Assessing The Allelopathic Effect of *Chromolaena Odorata* on Seedling Emergence and Growth of *Cucumis Sativus* and *Citrillus Lanatus*

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Abstract- This study investigated Chromolaena odorata's allelopathic influence on Citrillus lanatus and Cucumis sativus seedling emergence and growth. We used a completely randomized design with three treatments (T1: 5g, T2: 10g, T3: 15g) in 300g of soil, each with four replicates. We assessed seedling emergence percentage (SE%), seedling emergence index (SEI), time spread of emergence (TSE), allelopathic response index (ARI), seedling lengths (SL), and dry weights (DW), analyzing data with ANOVA and Tukey's HSD test. C. lanatus SE% (97.5%, 97.5%, 92.5%, 72.5%) and SEI (15.9, 14.9, 13.6, 10.9) were not significantly reduced. SE% (90%, 50%, 55%, 30%) and SEI (13.2, 9.5, 5.5, 2.3) of C. sativus decreased non-significantly. TSE values in the treatment plots were all higher than the control while ARI values were negative indicating delayed and inhibited emergence in both crops. Contrary to the inhibitory effect of T_1, T_2 and T_3 on SL of C. sativus, T_1 and T_2 stimulated SL in C. lanatus while T_3 inhibited growth. DWs did not reduce significantly but was concentration-dependent. This study underscores the variable allelopathic effects that C. odorata possesses which is influenced by plant species, allelopathic material concentration, and crop growth phase. Consequently, C. odorata can be strategically incorporated into crop rotation and weed control practices.

Indexed Terms— Allelopathic, Chromolaena Odorata, Seedling Emergence, Cucumis Sativus, Citrillus Lanatus, Stimulatory, Inhibitory

I. INTRODUCTION

Allelochemicals produced from allelopathic plants have been shown to inhibit or stimulate the germination and growth of other plants. These allelochemcials are discharged through various processes which include, root exudation, volatilization, leaching and decomposition of residues. The inhibitory effect on the target plants has been observed as inhibited germination, reduced growth, root swelling and necrosis, reduction in accumulation of dry weight and reduced reproduction [1]. On the other hand, allelochemicals have improved the growth of certain plant species. The extent to which the growth and germination of the plant is affected depends on residue biomass, growth stage, donor or receiver plant species and environmental factors [2]. These dual potentials of allelochemicals can be exploited for promoting growth, formulating herbicides and insecticides and protection of crops. Research on allelopathy is intended for the purpose of applying discoveries to agricultural production, reducing the use of synthetic chemicals and the following environmental pollution and developing sustainable agricultural and ecological systems [3]. In applying allelopathy in plants, it is important to be cautious of the effect that allelochemicals have on crop plants. When allelochemicals are released, the problem of "accumulation, stability, persistence and concentrations" in the soil may arise and subsequently affect the plant [4]. Hence, the need to study the effects of *Chromolaena odorata*, an allelopathic plant known for its aggressive invasive nature, on other crops as this will inform its use in vegetable crop production.

Chromolaena odorata L. is a member of the family *Asteraceae* and is of the biggest flowering group. It is also referred to as *Eupatorium sp.* and *Osmia sp*, etc. Its common names include siam weed, bitterweed, Queen Elizabeth plant, christmas bush, etc. Various studies have shown that *Chromolaena odorata* has "antibacterial, antiplasmodic, antiprotozoal, antitrypanosomal, antifungal, antihypertensive, anti-inflammatory, astringent, diuretic, hepatotropic, immunomodulatory and anticancer properties”. It has been applied as a treatment for bites from leeches, wounds from heat, infections involving the skin, diabetes, periodontis, sore throats, colds, etc. [5]. The concentration of allelochemicals in the foliar part of *C. odorata* has been reported to be the highest amount isolated from a plant species [6]. Its active phytochemicals include: saponins and tannins, flavonoid aglycones, alkaloids, terpenes, terpenoids, essential oils, phytoprostane, phenolic acids and phytoprostane compound [7], [8].

