± 9.27^{abc}	8.50± 0.65^{a}	7.46± 0.81^{b}	101.52±8.30^{abc}
40MI	6.25± 0.48^{ab}	5.36± 0.41^{cd}	22.03±1.52^{bcde}	7.00± 0.58^{abcd}	6.01± 0.84^{bcd}	38.95± 4.16^{bc}	8.50± 0.50^{bcd}	6.81± 0.36^{bc}	65.60± 14.61^{bcd}	9.05± 0.41^{a}	6.63± 0.31^{b}	94.80± 6.10^{abc}	8.50± 0.29^{a}	7.00± 0.31^{b}	96.28± 6.33^{abc}
60MI	6.25± 0.25^{ab}	5.06± 0.21^{d}	21.05± 3.42^{cde}	6.75± 0.48^{bcd}	6.69± 0.45^{abcd}	37.15± 6.66^{bc}	8.25± 0.75^{bcd}	6.24± 0.50^{bc}	63.58± 7.31^{bcd}	9.00± 0.00^{a}	6.44± 1.24^{b}	89.13± 13.10^{abc}	8.00± 0.41^{a}	6.65± 0.53^{b}	93.70± 14.64^{abc}
80MI	5.75± 0.48^{b}	4.96± 0.55^{d}	19.08± 2.57^{de}	6.50± 0.28^{cd}	6.37± 0.96^{bcd}	37.08± 1.02^{bc}	8.00± 0.41^{cd}	6.02± 0.99^{bc}	57.50± 10.60^{cd}	8.27± 0.85^{a}	6.23± 0.54^{b}	74.70± 11.52^{bc}	7.50± 0.50^{a}	6.62± 1.20^{b}	80.60± 14.90^{bc}
100MI	5.75± 0.25	4.43± 0.22	16.38± 1.04^{e}	6.25± 0.63^{d}	5.05± 0.15^{d}	31.03± 2.64	7.75± 0.48	5.76± 1.01^{c}	47.78 ± 3.74^{d}	8.25± 0.25^{a}	5.85± 1.13	67.25± 4.13^{bc}	7.25± 0.48^{a}	6.17± 1.07	74ss.03± 2.28

Mean Values ± S.E. with the same column having different superscripts are significantly different at p<0.05 using Duncan Multiple Range Test (DMRT).
A.I=*Azadirachta indicia*, S.S= *Senna siamea,* MI=*M. indica,* PH= plant heigh

Inhibitory influence of *A. indica*, *S. siamea* and *M. indica* LCE on vitamin determined in grains of *Z. mays* (Table 2a). Also, significant decrease was noticed on the effect of *S. siamea* LCE on vitamin content of *Z. mays* grains with increase in the cold extracts of the plant (Table 2b). A. *indica* LCE showed significant difference ($p < 0.05$) in the quantities of vitamins in the grains of *Z. mays* sprayed with the treatments. Highest quantity of vitamin A (1.31 mg/kg) was recorded in *Z. mays* sprayed with 20 ml *A. indica* LCE. Vitamin A (0.647 µg/100g), Vitamin B1 (0.67 µg/100g), vitamin B2 (1.473 µg/100g) and vitamin C (5.683 µg/100g) were significantly higher ($p < 0.05$) in *Z. mays* grains under control treatment (Table 2c).

In addition, LCE of *A. indica* showed significant reduction on the mineral composition of the *Z. mays* grains investigated with inclusion in the ml of the LCE of the plants. Sodium (162.63 mg/100g), potassium (49.21mg/100g), zinc (3.35mg/100g) and magnesium (2.69 mg/100g) were significantly higher in grains of *Z. mays* under control treatment compared with grains of the *Z. mays* sprayed with higher ml of *A. indica* LCE (Table 3a).

In the same trend, LCE of *S.siamea* showed significant reduction on mineral elements in *Z. mays* grains. Grains of *Z. mays* in control produced higher sodium (164.60 mg/100g), potassium (50.79 mg/100g), calcium (374.64 mg/100g), phosphorus (6.75 mg/100g), iron (296.03 mg/100g), zinc (3.57 mg/100g) and magnesium (2.68 mg/100g) (Table 3b). Similar observation was noticed on the effects of *M. indica* on the minerals in the *Z. mays* grains. Sodium (166.48 mg/100g), potassium (53.33 mg/100g), calcium (379.87 mg/100g), phosphorus (6.75 mg/100g), iron (325.87mg/100g), zinc (3.81mg/100g) and magnesium (2.92 mg/100g) were significantly higher in control while significant reduction of the minerals was recorded in the grains of *Z. mays* sprayed with 100 ml of *M. indica* LCE (Table.3c).

