International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

To cite this article: Ibrahim, S.E., Ochekwu, E.B. and Ngobiri, N.C. (2023). ALLELOPATHIC EFFECT OF Chromolaena odorata FOLIAGE AS SOIL AMENDMENT ON THE GROWTH AND CHLOROPHYLL CONTENT OF Solanum lycopersicum, Mucuna pruriens, Abelmoschus esculentus and Citrullus lanatus., International Journal of Applied Science and Engineering Review (IJASER) 4 (2): 96-118

ALLELOPATHIC EFFECT OF *Chromolaena odorata* FOLIAGE AS SOIL AMENDMENT ON THE GROWTH AND CHLOROPHYLL CONTENT OF *Solanum lycopersicum*, *Mucuna pruriens*, *Abelmoschus esculentus and Citrullus lanatus*.

Ibrahim, S.E[1]., Ochekwu, E.B[2]. and Ngobiri, N.C.[3]

[1]Institute of Natural Resources, Environment and Sustainable Development, University of Port Harcourt
[2]Department of Plant Science and Biotechnology, University of Port Harcourt
[3]Department of Pure and Industrial Chemistry, University of Port Harcourt

Corresponding Author: OCHEKWU, E.B. (edacheb@gmail.com)

DOI: https://doi.org/10.52267/IJASER.2023.4207

ABSTRACT

This study investigated the allelopathic effect of *Chromolaena odorata* foliage used as soil amendments on the leaf area, plant height, number of leaves, plant biomass and total chlorophyll content of *Solanum lycopersicum*, *Mucuna pruriens*, *Abelmuschus esculentus and Citrullus lanatus*. Seeds of the test crops were planted in pots amended with 0%w/w, 1.9%w/w, 3.8%w/w, 5.7%w/w and 7.7%w/w of foliage of *C. odorata* and parameters as leaf area, plant height, number of leaves, plant biomass and total chlorophyll content were measured. The data collated were analysed using analysis of variance and the means separated using Tukey's HSD. The leaf area, plant height, number of leaves and plant biomass showed a seemingly concentration-dependent, statistically significant increase in *C. lanatus*, *S. lycopersicum* and *A. esculentus* for all treatments, when compared to the 0%w/w treatment; and, although showing a visual and graphical increase for, *M. pruriens*, the increase in leaf area, plant height, number of leaves and plant biomass of *M. pruriens* were not statistically significant at 5% level of probability. The total chlorophyll content of all the plants studied showed concentration-dependent, statistically significant increments at 5% levels of probability, when compared to their respective 0%w/w treatments. The increase in the leaf area, plant height, number of leaves, plant biomass and total chlorophyll content of *C. lanatus*, *S. lycopersicum*, *A. esculentus* and *M. pruriens* due to the soil amendment with different amounts of *C. odorata* foliage is attributed to the possible effect of the allelochemicals in the leaves, which, although having a negative inhibitory effect on germination, had possibly undergone a bio-transformation to become stimulatory. Again, the foliar amendments increased the organic matter content of the soil, and

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

thus, in synergy with the bio-transformed allelochemicals, serve as a bio-fertilizer to improve the growth of the test crops. Owing to the possible inhibitory effect of *C. odorata* foliage on the germination of these same test crops, it is therefore recommended that the foliage of *C. odorata* should only be used as organic manure or bio-fertilizer only at the post-germination stage of the test crops, not at the pre-germination stage.

KEYWORDS: Allelopathy; *Chromolaena odorata*; *Solanum lycopersicum*; *Mucuna pruriens*; *Citrullus lanatus*; *Abelmoschus esculentus*; Allelopathy, soil amendment.

INTRODUCTION

Increasing human population has become a threat to food security, world over. It has put so much pressure on crop production. Other key factors contributing to the pressure on crop production and food security include insect pests, diseases, certain abiotic stresses, poor nutrition and weed invasion (Farooq *et al*., 2013). The chemicals released, to influence the growth or germination of other plants are called allelochemicals (Cheema *et al*., 2004). One weed that has been reported for its allelopathic effect is *Chromolaena odorata*; its aqueous foliar extract has been severally implicated by many reports as the most active and potent source of allelochemicals in the plant (Devi and Dutta, 2012; Otusanya *et al*., 2015). A member of the plant family Asteraceae, Siam weed (*Chromolaena odorata*) ((L.) R.M. King & H. Robinson) is described as an herbaceous, perennial, semi woody shrub that forms dense tangled bushes about 1.5 to 2.0 m in height (Phan, 2001). It bears three-veined, ovate-triangular leaves placed oppositely, and with a shallow, fibrous root system (Henderson, 2001). Gautier (1992) and Owolabi *et al*. (2010) explained that *C. odorata* is a weedy pioneering shrub native to the Americas which was introduced into diverse ecological areas of tropical lands where it has become one of the worst terrestrial invasive plants. Siam weed is currently recognized as one of the world's worst tropical weeds due to its extremely fast growth rate (up to 20 mm per day) and prolific seed production (Owolabi *et al*., 2010). In the tropics of Africa and Asia it has become agricultural weeds. From the definition of allelopathy, it is evident that allelochemicals can have either stimulatory or inhibitive effects on plants; and this effect would be determined by certain factors such as the concentration of extract, the plant species involved and the growth phase (pre-germination or post-germination) of the plant/crop (Mashood *et al*., 2014; Abbas *et al*., 2020). In agriculture, the stimulatory allelopathic effects of weeds such as *C. odorata* can be employed as organic fertilizers or bio-fertilizers for the cultivation of certain agriculturally important crops such as *Solanum lycopersicum* (tomato), *Citrullus lanatus* (wateremelon), *Abelmoschus esculentus* (okra) and *Mucuna pruriens* (velvet bean). Ranked as the second most important vegetable after potato, Tomato (*Solanum lycopersicum* L.) is an important berry-bearing vegetable crop from the family Solanaceae. *S. lycopersicum* is consumed both as fresh fruit and also as processed products such as diced products, pastes, juice, sauces and soups (Foolad, 2007). Aside being one of the most consumed food crops in the world,

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

the plant and its fruit conveys a plethora of medicinal and pharmacological benefits (Willcox *et al*., 2003; Borguini and Ferraz Da Silva Torres, 2009).

Belonging to the plant family Fabaceae, *Mucuna pruriens* (L). Dc., commonly known as Velvet bean, is a plant (Rajeshwar *et al.*, 2005), known popularly for its plethora of medicinal properties. The seed of *M. pruriens* is reportedly and notoriously established as a natural source of the amino acid L-3,4-dihydroxy phenyl alanine (L-DOPA) which serves as the direct precursor of dopamine, a neuro-transmitter used widely in the treatment of Parkinson's disease. Some other important chemicals established in *M. pruriens*, in addition to L-DOPA, are serotonin, oxitriptan, nicotine and bufotenine (Kavitha and Thangamani, 2014; Erowid, 2002*)*. Aside its medicinal properties, reports by (Kavitha and Vadivel, 2008; Diallo and Berhe, 2003) have shown that *M. pruriens is* also grown as a food crop, an ornamental plan and as a living mulch. Watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai), just like every other member of the plant family Cucurbitaceae, is a creeping, herbaceous fruit crop. *C. lanatus* has gained notoriety as the majorly produced crop in the Cucurbitaceae family (about 40%) (Alka *et al*., 2018; Vinhas *et al*., 2021). *Citrullus lanatus* (water melon) produces a fruit that is about 93% water which can be used as fresh salad, dessert, snack, fruit juice, and for decorations. Despite varying taste preferences of the consumers, the consumption quality of watermelon varieties is critically determined using the sugar content and sweetness. *C. lanatus* is known to be low in calories but highly nutritious and thirst quenching (Okonmah *et al*., 2011). Grown in tropical, subtropical, and warm temperate climates in different countries from Africa to Asia, Southern Europe, and America (Naveed *et al*., 2009), *Abelmoschus esculentus* L. (Moench), of the plant family Malvaceae, is an annual herb and an important vegetable crop native to Africa (Kumar *et al*., 2013). The plant produces a fruit/pod which is a greenish capsule with length of 10–30 cm long and a diameter of 1–4 cm, it is slightly curved, tapers to a blunt point, a six-chambered pod of fibrous texture, and contains numerous seeds (Tripathi *et al*., 2011). Okra is known for its good palatability among different regions and its culinary uses are wide. Its immature, fresh, green seed pods are eaten as vegetable, while the extract obtained from the fruit is used in different recipes to thicken stews, soup, and sauces to increase their mucilaginous consistency. Okra has also found use in the production of ice-cream, potato chips, and baked goods, as its water-soluble polysaccharides helps provide a healthy option and more stable shelf-life (Yuennan *et al*., 2014; Archana *et al*., 2015; Hu and Lai, 2016). Whether stimulatory or inhibitory, allelopathy can play an important in minimizing some of the very serious chemical hazards of modern agriculture, videlicet, environmental pollution, soil sickness, decline of crop diversity and reduction in crop yield; as it is organic agriculture in its practical sense (Mashood *et al*., 2014; Abbas *et al*., 2020). This study aims to investigate the allelopathic effect of *C. odorata* foliage as soil amendments on the leaf area, plant height, number of leaves, plant biomass and total chlorophyll content of certain agronomically important crops: *Solanum lycopersicum, Mucuna pruriens, Abelmuschus esculentus and Citrullus lanatus*.