Cucumis sativus and *Citrillus lanatus* are members of the cucurbitaceae family, each having nutritional and economic value. Both are important fruit and vegetable crops in Nigeria mostly cultivated by small-scale farmers. They are both important to the income, health and livelihood of Nigerians. In order to encourage organic farming of these crops where synthethic fertilizers and pesticides are avoided, the search for natural means of protecting crops is imperative. Results from this study will determine if *C. sativus* and *C. lanatus* will be affected by *Chromolaena odorata* and will determine if *Chromolaena odorata* can be strategically employed for vegetable crop protection. Therefore the objective of this study was to determine the effect of *Chromolaena odorata* on seedling emergence of *Cucumis sativus* and *Citrillus lanatus.*

II. MATERIALS AND METHODS

A. Experimental site

The experiment was carried out in the green house of the department of Plant science and biotechnology, University of Port Harcourt, Rivers state, Nigeria.

B. Collection of preparation of materials

Leaves of mature *Chromolaena odorata* plants were collected from the experimental farm, rinsed, dried to eliminate wetness and shredded. The shredded leaves were contained in Ziploc bags and refrigerated for proper preservation till when needed. Certified seeds (Technisem brand) of *Cucumis sativus* and *Citrillus lanatus* having a germination percentage of 100% were obtained from a local seed shop. Surface sterilization of the seeds was carried out using sodium hypochlorite. The experimental soil consisted of 82% sand, 6% silt, 12% clay and pH 3.41.

C. Seedling emergence experiment

Sixteen (16) containers were filled with experimental soil and moistened. The shredded *C. odorata* leaves were incorporated into the top soil at 5g, 10g and 15g and arranged in a completely randomised design, each treatment having four (4) replications. The control pots were administered with water only without the *C. odorata* treatments. Ten (10) seeds each of the test crops were sown into the soil twenty-four (24) hours after application of the treatments. These were monitored for emergence and the experiment lasted for ten (10) days after first emergence was noted. The following growth parameters were measured: emergence percentage (SE%), emergence index (SEI) [9], time spread of emergence (TSE) and allelopathic response index (ARI), seedling lengths, fresh and dry weights,.

D. Statistical analysis

Data collected were analysed using analysis of variance and the means separated for significance using Tukey HSD test ($P \leq 0.05$).

III. RESULTS

A. Citrillus lanatus

Results of emergence percentage, SE% (Fig. 1) and seedling emergence index, SEI (Fig. 2) showed that treatments of *C. odorata* did not significantly ($P \leq 0.05$) reduce SE% and SEI of *Citrillus lanatus* compared to the control. Both (SE%) and (SEI) reduced as treatment concentration increased. The SE% was inversely related to the concentration; Control - 97.5% > T_1 - 97.5% > T_2 - 92.5% > T_3 72.5%). All the treatment plots had higher TSE values (Fig. 3) than the control with highest value (9.0) in T_2 plots followed by T_1 and T_3 which had equal values (8.0g). The higher TSE value in the treatment plots showed that treatments caused delay in emergence compared to the control. All the ARI values (Fig. 4) were negative showing that the effects of the treatments were inhibitory to *C. lanatus.* There was significant difference between the lengths of the seedling (Fig. 5) and the values decreased in the order: T_2 (18.8cm), T_1 (16.2cm), control (15.5cm) and T_3 (13.6cm). The dry weights (Fig. 6) were concentration-dependent and reduced non-significantly with the control having the highest value (0.17g) followed by T_1 (0.16g), T_2 (0.16g) and T_3 (0.12g) respectively.

B. *Cucumis sativus*: Emergence percentage,SE% (Fig. 1) was significantly reduced by the treatments from 90% in control to 50%, 55% and 30% in T_1, T_2 and T_3 plots respectively. The SEI (Fig. 2) was also concentration dependent as it reduced with increased concentration of the treatments. The TSE values (Fig. 3) were directly proportional to the treatments, that is, as the treatments increased the TSE values increased (T_3 (5.0) = T_2 (5.0) > (6.0) T_1 and control (8.0)). The ARI values (Fig. 4) were all negative too showing that the treatments inhibited germination of the seeds. Although the treatments caused a reduction in the seedling lengths (Fig. 5) (14.22cm, 12.6cm, 12.6cm, 12.4cm), they were not significantly affected by the treatments. The dry weight values (Fig. 6) were not significantly affected but reduced as the treatments increased from 0.16g in control to 0.11g, 0.09g and 0.07g respectively.