.

Table 2a, b and c: Inhibitory effect of *A.indica, S.siamea* and *M. indica* leaf cold extracts on concentrations of vitamins contents) in *Z. mays* grains

Treatments (ml)	Vitamin (µg/100g)			
Table 2a *A. indica,*	Vitamin A	Vitamin B_1	Vitamin B_2	Vitamin C
Control	0.313 ± 0.03^{a}	4.803 ± 0.03^{a}	0.563 ± 0.02^{a}	0.542 ± 0.03^{a}
20	1.31 ± 0.06^{a}	4.757 ± 0.09^{a}	0.55 ± 0.06^{ab}	0.541 ± 0.01^{a}
40	0.307 ± 0.03^{ab}	4.597 ± 0.09^{b}	0.547 ± 0.09^{ab}	0.540 ± 0.02^{a}
60	0.29 ± 0.06^{cd}	4.503 ± 0.02^{b}	0.540 ± 0.06^{ab}	0.500 ± 0.01^{b}
80	0.293 ± 0.07^{bc}	4.407 ± 0.06^{c}	0.533 ± 0.07^{bc}	0.538 ± 0.02^{a}
100	0.277 ± 0.03^{d}	4.343 ± 0.02^{c}	0.513 ± 0.07^{c}	0.529 ± 0.02^{a}
Table 2b *S. siamea*				
Control	0.307 ± 0.03^{a}	5.257 ± 0.081^{a}	0.627 ± 0.07^{a}	0.573 ± 0.01^{a}
20	0.304 ± 0.04^{a}	4.81 ± 0.01^{b}	0.607 ± 0.07^{a}	0.568 ± 0.01^{a}
40	0.3 ± 0.06^{ab}	4.803 ± 0.03^{b}	0.583 ± 0.09^{b}	0.561 ± 0.02^{b}
60	0.293 ± 0.07^{ab}	4.733 ± 0.02^{bc}	0.553 ± 0.03^{c}	0.559 ± 0.01^{b}
80	0.287 ± 0.07^{bc}	4.667 ± 0.02^{cd}	0.547 ± 0.09^{c}	0.529 ± 0.02^{c}
100	0.28 ± 0.06^{c}	4.573 ± 0.02^{d}	0.533 ± 0.07^{c}	0.492 ± 0.03^{d}
Table 2c *M. indica*				
Control	0.647 ± 0.09^{a}	0.67 ± 0.06^{a}	1.473 ± 4.14^{a}	5.683 ± 0.02^{a}
20	0.643 ± 0.01^{a}	0.65 ± 0.01^{a}	0.24 ± 0.00^{b}	5.457 ± 0.03^{b}
40	0.622 ± 0.03^{b}	0.62 ± 0.01^{b}	0.22 ± 0.06^{b}	4.913 ± 0.07^{c}
60	0.612 ± 0.01^{b}	0.607 ± 0.09^{b}	0.205 ± 0.05^{b}	4.797 ± 0.03^{d}
80	0.584 ± 0.03^{c}	0.570 ± 0.06^{c}	0.203 ± 0.03^{b}	4.795 ± 0.05^{d}
100	0.529 ± 0.03^{d}	0.54 ± 0.00^{d}	0.167 ± 0.03^{b}	4.773 ± 0.02^{d}

Mean Values ± S.E. with the same column having different superscripts are significantly different at $p<0.05$ using Duncan Multiple Range Test (DMRT).

Table 3 a, b and c: Inhibitory effect of *A. indica, S. siamea* and *M.indica* leaf cold extracts on concentrations of mineral contents in *Z. mays* grain