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

MATERIALS AND METHODS

Experimental Site

The study was conducted in plastic pots in the Centre for Ecological Studies, Department of Plant Science and Biotechnology, and the chlorophyll content was analyzed at the Plant Physiology laboratory of the same department at the University of Port-Harcourt, Choba, Rivers State, Nigeria.

Plant Materials Used for the Study

The plant materials to be used for the study were obtained as follows:

1. the seeds of *Solanum lycopersicum* var. 82-B, *Mucuna pruriens*, *Abelmuschus esculentus* var. Clemson Spineless *and Citrullus lanatus* var. Kaolack were obtained from the headquarters of the Agricultural Development Program (ADP), Rivers State, Nigeria.
2. the foliage of *Chromolaena odorata* was obtained from the ecological forest of the UniPark Campus, University of Port-Harcourt, Choba, Rivers State, Nigeria.
3. the loam soil was obtained from the Faculty of Agriculture Research and Demonstration Farm of the University of Port Harcourt.

Preparation of soil amendment with foliage of *C. odorata*

Whole leaves of *C. odorata* were harvested from the ecological forest of the University of Port-Harcourt (4.9069°N, 6.9170°E), Choba, Port-Harcourt, Rivers State.

The collected leaves were rinsed in water to remove adhering dust and soil particles, and then air-dried for 30 minutes to remove surface water. The plants were pulverized using an electronic grinder. The pulverized foliage was sun-dried in a screen house for 72 hours. The sun-dried plant sample was incorporated into soil as an amendment and potted in small, perforated plastic buckets, as tabulated below:

Quantity of sand (g)	Quantity of plant sample (g)	Total weight (g)	Amount foliage in amendment (% w/w)
784	0	784	0 (control)
769	15	784	1.9
754	30	784	3.8
739	45	784	5.7
724	60	784	7.7

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

Establishment of allelopathic setup

Plastic pots filled with 784g of different soil amendments were allowed to stay under screenhouse conditions for a 1-week period, and each pot watered with 150ml of potable water. The seeds of *S. lycopersicum, Capsicum Mucuna pruriens, Abelmuschus esculentus and Citrullus lanatus* were planted, watered every two days with 150ml of potable water and left to germinate and acclimate for two weeks before collection of data commenced. The experiment was laid out in a completely randomized design (CRD) with four replicates. The soil was moistened every two days with 150ml of potable water throughout the 10 weeks duration of the experiment. Every 2 weeks, during the course of the study, data was collected and collated for leaf area, plant height and number of leaves. At termination (the 10th week), all data was collected and collated, including the total chlorophyll content (TCC) and the plant biomass.

Morphological Parameters studied

With slight modifications, but adopting the method of Uzoma *et al*. (2019), the morphological parameters studied include:

1. **Leaf Area**: The leaf area of images of leaves [taken with a white background (A4 paper) and a centimetric ruler] was measured using the NIH-approved ImageJ 1.53K/Java 1.8.0 software package.
2. **Plant Height**: this was measured using a metric rule to determine the height of the plant.
3. **Number of Leaves**: the number of leaves per plant was determined by visual count of the leaves.
4. **Plant Biomass**: At the termination of the field study, the uprooted plants were rinsed with tap water to remove adhering soil, and excess water was removed with paper towel. The plants were weighed to obtain the fresh weight. The weighed plants were subsequently labeled and oven-dried at 45 °C for 72 hours to obtain the dry weight. The plant biomass was therefore obtained by calculating the difference between the fresh weight and the dry weight of each plant.

$$Plant\ Biomass = Fresh\ weight - Dry\ weight$$

5. Determination of total chlorophyll content

The total chlorophylls content (TCC) of the leaves will be determined using the method of Uzoma *et al*. (2018) with some modifications.

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

$$Chl.A\ (mg/L) = 9.93\ \times Abs(600nm) - 0.77 \times Abs(643nm)$$

$$Chl.B\ (mg/L) = 17.6 \times Abs(660nm) - 2.81 \times Abs(643nm)$$

$$\%Chl.A\ or\ \%Chl.B = Conc.\frac{mg}{1000ml} \times \frac{[Total\ vol.of\ extract(10ml)]}{[Weight\ of\ sample\ extracted(mg)]} \times 100$$

$$Chl.Total = Chl.A + Chl.B$$

Experimental design

The experimental design for this study followed a completely randomized design (CRD) and was replicated four times.

Data analysis

Data collated was analyzed with Analysis of Variance (ANOVA) using statistical analyses SPSS 23 package. Means were separated using Tukey's Honest Significant Difference (HSD) at 5% level of probability, and represented on graphical plots using MS Excel.

RESULTS

The effect of applying the pulverized foliar amendment of *C. odorata* on the leaf area, plant height, number of leaves, biomass and total chlorophyll content of the test crops (*C. lanatus*, *S. lycopersicum*, *A. esculentus* and *M. pruriens*) have been depicted using graphs (Figures 1, 2, 3, 4, and 5) and tables (Tables 1, 2, 3, 4 and 5) as shown below:

Effect of *C. odorata* amendment on the leaf area of the test crops

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

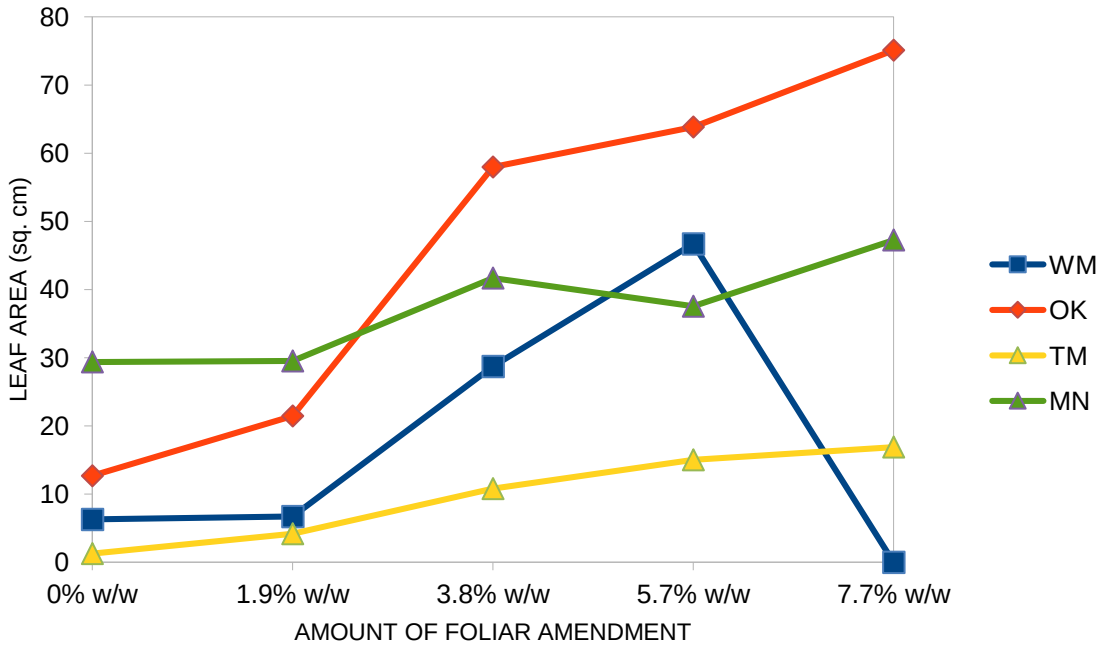

Figure 1: Plot of leaf area of the test crops against the amount of foliar amendment of *C. odorata*. (WM= watermelon [*C. lanatus*]; TM= tomato [*S. lycopersicum*]; OK= okra [*A. esculentus*]; MN= mucuna [*M. pruriens*])

The plot of leaf area against the amount of foliar amendment showed an increase in the leaf area of all subject crops as the amount of foliar amendment increased (except for the highest treatment for *C. lanatus*, which did not germinate or grow). This reflects a concentration-dependent increase of leaf area by the foliar amendment of *C. odorata*.