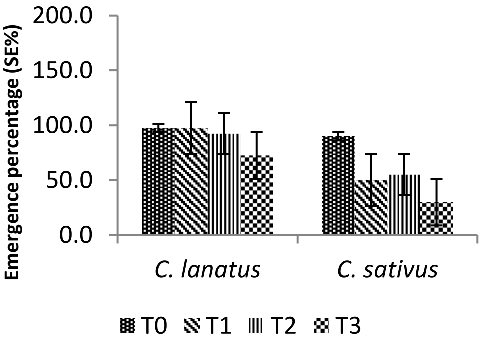

Fig. 1: Effect of *C. odorata* treatments on the seedling emergence percentage (SE%)

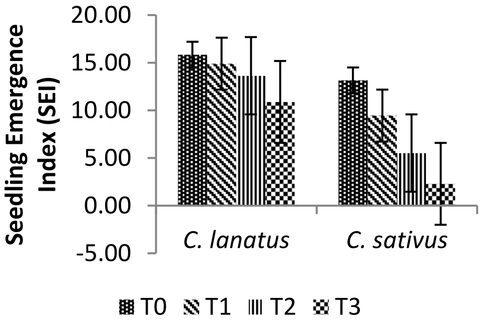

Fig. 2: Effect of *C. odorata* treatments on seedling emergence index (SEI)

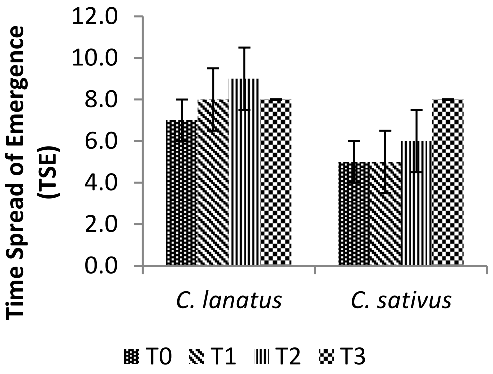

Fig. 3: Effect of *C. odorata* treatments on time spread of emergence (TSE)

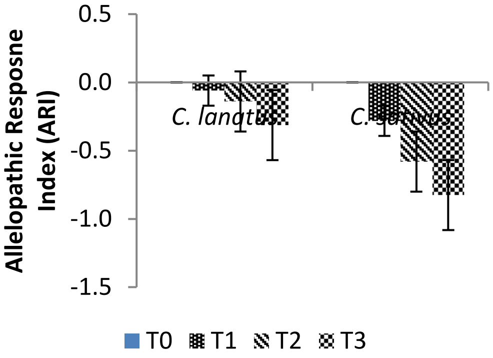

Fig. 4: Effect of *C. odorata* treatments on allelopathic response index (ARI)

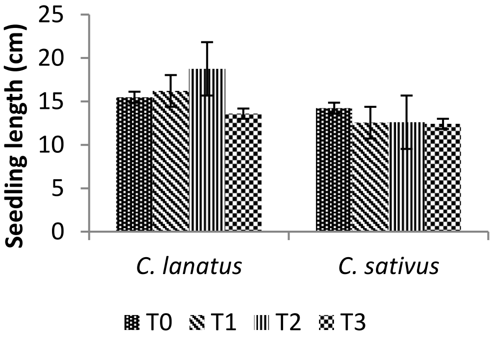

Fig. 5: Effect of *C. odorata* treatments on seedling length (cm)