Treatments(ml)	Mineral elements (mg/100g)						
	Na	K	Ca	P	Fe	Zn	Mg
Table 3a *A. indica,*							
Control	162.63 ± 0.12^{a}	49.21 ± 0.32^{a}	363.63 ± 0.56^{a}	6.75 ± 0.03^{a}	293.45 ± 0.62^{a}	3.35 ± 0.07^{a}	2.69 ± 0.06^{c}
20	160.45 ± 0.32^{b}	48.60 ± 0.06^{a}	357.40 ± 2.72^{a}	6.22 ± 0.35^{b}	284.75 ± 1.25^{b}	3.34 ± 0.04^{a}	2.62 ± 0.03^{ab}
40	158.87 ± 0.12^{c}	48.57 ± 0.12^{a}	349.63 ± 1.73^{b}	5.11 ± 0.08^{c}	283.67 ± 0.79^{b}	3.29 ± 0.09^{a}	2.60 ± 0.01^{ab}
60	158.41 ± 0.47^{c}	48.48 ± 0.39^{a}	344.13 ± 1.07^{bc}	4.95 ± 0.09^{c}	274.93 ± 1.48^{c}	3.06 ± 0.04^{b}	2.57 ± 0.02^{b}
80	156.81 ± 0.06^{d}	47.21 ± 0.20^{b}	336.75 ± 2.19^{c}	4.88 ± 0.02^{c}	274.81 ± 1.63^{c}	3.04 ± 0.05^{b}	2.55 ± 0.02^{c}
100	152.44 ± 0.07^{e}	45.85 ± 0.07^{c}	320.33 ± 4.28^{d}	4.82 ± 0.09^{c}	267.87 ± 0.62^{c}	2.86 ± 0.07^{b}	2.29 ± 0.03^{c}
Table 3b *S.siamea*							
Control	164.60 ± 0.10^{a}	50.79 ± 0.17^{a}	374.64 ± 1.47^{a}	6.75 ± 0.03^{a}	296.03 ± 1.39^{a}	3.57 ± 0.09^{a}	2.68 ± 0.01^{a}
20	164.21 ± 0.31^{a}	50.08 ± 0.31^{ab}	365.90 ± 0.90^{b}	5.35 ± 0.08^{b}	293.75 ± 1.59^{a}	3.43 ± 0.01^{ab}	2.65 ± 0.05^{b}
40	163.51 ± 0.27^{a}	49.79 ± 0.05^{b}	365.73 ± 0.58^{b}	5.33 ± 0.04^{b}	288.70 ± 0.97^{c}	3.30 ± 0.05^{bc}	2.55 ± 0.03^{c}
60	160.33 ± 1.19^{b}	49.55 ± 0.28^{b}	361.23 ± 1.26^{b}	4.94 ± 0.01^{c}	283.78 ± 1.54^{c}	3.29 ± 0.02^{bc}	2.53 ± 0.04^{b}
80	157.00 ± 0.10^{c}	49.50 ± 0.28^{b}	330.53 ± 4.29^{c}	4.83 ± 0.04^{c}	276.75 ± 3.00^{d}	3.27 ± 0.02^{c}	2.39 ± 0.01^{c}
100	152.47 ± 0.07^{d}	45.85 ± 0.47^{c}	320.33 ± 4.28^{d}	4.56 ± 0.05^{d}	274.81 ± 1.63^{d}	3.04 ± 0.05^{d}	2.38 ± 0.02^{c}
Table 3c *M.indica*							
Control	166.48 ± 0.37^{a}	53.33 ± 0.09^{a}	379.87 ± 1.27^{a}	6.75 ± 0.03^{a}	325.87 ± 1.42^{a}	3.81 ± 0.01^{a}	2.92 ± 0.02^{e}
20	166.40 ± 0.30^{a}	51.29 ± 0.60^{b}	374.40 ± 1.97^{ab}	6.52 ± 0.02^{b}	313.47 ± 0.73^{a}	3.62 ± 0.01^{b}	2.62 ± 0.01^{a}
40	165.08 ± 0.31^{b}	50.46 ± 0.36^{bc}	373.97 ± 0.69^{b}	5.83 ± 0.04^{c}	299.87 ± 0.37^{c}	3.44 ± 0.05^{c}	2.54 ± 0.02^{b}
60	164.52 ± 0.33^{b}	50.45 ± 0.49^{bc}	373.97 ± 0.45^{ab}	5.67 ± 0.01^{d}	296.67 ± 0.59^{d}	3.04 ± 0.05^{d}	2.45 ± 0.01^{c}
80	164.16 ± 0.32^{b}	49.10 ± 0.76^{b}	371.96 ± 0.78^{b}	4.96 ± 0.01^{e}	290.21 ± 0.62^{e}	2.96 ± 0.01^{de}	2.40 ± 0.01^{cd}
100	152.47 ± 0.07^{c}	45.85 ± 0.47^{d}	320.33 ± 4.28^{c}	4.86 ± 0.05^{f}	274.81 ± 1.63^{f}	2.87 ± 0.01^{e}	2.35 ± 0.02^{d}