For *C. lanatus*, the highest leaf area was observed for the 5.7% w/w treatment which pegged at 46.71 cm^2, and the lowest was observed for the 7.7% w/w treatment (which did not germinate), followed by the control treatment (0% w/w) which pegged at 6.27 cm^2. This reflects a 644.98% increase in leaf area of *C. lanatus*, when compared to the control treatment. This increase in leaf area was shown to be statistically significant at a 5% level of probability (Table 1).

For *S. lycopersicum*, the highest leaf area was observed for the 7.7% w/w treatment which pegged at 16.87 cm^2, and the lowest was observed for the control treatment (0% w/w) which pegged at 1.26 cm^2. This reflects a 1,238.89% increase in leaf area of *S. lycopersicum*, when compared to the control treatment. This increase in leaf area was shown to be statistically significant at a 5% level of probability (Table 1).
For *A. esculentus*, the highest leaf area was observed for the 7.7% w/w treatment which pegged at 75.1

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

cm^2, and the lowest was observed for the control treatment (0% w/w) which pegged at 12.69 cm^2. This reflects a 491.81% increase in leaf area of *A. esculentus*, when compared to the control treatment. This increase in leaf area was shown to be statistically significant at a 5% level of probability (Table 1).

For *M. pruriens*, the highest leaf area was observed for the 7.7% w/w treatment which pegged at 47.24 cm^2, and the lowest was observed for the control treatment (0% w/w) which pegged at 29.33 cm^2. This reflects a 61.06% increase in leaf area of *M. pruriens*, when compared to the control treatment. This increase in leaf area was shown to be statistically insignificant (obeying the null hypothesis) at a 5% level of probability (Table 1).

Table 1: Homogenous subset of means of leaf area of test crops

TREATMENT	LEAF AREA ± St. error (cm^2)			
	C. lanatus	*S. lycopersicum*	*A. esculentus*	*M. pruriens*
0% w/w	6.27 ± 0.43a	1.26 ± 0.16a	12.69 ± 0.81a	29.33 ± 3.34
1.9% w/w	6.73 ± 1.26a	4.18 ± 0.77ab	20.9 ± 0.93a	29.64 ± 6.38
3.8% w/w	28.7 ± 5.59b	10.79 ± 4.14ab	57.94 ± 6.69b	41.67 ± 2.76
5.7% w/w	46.71 ± 1.3c	14.998 ± 4.34b	63.85 ± 3.5b	37.54 ± 0.00
7.7% w/w	0.00 ± 0.00a	16.87 ± 4.44b	75.1 ± 19.74b	47.24 ± 0.00

*Means followed by same letter along the columns are not significantly different at 5% level of probability (Tukey's HSD)

Effect of *C. odorata* amendment on the plant height of the test crops

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

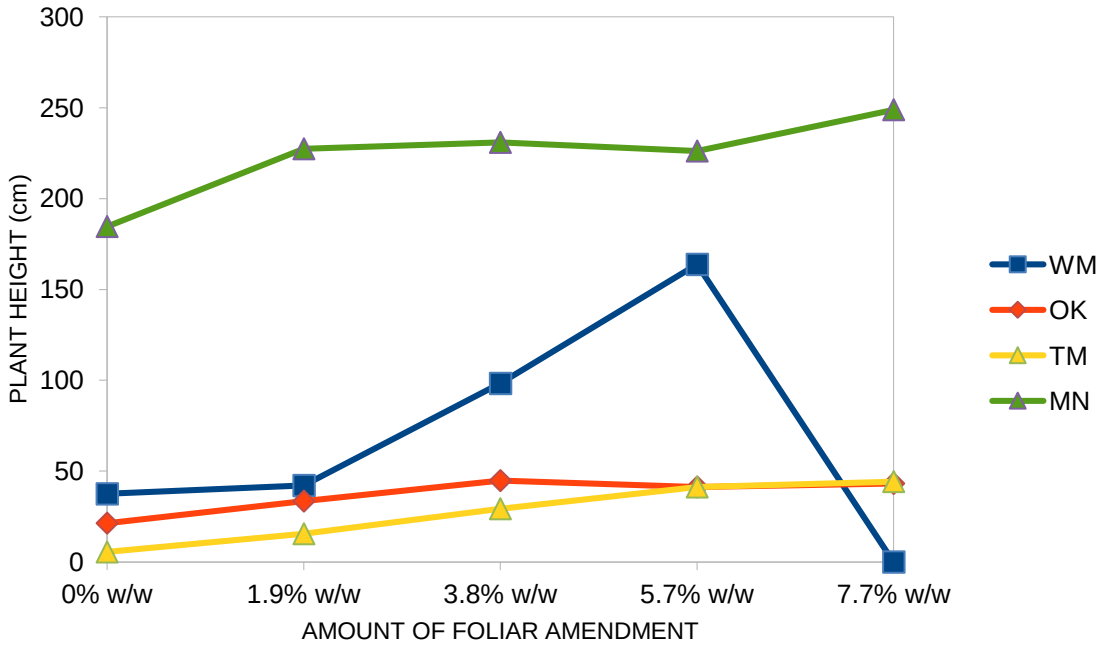

Figure 2: Plot of plant height of the test crops against the amount of foliar amendment of *C. odorata*. (WM= watermelon [*C. lanatus*]; TM= tomato [*S. lycopersicum*]; OK= okra [*A. esculentus*]; MN= mucuna [*M. pruriens*])

The plot of plant height against the amount of foliar amendment showed an increase in the plant height of all subject crops as the amount of foliar amendment increased (except for the highest treatment for *C. lanatus*, which did not germinate or grow). This reflects a concentration-dependent increase of plant height by the foliar amendment of *C. odorata*.

For *C. lanatus*, the highest plant height was observed for the 5.7% w/w treatment which pegged at 163.8 cm, and the lowest was observed for the 7.7% w/w treatment (which did not germinate), followed by the control treatment (0% w/w) which pegged at 37.63 cm. This reflects a 335.29% increase in plant height of *C. lanatus*, when compared to the control treatment. This increase in plant height was shown to be statistically significant at a 5% level of probability (Table 2).

For *S. lycopersicum*, the highest plant height was observed for the 7.7% w/w treatment which pegged at 44.2 cm, and the lowest was observed for the control treatment (0% w/w) which pegged at 5.6 cm. This reflects a 689.29% increase in plant height of *S. lycopersicum*, when compared to the control treatment. This increase in plant height was shown to be statistically significant at a 5% level of probability (Table

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

2).

For *A. esculentus*, the highest plant height was observed for the 7.7% w/w treatment which pegged at 43.2 cm, and the lowest was observed for the control treatment (0% w/w) which pegged at 21.35 cm. This reflects a 102.34% increase in plant height of *A. esculentus*, when compared to the control treatment. This increase in plant height was shown to be statistically significant at a 5% level of probability (Table 2).
For *M. pruriens*, the highest plant height was observed for the 7.7% w/w treatment which pegged at 248.8 cm, and the lowest was observed for the control treatment (0% w/w) which pegged at 184.58 cm. This reflects a 34.79% increase in plant height of *M. pruriens*, when compared to the control treatment. This increase in plant height was shown to be statistically insignificant (obeying the null hypothesis) at a 5% level of probability (Table 2).