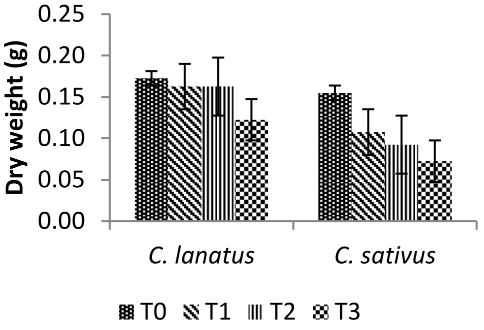

Figure 6: Effect of C. odorata treatments on dry weight (DW)

IV. DISCUSSIONS

The non-significant reduction in emergence of *Citrullus lanatus* due to *C. odorata* treatments aligns with the concept of allelopathy, where certain plants release chemicals that inhibit the growth of neighboring plants. It has been reported by that *C. odorata* possesses allelopathic compounds which include: phenolics, alkaloids and amino acids [10], that are responsible for the inhibition of *C. lanatus* seed emergence. These allelochemical include: In another study germination of both barnyard grass and paddy grass were significantly delayed by *C. odorata* and the effect was more on barnyard grass than paddy grass [11]. The higher the concentration of the treatments, the higher the allelopathic effect of the treatments compared to the control. The concentration-dependent response observed in this study is consistent with findings from other allelopathy studies. Higher concentrations of allelopathic compounds often lead to greater inhibitory effects on seed germination and seedling growth [12]. *C. odorata* has also been reported to have a concentration-dependent inhibitory effect on seed germination of *Vigna unguiculata* varieties [13]. The delay in emergence, indicated by higher TSG values in treatment plots, could be attributed to the time required for *C. lanatus* seeds to overcome the inhibitory effects of *C. odorata* compounds. Such delays are common when plants encounter allelopathic chemicals [14]. The allelopathic response index (ARI) also showed that all the treatments had allelopathic effect on the seeds, hindering germination and early growth. The negative Allelopathic Response Index (ARI) values confirm the inhibitory nature of *C. odorata* on *Citrullus lanatus*. Negative ARI values are typical when allelopathy is at play [15]. Unlike in the previous parameters, the SL in *C. lanatus* improved as the treatment increased from T_1 to T_2 but at T_3 the SL declined and was lower relative to the control and other treatments. This effect on seedling lengths suggests that while *C. odorata* treatments delayed emergence, lower concentrations did not have a negative effect on the post-emergence growth. This aligns with observations in previous allelopathy studies [16] and it also showed that lower concentration can stimulate growth but higher concentration can inhibit growth. This stimulated response has been reported by some authors to be a result of the growth stage of the recipient plant, implying that at early stage of growth, the plant is more susceptible to allelopathy but at a later growth stage the target plant is more tolerant or resistant to allelopathy [17]. Similarly, there was no significant difference between the mean values of fresh and dry weights across treatment groups. This suggests that the treatments did not substantially affect the overall biomass accumulation in *Citrullus lanatus* beyond the emergence stage. However, it's important to note that dry weights were concentration-dependent, with higher concentrations resulting in lower dry weights.

Considering the different effect of the treatments on the emergence of seedlings which involved inhibition of seedling emergence but stimulation of seedling elongation, it means that allelochemicals present in the allelopathic materials may affect specific biochemical or physiological pathways within the same plant differently. For instance, certain allelochemicals might primarily inhibit germination by affecting seed coat permeability but have less impact on subsequent seedling growth. Reference [18] discussed how allelopathic substances can exhibit both inhibitory and stimulatory effects on neighbouring plants, depending on factors such as concentration and exposure time. Reference [15] demonstrated that allelopathic substances can initially inhibit germination but later stimulate the growth of certain plant species. Some authors demonstrated that seed germination of lettuce was inhibited in a dose-dependent pattern but seedling elongation was stimulated by aqueous extract of three herbs – *Artemisia frigida*, *Stellera chamaejasme* and *Achnatherum splendens* [19].