Mean Values ± S.E. with the same column having different superscripts are significantly different at $p < 0.05$ using Duncan Multiple Range Test (DMRT)

Crude protein (4.83%), crude fibre (14.47%), ash (5.87 %) carbohydrate (11.18 %) and fat (76.73 %) were significantly higher in *Z. mays* in control while least of the parameters were recorded in the *Z. mays* sprayed with 100 ml LCE of the *A. indica* (Table 4a). Similar trend of observation was noticed using LCE of *S. siamea* on the *Z. mays* (Table 4b). Furthermore, crude protein (4.59%), crude fibre (14.45%) moisture content (4.27%), carbohydrate (11.05%) and fat (71.99%) were significantly higher in control compared with values of the parameter in *Z. mays* sprayed with LCE of *M. indica* (Table 4c).

The effects of allelochemicals suspected in *A. indica, S. siamea* and *M. indica* investigated affected the nutritional contents of the *Z. mays* grains as depicted in Tables 2a-4c. Lower quantity of Vitamin B1, vitamin B2 and vitamin C shown in Tables 2a-2c in *Z. mays* grains sprayed with 100 ml may be influenced by the presence of allelochemicals determined in the leaves of the plants. The chemicals might have caused disturbances to physiological functions such as water uptake, phytohormone metabolism, respiration, photosynthesis, and other metabolic process. This is in line with studies of Aladejimokun et al*,* [27[, who opined that allelopathic compounds may regulate plant growth and developmental processes involving photosynthesis, respiration, biochemical metabolism, protein and nucleic acid synthesis [28].

Table 4 a, b and c: Inhibitory effect of *A. indica, S. siamea* and *M. indica* leaf cold extracts on proximate contents in *Z. mays* grains

Treatments (ml)	Proximate contents (mg/100g)					
	Crude protein	Crude fibre	Ash	Moisture	Carbohydrate	Fat
Table 4a *A. indica,*						
Control	4.83 ± 0.02^{a}	14.47 ± 0.02^{a}	5.87 ± 0.15^{a}	3.81 ± 0.34^{a}	11.18 ± 0.13^{a}	76.73 ± 0.50^{a}
20	4.47 ± 0.15^{b}	13.95 ± 0.02^{b}	5.40 ± 0.22^{ab}	3.40 ± 0.01^{ab}	10.95 ± 0.08^{ab}	75.51 ± 0.30^{b}
40	4.25 ± 0.10^{bc}	13.62 ± 0.03^{c}	5.40 ± 0.01^{ab}	3.32 ± 0.08^{b}	10.87 ± 0.18^{ab}	75.26 ± 0.05^{b}
60	4.15 ± 0.10^{cd}	13.28 ± 0.15^{d}	5.22 ± 0.05^{b}	3.20 ± 0.04^{b}	10.84 ± 0.12^{ab}	74.82 ± 0.37^{b}
80	3.98 ± 0.02^{cd}	13.23 ± 0.15^{d}	4.93 ± 0.02^{bc}	3.19 ± 0.06^{b}	10.79 ± 0.03^{b}	74.54 ± 0.24^{b}
100	3.90 ± 0.11^{d}	12.54 ± 0.09^{e}	4.67 ± 0.29^{d}	3.16 ± 0.03^{b}	10.76 ± 0.04^{b}	73.09 ± 0.36^{c}
Table 4b *S. siamea*						
Control	4.32 ± 0.04^{a}	14.54 ± 0.07^{a}	5.54 ± 0.03^{ab}	4.11 ± 0.05^{a}	11.27 ± 0.10^{a}	76.73 ± 0.50^{a}
20	4.30 ± 0.06^{a}	14.26 ± 0.23^{ab}	5.41 ± 0.15^{a}	3.53 ± 0.03^{b}	10.97 ± 0.02^{a}	74.49 ± 0.03^{b}
40	4.00 ± 0.07^{b}	13.90 ± 0.01^{b}	5.41 ± 0.02^{cd}	3.45 ± 0.01^{bc}	10.93 ± 0.09^{a}	74.30 ± 0.03^{b}
60	3.96 ± 0.04^{b}	13.89 ± 0.04^{b}	5.39 ± 0.02^{a}	3.30 ± 0.02^{cd}	10.89 ± 0.02^{a}	74.23 ± 0.13^{b}
80	3.95 ± 0.02^{b}	13.33 ± 0.18^{d}	4.91 ± 0.03^{ab}	3.26 ± 0.05^{c}	10.87 ± 0.18^{a}	74.21 ± 0.36^{b}
100	3.90 ± 0.11^{b}	12.54 ± 0.09^{d}	4.67 ± 0.29	3.19 ± 0.06^{d}	10.79 ± 0.05^{a}	73.66 ± 0.30^{b}
Table 4c *M. indica*						
Control	4.59 ± 0.08^{a}	14.45 ± 0.14^{a}	11.54 ± 0.09^{a}	4.27 ± 0.09^{a}	11.05 ± 0.17^{a}	71.99 ± 0.44^{b}
20	4.50 ± 0.06^{a}	14.29 ± 0.17^{ab}	5.61 ± 0.06^{b}	3.79 ± 0.36^{b}	10.90 ± 0.15^{a}	71.79 ± 0.01^{b}
40	4.43 ± 0.29^{a}	13.92 ± 0.02^{bc}	5.30 ± 0.12^{c}	3.62 ± 0.01^{bc}	10.87 ± 0.18^{a}	71.45 ± 0.26^{b}
60	4.43 ± 0.02^{a}	13.84 ± 0.14^{c}	4.93 ± 0.02^{d}	3.41 ± 0.02^{bc}	10.81 ± 0.18^{a}	71.19 ± 0.22^{b}
80	4.32 ± 0.02^{a}	13.81 ± 0.11^{c}	4.79 ± 0.02^{d}	3.32 ± 0.01^{bc}	10.14 ± 0.01^{a}	69.28 ± 0.19^{c}
100	3.80 ± 0.03^{b}	4.90 ± 0.11^{d}	4.74 ± 0.04^{d}	3.19 ± 0.06^{c}	9.89 ± 0.02^{b}	30.16 ± 0.58^{a}