Table 2: Homogenous subset of means of plant height of test crops

TREATMENT	PLANT HEIGHT ± St. error (cm)			
	C. lanatus	*S. lycopersicum*	*A. esculentus*	*M. pruriens*
0% w/w	37.63 ± 4.5a	5.6 ± 0.15a	21.35 ± 0.69a	184.58 ± 12.86
1.9% w/w	42.08 ± 5.91a	15.63 ± 2.99ab	34.6 ± 2.7ab	227.3 ± 0.42
3.8% w/w	98.28 ± 10.73b	29.3 ± 8.04abc	41.15 ± 3.87b	230.98 ± 1.38
5.7% w/w	163.8 ± 17.2c	33.53 ± 7.87bc	41.35 ± 0.85b	226.1 ± 0.00
7.7% w/w	0.00 ± 0.00d	44.2 ± 5.69c	43.2 ± 5.1b	248.8 ± 0.00

*Means followed by same letter along the columns are not significantly different at 5% level of probability (Tukey's HSD)

Effect of *C. odorata* amendment on the number of leaves of the test crops

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

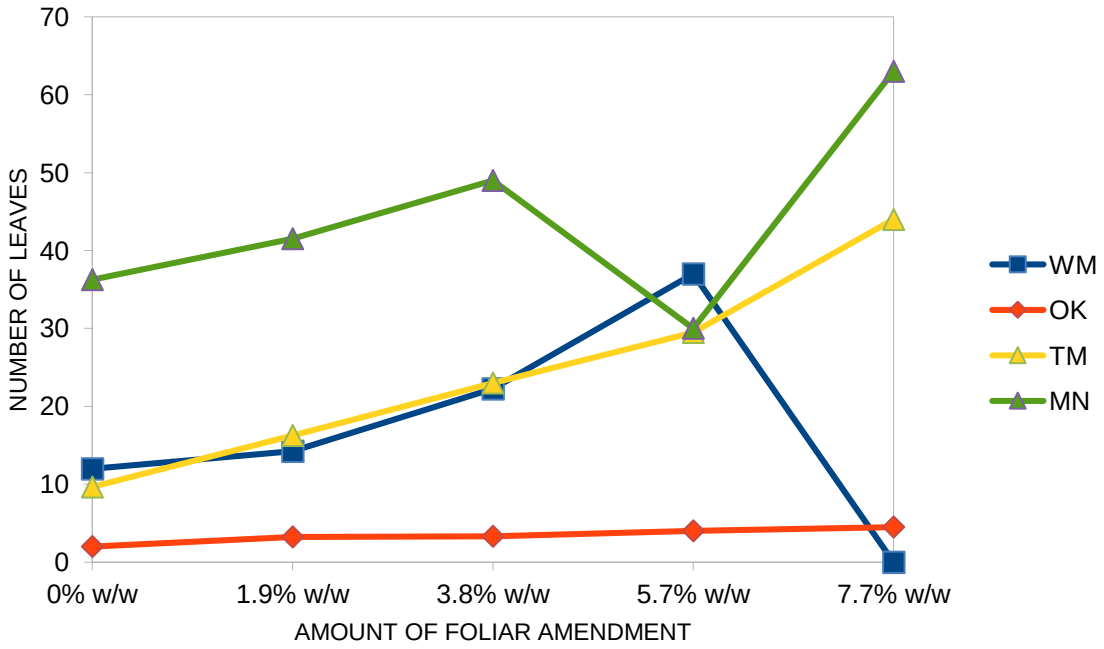

Figure 3: Plot of number of leaves of the test crops against the amount of foliar amendment of *C. odorata*. (WM= watermelon [*C. lanatus*]; TM= tomato [*S. lycopersicum*]; OK= okra [*A. esculentus*]; MN= mucuna [*M. pruriens*])

The plot of number of leaves against the amount of foliar amendment showed an increase in the number of leaves of all subject crops as the amount of foliar amendment increased (except for the highest treatment for *C. lanatus*, which did not germinate or grow). This reflects a concentration-dependent increase of number of leaves by the foliar amendment of *C. odorata*.

For *C. lanatus*, the highest mean number of leaves was observed for the 5.7% w/w treatment which pegged at 37.00 leaves, and the lowest was observed for the 7.7% w/w treatment (which did not germinate), followed by the control treatment (0% w/w) which pegged at 12.00 leaves. This reflects a 208.33% increase in number of leaves of *C. lanatus*, when compared to the control treatment. This increase in number of leaves was shown to be statistically significant at a 5% level of probability (Table 3).

For *S. lycopersicum*, the highest mean number of leaves was observed for the 7.7% w/w treatment which pegged at 44.00 leaves, and the lowest was observed for the control treatment (0% w/w) which pegged at 9.67 leaves. This reflects a 355.02% increase in number of leaves of *S. lycopersicum*, when compared to the control treatment. This increase in number of leaves was shown to be statistically significant at a 5%

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

level of probability (Table 3).

For *A. esculentus*, the highest mean number of leaves was observed for the 7.7% w/w treatment which pegged at 4.5 leaves, and the lowest was observed for the control treatment (0% w/w) which pegged at 2.00 leaves. This reflects a 125% increase in number of leaves of *A. esculentus*, when compared to the control treatment. This increase in number of leaves was shown to be statistically significant at a 5% level of probability (Table 3).

For *M. pruriens*, the highest mean number of leaves was observed for the 7.7% w/w treatment which pegged at 63.00 leaves, and the lowest was observed for the control treatment (0% w/w) which pegged at 36.25 leaves. This reflects a 73.79% increase in number of leaves of *M. pruriens*, when compared to the control treatment. This increase in number of leaves was shown to be statistically insignificant (obeying the null hypothesis) at a 5% level of probability (Table 3).

Table 3: Homogenous subset of means of number of leaves of test crops

TREATMENT	NUMBER OF LEAVES ± St. error			
	C. lanatus	*S. lycopersicum*	*A. esculentus*	*M. pruriens*
0% w/w	12.00 ± 1.53a	9.67 ± 2.73a	2.00 ± 0.00a	36.25 ± 3.73
1.9% w/w	14.25 ± 0.85a	16.25 ± 2.59ab	3.25 ± .25b	41.5 ± 1.19
3.8% w/w	22.25 ± 1.84b	23.00 ± 6.00ab	3.33 ± 0.33bc	49.00 ± 5.61
5.7% w/w	37.00 ± 3.00c	29.5 ± 3.07bc	4.00 ± 0.00bc	30.00 ± 0.00
7.7% w/w	0.00 ± 0.00d	44.00 ± 2.08c	4.5 ± 0.5c	63.00 ± 0.00

*Means followed by same letter along the columns are not significantly different at 5% level of probability (Tukey's HSD)