Alternatively, [20] and [4] reported that allelochemicals undergo transformation in the soil to a more or less simpler or complex form which changes their biological activity. The efficacy of allelochemicals in the soil reduces as a result of degradation [20] as has been shown in the case of DIBOA which has a half-life of 43 hours though its end product, 2-aminophenoxazin-3-one (APO) has a half-life of above 90 days [21]. It has been reported that allelochemicals can be transformed into “more active, less active or entirely inactive compounds” and this transformation is influenced by the chemical, physical and biological qualities of the soil environment [22] and [23]. According to [4] toxicity is highest at the early stage of decomposition of the allelopathic material than at the later stage. The allelochemicals in an oat variety which had shown toxicity became stimulatory within 4 days and inhibitory 14 days later. From the result of this experiment, it can therefore be deduced that at the early stage of the experiment, *C. odorata* inhibited the germination of *C. lanatus* seeds because it was phytotoxic at that initial period but as time progressed, the phytotoxic effect of the allelopathic material wore off or it simply changed form and became a stimulant to the elongation of the seedlings [24], [17].

Similar to *Citrullus lanatus, Cucumis sativus* also experienced a significant reduction in emergence percentage (SE%) due to *C. odorata* treatments. This reduction was concentration-dependent, with higher concentrations causing a more pronounced decrease in emergence. The reduction in emergence index (SEI) also followed a concentration-dependent pattern, further emphasizing the dose-response relationship of *C. odorata* treatments on seedling emergence. The decrease in SE% values with treatment concentration indicates a delay in the emergence of *Cucumis sativus* seeds. Delayed emergence can impact crop development and potentially affect agricultural practices, as crops that emerge later may face increased competition for resources such as sunlight, water, and nutrients [25]. This strategy is already employed in weed management because weed growth can be suppressed by inhibiting seed germination and seedling emergence. In Pakistan, a weed control technique involving an aqueous extract of 10% sorghum shoots left to ferment for several weeks is utilized. This solution, known as 'Sorgaab,' is applied as a post-emergence spray for weed management. Field experiments have indicated that 'Sorgaab' can significantly reduce weed density and weed biomass by up to 50%, with the effectiveness varying depending on the weed species [26], [27]. The significant reduction in emergence percentage (SE%) in response to *C. odorata* treatments is in line with the allelopathic effects reported in studies involving various plant species [28]. Cucumber seeds may have been particularly sensitive to allelopathic compounds released by *C. odorata*. The negative ARI values also confirm that the treatments inhibited germination of *C. sativus* seeds, reflecting the allelopathic effects of *C. odorata* treatments on this crop. The treatments caused a reduction in seedling lengths compared to the control, although these reductions were not statistically significant. This suggests that while the treatments may have inhibited growth, they did not drastically affect seedling elongation. Dry weights were not significantly affected but followed a concentration-dependent pattern. Higher concentrations led to lower dry weights in *C. sativus* seedlings, indicating a negative impact on seedling development.

In the study, the effect on the growth parameters differed as reflected by the DWs and SLs in *C. lanatus*, for example, while dry weights decreased with increased treatment, SL increased. This phenomena was referred to as “bilateral influence”, a situation where treatments inhibit or stimulate growth parameters of the same plant differentially, that is, while some parameters are stimulated, others are inhibited [29]. This phenomenon underscores the complexity and context-dependent nature of allelopathic interactions. Understanding the differential effects of allelochemicals on different growth parameters is valuable for agricultural and ecological management. It can inform strategies for weed control, crop rotation, and the selection of plant species in mixed plantings. In conclusion, bilateral influence in allelopathy is a fascinating phenomenon where allelochemicals produced by a plant can have divergent effects on various growth parameters of the same plant. This phenomenon underscores the dynamic and multifaceted nature of allelopathic interactions, which can be influenced by concentration, specificity, genetics, and environmental factors. It highlights the need for a comprehensive understanding of allelopathy in both natural and agricultural contexts.

CONCLUSION

This study has shown that *Chromolaena odorata* is an allelopathic plant that inhibits germination and growth of other plants. The effects are concentration-dependent, with higher concentrations of *C. odorata* treatments leading to more pronounced inhibitory effects. This study also showed that *C. odorata* treatments have stimulatory effect on seedling growth and this is dependent on species of the plant, growth stage of the receiving plant and concentration of the allelopathic material. Due to this dual effect on target plants, *C. odorata* can be strategically employed to promote growth in crops and inhibit weed growth.

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