Mean Values ± S.E. with the same column having different superscripts are significantly different at $p<0.05$ by Duncan Multiple Range Test (DMRT)

4. CONCLUSION

Results showed that *A. indica, S. siamea* and *M. indica* leaves contained appreciable amount of allelopathic contents. LCE of the three plants had inhibitory influence on the growth and reduced the nutritional compositions of grains of the *Z. mays* studied compared with *Z. mays* under control treatment. Therefore, this study recommends that *Z. mays* should not be planted under or around *A. indica, S. siamea* and *M .indica,* and that extracts of the three plants should be used to control weeds and pest.

COMPETING INTERESTS

No conflict of interest declared.

ACKNOWLEDGEMENT

The authors appreciate the technical support of Mr. Bankole Samuel, Chief technologist, Department of Horticulture, Federal University of Agriculture, Abeokuta, Ogun State, Nigeria.

FUNDING

No grant was awarded from any funding agency.

REFERENCES

1. Batish DR, Singh HP, Rana N, Kohli RK. Assessment of allelopathic interference of Chenopodium album through its leachates, debris extracts, rhizosphere and amended soil. Arch Agron Soil Sci. 2006 ;52: 705-715.
2. Hoda A, Abd El–Hamid Lamis MN. Ibrahim, Mohamed Y. Ammar and Mohamed A. Helmy. Allelopathic Effect of Neem (*Azadirachta indica* A. Juss) Aqueous leaf extract on The Germination and Growth of Some selected Crops and Weeds. Biolife.2017:5(4): 428-436
3. Singh NB, Singh D, Singh Modification of physiological responses of water stressed *Zea mays* seedlings by leachate of *Nicotiana plumbagifolia*. Gen. Appl. Plant Physiol. 2009: 35: 51-63
4. Mooza A, Nora A. and Shah AK. GC-MS Analysis, determination of total phenolics, flavonoid content and free radical scavenging activities of various crude extracts of *Moringa peregrina* (Forssk) Fiori leaves Asian Pac. J. Trop. Biomed. 2014;4(12):964-970
5. Sharma S, and Devkota A. Allelopathic potential and Phytochemical screening of four medicinal plants of Nepal. Sci. 2014;12(12) 56-61
6. Kadiri M, Ojewumi AW. and Amosun VE. Responses of Basella urbra to foliar applications of growth parameters. Int. Sci,: Basic .App. Res. 2016; 19 (2): 99-104
7. Ashafa OT, Ogbe AA. and Osinaike T. Inhibitory effect of mango (*Mangifera indicaL*.) leaf extracts on the germination of *Cassia occidentalis* seeds Afr. J. Agric. Res. 2012;7(33): 4634-4639.
8. Ojewumi AW, Bamkefa BA. and Kuku FB. Physicochemical Properties of plants used for preservation of fruits, Nig. of Pure and Appl. Sci. .2021;34 (2): L4058-4071.
9. Sofowora A. Medicinal Plants and Traditional Medicines in Africa. John Wiley and Sons, New York, Chichester: 97-145.
10. Harborne JB. Photochemical Methods: A Guide to Modern Techniques of Plant Analysis. Chapman A. and Hall, London, 1973:49-188.
11. Statistical Analysis System.: Statistical Analysis System User Guide, Version 9.3.SAS 2013 Institute Inc., Cary, NC., USA