Effect of *C. odorata* amendment on the plant biomass of the test crops

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

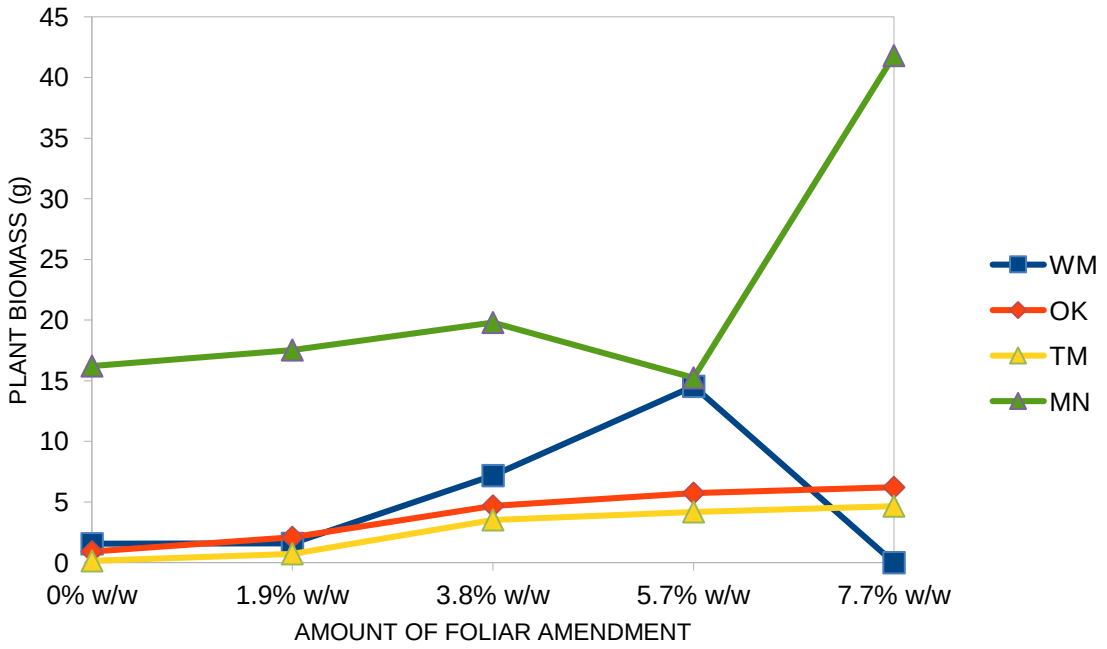

Figure 4: Plot of plant biomass of the test crops against the amount of foliar amendment of *C. odorata*. (WM= watermelon [*C. lanatus*]; TM= tomato [*S. lycopersicum*]; OK= okra [*A. esculentus*]; MN= mucuna [*M. pruriens*])

The plot of plant biomass against the amount of foliar amendment showed an increase in the plant biomass of all subject crops as the amount of foliar amendment increased (except for the highest treatment for *C. lanatus*, which did not germinate or grow). This reflects a concentration-dependent increase of plant biomass by the foliar amendment of *C. odorata*.

For *C. lanatus*, the highest mean plant biomass was observed for the 5.7% w/w treatment which pegged at 14.54g, and the lowest was observed for the 7.7% w/w treatment (which did not germinate), followed by the control treatment (0% w/w) which pegged at 7.69g. This reflects an 89.08% increase in plant biomass of *C. lanatus*, when compared to the control treatment. This increase in plant biomass was shown to be statistically significant at a 5% level of probability (Table 4).

For *S. lycopersicum*, the highest mean plant biomass was observed for the 7.7% w/w treatment which pegged at 4.65g, and the lowest was observed for the control treatment (0% w/w) which pegged at 0.14g. This reflects a 3,221.43% increase in plant biomass of *S. lycopersicum*, when compared to the control treatment. This increase in plant biomass was shown to be statistically significant at a 5% level of probability (Table 4).

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

For *A. esculentus*, the highest mean plant biomass was observed for the 7.7% w/w treatment which pegged at 6.21g, and the lowest was observed for the control treatment (0% w/w) which pegged at 0.91g. This reflects a 582.42% increase in plant biomass of *A. esculentus*, when compared to the control treatment. This increase in plant biomass was shown to be statistically significant at a 5% level of probability (Table 4).

For *M. pruriens*, the highest mean plant biomass was observed for the 7.7% w/w treatment which pegged at 41.8g, and the lowest was observed for the 5.7% w/w treatment which pegged at 15.24g. This reflects a 174.28% increase in plant biomass of *M. pruriens*, when compared to the control treatment. This increase in plant biomass was shown to be statistically insignificant (obeying the null hypothesis) at a 5% level of probability (Table 4).

Table 4: Homogenous subset of means of plant biomass of test crops

TREATMENT	PLANT BIOMASS ± St. error (g)			
	C. lanatus	*S. lycopersicum*	*A. esculentus*	*M. pruriens*
0% w/w	7.69 ± 3.44ab	0.14 ± 0.06a	0.91 ± 0.08a	16.21 ± 1.82
1.9% w/w	1.59 ± 0.28a	0.72 ± 0.12ab	2.1 ± 0.05ab	17.52 ± 0.5
3.8% w/w	7.19 ± 1.82ab	3.51 ± 0.83abc	4.67 ± 0.38bc	19.79 ± 1.76
5.7% w/w	14.54 ± 4.11b	4.17 ± 0.72bc	5.72 ± 0.7c	15.24 ± 0.00
7.7% w/w	0.00 ± 0.00a	4.65 ± 1.43c	6.21 ± 1.31c	41.80 ± 0.00

*Means followed by same letter along the columns are not significantly different at 5% level of probability (Tukey's HSD)

Effect of *C. odorata* amendment on the total chlorophyll content of the test crops

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

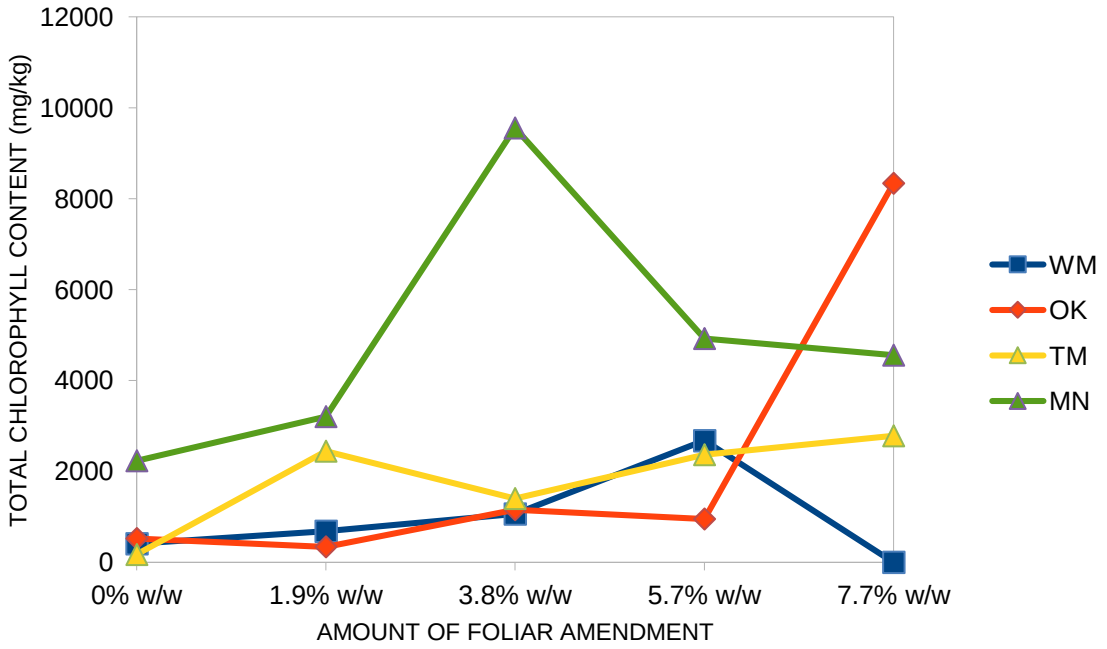

Figure 5: Plot of total chlorophyll content of the test crops against the amount of foliar amendment of *C. odorata*. (WM= watermelon [*C. lanatus*]; TM= tomato [*S. lycopersicum*]; OK= okra [*A. esculentus*]; MN= mucuna [*M. pruriens*])

The plot of total chlorophyll content against the amount of foliar amendment showed an increase in the total chlorophyll content of all subject crops as the amount of foliar amendment increased (except for the highest treatment for *C. lanatus*, which did not germinate or grow). This reflects a concentration-dependent increase of plant biomass by the foliar amendment of *C. odorata*.

Foremostly, *C. lanatus* with the highest mean total chlorophyll was observed for the 5.7% w/w treatment which pegged at 2680.27 mg/kg, and the lowest was observed for the 7.7% w/w treatment (which did not germinate), followed by the control treatment (0% w/w) which pegged at 407.33 mg/kg. This reflects a 558.01% increase in total chlorophyll of *C. lanatus*, when compared to the control treatment. This increase in total chlorophyll was shown to be statistically significant at a 5% level of probability (Table 5).