12. Ahmad S, Arfan M, Khan A L, Ullah R, Hussain J, Muhammad Z. Watanabe, K. N. Allelopathy of *Teucrium royleanum* wall. Ex benth. from J. Med. Plant. Res. 2011 5(5): 765-772.
13. Mesnage R, Bernay B, Séralini GE. Ethoxylated adjuvants of glyphosate-based herbicides are active principles of human cell toxicity. Toxicology. 2013; 313(2): 122-128.
14. Bagavathy S, Xavier GSA. Effects of aqueous extract of *Eucalyptus globuluson* germination and seedling growth of sorghum. Allelopathy J. 2007; 20(2): 395-402
15. Ademiluyi BO. Effect of *Tithonia diversifolia* (Hemsl) A. Gray on the Growth and Yield of Okra (*Abelmuscus esculentus*) J. Agric. Sci. Techno. .2012; 2 219-222.
16. Luningning M. Mendoza DS. Paragas The Allelopathic effect of *Mangifera indica* L eaves on Mustard Seeds Int. J. Agric. Techno. 2017; 13(7.3): 2575-2583
17. Muscolo A., Pauccio MR, Sidari M. The effects of phenolic acids extracted from two different soils in As-promonte on germination of Pinuslaricio seeds. Fresenius Environmental Bulletin. 2008;10: 659–66.
18. Md. Abdus S and Hisashi KN. Evaluation of Allelopathic Potential of Neem (*Azadirachta indica. A. Juss*) Against Seed Germination and Seedling Growth of Different Test Plant Species Int. J. Sustain. Agric. 2010;2 (2): 20-25
19. Ilori O, Otusanya O, Adelusis A. Phytotoxic effects of *Tithonia diversifolia* on germination and growth of Oryza sativa. Res. J. Bot. 2007; 2:23-32
20. Sisodia S. and Siddiqui, MB. Allelopathic potential of rhizophere soil of *Croton bonplandianumon* growth and establishment of some crop and weed plants. Afr. J. Agric. Res.2009;4: 461-467.
21. Saeid A, Mohammad S, Rida S. Allelopathic Effects of Spurge (*Euphorbia hierosolymitana*) on Wheat (*Triticum durum*). American-Eurasian J. Agric. Environ. Sci. 2010; 7:298-302

22. Tawaha AM, Turk MA. Allelopathic.effects of black musard (Brassica nigra) on germination and growth of wild barley (*Hordeum spontaneum*). J. Agron. Crop. Sci. 2003; 189:298-303
23. Modupe JA. Effect of aqueous extracts of the leaves of *Senna siamea* Lam. and *Pinus carribaea* (Jacq.) ex. Walp. on the germination and seedling growth of *Euphorbia heterophylla*. WSN. 2017; 87:12-23
24. John J, Shirmila J, Sarada J. and Anu S. Role of Allelopathy in vegetables Crop Production. Allelopathy J.. 2010;25: 275-311
25. Andrew IKS, Storkey J. and Sparkes DL. A review of the Potential for competitive cereal cultivars as a tool in integrated weed management. Weed Res. 2015: 55: 239-248
26. Singh NB, Singh D, Singh A. Modification of physiological responses of water stressed Zea mays seedlings by leachate of *Nicotiana plumbagifolia*. Gen. Appl. Plant Physiology. 2009; 35: 51-63.
27. Aladejimokun AO, Edagbo DE. and Adesina JM. Allelopathic Potential of *Tithonia diversifolia* (Hemsl.) A. Gray on Vegetative Performance of Cowpea and Maize Academia Arena. 2014;6(5)79-83
28. Chou CH. Introduction to Allelopathy. In: M. J. Reigosa, N. Pedrol and L. Gonzalez (eds). Allelopathy: A Physiological Process with Ecological Implications. Springer. The Netherlands.2006; 1 – 9.