Secondly *S. lycopersicum* had the highest mean total chlorophyll was observed for the 7.7% w/w treatment which pegged at 2783.55 mg/kg, and the lowest was observed for the control treatment (0% w/w) which pegged at 174.31 mg/kg. This reflects a 1,496.87% increase in total chlorophyll of *S. lycopersicum*, when compared to the control treatment. This increase in total chlorophyll was shown to be statistically significant at a 5% level of probability (Table 5).

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

Furthermore. *A. esculentus* had the highest mean total chlorophyll was observed for the 7.7% w/w treatment which pegged at 8336.95 mg/kg, and the lowest was observed for the control treatment (0% w/w) which pegged at 523.9 mg/kg. This reflects a 1,491.33% increase in total chlorophyll of *A. esculentus*, when compared to the control treatment. This increase in total chlorophyll was shown to be statistically significant at a 5% level of probability (Table 5).

For *M. pruriens*, the highest mean total chlorophyll was observed for the 3.8% w/w treatment which pegged at 9556.59 mg/kg, and the lowest was observed for the control treatment (0% w/w) which pegged at 2233.39 mg/kg. This reflects a 327.9% increase in total chlorophyll of *M. pruriens*, when compared to the control treatment. This increase in total chlorophyll was shown to be statistically significant at a 5% level of probability (Table 5).

Table 5: Homogenous subset of means of total chlorophyll content of test crops

TREATMENT	TOTAL CHLOROPHYLL ± St. error (mg/kg)			
	C. lanatus	*S. lycopersicum*	*A. esculentus*	*M. pruriens*
0% w/w	407.33 ± 0.64a	174.31 ± 0.29a	523.9 ± 1.01a	2233.39 ± 0.18a
1.9% w/w	682.69 ± 0.60b	2448.04 ± 0.76b	338.92 ± 0.27b	3202.36 ± 0.15b
3.8% w/w	1064.03 ± 0.46c	1406.08 ± 1.19c	1159.15 ± 0.36c	9556.59 ± 44.26c
5.7% w/w	2680.27 ± 20.08d	2369.09 ± 0.47d	950.97 ± 0.01d	4920.92 ± 0.48d
7.7% w/w	0.00 ± 0.00e	2783.55 ± 0.17e	8336.95 ± 0.88e	4554.9 ± 0.4e

*Means followed by same letter along the columns are not significantly different at 5% level of probability (Tukey's HSD)

DISCUSSION

The application of the foliage of *C. odorata* as a soil amendment significantly increased the leaf area, plant height, number of leaves, plant biomass and total chlorophyll content of all the crop plants – *C. lanatus*, *S. lycopersicum* and *A. esculentus* – except for *M. pruriens* which, despite the visual and graphical observation of increment in all its parameters studied, only the increment in total chlorophyll content was shown to be statistically significant, at a 5% level of probability. This implied that the soil treatment with foliar amendments of *C. odorata* showed a statistically significant, concentration-dependent increase in leaf area, plant height, number of leaves, plant biomass and total chlorophyll content of *C. lanatus*, *S.*

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

lycopersicum and *A. esculentus*; this is to the exception of *M. pruriens* which showed statically significant increments only in the total chlorophyll content, despite all other parameters showing visual and graphical increments. By implication, this shows that the application of *C. odorata* foliage as soil amendments has a positive (stimulatory) allelopathic effect on the crops investigated – *C. lanatus*, *S. lycopersicum*, *A. esculentus* and *M. pruriens*. This increase in the growth parameters of the test crops can be attributed to the action of foliage-borne allelochemicals in synergy with a possible increase in the soil organic matter due to the incorporation of *C. odorata* foliage as soil amendments (Nighat *et al*., 2015). Earlier workers (Ignat *et al.*, 2011; Abdalla 2014) have reported a similar finding: accumulation of chlorophyll b and total chlorophyll in the young shoot of *H. sabdariffa* subjected to fresh shoot extract of *C. odorata* treatment was significantly higher than that of the plants in the control group at $p<0.05$. This result also corroborates that of Otusanya *et al.* (2008, 2014) in which chlorophyll b and total chlorophyll accumulation in *Lycopersicon esculentum* and *Amaranthus dubius* plants treated with water soluble root exudate (WRE) of *T. diversifolia* was significantly enhanced at $p<0.05$.

Despite going against the findings of some workers (Devi *et al*., 2014), the findings of this study are in line with, cum supported by, the work of a plenitude of other workers (Ajewole *et al*., 2021; Otusanya *et al*., 2015). Devi *et al*. (2014) have reported that the extract of *C. odorata* showed a concentration-dependent inhibiton on *S. lycopersicum*. They reported reduction of plant height, number of leaves, biomass, and chlorophyll content. Poonpaiboonpipat *et al*. (2021), while supporting the finding of Devi *et al*. (2014), have suggested that one of the mechanisms responsible for the reduction of plant growth by *C. odorata* is the inhibitory effect it has on chlorophyll content, and photosynthesis (in concomitance). Using both laboratory and soil experiments to evaluate the impact of *C. odorata* on *Hibiscus sabdariffa*, Otusanya *et al*. (2015) have reported that the fresh shoot extract of *C. odorata* has Janus-faced effect on the plant *Hibiscus sabdariffa*. The workers reported that, while observing a concentration-dependent decline, even the lowest concentration of the fresh shoot aqueous extracts of *C. odorata* reduced the germination of *H. sabdariffa*, noting that the radicle was more reduced than the plumule. In what is a direct contrast to this, their soil experiments showed that, in older plants, the same extract significantly enhanced the growth parameters including the shoot height, stem girth, leaf area, biomass, number of leaves and total chlorophyll content of *H. sabdariffa*. The workers asserted that the aqueous fresh shoot extract of *C. odorata* "could play differing allelopathic physiological role, depending on the medium of growth and age of the target plant". They explained that phytotoxicity of *C. odorata* got degraded in the soil, thus making the extracts stimulatory to the growth of the target plants.

This idea of degradation, as reported by (Otusanya *et al*. 2015) and recast as "bio-transformation" in some texts, shows that it is possible that the allelochemicals in the plant extract or foliage that would have been phytotoxic to the target plant was "bio-transformed" by certain soil-borne factors (especially microbes) to

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

new allelochemicals with growth stimulatory effect. This is a possibility that has been reported by Jilani *et al*. (2008). This, therefore, necessitates the use of chemical profiling methodologies to determine the chemical changes in the soil due to the application of the aqueous fresh shoot extract of *C. odorata*, towards a better understanding of the mechanism of the Janus-faced allelopathy of *C. odorata*. The findings of Otusanya *et al*. (2015) suggested the possibility of using *C. odorata* as a green manure or bio-fertilizer to improve the growth and productivity of already established H. sabdariffa plants in the field. In line with the findings of this study as supported by the work of Otusanya *et al*. (2015), Ajewole *et al*. (2021) studied the effect of *C. odorata* leachates on the germination and growth parameters of *Abelmoschus esculentus*. Their study showed that, while the leachates showed a concentration-dependent inhibition of germination, it also showed a concentration-dependent increase of growth parameters including the plant height, the leaf area, protein and ash content. This supports the line of thought proposed in this investigation that allelopathy is not just species dependent, but is also dependent on time (duration-dependent), concentration (concentration-dependent) and also phase (germination-growth phase dependent). The report by Ajewole *et al*. (2021) showed the phase-dependence of allelopathy, as the *C. odorata* leachate inhibited *A. esculentus* at the germination phase, but stimulated the same plant at the growth phase. It is also noteworthy that *C. odorata* may inhibit the germination of crops, but the same cannot be said of its effect on the long-term growth of the plant, especially when its foliage is used as a soil amendment. Onwugbuta-Enyi (2001) has reported that the incorporation of *C. odorata* leaf material into the soil for the growing of *L. esculentum* (syn. *S. lycopersicum*) showed significant depression in growth over the two-week duration of the study. The author inferred that the reduction in the yield of the crops in the fields where *C. odorata* plants are present is due to the release of allelochemicals from the *C. odorata* leaves and residue.

From the findings of this study, it seems that the assertion by Onwugbuta-Enyi (2001) is a bit erroneous on the grounds of flaws in methodology. It is believed that if the plants were allowed more time to grow, the plants treated with the highest amount(s) of residue would outgrow the ones in lower residues due to a higher supply of organic minerals that comes with the higher foliar residue(s). The allelopathic effect of *C. odorata* cannot really be studied from germination to plant maturity, as a continuum; it is best studied differently: effect on germination should be studied separately and same done separately for effect on growth too. This is because, if studied as a continuum, the inhibition or delay of germination may reflect on the overall growth of the plant which didn't germinate at same time as the others with less concentration. This will make it seem that *C. odorata* actually reduced growth of the test plant. The results of the allelopathic effect of *C. odorata* on the growth of the subject plants should be discussed as "time-bound". The inference is that the leaf amendment actually does not reduce growth of plants; instead, what it reduces or delays is germination of the plants. If the study is done over a short period (say 4 weeks, or 2 weeks as followed by Onwugbuta-Enyi (2001)), with the effect of delayed germination on the plants

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

treated with higher concentration, it would seem like the plants with lower concentration of treatment are doing better because they germinated first. But, if the study is allowed a longer time, the plants treated with higher concentration (whose germination were delayed) must have germinated and used the organic mineral resources, made available by the higher concentration of *C. odorata* residue, to grow so fast that they cancel out the effect of their delayed germination. They end up being the better performing plants in terms of yield and other growth parameters. The argument therefore is that the *C. odorata* does not necessarily reduced the growth of plants, instead what it does is to delay or inhibit germination, thereby making it look like the plant whose germination was delayed was underperforming, over a short period of time. But, if the same setup is allowed enough time, then the plants whose germination were delayed or inhibited will overtake the early-germinating plants because they have a higher supply of organic minerals due to the presence of the *C. odorata* foliar residue in the soil. This is why some villagers and local farmers in Nigeria use *C. odorata* as post-emergence mulch in their farms. This finding may assert that most reports claiming that the addition of *C. odorata* residue reduces plant growth may be wrong, on the grounds of technical flaws or errors in methodology.

Another set of workers (Ogbu *et al*., 2020) have studied the effect of aqueous leaf extract of the legume *Pentaclethra macrophylla* on the germination and seedling growth of *Abelmoschus esculentus*. Working with five different concentrations (0 [control], 10, 20, 40 and 80%), the workers reported that the control treatment performed better than the other treatment concentrations in the germination studies; thus suggesting a concentration-dependent decline in germination of *A. esculentus* due to the application of the foliar extract of *P. macrophylla*. On a twist, in the 8-week seedling growth studies, the workers reported a concentration-dependent increase in the number of leaves, stem diameter, plant height and dry weight of okra with increasing concentration of aqueous leaf extract. This finding by Ogbu *et al*. (2020) is in line with the finding of this study, indicating a possible phase-dependent Janus-face to the concept of allelopathy. Some other workers (Maqbool and Sadiq, 2017) have established that the lower concentrations of a potentially allelopathic extract improve the growth and even the germination of plants. The workers applied the aqueous extract of sorghum leaves on drought-stressed maize seeds to study the effect of the extract on the germination, growth and physiological attributes of the test plant. Their study showed that more concentrated extract treatments were damaging, while lower concentration improved the root and shoot growth of the drought-stressed maize. Mashood *et al*. (2014) have asserted that the growth promoting effects of allelopathy can be used in various ways such as growing crops by foliar application of plants water extracts which have promotive effects on other crops. They also iterated that the allelopathic effect was not due to a single allelochemical, but an effect due to the synergistic action of more than one allelochemical.

International Journal of Applied Science and Engineering Review

IJASER

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

CONCLUSION

The application of the foliage of *C. odorata* as a soil amendment significantly increased the leaf area, plant height, number of leaves, plant biomass and total chlorophyll content of virtually all the crop plants – *C. lanatus*, *S. lycopersicum* and *A. esculentus* – except for *M. pruriens* which, despite the visual and graphical observation of increment in all its parameters studied, only the increment in total chlorophyll content was shown to be statistically significant, at a 5% level of probability. By implication, this shows that the application of *C. odorata* foliage as soil amendments has a positive (stimulatory) allelopathic effect on the crops investigated – *C. lanatus*, *S. lycopersicum*, *A. esculentus* and *M. pruriens*.

Compared with previous studies, the treatment of crops with foliage or foliar extracts of *C. odorata* showed a Janus-faced, phase dependent allelopathic effect on the test crops – *C. lanatus*, *S. lycopersicum*, *A. esculentus* and *M. pruriens*. It decreased the germination percentage (personal observation, undergoing publication) while it increased the other post-germination growth parameters (leaf area, plant height, number of leaves, plant biomass and total chlorophyll content) of the test crops.

This increase in the post-germination growth parameters of the test crops can be attributed to the action of the bio-transformed foliage-borne allelochemicals in synergy with a possible increase in the soil organic matter due to the incorporation of *C. odorata* foliage as soil amendments. It is possible that the allelochemicals in the plant *C. odorata* foliage that would have been phytotoxic to the target plant was "bio-transformed" by certain soil-borne factors (especially microbes) to form new allelochemicals with growth stimulatory effect.

C. odorata foliage can be recommended for used as soil amendment to boost crop growth only at the post-germination (growth) phase; this is because, if the foliage of *C. odorata* is used to amend the soil at the pre-germination phase, it will inhibit the germination of the crops and lead to possible economic losses for the farmer.

REFERENCES

Abbas, A., Huang, P., Hussain, S., Saqib, M., He, L., Shen, F. and Du, D. (2020). Application of allelopathic phenomena to enhance growth and production of camelina (*Camelina sativa* (L.)). *Applied Ecology and Environmental Research*. 19(1):453-469.

Abdalla, M. M. (2014). Boosting the growth of rocket plants in response to the application of *Moringa oleifera* extracts as a biostimulant. *Life Science Journal*. 11(11):1113-1121.

Ajewole, T.O., Ayesa, A.S., Popoola, K.M., Ajiboye, M.D., Oluwole, B.R. and Kolawole, O.S. (2021). Effects of fresh shoot biomass of siam weed *Chromolaena odorata* (L.) King and H. Robinson on the germination and growth of okra *Abelmoschus esculentus* (L.) Moench. *African Journal of*

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

Food, Agriculture, Nutrition and Development. 21(7): 18404-18413.

Alka, G., Anamika, S. and Ranu, P. (2018). A review on watermelon (*Citrullus lanatus*) medicinal seeds. *Journal of Pharmacognosy and Phytochemistry*. 7(3): 2222-2225

Archana, G., AzhaguSaravana, P., Babu, K., Sudharsan, K., Sabina, R., Palpandi Raja, M., SukumarSivarajan, M. (2015). Evaluation of fat uptake of polysaccharide coatings on deep-fat fried potato chips by confocal laser scanning microscopy. *International Journal of Food Properties.*19: 1583–1592.

Borguini, R. G. and FerrazDa Silva Torres, E. A. (2009). Tomatoes and tomato products as dietary sources of antioxidants. *Food Reviews Internationa*l. 25(4): 313–325.

Cheema, Z.A., Khaliq, A. and Saeed, S. (2004). Weed control in maize (*Zea mays* L.) through sorghum allelopathy. *Journal of Sustainable Agriculture*. 23:73-86.

Devi, O.I. and Dutta, B.K. (2012). Allelopathic Effect of the Aqueous Extract of *Parthenium hysterophorus* and *Chromolaena odorata* on the seed germination and seedling vigour of *Zea mays* L. *in vitro*. *Academic Journal of Plant Sciences*. 5(4): 110-113.

Devi, O.I., Dutta, B.K. and Choudhury, P. (2014). Allelopathic effects of some weed species on the growth of tomato plants (*Solanum lycopersicum* L.). *Journal of International Academic Research for Multidisciplinary*. 2(1): 445-454.

Diallo, O.K. and Berhe, T. (2003). Processing the *Mucuna* for human food in the Republic of Guinea. *Tropical and Subtropical Agroecosystems*. 1(2/3):193–196.

Erowid (2002). *Mucuna pruriens*. Created 2002-APR-22. *International Legume Database and Information Service*. Genus *Mucuna*. Version 10.01.

Farooq, M., Bajwa, A.A., Cheema, S.A. and Cheema, Z.A. (2013). Application of allelopathy in crop production. *International Journal of Agriculture and Biology*. 15: 1367–1378.

Foolad, M.R. (2007). Genome mapping and molecular breeding of tomato. *International Journal of Plant Genomics*. 2007: 64358.

Gautier, L. (1992). Taxonomy and distribution of a tropical weed, *Chromolaena odorata* (L.) R. King and H. Robinson. *Candollea*. 47: 645–662.

Henderson, L. (2001). *Alien Weeds and Invasive Plants*. Handbook No. 12. Pretoria, South Africa: ARC-PPRI.

Hu, S.-M. and Lai, H.-S. (2016). Developing low-fat banana bread by using okra gum as a fat replacer. *Journal of Culinary Science and Technology*.15: 36–42.

Ignat, I., A. Stingu, I. Volf, and Popa, V.I. (2011). Characterization of grape seed and aqueous extract and possible application in biological systems. *Cellulose Chemistry and Technology*. 45(3-4): 205-209.

Jilani, G., Mahmood, S. Chaudhry, A.N., Hassan, I. and Akram, M. (2008). Allelochemicals: sources, toxicity and microbial transformation in soil – a review. *Annals of Microbiology*. 58(3): 351 – 357.

Kavitha, C. and Thangamani, C. (2014). Amazing bean *"Mucuna pruriens"*: A comprehensive review.

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

Journal of Medicinal Plants Research. 8(2): 138-143.

Kavitha, C. and Vadivel, E (2008). Effect of organic manures and inorganic fertilizers on dry matter production and L DOPA content of *Mucuna pruriens* (L.) DC. – A leguminous medicinal plant. *Legume Research*. 31(1):44-47.

Kumar, D.S.; Tony, D.E.; Kumar, A.P.; Kumar, K.A.; Rao, D.B.S.; Nadendla, R. (2013). A review on: *AbelmoschusEsculentus*(okra). *International Research. Journal of Pharmaceutical and Applied Science. 3*: 129–132.

Maqbool, N. and Sadiq, R. (2017) Allelochemicals as Growth Stimulators for Drought Stressed Maize. *American Journal of Plant Sciences*. 8: 985-997.

Mashood, U.S., Muhammad, H., Ahmad Raza, M.T., Akbar Ali, M., Mubasher, A., Muhammad, M. and Muhammad, M. (2014). Role Of Allelopathy In The Growth Promotion Of Plants. *Scientia Agriculturae***.** 2 (3): 141-145.

Naveed, A., Khan, A.A., Khan, I.A. (2009). Generation mean analysis of water stress tolerance in okra (*Abelmoschus esculentus* L.). *Pakistan Journal of Botany*. 41:195– 205.

Nighat, S., Amna, S., Arshad, J. and Nafisa (2015). Effect of Neem leaves as soil amendment on Southern Blight disease, growth and physiology of chili. *Pakistan Journal of Phytopathology*. 27(2): 115-120.

Ogbu, J.U., Awodoyin, R.O. and Olubode, O.S. (2020). Allelopathic effect of *Pentaclethra macrophylla* Benth. leaf extracts on germination and seedling growth of maize and okra. *Asian Journal of Biological Sciences*. 13(3): 285-292.

Okonmah, L.U., Agbogidi, O.M., Nwagu, O.K. (2011). Evaluation of four varieties of watermelon (*Critrulluslanatus*Thumb) in Asaba agro-ecological environment. *International Journal of Advanced Biological Research*. 1(1):126-130.

Onwugbuta – Enyi, J. J. (2001). Allelopathic effects of *Chromolaena odorata L*. (R. M. King and Robinson – (Awolowo Plant')) Toxin on Tomatoes (*Lycopersicum esculentum* Mill). *Journal of Applied Sciences and Environmental Management*. 5(1): 69-73.

Otusanya, O.O., Ikonoh, O.W. and Ilori, O.J. (2008). Allelopathic potentials of *Tithonia diversifolia:* effect on the germination, growth and chlorophyll accumulation of *Capsicum annuum* L. and *Lycopersicon esculentum* Mill. *International Journal of Botany*. 4 (4): 471-475.

Otusanya, O.O., Ogunwole, A.A. and Tijani, M.O. (2015). Allelopathic effect of *Tithonia diversifolia* and *Chromolaena odorata* on the germination, growth and chlorophyll accumulation of *Hibiscus sabdariffa* (L.). *International Journal of Botany and Research*. 5(3): 1-14.

Otusanya, O.O., Sokan-Adeaga, A.A. and Ilori, O.J. (2014). Allelopathic effect of the root exudates of *Tithonia diversifolia* on the germination, growth and chlorophyll accumulation of *Amaranthus dubius* l. and *Solanum melongena* L.. *Research Journal of Botany*. 9: 13-23.

Owolabi, M.S., Ogundajo, A., Yusuf, K.O., Lajide, L., Villanueva, H.E., Tuten, J.A. and Setzer, W.N.

ISSN: 2582-6271

Vol. 4, Issue.2, March-April 2023, page no. 96-118

(2010). Chemical composition and bioactivity of the essential oil of *Chromolaena odorata* from Nigeria. *Records of Natural Products*. 4(1): 72-78.

Phan, T.T., See, P.O., Lee, S.T. and Chan, S.Y. (2001). Anti-oxidant effects of the extracts from the leaves of *Chromolaena odorata* on human dermal fibroblasts and epidermal keratinocytes against hydrogen peroxide and hypoxanthine-xanthine oxidase induced damage. *Burns*. 27(4): 319-327.

Poonpaiboonpipat, T., Krumsri, R. and Kato-Noguchi, H. (2021). Allelopathic and herbicidal effects of crude extract from *Chromolaena odorata* (L.) R.M.King and H.Rob. on *Echinochloa crus-galli* and *Amaranthus viridis*. *Plants*. 10: 1609.

Rajeshwar, Y., Kumar, S., Gupta, M., Mazumder, U.K. (2005). Studies on *in vitro* antioxidant activities of methanol extract of *Mucuna pruriens* (*Fabaceae*) seeds. *European Bulletin of Drug Research*. 13(1): 31-39.

Tripathi, K.K., Warrier, R., Govila, O.P., Ahuja, V. (2011). *Biology of Abelmoschus esculentus* L. *(okra). Series of Crop Specific Biology Documents*. Ministry of Environment and Forests Government of India: New Delhi, India, 2011.

Uzoma, M.C., Mensah, S.I. and Ochekwu, E.B. (2018). Allelopathic effect of aqueous extracts of *Axonopus compressus*(Swartz) P. Beauv on the chlorophylls and phenolic content of *Kalanchoe pinnata* (Lam.) Pers. *Nigerian Journal of Agricultural Technology*. 15(1): 22-26.

Uzoma, M.C., Mensah, S.I. and Ochekwu, E.B. (2019). Studies on the allelopathic effect of *Axonopus compressus* (Swartz) P. Beauv on some growth parameters and phenolic content of *Kalanchoe pinnata* (Lam.) Pers. *Toxicology Digest*. 4(1): 74-93.

Vinhas, V.A., Sousa, C., Matos, C., Moutinho, C. and Vinha, A.F. (2021). Valorization of watermelon fruit (*Citrullus lanatus*) byproducts: Phytochemical and biofunctional properties with emphasis on recent trends and advances. *World Journal of Advance Healthcare Research*. 5(1): 302 - 309

Willcox, J.K., Catignani, G.L., and Lazarus, S. (2003). Tomatoes and cardiovascular health. *Taylor & Francis Group*. 43(1): 1-18.

Yuennan, P., Sajjaanantakul, T. and Goff, H.D. (2014). Effect of okra cell wall and polysaccharide on physical properties and stability of ice cream. *Journal of Food Science.* 79:E1522–E1527.